Effects of PM2.5 on Children's Health in Indiana[1]

1. Background

The Environmental Protection Agency (EPA 2006) defines particulate matter (PM) as particles in the air, including dust, dirt, soot, smoke and liquid droplets; it is a complex chemical mixture that includes acids, organic chemicals, metals, soil, or dust particles. The chemical composition and size of PM are two important characteristics that affect the impact of particles on the environment and health.[2] Chemical composition is important because it identifies the toxicity, or innate ability to cause harm, that is associated with particulate matter, regardless of particle size. Particle size determines whether the particle will be filtered and removed from the upper respiratory tract or be inhaled into the middle and lower regions of the lung. These two factors in combination with other characteristics, such as the pH and solubility of the PM, determine where particles deposit in the respiratory tract, how long they remain, and the adverse effects they will produce. The EPA regulates PM as PM10 and PM2.5:

- PM10 or coarse inhalable particles have a diameter larger than 2.5 microns but smaller than 10 microns. PM10 particles are produced by mechanical actions such as crushing or grinding of larger material and the generation of dust from paved or unpaved roads.
- PM2.5 or fine particles have a diameter that is 2.5 microns or smaller. These particles are released directly from sources such as forest fires and other combustion sources, or they can be formed by complex chemical processes that involve the reaction sunlight and water vapor in the air with gases (primarily sulfur dioxide, nitrogen dioxide, and ammonia and particles from a variety of natural and anthropogenic (man-made) sources. Examples of anthropogenic sources that release PM2.5 include motor vehicles, diesel locomotives, coal- and oil-fired power plants, open burning, woodstoves and fireplaces, and some industrial processes. PM2.5 is also present in smoke and haze. These particles can remain suspended in the air for a long time because of their small size.

PM10 can penetrate the defense mechanisms of the upper and middle regions of the respiratory tract, while PM2.5 is transported into the lower pulmonary system.[3] After particles are deposited, they may be retained by or cleared from the respiratory system. Clearance from the upper and middle regions of the respiratory tract in a healthy person occurs in less than a day, while clearance from the pulmonary region, where gas exchange occurs, may take weeks to months. The slow clearance rate from the pulmonary region means that PM2.5 toxic particles are

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[2] See the EPA's Air Quality Criteria for Particulate Matter, Vol. 1, Chapters 2 (Physics, Chemistry, and Measurement of Particulate Matter) and 3 (Concentrations, Sources, and Emissions of Atmospheric Particulate Matter) for a thorough discussion of particle chemistry, size, composition and sources. U.S. EPA (October 2004), available at http://cfpub2.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903

[3] The upper upper region of the respiratory system (nasopharyngeal region) consists of the nasal passages, nasophyarynx, oropharynx, and glottis; the middle region (tracheobronchial region) includes the trachea, bronchi, and bronchioles; the lower region (pulmonary system) includes the respiratory bronchioles, alveolar ducts and alveoli, where air exchange occurs (Godish, T. (1997).

in contact with sensitive tissues for longer times than particles trapped in other regions of the respiratory tract. (Godish 1997)

Another emerging concern is the potential effects ultrafine particles (UFPs) on health. UFPs are a subset of PM2.5 particles, and they have a size that is less than 0.1 μm in diameter. These particles are generated primarily by high-temperature combustion sources such as motor vehicles. Because of their very small size, UFPs may be more important from a health perspective than PM2.5 particles because they are present in larger numbers; have large surface areas, which means that UFPs can carry large amounts of adsorbed or condensed toxic air pollutants; and they have high lung deposition efficiencies. There is growing concern that UFPs can produce the most inflammation per unit PM mass because of these factors. (Sioutas, Delfino, and Singh 2005; Delfino, Sioutas, and Singh 2005).

A diagram showing the relationships among different sizes of particles (UFP, PM2.5, PM10) against the size of bacteria, viruses, and other particles is available at http://circ.ahajournals.org/cgi/content/full/109/21/2655/FIG1.

