Health Consultation

Review of Ambient Air Monitoring Data

MIRANT POTOMAC RIVER GENERATING STATION
ALEXANDRIA, VIRGINIA

EPA FACILITY ID: VAD000731588

MARCH 21, 2011

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry (ATSDR)
Exposure Investigations & Site Assessment Branch

FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct public health assessment activities at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment program allows the scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations - the structure may vary from site to site. Nevertheless, the public health assessment process is not considered complete until the public health issues at the site are addressed.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan.

ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Agency for Toxic Substances and Disease Registry
ATTN: Records Center
1600 Clifton Road, NE (Mail Stop F-09)
Atlanta, GA 30333

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Tables and Figures

Abbreviations

ACS	American Cancer Society
AQS	Air Quality System (EPA)
ATSDR	Agency for Toxic Substances and Disease Registry
CREG	Cancer Risk Evaluation Guide (ATSDR)
DOE	Department of Energy
EI	Exposure Investigation
EPA	U.S. Environmental Protection Agency
MRL	Minimal Risk Level (ATSDR)
NAAQS	National Ambient Air Quality Standard (EPA)
NWS	National Weather Service
PM	particulate matter
PM_{10}	particulate matter having aerodynamic diameter less than or equal to 10 microns
$PM_{2.5}$	particulate matter having aerodynamic diameter less than or equal to 2.5 microns
ppb	parts per billion
REL	Reference Exposure Level (California EPA)
RfC	Reference Concentration (EPA)
$\mu g/m^3$	micrograms per cubic meter
TSP	total suspended particulate matter
WHO	World Health Organization
VDEQ	Virginia Department of Environmental Quality
VDH	Virginia Department of Health

Mirant PRGS Summary

Introduction

In 2006, the Alexandria, VA Health Department Director requested that ATSDR review the Mirant Potomac River Generating Station's (PRGS)[1] operations-related air dispersion modeling data. Specifically, the director asked ATSDR to assess potential health effects for nearby residents and to recommend next steps. After its initial assessment, ATSDR raised public health concerns regarding potential exposures to 5-minute-peak sulfur dioxide concentrations for sensitive persons.

In 2007, ATSDR conducted an exposure investigation that sampled Mirant PRGS ambient air for sulfur dioxide peaks, particulate matter, and selected metals. In 2008, ATSDR received peak sulfur dioxide data from Mirant. Working with ATSDR, Mirant, and Virginia Department of Environmental Quality data, ATSDR further evaluated exposures to particulate matter, sulfur dioxide, and metals.

In January 2009, Mirant completed a stack merge project, expected to enhance atmospheric dispersion of emissions but not expected to affect respective emission rates. In response to the City of Alexandria's request to include an analysis of post stack merge sulfur dioxide data in the final report, ATSDR has included the analysis in Appendix I.

On December 3, 2010, Mirant and RRI Energy announced that they have completed their merger to form GenOn Energy, Inc. The generating station that is the subject of this report is now called the GenOn Potomac River Generating Station. For consistency purposes with this report, ATSDR will continue to refer to this generating station as the Mirant Potomac River Generating Station or Mirant site.

Conclusions

ATSDR reached five conclusions for communities located near the Mirant PRGS facility.

[1] Throughout this document the Mirant PRGS is sometimes referred to as the "facility."

Conclusion 1

Breathing air around Mirant PRGS contaminated with sulfur dioxide for short periods (5 minutes) could harm the health of sensitive persons (e.g., persons with asthma) functioning at elevated ventilation rates, perhaps by exercising, working outdoors, gardening, or climbing steps. These exposure levels have been infrequent and have been limited to areas within ¼-mile of Mirant PRGS and generally between noon and 5 pm. When sulfur dioxide concentrations exceed 400 ppb, such persons may experience symptoms such as coughing, wheezing, and chest tightness. At lower sulfur dioxide concentrations (200 ppb to 400 ppb), sensitive persons functioning at elevated ventilation rates may experience asymptomatic effects (e.g., mild constriction of bronchial passages). Adverse health effects from exposures to less than 200 ppb are uncertain but may occur in some persons more sensitive or vulnerable than those participating in clinical investigations.

People with asthma, children, and older adults (65+ years) have been identified as groups susceptible to the health problems associated with breathing SO_2. Clinical investigations and epidemiological studies have provided strong evidence of a causal relationship between SO_2 and respiratory morbidity in people with asthma and more limited epidemiological studies have consistently reported that children and older adults may be at increased risk for SO_2-associated adverse respiratory effects. Potentially susceptible groups to air pollutants include obese persons, those with preexisting cardiopulmonary disease, and those with a pro-inflammatory condition such as diabetes, but some of these relationships have not been examined specifically in relation to SO_2.

Conclusion basis

Evaluation of peer-reviewed scientific studies involving clinical investigations of persons with mild-to-moderate asthma exposed to sulfur dioxide while functioning at elevated ventilation rates.

Next steps

To reduce peak exposures to sulfur dioxide for sensitive persons functioning at elevated ventilation rates, ATSDR recommends

- The Virginia Department of Environmental Quality continue its efforts to reduce peak acid gas emissions from the Mirant PRGS.
- ATSDR continue to share health education materials identifying potential locations and times sulfur dioxide may be present at levels of public health concern for susceptible and potentially susceptible populations. Public outreach and education already completed to address this recommendation included an open house, community fact sheet, educational information on the ATSDR Web site, meetings with local community groups, and a link from local public health agencies

	to the ATSDR Web site for public access to site-related educational materials.
Conclusion 2	Breathing air around Mirant PRGS contaminated with sulfur dioxide is not expected to harm the health of the general population or the health of sensitive populations not functioning at elevated ventilation rates.
Conclusion basis	Using current science, ATSDR found that sulfur dioxide levels measured around Mirant PRGS are below levels reported to cause harmful effects in nonsensitive populations.
Next steps	For this conclusion, no actions or recommendations are necessary.
Conclusion 3	People in Alexandria, VA who over many years breathe air contaminated with particulate matter equal to or below 2.5 microns ($PM_{2.5}$) could experience harmful health effects. The $PM_{2.5}$ levels observed in the local Alexandria area are similar to levels measured in multiple locations throughout northern Virginia. Thus $PM_{2.5}$ levels in the local Alexandria area are in fact a regional concern, with a range of contributing factors including but not limited to Mirant PRGS emissions.
Conclusion basis	The reported levels of $PM_{2.5}$ in ambient air were compared with epidemiological studies of people exposed to similar ambient air conditions. The studies concluded that if over several years annual mean concentrations were in the range of those reported in or near Alexandria, health effects may be possible.
Next steps	To reduce particulate matter exposure, ATSDR recommends • The VDEQ and the City of Alexandria continue efforts to reduce particulate matter emissions in the City of Alexandria and in the State of Virginia, including available measures to reduce and monitor particulate matter emissions as specified in the City of Alexandria–Mirant PRGS settlement agreement. • ATSDR continue to share health education materials identifying potential locations and times sulfur dioxide may be present at levels of public health concern for susceptible and potentially susceptible populations. Public outreach and education already completed to address this recommendation included an open house, community fact sheet, educational information on the ATSDR Web site, meetings with local community groups, a link from the local public health agencies to the ATSDR Web site for public access to site-related educational materials, and two webinars for health professionals on particulate matter and patient health.

Conclusion 4	The measured metals levels found in the air near Mirant PRGS were generally lower than those previously estimated by air dispersion modeling. With two exceptions, each metal measured in the air samples was below potential health concern levels. Arsenic and chromium were found at levels that could present a slight to low increase in estimated cancer risk. The arsenic and chromium levels were consistent with those routinely observed in suburban and urban locations nationwide and likely reflected contributions from many emissions sources.
Conclusion basis	Peer-reviewed scientific studies resulting in established health-based comparison values.
Next steps	Reduce particulate matter exposures (see Conclusion 3), which should also reduce arsenic and chromium exposures.
Conclusion 5	ATSDR cannot determine whether people near Mirant PRGS who breathe sulfur-dioxide contaminated air for 5 minutes while also breathing $PM_{2.5}$ or after breathing ozone would experience health effects beyond those for sulfur dioxide or $PM_{2.5}$ exposure alone. Whether the severity of effects would increase as a result of a potential multiple-contaminant exposure is unlikely, although the number of affected persons could increase because the same effects could occur at a lower sulfur dioxide concentration. Therefore, during the summer months at certain times of day and at certain locations, given sufficient concentrations, such contaminant exposures are expected to result in limited health effects.
Conclusion basis	Professional judgment based on peer-reviewed, scientific studies reporting potential coexposures to sulfur dioxide, particulate matter, or ozone.
Next steps	ATSDR recommends reducing exposure to sulfur dioxide peaks and to $PM_{2.5}$ (see Conclusion 1 and Conclusion 3). These reductions are expected to reduce the likelihood of harmful effects from multiple contaminant exposures.

Statement of issues

ATSDR's first task was to define clearly the scope of its evaluation. Listed below are specific issues evaluated in this health consultation.

What *timeframe* does this health consultation address?

Air pollution levels were measured in 2007 and 2008—the timeframe with the most extensive outdoor air pollution measurements.

Which *pollutants* does this health consultation address?

Pollutants that coal-fired power plants are known to emit and that have measureable health endpoints. The specific pollutants evaluated were sulfur dioxide, particulate matter, and metals.

What *exposure scenarios* does this health consultation address?

Community inhalation exposures to air pollutants released from Mirant PRGS. The health consultation does not address workers' exposures or residents' potential exposures to site-related pollutants possibly present in other environmental media such as water or soil.

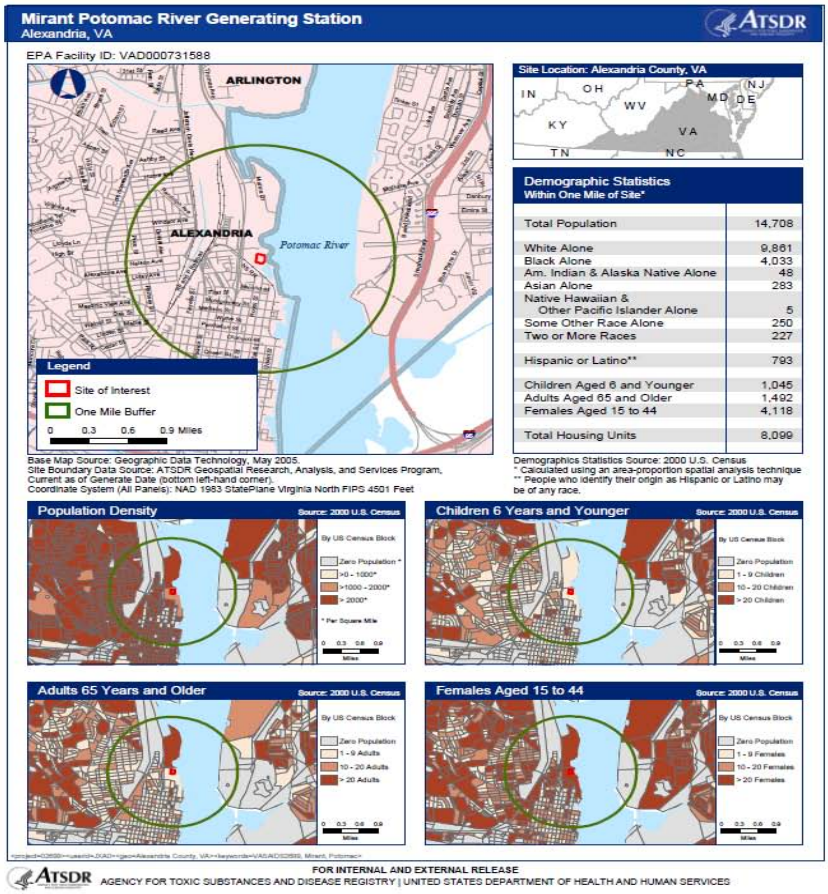
Background

Site description and history

Mirant Potomac River Generating Station (Mirant PRGS) began generating electricity in 1949. Mirant PRGS is in the City of Alexandria, along the Potomac River in northeastern Virginia, approximately 3 miles from the Ronald Reagan Washington National Airport and about 5 miles from the U.S. Capitol building (Figure 1). In 2000, Mirant purchased the generating station from the Potomac Electric Power Company (PEPCO). Residential and commercial properties surround the Mirant PRGS facility, with a condominium building (Marina Towers) built in the 1960s approximately 300 yards away. Numerous condominiums in Marina Towers have balconies that face directly toward Mirant PRGS. A section of the Mt. Vernon Trail—a multi-use recreation trail extensively used for walking, jogging, bicycling, and other activities—is immediately adjacent to Mirant PRGS.

Mirant PRGS' five generating units are capable of producing 482 megawatts (MW) of electricity. This product supplies the Pennsylvania/New Jersey/Maryland distribution grid, and services numerous customers throughout Washington, D.C. Although fuel oil preheats the generating units, burning coal supplies the generating energy. To reduce air pollutants emissions, Mirant PRGS units are equipped with air pollution control technologies. Some of the more prominent controls include electrostatic precipitators, low nitrogen oxide (NO_x) boilers, and dry sorbent injection of trona to reduce sulfur dioxide emissions. VDEQ is the air permitting authority for Mirant PRGS. The air permits carry extensive operating, monitoring, recordkeeping, reporting, and other requirements.

Figure 1. Demographics map.



Over the years, operation levels at Mirant PRGS have varied considerably. Since 2005, changes have resulted primarily from concerns that facility emissions caused local air pollution levels to exceed U.S. EPA's health-based National Ambient Air Quality Standards (NAAQS). This concern has been greatest for locations in immediate proximity to the facility, due to the influences of "building downwash."

What is building downwash?
Building downwash is a phenomenon that under certain stack configurations and meteorological conditions can cause emissions to blow down to ground level in the wake of nearby buildings rather than disperse into ambient air.

In January 2009, Mirant PRGS reconfigured its stack emissions to mitigate "building downwash" and improve local air quality. Previously, Mirant PRGS had operated with five boilers and five stacks—each boiler was connected to its own stack. After the stack reconfiguration, boiler exhaust is now vented through two stacks at a higher exit velocity. This reconfiguration, which VDEQ authorized in its latest facility operating permit, does not affect the amount of emissions released but, because of the higher exit velocity, does disperse those emissions more effectively.

Like all coal-fired power plants, Mirant PRGS emits a wide range of pollutants, most of which are combustion byproducts. These include various criteria pollutants (e.g., sulfur dioxide, particulate matter) and air toxics (e.g., metals). Facility emissions affect local air pollution levels and contribute to regional air quality issues. But these levels and issues are also affected by many emissions sources, including other industrial and mobile sources.

Table 1 chronicles major milestones during Mirant PRGS recent history, including steps taken to operate the facility in a manner that does not exceed the NAAQS. When planning public health actions for this site and when preparing this health consultation, ATSDR fully considered the milestones in Table 1, as well as other available background information and events not listed in the table.

Table 1. Timeline of Recent Events

Date	*Event*
September 23, 2004	Mirant agrees to a consent order with VDEQ requiring that Mirant use dispersion models to estimate how actual emissions might affect local air pollution levels for selected pollutants.
August 19, 2005	Mirant submits a report documenting the dispersion modeling analysis conducted pursuant to the consent order. A Mirant contractor (ENSR Corporation) conducted the analysis, which revealed that facility emissions generated air concentrations of sulfur dioxide, nitrogen dioxide, and particulate matter estimated at smaller than 10 microns (PM_{10}), but exceeding U.S. EPA's corresponding National Ambient Air Quality Standards (NAAQS). VDEQ issues request to Mirant to take action immediately to reduce human health effects from its operations.
August 24, 2005	Mirant shuts down the facility's electricity generating operations until it can determine what modifications were needed to operate in a manner that did not cause elevated air quality health effects.
August 26, 2005	The City of Alexandria releases its own dispersion modeling analysis, conducted by AERO Corporation. The magnitude of estimated air quality effects predicted by this study differed from those reported in the Mirant study. Both modeling studies predicted, however, that Mirant PRGS's emissions led to estimated ambient air concentrations higher than U.S. EPA's NAAQS.
September 20, 2005	Mirant submits an updated modeling analysis identifying specific operating conditions not expected to cause off-site air quality effects exceeding U.S. EPA's NAAQS. The next day, Mirant PRGS resumes electricity generating operations at significantly reduced levels, consistent with those identified in the updated modeling analysis.
December 30, 2005	Mirant completes a compliance plan identifying several options for process and technology modifications that would allow the facility to operate at levels below modeled NAAQS exceedances. In the following months, Mirant submits multiple supplements to this plan.
January 24, 2006	Letter from the Alexandria Health Department requesting ATSDR's review of existing environmental data related to Mirant PRGS's operations, assessing the potential for health effects for nearby residents and recommending next steps.
June 1, 2006	U.S. EPA issues an administrative order allowing Mirant PRGS to continue operating but requiring measures to ensure that such operations do not lead to off-site exceedances of sulfur dioxide NAAQS. Mirant PRGS must conduct daily dispersion modeling analyses of the planned operational scenarios to ensure that emissions would not cause local air pollution to exceed levels of U.S. EPA's corresponding NAAQS. Additionally, Mirant PRGS must continuously monitor ambient air concentrations of sulfur dioxide at six locations believed to have the greatest air quality effects. This requirement applied through May 31, 2007.

June – July, 2006	Mirant PRGS installs six ambient air monitoring stations that continuously measure outdoor air sulfur dioxide concentrations. The first monitoring station begins collecting valid data on June 2. Mirant PRGS later documents the measured concentrations in monthly summary reports submitted to U.S. EPA and VDEQ.
January 4, 2007	ATSDR reviewed available air modeling and emissions data for Mirant PRGS and, in a letter health consultation to the Alexandria Health Department, released preliminary findings.
June 1, 2007	VDEQ issues an operating permit to Mirant PRGS. The permit contains hourly and annual emissions limits for sulfur dioxide protective of public health and requires Mirant PRGS to continue to operate the six ambient air monitoring stations originally required in the U.S. EPA administrative order.
June – July, 2007	ATSDR conducts an Exposure Investigation to measure at multiple locations near Mirant PRGS ambient air concentrations of sulfur dioxide, particulate matter, and metals. ATSDR selected monitoring locations to correlate with modeled 1-hour SO_2 maximum concentrations, which tend to occur at different locations than do the 24-hour and annual average maximums and included as well a limited number of indoor locations.
July 1, 2008	The City of Alexandria enters into a settlement agreement with Mirant. The agreement requires, among other things, that Mirant invest additional funds in implementing pollution controls and that Mirant conduct additional ambient air monitoring for fine particulate matter.
July 31, 2008	VDEQ issues an updated facility operating permit, which includes extensive operating, monitoring, recordkeeping, reporting, and other requirements. This version of the permit allows for future stack reconfigurations (i.e., "stack merges"). The permit also includes emission limits for multiple pollutants (sulfur dioxide, particulate matter, carbon monoxide, nitrogen oxides, volatile organic compounds, and acid gases). The permit no longer requires Mirant to operate its ambient air monitoring network.
January, 2009	Mirant PRGS completes its stack merge project. Rather than having five separate boilers each connected to its own stack, boiler emissions are now vented with higher exit velocity through just two stacks.
December 2008–November 2009	ATSDR conducted side by side comparisons of the co-located ATSDR and Mirant monitors. The new technology ATSDR employed for SO_2 did not perform to the manufacturing specifications. ATSDR initiated and conducted a field comparison study of the monitors. ATSDR revised and updated the health consultation document accordingly. In June 2009, ATSDR met with and briefed the new Alexandria Health Department director.
November 2009	ATSDR distributes a letter update to community members, agencies, and other interested stakeholders regarding the status of the health consultation and the EI SO_2 monitor issue.
December 2009	ATSDR submitted this health consultation for external scientific peer review.
July 2010	ATSDR released a draft of the Health Consultation for public comment.

Demographics

ATSDR examined demographic data to determine the number of persons who were potentially exposed to site-related environmental contaminants and to determine the presence of potentially sensitive populations such as children (age 6 years and younger), women of childbearing age (between ages 15 and 44 years), and older adults (65+ years). ATSDR's review of demographic data found

- **General population trends.** Figure 1 summarizes demographic data for areas within 1 mile of Mirant PRGS, based on information compiled in the 2000 U.S. Census. Overall, an estimated 14,708 persons—mostly Alexandria residents—live within 1 mile of the facility. According to the Census data, 7% of the population within 1 mile of Mirant PRGS are children aged 6 and younger, 10% are considered older adults (65+ years), and 28% are women of childbearing age (15–44).
- **Residents closest to the site.** Two groups of residents are within approximately 300 yards (900 feet) of the Mirant PRGS stacks. The Marina Towers condominiums are northwest of Mirant PRGS and house nearly 500 residents. The 15-story condominium building is approximately 150 feet tall. Some units within Marina Towers face directly toward Mirant PRGS boiler stacks. Another residential area is southwest of the facility, within approximately 300 yards of the Mirant PRGS stacks in the area bounded by Royal Street, Bashford Lane, and Abington Drive. These residential buildings are also condominiums. All other local residents live at least 300 yards (900 feet) from the Mirant PRGS stacks.

Other exposed populations. Even if they do not live in this area, people who spend time in the Mirant PRGS vicinity can be exposed to the facility's emissions. These other exposed populations in close proximity to Mirant PRGS would include users of the Mt. Vernon Trail, visitors to Daingerfield Island north of Marina Towers, and people otherwise spending time outdoors in the vicinity of Marina Towers and in the residential area immediately southwest of Mirant PRGS. Note that in regard to other exposed populations, however, that this health consultation does not address workers' exposures or residents' potential exposures to site-related pollutants possibly found in other environmental media such as water or soil.

Later sections of this health consultation contain the demographic data referred to here. Specifically, the Discussion and Child Health Considerations sections include information on public health implications of exposure to the facility's air emissions, particularly considering local susceptible populations.

Environmental setting

ATSDR gathered background information on Mirant PRGS's environmental setting. This included understanding the local climate and prevailing wind patterns to identify potentially exposed populations and to research the area's air pollution history so as to distinguish site-related effects from regional air quality issues.

- **Climate and prevailing wind patterns.** Local meteorological conditions in Alexandria, VA vary by season. Average monthly temperatures range from 35.6 degrees Fahrenheit in January to 78.7 degrees Fahrenheit in July. Monthly precipitation ranges from 2.7 to 3.9 inches, with frozen precipitation limited to the winter months. Summers are generally humid. The prevailing wind directions at Ronald Reagan Washington National Airport are out of the south and south-southwest and out of the north and north-northwest (DOE 2006). As noted later in this health consultation, however, prevailing wind patterns at finer scales—such as in the immediate vicinity of Mirant PRGS and atop the Marina Towers condominiums—vary from those observed at the airport's National Weather Service meteorological station.

- **General air quality.** For more than 20 years, U.S.EPA and state environmental agencies have monitored outdoor air quality in populated areas throughout the United States. These monitoring efforts have typically focused on pollutants most commonly found in urban settings. In Alexandria and surrounding areas, two of these pollutants—ozone and particulate matter—have in the past exceeded U.S.EPA's health-based NAAQS.

In an area designated as the "Northern Virginia Nonattainment Area," VDEQ monitors summertime ozone levels at nine locations. The Nonattainment Area includes Alexandria and nearby counties (Arlington, Fairfax, Loudon, and Prince William). These are areas where ambient air concentrations of ozone (see text box) have occasionally exceeded U.S.EPA's NAAQS, suggesting that air quality is at times unhealthy. But the ozone air quality issue in northern Virginia is not unique. In fact, at some time during the summer months, nearly every major metropolitan area along the East Coast has unhealthy ozone levels. Note too that the ozone problems in northern Virginia are complex; they result from industrial and motor vehicle emissions that occur over a broad geographic region. In short, northern Virginia's ozone air quality issue is regional in nature. As such, this health consultation does not address the air quality under consideration as a site-specific issue.

What is ozone?
Ozone forms in air when emissions from numerous sources, including motor vehicles and industry, mix together and react with sunlight. Ozone levels are typically highest during the afternoon hours of the summer months, when the influence of direct sunlight is greatest. When airborne ozone levels are elevated, people may experience respiratory health problems.

VDEQ also monitors airborne levels of particulate matter (PM) at numerous locations statewide, including several stations in northern Virginia. The monitoring data collected in this network suggest that concentrations of airborne particles smaller than 10 microns (PM_{10}, see text box) are below U.S.EPA's health-based NAAQS. That said, Alexandria and surrounding counties (Arlington, Fairfax, Loudon, and Prince William) have been designated a nonattainment area for finer airborne particles ($PM_{2.5}$, see text box). Like ozone, $PM_{2.5}$ exceeds health-based standards (NAAQS) in urban areas throughout much of the East Coast. In most cases, elevated $PM_{2.5}$ concentrations are not single-source attributable, given that this pollutant forms in the air from precursors that originate from multiple combustion and industrial sources over broad areas. Mirant PRGS is nonetheless a major local source of $PM_{2.5}$ and its precursors, yet those emissions alone are most likely not responsible for the entire regional air quality issue.

What is particulate matter (PM)?
PM refers to airborne particles of varying size and chemical composition. Many different industrial, mobile, natural, agricultural, and other sources release PM into the air or release pollutants (precursors) that form PM after emission. U.S.EPA has NAAQS for particulate matter smaller than 10 microns (PM_{10}) and particulate matter smaller than 2.5 microns ($PM_{2.5}$).

In summary, northern Virginia has well-known and studied air quality problems that are regional in nature. In recent years at locations in northern Virginia and at one time or another, ozone and $PM_{2.5}$ ambient air concentrations have exceeded U.S.EPA's health-based NAAQS. Although this health consultation considers these pollutants' elevated concentrations as a regional air quality issue, emissions from Mirant PRGS—together with those from numerous other sources—undoubtedly contribute to such elevated concentrations.

ATSDR involvement

ATSDR's involvement with the Mirant PRGS site began after the agency received the January, 2006, request from the Alexandria Health Department to review then-current environmental data (specifically air dispersion modeling data) related to Mirant PRGS's operations, assess the potential for health effects for nearby residents, and recommend next steps. In response, ATSDR has completed:

A community outreach

To respond thoroughly to the requester and the community, ATSDR worked to gain an understanding of the community's underlying health concerns. ATSDR staff visited Alexandria to meet with various interested parties. In August 2007, ATSDR held meetings with the Alexandria Health Department, the City of Alexandria, VDEQ, the Virginia Department of Health (VDH), U.S.EPA, Mirant representatives, and concerned citizens. ATSDR hosted an open house for citizens to learn about ATSDR, the agency's involvement with local air concerns and with community-based air monitoring efforts, and future activities.

To keep citizens and involved agencies aware of our activities, ATSDR developed a Web page (http://www.atsdr.cdc.gov/sites/mirant) that residents can visit to obtain fact sheets about ATSDR activities, general environmental health information, resources for citizens and health care providers, and copies of ATSDR's site-related publications.

A dispersion modeling analysis

In response to the initial VDEQ request, ATSDR reviewed multiple dispersion modeling studies, including those conducted by or for U.S.EPA, VDEQ, the City of Alexandria, and Mirant. Appendix A contains ATSDR's detailed technical review, which found that between 2000 and 2004, estimated ambient air concentrations of sulfur dioxide and PM reached levels of public health concern. The absence of ambient air monitoring data collected during that timeframe did not, however, allow ATSDR to validate the modeling estimates or reach definitive conclusions about past public health exposures in this community.

ATSDR also reviewed modeling studies conducted in 2005 and in subsequent years. These studies predicted offsite sulfur dioxide concentrations for averaging periods as short as 3 hours, consistent with the averaging periods for U.S.EPA's NAAQS. But ATSDR was concerned that these modeling studies did not quantify acute exposures to peak (5-minute average) sulfur dioxide concentrations, which the NAAQS do not address but which may be of local health concern.

Following its review of these data, ATSDR conducted its own modeling to estimate sulfur dioxide exposures over shorter timeframes (1-hour average concentrations). Using the same inputs as previous modeling, meteorological data limited ATSDR to 1-hour outputs. This modeling suggested that 1-hour maximum concentration locations could occur at different locations than did the annual average maximums (Figure A-1, Appendix A).

Overall, this review of dispersion modeling studies and ATSDR's own modeling study suggested that to better address health concerns regarding potential exposure to Mirant PRGS's stack emissions, short-term sulfur dioxide concentrations required additional, direct measurement investigation.

January 2007 ATSDR recommendations

In January 2007, ATSDR summarized its initial review findings in a letter to the Alexandria Health Department (Appendix B). That letter identified the need for:

- Monitoring data to evaluate modeling estimates of the concentration and location of contaminant levels of potential health concern,
- Data on the intensity, duration, and frequency of air quality effects at the "subhourly" level, and
- Data to examine the relationship between indoor and outdoor air concentrations.

Exposure investigation (EI)

In cooperation with the Alexandria Health Department, ATSDR proposed conducting an exposure investigation (EI) to help meet some of the information needs identified in the agency's 2007 letter. At that time, ATSDR did not have access to any subhourly sulfur dioxide monitoring data that Mirant PRGS had collected. ATSDR's EI was specifically designed to fill the three information needs identified above.

The EI Protocol (see Appendix C, EI Protocol) underwent external peer review. During the EI, ATSDR measured ambient air concentrations of PM_{10}, $PM_{2.5}$, and several metals that Mirant PRGS likely emitted. Moreover, some of the data collected during the EI (e.g., metals data) provided additional information that no previous field sampling effort had addressed.

Community health concerns

This health consultation was prepared to respond to community health concerns; specifically, the concerns originally identified in the Alexandria, VA Health Department's request. As noted previously, the health department request asked ATSDR to review then-available environmental data for Mirant PRGS (particularly, air dispersion modeling data), assess the potential health effects for nearby residents, and recommend next steps.

Through direct communications with residents and a review of publications in various agency document inventories, ATSDR identified additional community health concerns. ATSDR found many residents complained about health concerns related to outdoor air quality problems they attributed to Mirant PRGS's emissions. Residents also had questions about soot and other material that had deposited on cars and other surfaces near the facility, as well as mercury emissions.

Discussion

ATSDR evaluates here ambient air monitoring data recently collected near Mirant PRGS, focusing primarily on measurements collected in 2007 and 2008. The discussion integrates modeling study inferences as appropriate. ATSDR focuses its evaluation on pollutants that 1) Mirant PRGS emits, 2) have measurable health endpoints, and 3) that community concerns have identified.

ATSDR first evaluates various pollutants or groups of pollutants, then considers the public health implications of pollutant mixtures exposure. The section concludes by acknowledging data gaps and evaluation limitations.

Sulfur dioxide

Sulfur dioxide gas forms when raw materials containing sulfur—such as coal—are burned. Electricity-generating facilities are the largest source category of sulfur dioxide emissions in the United States, accounting for 69 percent of the emissions nationwide (USEPA 2009a).

As noted previously, some community members expressed concern that building downwash from Mirant PRGS's stack emissions could lead to elevated short-term sulfur dioxide concentrations near the facility. While the available modeling and monitoring data suggest that sulfur dioxide concentrations do not exceed U.S.EPA's health-based NAAQS, no health-based NAAQS is available for exposures with less than a 24-hour duration. ATSDR evaluated the recently collected ambient air monitoring data to determine whether subhourly concentrations reached levels of public health concern. This section summarizes ATSDR's evaluation.

In November 2009, U.S.EPA proposed revision of the primary SO_2 standard designed to protect public health. The then-current primary standards were 140 ppb measured over 24-hours, and 30 ppb measured over a year. U.S.EPA proposed reductions to a level between 50 and 100 parts per billion (ppb) measured over 1-hour. U.S.EPA also invited comment on alternative levels for the 1-hour standard up to 150 ppb (USEPA 2009d).

Conclusions for Sulfur Dioxide

For the *general population,** breathing sulfur dioxide at measured concentrations around Mirant PRGS for peak (5-minute) exposures is not expected to be harmful.

Sensitive populations (e.g., persons with asthma) may experience respiratory symptoms if they are exposed to peak sulfur dioxide concentrations higher than 400 ppb during times of elevated inhalation rates, such as while exercising. Reported concentrations infrequently reached these levels, and only at locations within ¼-mile of Mirant PRGS stacks and mostly between 12pm and 5pm. Symptoms may include coughing, wheezing, or chest tightness, and are likely reversible. For concentrations lower than 400 ppb sulfur dioxide, sensitive persons at elevated inhalation rates may experience effects such as bronchoconstriction without developing symptoms.

People with asthma, children, and older adults (65+ years) have been identified as groups susceptible to the health problems associated with breathing SO_2. Clinical investigations and epidemiological studies have provided strong evidence of a causal relationship between SO_2 and respiratory morbidity in people with asthma and more limited epidemiological studies have consistently reported that children and older adults (65+ years) may be at increased risk for SO_2-associated adverse respiratory effects. Potentially susceptible groups to air pollutants include obese persons, those with preexisting cardiopulmonary disease, and those with a pro-inflammatory condition such as diabetes, but some of these relationships have not been examined specifically in relation to SO_2.

*The term "general population" includes population members not expressing an increased susceptibility to the health effects of an environmental exposure to sulfur dioxide (American Lung Association 2001).

Ambient monitoring data

ATSDR identified two ambient air monitoring data sources for sulfur dioxide: VDEQ's monitoring at North Saint Asaph Street in Alexandria, and Mirant PRGS's monitoring conducted pursuant to the U.S.EPA administrative order. The map in Figure 2 shows the VDEQ and Mirant PRGS sulfur dioxide monitoring station locations. Table 2 describes the site and pollutants

measured. The following reviews the data collected from both programs. The focus is on Mirant PRGS's data given that, for reasons described below, it provides the most extensive and representative account of sulfur dioxide levels.

Note that ATSDR considered, but ultimately rejected, a third SO_2 monitoring data source. This third source was the continuous SO_2 monitoring data that ATSDR collected at 10 locations near Mirant as part of its 2007 Exposure Investigation (EI). In that EI, single Point Monitor (SPM) devices made continuous measurements, and a pre-EI laboratory study suggested that SPMs would measure airborne SO_2 concentrations accurately. But during the EI, the SPM SO_2 level measurements were consistently lower than the SO_2 levels the Mirant monitors concurrently measured using U.S.EPA-approved methods. ATSDR then conducted a follow-up field study comparing the SPM performance to devices similar to those Mirant used. The study confirmed that the SPMs consistently underreported ambient air SO_2 concentrations (ATSDR 2009).

Why the SPMs performed well in the controlled laboratory setting but not when deployed in the field is unclear. In any case, with evidence that the SPMs consistently underreported SO_2 concentrations, ATSDR deemed the entire EI SO_2 monitoring dataset—including indoor air monitoring data—of insufficient quality to characterize accurately human exposures.

In this report, EI SO_2 data are neither presented nor discussed further. Fortunately, the Mirant data became available to ATSDR and, together with VADEQ data, form an adequate basis for evaluating potential exposures. All other measurements (i.e., metals, particulate matter) collected during the EI were judged to be of a known and high quality. Appendix D provides further information on the SO_2 monitoring data collected during the EI, and the subsequent field study explains in greater detail why those data were not included in this evaluation (ATSDR 2009).

