UNC
SCHOOL OF MEDICINE
CENTER FOR
ENVIRONMENTAL MEDICINE,
ASTHMA & LUNG BIOLOGY

October 25, 2006

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Dear Mr. Gulick:

The following is a brief written overview of my expert opinion regarding the impact of air pollutants on various aspects of human health. These opinions are specifically relevant for particulates and ozone that result from coal-fired power plant emissions. I am the Director of the UNC Center for Environmental Medicine, Asthma and Lung Biology and am directly involved in research regarding the biological effects of pollutants in humans, as well as involvement at a national level regarding this topic. For full disclosure, I have never given testimony in court on this topic (or any other for that matter), and as an employee of the University of North Carolina at Chapel Hill, any payment that might be made would only be to compensate UNC for my time away from campus. I would not expect direct compensation for this testimony.

There is certainly a relationship between exposure to increased levels of ambient air pollutants and increased occurrence of adverse health outcomes. A number of epidemiological studies have revealed that increases in PM2.5 are linked to premature death due to cardiovascular causes as well as cancer. Cardiovascular deaths include deaths associated with myocardial infarction, likely arrhythmia, and stroke. Many of these deaths are linked to exposures which are below the national ambient air quality standard for PM 2.5. Increased death due to COPD and asthma has also been reported as a result of exposure to PM2.5. Perhaps even more notable than effects on stroke and cardiovascular deaths in adults is the growing body of evidence that infant deaths can be linked to changes in ambient air PM. These deaths include deaths due to respiratory causes as well as SIDS in infants. Similar data exist for exposures to ozone as well.

Likewise, there are several reports linking increased hospitalization rates and ER visits for a number of diseases to increased levels of ozone, NOx, PM2.5 and total suspended particulates. These include hospitalizations for myocardial infarction, stroke, COPD and asthma. In addition to hospitalizations, exacerbations of disease which require increased use of asthma rescue mediations have been extensively reported. The primary pollutants

associated with these changes include ozone and PM, though oxides of nitrogen are also linked to disease exacerbation. In addition to overt exacerbation of disease, there is growing evidence that airborne pollutants are linked to poor health in children. In one study, children living predominantly in areas which experience high levels of ozone, PM and NOx pollution have decreased lung growth relative to children raised in less polluted locations. Likewise, a recent study has shown that children living in a high ozone area and who had extensive exposure to ozone had a 3.3 times higher likelihood of developing asthma compared to those living in cleaner regions. Together, these and other studied indicate that exposures to pollutants not only result in exacerbation of disease, but in decreased lung development and occurrence of disease as well.

Many of these observations, especially those which concern asthma and mortality outcomes, indicate that the health event lags behind the occurrence of the pollutant exposure for 1-3 days. This lag time has suggested that pollutant exposures (either with PM or ozone) exert effects which require time to result in disease. This is very relevant for a number of inflammatory events, which contribute to asthma, COPD and cardiovascular disease. In our own laboratory, we have been very interested in the effects of air pollutants on airway inflammation. Our studies have shown that exposure to either ozone or endotoxin (a component of particulate air pollutants) enhances the response of people with allergic asthma to allergens (things to which one is allergic). We have also examined which events occur in the airway which may account for these changes. Our studies show that ozone and endotoxin can cause increased numbers of neutrophils and eosinophils to be recruited into the airways of allergic people. However, at even lower levels of exposure, we have observed that pollutants cause changes in monocytes and related cells which facilitate having allergens interact with other elements of the immune system, resulting in increased inflammatory responses to the allergens.

Our Center has also conducted panel studies examining the relationship between PM exposure with cardiovascular outcomes in healthy volunteers and asthmatics. In one such study, North Carolina State Troopers agreed to undergo frequent blood draws as well as to be monitored for changes in heart rate and assessment of heart rate variability (essentially a very sophisticated ECG type assessment which predicts the ability of the heart to adjust to changing physiological demands, with decreased heart rate variability being associated with numerous heart pathologies). PM levels were monitored in each patrol car and blood samples were assessed. In-vehicle $PM_{2.5}$ (average of 24 $\mu g/m^3$) was associated with decreased lymphocytes (–11% per 10 $\mu g/m^3$) and increased red blood cell indices (1% mean corpuscular volume), neutrophils (6%), C-reactive protein (32%), von Willebrand factor (12%), next-morning heart beat cycle length (6%), next-morning heart rate variability parameters, and ectopic beats throughout the recording (20%). The observations in these healthy young men suggest that in-vehicle exposure to $PM_{2.5}$ may cause pathophysiologic changes that involve inflammation, coagulation, and cardiac rhythm. We have also examined the effect of PM exposures in asthmatics on controller medication. Of note, we saw increased relationship between coarse particulates and heart rate variability, serum triglyerides and cholesterol. Our data are consistent with those from a number of investigators which link PM exposures to adverse cardiovascular disease.

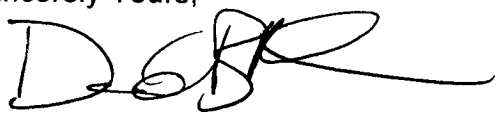
The underlying mechanisms for the effects of pollutants are incompletely understood, but it is very likely that the root of many of these effects reside in changes in inflammation and immune function. Again, investigators in our laboratory have demonstrated that pollutants

exert significant inflammatory effects in epithelial and circulating immune cells. Recent studies suggest that particulates likely enhance response to viral infection, in addition to allergens. We have also demonstrated that anti-inflammatory drugs can interfere with the effects of pollutants, again suggesting a pro-inflammatory effect of these agents.

It is also important to note that many of these health outcomes are observed at pollutant levels that are below the current National Ambient Air Quality Standards for these pollutants. This underscores the need to maintain ambient air pollutants to as low a level as possible to decrease the occurrence of a wide variety of health outcomes, including asthma, COPD, heart disease, premature adult death and infant death.

The bases for my opinion derive from both my own research regarding the mechanisms of the effects of pollutants on airway inflammation and immune function in asthma and extensive review of the literature on this topic. Listed below (after my signature) are selected references which form part of the bases of my opinion. Also attached is my CV, which contains more references which I have authored and also contributes to the bases of my opinion.

Sincerely Yours,



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