The composition of fine particles varies depending on the sources and atmospheric history of the particles. The predominant chemical species associated with fine particles are sulfates, nitrates, elemental carbon (soot), condensed organic compounds, and trace metals, but there are regional differences, seasonal differences, and differences between urban and rural areas. There are many studies that have evaluated these differences – the EPAs criteria document for particulate matter provides an extensive review (U.S. EPA October 2004) and the EPA has also summarized regional differences (December 2003).

The mix of local versus regional sources varies throughout the U.S., but local contributions are typically lower in the eastern states than in the western states. Regional pollution contributes more than half of the PM2.5 concentrations in the eastern region. Sulfates predominate in the eastern U.S. and nitrates in southern California. The eastern half of the U.S. typically has higher PM2.5 levels during the summer months (July-September), when sulfates are more readily by from emission from power plants and transported into the region. In contrast, southern California experiences higher levels in the fourth calendar quarter (October-December) because of the contribution of nitrates, which are produced more readily during cooler months. (U.S. EPA December 2003)

Fine particle air pollution was identified as a public health problem more than 20 years ago (Reichhardt 1995), and research since that time has strengthened concerns about the health effects of fine particles. Because of their small size (by comparison a human hair is about 70 microns in diameter), fine particles (diameters less than 2.5 microns) are considered to pose the greatest health risk because they can travel and lodge deep within the lung, but coarse inhalable particles (diameters between 2.5 microns to more than 40 microns) can also cause unwanted health effects. The role of fine particle composition has also been under study, and some of the trace elements detected the particulate composition studies are thought to be responsible for cardiovascular effects caused by the inhalation of PM 2.5 (Bhatnagar 2006).

Table 1 summarizes EPA's findings for health effects associated with exposure to fine and coarse particles; this table summarizes EPA's review of the scientific literature for its most recent air quality criteria report for PM (U.S. EPA October 2004).

Table 1

EPA Findings for Health Effects Associated with Exposure to Fine and Coarse Particles

Short-term exposure to PM2.5	*Long- -term exposure to PM2.5*	*Short-term exposure to PM10*
• Premature death in people with heart and lung disease • Non-fatal heart attacks • Increased hospital admissions, emergency room visits and doctor's visits for respiratory diseases • Increased hospital admission and ER visits for cardiovascular diseases • Increased respiratory symptoms such as coughing, wheezing and shortness of breath • **Lung function changes, especially in children and people with lung disease such as asthma** • Changes in heart rate variability • Irregular heartbeat	• Premature death in people with heart and lung disease, including death from lung cancer • Reduced lung function • **Development of chronic respiratory disease in children**	• Premature death in people with heart or lung disease • Hospital admissions for heart disease • Increased hospital admissions and doctors' visits for respiratory disease • **Increased respiratory symptoms in children** • Decreased lung function
Source: U.S. EPA (October 2004), Retrieved March 30, 2007, from http://cfpub2.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903		

Children are at greater risk from exposure to air pollution, including fine particles, than adults because their bodies are still growing, they take in a greater volume of air per pound of body weight than adults do, and they spend more time doing physical activities outdoors. As shown in Table 1, the long-term effects of PM2.5 particles on children include both lung function changes and development of chronic respiratory disease, and short-term exposures to PM-10 can result in increased respiratory symptoms. The EPA's criteria document for particulate matter (October 2004) and its review of more recent studies (July 2006) provide a detailed summary of the extensive literature on health effects of PM. Although a detailed review is beyond the scope of this paper, a few examples are illustrative.

The Children's Health study (CHS), which began in Southern California in 1993, is one of the largest and most comprehensive investigations of the long-term consequences of air pollution on children's respiratory health. This study has included more than 6000 public school children from 12 different communities across the region, and tracked their respiratory health and many other personal, family, and lifestyle characteristics. The study has provided numerous significant findings about children's environmental health in relation to air pollution, including PM. The many research papers emerging from this study have produced findings showing that exposure to air pollution in the region has resulted in increased school absences, asthma exacerbation, and new-onset asthma. (Künzli et al. 2003).