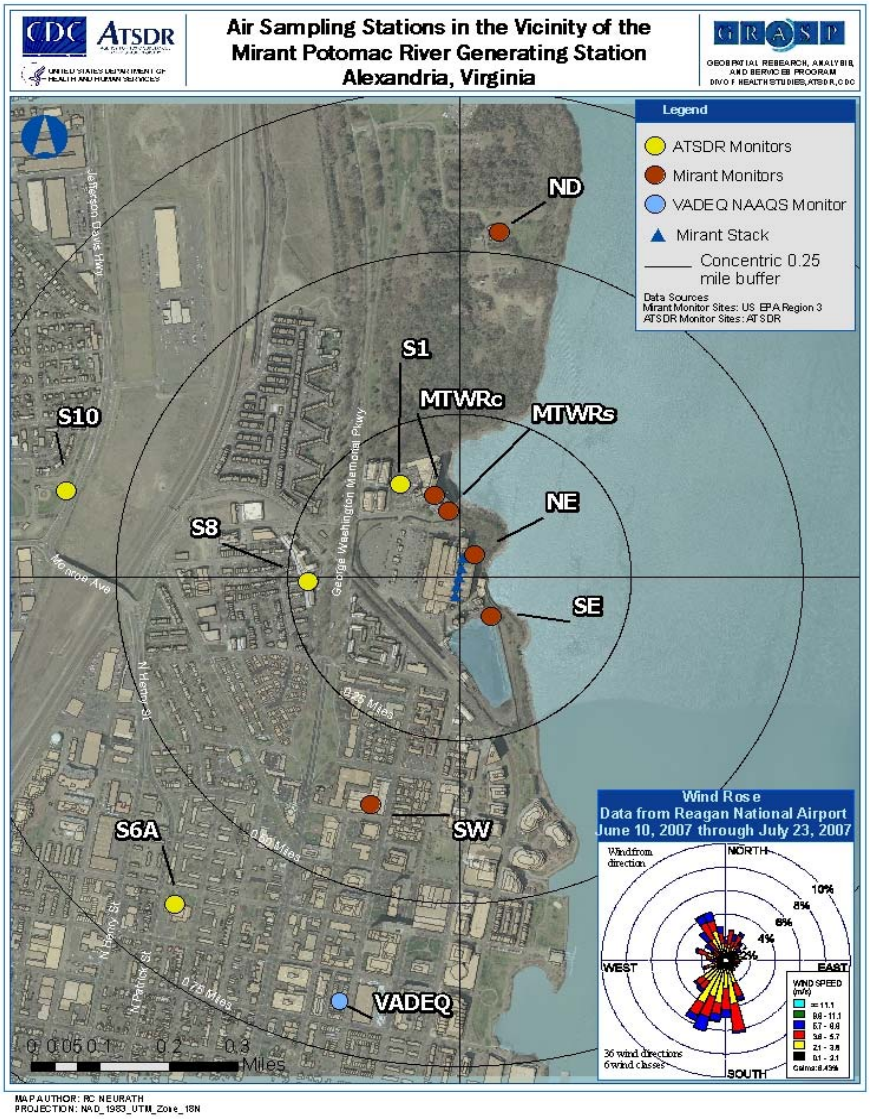
Table 2. Site-Specific Monitoring Information

	Site ID	***Site Description***	***Contaminant***
ATSDR Sites *	S1	Private building (roof/15th floor)	PM10, PM2.5
			TSP/trace metals
	S6A	Public building (ground level)	PM2.5
			TSP/trace metals
	S8	Private building (roof/5th floor)	PM2.5
			TSP/trace metals
	S10	Public park (ground level)	TSP/trace metals
Mirant Sites	MTWRc	Center of the roof of Marina Towers.	SO2
	MTWRs	South end of the roof of Marina Towers	SO2, PM2.5
	SE	Southeast Mirant fenceline	SO2, PM2.5
	NE	Northeast Mirant fenceline	SO2
	SW	Holiday Inn roof on First Street	SO2
	ND	Daingerfield Island	SO2

VDEQ	NAAQS	North Saint Asaph Street	SO2
	NAAQS	Arlington County	PM2.5

* ATSDR SO_2 monitoring sites are not shown in the Table, as discussed in the Sulfur Dioxide text.

Figure 2. Monitor Location Map. See Table 2 for site descriptions.



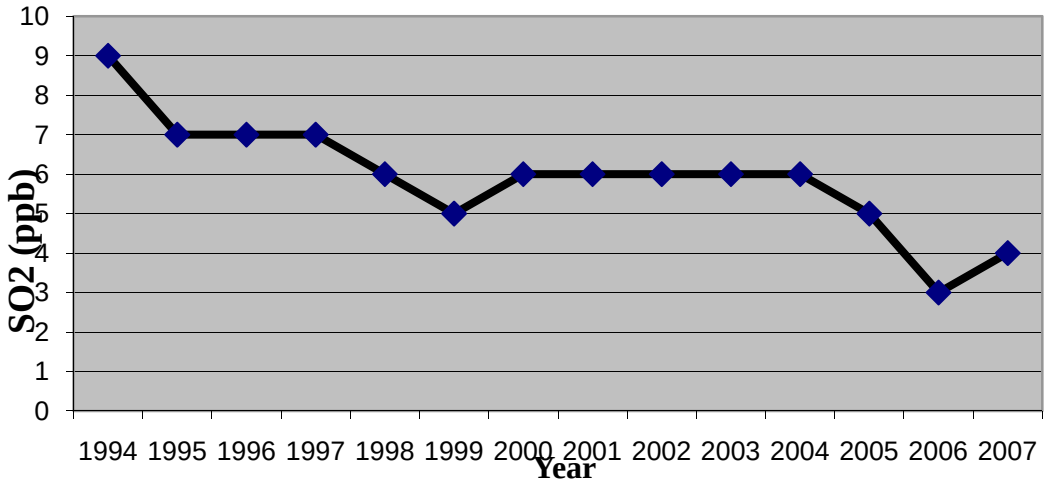
Long-term exposures

Exposures to SO_2 have not exceeded U.S.EPA's annual average NAAQS. VDEQ continuously measures ambient air concentrations of sulfur dioxide at ten monitoring stations statewide. One of these stations is in Alexandria at North Saint Asaph Street, just over ½-mile south of Mirant PRGS. This station has been in operation for more than 30 years, and a U.S.EPA-approved device measures concentrations. VDEQ downloads the measured results, validates the data, and reports the final measurements to U.S.EPA's Air Quality System (AQS)—an online clearinghouse of ambient air monitoring data. ATSDR examined data for recent years and verified that the measured sulfur dioxide levels were lower than U.S.EPA's health-based NAAQS both for annual and 24-hour averaging times. Over the most recent 15 years, annual

average concentrations (calculated from the continuous measurements) at VDEQ's monitoring station decreased from 8.6 ppb in 1994 to 4.0 ppb in 2007 (Figure 3), and all annual average values were considerably lower than U.S.EPA's annual NAAQS (30 ppb). In 2008, the annual average sulfur dioxide concentration measured at VDEQ's Alexandria station (3.2 ppb) ranked fifth among the ten stations the state operates and fell in the range of levels (1.8 to 4.9 ppb) measured in other urban and suburban areas statewide.

U.S.EPA has recently proposed revoking the annual average and 24-hour sulfur dioxide NAAQS and replacing them with 1-hour NAAQS (USEPA 2009d).

Figure 3. Annual Average Sulfur Dioxide Concentration Trend at VDEQ's Alexandria Monitoring Station



Source: USEPA 2009b.

Note: USEPA's NAAQS for annual average concentrations is 30 ppb.

Short-term exposures

During the June–July 2007 EI monitoring period, the highest Mirant PRGS 24-hour average was 48.06 ppb. Also during the monitoring period, measurements did not exceed the 24-hour NAAQS of 140 ppb.

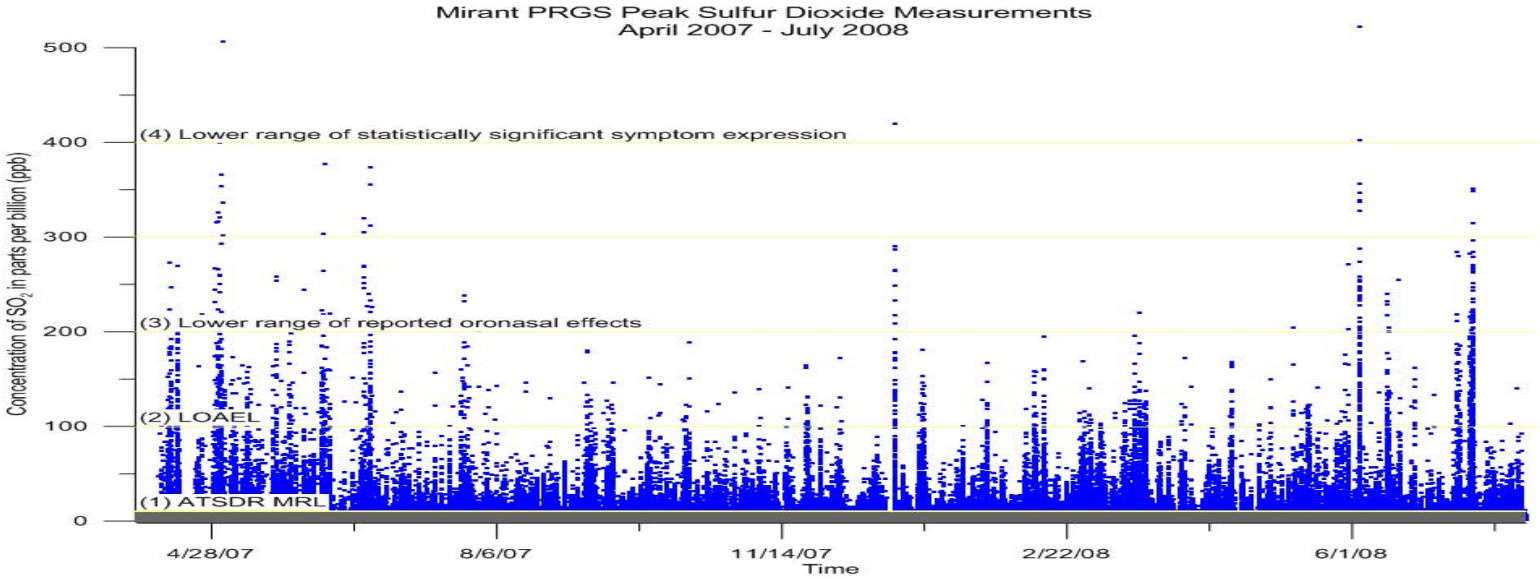
Peak (5-Minute) exposures

Although Mirant PRGS collected ambient SO_2 data before April 2007, these data were not available to ATSDR for evaluation, and consequently not included in this health consultation. Following an agreement with the City of Alexandria, in September 2008, Mirant released to ATSDR 5-minute SO_2 data collected April 2007 through July 2008.

As suggested by ATSDR, during April 2007 through July 2008, Mirant collected PRGS data for peak (5-minute) SO_2. Mirant PRGS's six monitoring stations in use during April 2007–July 2008 were in areas north and south of the facility. Figure 4 shows the composite of 5-minute SO_2 data points for all monitoring stations for the April 2007–July 2008 sampling period. Acute health

benchmarks appear along the left axis. The health consultation's Public Health Implications section addresses the public health implications of peak (5-minute) SO_2 exposures.

Figure 4. Peak (5-Minute) sulfur dioxide measurements in ambient air



1. ATSDR MRL – ATSDR's acute Minimal Risk Level (10 ppb) for Sulfur Dioxide. ATSDR 1998: Toxicological profile for sulfur dioxide.

2. LOAEL – ATSDR acute Lowest Observed Adverse Effect Level (LOAEL)(100 ppb) using mouthpiece exposure in human clinical study. Shepard et al. 1981: Exercise increases sulfur dioxide-induced bronchoconstriction in asthmatic subjects. Am Rev Respir Dis 123:486-491.

3. Lower range of reported oronasal effects (200 ppb), based on several studies. USEPA 2008b: Integrated science assessment for sulfur oxides – health criteria. Office of Research and Development. EPA/600/R-08/047FA.

4. Lower range of statistically significant symptom expression (400 ppb), based on several studies. USEPA 2009c: Risk and exposure assessment to support the review of the SO_2 Primary National Ambient Air Quality Standards: second draft.

Characterization of SO_2 monitoring results

Mirant PRGS and Virginia DEQ monitors provided the SO_2 data for evaluation of ambient air SO_2 exposure. These monitors combined to provide a more complete exposure characterization than could either monitoring network provide alone. The VDEQ NAAQS monitor supplied data on long-term SO_2 levels collected since 1994, as well as its own hourly data to corroborate Mirant PRGS hourly data. Mirant PRGS monitors provided peak (5-minute) SO_2 data.

To characterize SO_2 monitoring results around Mirant PRGS, ATSDR evaluated the intensity (concentration level), spatial distribution (location), frequency (how often peaks occur), and the temporal distribution (what time of day the peaks occur). ATSDR believes the public, especially sensitive populations and the parents of sensitive children need to understand the environmental characterization. In this way they can act to protect themselves or their children from potential exposure.

Figure 4 and Table 3 show the *intensity* (concentration level) of peak (5-minute) SO_2 detections. Figure 4 shows the SO_2 detections timeline for the sampling period and exposure concentrations of interest. Table 3 shows the *frequency* of measured SO_2 concentrations by monitoring site. Appendix G contains the detailed statistical analysis.

Of the 5-minute SO_2 data collected continuously over the 16-month monitoring period, more than 99.9% of detections were less than 200 ppb. SO_2 was not detected at concentrations higher than 200 ppb beyond 0.25 miles of the plant. Using data collected during this period, 5-minute peaks higher than 200 ppb were observed on average less than three times per week. Concentrations measured during the sampling period are not expected to affect the general population who are not sensitive to SO_2. At any location during the monitoring period, concentrations (>400 ppb) resulting in symptoms in sensitive populations at elevated ventilation rates were detected less than 0.0007% of the time.

Table 3. Percentage Peak (5-Minute Average) Sulfur Dioxide Concentrations by Monitoring Station – Mirant PRGS Data April 2007 – August 2008. See Table 2 for site descriptions.

Percentage of Peak (5-minute average) Sulfur Dioxide Concentrations by Monitoring Station (April 2007 – July 2008)				
Monitoring Station	***Sulfur Dioxide Concentration (ppb)***			
	% Greater than 400	***% 201–400***	***% 101–200***	***% 11–100***
Mirant MTWRc	< 0.1	< 0.1	0.3	14
Mirant MTWRs	< 0.03	< 0.03	0.2	8
Mirant SE	< 0.1	< 0.1	0.4	17
Mirant SW	0	0	< 0.1	12
Mirant NE	0	< 0.1	< 0.1	4
Mirant ND	0	0	< 0.1	8

ppb–parts per billion

< –less than

Figure 5 shows the *spatial* distribution (location) of SO_2 data. The spatial assessment of SO_2 peaks suggests the higher concentrations were confined to populated areas *within* 0.25 miles of Mirant PRGS, north toward Daingerfield Island, and south and southwest of Mirant PRGS (Figure 5). Populated areas *beyond* 0.25 mile from Mirant PRGS north, south, and southwest are not likely exposure sites for SO_2 concentrations resulting in symptoms, even for sensitive populations functioning at elevated ventilation rates.

Figure 6 shows the *frequency* (i.e., how often the peaks occur) of peak (5-minute) SO_2 detections higher than 100 ppb by time of day during the 16-month monitoring period for each Mirant PRGS monitoring station. Because of the infrequency of detections above 200 ppb, 100 ppb became the frequency metric to visually demonstrate the frequency of detections by time of day and monitoring station. The roof of Marina Towers (MTWRc and MTWRs) and southeast of the Plant (SE) registered the largest number of detections above 100 ppb.

Figures 6 and 7 show the *temporal* (i.e., time of day) distribution of SO_2 detections. Figure 7 shows the average hourly SO_2 data from all data stations, as well as, for comparison, Mirant PRGS's operating output for the same timeframe. Note that the SO_2 concentrations generally reflect Mirant PRGS's operating output. The temporal assessment of peak (5-minute) SO_2 detections suggests that the time of day SO_2 is most likely present ranges from early morning (about 7 a.m.) until late afternoon (6 p.m.), with the highest detection frequency above 200 ppb occurring between 12 p.m. and 5:00 p.m. (Figure 8). Concentrations above 200 ppb are infrequent, representing less than 0.02 % of detections at all locations (Table 3).

These data and the statistical analyses thereof suggest that the highest frequency of elevated SO_2 concentrations (more than 200 ppb) are more likely to occur between 12:00 noon and 5:00 p.m. Exposure during this timeframe depends on a person's location relative to Mirant PRGS, with the highest percentage of SO_2 readings above 100 ppb occurring on the roof of Marina Towers and at the southeast Mirant PRGS fenceline location. The conditions for likely effects include a sensitive person's exposure while at an elevated ventilation rate (e.g., running, working, climbing) for approximately 5 minutes or more. Likely effects further depend on that sensitive person finding himself or herself in a location where a peak is occurring during the hours indicated.

Figure 5. Spatial distribution of sulfur dioxide peak concentrations by monitoring site.

(Data from Table 3). See Table 2 for site descriptions.

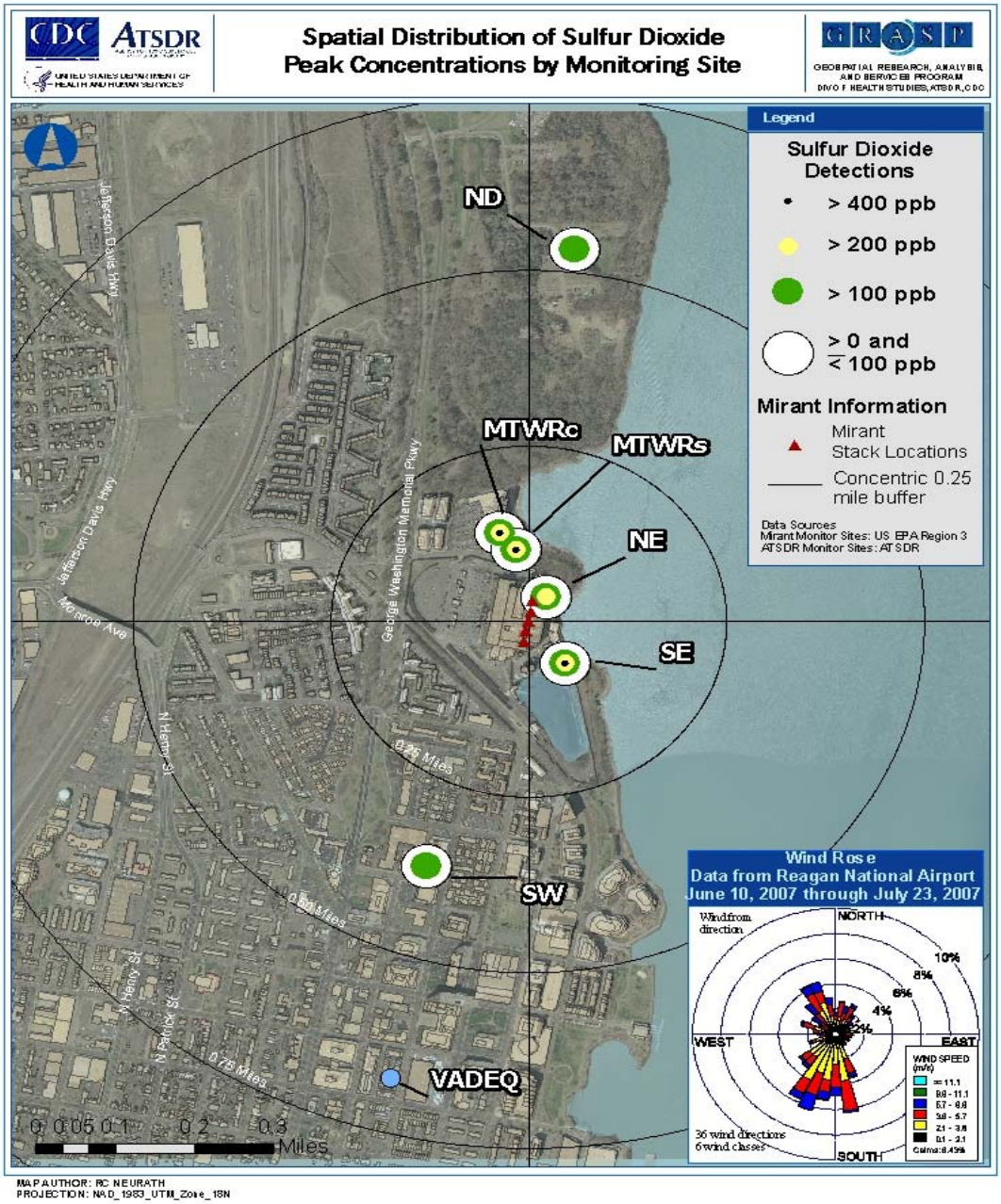


Figure 6. Frequency of SO_2 Detection above 100 ppb v. Time. See Table 2 for site descriptions.

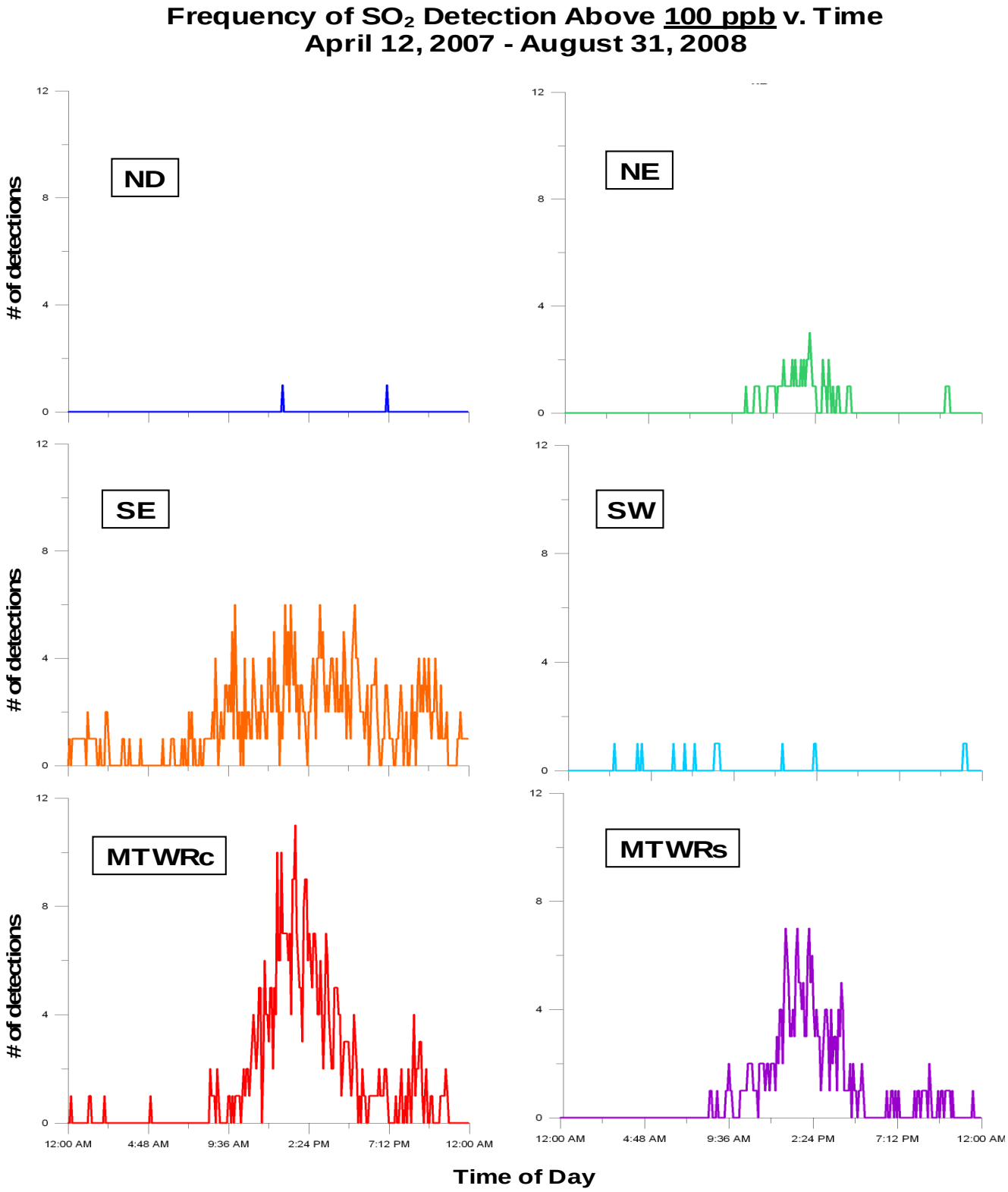


Figure 7. Average hourly Mirant and VDEQ SO_2 data and Mirant PRGS operations output by hour for June and July, 2007. See Table 2 for site descriptions.

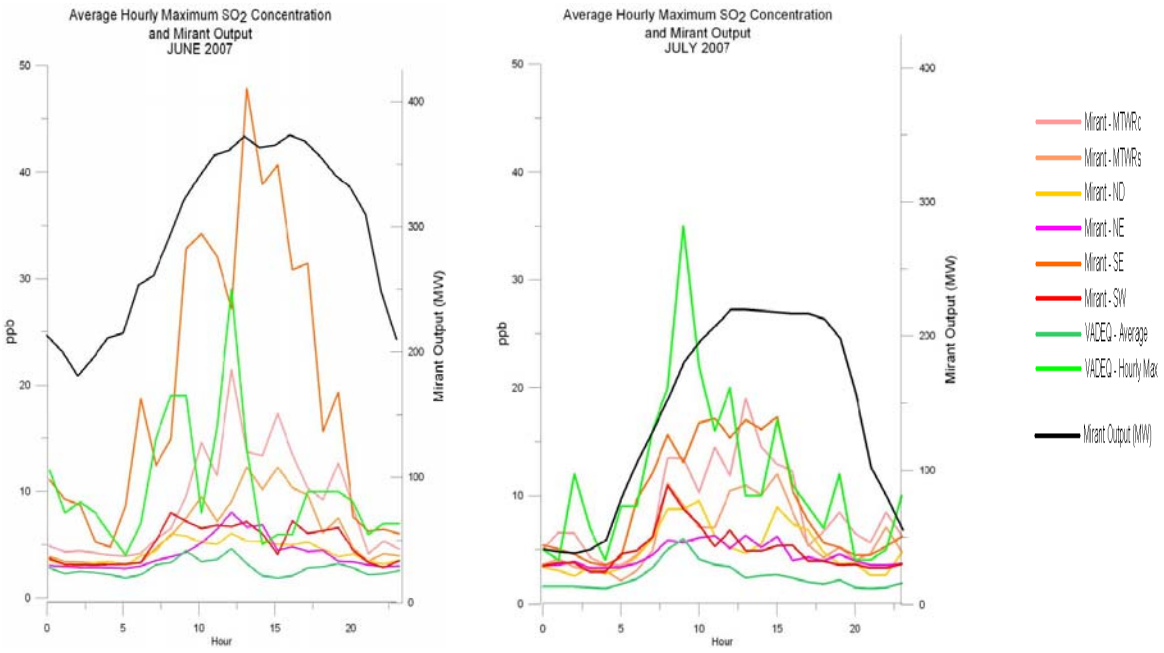
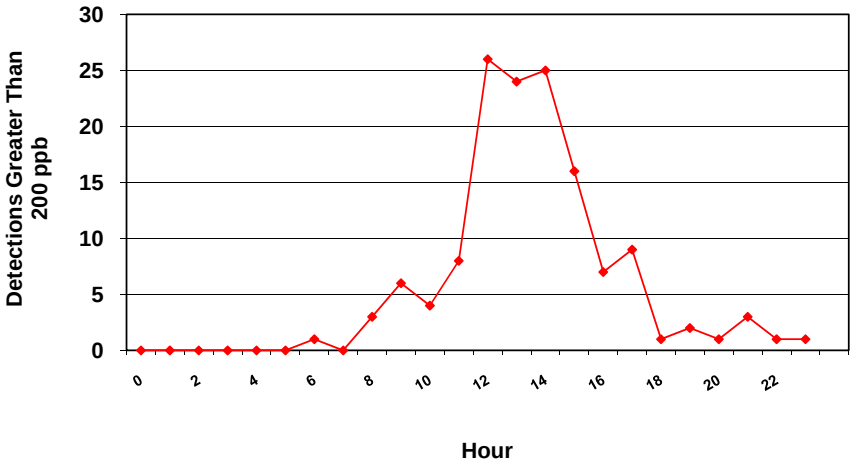


Figure 8. SO2 Detections above 200 ppb by Hour for all Mirant PRGS monitors.



Between April 6, 2007, 10:15 and July 31, 2008, 23:55, 138,979 5-minute intervals. Stations had varying numbers of readings due to missing data. The plotted count is based on approximately 5,796 readings for that hour.

Public Health Implications

Sulfur dioxide

Long-term SO_2 exposure has not been a public health concern in Alexandria as annual average ambient air levels are below the annual average NAAQS. That said, U.S.EPA has proposed revocation of the annual average and the 24-hour average NAAQS for a more protective 1-hour

average NAAQS (USEPA 2009d). Peak exposures—unregulated by U.S.EPA—measured over 5 minutes by Mirant PRGS may be of concern to sensitive persons functioning at elevated ventilation rates at certain times of the day in certain locations. These concentrations will not affect those not sensitive to SO_2.

What about indoor air exposures?

Outdoor SO_2 can enter indoor settings, primarily when residents have their windows open. No valid SO_2 indoor air monitoring data are, however, available at this site. Indoor air concentrations likely will not exceed the peak outdoor concentrations noted in this section, unless a resident has a significant indoor source. When windows are open, we expect the same conclusions presented here for outdoor settings to apply to indoor settings.

SO_2 peak (5-minute) exposure summary

ATSDR grouped the 5-minute peak SO_2 concentrations into concentration categories based on health endpoints (Appendix E provides a detailed discussion). Clinical studies reported in peer-reviewed scientific literature provided the basis for the health endpoint derivations.

Clinical investigations have limitations in that participants in those peer-reviewed clinical investigations were healthy and were usually mild to moderate asthmatics. Clinical investigations have not included participants such as those with severe asthma or children. Some persons may also be more sensitive than those participating in clinical investigations. Effects for sensitive persons at increased ventilation rates exposed to SO_2 concentrations below 200 ppb are uncertain as studies in free-breathing exposures have not been conducted at less than 200 ppb. Exposure conditions included controlled humidity and temperature and colder, dryer air has been reported to induce effects at lower SO_2 concentrations.

People with asthma, children, and older adults (65+ years) have been identified as groups susceptible to the health problems associated with breathing SO_2 (USEPA 2010a). Clinical investigations and epidemiological studies have provided strong evidence of a causal relationship between SO_2 and respiratory morbidity in people with asthma and more limited epidemiological studies have consistently reported that children and older adults may be at increased risk for SO_2-associated adverse respiratory effects (USEPA 2010b, USEPA 2009g). Potentially susceptible groups to air pollutants include obese persons, those with preexisting cardiopulmonary disease, and those with a pro-inflammatory condition such as diabetes (USEPA, 2008b), but some of these relationships have not been examined specifically in relation to SO_2.

Analysis of the 16-month sampling period resulted in the following average exposure estimates by concentration category.

Greater than (>) 400 ppb

ATSDR estimates that during the 16-month sampling period an average of one 5-minute SO_2 exposure >400 ppb occurred every 80 days within 0.25 miles of the facility (north to Marina Towers and south to the Mirant PRGS southeast fenceline). During the 16-month sampling period, two 5-minute SO_2 detections >500 ppb and four 5-minute SO_2 detections >400 ppb occurred.

Exposure of sensitive persons at increased ventilation rates to levels above 400 ppb could result in bronchoconstriction resulting in *symptoms* such as coughing, wheezing, or chest tightness. For concentrations >500 ppb, exposure to sensitive persons may more often result in use of medication, seeking medical assistance, or cessation of physical activity. These exposures are

estimated to have occurred 0.0007% of the time and to have been temporally and spatially limited.

200 ppb - 400 ppb

ATSDR estimates an average SO_2 exposure of fewer than three 5-minute events per week (200 ppb–400 ppb) within 0.25 miles of the facility (north beyond Marina Towers and the south to the Mirant PRGS southeast fenceline). During the 16-month sampling period, 138 five-minute SO_2 detections (200 ppb–400 ppb) occurred.

Exposure of sensitive persons at increased ventilation rates to this SO_2 concentration range could result in effects such as mild bronchoconstriction *without* experiencing *symptoms* such as coughing, wheezing, or chest tightness. Affected persons may not be aware of the bronchoconstriction, which is estimated as mild and transient. Exposure is estimated to have occurred 0.02% of the time and to have been temporally and spatially limited.

Below 200 ppb

Detections below 200 ppb SO_2 were, on the other hand, multiple and widespread. For the concentration range higher than 10 ppb and below 200 ppb, ATSDR estimates an average of fewer than seven exposures per hour. During the 16-month sampling period then, a 5-minute SO_2 peak between 10 ppb and 200 ppb was detected an average of about 10% of the time.

In clinical studies, sensitive persons (such as those with mild to moderate asthma) using a mouthpiece have experienced effects from exposures to fewer than 200 ppb (Sheppard et al. 1981). Whether exposures below 200 ppb may cause effects in sensitive persons at increased ventilation rates under normal environmental conditions is uncertain, given that clinical investigations have not been conducted in persons with free-breathing asthma at concentrations below 200 ppb. The number of detections in this concentration range is, however, much greater than at higher concentrations, suggesting an exposure increase.

Conclusion for $PM_{2.5}$
Emissions from motor vehicle and industrial sources throughout the Washington, DC metropolitan area and beyond contribute to airborne $PM_{2.5}$ detected in and near Alexandria. Modeling studies suggest that Mirant PRGS's emissions likely account for a relatively small portion (roughly 5%) of the $PM_{2.5}$ levels in Alexandria. The long-term $PM_{2.5}$ concentrations measured are near the lower end of concentrations reported as associated with adverse health effects in epidemiological studies. Thus, breathing air containing $PM_{2.5}$ levels observed in and near Alexandria for many years can harm people's health. Public health concern for such long-term exposures is warranted, especially for persons with preexisting respiratory and cardiac disease.

Fine particulate matter ($PM_{2.5}$)

Airborne particulate matter smaller than 2.5 microns ($PM_{2.5}$)—also known as fine particulate matter—originates from many sources. "Primary" emissions sources, or sources that release $PM_{2.5}$ directly into the air, are responsible for some airborne $PM_{2.5}$. U.S.EPA has recently estimated that fuel combustion sources, including electricity generating facilities, account for 22% of the nation's primary $PM_{2.5}$ emissions (USEPA 2008a).

In addition, "secondary" particles form in the air from chemical reactions involving precursor gaseous emissions, such as sulfur dioxide and nitrogen oxides. Note that these secondary particles can form at locations far from those emissions sources that released the precursors

(USEPA 2008a). Airborne $PM_{2.5}$ observed near Mirant PRGS may therefore reflect contributions from this facility's primary emissions as well as from the combined effect of industrial and mobile emissions sources throughout the metropolitan area and beyond.

The remainder of this section reviews the measured concentrations of $PM_{2.5}$ near Mirant PRGS and comments on the public health implications of exposure.

Ambient air monitoring data

ATSDR identified three sources of PM2.5 ambient air monitoring data:

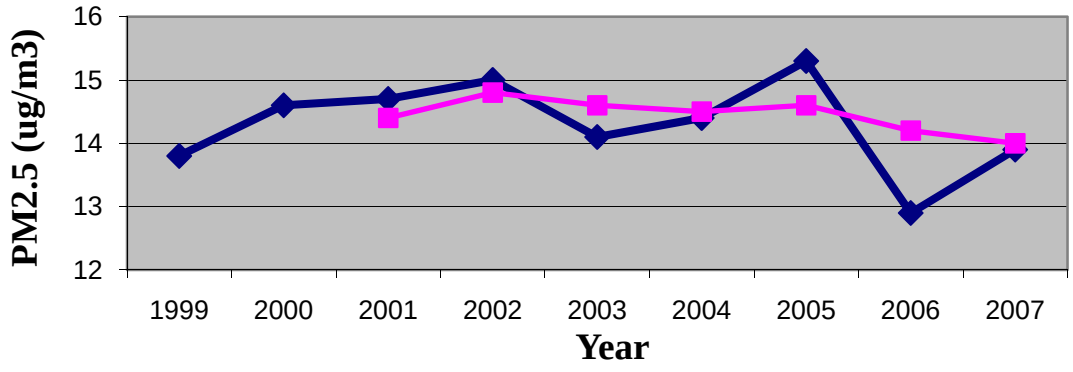
1. VDEQ's monitoring in nearby counties,
2. ATSDR's monitoring during the EI, and
3. Mirant's PRGS monitoring at two off-site locations.

The following describes the scope of these monitoring efforts and reviews the data collected from all three programs.

VDEQ monitoring.

Although VDEQ does not operate any $PM_{2.5}$ monitoring stations in Alexandria, it does have several stations sited in nearby Arlington, Loudoun, and Fairfax Counties. VDEQ's closest $PM_{2.5}$ monitoring station to Mirant PRGS is just over 2 miles north of Mirant PRGS at the Aurora Hills Visitors Center in Arlington. At this station, VDEQ uses a U.S.EPA-approved "Federal Reference Method" to measure PM2.5 concentrations, with 24-hour average samples collected once every 3 days. Between 1999 and 2007, annual average concentrations of PM2.5 ranged from 12.9 micrograms per cubic meter (µg/m3) to 15.3 µg/m3 (Figure 9).

Figure 9. Annual average (blue) and three-year average (red) $PM_{2.5}$ concentration trend at VDEQ's Arlington Monitoring Station



Source: VDEQ, 2009.

Note: EPA's NAAQS requires that the average of three consecutive seasonally-weighted annual average concentrations not exceed 15 µg/m^3.

The annual average $PM_{2.5}$ concentrations observed at VDEQ's other monitoring stations in nearby Loudoun and Fairfax Counties were typically comparable to those observed in Arlington,

generally differing by 15% or less (VDEQ 2009). The consistent values measured throughout these counties suggest that the overall contribution of regional emissions sources to $PM_{2.5}$ levels may be on the order of the levels shown in Figure 9.

ATSDR and Mirant PRGS Monitoring.

VDEQ data characterize typical $PM_{2.5}$ levels observed throughout selected counties in northern Virginia. ATSDR and Mirant PRGS, however, located their $PM_{2.5}$ monitors in a manner intended to capture facility effects. Otherwise stated, ATSDR and Mirant PRGS's monitors provide perspective on the potential incremental air quality effects caused by the facility's emissions. Table 4 shows descriptive summary statistics for the $PM_{2.5}$ monitoring data collected by ATSDR and Mirant PRGS in June and July, 2007. Summary statistics for the VDEQ monitoring station are included in the table for comparison. Further information on this monitoring follows:

- During the EI (June 8, 2007–July 23, 2007), ATSDR operated three continuous $PM_{2.5}$ monitoring stations. Concentrations were measured using Electronic Beta Attenuation Monitors (EBAMs) manufactured by Met One Instruments, Inc. These portable devices meet or exceed all U.S.EPA requirements for automated particulate matter measurements. The monitors were placed at Sites 1, 6A, and 8 (Figure 2).
- As Table 4 shows, during the EI the average $PM_{2.5}$ concentrations at these stations ranged from 17.9 to 21.5 $\mu g/m^3$. These values are all higher than U.S.EPA's NAAQS; the measured concentrations during the EI are not, however, directly comparable to the NAAQS. U.S.EPA's standard is based on annual average concentrations (measured over a 3-year time frame), but the EI lasted just over 6 weeks. On 4 days during the EI, the 24-hour average concentrations exceeded the 24-hour NAAQS (35 $\mu g/m^3$), and the highest concentrations at each site were 48.0 $\mu g/m^3$ (Site 1), 44.4 $\mu g/m^3$ (Site 6A), and 55.3 $\mu g/m^3$ (Site 8).

Table 4. $PM_{2.5}$ Concentrations Measured in 2007

Monitoring Program	*Monitoring Station*	*Date Range (in 2007)*	*Summary Statistics for 24-Hour Average $PM_{2.5}$ Concentrations ($\mu g/m^3$)*			
			Average	*Median*	*90th Percentile*	*Highest*
VDEQ	Arlington	January 1 – December 31	13.9	12.4	23.9	44.5
ATSDR EI	Site 1	June 8 – July 23	21.5	20.0	33.3	48.0
	Site 6A		17.9	16.6	31.9	44.4
	Site 8		18.4	15.9	31.7	55.3
Mirant PRGS	Marina Towers Roof	June 8 – July 23	15.0	14.9	23.5	29.0
	Southeast Fenceline		19.7	20.1	32.8	49.6

Source: VDEQ 2009; USEPA 2009b; ATSDR 2009; Mirant 2008.

Notes: The averaging period for the EI spans several weeks. For comparison purposes, this table uses the same averaging period for the Mirant PRGS data, even though Mirant PRGS's monitors collected additional $PM_{2.5}$ measurements in 2007. Data are presented for VDEQ's Arlington monitoring station (for the entire calendar year) as a reference.

- During the EI timeframe, Mirant PRGS operated $PM_{2.5}$ monitoring equipment at the Marina Towers rooftop and at the facility's southeast corner (Figure 2). Concentrations were measured using methods that meet or exceed U.S.EPA's requirements for fine particulate matter measurements. As Table 4 shows, $PM_{2.5}$ concentrations at Mirant PRGS's two monitors during the EI's timeframe were reasonably consistent with ATSDR's measured levels.

In summary, VDEQ, ATSDR, and Mirant PRGS have in recent years all measured ambient air concentrations of $PM_{2.5}$. VDEQ's measurements confirm that much of northern Virginia has annual average ambient air concentrations of $PM_{2.5}$, near U.S.EPA's NAAQS level. This observation is consistent with the fact that the City of Alexandria and several nearby areas (Arlington County, Fairfax County, Loudoun County, Prince William County) are currently designated as a $PM_{2.5}$ nonattainment area—ambient concentrations do not meet U.S.EPA's health-based NAAQS. As noted previously, VDEQ's monitoring points to a regional air quality issue.

The ATSDR and Mirant PRGS monitoring not only characterizes regional $PM_{2.5}$ levels, but also helps quantify incremental effects observed as attributable due to local sources, including Mirant PRGS operations, aircraft emissions, and motor vehicle traffic. The EI data suggest that $PM_{2.5}$ levels in the immediate vicinity of Mirant PRGS may be slightly higher than the regional values typically measured elsewhere in northern Virginia. These findings are reasonably consistent with previous modeling studies (e.g., Levy 2004), which suggested that in 1999 Mirant PRGS's emissions might contribute up to 0.6 µg/m3 of $PM_{2.5}$ to locations in Alexandria. In other words, this modeling suggests that emissions from Mirant PRGS account for approximately 5% of the airborne $PM_{2.5}$ levels in Alexandria.

Public health implications

In much of the United States, fine particulate matter is an important outdoor air quality issue. In the Mid-Atlantic States, $PM_{2.5}$ levels tend to be highest in the summer. For elevated levels to be observed at monitoring stations throughout the region on the same days is not unusual (MARAMA 2005). From 1999 to 2007, annual average $PM_{2.5}$ concentrations measured in Arlington—just over 2 miles north of Mirant PRGS—ranged from 12.9 to 15.3 $\mu g/m^3$ (Figure 9). As noted previously, for $PM_{2.5}$ Alexandria is still a nonattainment area.

Mortality and cardiovascular and respiratory morbidity have been associated with both short-and long-term exposure to $PM_{2.5}$ (USEPA 2008c). Characterization of short-term exposures around Mirant PRGS is insufficient, but long-term exposures suggest a cause for concern. As thresholds have not been identified, and given a substantial interpersonal variability in exposure and in the response to a given particulate matter exposure, that any standard or guideline value will lead to complete protection for everyone against all possible adverse health effects is unlikely (WHO 2006). Population subgroups that may be more susceptible to the effects of PM exposure include infants, older adults (65+ years), persons with asthma or with COPD or cardiovascular disease, diabetics, lower socioeconomic status, and those with certain genetic polymorphisms (USEPA 2008c).

Several significant health studies have investigated potential health effects resulting from long-term exposure to particulate matter. The historical mean $PM_{2.5}$ concentration was 18 $\mu g/m^3$ (range 11.0 - 29.6 $\mu g/m^3$) in the Six-Cities Study and 20 µg/m3 (range 9.0 – 33.5 $\mu g/m^3$) in the

American Cancer Society (ACS) study (Dockery et al. 1993; Pope et al. 1995, 2002; HEI 2000; Jerrett 2005).

Thresholds are not apparent in these studies; thus the precise periods and patterns of relevant exposure could not be ascertained. In the ACS study, statistical uncertainty in the risk estimates becomes apparent at concentrations of about 13 $\mu g/m^3$, below which the confidence bounds significantly widen due to the variability in the exposure concentrations. According to the results of the Dockery et al. (1993) study, the risks are similar in the cities with the lowest long-term $PM_{2.5}$ concentrations (i.e., 11 and 12.5 $\mu g/m^3$). Increases in risk are apparent in the city with the next-lowest long-term $PM_{2.5}$ average concentration (i.e., 14.9 $\mu g/m^3$), indicating that when annual mean concentrations are in the range of 11–15 $\mu g/m^3$, health effects can be expected (WHO 2006).

Trona

Trona (sodium sesquicarbonate) is a powdered chemical. Mirant adds it to the emissions flue gas to remove acid gases such as sulfur dioxide. Most of the created, solid byproducts are then captured for disposal. In response to community concerns, VDEQ requested that VDH provide a summary report on the possible health effects of trona exposure. Because similar concerns were expressed to ATSDR, this section on trona is included here.

Appendix F of this health consultation contains detailed information that VDH compiled on trona. When injected into the stack, much of the trona reacts with sulfur oxides and acid gases to form sodium salt byproducts, which before stack emission are physically removed from the gas stream. An unknown amount of trona may be emitted without reacting with stack gases, entering the ambient air as particulate matter.

No ambient air monitoring data have measured trona concentrations near Mirant PRGS. But no regulations require such monitoring (federal guidelines treat trona as particulate matter not otherwise regulated), nor is ATSDR aware of any comparable community settings where trona has been measured. That said, to a first approximation, ambient air concentrations of trona (using particulate matter as a surrogate) do not exceed the particulate matter concentrations that VDEQ, ATSDR, and Mirant PRGS have measured in the area.

As VDH concluded (see Appendix F), only limited medical, toxicological, and public health literature address health effects resulting from trona dust exposure. Trona is not considered a probable or suspected human carcinogen. Elevated exposures have, however, caused noncancerous effects. Studies of highly exposed workers found evidence that at some threshold level trona can be irritating to the upper respiratory tract, mucous membranes, and skin. But the range of personal exposures in the study with exposure measurements was 100 to 11,000 $\mu g/m^3$ of respirable dust—concentrations far higher than the ambient $PM_{2.5}$ levels recorded in Mirant PRGS's vicinity. Thus while the worker studies might offer useful insights, they do not provide information on potential trona-related health effects among populations with increased susceptibility to airborne irritants.

Refer to Appendix F for more information on this material and to the previous section for ATSDR's findings regarding exposures to airborne particulate matter.

Metals

Analyses of Mirant PRGS air dispersion stack-emissions models (e.g., see Appendix A, Table A-2) had found that estimated maximum annual concentrations of some metals at locations near the facility might exceed health screening values. Maximum 1-hour concentrations, however, did not exceed acute comparison values. Since completion of the modeling studies, ATSDR's EI measured ambient air concentrations of metals at four monitoring stations. Summarized here are those ambient air monitoring data and their public health implications.

Ambient air monitoring data

In June and July 2007, ATSDR measured 24-hour average concentrations of 11 metals at four locations near Mirant PRGS. Specifically, metals sampling occurred at two stations within ¼-mile of Mirant PRGS stacks (Sites 1 and 8) and two locations more than ½-mile from the facility (Sites 6 and 10). ATSDR measured metals concentrations in total suspended particulate matter (TSP). Use of this size fraction (i.e., TSP) of airborne particles, which includes nonrespirable, larger particles, provides an overestimate of the actual amount of metals that people might inhale into their lungs.

Conclusion for Metals
Previous dispersion modeling analyses estimated that Mirant's emissions resulted in elevated ambient air concentrations of several metals in nearby areas. ATSDR's EI, which included 68 samples that were analyzed for metals, showed that measured concentrations were generally lower than the models estimated. With two exceptions, every metal measured in the air samples was below levels of potential health concern. Arsenic and chromium were found at levels that could present a slight to low increase in the estimated risk for developing cancer. The arsenic and chromium levels observed were consistent with those routinely observed in suburban and urban locations nationwide and likely reflect contributions from many emissions sources.

TSP was collected on filters according to U.S.EPA Method IO-2.1 (USEPA 1999). A laboratory received these sampling filters and analyzed them for trace metals, according to U.S.EPA Method IO-3.5 (USEPA 1999). The analytical laboratory has been accredited under the National Environmental Laboratory Accreditation Program and is certified for performing these metals analyses. For chromium, mercury, and nickel, the loadings on the sampling filters were comparable to the amounts of metals found in the blank filters. Measured concentrations for these three metals are therefore considered estimated values and are cautiously interpreted.

Table 5 summarizes the metals concentrations measured during ATSDR's EI. For each of the 11 metals, the table shows the average concentration for the four monitoring stations and compares these averages with health-based comparison values. As the table shows, average metal concentrations did not vary considerably across the four monitoring stations, despite their varying distances from Mirant PRGS and orientation with respect to prevailing wind directions. Comparisons between Table 5 and Table A-2 in Appendix A show that the measured ambient air concentrations were generally lower than the estimated concentrations predicted in the dispersion modeling analysis.

Public health implications

Of the 11 metals shown in Table 5, nine had average concentrations below their corresponding health-based comparison values. For these nine; antimony, beryllium, cadmium, cobalt, lead,

manganese, mercury, nickel, and selenium, the measured concentrations are below health concern levels (see discussion in the following paragraph).

For arsenic and chromium, the average concentrations shown in Table 5 are higher than the screening health-based comparison values. Note that most comparison values are used for screening purposes only and should be interpreted as follows:

> Concentrations lower than health-based comparison values are generally considered safe and not expected to cause harmful health effects. The opposite, however, is not true. Concentrations higher than comparison values are not necessarily harmful; rather, to assess public health implications, they require a more detailed evaluation.

Following is ATSDR's more detailed evaluation for the two metals that had concentrations higher than health-based comparison values.

Table 5. Ambient Air Concentrations of Metals Measured during the 2007 Exposure Investigation.

Metal	*Program-Average Concentrations (µg/m³), by Site*				*Health-Based Comparison Values (µg/m³)*
	Site 1	*Site 6*	*Site 8*	*Site 10*	
Antimony	0.0015	0.0019	0.0015	0.0025	RfC = 0.2
					VDEQ = 1
Arsenic	0.00084	0.00080	0.00085	0.00088	RfC = 0.3
					VDEQ = 0.4
					CREG = 0.0002 (Risk = 4 in 1,000,000**)
Beryllium	0.000014	0.000014	0.000014	0.000016	RfC = 0.02
					VDEQ = 0.1
					CREG = 0.0006
Cadmium	0.00015	0.00014	0.00013	0.00022	RfC = 0.02
					VDEQ = 0.004
					CREG = 0.0006
Chromium (total)*	0.0023	0.0023	0.0022	0.0028	RfC = 0.1
					VDEQ = 0.1
					CREG = 0.00008 (Risk = 3 in 100,000**)
Cobalt	0.00019	0.00025	0.00020	0.00038	Chronic MRL = 0.1
					VDEQ = 0.1
Lead	0.0050	0.0067	0.0046	0.0049	EPA NAAQS = 0.15 (quarterly average)
					VDEQ = 0.3
Manganese	0.0083	0.011	0.0089	0.014	Chronic MRL = 0.04
					VDEQ = 10
Mercury*	0.000029	0.000021	0.000017	0.000018	Chronic MRL = 0.2
					VDEQ = 0.2
Nickel*	0.0018	0.0017	0.0016	0.0029	Chronic MRL = 0.09
					VDEQ = 0.2
Selenium	0.0012	0.0012	0.0013	0.0011	Chronic REL = 20
					VDEQ = 0.4

Source: ATSDR 2009.

Notes: At all four sampling stations, 17 valid samples were collected. The numbers presented are the averages of the 17 measured concentrations.

*In the ambient air samples, metal loadings for chromium, mercury, and nickel were comparable to the average loadings of these metals in blank samples (see discussion for more detail). Accordingly, ambient concentrations for these metals should be viewed as estimated results.

**The theoretical cancer risk estimates were calculated by multiplying the average of the program-average concentrations by the metal's unit risk factor (arsenic = 0.0043/µg/m^3; hexavalent chromium = 0.084/µg/m^3). The calculation for chromium risk in this table assumes that 1/6 of the chromium detected is in the hexavalent form (see discussion).

Codes for health-based comparison values:

Chronic MRL = Minimal Risk Level (ATSDR) for chronic exposure durations

Chronic REL = Reference Exposure Level (California EPA) for chronic exposure durations

CREG = Cancer Risk Evaluation Guide (ATSDR)

RfC = Reference Concentration (EPA)

VDEQ = Virginia Department of Environmental Quality Guideline Standard. Chapter 10, Toxic Air Pollutants, Appendix FF. AQP-5 Priority Pollutants Tables. Values are yearly.

Arsenic

The measured concentrations of arsenic near Mirant PRGS (Table 5) were all lower than health-based comparison values for health effects other than cancer. This suggests that exposures to the measured concentrations would not be expected to cause noncancer health effects. Because inorganic arsenic is a known human carcinogen, ATSDR evaluated the potential for carcinogenic effects. The cancer risk estimates are based on 1) particulate matter measurements collected in the summer when concentrations tend to be highest, and 2) TSP, which includes some particles too large for respiration. The arsenic levels measured in total suspended particulate matter (TSP) near Mirant PRGS correspond to a slight (4 in 1,000,000) increase in the estimated risk for developing cancer following a lifetime of exposure.

The measured arsenic concentrations near Mirant PRGS (Table 5) are consistent with "background" levels observed in urban and suburban locations throughout the United States. A recent review of arsenic monitoring data collected between 2003 and 2005 and reported to U.S.EPA found that 59% of monitoring locations had arsenic concentrations higher than the 1 in 1,000,000 estimated cancer risk level (McCarthy et al. 2009). Other ambient monitoring data reviews also suggest that concentrations measured near Mirant PRGS are consistent with levels routinely observed in various settings nationwide (ATSDR 2007).

Chromium

The measured concentrations of total chromium near Mirant PRGS (Table 5) were all lower than health-based comparison values for health effects other than cancer. This suggests that exposures to the measured concentrations would not be expected to cause health effects. Because hexavalent chromium is also a known human carcinogen, ATSDR evaluated its carcinogenic effects potential.

Before conducting this evaluation, ATSDR reviewed in detail the chromium sampling data. The concentrations measured during the EI are based on the amount of chromium collected on the TSP sampling filters. In this program, ATSDR used ultra-high purity quartz filters, considered the most durable media for the high-volume sampling that occurred. But the filter medium itself contains trace amounts of metals, including chromium. The method can accurately measure ambient air concentrations of chromium, but only when the amount of chromium sampled consistently exceeds the trace quantities found in the ultra-high purity filters.

As Appendix D notes, during the EI, ATSDR analyzed multiple "blank" samples. The blank samples were used to assess whether the measured concentrations reflected contributions from outdoor air pollution or from metals found in the sampling media. During these blank sampling events, filters are submitted to the laboratory for analysis without exposure to ambient air. As Appendix D notes (see Table 3-11 in the appendix), in the "blank" samples, chromium was detected at higher levels than was any other metal. In fact, the average mass of chromium found on the filters in the blank samples was 2.75µg, while the average chromium mass loading on the actual sample filters was 4.34µg. Thus a considerable portion of the total chromium shown in

Table 5 might actually reflect impurity of the sampling media—not outdoor air pollution. In other words, the ambient air sampled at Mirant PRGS did not contain chromium at sufficiently high concentrations for reliable and accurate detection by the employed TSP sampling method.

Recognizing the limitations the contaminated blanks introduced, ATSDR nonetheless evaluated the measured concentrations (Table 5), assuming they represented actual outdoor air pollution levels. In this way, the evaluation could create a worst-case scenario. A complicating factor, however, was that ambient air chromium takes on many forms, all with differing toxicities. The most common forms are trivalent and hexavalent chromium. Of these, only hexavalent chromium is a known human carcinogen. Still, most commonly used environmental sampling and analytical methods measure ambient air concentrations of total chromium without specifying the relative amounts of the hexavalent and trivalent forms.[2] As a first approximation, ATSDR assumed that one-sixth of the total chromium is in the hexavalent form—an assumption frequently used and suggested in a U.S.EPA risk assessment publication (USEPA 2009e). Following lifetime exposure, the estimated increased cancer risk would then be 3 in 100,000—a low cancer-risk increase.

Again, due to chromium in the filter sampling media, some uncertainty clouds this estimate. But ATSDR notes that the measured concentrations—even if accurate—are comparable to "background" levels documented in multiple scientific studies (ATSDR 2008). Moreover, that Mirant PRGS's emissions account for a local "hot spot" of hexavalent chromium is unlikely, given that approximately 0.2% of chromium emissions from coal combustion sources are typically in the hexavalent form, a far lower proportion than that released from other industrial sources (ATSDR 2008).

Mixtures

Throughout this section, the health evaluations have focused on individual pollutants. This is consistent with the underlying available toxicological literature, which also focuses on health effects following single pollutant exposures. At Mirant PRGS, however, as with many industrial sites, real-world environmental exposures occur simultaneously and involve multiple pollutants. This section considers the public health implications of such exposures, focusing particularly on the potential for coexposures to ozone, $PM_{2.5}$, and sulfur dioxide.

Using the available ambient air monitoring data, ATSDR first notes where and when individual pollutants reached their peak levels:

- **Ozone.** Ambient air concentrations of ozone in the "Washington-Baltimore-Northern Virginia" area tend to peak in the summer. Levels are typically highest between 1:00 p.m. and 5:00 p.m., with elevated levels observed less frequently during other daylight hours (USEPA 2006).
- **$PM_{2.5}$.** Levels in northern Virginia also tend to be highest during July–September (VDEQ 2007). Moreover, the monitoring data that ATSDR collected during the EI found that

[2] Hexavalent chromium monitoring methods are available and could be used in future monitoring efforts. Still, the particulate sampling and analytical method used in the EI was selected to provide insights on a broader range of metals, and not to focus on just hexavalent chromium with the understanding that hexavalent chromium sampling could be recommended if hexavalent chromium was detected by the TSP method at significant enough concentrations to warrant additional sampling.

$PM_{2.5}$ concentrations were higher between 6:00 p.m. and 11:00 p.m. compared with 12:00 p.m. to 5:00 p.m., when ozone and SO_2 are highest.

- **Sulfur dioxide.** Mirant PRGS's monitoring data indicated elevated sulfur dioxide concentrations (i.e., higher than 200 ppb). Concentrations in this range occur most frequently during the afternoon hours, between noon and 5:00 p.m. As noted previously, the concentrations higher than 200 ppb were predominantly limited to locations within ¼-mile of Mirant PRGS.

Taken together, the previous observations suggest that the timeframe of greatest concern for exposures to mixtures is during the afternoon hours in the summer. This concern would be greatest for the immediate vicinity of Mirant PRGS, where the highest sulfur dioxide concentrations are estimated to occur. In this area, coexposures are possible between elevated levels of sulfur dioxide and ozone or sulfur dioxide and $PM_{2.5}$, or possibly all three pollutants combined.

Some sulfur-dioxide sensitive persons functioning at elevated ventilation rates may experience enhanced effects from exposure to a mixture of sulfur dioxide and ozone or $PM_{2.5}$. Scientific information is insufficient to allow meaningful quantitative analysis, but is sufficient to warrant concern for sensitive populations at elevated ventilation rates. Still, exposure to mixtures is estimated as limited temporally and spatially by the presence of sulfur dioxide. Given the infrequent elevations of SO_2 above 200 ppb and the spatial and temporal limitations identified here, ATSDR believes the severity of health effects from a mixture exposure is not likely to exceed those discussed for SO_2 or $PM_{2.5}$ exposure alone. Because, however, effects may occur at a lower SO_2 concentration, the number of affected persons may increase.

Near-roadway exposures

Though this health consultation's focus is on air quality effects of pollutants released from Mirant PRGS, multiple emissions sources affect air pollution levels near the facility. For nearly every urban and suburban location where air pollution measurements have been collected, the outdoor air presence of mobile-source air toxics is well documented. Given that several major thoroughfares pass in close proximity to Mirant PRGS (e.g., George Washington Memorial Parkway, Route 1), to inform community members further, ATSDR is providing information on mobile-source and near-roadway pollution levels. Note that this section is not meant to imply that either mobile sources or Mirant PRGS sources are more important than the other.

What are toxic air pollutants?

Toxic air pollutants, also known as hazardous air pollutants, are those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. EPA is working with state, local, and tribal governments to reduce air toxics releases of 188 pollutants to the environment. Examples of toxic air pollutants include benzene, which is found in gasoline; perchloroethylene, which is emitted from some dry cleaning facilities; and methylene chloride, which is used as a solvent and paint stripper by a number of industries. Examples of other listed air toxics include dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium, and lead compounds (USEPA 2009f).

Mobile sources release hundreds of air pollutants. These include several criteria pollutants (e.g., carbon monoxide, particulate matter, nitrogen dioxide) and dozens of so-called "air toxics." These air toxics include known or suspected carcinogens (e.g., benzene, 1,3-butadiene, diesel exhaust particulate matter, formaldehyde) as well as pollutants that cause various health effects

other than cancer. In the immediate proximity of roadways and particularly major thoroughfares, ambient air concentrations of these mobile source air toxics can far exceed levels found at more distant downwind locations. But in a given area many factors determine the extent of mobile source pollution, such as the amount of nearby traffic, the different types of mobile sources found, and the age and design of the vehicles passing through the area.

Many researchers have investigated the potential health implications of near-roadway air pollutant exposures. For example, U.S. EPA has recently estimated that approximately one-third of the U.S. population lives in areas where mobile source air toxics account for air pollution levels that present an elevated theoretical lifetime cancer risk, and that these risks are most pronounced in areas with the highest motor vehicle traffic (USEPA 2007). Moreover, various health studies have found evidence of adverse health effects among populations who live in closest proximity to major roadways. A large study of southern California residents found an increased risk in lifetime asthma and wheeze for children (5 to 7 years old) who live within 75 meters of a major roadway, but that risk decreased with distance from the major roadways and approached background rates for populations living 150 to 200 meters from the major roadways (McConnell et al. 2006). Another study examined lung function of nearly 3,700 children 10 to 18 years old in southern California. This study found that children who lived within 500 meters of freeways had substantial deficits in lung function as compared with those who lived more than 1,500 meters away from freeways (Gauderman et al. 2007). While not a comprehensive review of the scientific literature of near-roadway exposures, this information is presented to inform residents that near-roadway exposure may carry increased risks for certain health effects associated with mobile source air toxics.

Overall, some insights into the various factors that affect air quality in urban and suburban settings may be helpful. Research has demonstrated the potential air quality effects from mobile sources, particularly those in close proximity to major roadways. Note, however, that the findings in this health consultation are based on actual air pollution levels near Mirant PRGS as measured by multiple parties, regardless of pollutant origin. While mobile sources contribute to air pollution levels near Mirant PRGS, they are not a dominant factor for all pollutants.

Gaps and Limitations

In this health consultation, ATSDR considered the public health implications of the measured and estimated air pollution levels near Mirant PRGS. ATSDR also considered whether the available data form an adequate basis for reaching conclusions. For example, an important consideration was whether the data provided adequate spatial and temporal coverage to assess current exposures.

ATSDR's conclusions for sulfur dioxide were based mainly on 16 months of continuous monitoring and conclusions for $PM_{2.5}$ were based on VDEQ multiyear data and ATSDR EI PM data. This monitoring was conducted in multiple locations, including those believed to have the greatest air quality effects. Data from additional monitoring locations would provide additional evidence for this document's conclusions. But ATSDR has concluded that the existing networks were adequate for 1) capturing the highest off-site exposure concentrations for sulfur dioxide and $PM_{2.5}$, 2) capturing concentrations resulting from Mirant PRGS's air emissions during the time measured with the stack configuration present at the time, and 3) measuring at locations nearest Mirant PRGS.

But as stated, the Mirant PRGS's stack configuration has subsequently been modified. Some uncertainty thus clouds the question of whether measured ambient concentration data and this health evaluation are applicable to current conditions in proximity to the Mirant PRGS facility.

ATSDR also considered the monitoring data's temporal coverage. The evaluations in this section are based primarily on continuous monitoring that occurred in recent years consistent with the original request to ATSDR, including data covering all seasons and various meteorological conditions. Continuous sulfur dioxide and particulate matter measurements provided assurance that these measurements did not miss peak exposures. While ATSDR has not evaluated monitoring data since the January 2009 completion of the Mirant PRGS stack merge project, the lack of post-project data is not a significant limitation. The stack merge should enhance the atmospheric dispersion of emissions and should not affect respective emission rates. The stack merge purpose was, after all, to reduce ground-level concentrations by allowing greater dispersion before contaminant reached the ground. Hence ATSDR does not expect the stack merge project would cause ambient air concentrations nearest Mirant PRGS to increase above concentrations measured in April–July 2008, before the stack merge.

ATSDR also evaluated whether the current monitoring networks addressed the pollutants of greatest concern. As this section notes, extensive data are available for sulfur dioxide, particulate matter, and several metals. While such a list does not include every pollutant emitted by coal-fired power plants, monitoring has occurred for several air pollutants that 1) are known to be released by Mirant PRGS, 2) were previously identified in modeling analyses as possibly reaching levels of health concern, and 3) have measureable health endpoints.

Finally, ATSDR notes that a limitation inherent in the public health assessment process is that scientists do not have a complete understanding how simultaneous exposures to environmental contaminants may cause health effects. For the pollutants considered in this analysis, however—especially sulfur dioxide and particulate matter—hundreds of toxicological and epidemiological studies have examined how exposures are possibly related to health effects in humans. Therefore, the evaluations of individual pollutants considered in this health consultation are based on extensive scientific research, though the scientific understanding of the health effects of exposures to pollutant mixtures is less advanced.

Overall, as with most site-specific environmental health evaluations ATSDR conducts, the finding and conclusions in this health consultation have some inherent gaps and limitations. But for the reasons cited above, ATSDR concludes that the study does not have such major data gaps or limitations as would preclude scientifically defensible conclusions.

Child Health Considerations

In communities faced with air pollution issues, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children frequently play outdoors, especially during the summertime, which can increase their exposure potential. Further, a child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification.

Thus adults need as much information as possible to make informed decisions regarding their children's health.

When preparing this health consultation, ATSDR considered these and other children's health issues. For instance, when selecting health-based comparison values for the exposure evaluation, ATSDR identified, when available, comparison values protective of children's exposure and of health conditions more common in children, like asthma. As one example, ATSDR used U.S.EPA's National Ambient Air Quality Standards to screen air pollution levels for lead, ozone, particulate matter, and sulfur dioxide. U.S.EPA developed these standards to protect the health of sensitive populations, including children.

Children may be at increased risk from exposure to ambient air contaminants with respect to both toxicology and exposure. It is not clear that children are more toxicologically sensitive to SO_2 but may be more vulnerable because of increased exposure. While physiologically-based pharmacokinetic modeling has suggested that children may be more vulnerable in the pulmonary region to fine particulate matter, it also suggests that children's airways may not be more sensitive than adults to reactive gases such as SO_2 (Ginsberg et al. 2005).

Factors that may contribute to enhanced lung deposition in children include higher ventilation rates, less contribution from nasal breathing, less efficient uptake of particles in the nasal airways, and greater deposition efficiency of particle and some vapor phase chemicals in the lower respiratory tract. A child breathes faster compared to an adult, which may result in increased uptake (Koenig et al. 2000). Children spend 3 times as much time outdoors as adults and engage in 3 times as much time playing sports and other vigorous activities (USEPA 1997). Based on these parameters, children are more likely to be exposed to more outdoor air pollution than adults. Epidemiological evidence suggests that air pollution effects (lung function decrements) in children may not be fully reversible, even if the exposure stops, although SO_2 was not a major contaminant in these studies (Gauderman et al. 2004).

ATSDR identified other environmental health issues of particular concern to children for this site: elevated airborne levels of ozone and fine particulate matter. Many children who live near Mirant PRGS, like children who live in numerous urban and suburban areas in northern Virginia and across the country, have a greater risk of suffering from ozone- and particle-related adverse health effects than do adults.

ATSDR's concern for this issue is based partly from the fact that ozone and $PM_{2.5}$ levels are generally highest during the afternoon hours on sunny summer days, when most children are not in school and may be playing outdoors. Another reason for concern is that people with asthma have been identified as a sensitive population for both ozone and $PM_{2.5}$ exposure, and asthma is more prevalent among children than among adults (Mannino et al. 2002). Finally, children might not seek or understand information in important air quality forecasts. These factors are of concern because asthmatic children or children who engage in moderate to strenuous exercise (e.g., swimming and running) during poor air quality days are at risk for respiratory problems.

Many resources are available to help prevent children from exposure to unhealthful levels of ozone and $PM_{2.5}$. On days with the most elevated air pollution levels, VDEQ issues air quality alerts or forecasts, which are typically broadcast by the local media. Parents should encourage their children, especially asthmatic children, to play indoors on days when air pollution levels are predicted to be unhealthful. Further, U.S.EPA's Web site now includes a significant amount of information on ozone, $PM_{2.5}$, and related air quality issues. Adults are encouraged to access this

information, whether from their home computers or those at local libraries, at www.epa.gov/airnow. Additionally, U.S.EPA has recently launched a Web site that targets health-related air pollution information to children. The site, "Air Quality Index for Kids!" is available in English and Spanish at www.epa.gov/airnow/aqikids.

Conclusions and recommendations

The following conclusions and recommendations are based on pre-July 2008 data for communities nearest the Mirant PRGS facility:

1. Sulfur dioxide exposures : sensitive populations (e.g., persons with asthma)

Conclusion

Breathing air around Mirant PRGS contaminated with sulfur dioxide for short periods (5 minutes) could harm the health of sensitive persons (e.g., persons with asthma) functioning at elevated ventilation rates, perhaps by exercising, working outdoors, gardening, or climbing steps. These exposure levels have been infrequent and have been limited to areas within ¼-mile of Mirant PRGS and generally between noon and 5 pm. When sulfur dioxide concentrations exceed 400 ppb, such persons may experience symptoms such as coughing, wheezing, and chest tightness.. At lower sulfur dioxide concentrations (200 ppb to 400 ppb), sensitive persons functioning at elevated ventilation rates may experience asymptomatic effects (e.g., mild constriction of bronchial passages). Adverse health effects from exposures to fewer than 200 ppb are uncertain but may occur in some persons more sensitive or vulnerable than those participating in clinical investigations.

People with asthma, children, and older adults (65+ years) have been identified as groups susceptible to the health problems associated with breathing SO_2. Clinical investigations and epidemiological studies have provided strong evidence of a causal relationship between SO_2 and respiratory morbidity in people with asthma and more limited epidemiological studies have consistently reported that children and older adults may be at increased risk for SO_2-associated adverse respiratory effects. Potentially susceptible groups to air pollutants include obese persons, those with preexisting cardiopulmonary disease, and those with a pro-inflammatory condition such as diabetes, but some of these relationships have not been examined specifically in relation to SO_2.

Recommendations

To reduce peak exposures to sulfur dioxide, ATSDR recommends the following:

- Reduce emissions—VDEQ should continue efforts to regulate peak acid gas emissions from Mirant PRGS. VDEQ may consider confirming that the stack merge has in fact resulted in reduced exposure.
- Reduce exposures— ATSDR should continue to share health education materials identifying potential locations and times sulfur dioxide may be present at levels of public health concern for susceptible and potentially susceptible populations. Public outreach and education already completed to address this recommendation included an open house, community fact sheet, educational information on the ATSDR Web site, meetings

with local community groups, and a link from the local public health agencies to the ATSDR Web site for public access to site-related educational materials.

2. Sulfur dioxide exposures : general population

Breathing air around Mirant PRGS contaminated with sulfur dioxide is not expected to harm the health of the general population or the health of sensitive populations not functioning at elevated ventilation rates.

3. Fine particulate matter ($PM_{2.5}$) exposures

Conclusion

ATSDR concludes that breathing for many years Alexandria, VA air contaminated with $PM_{2.5}$ could harm people's health. $PM_{2.5}$ is, however, a regional air quality issue. The $PM_{2.5}$ levels observed in the local Alexandria area are not considerably different from levels measured in multiple locations throughout northern Virginia. These $PM_{2.5}$ levels are caused by emissions from mobile and industrial sources throughout this area and beyond. Nevertheless, public health concern is warranted for adverse health effects from long-term exposure to particulate matter ($PM_{2.5}$), especially for those with preexisting respiratory and cardiac disease. Concern is further warranted because in Alexandria exposure has been long-term in and continues, albeit at reduced levels of concern. Current and past annual average $PM_{2.5}$ levels are near the lower level of reported cardiopulmonary health effects in epidemiological studies. That said, ATSDR considers ongoing reduction of exposure to particulate matter prudent public health practice.

Recommendations

To reduce $PM_{2.5}$ exposure, ATSDR recommends the following:

- Reduce emissions—continued efforts by VDEQ and the City of Alexandria to reduce particulate matter emissions in the City of Alexandria and the State of Virginia, including available steps to reduce and monitor particulate matter emissions at Mirant PRGS as negotiated under the City of Alexandria's settlement agreement with the facility.
- ATSDR should continue to share health education materials identifying potential locations and times sulfur dioxide may be present at levels of public health concern for susceptible and potentially susceptible populations. Public outreach and education already completed to address this recommendation included an open house, community fact sheet, educational information on the ATSDR Web site, meetings with local community groups, a link from the local public health agency to the ATSDR Web site for public access to site-related educational materials, and two webinars for health professionals on particulate matter and patient health.