Gauderman et al. (2004) found decrements clinical and statistically significant decrements in lung function in a long-term student of air pollution in school-aged children in southern California. This study found that decrements in lung function were related to exposures to nitrogen dioxide, acid vapor, and PM2.5, and it demonstrated that air pollution affects the growth of lung function during the period of rapid lung development between the ages of 10 and 18 years.

A more recent study by Gauderman et al. (2007) emphasized the importance of proximity to freeways as another factor affecting lung function in children. In this study, children living in southern California (mean age = 10 years) living 500 yards from freeways had substantial deficits in lunch function growth compared to children living at least 1500 meters from a freeway.

Srám et al. (2005), based on a review of the literature related to possible adverse effects of ambient air pollution on birth outcomes, conclude that there was sufficient evidence to support a causal relationship between particulate air pollution and respiratory deaths in the postneonatal period (28 to 365 days), and there was suggestive evidence for other birth outcomes. A significant relationship was also found between postneonatal mortality from respiratory causes and long-term exposure to PM2.5 (Woodruff, Parker, & Schoendorf 2006).

2. Environmental Risk Factors

A child's exposure to PM2.5 occurs in a variety of outdoor settings, and in some instances, outdoor PM can move indoors through windows, open doors, and other openings or through the ventilation system, resulting in higher overall exposures of PM2.5 (and other pollutants). Children are potentially at risk anytime they outdoors; risks are likely to be higher for children who are active, but even sedentary children, who have asthma or other underlying lung conditions, are at increased risk. Children who engage in strenuous activity when PM2.5 is elevated are at increased risk.

Residing close to major streets and highways increases the risk of developing adverse health effects, as does living near other potential sources, especially high-risk sources such as outdoor wood boilers, open burning of yard and household trash, and burning of agricultural and construction wastes.

Meteorological conditions pose another risk factor when large high-pressure systems move over Indiana and adjacent states and remain stagnant for several days. These conditions cause ground-level PM2.5 concentrations to increase while PM (and other pollutants) are trapped by the stagnant air. Unlike ozone formation, which is temperature dependent, stagnant conditions favoring the buildup of PM2.5 can occur at any time during the year.

Environmental risk factors for fine particulates and children's health are likely to vary between urban and rural areas, but all of Indiana's children are potentially at risk. In urban areas, sources are more likely to produce organic carbon-based fine particulates than in rural areas, but sulfates, nitrates and metals are likely in all areas, although the proportion of each may differ. Because of the greater concentration of mobile and other sources in urban areas than in rural areas, children living in these areas may be at higher risk for PM2.5 (and UFPs) associated with these sources. Similarly, because rural areas are subject to ozone precursors, which also contribute to fine particle formation, children in these areas may be at greater risk for PM2.5 associated with sulfates and nitrates. The concentration and location of the state's coal-fired power plants can also contribute to higher sulfate levels in some areas.

Agricultural dust, though primarily larger in size, may also contribute to the PM2.5, and there are potential concerns about pesticides associated with these dust particles.

Long-range transport of ozone precursors and/or wind-blown dust, which has been well-documented, from areas outside of Indiana is another potential risk factor for exposing children to PM.

3. Extent of Problem in Indiana

3.1. PM2.5 Concentrations

In April 2005, there were 12 counties and portions of five additional counties, which were designated by the EPA as nonattainment for PM2.5 (see Appendix A). Defining the extent of PM2.5 air pollution in Indiana is difficult, however, because although the monitoring network meets federal requirements, it is limited in coverage. Indiana's 92 counties have 39 PM2.5 monitors, and all but four are located in cities, which makes it difficult to know the distribution of rural PM2.5 concentrations (see Appendix A).

Table 2 provides a summary of the annual averages for 2003-2005; data for individual sites are available at http://www.in.gov/idem/programs/air/catalog/pmsummary2000to2005.pdf. These data show the variability of PM2.5 from year to year, differences between background and community and transport/source-oriented sites, and seasonal variation.

The EPA's determination of compliance with the annual PM2.5 standard of 15 $\mu g/m^3$ is based on annual concentrations averaged over a three-year period. Based on this determination 7/32 (22%) community monitoring sites; 4/5 (80%) of transport and source-oriented sites; and 0/2 (0%) of background sites exceeded the three-year design values for 2003-2005 (IDEM 2005).

Although there are variations in the seasonal concentrations, overall the highest concentrations of PM2.5 occur during the 3rd quarter (summer), which is consistent with seasonal variation in other industrial midwest, southeast, and northeast regions (see U.S. EPA December 2004, available at http://www.epa.gov/air/airtrends/aqtrnd04/pm.html).

3.2 PM2.5 Sources and Emissions Estimates

As noted previously, local and regional sources of PM2.5 each contribute to the PM2.5 concentrations at a given location. Data from the national PM2.5 emissions inventory[4] identifies miscellaneous natural sources as the largest contributor (70.6% of total emissions) to direct PM2.5 emissions, followed by industrial processes (11.8%), fuel combustion (9.8%) and transportation (7.8%).

The largest individual contributors to total PM2.5 emissions are fugitive dust from paved and unpaved roads (26.7%), open burning of residential and land clearing debris (6.4%), combustion of residential wood from fireplaces and wood stoves (4.4%), on-road diesels (3.8%), non-road diesels (2.9%). In sum, these sources, which represent about 6% of the individual source categories, account for about 44% of the total direct PM2.5 emissions, which provides insight into potential areas of focus for strategies to reduce exposures. Although Indiana's profile may vary somewhat, the overall source contributions are likely to be representative.

The picture is complicated, however, by the impact of regional sources on local emissions. The EPA is studying the contribution of local versus regional sources to the concentrations of PM2.5 in selected areas, and some data are available for selected cities, including Indianapolis. It is estimated that about 25% of the measured PM2.5 concentrations in Indianapolis are from local sources, with the remaining 75% from regional sources,[5] which suggests that making significant decreases in PM2.5 for a given community will depend on regional improvements.

A consideration of the chemical composition of the PM2.5 provides additional insight into the contribution of regional sources to local PM2.5 concentrations. The regional contributions are estimated by pairing urban monitoring sites to nearby rural sites, and then subtracting the average rural concentration from the urban concentration. In Indianapolis, almost all of the sulfates derive from regional sources (sulfur dioxide from power plants), in contrast to carbon and nitrates. The local versus regional contributions to carbon are roughly equal; and the regional contribution would include natural emissions sources such as vegetation and wildfires and region-wide sources such as cars and trucks. The regional contribution for nitrates is about 60%, and both local and regional sources would include cars, trucks, and small stationary combustion sources.

Table 2

Indiana PM2.5 Summary, 2003-2005 ($\mu g/m^3$)*

	2003	**2004**	**2005**
Community Monitoring Sites (n=32)			
Average ± Standard Deviation	14.38 ± 0.90	13.02 ± 0.92	15.87 ± 1.09
Minimum	12.94	11.73	13.77
Maximum	15.78	15.07	18.54
Percent of Sites > 15$\mu g/m^3$	22%	3%	78%
Transport and Source-Oriented Monitoring Sites (n=5)			
Average	16.67 ± 1.18	15.43 ± 1.87	18.47 ± 0.98
Minimum	14.63	12.16	18.31
Maximum	17.46	16.67	19.36
Percent of Sites > 15$\mu g/m^3$	80%	80%	100%
Background Monitoring Sites (n=2)			
Average	13.61	12.25	15.74
Minimum	13.36	11.89	15.64
Maximum	13.96	12.1	15.84
Percent of Sites > 15$\mu g/m^3$	0%	0%	100%

*Source: IDEM (2005), Retrieved March 15, 2007, from http://www.in.gov/idem/programs/air/pm25standard/index.html