4. Metals

Conclusion

As previously estimated by models, in nearby areas Mirant PRGS's emissions could have resulted in elevated ambient air concentrations of several metals. ATSDR's Exposure Investigation, which included 68 samples analyzed for metals, showed that measured concentrations were generally lower than the model estimates. With two exceptions, every metal measured in the air samples was below levels of potential health concern. Arsenic and chromium

were at levels that could present a slight to low increase in the estimated cancer risk. The observed arsenic and chromium levels were consistent with those routinely observed in suburban and urban locations nationwide, were likely to reflect contributions from many emissions sources, and were not attributable solely to Mirant PRGS emissions.

Recommendation

Because airborne arsenic and chromium are typically part of particulate matter, reducing overall exposure will likely reduce exposure to these metals. ATSDR has recommended measures to reduce particulate matter exposures.

5. Mixtures exposure

Conclusion

ATSDR can reach no conclusion regarding whether near Mirant PRGS, breathing air contaminated with sulfur dioxide for 5 minutes while breathing $PM_{2.5}$, or after breathing ozone, will harm people's health beyond effects for sulfur dioxide or $PM_{2.5}$ exposure alone. ATSDR believes it is unlikely that the severity of effects would increase as a result of a potential multiple contaminant exposure, although the number of persons affected may increase because effects may occur at a lower sulfur dioxide concentration. Potential effects would be limited to an exposure to those contaminants present at sufficient concentration during the same time of day at the same locations during the summer months.

Recommendation

To reduce the likelihood of multiple contaminants exposure, ATSDR recommends reducing exposure to sulfur dioxide peaks under Conclusion 1 and to $PM_{2.5}$ under Conclusion 3. These reductions will reduce the likelihood of multiple contaminant exposures.

Public Health Action Plan

Since beginning its evaluation of the Mirant PRGS site's public health concerns, ATSDR has researched and evaluated air pollution levels and worked with the local community. A timeline of the main activities conducted as of the completion of this consultation include

- In January 2006, the Health Director of the Alexandria Health Department requested that ATSDR review then-available air quality and other environmental data related to operations at the Mirant PRGS facility. The Health Director also asked ATSDR to assess whether then-current data indicated a potential for health effects for nearby residents and to recommend next steps.
- In February 2006, the ATSDR Triage team evaluated and accepted this request for public health activities.
- In March 2006, ATSDR participated in a planning and information gathering conference call with Alexandria Health Department officials.
- In July 2006, ATSDR met with Alexandria Health Department, VDEQ, VDH, and city officials. ATSDR conducted a tour of the site area, including Marina Towers.
- In January 2007, ATSDR reviewed available air modeling and emissions data and in a letter health consultation, provided preliminary findings to the Alexandria Health

Department. The Alexandria Health Department initiated an Internet site to collect health concerns and complaints from community members.

- In February 2007, ATSDR participated with the Alexandria Health Department in a Mirant Community Working Group public meeting to share the results of ATSDR's preliminary findings.
- In March 2007, ATSDR toured the Mirant PRGS site.
- In May 2007, ATSDR published the protocol for its Exposure Investigation, which detailed the procedures, methods, and design of the ATSDR Community-based Air Monitoring Effort. ATSDR officials briefed U.S. Department of Health and Human Services (DHHS) on site activities.
- In June–July 2007, ATSDR set up short-term air monitoring stations in areas where people lived and worked in the Alexandria, VA community, near the Mirant PRGS Plant. The monitoring took place for 6 weeks.
- In July 2007, ATSDR developed and shared factsheets on Air Quality and Health in Alexandria and ATSDR's Public Health Activities in Alexandria. ATSDR also developed a site webpage with sections on healthcare provider resources.
- In July and early August 2007, ATSDR met with stakeholder groups, including community organizations and federal, state, local, and facility officials, and conducted a community open house to share activities and future plans, and to address questions.
- In December 2007 through May 2008, ATSDR requested and received facility operating data from VDEQ and prepared electronic analyses thereof.
- In May 2008, U.S. EPA Office of Air Quality Planning and Standards (OAQPS) requested ATSDR participation on a Trona Research Workgroup, to which request ATSDR agreed.
- In June 2008, at Mirant's request, ATSDR officials met with Mirant at ATSDR headquarters. The Alexandria Health Department participated in this meeting. The purpose of the meeting was for Mirant to voice concerns to ATSDR management because ATSDR scientists did not agree with Mirant's sulfur dioxide comparison value.
- In June 2008, the City of Alexandria and Mirant reached a negotiated agreement for a $34 million dollar investment in new pollution controls at the facility and for pursuit of the stack merge.
- In September 2008, ATSDR received Mirant PRGS's short-duration monitoring network data and with this information began updating all of ATSDR's monitoring data analyses.
- In 2009, ATSDR completed the Mirant sulfur dioxide data analysis and conducted an off-site study comparing analytical sulfur dioxide sampling methods.
- In June 2009, ATSDR met and briefed the new Alexandria Health Department director regarding evaluation status.
- In October 2009, ATSDR entered its draft health consultation into the external peer review process.

- In November 2009, ATSDR distributed a letter update to community members, agencies and other interested stakeholders regarding the health consultation status and the ATSDR EI SO_2 monitors.
- In December 2009, ATSDR submitted this health consultation document for external scientific peer review.
- In February 2010, ATSDR completed responses to comments from the external peer review process and submitted the health consultation for agency clearance.
- In July 2010, the public comment version of the Health Consultation was released. Written comments were received from the EPA, the City of Alexandria, and the Utility Air Regulatory Group.
- In August 2010, ATSDR received post stack merge sulfur dioxide data from Mirant PRGS.
- In October 2010, ATSDR received Mirant operations data from the Virginia Department of Environmental Quality for the post stack merge time period.
- In January 2011, ATSDR completed evaluation of post stack merge sulfur dioxide data Mirant operations data, responded to comments received during the public comment period, and submitted the health consultations for agency clearance.
- In February 2011, ATSDR partnered with the American College of Medical Toxicology to offer two free webinars on particulate matter and health for clinical and public health professionals. Information regarding this webinar was shared with the City of Alexandria, the Alexandria Health Department, and the Virginia Department of Health, as well as ATSDR/CDC and EPA contact lists for the region. The presentations offered continuing education credits for medical and public health professionals. The first webinar focused on what is particulate matter, how it gets into the environment, trends in air quality, air quality regulations, where to find air quality information and how air quality affects the health status of a community. The second webinar focused on clinical impacts of particulate matter in the environment, sensitive populations and appropriate interventions. The webinars will be archived at www.acmt.org and will be available for continuing education credits through February 2013.
- Future plans – ATSDR has addressed comments received during the public comment period in this final health consultation. ATSDR will share this final document with interested stakeholders and publish it on the ATSDR website. If requested, ATSDR will meet with interested stakeholders to discuss this final report and address questions. If additional data and/or studies related to this site are provided to ATSDR in the future, ATSDR will consider evaluating this information further.

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Appendix A. Air Dispersion Modeling Results

Appendix A. Air Dispersion Modeling Results

Historical Air Dispersion Modeling

Until August 2005, Mirant Potomac River Generating Station (PRGS) operated in a manner such that power production was dictated by economics. Mirant PRGS operated without permit controls on sulfur dioxide (SO_2) emissions. Several professional entities have modeled air emissions from Mirant PRGS using varied assumptions involving emissions, operations, and meteorology. Historical air dispersion modeling was conducted by ENSR Corporation (ENSR, 2005), AERO Engineering Services (AERO, 2005), and the Department of Energy (DOE, 2006). All modeling entities agree that historical air dispersion modeling showed significant modeled exceedances of the three U.S. Environmental Protection Agency (EPA) National Ambient Air Quality Standard (NAAQS) criteria pollutants: SO_2, nitrogen dioxide (NO_2), and particulate matter 10 microns and smaller in diameter (PM_{10}), but not carbon monoxide or mercury. A summary of the relevant results follow and are described in Tables A-1 (for SO_2, NO_2, $PM_{2.5}$, and PM_{10}) and Table A-2 (for hazardous air pollutants and metals).

Table A-1. Historical Air Dispersion Modeling Results for Nitrogen Oxides, Sulfur Dioxide and Particulate Matter.

Historical Air Dispersion Modeling Results								
Source	**Nitrogen Dioxide (ppb)**	**Sulfur Dioxide (ppb)**			**$PM_{2.5}$ ($\mu g/m^3$)**		**PM_{10} ($\mu g/m^3$)**	
	Annual Average	**3-hour Average**	**24-hour Average**	**Annual Average**	**24-hour Average**	**Annual Average**	**24-hour average**	**Annual Average**
AERO[1]	159	3686	2490	353	505	78	680	147
ENSR[2]	60	3035	1555	196	NA	NA	321	43
DOE[3]	NA[6]	2121	1132	114	NA	NA	150	25
NAAQS[4]	53	500	140	30	35	15	150	Revoked[7]
Background[5]	26	91	19	6	39	15	45	21

[1]AERO Engineering Services. Data from Ambient Air Quality Analysis – Potomac River Generating Station – Alexandria, Virginia. August, 2005. Numbers shown represents the mean from maximum annual averages 2000-2004, excluding background

[2]ENSR Corporation. A Dispersion Modeling Analysis of Downwash from Mirant's Potomac River Power Plant, August, 2005, Document number 10350-002-410. Numbers shown represents the mean from maximum annual averages 2000-2004, excluding background

[3]DOE – Department of Energy. Data from U.S. Department of Energy, Special Environmental Analysis, November 2006, DOE/SEA-04.

[4]NAAQS – National Ambient Air Quality Standard

[5]Background concentrations for sulfur dioxide are maximum values observed for the specified averaging periods from 2000-2004 at the ambient air monitor at 517 Saint Asaph Street, Alexandria, VA. Background concentrations for PM_{10} is the arithmetic mean reported in VDEQ 2005, page 49, monitoring site L-46-B3.

[6]NA Not Available

[7]The PM_{10} annual average standard was revoked in 2006 due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution.

Table A-2. Historical Air Dispersion Modeling Results for Hazardous Air Pollutants.

Air Dispersion Modeling Results Hazardous Air Pollutants (HAPs)[1,2]				
HAP	**Maximum 1 hour**	**Acute Comparison Value[3]**	**Maximum Annual**	**Chronic Comparison Values[3]**
Acrolein	0.1006	aREL 0.19 VADEQ 17.25	0.0082	RfC 0.02 VADEQ 0.46
Arsenic	0.13	aREL 0.19 (4 hours) VADEQ 10	0.01	RfC 0.03, VADEQ 0.4 CREG 0.0002, Risk 9E-05
Beryllium	0.0068	PAC 5 VADEQ 0.1	0.0005	RfC 0.02 VADEQ 0.004 CREG 0.0004, Risk 1E-06
Cadmium	0.017	PAC 30 VA DEQ 2.5	0.0013	cREL 0.02, VADEQ 0.1 CREG 0.0006, Risk 7E-06
Chromium	0.0836	PAC 1500 VADEQ 25	0.0068	VADEQ 1
Chromium (VI) (particulate)	0.0254	PAC 339 VADEQ 2.5	0.0021	RfC 0.1 VADEQ 0.1 CREG 0.00008, Risk 3E-05
Cobalt	0.0322	PAC 3000 VADEQ 2.5	0.0026	cMRL 0.1 VADEQ 0.1
Formaldehyde	0.0832	aMRL 50 VADEQ 62.5	0.0067	cMRL 10 VADEQ 2.4 CREG 0.08, Risk 9E-08
Hydrogen chloride	386	aREL 2100 TEEL 750 VA DEQ 187.5	NA[4]	NA
Hydrogen fluoride	50	aREL 240 aMRL 16 VA DEQ 65	NA	NA
Lead	0.1351	TEEL 50 VADEQ 7.5	0.011	1.5 quarterly average VADEQ 0.3
Manganese	0.1576	TEEL 200 VADEQ 250	0.0128	cMRL 0.04 VADEQ 10
Mercury	0.43	aREL 1.8 VA DEQ 5	0.034	cMRL 0.2 VA DEQ 0.2
Methyl hydrazine	0.059	PAC 350 VADEQ 9.5	0.0048	NA
Nickel	0.0901	TEEL 1000 VADEQ 5	0.0073	cMRL 0.09 VADEQ 0.2
Selenium	0.4182	PAC 600 VADEQ 10	0.0339	cREL 20 VADEQ 0.4

[1]All concentrations are in $\mu g/m^3$.
[2]All chemicals and concentrations are from AERO, 2005.
[3]All comparison values were selected by ATSDR and include:

Acute comparison values for the 1-hour exposure values. All values are assumed to apply to 1-hour exposures, unless otherwise indicated:

PAC Protective Action Criteria (PAC-1) based on the applicable Acute Exposure Guidance Level-1 (AEGL-1), Emergency Response Planning Guideline (ERPG-1), or Temporary Emergency Exposure Limits-1 (TEEL-1).

TEEL Temporary Emergency Exposure Limit. The threshold concentration below with most people will experience no adverse health effects (TEEL-0).
aREL Acute Reference Exposure Level. From California EPA, a reference level at which adverse health effects are not expected.
aMRL Acute Minimal Risk Level. ATSDR level at which non-cancer adverse health effects are not expected, even to sensitive populations.
VADEQ Virginia Department of Environmental Quality Guideline Standard. Chapter 10, Toxic Air Pollutants. Appendix FF. AQP-5 Priority Pollutant Tables. Acute values are hourly and chronic values are yearly.

Chronic comparison values for annual exposures:

cMRL Chronic Minimal Risk Level. ATSDR level at which adverse non-cancer health effects are not expected when exposed continuously for a lifetime, even to sensitive populations.
cREL Chronic Reference Exposure Level. California EPA derived air comparison value at which no adverse health effects are expected.
RfC Reference Concentration. US EPA derived non-cancer value at which no adverse health effects are expected after continuous lifetime exposure to air, even in sensitive populations.
CREG Cancer Risk Evaluation Guide. ATSDR derived value which identifies a cancer health risk of 1:1,000,000 for a continuous exposure for 70 years. Calculated risk assumes a 50 year exposure (1955 – 2005).
VA DEQ Virginia Department of Environmental Quality Guideline Standard

[4]NA Not Available

Summary of results of historical air dispersion modeling.

An EPA judicial consent decree established in 2004, later amended in 2006, has resulted in required modeling efforts by the facility and emissions limits for some pollutants, including SO_2 and PM_{10}. Modeling conducted by Mirant PRGS has indicated that estimated concentrations of three pollutants—SO_2, NO_2, and PM_{10}—from downwash, might significantly exceed their corresponding NAAQS at locations near the facility boundary (DOE 2006).

SO_2
Maximum annual averages for SO_2 exceeded the NAAQS by 6-10 fold (ENSR and AERO, respectively).
Maximum 24-hour averages for SO_2 exceeded the NAAQS by 11-17 fold (ENSR and AERO, respectively).
Max 3-hour averages for SO_2 exceeded the NAAQS by 6-7 fold (ENSR and AERO, respectively).

PM
Maximum 24-hour averages for PM_{10} exceeded the NAAQS by 2-5 fold (ENSR and AERO, respectively).
Maximum annual averages for $PM_{2.5}$ exceeded the NAAQS by about 4 fold (AERO 2005).
Maximum 24-hour averages for $PM_{2.5}$ exceeded the NAAQS by about 5 fold (AERO 2005).

Nitrogen oxides
Maximum annual average NO_2 concentrations exceeded the NAAQS by about 2 fold (ENSR and AERO).

Hazardous Air Pollutants (HAPs).
HF (max 1-hour, 50 $\mu g/m^3$ exceeded ATSDR's acute MRL (16 $\mu g/m^3$).
HCl (max 1-hour, 386 $\mu g/m^3$ exceeded VA DEQ Guideline (187.5 $\mu g/m^3$).
Arsenic, beryllium, cadmium, and chromium (VI) exceeded ATSDR's cancer risk evaluation guide (CREG) (ATSDR 2007, 2002, 2008a, 2008b).

Conclusions - Historical Modeling Results
Historical air emissions from Mirant PRGS have been modeled by several interested parties including Mirant, the City of Alexandria, EPA, and DOE. Modeling results depended on the assumptions used for input to the model, including operating scenarios (such as maximum possible, actual from selected years, selection of generators and loading), emission factors (such as efficiency, type of coal, temperature), fugitive emissions, Trona efficiency, meteorological database, and other assumptions. Foregoing an extensive comparative analysis of each entity's modeling assumptions and results, The Agency for Toxic Substances and Disease Registry (ATSDR) concludes that the historical level of contamination estimated by all modeling entities suggests that a public health hazard would have existed if populations were exposed to those levels of contamination, particularly SO_2 and PM.

Based on the AERO air dispersion modeling, ATSDR calculated some increased cancer risk from exposures to arsenic, beryllium, cadmium and chromium VI (Table A-2) (ATSDR 2007, 2002, 2008a, 2008b). The concentrations in Table A-2 represent the max value of contaminant. Cancer risks are calculated based on continuous exposure for 50 years, in this case (1955-2005). Maximum values are inappropriate to be used to represent a cancer risk exposure because individuals are not exposed continuously to the maximum and a more appropriate value like the mean was not provided. Maximum values were used to calculate risk to view a worst-case scenario recognizing that the resultant would overestimate risk. ATSDR has included these metals in the exposure investigation to verify current levels of these metals.

Modeling estimates of maximum acid (HCl and HF) levels suggest that these levels may cause nasal or upper respiratory irritation in some individuals. HF exceeded ATSDR's acute MRL (16 $\mu g/m^3$, which is a safe level) but did not exceed the lowest observed adverse effect level (LOAEL, 417 $\mu g/m^3$) upon with the MRL is based (ATSDR, 2003). It is not known how often levels would have exceeded health-based comparison values and hence may have caused irritation. Current use of Trona or bicarbonate should reduce acid levels below a level of concern. Acid gases from Mirant PRGS are now regulated by the Virginia Department of Environmental Quality (VDEQ).

While air dispersion modeling suggests a public health hazard may have existed in the past from exposure to criteria pollutants, the uncertainty in the modeling results

compared to current monitoring results raises questions as to the validity of modeling results when compared with the limited monitoring results. While long-term modeling and monitoring have generally demonstrated good agreement, the peak modeling and monitoring at this site have not demonstrated good agreement. Since no sampling data are available for historical pre-shutdown operations at Mirant PRGS, and current monitoring levels are far below levels estimated by current air dispersion modeling, the historical air dispersion modeling results are considered an *indeterminate public health hazard* by ATSDR. While there is confidence as to the amount of SO_2 that was emitted from Mirant PRGS, there is much uncertainty as to the location and concentration of SO_2 to which the community may actually have been exposed.

Current Air Dispersion Modeling

Many current modeling scenarios were performed by Mirant PRGS with the results depending on the selected configuration of operations. Mirant PRGS has 5 generators that can be on line in different configurations and operated to a different output levels. Mirant PRGS operations during the Modeling Evaluation Study (which began during the summer of 2006) were evaluated with daily predictive meteorology for the following day with output determined not to exceed the NAAQS for SO_2.

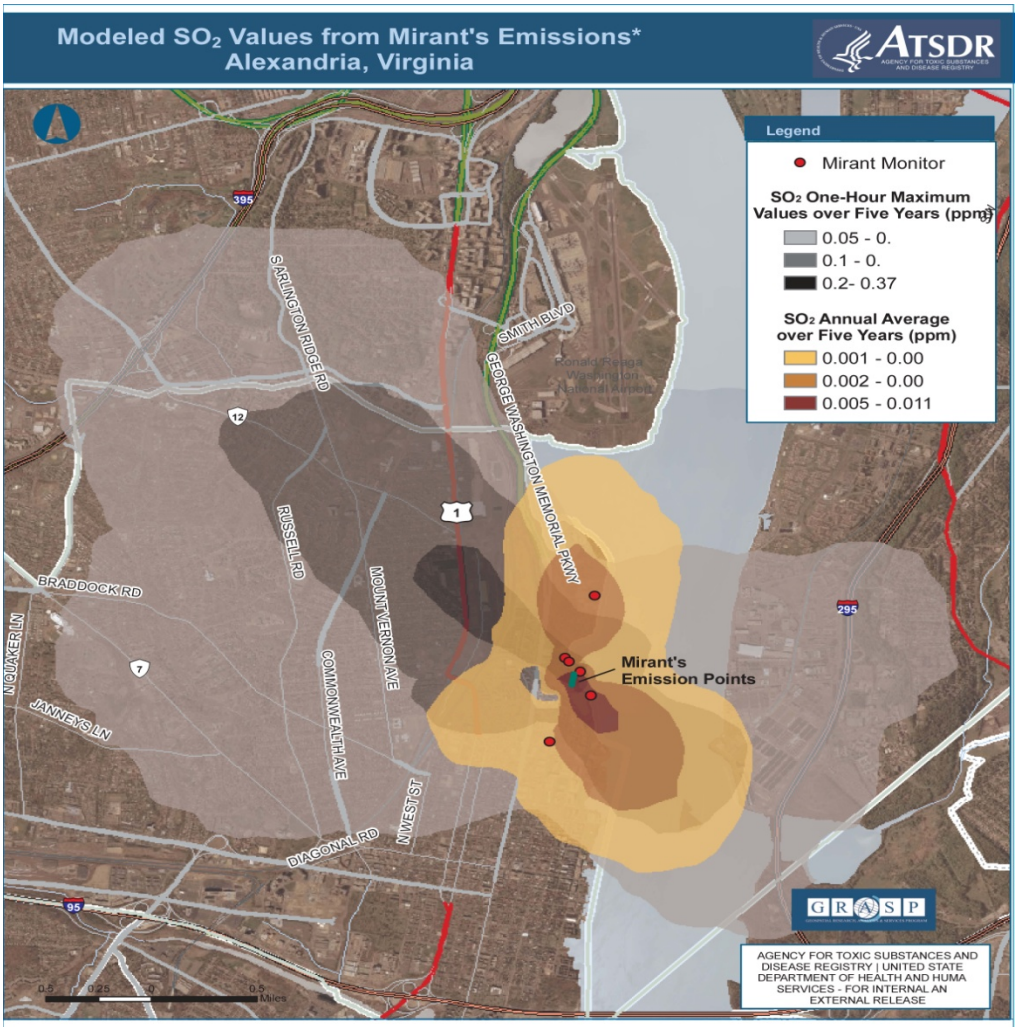
Monitors were installed in locations based on discussions among Mirant, DOE, and EPA modeling and meteorological experts. Six monitoring sites were selected. Two are located on the roof of Marina Towers, one on the west bank of the Potomac River, one southeast of Mirant PRGS along the fence line near the river, one at Daingerfield Island, on one on the roof of Harbor Terrace (Holiday Inn) southwest of Mirant PRGS. Mirant PRGS used the meteorology predicted for the following day to set up operations to not exceed the NAAQS for SO_2. After recording the observed values for SO_2, Mirant PRGS used the observed meteorology for that day to estimate what the observed SO_2 values should have been according to the model. Generally, the observed monitoring results were not predicted by the Daily Predictive Modeling or the follow-up modeling using the observed meteorology. Observed SO_2 values were much lower than predicted by modeling. The reasons for the discrepancy between monitored and modeled concentrations are not apparent (DOE 2006).

ATSDR believes that the complexity in meteorological conditions may contribute greatly to the modeling/modeling discrepancies. The statistical analysis of meteorological stations at Reagan Washington National Airport (modeling input used data from Reagan) and ATSDR meteorological stations at Site 1 and Site 10 demonstrates that the data from the local ATSDR stations are statistically significantly different from the Reagan meteorological station. (Appendix G, Tables G-4 through G-14).

The locations selected for the Mirant PRGS monitors are consistent with locations of predicted SO_2 maximums based on annual average and 24-hour average modeling. ATSDR performed 1-hour modeling for SO_2 maximums with results suggesting that 1-hour maximums occurred in locations not described by longer-term modeling (Figure A-1). The limited Mirant PRGS monitoring network and the lack of sub-hourly data

influenced ATSDR's recommendation for an exposure investigation to collect sub-hourly SO_2 data in areas not currently monitored.

Figure A-1. Air Dispersion Modeling Plumes and Monitor Locations.



* Based on emissions from Unit 1 at 1.2 lbs of SO_2 per million BTU heat input operating from 8am to 4pm at maximum load (88MW); from 4am to 8am at minimum load (35MW); and is off line for 8 hours per day. The tabulated results do not include background concentrations. Model results produced with the assistance of Denis Lohman, Meteorologist Air Quality Analysis Branch Air Protection Division, US EPA - Region 3. AERMOD was used with meteorological data from 2000 through 2004. Modeled results were kriged. GRASP digitized locations for monitors. USGS DOQQ Urban for imagery.

<project=02672><userid=bck2><geo=Alexandria, Virginia><keywords=air, monitor, power plant>

Monitoring vs. Modeling

ATSDR's initial evaluation of Mirant PRGS modeling and monitoring results during the Modeling Evaluation Study suggested that modeling predictions were not supported well by monitoring results. Although longer-term modeling has generally compared favorably with longer-term monitoring (within a factor of 2), 3-hour average modeling for maximum impacts and monitoring for December, for example, differed by a mean factor of 13 with a range 1-40 (Mirant. 2006). Follow-up modeling (using observed

meteorology) and observed emissions did not resolve the discrepancy. The reasons for the discrepancy between monitored and maximum concentrations from follow-up modeling are not apparent (DOE, 2006). These results indicate much uncertainty in the actual exposures occurring around Mirant PRGS.

ATSDR Conclusions about Current Air Dispersion Modeling

After Mirant PRGS reduced operations in 2005 and hence reduced emissions, the air dispersion modeling estimated contaminant levels which did not exceed the NAAQS. The NAAQS for SO_2 are 30 ppb annual average, 140 ppb 24-hour average, and 500 ppb 3-hour average (this standard is not a health-based standard, but is derived as a secondary standard for protection of vegetation and building construction). However, the absence of a short-term (subhourly) SO_2 standard requires that ATSDR evaluate short-term exposures to SO_2 in more detail. Adverse health effects can occur to sensitive individuals from exposure to SO_2 in a matter of minutes rather than hours or days. Acute exposures to peak (subhourly) levels of SO_2 are of concern to ATSDR as effects are known to occur to sensitive populations in as little as 5 minutes. Appendix E contains more detail of the toxicology of sulfur dioxide. While Mirant PRGS operations are currently planned so as not to exceed the NAAQS, the shortest term NAAQS is a 3-hour average of 500 ppb.

ATSDR concluded that a 3-hour average of 500 ppb SO_2 might not be sufficient to protect sensitive populations, depending on the level of exposure to SO_2, the frequency of exposure, and the duration of exposure. To explain, an average level of 500 ppb for 3 hours means that the level was likely higher for part of the time and lower for part of the time. EPA has conducted studies around power plants, though not Mirant PRGS, and found that short-term levels may be several times higher than longer-term levels. Although sometimes higher, usually the peak (short-term or 5 minutes) has been observed to be 2 or 3 times the mean (average). Therefore, for a 3-hour average, the peak concentrations could be 2 or 3 times the average. Theoretically, the peak could be 12 times the hourly average as there are 12 5-minute periods in 60 minutes. While the modeling data might suggest a hazard to vulnerable populations from short-term, acute SO_2 exposures, the uncertainty with the modeling data precludes any conclusion in that the modeling data may significantly overestimate exposures.

Therefore, in a letter to the Alexandria Health Department, ATSDR recommended that subhourly data be collected, especially in areas not currently monitored but predicted by 1-hour modeling to contain maximum SO_2 concentrations (Appendix B). While Mirant PRGS subhourly data were unavailable, this recommendation led to the conduction of an exposure investigation (EI) in which ATSDR collected subhourly data on SO_2 at 11 locations, 2 indoor and 9 outdoor locations (See Appendix C). The objective of the EI was not only to collect subhourly SO_2 data but to obtain information on the frequency, duration, and location of potential SO_2 exposures.

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Mirant. 2006. Mirant Monitoring Report. December.

Appendix B. ATSDR Letter to Alexandria Health Department.

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Agency for Toxic Substances
and Disease Registry
Atlanta GA 30333

JAN 4 2007

Charles Konigsberg, Jr., M.D., M.P.H.
Health Director
Alexandria Health Department
4480 King Street
Alexandria, Virginia 22302

Dear Dr. Konigsberg:

Last January, you requested that the Agency for Toxic Substances and Disease Registry (ATSDR) review existing air quality and other environmental data related to operations at the Mirant Potomac River Generating Station. You also asked ATSDR to assess whether existing data indicate a potential for health effects for nearby residents and to recommend the need for additional data. I am writing today to respond to these requests.

For the purpose of this report, ATSDR reviewed information provided by Mirant, the City of Alexandria, the Virginia Department of Environmental Quality (VDEQ), and the Environmental Protection Agency (EPA).

Our initial review of air dispersal modeling suggests a hazard to vulnerable populations from short-term, acute sulfur dioxide (SO_2) exposures based on ATSDR health-based guidance values. However, there is significant uncertainty with the modeling data and this interpretation. On-going monitoring for air pollutants may show that the air dispersal model has over-estimated SO_2 exposures. Because of the uncertainty in the air dispersal model and the need to collect additional monitoring data, we cannot determine at this time if a public health hazard exists. ATSDR's evaluation has identified the need for the following additional data:

- Monitoring data to evaluate modeling estimates of the concentration and location of contaminant levels of potential health concern. Mirant is currently conducting a Model Evaluation Study, which will include a modeling and monitoring comparison. This study was approved by EPA and reviewed by the VDEQ. The regulatory agencies are currently reviewing the initial monitoring results from this study. Monitoring data began to be collected under this study in June 2006. The Model Evaluation Study may require as much as a year of monitoring data. Therefore, EPA is not expected to reach a conclusion about the accuracy of the modeled concentrations before late 2007. At your request, ATSDR is also available to evaluate the study results after data collection is complete; and

- Data on the intensity, duration, and frequency of emissions at a subhourly level. ATSDR will discuss this further with Mirant in early 2007, but this information is not collected by the regulatory agencies and may not be available for this site; and

- Indoor/outdoor contaminant ratio data. The relationship between indoor and outdoor air contaminant concentrations will help us estimate actual exposures. At your request, ATSDR is available to pursue an exposure investigation to collect these sampling data in the community.

You may wish to provide health messages to your community. We recognize the difficulty of doing so with incomplete information. Still, some messages may be worthwhile. Messages designed to educate teachers, parents, and children about the importance of recognizing and treating asthma and the hazards of certain air pollutants seem reasonable. Feel free to contact my staff should you need any assistance in developing such messages.

Thank you for your patience during our initial evaluation. ATSDR looks forward to continuing to work with you and is available for additional consultation. Please contact Ms. Lora Werner, ATSDR Senior Regional Representative, at (215) 814-3141 if you have any questions concerning this response.

Sincerely yours,

William Cibulas

William Cibulas, Jr., Ph.D.
CAPT, U. S. Public Health Service
Director
Division of Health Assessment and Consultation

Enclosure

Attachment

ATSDR considers whether evidence of adverse health effects has been reported in animal or human studies when exposures to a pollutant of concern may have been near ambient levels estimated by air dispersion modeling. ATSDR uses an assessment approach to apply professional judgment to the strength of evidence from available sources. In general, ATSDR assigns greater weight to human studies such as controlled exposures than to epidemiological studies or experimental animal studies, although all evidence is considered at varying levels of uncertainty. Scientific uncertainty decreases as the preponderance of evidence increases. Although individual responses cannot be predicted at most exposure levels with any degree of certainty, ATSDR tries to describe the likelihood of effects occurring for a described exposure based on site-specific factors.

ATSDR evaluated scientific information about sulfur dioxide (SO_2) in terms of short- and long-term exposures. ATSDR considers the scientific literature strongest for short-term exposures, which are generally described as acute exposures to human subjects in a controlled environment such as a chamber or the use of a mouthpiece or facemask. Long-term exposures to human populations are described in epidemiological studies, which cannot prove cause and effect for a contaminant, but can provide associations between a contaminant and health effects that suggest potential causes. Although experimental animal studies provide the most control of both exposure and genetic homogeneity, their exposure, responses, and relevance to human exposures and responses may not be equivalent.

Short-term Exposures

The strongest scientific information was generated in controlled acute human exposures to levels of SO_2 that were similar to ambient air levels estimated by air dispersion modeling of air emissions from Mirant. A level of concern was generally exceeded for past operating scenarios and for short-term current operating scenarios. Acute exposures to short-term SO_2 levels estimated by air dispersion modeling of Mirant air emissions under current operating conditions may be of public health concern to exercising asthmatics and asthmatic children. Healthy, nonasthmatic individuals are generally

unaffected by acute exposures to concentrations of SO_2 that are below about 1 parts per million (ppm) (2600 micrograms per cubic meter [$\mu g/m^3$]) – 2 ppm (5200 $\mu g/m^3$). ATSDR concludes that considerable evidence exists that brief exposure (5-10 minutes) to SO_2 levels greater than 0.5 ppm (1300 $\mu g/m^3$) may cause adverse health effects or reduced quality of life in exercising asthmatics. Adverse health effects or reduced quality of life is defined as resulting in the disruption of ongoing activities, the need for medication, or the seeking of medical attention.

For brief exposures (5-10 minutes) between 0.1 ppm (260 $\mu g/m^3$) and 0.5 ppm (1300 $\mu g/m^3$), the evidence is less certain for a response that would result in disruption of ongoing activities, the need for medication, or the seeking of medical attention. In this range of exposure, subjects generally exhibited a response that may be considered adverse or may be considered adaptive when the response is equivalent to a response to other stimuli (such as cold air or dry air or exercise) or within the normal daily variation. One study measured a response in some asthmatic individuals to concentrations as low as 0.1 ppm (260 $\mu g/m^3$)(Sheppard D, Saisho A, Nadel JA, et al. 1981 Exercise increases sulfur dioxide-induced bronchoconstriction in asthmatic subjects. Am Rev Respir Dis 123:486-491). ATSDR's minimum risk level (MRL) for acute inhalation exposure to SO_2 (0.01 ppm) was based on this study. The extent to which the participants in the studies reflect the asthmatic population is not known, but the types of responses have been generally consistent.

Therefore, for exposure to levels between 0.1 ppm (260 $\mu g/m^3$) and 1 ppm (2600 $\mu g/m^3$) to have resulted in a response, the individuals have been asthmatic or atopic, moderately exercising, or breathing through both the mouth and nose. (Nasal only breathing has a scrubbing effect, reducing the SO_2 delivered to the lungs. Deep, rapid breathing simulates breathing during exercise and results in similar effects at similar levels.) The following table summarizes the above information.

Sulfur dioxide	General health effects
< 0.1 ppm (260 $\mu g/m^3$)	No response has been reported in asthmatics.
0.1 – 0.5 ppm (260-1300 $\mu g/m^3$)	Some asthmatic subjects experienced increased airway resistance, decreased expiratory volume.
0.5 – 1.0 ppm (1300-2600 $\mu g/m^3$)	Some asthmatic subjects required medication, had to stop exercising, or sought medical attention. Some experienced wheezing, chest tightness, cough, and/or dyspnea (shortness of breath).
> 1.0 ppm (2600 $\mu g/m^3$)	Some nonasthmatics start to develop symptoms such as increased airway resistance, sense of irritation, cough; also reported are increased pulse, increased inflammatory cells in lavage fluid, and decreased tidal volume.

Air dispersion modeling of Mirant SO_2 emissions showed historical maximum 3-hour and 24-hour averages (AERO Engineering, August, 2005) estimated to be in excess of levels reported to cause health effects in sensitive populations and in excess of levels reported to cause health effects in nonsensitive populations. Historical SO_2 air modeling estimates (ENSR Corporation, August, 2005) exceeded 2.6 ppm (7000 $\mu g/m^3$) for maximum 3-hour averages, and 24-hour maximum averages ranged from 1.2 ppm (3000 $\mu g/m^3$) to 1.9 ppm (5000 $\mu g/m^3$) in each of the years modeled (2000 – 2004). Other maximum modeling estimates of SO_2 were as high as 3.8 ppm (10,000 $\mu g/m^3$) for a 3-hour average (AERO Engineering, August, 2005).