4. Applicable Statutes and Regulations

4.1 PM2.5 Ambient Air Quality Regulations

PM2.5 is regulated as a criteria pollutant under the Clean Air Act, which requires the EPA to set and National Ambient Air Quality Standards (40 CFR Part 50) for pollutant considered to be harmful to the public health and the environment. Primary standards are established to protect public health, including the health of 'sensitive'

[4] Data summarized from Table A-8 of National Air Quality and Emissions Trends Report, 2003 Special Studies Edition. (U.S. EPA 2003) Retrieved March 30, 2007, from http://www.epa.gov/air/airtrends/aqtrnd03/.
[5] Percentages estimated from U.S. EPA (2003), Figure 5. ,

subgroups such as children, the elderly, and asthmatics. Secondary standards are established to protect public welfare. The most recent revision of the PM2.5 standard became effective in December 17, 2006. The state implementations plans will undergo revisions based on nonattainment designations that will be based on 2004-2006 data.

The PM2.5 primary annual standard is set at 15 $\mu g/m^3$; compliance is based on the 3-year average of the weighted annual mean PM2.5 concentrations from single or multiple community-oriented monitors.

The PM2.5 primary 24-hour standard is set at 35 $\mu g/m^3$; compliance is based on the 3-year average of the 98^{th} percentile of 24-hour concentrations at each population-oriented monitor within an area.

Although the revised annual and 24-hour standards are lower than the previous standards, there is concern that the annual standard may not be sufficiently protective. The Clean Air Scientific Advisory Committee, which is mandated by the Clean Air Act to provide scientific advice on setting air quality standards, argued that the annual primary PM2.5 standard should be 13-14 $\mu g/m^3$ to ensure that it was protective of health with an adequate margin of safety as required by the Act, and because "*there is clear and convincing scientific evidence that significant adverse human-health effects occur in response to short-term and chronic particulate matter exposures at and below 15* $\mu g/m^3$*, the level of the current annual PM2.5 standard*" (CASAC 2006).

4.2 Emissions and Regulations

There are many programs at the federal, state and local level to control and reduce PM. States must develop rules and programs to assure that the PM2.5 standard is met. Indiana has adopted the following regulations to reduce PM: Particulate Emissions (326-IAC-6), Fugitive Dust (326-IAC-6-4), and Open Burning (326-IAC-4-1), and the State Implementation Plan includes additional strategies to bring areas that are not in compliance into compliance with the PM2.5 standard. In addition, Indiana participates in a variety of federal programs aimed at reducing PM emissions directly from sources or indirectly through controls for acid rain and ozone precursors (see Appendix B).

Some local jurisdictions, such as the City of Indianapolis, have the authority to regulate air quality by adopting the state regulations or more stringent regulations. Local jurisdictions can also adopt regulations for specific concerns such as open burning, wood boilers, diesel exhaust, and fugitive dust.

Open Burning. 326-IAC-4-1 regulates open burning, which is banned, unless exempted or allowed; sale and reuse are encouraged.[6] Residential burning is banned in Clark, Floyd, Lake, and Porter counties. Private residential burning (where the building contains four or fewer dwelling units) is allowed in other counties, provided only clean wood products and paper are burned and the burning takes place in a noncombustible container that is sufficiently vented to induce adequate primary combustion and has enclosed sides and a bottom.

Other types of burning are also allowed. Allowable burning includes recreational or ceremonial fires, burning of waste oil resulting from spills during oil well testing, burning by certain agencies for the purposes of managing public lands, burning of marijuana by law enforcement, burning for purposes of heating, burning of vegetation for fire control, and the burning of clean petroleum products (not previously used) for fire extinguisher training. Exempted burning includes the burning of vegetation from a farm, orchard, nursery, tree farm, or drainage

[6] The regulation is available at http://www.in.gov/legislative/iac/title326.html. Accessed August 5, 2004.

ditch; certain wood and vegetation that are not coated with stain, paint, glue or other coating materials; and clean petroleum products.

Conditions that apply to allowable or exempted open burning are that burning is restricted to daylight hours; burning is prohibited under unfavorable meteorological conditions such as high winds, temperature inversions, or air stagnation; and fires must be extinguished if a fire creates a pollution problem or threat to public health. Burning for the purposes of heating is restricted to the period from October 1 and May 15, and such burning may used for disposal purposes.

Evansville regulates open burning under MCE 3.30.214 (Burning Regulations).[7] Within the city limits, only recreational fires are permitted. Outside the city limits but within the jurisdiction of the agency, options include open burning variances and air curtain incinerator permits. An open burn permit can be obtained for private residential burning if the building contains only one or two dwelling units. This rule is similar in other respects to the state rule, but it does specifically identify that no burning shall be conducted during an Ozone alert or an air pollution alert (and other unfavorable meteorological conditions).

Wood Boilers. The City of Indianapolis banned the use of wood-fired heating devices (wood boilers) in 2005 [Regulation 4, Section 3.3].[8]

Diesel Exhaust. The city of Hammond uses two regulations to address PM, including PM2.5, sources. Chapter 97 (Noise) reduces noise by limiting the idling of heavy vehicles (> 10,000 lbs) or any attached auxiliary equipment.[9] Idling by these vehicles is limited to less than or equal to 3 minutes per hour on public or private property and not within a completely enclosed structure. The regulation does not apply to buses and taxis that are standing in established bus or taxi turnarounds, terminals, lots, or storage yards when these vehicles operate for the purpose of transporting passengers. Chapter 90 (Air Pollution) prohibits the emission of quantities of air contaminants from any source "as to be detrimental to any person or to the public, or to endanger the health, comfort, or safety of any person or the public." Taken together, these regulations provide the Air pollution Control Department and the Police Department, who jointly administer the regulations, with authority to prevent vehicles or other sources from releasing pollutants, including PM2.5, that are harmful to health. The enforcement program is funded in part by monies from an environmental settlement.

5. Recommendations

The solution to the fine particulate control problem is complicated by myriad sources and limited monitoring data. This is in contrast to more targeted environmental health issues such as acid precipitation, where the problem was controlling or reducing the emissions from a relatively small number of very large coal burning electric generating plants, which allowed for focused control through national regulation. Government, industry, and communities will need to work aggressively in integrated programs to continue to reduce exposures to PM2.5

[7] The regulation is available at http://www.evansvillegov.org/citycodes/. Accessed March 30, 2007.
[8] The regulation is available at available at http://www.indygov.org/eGov/City/DPW/Environment/AirQuality/Air+Ordinances+-+Regs+2006-9-28.htm. Accessed March 30, 2007.
[9] (see http://www.amlegal.com/nxt/gateway.dll/?f=templates&fn=default.htm).

through existing regulatory programs and additional initiatives that promote improved engine technology, increases in fuel efficiency, development and use of zero emission vehicles, adoption of mass transit that produces minimal PM2.5, and energy conservation.

With PM 2.5, every combustion unit – industrial boilers, school bus, truck, lawnmower, fireplace, wood boiler, etc - is a source of fine particulate matter. Ultimately, controls of specific sources must be combined with overall reductions in carbon-containing fuels, and the state and its communities working in partnership with the private and voluntary/nonprofit sectors can play a pivotal role in achieving these reductions. Some specific recommendations are given below for reducing exposures to PM through strategies for reducing idling, diesel emissions, regional exposures, energy usage, open burning, and other childhood exposures.

Reduce Idling:

- Encourage schools, businesses, and government to adopt no idle programs. These programs reduce PM2.5 and have added benefits of reducing of non-PM2.5 emissions, reducing fuel usage,[10] and saving money. EPA's National Idle Reduction campaign (http://www.epa.gov/cleanschoolbus/antiidling.htm#bkgrd) can easily be applied to a statewide campaign. Partnerships such as the Smart Schools Don't Idle pilot program between the City of Indianapolis Knozone Program and Improving Kids' Environment provide a model (http://www.ikecoalition.org/Schools/Smart_Schools/Index.htm). Sponsorship of a statewide program through the Governor's office would further emphasize the importance of no-idle programs.
- Statewide adoption of anti-idling rules for school buses and commercial motor vehicles. An example is California's Air Resources Board regulations for school bus idling and diesel-fueled commercial motor vehicle idling (see http://www.arb.ca.gov/toxics/sbidling/sbidling.htm).
- Public education to emphasize reduced idling. The City of Indianapolis Knozone program is an example of a successful local program that has shown changes in personal behavior over time.