Current ambient air maximums have been estimated to average 0.35 ppm (900 $\mu g/m^3$) – 0.39 ppm (1000 $\mu g/m^3$) for 3-hour average concentrations (ENSR Corporation, January 2006, Options A and B, Updates 5 and 6). Adverse health effects and reduced quality of life become more likely considering that the 3-hour estimate is an average value and adverse health effects and reduced quality of life have been demonstrated at lower levels during 5-10 minute durations. Some nonsensitive individuals may also be affected because peaks may be high enough to cause a response during brief exposures. An important data gap is the frequency and duration at which exposures of concern may occur. The nature of emissions becomes important in predicting ambient levels and potential health effects in relation to the average values.

Long-term Exposures

Potential health effects from chronic exposures are less clear, but evidence from epidemiology studies suggest an association between adverse health effects and SO_2 exposure, although cause and effect is uncertain. Developing information on the pathophysiology of asthma is providing insights into potential chronic health effects from repeated short-term inflammatory responses, such as may occur during short-term SO_2 exposure. Inflammation is often, but not always, a feature of mild or moderate persistent asthma. Chronic inflammation may help to explain some of the potential chronic health effects associated with air pollution in epidemiology studies.

In actual practice, exposure occurs to more than one contaminant, and the potential for adverse health effects from exposure should include potential effects from coexposures, such as SO_2 and particulate matter. In addition, exposures should be further characterized by how often peaks occur, the extent of the peak, and where the peak is located.

Exposure Investigation

Airborne Exposures to Sulfur Dioxide, Particulate Matter, and Selected Metals

Mirant Potomac River Generating Station (Mirant)
Alexandria, VA

Cost Recovery Number A08K

May 2007

Prepared by:

Debra Gable
Agency for Toxic Substances and Disease Registry
Division of Health Assessments and Consultations
Exposure Investigations and Site Assessment Branch

Introduction

Purpose of the Exposure Investigation

In order to better assess potential human exposure to airborne concentrations of sulfur dioxide (SO_2), particulate matter with aerodynamic particle size of 10 microns or less (PM_{10}), particulate matter with aerodynamic particle size of 2.5 microns or less ($PM_{2.5}$), and selected metals (antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium), the Agency for Toxic Substances and Disease Registry (ATSDR) will conduct an Exposure Investigation (EI). During this EI, an ambient and limited indoor air monitoring/sampling program will be conducted over a four to six week period to obtain representative concentration data of SO_2, PM_{10}, $PM_{2.5}$, metals, as well as meteorological parameters in residential and community areas near the Mirant Potomac River Generating Station (Mirant) located in Alexandria, VA.

This Exposure Investigation is designed to provide information that can be used in the evaluation of public health implications of possible community exposures to airborne contaminants in areas near the Mirant facility. As part of the public health evaluation, the information collected from this Exposure Investigation will be used to evaluate the need for additional air dispersion modeling and type of modeling needed and if additional air monitors are needed to more fully evaluate public health impacts in the investigation area. This investigation is not designed to determine adherence to any National Ambient Air Quality Standards (NAAQS).

Objectives of the Exposure Investigation

Sulfur Dioxide

The primary objective of the Exposure Investigation is to determine if community exposures to SO_2 are occurring in areas near the Mirant facility. Possible community exposures to sulfur dioxide have been suggested by 1-hour air dispersion modeling as potential areas for short-term health impacts. Adverse health effects (in controlled clinical studies with exercising asthmatic volunteers) from SO_2 exposures have been reported at concentrations as low as 260 $\mu g/m^3$ (ATSDR's MRL is 26 $\mu g/m^3$ based on the same study). For the Mirant facility, modeled 5-year maximum1-hour concentrations averaged from 300-900 $\mu g/m^3$ for one generator unit operating for 16 hours/day (8 hours at maximum output, 8 hours at minimum output). The Mirant facility has five generator units.

The data collected through this EI will allow ATSDR to determine whether people living near the Mirant facility are being exposed to SO_2 at concentrations that pose a public health hazard. Air monitors will be placed both indoors and outdoors at two to three locations to attempt to determine correlations of ambient SO_2 measurements and indoor (point of exposure) SO_2 concentrations. ATSDR will examine the data for public health implications by considering the concentrations of sulfur dioxide measured, the frequency, duration, and location of exposure as well as meteorological conditions and emissions information (if available).

Particulate Matter10, Particulate Matter2.5, and Metals

The secondary objective of the Exposure Investigation is obtain PM_{10}, $PM_{2.5}$, and metals data. Currently, only limited concentration data is available for metals and particulates in the investigation area. For public health evaluation purposes, ATSDR will monitor/sample for metals, PM_{10}, and $PM_{2.5}$ to determine the presence of these contaminants in the investigation area where limited or no monitoring/sampling information is currently available.

The data collected through this EI will allow ATSDR to determine whether PM_{10}, $PM_{2.5}$, and metals exposures may be occurring in populations near to the Mirant facility. ATSDR will examine the data for public health implications by considering the concentrations of PM_{10}, $PM_{2.5}$ and metals measured, the frequency, duration, and location of exposure as well as meteorological conditions and emissions information (if available).

Exposure Investigation Definition

An exposure investigation is defined as the collection and analysis of site- specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

An exposure investigation is an approach ATSDR uses to fill data gaps in evaluating community exposure pathways. Its purpose is to better characterize past, present, and possible future exposures to hazardous substances in the environment and evaluate possible health effects related to those exposures.

Exposure investigations must meet four criteria. They are

1. Can an exposed population be identified?
2. Does a data gap exist that affects your ability to determine if a health hazard exists?
3. Can an exposure investigation be designed that will address this data gap?
4. Will the EI results impact the public health decision for the site?

An exposure investigation is NOT a study. Rather, it is a biased attempt at identifying the individuals most highly exposed and sampling their exposure. Our results are a public health service directed to individual participants and are not generalizable to other populations.

Background

The Mirant Potomac River Generating Station is a 482-MW electricity generating facility located on the Potomac River in Alexandria, Virginia (see Figure 1). The plant consists of five generating units. It is three miles from the Ronald Reagan Washington National Airport and five miles from the U.S. capitol building. The plant uses oil to pre-heat each of its units and then burns coal, which it receives via rail car, to generate electricity. The plant site was relatively remote in 1949 when the plant began operating, but residential and commercial properties now surround the facility. In particular, a condominium building (Marina Towers) was built only 300 yards from the facility in the 1960s. Since 2001, nearby residents have complained about health concerns related to air quality problems that they have attributed to the facility (DOE, 2006).

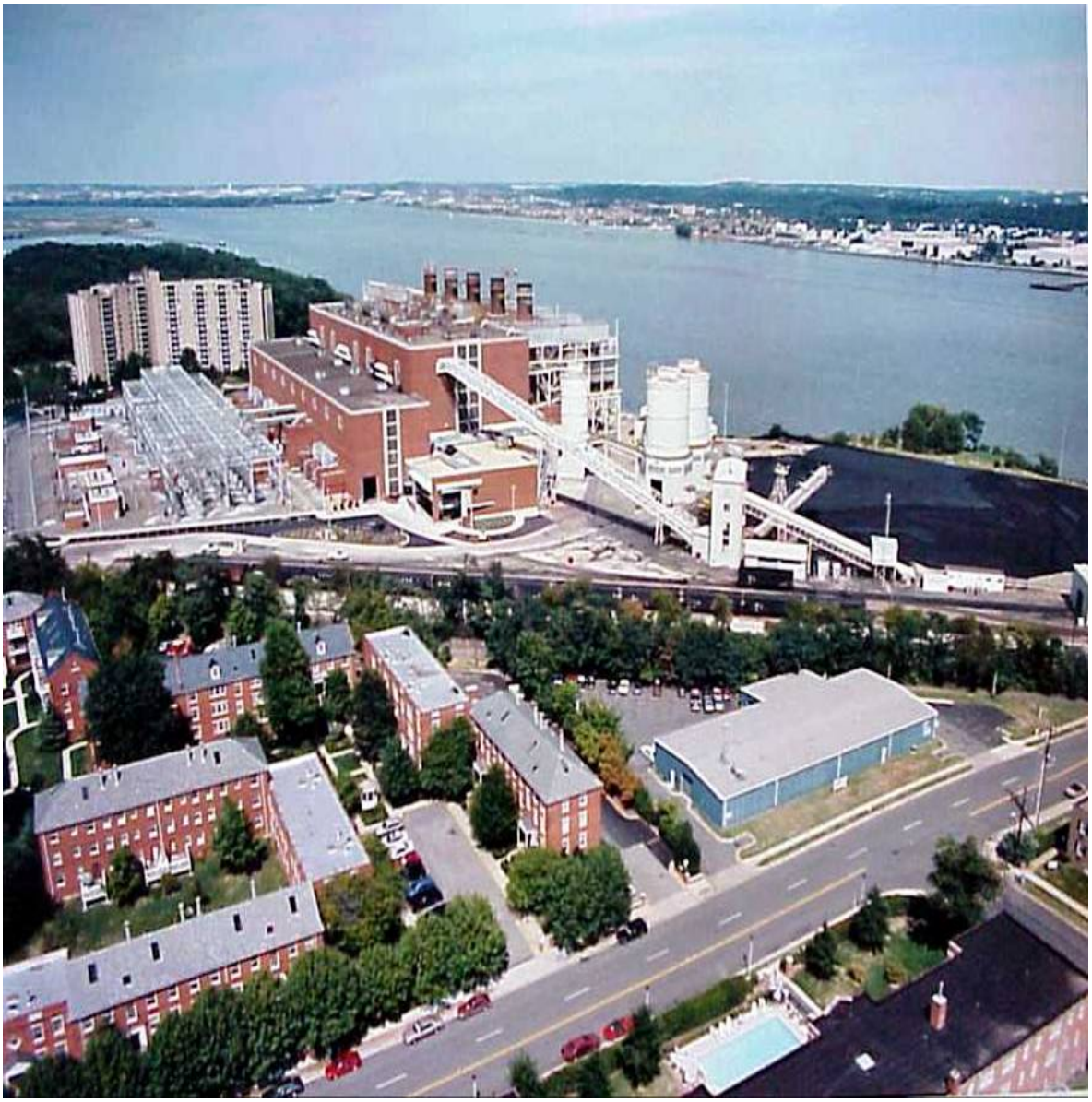
Since 2003, state and Federal environmental agencies have been working with Mirant to settle alleged violations of the plant's operating permit limit for NOx. These efforts resulted in an EPA judicial consent decree in September 2004; this decree was further amended in May 2006. The 2004 settlement required Mirant to perform modeling analysis to predict the effect of "downwash" from the plant on ambient concentrations of several NAAQS pollutants. The resulting study showed significant modeled exceedances of three NAAQS pollutants from downwash – SO_2, NO_2, and PM_{10}. Based on these findings and VA DEQ's subsequent August 19, 2005 letter to the facility, the plant voluntarily shutdown for approximately one month. The District of Columbia Public Service Commission subsequently filed an emergency petition with DOE arguing that the shutdown had a drastic and potentially immediate effect on the reliability of the electricity supply of the central DC area. On September 21, 2005, Mirant decided to restart the plant on a limited basis, and began experimental use of measures to control SO_2 (e.g., combustion of low-sulfur coal and injection of trona into flue gases). On December 20, 2005, DOE issued an emergency order to Mirant to operate the plant under certain conditions based on their finding that the plant was necessary to meet critical reliability (electrical energy) needs (DOE, 2006).

In January 2006, Dr. Charles Konigsberg, Health Director of the Alexandria Health Department requested that the ATSDR review existing air quality and other environmental data related to operations at Mirant. He also asked ATSDR to assess whether existing data indicated a potential for health effects for nearby residents and to recommend next steps (Konigsberg, 2006). This is a standard request from a Health Department to ATSDR. When ongoing exposures are suspected, ATSDR evaluates the available data to determine if a public health intervention is needed to minimize any acute exposures. On February 13, 2006, this request was evaluated and accepted by ATSDR's Triage Review committee. ATSDR began its review of the available modeling data and the health department's concerns in March 2006.

On June 1, 2006, EPA issued an Administrative Compliance Order to Mirant, directing the plant to operate the plant under the conditions specified under the DOE order during line outage situations but requiring the facility to take all reasonable steps to limit SO_2, PM_{10}, and NOx emissions. In non-line outage situations, the EPA order authorizes the plant to operate under "daily predictive modeling" after certain conditions are met. The order entailed the installation and operation of a network of ambient SO_2 monitors in the vicinity of the plant (DOE, 2006).

On January 4, 2007, ATSDR sent a response to Dr. Konigsberg with the results of ATSDR's initial review of the public health concerns regarding this facility. ATSDR's review of air dispersal modeling suggested a hazard to vulnerable populations from short-term, acute sulfur dioxide exposures based on ATSDR health-based guidance values. However, ATSDR found significant uncertainty with the modeling data and this interpretation (ATSDR, 2007). Until additional data is collected and reviewed, ATSDR is unable to determine if a public health hazard exists. To fill the data gaps identified, ASTDR proposed to conduct this exposure investigation.

Figure 1. Mirant Potomac River Generating Station.



Exposure Investigation Parameters

Investigators/Collaborators

Agency for Toxic Substances and Disease Registry

The EI Principal Investigator and Technical Monitor for field activities for this project will be Ms. Debra Gable. In the capacity of EI Principal Investigator, Ms. Gable will serve as the primary liaison between ATSDR and Eastern Research Group (ERG). Eastern Research Group, as ATSDR's mission support contractor, will assist ATSDR with the exposure investigation. Ms. Gable will be responsible for providing direction on the overall goals and approaches of the EI to ensure that the objectives of the monitoring project are met. She will develop, review, and/or provide comments on the EI Protocol, Monitoring Protocol and Health and Safety Plan, progress reports, and the Draft and Final EI Field Reports. Ms. Gable will be responsible for obtaining consent agreements from potential program participants identified. In the capacity of Technical Monitor, Ms. Gable will be responsible for overseeing overall coordination and logistics, approving project costs, approving changes to the Monitoring Program, and will serve as a technical advisor. Ms. Gable will also serve as a Field Scientist.

Dr. David Fowler and Ms. Lora Werner will serve as Co-Site Leads for the public health consultation. They will be responsible for development of the health consultation (health report) and coordination of consultation activities. Dr. Fowler and Ms. Werner will also be the primary contacts with other interested agencies (i.e., federal, state, and local).

Dr. Ketna Mistry will serve as the EI Medical Officer. Dr. Mistry will interface with medical staff in the City of Alexandria, will direct health education activities, and will assist with data interpretation and report generation.

Eastern Research Group, Inc.

The ERG Project Co-Directors for this EI will be Mr. Dave Dayton and Mr. Scott Sholar. They will report directly to the ATSDR EI Principal Investigator. In the capacity of Project Co-Directors, Mr. Dayton and Mr. Sholar will be responsible for the overall quality of the work conducted by ERG. They will oversee all activities associated with the monitoring project, from planning through reporting.

As well as managing the monitoring project, Mr. Dayton and Mr. Sholar will also serve as Field Scientists. In this capacity, they will secure equipment, perform the pre-deployment check out of the measurement and sample collection systems, deploy those systems, perform daily site visits, perform the sample collections, perform data downloading, and conduct the equipment recovery efforts.

Ms. Donna Tedder will serve as the ERG Analytical Task Leader. In this capacity she will oversee the analysis of project samples for total suspended particulates (TSP) mass and toxic metals at the ERG laboratory, and be a point of contact for the field staff.

Description of Target Populations

Demographics

Alexandria is a medium sized city of approximately 133,479 people in northeastern Virginia, across the Potomac River from Washington D.C. The median household income (in 2005 inflation adjusted dollars) is $66,116 [Appendix B]. (U.S. Census Bureau, 2000).

Age and Gender of the Target Population

In Alexandria there are 70,897 women (53.1%) and 62,582 men (46.9%). The median age is 36.2 years. Approximately 9.1% of the population is less than 5 years old and 10% of the population is older than 65 years (U.S. Census Bureau, 2000).

Race/ Ethnicity of the Target Population

The percentage of population in Alexandria is as follows: White (91,052), black or African American (26,784), American Indian and Alaska Native (374), Asian (7,584).

Special Populations

Pregnant women, children, the elderly, and people with chronic health conditions are considered as populations that may have increased susceptibility within the general target population. To address this concern, the EI will include areas where children range in age from 5 to 17 years and areas where residents live.

Exclusion Criteria

Biologic sampling will not be conducted.

Rationale for Environmental Sampling (Pollutants to be Measured)

"Air emissions from the stack gases from coal- and oil-fired boilers include four of the six criteria pollutants regulated through the National Ambient Air Quality Standards (NAAQS) under the Clean Air Act (CAA) as amended: NOx, CO, SO_2, and PM. Amounts of SO_2 emitted depend largely on the amount of sulfur present in the coal or oil and the method used to generate steam.

Other emissions regulated by the CAA commonly contained in emission gases are total organic carbon as methane, non-methane hydrocarbons, and VOCs. Traces of lead, another criteria pollutant, and other metals and minerals are also found. These metals are present in the coal and oil. Sulfur is also found in these fuels (more in coal than in oil), and fly ash is the product of sulfur and other minerals materials that do not combust." (EPA, 1997)

This EI will focus on the ambient air monitoring/sampling of sulfur dioxide, particulates, and select metals. In addition, sulfur dioxide monitors will be placed at a few indoor locations. These pollutants were selected for monitoring during this EI because these compounds present a high potential to be emitted from coal-fired power plants, and have measurable health endpoints or will be useful during the health implication evaluation. Table 1 lists pollutants that will be measured during the EI and associated comparison values, if available.

Indoor and ambient sulfur dioxide measurements will be collected at a few locations to better characterize SO_2 point of exposure by identifying the concentrations of contaminants in indoor air relative to outdoor air. Determining indoor concentrations are particularly crucial because individuals spend, on average, about 90% of their time indoors (70% in homes).

Rationale for Selection of the Investigation Time Period and Duration (Length of Time Sampling/Monitoring Will Occur)

Exposure investigations are not designed to be long-term environmental sampling programs. If a need for longer term sampling is identified as a result of an exposure investigation, ATSDR may recommend to the appropriate agency or authority that additional sampling data be collected and indicate the sampling duration needed. An EI is also not designed to characterize emissions from a facility or monitor facility emissions. The objectives of an EI, by design, are to fill data gaps relating to community exposures to environmental contaminants.

For the Mirant EI, the monitoring period for the EI was chosen to coincide with the expected worst case emissions from the Mirant facility. That is, Mirant is expected to operate at or near full operating capacity in May-June 2007 (due to maintenance work on the electrical power grid transmission lines, it is anticipated Mirant will need to provide extra electrical power to the Washington D.C. area that may normally be supplied or supplemented by other electrical power suppliers on the grid). Although the monitoring duration of the EI will be only 4-6 weeks, conducting community-based monitoring during worst case facility emissions is expected to provide information regarding worst case community exposures.

Table 1. Pollutants to be Measured During EI and Health Comparison Values.

Pollutant	Comparison Value	Source
Sulfur dioxide	10 ppb 0.03 ppm 0.14 ppm 0.5 ppm	ATSDR: Acute MRL EPA: NAAQS, Annual Primary EPA: NAAQS, 24 hr Primary EPA: NAAQS, 3 hr Secondary
PM 10	150 $\mu g/m^3$	EPA: NAAQS, 24 hr Primary
PM 2.5	35 $\mu g/m^3$ 15 $\mu g/m^3$	EPA: NAAQS, 24 hr Primary EPA: NAAQS, Annual Primary
Metals		
Antimony (trioxide)	0.2 $\mu g/m^3$	EPA: RfC
Arsenic	0.0002 $\mu g/m^3$ 0.19 $\mu g/m^3$ 0.03 $\mu g/m^3$	ATSDR: CREG CA: Acute REL CA: Chronic REL
Beryllium	0.0004 $\mu g/m^3$ 0.02 $\mu g/m^3$	ATSDR: CREG EPA: RfC
Cadmium	0.0006 $\mu g/m^3$ 0.02 $\mu g/m^3$	ATSDR: CREG CA: Chronic REL
Chromium, hexavalent	0.00008 $\mu g/m^3$ 1 $\mu g/m^3$ 0.1 $\mu g/m^3$	ATSDR: CREG ATSDR: Intermediate MRL EPA: RfC
Cobalt	0.1 $\mu g/m^3$	ATSDR: Chronic MRL
Lead	1.5 $\mu g/m^3$	EPA: NAAQS
Manganese	0.04 $\mu g/m^3$	ATSDR: Chronic MRL
Mercury	0.2 $\mu g/m^3$	ATSDR: Chronic MRL
Nickel	0.09 $\mu g/m^3$ 0.2 $\mu g/m^3$	ATSDR: Chronic MRL ATSDR: Intermediate MRL
Selenium	18 $\mu g/m^3$	EPA: Region III RBC (n)

CREG: cancer risk evaluation guide
MRL: minimal risk level
NAAQS: national ambient air quality standards
NA: none available
RBC (n): risk-based concentration – non-cancer
REL: reference exposure level for no adverse effects
RfC: reference concentration
ppb: parts per billion
$\mu g/m^3$: micrograms per cubic meter
Health-based screening values are periodically updated.

Criteria for Choosing the Target Area (Siting)

It is anticipated that the program will include a network of monitoring/sampling locations staged in a grid pattern. The network is expected to consist of as few as six, or as many as eleven, monitoring/sampling locations (sites). Figure 2 presents a map of areas near the Mirant plant laid out in 0.25 mile grid rings. The technical approach to siting will be to place two to four sites in the 0.00 - 0.25 mile grid ring, two to four sites in the 0.25 - 0.50 mile grid ring, and two to four sites in the 0.50 - 0.75 mile grid ring – to the Northwest, West, and South or Southwest of Mirant. The actual placement of monitoring/sampling equipment will depend on whether viable sites and willing participants can be identified. Sites are not currently planned due North of the facility since the closest suitable community site is farther than 0.75 miles from the facility. In addition, sites are not planned east of the facility since Mirant and the closest communities are bounded on the east by the Potomac River.

This grid pattern for monitoring/sampling siting was chosen to ensure suitable sites are identified; to attempt to determine if building downwash is occurring and if so, downwash characteristics; and to account for the various meteorological conditions that may occur during monitoring/sampling activities. The final number and location of sites will be dependent on actual site conditions at the time of equipment deployment. Some sites may only collect a subset of the target pollutants.

As part of the site selection process, ATSDR and ERG staff will conduct a pre-site survey. During the pre-site survey, ATSDR and ERG will visit the proposed EI area and meet with Mirant and the City of Alexandria representatives. The team will become familiar with the layout of the city at and near the Mirant plant to identify areas of both high and low exposure potential or impact. This information will be used to determine candidate monitoring site locations and prepare the overall design of the monitoring approach. To aid in the site selection process, 2005/2006 Annual and Springtime Average Wind Roses presenting data from the National Weather Service station located at Reagan National Airport have been prepared (see Figures 3 and 4). Reagan National Airport is located approximately 2 miles to the north of Mirant. These wind rose assessments are considered representative and will be used to establish the typical wind flow patterns for the expected investigation area, and the relationship to sites being considered (see Appendix C, Monitoring and Health and Safety Plan, Section 3.2).

ATSDR will identify candidate participants (i.e., private and/or public sector) located in the proposed study area who may agree to have monitoring equipment located on their properties during the EI monitoring program. ATSDR will inform potential participants of what is generally involved with program participation. After the recruiting efforts have been completed, ATSDR will select participants to host monitoring site locations. ATSDR will secure signed consent forms for each of the host sites.

Figure 2. Map of Proposed Monitoring Locations

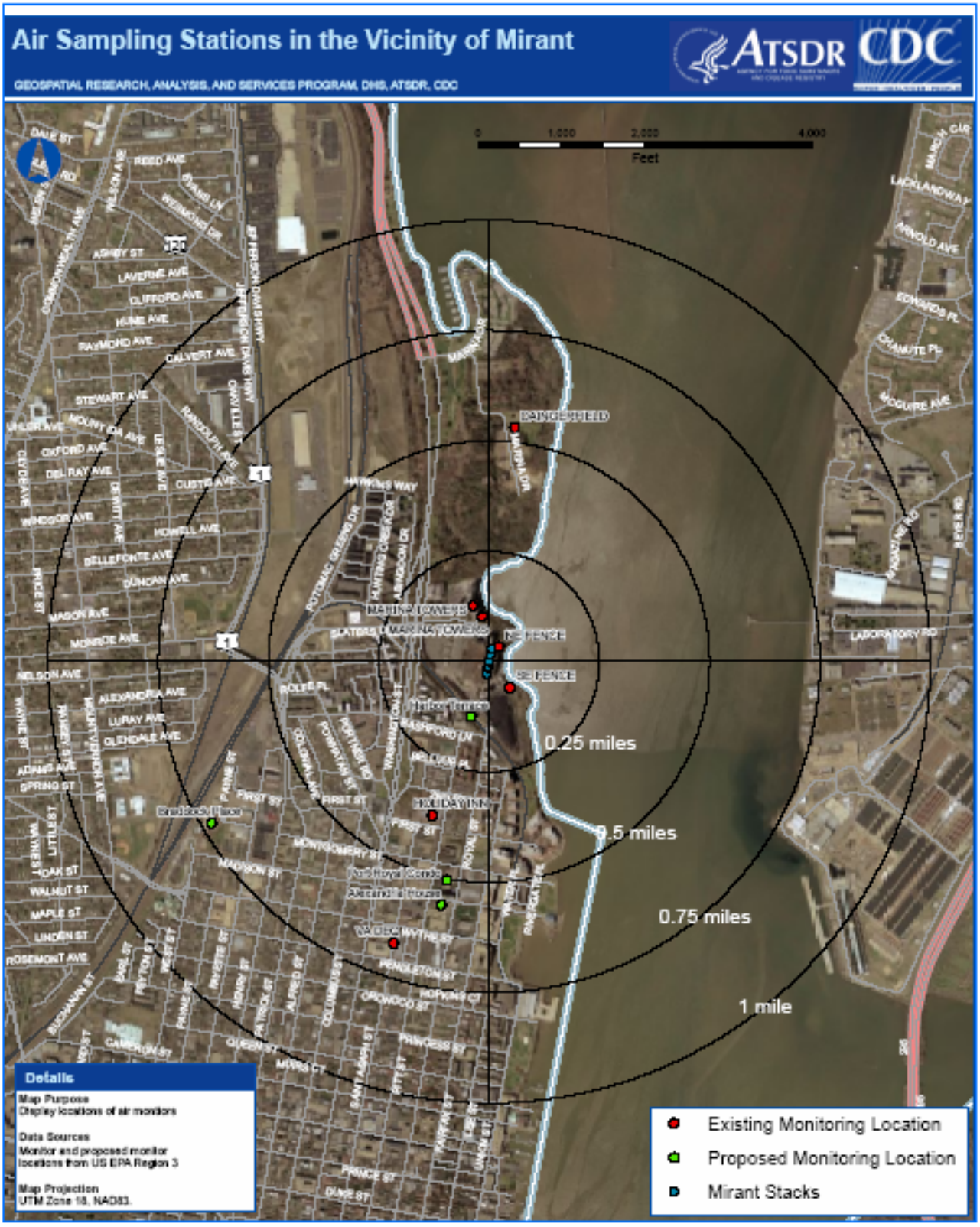


Figure 3. 2005/2006 Annual Wind Rose for Reagan National Airport

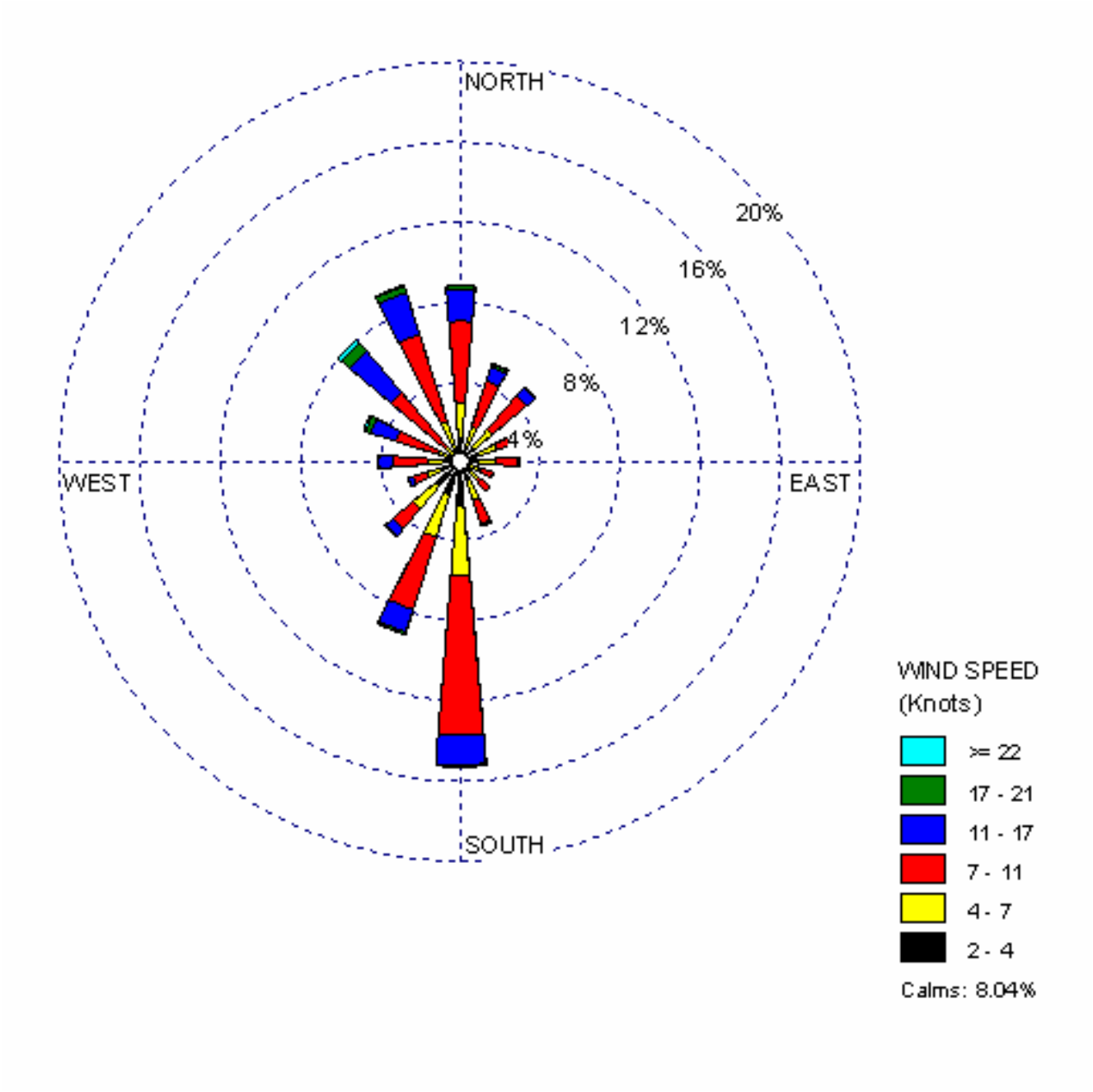
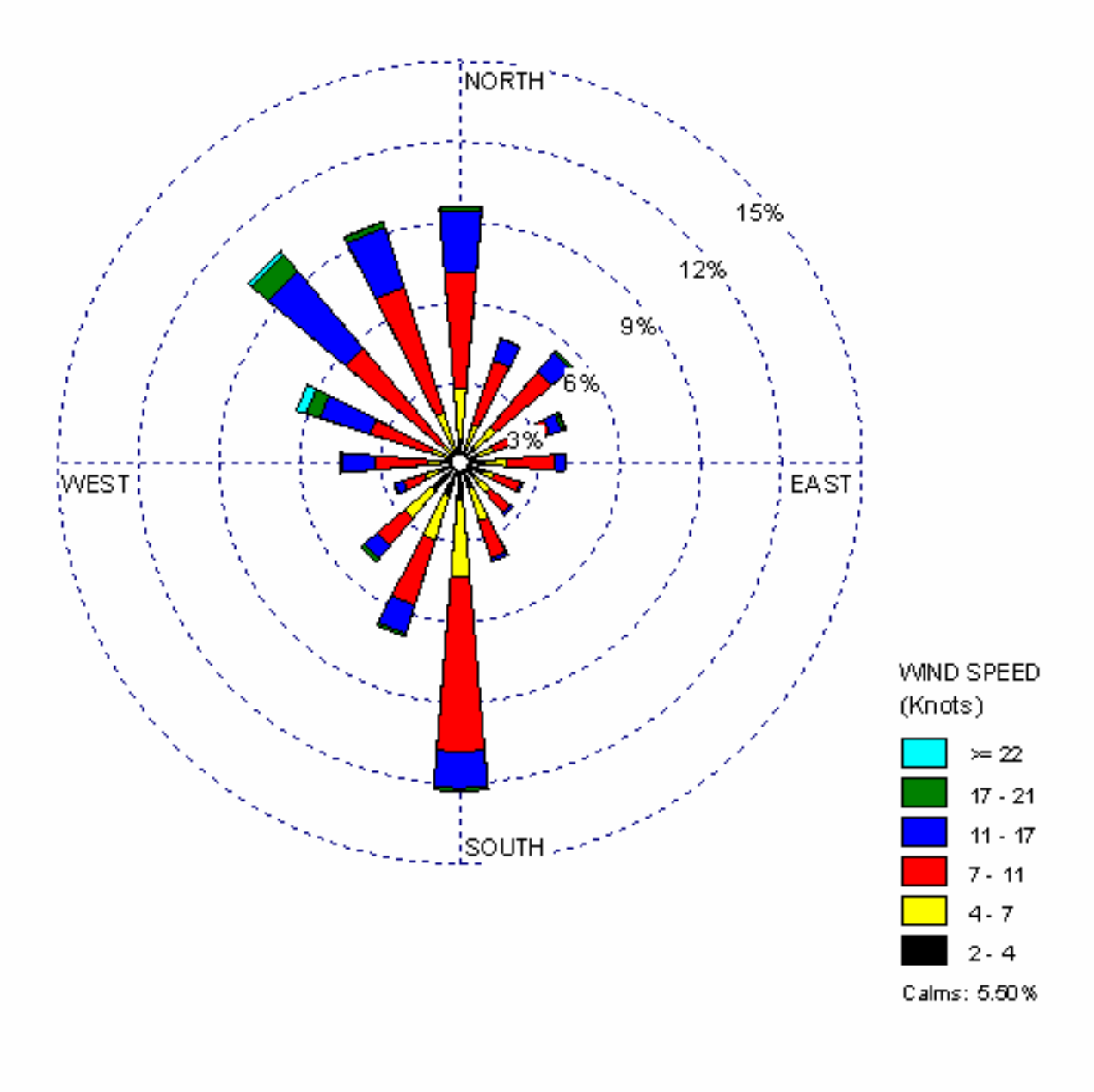


Figure 4. 2005/2006 Springtime Average (Mar-May) Wind Rose for Reagan National Airport



Confidentiality

The only personal identifiers collected during the EI will be adult names and property addresses for correlation with sampling results. Names will be used to ensure a point of contact for reporting results of testing. These personal identifiers will not be included in any data sets produced for the investigation and will not be used for any other purpose.

Risks/Benefits Information

There are minimal risks associated with this exposure investigation. The primary risks are that property owners/occupants could be slightly inconvenienced during set-up, checks, and demobilization of equipment. To reduce any inconvenience associated with the operation of the EI, field personnel will adhere to predetermined timeframes as agreed by participants to access property. The second risk is that electric power will be required to operate monitoring/sampling equipment. A single 110 power source will be needed for most monitoring/sampling locations. Field personnel will provide all supplies and equipment needed to access electrical power and will ensure all equipment are secured.

The potential benefits for this EI are that participants will learn whether they and/or their children are being exposed to the measured EI target compounds at levels of health concerns. The results of the EI are expected to provide ATSDR or other agencies information to evaluate public health concerns of community members in the areas of Alexandria in the vicinity of the Mirant facility. The results of this EI may also be used to inform decisions by the Mayor of Alexandria, school superintendents, the Virginia Department of Health and the affiliated Alexandria Health Department, the U.S. EPA, the City of Alexandria Transportation and Environmental Services, the Virginia Department of Environmental Quality, and other agencies.

Informed Consent Procedures

If participants indicate a willingness to allow air monitoring/sampling near or on their property, ATSDR personnel will explain what the exposure investigation will entail, and will obtain written, informed consent [Appendix A]. It will be stressed that participation in the EI is strictly voluntary, and if they choose to participate, participants may withdraw from the investigation at any time without penalty.