Reduce Diesel Emissions:

- Reduce diesel exhaust for on-road vehicles through retrofits (particulate matter traps, oxidation catalysts, biodiesel and alternative fuels), electrification projects, and no-idling ordinances. Seek innovative partnerships to expand programs such as the diesel emissions reduction initiative in northwest Indiana. Encourage communities statewide to jump-start these efforts by local jurisdictions, and help communities seek funding for these programs. [One such example is an EPA grant awarded to the City of Indianapolis to retrofit large diesel trucks with catalytic converters.] Attractive tax incentives may also encourage retrofit programs.
- Reduce diesel exhaust for non-road vehicles through retrofit/rebuild programs. Provide grants and incentives to promote retrofits.

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[10] According to the EPA, a typical school bus engines burn about half a gallon of fuel per hour of idling ; EPA's website, available at http://www.epa.gov/cleanschoolbus/antiidling.htm#bkgrd.

Reduce Regional PM2.5 Exposures:

- Establish a regional air pollution control authority for central Indiana and other higher population areas to allow for more effective coordination of education, regulatory and control programs to reduce PM2.5.
- Improve public transportation in urban areas, with a longer-term strategy to build a rapid transit system powered by technology that produces minimal fine particulate emissions.
- Expand public education about the health risks of PM2.5 and personal actions individuals and communities can take to reduce emissions and exposures.

Improve Energy Usage:

- Expand public education to emphasize energy conservation.
- Require mandatory conservation programs for government agencies and state universities. Strategies to reduce energy consumption for heating and cooling must be balanced with indoor fresh air requirements to prevent indoor air quality problems.

Reduce Open Burning:

- Strengthen the existing state law IAC 4-1 Open Burning.
- Promote the adoption and enforcement of a local model burn ban ordinance.

Additional Strategies to Reduce Childhood Exposures:

- Prohibit new schools and day-care centers from locating in parks.
- Determine if education programs for physicians, nurses, and others involved in caring for patients with asthma receive adequate instruction with respect to outdoor air pollution risk factors for asthma. Devise training programs based on results.

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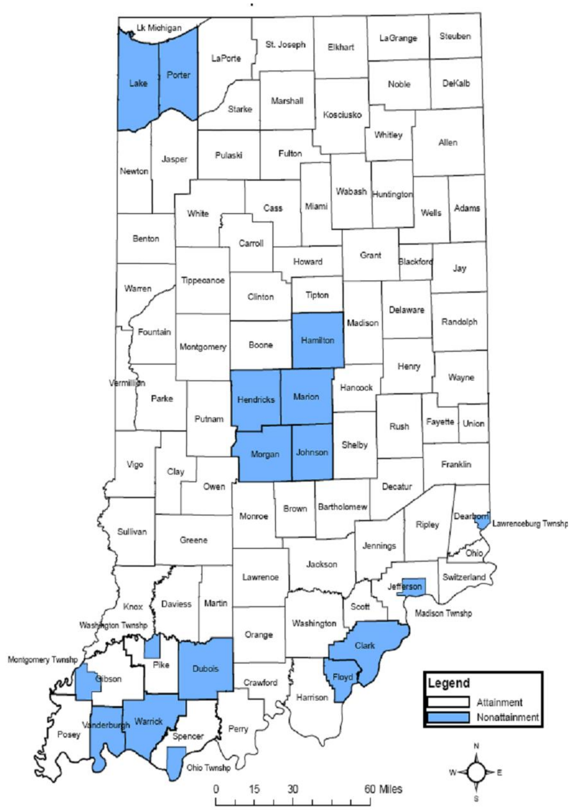
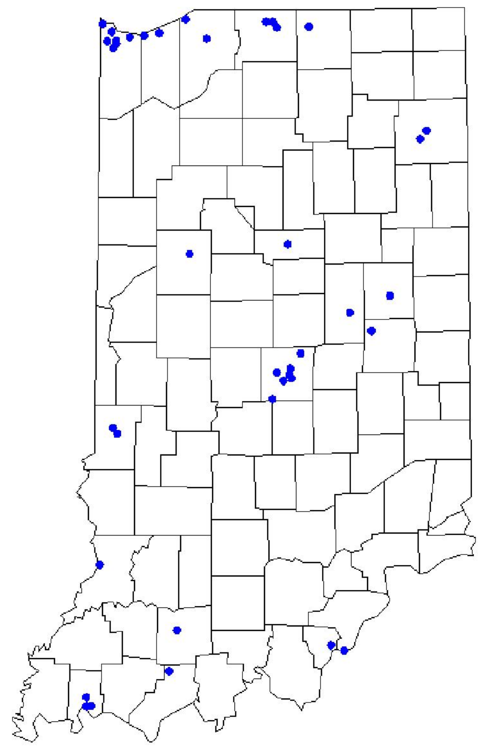
Appendix A
PM2.5 Nonattainment Areas and PM2.5 Monitoring Sites