Methods

The methodologies to be followed in this EI are provided in the attached Monitoring and Health and Safety Plan [Appendix C]. Detailed information regarding the EI include monitoring/sampling methods, equipment siting, staging, data collection, monitoring, monitoring schedules, project schedule, data quality objectives, quality assurance and control, and the site health and safety plan. A summary of sample collection methods for sulfur dioxide, PM_{10}, $PM_{2.5}$, TSP, metals, and meteorological parameters are given below.

Sulfur Dioxide

Measurements of SO_2 will be made using Honeywell SPMs owned by ATSDR. Primary calibration of these instruments is performed at the factory. Two-point internal optical calibration performance checks will be conducted (i.e., initially before deployment, weekly onsite, and again after equipment recovery). Two range setting ChemKeys® will be used as necessary during the program, based on concentrations measured during pre-monitoring and program monitoring activities. The linear detection range for the low range ChemKey® is 5-200 parts per billion by volume (ppbV). However, the instruments will be calibrated from 0-200 ppbV. The linear detection range for the high range ChemKey® is 0.2-6.0 parts per million by volume (ppmV). Ambient air is drawn into the instrument through a length of Teflon tubing (i.e., 0.250 inch outside diameter), outfitted with an inverted glass funnel connected at the inlet end. Electronic signals from the SO_2 systems will be collected and stored using HOBO Micro Station® DASs with 4-20 mA adapters and BoxCar® Pro 4.3 software. Each DAS is capable of collecting four channels of amperage input simultaneously, and offers internal storage for 1 million data points per system.

As an element of the EI quality assurance and control (QA/QC) program, ATSDR and ERG staff will conduct a pre-monitoring SO_2 survey. The purpose of this survey will be to establish the level of SO_2 present in the anticipated EI monitoring area prior to the actual start of the monitoring program. The data obtained will be used to ensure that the instruments are properly configured (i.e., have the correct range key and collection tape material) for the SO_2 concentration level expected during the EI.

ATSDR and ERG will set up and operate ATSDR SO_2 single-point monitors (SPMs) at two sites in the investigation area. One site will be located within the 0.00 - 0.25 mile grid ring (see Figure 2), and the other site will be located within the 0.25 - 0.50 mile grid ring. The systems will measure SO_2 concentrations in the outside ambient air for 3-5 days. If possible, two additional systems will be set-up to simultaneously measure the concentration of SO_2 indoors at the same locations over the same duration.

Particulate Matter

Measurements of continuous PM_{10} and $PM_{2.5}$ particulate will be made using Met One Instruments EBAM real-time beta attenuation monitors. The EBAMs are portable self-contained units that meet or exceed all EPA requirements for automated particulate measurement. The measurement range for these units is 0-10 mg/m^3. These units will provide measurement data on an hourly basis. Data is stored automatically to a unit specific internal DAS. The monitors used to measure $PM_{2.5}$ will incorporate a PM_{10} pre-cutter inlet followed by a Sharp Cut $PM_{2.5}$ cyclone. The monitors used to measure PM_{10} will incorporate a PM_{10} pre-cutter inlet only.

Meteorological Parameters

Measurements of meteorological parameters will be made using two stand alone meteorological monitoring systems, attached to secured tripods or mast assemblies. Each system incorporates a cup anemometer to measure wind speed, a directional mast and vane to measure wind direction,

a wound bobbin assembly to measure relative humidity, and a thermistor temperature probe to measure ambient temperature. Measurements will be made at a height of approximately 10-12 feet above grade or roof top level (site dependent). Electronic signals from the meteorological monitoring systems will be collected and stored using HOBO Micro Station DASs and BoxCar® Pro 4.3 software. Each DAS is capable of collecting four channels of input signal simultaneously, and offers internal storage for 1 million data points per system.

Total Suspended Particulate

Samples for determining mass gain of TSP by gravimetric analysis will be made in accordance with EPA Method IO-2.1. Method IO-2.1 employs high volume samplers to volumetrically collect representative aliquots of suspended particulate matter with an aerodynamic particle size above 0.01µm. Five-point flow rate calibration curves will be compiled for each sampler at the ERG lab prior to deployment. Single-point flow rate checks will be made in the field, prior to and after each collection event. All TSP filters will present a unique filter identification number. Each filter will be equilibrated and weighed prior to transport to the field (i.e., pre-sampling), and then equilibrated and re-weighted when received at the ERG laboratory after each collection event (post-sampling). The mass gain is determined by subtracting the pre-sampling weight from the post-sampling weight.

Metals

Determination of the concentration of toxic metals will be performed on the TSP filter samples after gravimetric analysis has been completed. Analyses for toxics metals will be made in accordance with EPA Method IO-3.5, as described in the "*Technical Assistance Document for the National Ambient Air Toxics Trends and Assessment Program*". ERG is National Environmental Laboratory Accreditation (NELAC) Program accredited laboratory, and is NELAC certified to perform this analysis. Target metals for this EI, and their associated method detection limit (MDL), are presented in Table 2.

Table 2. Target Metals and Associated MDLs

Target Metal	MDL (ng/filter)
Antimony	20.0
Arsenic	17.9
Beryllium	40.0
Cadmium	16.9
Chromium	284
Cobalt	19.9
Lead	36.2
Manganese	31.2
Mercury	18.6
Nickel	176.0
Selenium	35.9

EPA Compendium Method IO-3.5 provides the procedures for the multi-element determination of trace elements by ICP/MS. Ambient air is pulled through filter media using a high volume sampler. Particulate phase sample is collected on the filter, and the filter is digested yielding the sample material in solution. Sample material in solution is introduced by pneumatic nebulization into a radio frequency plasma where energy transfer processes cause desolvation, atomization, and ionization. The ions are extracted from the plasma through a differentially pumped vacuum interface and separated on the basis of their mass-to-charge ratio by a quadrupole mass spectrometer having a minimum resolution capability of 1 amu peak width at 5% peak height. The ions transmitted through the quadrupole are registered by a continuous dynode electron multiplier, and the ion information is processed by a data handling system.

Data Quality Objectives

The project Data Quality Objectives (DQOs) provide the answer to the critical question of how good data must be in order to achieve the project goals. DQOs are used to develop the criteria that a data collection design should satisfy including where to conduct monitoring, when to conduct monitoring, measurement frequency, and acceptable measurement precision and

accuracy. Considering the targeted compounds, information obtained during the site selection survey, and specifications associated with the monitoring and sample collection systems that will be utilized, DQOs for this EI are presented in Table 3.

Table 3. Data Quality Objectives

Element	Objective
Where to Conduct Monitoring	All sites must be located in close proximity to the potentially impacted populous, in accordance with the grid ring approach presented in the Criteria for Choosing the Target Area section.
When to Conduct Monitoring	Daily – from 0000 to 2359 hours
Frequency of Monitoring	Continuous for SO_2, PM_{10}, $PM_{2.5}$, and meteorological parameters so that short duration excursions can be assessed, and hourly and daily average concentration can be calculated. TSP and metals samples will be collected on an every-other-day schedule.
Overall Completeness	80 % data capture
Acceptable Measurement Precision for SPMs	+/- 20 % relative standard deviation (RSD)
Acceptable Measurement Accuracy for SPMs	+/- 15 % RSD
Acceptable Measurement Precision for metals	+/- 20 % RSD
Acceptable Measurement Accuracy for metals	+/- 25 % RSD

Reporting of Results

Reporting Results to Participants

ATSDR will evaluate the results of this EI for health significance. Upon completion of the investigation ATSDR will send a copy of the EI report to each exposure investigation participant.

Final Report

At the conclusion of this investigation, ATSDR will prepare a written summary in the form of an exposure investigation along with an overall public health interpretation. If contaminants are found at levels of health concern, appropriate local, state, and/or federal environmental and health agencies will be notified**.** The report will be available to community residents, the City of Alexandria Mayor, the Alexandria Health Department, the City of Alexandria Transportation and Environmental Services, Mirant Potomac River, LLC, the VA Department of Health, the U.S. EPA, and other federal, state, and local environmental and public health agencies. Depending on the findings, recommendations for follow-up activities may include, but are not limited to, additional monitoring/sampling, modeling, educating community members on mitigating exposures, and/or further study.

Limitations of Exposure Investigation

This EI has two main limitations. The first is that the EI will only capture ambient and a few selected indoor air quality locations during a four-six week period. This time frame may not be long enough to fully evaluate characteristic exposures to community members/residents. However, by choosing four weeks in June-July as the monitoring period, the EI will collect data during what is expected to be the worst case scenario and will allow ATSDR to measure ambient air when the Mirant facility will be expected to operate at or near full generating capacity..

The second limitation of the EI is that only a few of the numerous potential contaminants will be measured. All efforts in this EI have been made to measure those contaminants considered most likely to be of health concerns based on information provided by community members, public health and environmental representatives, and currently available information from the Mirant facility.

References

U.S. Department of Energy (DOE). Special Environmental Analysis for Actions Taken Under U.S. Department of Energy Emergency Orders Regarding Operation of the Potomac River Generating Station in Alexandria, Virginia. November 2006. Available from: URL: http://www.oe.energy.gov/DocumentsandMedia/DOE_Special_Environmental_Analysis2.pdf

Alexandria Health Department. Letter, Dr. Charles Konigsberg, Health Director, to Assistant Administrator, ATSDR. January 24, 2006.

ATSDR. Letter, Dr. William Cibulas, Director, Division of health Assessment and Consultation, to Dr. Charles Konigsberg, Health Director, Alexandria health Department. January 4, 2007.

Bureau of the Census. Census 2000 Demographic Profile Highlights for Alexandria, VA. Washington: US Department of Commerce. Available from: URL: http://factfinder.census.gov/servlet/SAFFFacts?_event=ChangeGeoContext&geo_id=05000US51510&_geoContext=01000US%7C04000US17%7C16000US1708186&_street=&_county=Alexandria&_cityTown=Alexandria&_state=04000US51&_zip=&_lang=en&_sse=on&ActiveGeoDiv=geoSelect&_useEV=

U. S. Environmental Protection Agency (EPA). EPA Office of Compliance Sector Notebook Project. Profile of the Fossil Fuel Electric Power Generation Industry. September 1997.

Attachments

Appendix A: Consent Form

Appendix B: U.S. Census Bureau

Appendix C: Monitoring and Health and Safety Plan

Appendix A: Consent Form

Consent for Environmental Testing

Alexandria, Virginia

We are from the Agency for Toxic Substances and Disease Registry (ATSDR). We would like to invite you to be part of an Exposure Investigation to learn what levels of sulfur dioxide (SO_2) and particulate matter (PM) may be present in outdoor, and in some cases, indoor air in your community. We have asked you to help in this investigation because your home/school/property or business is located in areas in Bridgeport that may have high levels of the chemicals we want to measure. We want to test the outside, and in some cases, indoor air of several areas in your city for 4 weeks.

Procedure
We will place air measuring equipment, about the size of a briefcase, on your property. The air equipment will be on your property for 4 to 8 weeks. We will set-up the air monitoring equipment. It will take a few hours to set-up. Some of the equipment contains a small pump that draws in air for measuring. The pump sounds like a fish tank air pump. We will need to plug the equipment into one or two of your electric outlets.

Once a day, we will schedule a time to visit your home to check that the air monitors are working properly. These visits will be scheduled at a time that is good for you. These checks will take about 30 minutes. We will give you a phone number to call if the air monitors stop working properly or if you want us to take them away.

Benefits
Being part of this project will benefit you because you will find out if any of the chemicals we measure are in the outdoor, and in some cases, indoor air near your home or property. Also, by being part of this project you will also help your community find out if any of the chemicals we measure are in the outdoor, and in some cases, indoor air in your community.

Risks
You may be bothered by the air monitors on your property. You may also be bothered by our contractor checking the equipment. We will arrange a time with you for us to be on your property so that we bother you as little as possible. You may also have a small increase in your electric bill since we will need to use your power outlets.

Participation
You are free to choose whether or not to be part of this project. If you agree to help us, you may change your mind any time and drop out of the project. If you do this nothing will happen to you. You must sign this form to be part of the project.

Results
We expect to mail you the results of the air test within nine to twelve months of when we remove the air measuring equipment.

Confidentiality
We will protect your privacy as much as the law allows. The reports we write about this project will group all of the results together. We will not use your name or address in any of our reports. Still we are only including a small number of people in this project and it might be possible for someone to know that you were part of this. We will keep the forms with your personal information in a locked cabinet at ATSDR. We may share the results of the project with other federal, state, or local government agencies. They will also protect your information in the same way.

Contacts
If you have any more questions, you may contact Debra Gable or David Fowler at ATSDR toll-free at 1 (888) 422-8737.

Consent

This exposure investigation has been explained to me. My questions have been answered. I agree of my own free will to allow the air monitoring described in this paper.

I, (print) _____, agree to have air monitoring on my property.

Signature: _____ Date: _____

Address: _____
Street

_____
City State Zip Code

Phone #: _____

Witness: _____
(signature)

Appendix B: U.S. Census Bureau
Alexandria, VA

United States | Virginia | **Alexandria city**

Alexandria city, Virginia

street address search tips

city or town: Alexandria | state: Virginia | ZIP code: GO

clear « back

United States | Virginia | **Alexandria city**

Alexandria city, Virginia

city/ town, county, or zip: Alexandria

state: Virginia GO

search by address »

2005 2000

View a Fact Sheet for a **race, ethnic, or ancestry group**

Reference Map

Census 2000 Demographic Profile Highlights:

General Characteristics - show more >>	Number	Percent	U.S.		
Total population	128,283			map	brief
Male	61,974	48.3	49.1%	map	brief
Female	66,309	51.7	50.9%	map	brief
Median age (years)	34.4	(X)	35.3	map	brief
Under 5 years	7,962	6.2	6.8%	map	
18 years and over	106,746	83.2	74.3%		
65 years and over	11,605	9.0	12.4%	map	brief
One race	122,800	95.7	97.6%		
White	76,702	59.8	75.1%	map	brief
Black or African American	28,915	22.5	12.3%	map	brief
American Indian and Alaska Native	355	0.3	0.9%	map	brief
Asian	7,249	5.7	3.6%	map	brief
Native Hawaiian and Other Pacific Islander	112	0.1	0.1%	map	brief
Some other race	9,467	7.4	5.5%	map	
Two or more races	5,483	4.3	2.4%	map	brief
Hispanic or Latino (of any race)	18,882	14.7	12.5%	map	brief
Household population	126,382	98.5	97.2%	map	brief
Group quarters population	1,901	1.5	2.8%	map	
Average household size	2.04	(X)	2.59	map	brief
Average family size	2.87	(X)	3.14	map	
Total housing units	64,251			map	
Occupied housing units	61,889	96.3	91.0%		brief
Owner-occupied housing units	24,745	40.0	66.2%	map	
Renter-occupied housing units	37,144	60.0	33.8%	map	brief

Vacant housing units	2,362	3.7	9.0%	map	

Social Characteristics - show more >>	**Number**	**Percent**	**U.S.**		
Population 25 years and over	95,730				
High school graduate or higher	83,133	86.8	80.4%	map	brief
Bachelor's degree or higher	51,982	54.3	24.4%	map	
Civilian veterans (civilian population 18 years and over)	11,828	11.3	12.7%	map	brief
Disability status (population 5 years and over)	17,559	15.0	19.3%	map	brief
Foreign born	32,600	25.4	11.1%	map	brief
Male, Now married, except separated (population 15 years and over)	23,861	45.4	56.7%		brief
Female, Now married, except separated (population 15 years and over)	23,378	41.0	52.1%		brief
Speak a language other than English at home (population 5 years and over)	36,038	30.0	17.9%	map	brief

Economic Characteristics - show more >>	**Number**	**Percent**	**U.S.**		
In labor force (population 16 years and over)	80,949	74.4	63.9%		brief
Mean travel time to work in minutes (workers 16 years and over)	29.7	(X)	25.5	map	brief
Median household income in 1999 (dollars)	56,054	(X)	41,994	map	
Median family income in 1999 (dollars)	67,023	(X)	50,046	map	
Per capita income in 1999 (dollars)	37,645	(X)	21,587	map	
Families below poverty level	1,921	6.8	9.2%	map	brief
Individuals below poverty level	11,279	8.9	12.4%	map	

Housing Characteristics - show more >>	**Number**	**Percent**	**U.S.**		
Single-family owner-occupied homes	16,836				brief
Median value (dollars)	252,800	(X)	119,600	map	brief
Median of selected monthly owner costs	(X)	(X)			brief
With a mortgage (dollars)	1,772	(X)	1,088	map	
Not mortgaged (dollars)	433	(X)	295		

(X) Not applicable.
Source: U.S. Census Bureau, Summary File 1 (SF 1) and Summary File 3 (SF 3)

Appendix C: Monitoring Protocol Health and Safety Plan

Exposure Investigation

Monitoring and Health and Safety Plan

Mirant Potomac River Power Generation Plant
Alexandria, VA

Contract No. GS-10F-0036K
Order No. 200-2005-F-13562

Prepared by:

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May 2007

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Co-Project Directors
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DISTRIBUTION LIST

Copies of this plan and all revisions will be provided to the following individuals:

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LIST OF TABLES AND FIGURES

ACRONYMS

Acronym	Definition
ATSDR	Agency for Toxic Substances and Disease Registry
CMSA	Consolidated Metropolitan Statistical Area
DAS	Data Acquisition System
DOE	Department of Energy
DQOs	Data Quality Objectives
EBAM	Beta Attenuation Monitor
EI	Exposure Investigation
ERG	Eastern Research Group, Inc.
F	Fahrenheit
FAA	Federal Aviation Administration
GPS	Global Positioning System
HASP	Health and Safety Plan
HAZWOPER	Hazard Waste Operations
MDL	Method Detection Limit
mg/m^3	Milligrams per cubic meter
NAAQS	National Ambient Air Quality Standards
NELAC	National Environmental Laboratory Accreditation
NO_x	Oxides of Nitrogen
OSHA	Occupational Health and Safety Administration
ppbV	Parts per billion by volume
PPE	Personal Protective Equipment
PM^{10}	Particulate Matter ≤ 2.5 micron
$PM^{2.5}$	Particulate Matter ≤ 10.0 micron
ppmV	Parts per million by volume

ACRONYMS (Continued)

Acronym	Definition
QA	Quality Assurance
QC	Quality Control
RSD	Relative Standard Deviation
SO_2	Sulfur Dioxide
SOP	Standard Operating Procedures
SPM	Single Point Monitor
U.S. EPA	United States Environmental Protection Agency

A – EXPOSURE INVESTIGATION OVERVIEW

SECTION 1
PROBLEM DESCRIPTION

1.1 Background

The Mirant Potomac River Power Generation (Mirant) plant is located on 26 acres within the city limits of Alexandria, Virginia. Mirant operates five coal-fired boilers and electric generators. Each has its own emissions stack. The plant is located on the flight path for Reagan National Airport. Accordingly, the emissions stacks are very short, as required by the Federal Aviation Administration (FFA), compared to the stack height that would typically be required as an operating permit specification for a facility of this type. The facility, completed in 1955, operated continuously until it was voluntarily shut down on August 24, 2005. This voluntary shutdown was based on down wash dispersion modeling data that indicated that there was a great potential for exceeding the National Ambient Air Quality Standards (NAAQS) for oxides of nitrogen (NO_X), sulfur dioxide (SO_2), and fine particulate matter. However, on September 21, 2005, at the request of the Department of Energy (DOE) under the War Powers Act, Mirant re-opened and began operating on a limited basis to provide electricity as needed to feed the New Jersey-Pennsylvania power grid.

Alexandria is a medium-sized city located in northern Virginia along the Potomac River. It is part of the Washington, D.C., consolidated metropolitan statistical area (CMSA). According to the 2004 United States census, approximately 137,000 people live within the greater Alexandria area, which encompasses approximately 15 square miles.

1.2 Problem Definition

The Alexandria Department of Health requested that the Agency for Toxic Substances and Disease Registry (ATSDR) review emerging information about Mirant plant emissions and possible negative health impacts to people living and working in the community. ATSDR reviewed available modeling data and emissions data, and performed its own dispersion modeling. Based on an initial review of modeling data, ATSDR has determined the need to

conduct an exposure investigation (EI) in Alexandria to further assess air quality. Contaminants of potential concern include SO_2, particulate matter (total suspended, inhalable, and respirable), and toxic metals.

1.3 Project Objectives

The objectives of the ATSDR EI to be conducted in Alexandria, Virginia, are as follows:

- To obtain sufficient information to calibrate the different air models run to date.
- To obtain data to determine the indoor-to-outdoor ratios of contaminants of interest (where possible).
- To determine whether the highest human impact areas are being adequately captured by existing monitoring networks (e.g., those installed by the city of Alexandria and Mirant).

To meet these objectives, an air monitoring program will be conducted to obtain representative ambient and selected indoor air measurements data for:

- SO_2 concentrations
- Toxic metals concentrations
- Total suspended particulate (TSP) mass
- Particulate matter ≤10 micron (PM^{10}) mass
- Particulate matter ≤2.5 micron ($PM^{2.5}$) mass
- Meteorological parameters

This exposure investigation will be conducted by ATSDR. The monitoring program of the exposure investigation will be operated primarily by Eastern Research Group, Inc. (ERG) under the guidance of ATSDR.

The components that will be measured during the EI were selected because they present a high potential to be emitted from the Mirant Plant.

SECTION 2
PROJECT ORGANIZATION

2.1 Agency for Toxic Substances and Disease Registry

The EI Manager and Technical Monitor for this project will be Ms. Debra Gable. In the capacity of EI Manager, Ms. Gable will serve as the primary interface between ATSDR and ERG. She will be responsible for providing direction on the overall goals and approaches of the EI to ensure that the objectives of the monitoring project are met. Ms. Gable will review and provide comments on the Exposure Investigation Monitoring and Health and Safety Plan, progress reports, and the Draft and Final EI Monitoring Reports. She will also be the primary contact with other interested agencies (i.e., federal, state, and local) and be responsible for obtaining consent agreements from potential program participants identified. In the capacity of Technical Monitor, Ms. Gable will be responsible for overseeing overall coordination and logistics of the program, and serve as a technical advisor. Ms. Gable will also serve as a Field Scientist.

2.2 Eastern Research Group, Inc.

The Project Co-directors for this EI will be Mr. Dave Dayton and Mr. Scott Sholar. They will report directly to the ATSDR EI Manager. In the capacity of Project Co-Directors, Mr. Dayton and Mr. Sholar will be responsible for the overall quality of the work conducted by ERG. They will oversee all activities associated with the monitoring project, from planning through reporting.

As well as managing the monitoring project, Mr. Dayton and Mr. Sholar will also serve as Field Scientists. In this capacity, they will secure equipment, perform the pre-deployment check out of the measurement and sample collection systems, deploy those systems, perform daily site visits, perform the sample collections, perform data downloading, and conduct the equipment recovery efforts.

Ms. Donna Tedder will serve as the Analytical Task Leader. In this capacity she will oversee the analysis of project samples for TSP mass and toxic metals at the ERG laboratory,

and be a point of contact for the field staff.

SECTION 3
PROJECT DESCRIPTION

3.1 Siting

Siting will be the joint responsibility of ATSDR and ERG. It is anticipated that the program will include a network of monitoring/sampling locations staged in a grid pattern. The network is expected to consist of as few as six, or as many as eleven, monitoring/sampling locations (sites). Figure 2 presents a map of areas near the Mirant plant laid out in 0.25 mile grid rings. The technical approach to siting will be to place two to four sites in the 0.00 - 0.25 mile grid ring, two to four sites in the 0.25 - 0.50 mile grid ring, and two to four sites in the 0.50 - 0.75 mile grid ring – to the Northwest, West, and South or Southwest of Mirant. The actual placement of monitoring/sampling equipment will depend on whether viable sites and willing participants can be identified. Sites are not currently planned due North of the facility since the closest suitable community site is farther than 0.75 miles from the facility. In addition, sites are not planned east of the facility since Mirant and the closest communities are bounded on the east by the Potomac River.

This grid pattern for monitoring/sampling siting was chosen to ensure suitable sites are identified; to attempt to determine if building downwash is occurring and if so, downwash characteristics; and to account for the various meteorological conditions that may occur during monitoring/sampling activities. The final number and location of sites will be dependent on actual site conditions at the time of equipment deployment. Some sites may only collect a subset of the target pollutants. See additional siting strategies described in Section 3.2.

ATSDR will identify candidate participants (i.e., private and/or public sector) located in the proposed investigation area who may agree to have monitoring equipment located on their properties during the EI monitoring program. ATSDR will inform potential participants of what is generally involved with program participation. After the recruiting efforts have been completed, ATSDR and ERG will select participants to host monitoring site locations. ATSDR will secure signed consent forms for each of the host sites. ATSDR will not release any vital information pertaining to the participants, except to government agencies, and then only with

prior consent from each participant. After the sites have been selected, and participation consent has been obtained, ERG will contact the participants directly to schedule site events (i.e., deployment, operation, and recovery).

ERG will locate a mobile laboratory at one of the selected sites to serve as a field base of operations and central support for the program. The ERG mobile laboratory is spacious and has appropriate power circuitry to accommodate monitoring requirements. The ERG mobile laboratory will house SO_2 measurement systems and one of the systems used to collect meteorological parameters data. The laboratory will also provide a place to store ancillary equipment and supplies, and facilitate equipment repair if required.

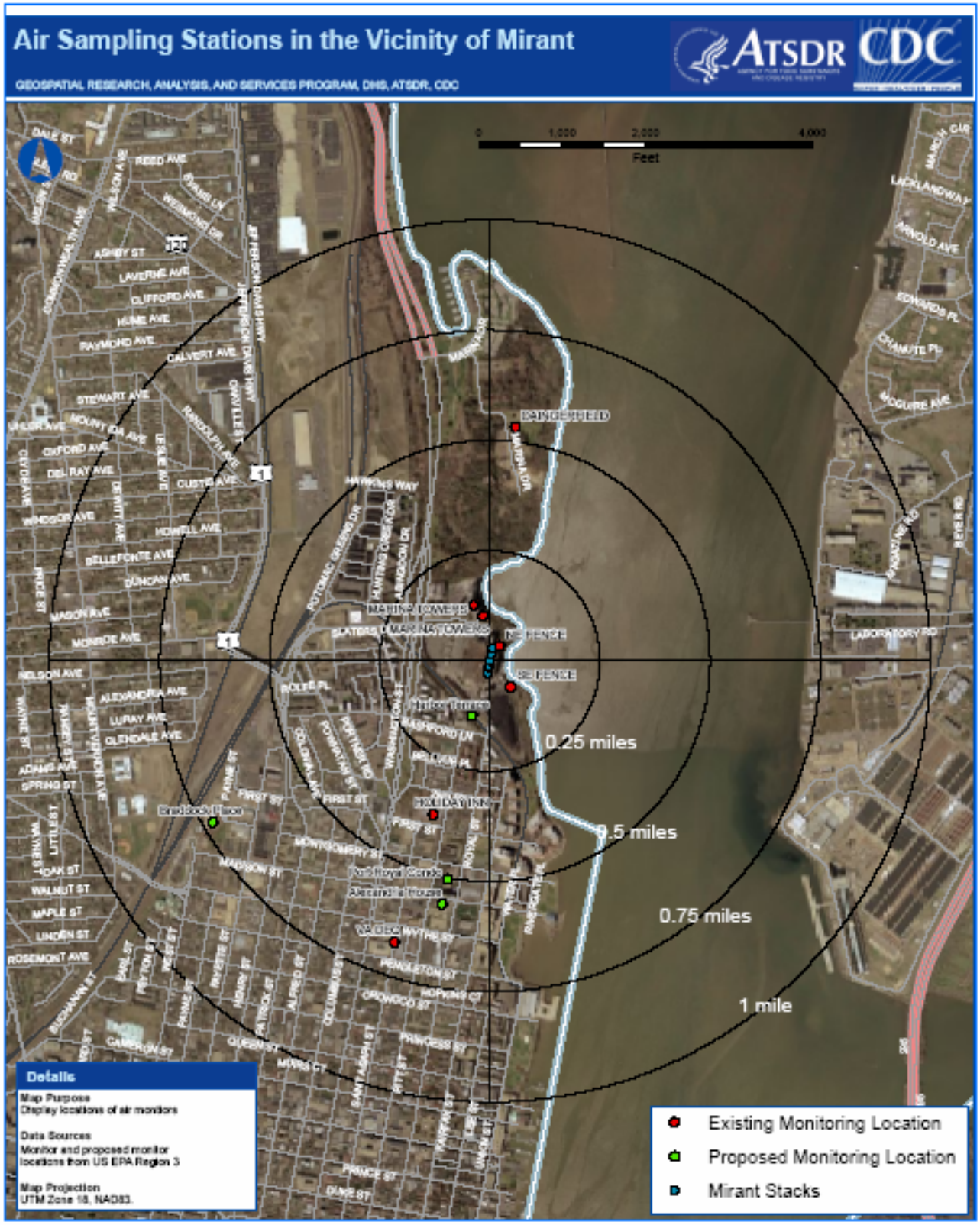

Figure 1. Grid ring map of Alexandria in 0.25 mile increments.

It must be noted that ERG will not assume any liability for damages or injuries resulting from locating/operating the ambient air monitoring equipment that will be used during the monitoring program. Should liabilities be encountered they will be project/contract borne.

3.2 Pre-Site Survey

As part of the site selection process, ATSDR and ERG staff will conduct a pre-site survey. During the pre-site survey, ATSDR and ERG will visit the proposed EI area and meet with Mirant and the City of Alexandria representatives. The team will become familiar with the layout of the city at and near the Mirant plant to identify areas of both high and low exposure potential or impact. This information will be used to determine candidate monitoring site locations and prepare the overall design of the monitoring approach. To aid in the site selection process, 2005/2006 Annual and Springtime Average Wind Roses presenting data from the National Weather Service station located at Reagan National Airport have been prepared. Reagan National Airport is located approximately 2 miles to the north of Mirant. These wind rose assessments are considered representative and will be used to establish the typical wind flow patterns for the expected investigation area, and the relationship to sites being considered. The 2005/2006 Annual Average Wind Rose (i.e., March - May) is presented in Figure 2. The 2005/2006 Springtime Average Wind Rose (i.e., March - May) is presented in Figure 3.

After the pre-site survey is completed, ATSDR and ERG will visit each of the selected monitoring site locations. Site locations will be documented by longitude and latitude using a hand-held global positioning system (GPS). ATSDR and ERG will determine all site specific needs associated with installing and operating the monitoring systems (i.e., access, ability to utilize sampling probes, adequate power, internal/external physical constraints, compatibility with the specifications of the equipment to be deployed, special materials needed) prior to deployment, or identify problems that may preclude use of a selected site. If, needed, ERG will also arrange for the power drop to be installed to supply the ERG mobile laboratory.

3.3 Pre-Monitoring Survey

As an element of the EI quality assurance and control (QA/QC) program, ATSDR and ERG staff will conduct a pre-monitoring SO_2 survey. The purpose of this survey will be to

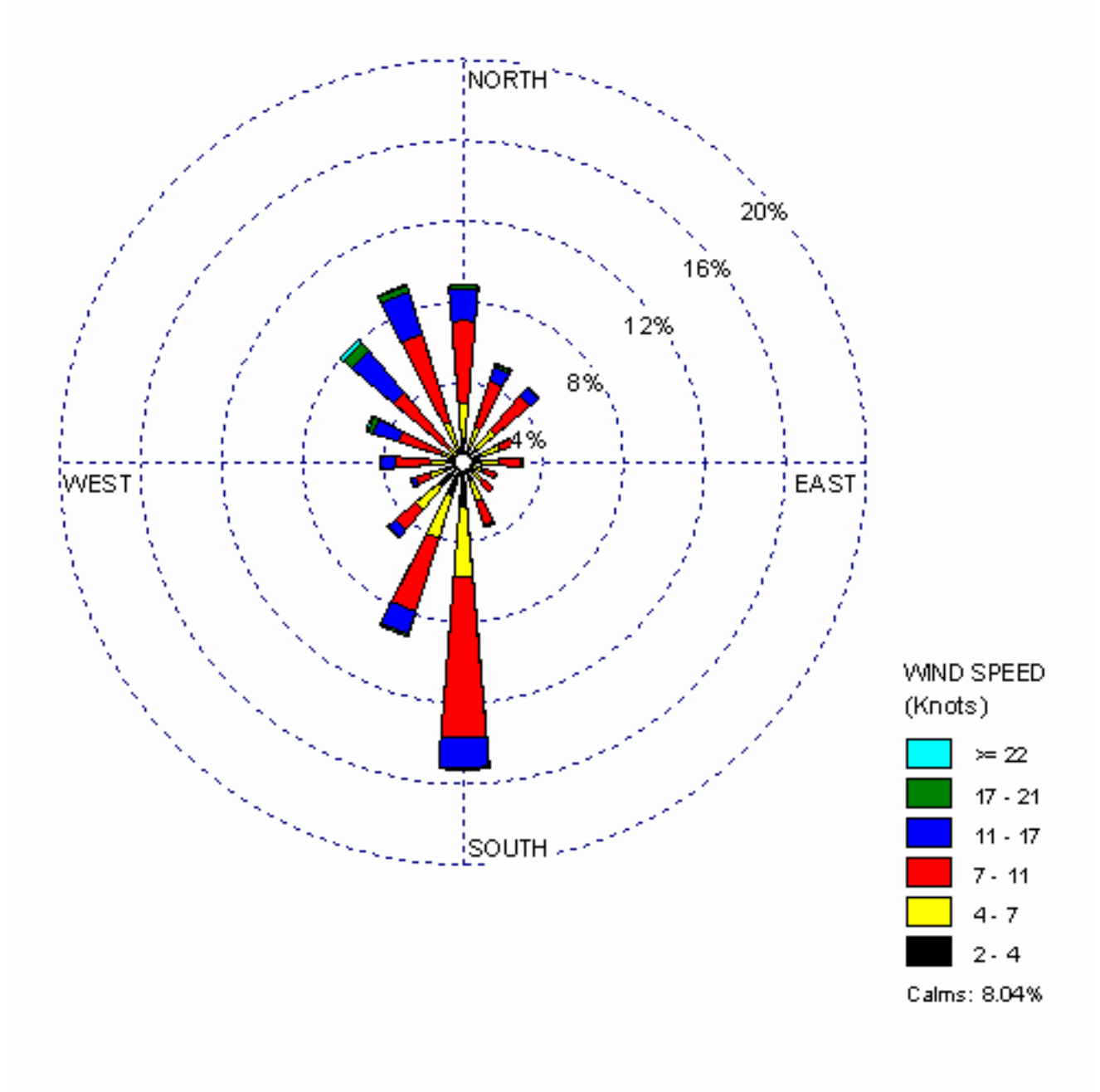

Figure 2. 2005/2006 Annual Wind Rose for Reagan National Airport

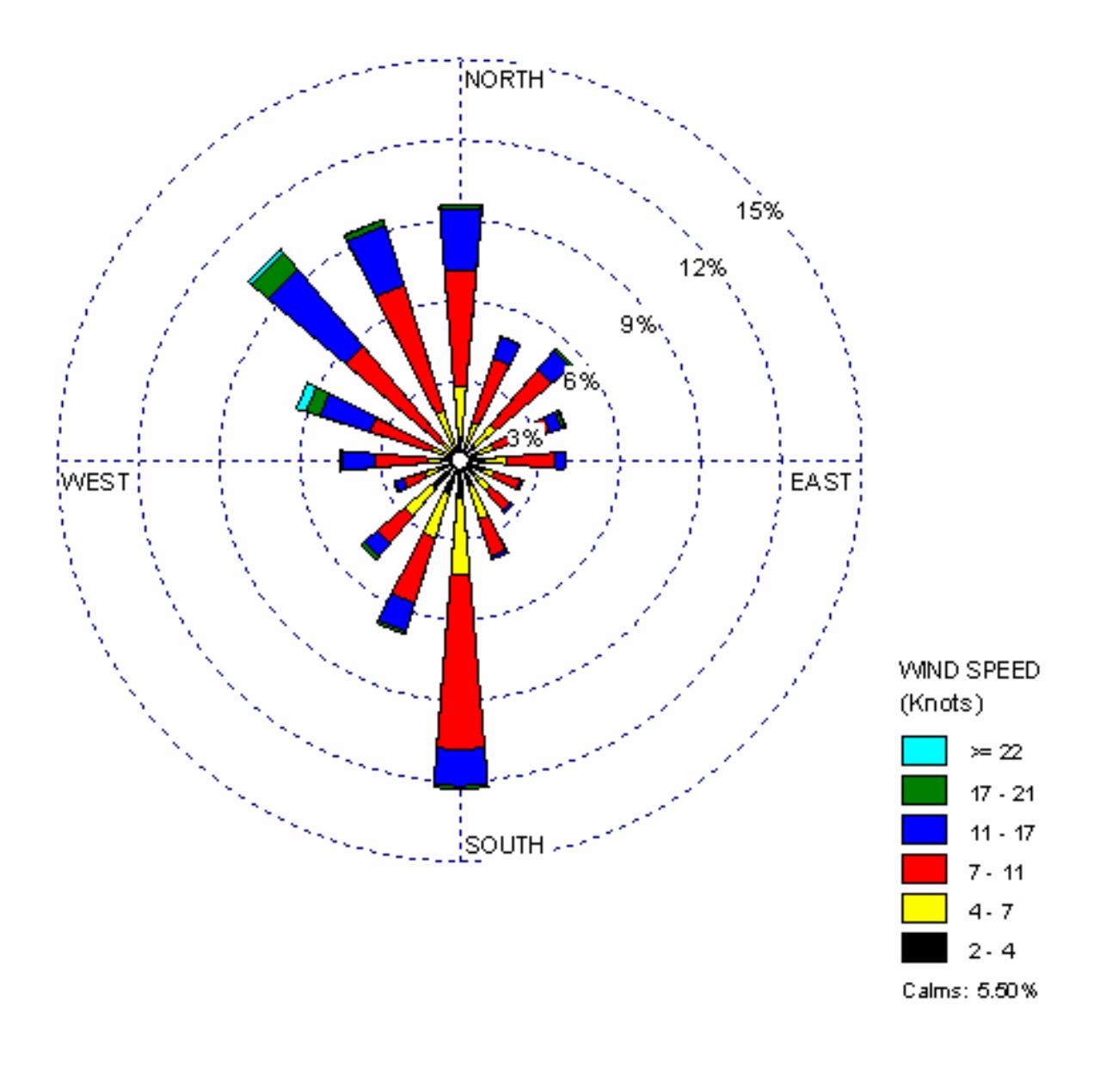

Figure 3. 2005/2006 Springtime Average (Mar-May)
Wind Rose for Reagan National Airport

establish the level of SO_2 present in the anticipated EI monitoring area prior to the actual start of the four-six week monitoring program. The data obtained will be used to ensure that the instruments are properly configured (i.e., have the correct range key and collection tape material) for the SO_2 concentration level expected during the EI.

ATSDR and ERG will set up and operate ATSDR SO_2 single-point monitors (SPMs) at two sites in the investigation area during the pre-monitoring SO_2 survey. One site will be located within the 0.00 - 0.25 mile grid ring (see Figure 1), and the other site will be located within the 0.25 - 0.50 mile grid ring. The systems will measure SO_2 concentrations in the outside ambient air for 3-5 days. If possible, two additional systems will be set-up to simultaneously measure the concentration of SO_2 indoors at the same locations over the same duration.

3.4 Staging

Continuous measurement systems for this project will be provided by ATSDR. These systems for the four-six week monitoring program will include 13 SPMs for SO_2, three beta attenuation monitors (EBAM) for respirable particulate matter ≤2.5 micron ($PM^{2.5}$), one EBAM for particulate matter ≤10.0 micron (PM^{10}), two meteorological monitoring systems, and 10 data acquisition systems (DAS). All of the systems/equipment supplied by ATSDR are resident at, or will be shipped to, ERG's laboratory facility in Research Triangle Park, North Carolina. The systems/equipment will be set up and rigorously checked to insure that all equipment is functioning correctly prior to field deployment. For the SPMs ERG will perform pre-deployment calibration and mid-point QC checks to qualify precision and accuracy before the systems are deployed. Each site specific DAS will be set up, configured, and tested.

ERG will provide all equipment required to collect time-integrated 24-hour Total Suspended Particulate (TSP) samples for gravimetric determination of mass and analysis for metals. All of the high volume collection systems used to collect TSP samples will be calibrated prior to deployment.

ERG will obtain all required ancillary equipment/hardware/parts that will be utilized for this EI. ERG will obtain all required compressed gas standards as required. ERG will design and

fabricate any specialty hardware needed to support effective deployment and/or operation of the systems in the field. When all design, fabrication, and checkout activities are completed, ERG will pack the equipment for transport to the investigation area.

3.5 Deployment

ERG will transport the equipment and the ERG mobile laboratory to the investigation area and site locations. ERG will place the mobile laboratory at the appointed location and facilitate connection to electrical power. ERG will set up each of the chemical and mass measurement systems, mass/metals sample collection systems, and meteorological measurement systems in accordance with the site specific approaches developed during the pre-site survey. Once the equipment is set up ERG will test each system to ensure that no damage occurred during transport. When the continuous chemical and mass measurement systems are determined to be operating correctly, they will be brought on-line. ERG will test the meteorological monitoring system and perform a QC check of the wind speed sensor (using a constant speed motor), and the temperature sensor (using a traceable temperature measurement device) in the laboratory prior to transport to the field. ERG will position each wind direction sensor in the field using a digital compass. When the meteorological monitoring systems are considered to be operating correctly, they will be brought on-line. ATSDR will approve the field set-ups.

3.6 Monitoring

From the point that the continuous measurements and sample collection systems are brought on-line, monitoring will be conducted continuously for duration of not less than 4-weeks, but not more than 6-weeks. The actual final duration will be determined on-going based on the weekly measurement data obtained.

ATSDR and ERG will have at least one staff member (Field Scientist) resident in the investigation area throughout the monitoring program. The Field Scientist will visit the sites daily to assess the functional status of the chemical, mass, and meteorological measurement equipment and correct any problems identified. For the SO_2 monitors, the Field Scientist will check the status of the chemcassetes daily and reload them as required. The Field Scientist will

perform 2-point internal optical calibration checks and download data from the DASs weekly. For the continuous particulate monitors, the Field Scientist will check the status of the filter tapes daily and reload them as required, and download data from the DASs weekly. ERG will perform a weekly sample flow rate check on the SPMs using a primary flow measurement standard (i.e., Buck Calibrator); this will occur at the time of data download. For the meteorological monitoring systems, The Field Scientist will perform a visual check of the meteorological sensors daily, and download data from the DASs weekly. For the TSP high volume samplers, the Field Scientist will check the motor brushes weekly, and replace them as necessary. TSP samples will be collected on an every-other-day schedule at four sites across the duration of the investigation.

There presently is one redundant or backup SO_2 SPM planned for this investigation. In the event that there is a failure of one of the primary SO_2 SPMs, the back up SPM will be substituted. The failed system will be repaired as quickly as possible and then returned to the network as needed. There presently are no redundant or backup meteorological parameters monitoring sensors for this investigation. If there is a failure of one of the meteorological parameters monitoring sensors, it will be repaired as quickly as possible and returned to the network. There presently is one redundant or backup TSP high volume sampler planned for this investigation. If there is a failure of one of the primary systems used to collect TSP/metals samples, the back up unit will be substituted. The failed sampler will be repaired as quickly as possible and returned to the network as needed. Any sample collection that is missed will be re-scheduled and completed.

3.7 Recovery

When the monitoring effort has been completed, ATSDR and ERG will visit each site to perform the internal optical 2-point calibration checks for the SPMs and download all data for the last time. After these activities have been completed, ERG will breakdown and pack all equipment, and return that equipment to the ERG Laboratory in Research Triangle Park, North Carolina. To the greatest extent possible, the monitoring sites will be returned to the condition they were in prior to installing the equipment. ERG will set up the SO_2 monitors at the ERG Laboratory and perform post-deployment calibration and QC checks to qualify precision and accuracy. Equipment belonging to ATSDR and/or ERG will be serviced, packed, and properly

stored for use in future ATSDR monitoring programs.

3.8 Reporting

After all data collection activities have been completed, ATSDR and ERG will prepare a Draft and Final EI Field Monitoring Report. The report will include the following:

- Introduction
- Methods (siting and monitoring approach)
- QA/QC
- Results
- Data Characterization
- Conclusions/Discussion

A Health Consultation reflecting data collected during this EI will be prepared separately from the Final EI Monitoring Report.

3.9 Proposed Project Schedule

The proposed schedule of major program events (tentative) is presented in Table 1. If the schedule has to be revised, the schedule will be revised in 1-week increments.

Table 1. Proposed Schedule of Major Program Events
(based on information available at the time of preparation of this document)

Event	Activity	Date
Pre-Site Survey	Meet with the Mirant/City of Alexandria staff, identify potential site locations. Initial visit to determine potential locations, site specific requirements.	March 12 - March 13
Siting	Site selection and agreements obtained with host residents (ATSDR responsibility).	March 10 - April 15
Management	Preparation, review, revision (as needed) and acceptance of the Monitoring Plan.	March 19 - April 30
Management	Preparation, review, revision (as needed) and acceptance of the cost estimate.	March 30 - April 30
Pre-Monitoring Survey	Collect SO_2 data at two sites to gauge the level of SO_2 present prior to start of the actual monitoring effort.	April 16 - April 20
Staging	Acquire/obtain instrumentation and related ancillary equipment and materials. Fabricate all support systems and equipment. Mount data acquisition systems in protective chassis boxes, and configure associated software for data collection and retrieval for each site.	March 1 - May 17
Staging	Set up and perform a functional checkout on all instrumentation at the ERG laboratory. Perform instrument calibrations and pre-deployment QC checks.	March 1 - May 21
Staging	Breakdown and pack all instrumentation, equipment, materials, and supplies, and prepare them for transport to the sites.	May 22 - May 24
Deployment	Transport equipment to sites. Position mobile laboratory and connect it to electrical power.	May 26 - May 27
Deployment	Install/set up all equipment associated with the ERG mobile laboratory site. Check out and QC equipment. Bring systems on line. Repeat for all other sites.	May 28 - May 31
Monitoring	Week 1 – Check and service equipment daily. Perform sample collections as scheduled. Ship TSP samples to ERG laboratory weekly.	June 2 - June 8
Monitoring	Week 1 – Download data, electronically transfer data to ERG Reporting Task Manager, and perform SO_2 optical QC checks.	June 8
Monitoring	Week 2 – Check and service equipment daily. Perform sample collections as scheduled. Ship TSP samples to ERG laboratory weekly.	June 9 - June 15

Table 1. Proposed Schedule of Major Program Events
(based on information available at the time of preparation of this document)
(Continued)

Event	Activity	Date
Monitoring	Week 2 – Download data, electronically transfer data to ERG Reporting Task Manager, and perform SO_2 optical QC checks.	June 15
Monitoring	Week 3 – Check and service equipment daily. Perform sample collections as scheduled. Ship TSP samples to ERG laboratory weekly.	June 16 - June 22
Monitoring	Week 3 – Download data, electronically transfer data to ERG Reporting Task Manager, and perform SO_2 optical QC checks.	June 22
Monitoring	Week 4 – Check and service equipment daily. Perform sample collections as scheduled. Ship samples to ERG laboratory the same day they are collected.	June 23 - June 29
Monitoring	Week 4 – Download data, electronically transfer data to ERG Reporting Task Manager, and perform SO_2 optical QC checks.	June 29
Monitoring	Note: If week 5 and/or 6 is determined to be necessary, they would encompass the dates of June 30- July 6 and July 7 – July 13. Recovery and reporting effort dates would then be adjusted by 1 or 2 weeks as applicable.	June 30 - July 13 (tentative)
Recovery	Breakdown and pack equipment for transport, return site locations to their pre-deployment status.	June 30 - July 2
Recovery	Transport equipment to Research Triangle Park.	July 2
Recovery	Set up SO_2 instruments at the ERG laboratory, perform instrument calibrations and post-deployment QC checks.	July 9- July 13
Recovery	Perform any required service on ATSDR owned equipment and store for future application. Return any borrowed or rented equipment. Return or dispose of any unconsumed materials/supplies (as appropriate).	June 14 - August 20
Reporting	Prepare the Draft EI Monitoring Report.	August 1 - September 1
Reporting	Submit Draft EI Monitoring Report for review and comment.	September 3
Reporting	Receive review comments.	September 30
Reporting	Submit Final EI Monitoring Report.	October 19

SECTION 4
QUALITY ASSURANCE AND CONTROL

4.1 Data Quality Objectives

The project Data Quality Objectives (DQOs) provide the answer to the critical question of how good data must be in order to achieve the project goals. DQOs are used to develop the criteria that a data collection design should satisfy including where to conduct monitoring, when to conduct monitoring, measurement frequency, and acceptable measurement precision and accuracy. Considering the targeted compounds, information obtained during the site selection survey, and specifications associated with the monitoring and sample collection systems that will be utilized, DQOs for this EI are presented in Table 2.

Table 2. Data Quality Objectives

Element	Objective
Where to Conduct Monitoring	All sites must be located in close proximity to the potentially impacted populous, in accordance with the grid ring approach presented in Section 3.1.
When to Conduct Monitoring	Daily – from 0000 to 2359 hours
Frequency of Monitoring	Continuous for SO_2, PM^{10}, $PM^{2.5}$, and meteorological parameters so that short duration excursions can be assessed, and hourly and daily average concentration can be calculated. TSP and metals samples will be collected on an every-other-day schedule.
Overall Completeness	80 % data capture
Acceptable Measurement Precision for SPMs	+/- 20 % relative standard deviation (RSD)
Acceptable Measurement Accuracy for SPMs	+/- 15 % RSD
Acceptable Measurement Precision for metals	+/- 20 % RSD
Acceptable Measurement Accuracy for metals	+/- 25 % RSD

4.2 Measurement Accuracy

Measurement accuracy for this project is defined as the ability to acquire the correct concentration measurement from an instrument or analysis with an acceptable level of uncertainty.

To determine the measurement accuracy associated with the SO_2 SPM instruments used on this EI, a QC sample will be measured. The difference between the concentrations obtained from each instrument compared to the known concentration of the corresponding QC check standard will be calculated and expressed as the Relative Standard Deviation (RSD). Measurement accuracy checks will be performed initially (i.e., while the systems are being checked out during the staging efforts) and again after the equipment has been recovered and returned to the ERG Laboratory.

Accuracy for the metals analyses will be established through audits prepared by U.S. EPA and submitted to ERG as a regular function of the National Monitoring Programs (which ERG operates under contract to U.S. EPA).

4.3 Measurement Precision

Measurement precision is defined as the ability to acquire the same concentration from different instruments with an acceptable level of uncertainty, while they are sampling the same gas stream. For this EI, measurement precision will be assessed as follows:

- *SO_2 between two instruments*—Collocated SO_2 SPM instruments will be located at the site where the ERG mobile laboratory will be positioned. The difference between simultaneous concentration determinations from each instrument while sampling a common ambient air parcel will be calculated and expressed as RSD.

- *SO_2 across instruments by type*—As part of the pre- and post-deployment QC checks, the SO_2 SPM instruments will simultaneously perform 10 concentration determinations each. The average concentration from the 10 determinations will be calculated on an instrument specific basis. The 10 averages will then be compared to each other and expressed as RSD.

- *Metals*—Precision will be determined by analyzing 4 sets of field samples (1 from each TSP site) in replicate. The average concentration for each compound measured from each set of 4 determinations will be calculated on a compound specific basis. Each set of 4 averages will then be compared to each other and expressed as RSD.

SECTION 5
SPECIAL TRAINING REQUIREMENTS

ERG field personnel involved in this project have been trained in their tasks and have from four to 33 years of experience in the duties they will be performing. ERG staff will be subject to surveillance from the ERG QA Officer (Dr. Raymond Merrill) with appropriate corrective action enforced, if necessary. No additional special personnel will be required to augment the ERG personnel. ERG provides employee training through both specialized, in-house training classes, and by on-the-job training by their supervisors and co-workers. There are no unusual hazards and no special safety training or equipment other than standard personal protective equipment (PPE) will be required. Safety and hazard communication training have been completed by ERG laboratory staff. The ATSDR EI Manager and ERG Project Co-Directors are 40-hour Hazardous Waste Operations (HAZWOPER) certified.

SECTION 6
DOCUMENTS AND RECORDS

A field project notebook will be used to record the monitoring systems' operational parameters. Analysis documentation will include the use of bound laboratory notebooks to record experimental conditions, data, and pertinent observations. Hard copies of instrumentation records including calibration, QC checks, and any raw data will be archived in a Project Masterfile.

The project final summary report (see Section 3.8) will include all applicable raw data and records. A summary of any outliers or findings will be presented in the report. The report will undergo a technical review before submission. After submission, the report will be filed at ERG for a period of no less than three years. The file will also include electronic copies of all data used in the development of the report.

B – MEASUREMENTS / DATA ACQUISITION

SECTION 7
MONITORING APPROACHES

7.1 Continuous Sulfur Dioxide

Measurements of SO_2 will be made using Honeywell SPMs owned by ATSDR. Primary calibration of these instruments is performed at the factory. Two-point internal optical calibration performance checks will be conducted (i.e., initially before deployment, weekly onsite, and again after equipment recovery). Two range setting ChemKeys® will be used as necessary during the program, based on concentrations measured during pre-monitoring and program monitoring activities. The linear detection range for the low range ChemKey® is 5-200 parts per billion by volume (ppbV). However, the instruments will be calibrated from 0-200 ppbV. The linear detection range for the high range ChemKey® is 0.2-6.0 parts per million by volume (ppmV). Ambient air is drawn into the instrument through a length of Teflon tubing (i.e., 0.250 inch outside diameter), outfitted with an inverted glass funnel connected at the inlet end. Electronic signals from the SO_2 systems will be collected and stored using HOBO Micro Station® DASs with 4-20 mA adapters and BoxCar® Pro 4.3 software. Each DAS is capable of collecting four channels of amperage input simultaneously, and offers internal storage for 1 million data points per system.

7.2 Continuous Particulate

Measurements of continuous PM^{10} and $PM^{2.5}$ particulate will be made using Met One Instruments EBAM real-time beta attenuation monitors. The EBAMs are portable self-contained units that meet or exceed all EPA requirements for automated particulate measurement. The measurement range for these units is 0-10mg/m^3. These units will provide measurement data on an hourly basis. Data is stored automatically to a unit specific internal DAS. The monitors used to measure $PM^{2.5}$ will incorporate a PM^{10} pre-cutter inlet followed by a Sharp Cut $PM^{2.5}$ cyclone. The monitors used to measure PM^{10} will incorporate a PM^{10} pre-cutter inlet only.

7.3 Meteorological Parameters

Measurements of meteorological parameters will be made using two stand alone meteorological monitoring systems, attached to secured tripods or mast assemblies. Each system incorporates a cup anemometer to measure wind speed, a directional mast and vane to measure wind direction, a wound bobbin assembly to measure relative humidity, and a thermistor temperature probe to measure ambient temperature. Measurements will be made at a height of approximately 10-12 feet above grade or roof top level (site dependent). Electronic signals from the meteorological monitoring systems will be collected and stored using HOBO Micro Station DASs and BoxCar® Pro 4.3 software. Each DAS is capable of collecting four channels of input signal simultaneously, and offers internal storage for 1 million data points per system.

7.4 Total Suspended Particulate

Samples for determining mass gain of TSP by gravimetric analysis will be made in accordance with EPA Method IO-2.1[1]. Method IO-2.1 employs high volume samplers to volumetrically collect representative aliquots of suspended particulate matter with an aerodynamic particle size above 0.01µm. Five-point flow rate calibration curves will be compiled for each sampler at the ERG prior to deployment. Single-point flow rate checks will be made in the field , prior to and after each collection event. All TSP filters will present a unique filter identification number. Each filter will be equilibrated and weighed prior to transport to the field (i.e., pre-sampling), and then equilibrated and re-weighted when received at the ERG laboratory after each collection event (post-sampling). The mass gain is determined by subtracting the pre-sampling weight from the post-sampling weight.

7.5 Metals

Determination of the concentration of toxic metals will be performed on the TSP filter samples (as described in Section 7.4) after gravimetric analysis has been completed. Analyses for toxics metals will be made in accordance with EPA Method IO-3.5[2], as described in the *"Technical Assistance Document for the National Ambient Air Toxics Trends and Assessment*

Program"[3]. ERG is National Environmental Laboratory Accreditation (NELAC) Program accredited laboratory, and is NELAC certified to perform this analysis. Target metals for this EI, and their associated method detection limit (MDL), are presented in Table 3.

Table 3. Target Metals and Associated MDLs

Target Metal	MDL (ng/filter)
Antimony	20.0
Arsenic	17.9
Beryllium	40.0
Cadmium	16.9
Chromium	284
Cobalt	19.9
Lead	36.2
Manganese	31.2
Mercury	18.6
Nickel	176.0
Selenium	35.9

EPA Compendium Method IO-3.5[2] provides the procedures for the multi-element determination of trace elements by ICP/MS. Ambient air is pulled through filter media using a high volume sampler. Particulate phase sample is collected on the filter, and the filter is digested yielding the sample material in solution. Sample material in solution is introduced by pneumatic nebulization into radio frequency plasma where energy transfer processes cause desolvation, atomization, and ionization. The ions are extracted from the plasma through a differentially pumped vacuum interface and separated on the basis of their mass-to-charge ratio by a

quadrupole mass spectrometer having a minimum resolution capability of 1 amu peak width at 5% peak height. The ions transmitted through the quadrupole are registered by a continuous dynode electron multiplier, and the ion information is processed by a data handling system.

SECTION 8
DATA VALIDATION AND USABILITY

8.1 Verification and Usability Processes

A two-step process of verification and validation for data review will be performed. This process will begin with an objective review of whether or not the data collection plans and protocols were followed and whether the basic operations, calculations, and statistical evaluations were performed correctly. Ongoing QA review that started with the development of this EI Monitoring Plan will be reviewed to verify that the sampling and analytical methodology planned for this project was accomplished or that changes were identified, documented and met project quality objectives. ERG will be concerned only with the review and validation of data collected by ERG.

The second step will be to validate the technical usability of the data by determining whether the procedures followed were appropriate for the actual situations encountered, and whether the results make sense in the context of the investigation objectives. This validation will be done by comparing the original investigation objectives and data quality objectives with the actual circumstances encountered by ATSDR and ERG.

8.2 Verification Methods

Evaluation of the Experimental Design—The first step in validating the data set is to assess if the project, as executed, meets the requirements of the sampling design.

Sample Collection Procedures—Actual sample collection procedures will be documented in the field notebook and on applicable data sheets, and checked against any applicable requirements contained in this EI Monitoring Plan. Deviations from the EI Monitoring Plan will be classified as acceptable or unacceptable, and critical, or non-critical.

Sample Handling—Internal sample handling and tracking procedures for samples generated in the laboratory will be checked. Holding times will be monitored to ensure timely analysis and reporting of analytical results. Labeling and sample identification will be checked for variation from the EI Plan; Good Laboratory Practices will be followed in the labeling of samples and standards. All deviations will be documented in the final summary report.

8.3 Validation Methods

Calibration — Documentation of equipment calibration (i.e., where applicable) will be assessed to ensure that the values obtained are appropriate for data collection. Errors and omissions will be discussed in the final summary report. The documentation will be checked to ensure that the calibrations: (1) were performed at the specified intervals, (2) included the proper number of calibration points, and (3) were performed using appropriate approaches/standards for the reported measurements. Results generated during periods when calibration requirements are met will be considered conditionally valid and ready for Quality Control Validation review.

Data Reduction and Processing — The data processing system will be checked by using example raw data for which calculated values are already known. The example data are input into the system and the calculated results are compared to the known. Hand calculations will be used to check the data processing system. Findings from these audits will be included in the final report. Data will be considered conditionally valid if manual calculations are reconciled with automated data processing results.

QC Results and Procedures — QC measurements and QC procedures performed during the experimental program will be checked against the monitoring program requirements. Omissions will be discussed in the final summary report. Quality control results will be reviewed. Results that meet the DQOs and all other validation are considered valid. All results outside specified parameters will be discussed with the ATSDR EI Manager for corrective action.

C – HEALTH AND SAFETY

SECTION 9
HEALTH AND SAFETY

9.1 Purpose

The purpose of this Health and Safety Section is to inform personnel of known or potential health and safety hazards that may be encountered during ambient and indoor air monitoring activities planned for Alexandria, Virginia. Accordingly, this HASP describes the possible hazards and the procedures required to minimize the potential for exposure, accidents and/or injuries during the scheduled work activities. This information has been reviewed by the ERG Laboratory Health and Safety Coordinator.

9.2 Scope

In order to better assess potential human exposure to selected chemical species and particulates in ambient and/or indoor air in Alexandria, Virginia, ATSDR will conduct an EI. During this EI, an ambient air monitoring program will be operated to obtain representative concentration data for:

- SO_2 concentrations
- Toxic metals concentrations
- TSP mass
- PM^{10} mass
- $PM^{2.5}$ mass
- Meteorological parameters

9.3 Physical Hazards Assessment

Possible dangers associated with project activities include physical hazards related to heat and cold stress; slips, trips, or falls; electrical hazards; excessive noise; lifting; and animals, poisonous plants, and poisonous insects. Brief descriptions of these potential physical hazards and measures for preventing, or mitigating the consequences of, the hazards follow:

- Heat Stress — Ambient temperatures may be high enough to induce heat stress if field staff does not take appropriate preventive measures. Low winds and high humidity also contribute to heat stress, and both of these conditions may persist in Alexandria, Virginia during the summer. ERG staff must be familiar with the signs and symptoms of heat stress as presented below, and be aware of measures necessary to prevent its occurrence. Field staff can prevent heat stress using good common sense and awareness. ERG sampling team members should wear appropriate clothing and drink ample quantities of water and electrolyte solutions (water and drinks such as Gatorade should be purchased ahead of time). Flexible working and resting schedules should be used as needed depending upon conditions. If ambient temperatures exceed 90°Fahrenheit (F), ERG personnel should make efforts to limit their time in hot sunny areas and rotate where possible into cooler areas. If such heat waves persist, ERG personnel should monitor their heart rates on a regular basis. The resting pulse rate should not exceed 110 beats per minute. If employees note than their one-minute pulses exceed 110, they should stop work and contact the field team leader immediately and reduce work loads accordingly.

    - *Heat Rash*. Heat rashes may result from continuous exposure to excessive heat and humidity. Field staff with heat rashes will be instructed to seek medical attention if symptoms persist.

    - *Heat Cramps*. Heat cramps are caused by heavy sweating with inadequate electrolyte replacement. Symptoms include muscle spasms and pain in the hands, feet, and abdomen. Field staff with heat cramps will be instructed to seek medical attention if any of the symptoms persist.

    - *Heat Exhaustion*. Heat exhaustion occurs when one's body loses the ability to maintain proper temperature. The signs of heat exhaustion include shallow breathing; pale, cool, and moist skin; profuse sweating; dizziness; nausea; and fatigue. Field staff will be trained in the recognition of these symptoms and will be provided electrolyte solutions to help prevent heat exhaustion. If symptoms of heat exhaustion persist, the employees will be instructed to immediately move to a cool location and contact emergency medical services.

    - *Heat Stroke*. Heat stroke, with an estimated mortality rate of 50 percent, is the most severe form of heat stress. The signs and symptoms of heat stroke include red, hot, and dry skin; body temperatures exceeding 105°F; lack of perspiration; strong, rapid pulse; nausea; dizziness; confusion; and unconsciousness. If signs of heat stroke occur, victims will be instructed to immediately retreat to a cool place and contact the nearest medical facility (see Emergency Response Procedures). The affected person may return

to work only after obtaining the approval of a doctor.

- Slips, Trips, and Falls — Testing at the site is expected to occur at both ground and roof top level. ERG personnel will use good safety sense in evaluating walking and working surfaces. It is expected that ATSDR will select monitoring sites such that neither testing personnel nor the general public will be injured by tripping or falling over test equipment. For work conducted above ground level (e.g., on rooftops, etc.), ERG personnel must take measures to ensure the safe access to these areas, including the use of safe equipment and remaining at a safe distance (at least 10 feet) from a building's edge. All ladders or stairways must meet Occupational Health and Safety Administration (OSHA) standards. Where possible, roofs should be accessed from windows or stairways. Field team leaders will review applicable OSHA rules with team members prior to assigning employees to work on roofs.

- Electrical — Prior to installing equipment in the field, ERG field staff will verify that all electrical equipment and cords are in good working condition. If additional extension cords are needed after arriving on site, the field team leader will purchase a high quality extension cord that works well under the testing conditions. Field staff will be instructed to immediately report to their team leaders any signs of malfunctioning electrical equipment.

- Lifting Hazards — When carrying and lifting equipment, ERG field staff should practice good lifting techniques and avoid carrying heavy loads.

- Animals, Poisonous Insects, and Poisonous Plants — ERG field staff should be alert for and stay clear of wild and unsupervised animals, poisonous insects and poisonous plants (e.g., poison ivy). Team members should also be aware of multiple poisonous spiders (e.g. brown recluse, black widow, etc.) that are indigenous to urban environments.

    - ERG field staff will wear thick leather gloves. When entering the room that houses the monitoring equipment turn on all lights, if lights not available use a flash light to look around the sampling area before opening sampling container. Be aware of your surroundings, do not just blindly wander in the monitoring locations. Observation is critical to avoidance. Learn to check around with a sweeping glance for anything that seems out of place, your subconscious may notice a camouflaged animal. All monitoring equipment will be kept in a large sealed container, the vents will be screened to reduce the chance of animals and insects from entering the container.

    - Tap the monitoring container before opening the container. Snakes and other animals have many sensing devices to warn them of your presence. Make plenty of noise and movements while entering the

monitoring room to announce your presence.

- If an ERG field staff is bitten by a snake, rodent, or spider, they should be taken to a medical facility immediately for treatment. Give the medical staff as much detailed information about the animal as possible. Describe the size, shape, and color of the animal.

9.4 Chemical Hazards Assessment

The only chemicals to be used by the field staff are the calibration and QC check chemicals for the SO_2 monitoring systems. The ERG Laboratory Health and Safety coordinator will obtain Material Safety Data Sheets for these materials and review the relevant safety information with the team members. There will be compressed gases in the trailer used to QC the SO_2 instruments. These gases will contain SO_2 in air, and zero air. Because these chemicals are inhalation hazards a thorough leak check of the monitoring system will be performed at the beginning of the project. Additional leak checks should be performed each month during the testing. Prior to entering the ERG sampling trailer, open both doors and ventilate for at least 5 minutes. Perform a leak check of the instruments if you suspect a leak from the calibration gases.

9.5 Contacts for Local Emergency Services

Prior to the first ERG field activity, ERG will provide each of its field staff with the pertinent emergency contact information for the investigation area. This information will include the phone number(s) and address for the following:

Alexandria Police Dept.
2003 Mill Rd
Alexandria, VA 22314
Emergency: 911
Non-emergency: (703)838-4444

Alexandria Fire Dept.
Station 208
175 N Paxton St.
Alexandria, VA 22304
Emergency: 911
Non-emergency: (703)838-4658

Inova Alexandria Hospital
4320 Seminary Road
Alexandria, Virginia 22304
Emergency: 911
Non-emergency: (703)504-3000

9.6 Staff Concurrences

Prior to working on this ambient air monitoring program, ERG will require all of its associated field staff to read and understand these health and safety provisions.

ERG STAFF CONCURRENCE SHEET

I have read, understood, and agree to comply with this Project Health and Safety Plan.

Signature	Printed Name	Date
Signature	Printed Name	Date
Signature	Printed Name	Date
Signature	Printed Name	Date

D– REFERENCES

SECTION 10
REFERENCES

1. U.S. EPA Compendium Method IO-2.1; *"Sampling of Ambient Air for Total Suspended Particulate or PM^{10} Using High Volume Sampling"*, EPA/625/R-96/010a, June 1999.

2. U.S. EPA Compendium Method IO-3.5; *"Determination of Metals in Ambient Particulate Matter Using Inductively Coupled Plasma/Mass Spectrometry (ICP/MS)"*; EPA/625/R-96/01a; U.S. Environmental Protection Agency: Research Triangle Park, NC, July 1999.

3. *"Technical Assistance Document for the National Ambient Air Toxics Trends and Assessment Program"*; U.S. EPA, January 1, 2007, Compendium Method IO-3.5, Section 4.0, page 82.

Appendix D. Exposure Investigation Field Report

Exposure Investigation Field Report

Mirant Potomac River Generating Station (Mirant)

Alexandria, VA

Cost Recovery Number A08K

October 2009

Prepared by
Division of Health Assessment and Consultation
Exposure Investigation and Site Assessment Branch Agency for Toxic Substances and Disease Registry

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List of Acronyms

amu	atomic mass unit
ATSDR	Agency for Toxic Substances and Disease Registry
CAA	Clean Air Act
DAS	data acquisition system
DQOs	Data quality objectives
EBAM	Electronic Beta Attenuation Monitor
EI	exposure investigation
ERG	Eastern Research Group, Inc.
ERM	equivalent reference method
^{B}F	Fahrenheit
GPS	global positioning system
ICP/MS	inductively coupled plasma/mass spectrometry
KeV	kilo electron volt
Lpm	liters per minute
mA	milliampre
MDL	method detection limit
µm	micrometers
mg/m^3	milligrams per cubic meter
MRL	minimal risk level
m/s	meters per second
MW	megawatts
NAAQS	national ambient air quality standard
NATTS	National Air Toxics Trends Stations
NELAC	National Environmental Laboratory Accreditation
NWS	National Weather Service
PE	performance evaluation
$PM_{2.5}$	particulate matter with aerodynamic particle size of 2.5 microns or less
PM_{10}	particulate matter with aerodynamic particle size of 10 microns or less
ppb	parts per billion
ppbv	parts per billion by volume
QA/QC	quality assurance/quality control
RSD	relative standard deviation
RTD	resistance temperature detector
SO_2	sulfur dioxide
SOPs	standard operating procedures
SPMs	single point monitors
TSP	total suspended particulate

1.0 Introduction

Mirant Potomac River Generating Station (Mirant PRGS), an electricity generating facility that began operating in 1949, is located on the Potomac River in Alexandria, Virginia (see Figure 1 in Appendix A). Mirant PRGS operates five generating units capable of producing a total of 482 megawatts (MW) of electricity. The plant generates electricity by burning coal, and pre-heats its units by burning oil. The facility transmits generated electricity to customers in the northeast electric power grid. The facility lies in northeastern Virginia, 3 miles from the Ronald Reagan Washington National Airport and 5 miles from the U.S. Capitol building. Residential and commercial properties surround the Mirant PRGS facility, with a condominium building (Marina Towers) built in the 1960s located 300 yards from the facility. Since 2001, nearby residents have complained about health concerns related to air quality problems that they attribute to the facility (DOE 2006).

A U.S. Environmental Protection Agency (EPA) judicial consent decree established in 2004, which was later amended in 2006, has resulted in required modeling efforts by the facility and emissions limits for some pollutants, including sulfur dioxide (SO_2) and particulate matter 10 microns or smaller (PM_{10}). Modeling conducted by Mirant PRGS has indicated that estimated concentrations of three pollutants—SO_2, nitrogen dioxide (NO_2), and PM_{10}—from downwash might significantly exceed their corresponding national ambient air quality standards (NAAQS) at locations near the facility boundary.

In January 2006, the Health Director of the Alexandria Health Department requested that ATSDR review environmental data related to Mirant PRGS's operations, assess the potential for health effects for nearby residents, and recommend next steps (Konigsberg 2006). ATSDR's review of air dispersion modeling, completed in January 2007, suggested a potential hazard to vulnerable populations based on estimated short-term, acute exposures to SO_2. However, ATSDR also found significant uncertainty with the modeling results and the Agency's interpretations based on these results (ATSDR 2007). Accordingly, ATSDR conducted this exposure investigation (EI) to address identified data gaps and to determine if a public health hazard exists in the surrounding area.

The exposure investigation consisted of an ambient air monitoring program designed to obtain representative meteorological data and concentration measurements data for SO_2, mass measurements for multiple size fractions of particulate matter, and trace metals. During the monitoring program, air quality measurements were collected for 6 weeks at 10 monitoring locations within the investigation area. Based on the data collected during the EI and other data sources, ATSDR will determine whether a need exists for additional air dispersion modeling or monitoring to more fully evaluate public health impacts in the investigation area. ATSDR was assisted with this EI by ATSDR's mission support contractor, Eastern Research Group, Inc. (ERG).