U.S EPA Final Designations for Fine Particle PM2.5 Standard
April 2005



Source: IDEM, Retrieved March 30, 2007, from http://www.in.gov/idem/programs/air/catalog/pm25revisedfinalmap.pdf

PM2.5 Air Quality Trend Sites in Indiana
1999 to 2005



Source: U.S. EPA, Air Trends, Retrieved March 30, 200, from http://www.epa.gov/cgi-bin/broker?_service=data&_debug=0&_program=dataprog.maptest7.sas&parm=88101&stfips=18

Appendix B

Table 1. A Selection of Emission Control Programs Contributing to PM Emission Reductions, 1995–2015

Program	Sector	Direct PM[a] Reductions	PM Precursors SO_2 Reductions	PM Precursors NO_x Reductions	PM Precursors VOC Reductions	Implementation Date
Clean Air Nonroad Diesel Rule	Mobile sources	X	X	X		2004-2015
Clean Air Interstate Rule (proposed December 2003)	Electric Utilities	X	X	X		2010-2015
Acid Rain Program	Electric Utilities		X	X		1995-2010
NO_x SIP Call	Electric Utilities		X	X		2004
Regional Haze Rule/ Best Available Retrofit Technology	Electric Utilities[b]	X	X	X		2013-2015
$PM_{2.5}$ Implementation[c]	Stationary/Area/ Mobile sources	X	X	X	X	2008-2015
PM_{10} SIPs (e.g., San Joaquin Valley)	Stationary/Area/ Mobile sources	X	X	X	X	Ongoing
Maximum Achievable Control Technology (MACT) Standards[d]	Stationary/Area	X			X	1996-2003
Various Mobile Source Programs[e]		X	X	X	X	Ongoing

[a] Includes elemental and organic carbon, metals, and other direct emissions of PM.

[b] Also applies to industrial boiler and the other source categories also covered under Prevention of Significant Deterioration (PSD).

[c] Includes Reasonably Available Control Technology (RACT) and Reasonably Available Control Measures (RACM).

[d] Includes a variety of source categories such as Boilers and Process heaters, Pulp and Paper, Petroleum Refineries, various minerals and ores, and others. While these standards are for hazardous air pollutants (HAPs) such as metals, measures to reduce HAPs in many cases also reduce PM emissions.

[e] Includes such programs as onroad diesel and gasoline engines, nonroad gasoline engines, Low Sulfur Diesel and Gasoline Fuel Limits for onroad and offroad engines, Motorcycles, Land-based recreational vehicles, and Marine diesel engines.

Source: U.S. EPA (December 2004), Retrieved March 30, 2007, from
http://www.epa.gov/air/airtrends/aqtrnd04/pmreport03/pmexplain_2405.pdf#page=4