The exposure investigation design was documented in the exposure investigation protocol titled "*Exposure Investigation: Airborne Exposures to Sulfur Dioxide, Particulate Matter, and Selected Metals, Mirant Potomac River Generating Station (Mirant), Alexandria, VA*". The exposure investigation protocol was peer reviewed by external (non-ATSDR) expert scientists. For more information, see the exposure investigation protocol presented in Appendix A.

1.1 Exposure Investigation Overview

Exposure investigations (EI) are not designed to be long-term environmental sampling programs. If a need for longer term sampling is identified as a result of an exposure investigation, ATSDR may recommend to the appropriate agency or authority that sampling data be collected and indicate the sampling duration needed. An EI is also not designed to characterize emissions from a facility or monitor facility emissions. The objectives of an EI, by design, are to fill data gaps relating to community exposures to environmental contaminants. EI results are a public health service directed to individual participants and are not generalizable to other populations.

Because exposure investigations are, by design, intended to collect community-based exposure data, instrumentation and methods used during an environmental EI may need to be different from or modified EPA or state standard methods. In addition, ATSDR may on occasion need to utilize new technology because existing methods may not be available or appropriate to gather community-based data that meet the objectives of the exposure investigation. In these cases, applicable data quality objectives as well as quality control procedures are implemented in order that the validity of the collected data can be determined. It is also understood the data collected is a public health service and is not collected for regulatory purposes.

The following section summarizes the EI conducted for this site including targeted pollutants and siting criteria. Additional details are provided in ATSDR's Exposure Investigation Protocol and the Monitoring and Health and Safety Plan for this EI, both of which are presented in Appendix A.

1.1.1 Targeted Pollutants

In this EI, ATSDR considered pollutants with measurable health endpoints that are likely to be emitted from coal-fired electricity generating facilities. The selected pollutants were SO_2, particulate matter with aerodynamic particle size of 10 microns or less (PM_{10}), particulate matter with aerodynamic particle size of 2.5 microns or less ($PM_{2.5}$), total suspended particulate (TSP), and 11 trace metals (i.e., antimony, arsenic, beryllium, cadmium, total chromium, cobalt, lead, manganese, mercury, nickel, and selenium).

These targeted pollutants correspond were determined by the objectives of the EI. The primary objective of the EI was to determine if nearby communities were being exposed to SO_2 released from the Mirant PRGS facility. Results of 1-hour air dispersion modeling have suggested possible community exposures to SO_2, indicating the potential for short-term health impacts. The secondary objective of the EI was to obtain PM_{10}, $PM_{2.5}$, and trace metals data. Prior to the EI, only limited data were available for these pollutants in the investigation area. ATSDR used the data collected during this EI (with the exception of measured SO_2 data, see Section 3) to determine the presence of these pollutants in the investigation area, and to evaluate whether people living near the Mirant PRGS facility are exposed to SO_2, PM_{10}, $PM_{2.5}$, and trace metals at concentrations that pose a public health hazard.

1.1.2 Siting Criteria

As part of the site selection process, a pre-site survey of the investigation area was conducted. Information gathered during the pre-site survey was used to determine candidate monitoring locations and to design the overall monitoring approach.

To aid in the site selection process wind roses were prepared from meteorological data collected at the National Weather Service (NWS) station located at Ronald Reagan Washington National Airport (see Figures 3 and 4 in Appendix A). The airport is located approximately 3 miles north of the Mirant PRGS facility. The wind roses were considered to be representative of weather patterns for the investigation area and were used to establish the typical wind flow patterns for the area and the relationship to sites being considered for the EI. See Appendix A for more information.

Several candidate monitoring locations were identified during the pre-site survey. Based on this survey, ten monitoring locations were eventually selected that closely met siting criteria such proximity to the Mirant PRGS facility, representative community settings, electrical power availability, secure locations, and willingness of property owners to participant in the exposure investigation. Written consent to participate in the EI was then obtained for each of the ten locations. The location of each monitoring site was documented by longitude and latitude using a hand held global positioning system.

2.0 Monitoring Locations, Sample Collection, and Monitoring Methods

This section describes the monitoring sites, sample collection, and monitoring methodologies used during the EI.

2.1 Monitoring Sites

To identify monitoring locations for the EI, areas near the Mirant PRGS facility were plotted using concentric 0.25-mile rings. As shown in Figure 2-1, the EI used a network of ten monitoring locations: four of the monitoring locations were in the 0.00–0.25 mile ring, three were in the 0.26–0.50 mile ring, and four were in the 0.51–0.75 mile ring. These monitoring locations were selected to provide a representative cross-section of potential exposure scenarios specific to the characteristics of the area being investigated (e.g., population, transportation patterns, employment, city services, potential for building downwash, varying meteorological conditions).

Table 2-1 presents information on the 10 monitoring locations, including the site identification (site ID) number used in the project database, a brief site description, the pollutants measured, and the type of measurements made (i.e., continuous measurements or 24-hour integrated samples). Figures 2-2 through 2-12 present photographs of the sampling equipment installed at each site. All monitoring sites were located in Alexandria.

Table 2-1. Site-Specific Information

Site ID	*Site Description*	*Location*	*Pollutant*	

S1	Private building (roof/15th floor)	Outdoor	SO_2, PM_{10}, $PM_{2.5}$	Continuous monitoring
			TSP/trace metals	24-hour integrated samples
S2	Private building (4th floor)	Indoor	SO_2	Continuous monitoring
S3	Private building (ground Level)	Outdoor	SO_2	Continuous monitoring
S4	Private building (roof/25th floor)	Outdoor	SO_2	Continuous monitoring
S5	Private building (roof/5th floor)	Outdoor	SO_2	Continuous monitoring
S6A	Public building (ground level)	Outdoor	SO_2, $PM_{2.5}$	Continuous monitoring
			TSP/trace metals	24-hour integrated samples
S6B	Public building (ground level)	Indoor	SO_2	Continuous monitoring
S7	Public building (ground level)	Outdoor	SO_2	Continuous monitoring
S8	Private building (roof/5th floor)	Outdoor	SO_2, $PM_{2.5}$	Continuous monitoring
			TSP/trace metals	24-hour integrated samples
S9	Private building (ground level)	Outdoor	SO_2	Continuous monitoring
S10	Public park (ground level)	Outdoor	SO_2	Continuous monitoring
			TSP/trace metals	24-hour integrated samples

Figure 2-1. Monitoring Locations

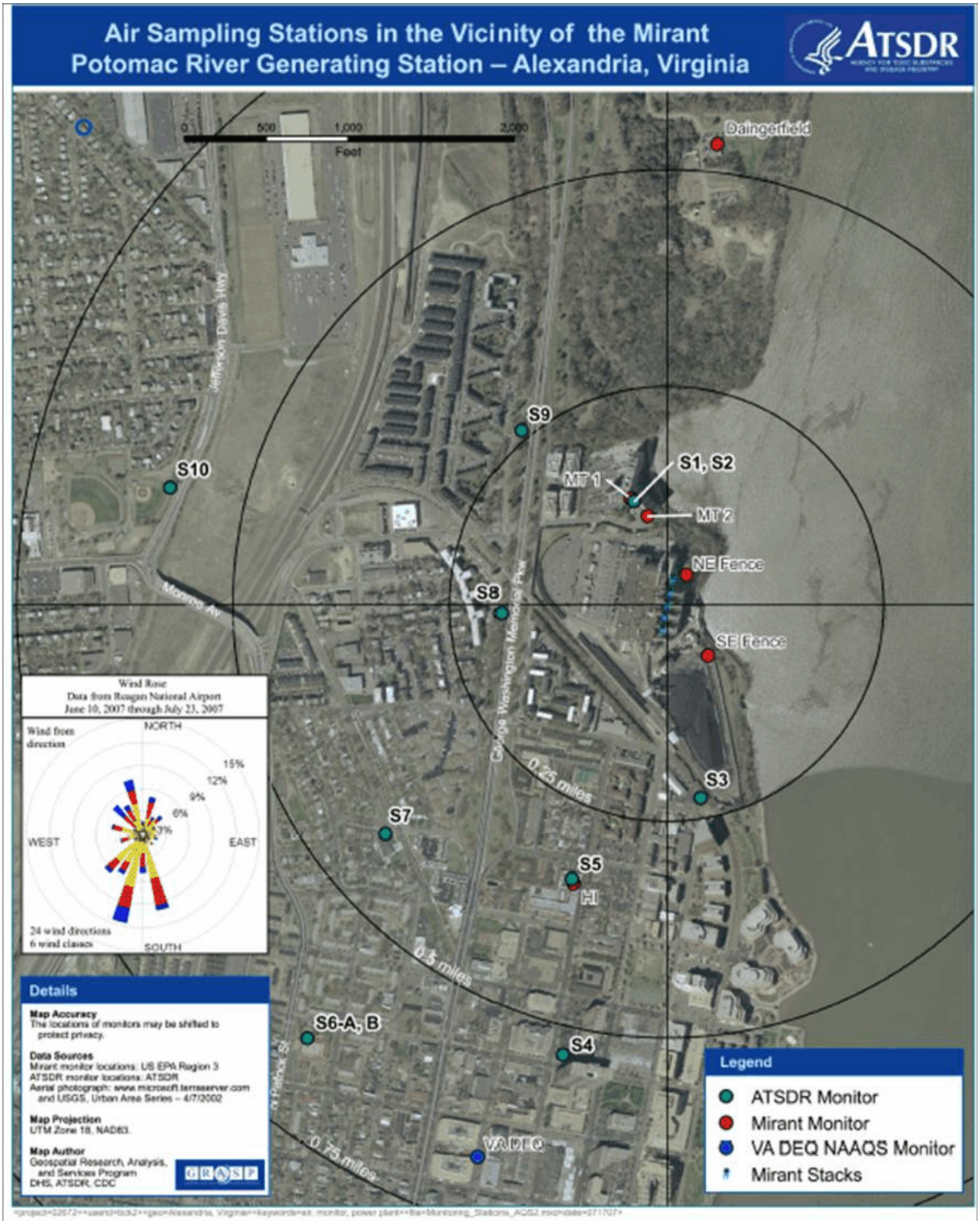


Figure 2-2. Site 1 Equipment and Setup

Figure 2-3. Site 2 Equipment and Setup

Figure 2-4. Site 3 Equipment and Setup

Figure 2-5. Site 4 Equipment and Setup

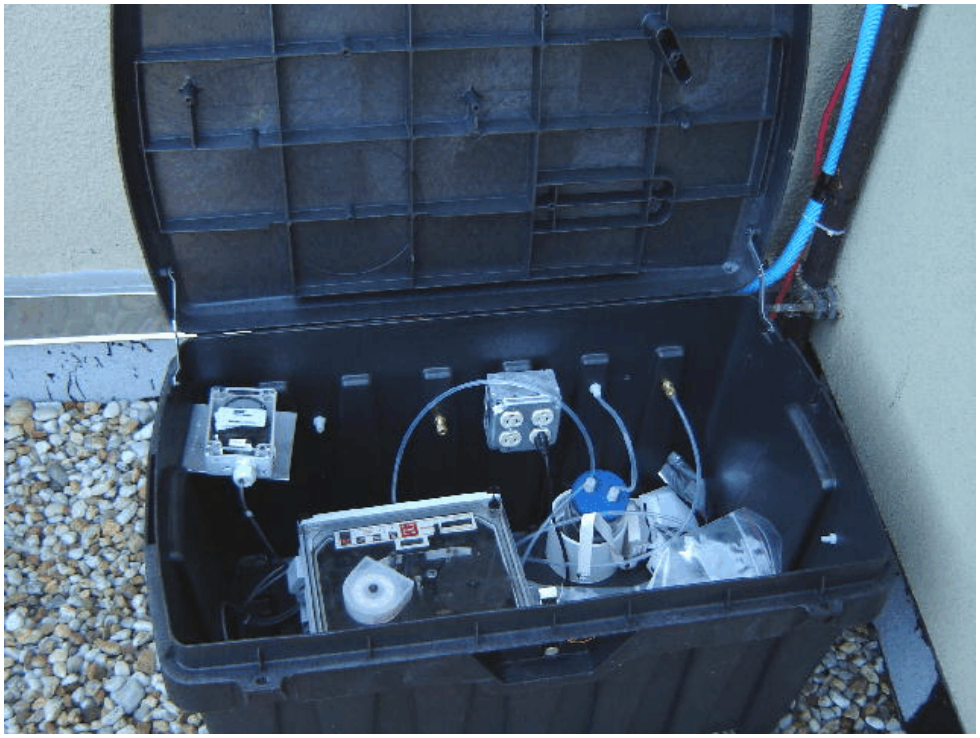


Figure 2-6. Site 5 Equipment and Setup

Figure 2-7. Site 6A Equipment and Setup

Figure 2-8. Site 6B Equipment and Setup

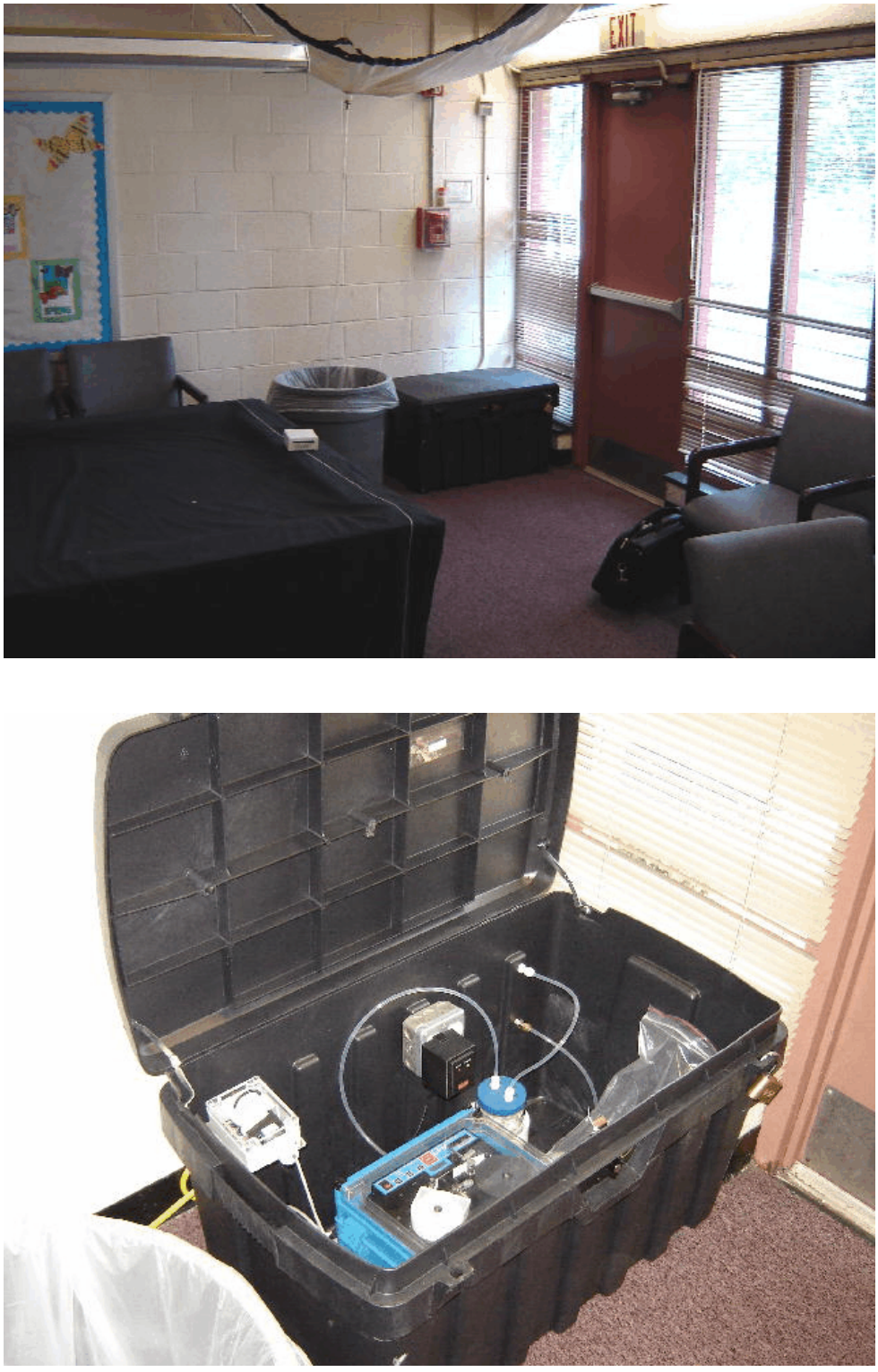


Figure 2-9. Site 7 Site Equipment and Setup

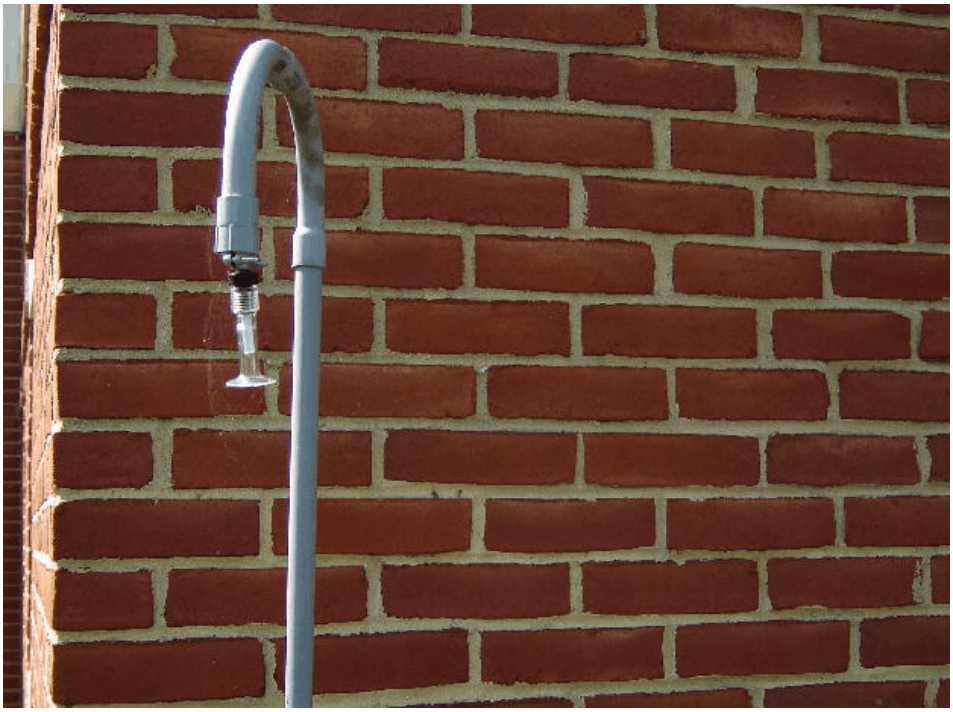


Figure 2-10. Site 8 Site Equipment and Setup

Figure 2-11. Site 9 Site Equipment and Setup

Figure 2-12. Site 10 Site Equipment and Setup

2.1.1 Deployment

Monitoring equipment, sample collections systems, and meteorological measurement systems were transported and installed at the applicable sites (see Table 2-1). After equipment set-up all measurement systems were tested to ensure that no damage occurred during transport. Sampling at each monitoring location commenced after that location's measurement systems were determined to be operating correctly.

2.1.2 Duration/Schedule

ATSDR selected the EI monitoring period to correspond with the expected worst-case emissions from the Mirant PRGS facility. Specifically, Mirant PRGS was expected to operate at or near full operating capacity in June and July 2007: due to maintenance work on the electrical power grid transmission lines, Mirant PRGS was anticipated to provide extra electrical power to parts of the northeast that were normally supplied or supplemented by other electrical power suppliers on the grid. After the sampling and monitoring systems were brought on line, monitoring was conducted continuously for just over 6 weeks.

Field sampling personnel visited the monitoring sites daily to assess the functional status of the measurement equipment and to correct any identified problems. On a weekly basis, the field sampling personnel downloaded data from the SO_2, PM_{10}, and $PM_{2.5}$ monitors, and performed numerous quality assurance activities. Maintenance was performed on these monitoring systems as required. In addition, meteorological monitoring system data was downloaded weekly from the two on-site meteorological monitoring locations. Visual checks of the meteorological sensors were performed daily. Table 2-2 documents the sampling and monitoring schedules used throughout the EI.

Table 2-2. Schedule of Pollutant Sample Collection for the EI

Pollutant	*Site ID*	*Collection Dates*
SO_2 (measured continuously)	Site 1	6/8/07–7/22/07
	Site 2	6/8/07–7/22/07
	Site 3	6/10/07–7/22/07
	Site 4	6/8/07–7/22/07
	Site 5	6/8/07–7/22/07
	Site 6A	6/8/07–7/22/07
	Site 6B	6/8/07–7/23/07
	Site 7	6/8/07–7/22/07
	Site 8	6/9/07–7/22/07
	Site 9	6/8/07–7/22/07
	Site 10-primary	6/8/07–7/22/07
	Site 10-collocated	6/8/07–7/22/07
PM_{10} (measured continuously)	Site 1	6/8/07–7/23/07
$PM_{2.5}$ (measured continuously)	Site 1	6/8/07–7/23/07
	Site 6A	6/8/07–7/23/07
	Site 8	6/9/07–7/23/07
TSP/Trace metals (24-hour integrated samples)	Site 1 Site 6A Site 8 Site 10	6/10/07, 6/12/07, 6/14/07, 6/16/07, 6/18/07, 6/20/07, 6/23/07, 6/26/07, 6/29/07, 7/2/07, 7/5/07, 7/8/07, 7/11/07, 7/14/07, 7/17/07, 7/20/07, and 7/22/07

2.2 Sampling and Monitoring Methodologies

2.2.1 Continuous SO_2

Honeywell single point monitors (SPMs) were used to measure SO_2 continuously at all ten monitoring locations during the EI. SPMs detect the presence of target analytes and calculate corresponding concentrations using a colormetric detection method. This method utilizes an optical scanning system that quantifies ambient air concentrations by measuring color change on a chemically impregnated paper tape specific to the target analyte. In this program, ATSDR used a measurement tape impregnated with a specially formulated chemical reagent specific for SO_2.

For each monitor, ambient air was drawn through a humidifier containing distilled/de-ionized water and into the instrument through a thin wall Teflon tubing sample line. An inverted glass funnel was connected at the inlet end of the sample line to prevent rain from entering the measurement device. As the sampled air passed over the instrument's measurement tape, SO_2 in the sampled air reacted with the reagent on the tape to form a colored stain. The intensity of the stain is proportionate to the concentration of SO_2 present in the sampled air (i.e., the darker the stain, the higher the concentration of SO_2). An electro-optical system measured the stain intensity, which is then converted to a measured concentration of SO_2 based on instrument-specific calibration data.

Measurement of SO_2 was continuous and automatic, and the resulting output signal (i.e., 4–20 mA) was logged using a dedicated HOBO Micro Station[7] data acquisition system (DAS) with a 4–20 mA adapter. The level of distilled/de-ionized water was checked and supplemented daily as needed across the duration of the monitoring program.

The manufacturer performs primary calibration certification of SPMs. However, supplemental calibration checks on these instruments were also conducted on each SPM at the staging laboratory prior to field deployment, and again after the EI was completed. In addition, two-point internal optical performance checks were conducted during deployment, mid-way through the program, and again during equipment recovery. Results from the calibration and optical checks are presented in Section 3.

The detection range for the monitors as configured and checked was 0–200 parts per billion by volume (ppbv). However, the linear detection range for these instruments is 4–200 ppbv. Accordingly, measured values between 4–200 ppbv are considered to be quantitative, while any measured values less than 4 ppbv are considered to be qualitative. The measurement frequency for the SPMs was once per minute.

2.2.2 TSP

TSP samples were collected at four sites (i.e., Site 1, Site 6A, Site 8, and Site 10) during the EI. Samples were collected using EPA Method IO-2.1[1], which quantifies TSP concentrations by gravimetric analysis of mass gain of TSP on sampling filters. Method IO-2.1 employs high volume samplers to volumetrically collect representative 24-hour aliquots of suspended particulate matter with an aerodynamic particle size above 0.01 micrometers (μm). In accordance with method procedures, a 5-point flow rate calibration curve was developed for each sampler at

the staging laboratory prior to deployment. These curves were used to calculate the corrected flow rates and the volume of gas sampled for each sample collection. Single-point flow rate checks were made in the field, prior to and after each collection event. Field data sheets for all collection events are presented in Appendix B.

Each TSP filter used had a unique filter identification number embedded in the filter border. Prior to deployment, each filter was equilibrated to 50% relative humidity (+/- 2%) and 70° F (+/- 2° F) for 1 week in a controlled weight room at the laboratory. Filters were weighed using a calibrated 5-place balance just prior to transport to the field (i.e., pre-sampling). After each 24-hour average sampling event concluded, the sampling filters were returned to the laboratory, re-equilibrated to the same conditions for 1 week, and re-weighed. The mass gain was determined by subtracting the pre-sampling weight from the post-sampling weight. EPA-approved standard operating procedures (SOPs) were followed for these analyses.

2.2.3 Trace Metals

Analyses to determine the concentration of trace metals were performed on all TSP samples collected during the EI, after gravimetric analyses were completed. Analyses for trace metals were conducted in accordance with EPA Method IO-3.5, as described in the "*Technical Assistance Document for the National Ambient Air Toxics Trends and Assessment Program*" (ERG 2007). ERG's laboratory has been accredited under the National Environmental Laboratory Accreditation (NELAC) Program, and is NELAC-certified to perform this analysis. Target trace metals for this EI, and their associated method detection limits (MDLs), are presented in Table 2-3.

Table 2-3. Target Trace Metals and Associated MDLs

Target Trace Metal	*MDL (ng/filter)*	*MDL (µg/m^3)^A*
Antimony	20.0	0.000010
Arsenic	17.9	0.000009
Beryllium	40.0	0.000002
Cadmium	16.9	0.000009
Chromium (total)	284	0.000142
Cobalt	19.9	0.000010
Lead	36.2	0.000018
Manganese	31.2	0.000016
Mercury	18.6	0.000009
Nickel	176.0	0.000088
Selenium	35.9	0.000018

^{A} = Assumes a collection volume of 2,000 m^3.

EPA Compendium Method IO-3.5 specifies procedures for the multi-element determination of trace elements by inductively coupled plasma/mass spectrometry (ICP/MS). For this method, ambient air is pulled through filter media using a high volume sampler as described in Section 2.2.2. The particulate phase sample is collected on the filter, after which the filter (containing the sampled particulate) is digested in an acid solution. The sample material in solution is transferred by pneumatic nebulization into a source of radio frequency plasma where energy transfer processes cause desolvation, atomization, and ionization. The ions are extracted from the plasma

through a differentially pumped vacuum interface and separated on the basis of their mass-to-charge ratio by a quadrapole mass spectrometer having a minimum resolution capability of 1 atomic mass unit (amu) peak width at 5% peak height. The ions transmitted through the quadrapole are registered by a continuous dynode electron multiplier, and the ion information is processed by a data handling system yielding measured concentrations. EPA-approved SOPs were adhered to for these analyses. Certificate of analyses for all trace metal samples are presented in Appendix C.

2.2.4 Continuous Particulate Measurements

Met One Instrument's real-time Electronic Beta Attenuation Monitor (EBAM) was used to collect continuous volumetric mass measurements of PM_{10} at one site (i.e., Site 1) and $PM_{2.5}$ at three sites (i.e., Sites 1, 6A, and 8). EBAMs are portable self-contained units that meet or exceed all EPA requirements for automated particulate measurement.

Beta attenuation is the measurement of the decrease in the number of beta particles due to absorption by the filter media employed. The EBAM uses ^{14}Carbon, a naturally occurring radioactive isotope, as the source for beta particles. ^{14}Carbon beta particles are electrons emitted from the nucleus of an atom when a neutron decays to a proton and an electron. This electron is a subatomic particle with a mass of 0.00054858 amu and an average energy of 49 kilo electron volt (KeV). Due to the low mass and energy, beta particles can only travel short distances through the air (e.g., 1–2 feet); this allows the beta particles to be completely attenuated on the filter media used by the system, which in turn, allows the mass measurements to be made.

For each 10-minute averaging period, the EBAM devices measure collected particulate in a three-step process:

- Step 1: A first, or preliminary, particle count was made across the unexposed filter media.
- Step 2: Particle laden air was passed through the filter media and the associated particulate was deposited for measurement.
- Step 3: A second, or final, count was made across the filter media with the deposited particulate.

The second count was less than the first count due to the absorption of beta particles by the deposited particulate. Based on calibration data, particulate mass was quantitated based on the beta particle reduction observed. The measured mass was then divided by the volume of air sampled across the 10-minute duration to calculate the concentration of mass per volume of air sampled.

The monitors used to measure $PM_{2.5}$ incorporated a PM_{10} pre-cutter inlet followed by a Sharp Cut $PM_{2.5}$ cyclone. The monitors used to measure PM_{10}, however, incorporated a PM_{10} pre-cutter inlet only. These components ensure that the devices measure the desired particle size ranges. The measurement range for the EBAMs was 0–10 milligrams per cubic meter (mg/m^3), and the

measurement frequency was one averaged concentration per every 10 minutes of sampling. Data were stored automatically to a unit-specific internal DAS.

2.2.5 Meteorological Measurements

Meteorological parameters were measured using two stand-alone meteorological monitoring systems attached to secured tripods or mast assemblies. One monitoring system was set up at Site 1 and another at Site 10. Each system incorporated the following sensor technologies:

- A cup anemometer to measure wind speed: The cup anemometer used three wind-catching cups that relate the rate of rotation (i.e., revolutions per second) to the speed of the wind at the time of measurement. Calibration data for the sensor measuring the revolutions per second were used to calculate the corresponding wind speed in meters per second.

- A directional mast and vane to measure wind direction: The mast and vane used a balanced fin, mounted on a vertical shaft. As wind force was applied, the shaft rotated seeking the minimum force position. The shaft turned within a vane transducer/potentiometer and supplied an analog output signal. The transducer was fixed in a position orientating it towards the direction of North. Transducer calibration data allowed the analog signal to be converted into 0–360 degree compass directions.

- A resistance temperature detector (RTD) to measure ambient temperature: The RTD used a thermistor resistance bridge to provide the relationship between temperature (as ^{B}F) and output signal change. Calibration data for the thermistor were used to calculate corresponding temperature measurements.

- A resistance/capacitance wire-wound salt-coated bobbin assembly to measure relative humidity: The bobbin assembly used a thin hygroscopic film affected by the presence of moisture to provide the relationship between percent relative humidity and output signal change. Calibration data for the bobbin sensor were used to calculate the corresponding relative humidity measurements.

Measurements were made at a height of approximately 160 feet above grade (15th story roof top level) at Site 1, and approximately 10–12 feet above grade at Site 10. Electronic signals from the meteorological monitoring systems' sensors were collected and stored using HOBO Micro Station DASs and BoxCar^{7} Pro 4.3 software.

3.0 Quality Assurance/Quality Control

This section presents various quality assurance and quality control (QA/QC) measures implemented throughout the Mirant PRGS EI.

3.1 Data Quality Objectives

Data quality objectives (DQOs) determine how good data must be to achieve a project's specific technical goals and objectives. This EI used DQOs to develop the criteria that the data collection

design should satisfy, including where to conduct monitoring, when to conduct monitoring, measurement frequency, and acceptable measurement precision and accuracy. The operational DQOs (see Table 3-1) and technical DQOs (see Table 3-2) are consistent with the goals and objectives of this EI, considering the monitoring logistics, target pollutants, and specifications of the monitoring and sampling collection systems used.

Table 3-1. Operational DQOs

Operational Element	*Objective*
Where to conduct monitoring (siting)	All monitoring locations must be in close proximity to the potentially impacted population.
When to conduct monitoring (duration)	Daily from 0000 to 2359 hours across 6 continuous weeks.
Frequency of monitoring (measurement intervals)	Continuous for SO_2, $PM_{2.5}$, PM_{10}, and meteorological parameters to allow assessment of short duration excursions and calculations of hourly and daily average concentrations. For TSP/trace metals samples, 24-hour average measurements on a pre-determined schedule that includes all days of the week across the duration of the EI.

Table 3-2. Technical DQOs

Technical Element	*Objective*
Measurement completeness	80% data capture or greater
SO_2 measurement precision	+/- 20% relative standard deviation (RSD)
SO_2 measurement accuracy	+/- 15% difference
Trace metals measurement precision	+/- 20% RSD
Trace metals measurement accuracy	+/- 25% difference

3.1.1 Operational DQOs

The Mirant PRGS EI met all of its specified operational DQOs. Detailed operational DQO performance information is presented below.

- Siting: As presented in Section 2.1, all monitoring locations were within 0.75 miles of the Mirant PRGS facility: four were located less than 0.25 miles from the facility, two were between 0.25 and 0.50 miles away, and the remaining four were between 0.50 and 0.75 miles away. The selected monitoring locations represent a mixture of settings in terms of population density, transportation patterns, potential for building downwash, and other factors.

- Duration: The monitoring program began on June 8 and ended on July 23, for a total duration of just over 6 weeks. Measurements occurred throughout the day, whether using continuous monitoring or integrated sampling techniques. See Table 2-2 for the duration of sampling organized by monitoring location and pollutant.

- Measurement intervals: SO_2 and meteorological measurements occurred continuously, with outputs recorded every minute. $PM_{2.5}$ and PM_{10} were also measured continuously, with

outputs recorded at 10-minute intervals. The TSP and trace metals measurements were based on 24-hour integrated samples, following the sampling schedule in Table 2-2.

3.1.2 Technical DQOs

The Mirant PRGS EI met all of its technical DQOs, except for the technical DQO for SO_2 measurement accuracy (as described further below):

- Measurement completeness: For this EI, completeness was defined as the number of valid measurements collected, compared to the number of possible measurements expected. Monitoring programs that consistently generate valid results tend to have higher measurement completeness than programs that consistently invalidate samples. Therefore, the completeness of an air monitoring program is a qualitative measure of the reliability of air sampling and laboratory analytical equipment and the efficiency with which the field program and laboratory analysis was managed.

- Measurement precision: For this EI, measurement precision was defined as the ability to acquire the same concentration from the same or from different instruments with an acceptable level of uncertainty, while concurrently sampling the same gas stream. In other words, precision characterizes the repeatability of measurements made by a particular monitoring or measurement approach.

- Measurement accuracy: For this EI, measurement accuracy was defined as the ability to acquire the correct concentration measurement from an instrument or an analysis within an acceptable level of uncertainty. Accuracy was assessed to determine whether systematic deviations occurred from the true concentrations being reported.

Technical DQO performance and quality control information is presented below, organized by pollutant.

3.1.2.1 SO_2

Measurement Completeness

Measurement completeness for SO_2 ranged from 96.16% at Site 8 to 100.00% at Site 7, with an overall completeness of 99.29% (see Table 3-3).

Measurement Precision

As part of the pre- and post-deployment QC checks, the SO_2 SPM instruments were challenged with known concentrations of SO_2 standard gas. During these challenges, 13 instruments[1] each completed 10 concentration determinations (labeled in Table 3-4 as "M-1" through "M-10") during the pre- and post-deployment challenges. An overall estimate of measurement precision, expressed as % RSD, was calculated using the average concentration from the 10 determinations

[1] Thirteen instruments were considered in this testing. Some of these instruments were deployed to the field as back-up devices to be used if any measurement instrument malfunctioned.

Table 3-3. SO_2 Measurement Completeness

Site ID	*Total Possible Measurements*	*Valid Measurements*	*Invalid Measurements*	*Completeness (%)*
Site 1	62,978	62,970	8	99.99
Site 2	63,009	63,002	7	99.99
Site 3	60,287	59,627	660	98.91
Site 4	62,791	62,135	656	98.96
Site 5	62,878	62,231	647	98.97
Site 6A	63,256	63,248	8	99.99
Site 6B	64,694	64,689	5	99.99
Site 7	63,184	63,181	3	100.00
Site 8	61,621	59,256	2,365	96.16
Site 9	63,113	63,108	5	99.99
Site 10—primary	64,135	63,220	915	98.57
Site 10—collocated	63,292	63,221	71	99.89
Overall	755,238	749,888	5,350	99.29

made by the 13 instruments considered; instrument-specific measurement precision was also quantified. As Table 3-4 shows, the pre-deployment challenge revealed instrument-specific measurement precision ranging from 0.26% RSD to 0.82% RSD, with an overall method measurement precision of 0.45% RSD, and the post-deployment challenge revealed instrument-specific measurement precision ranging from 0.33% RSD to 0.85% RSD, with an overall method measurement precision of 0.56% RSD.

Further insights into measurement precision were gleaned from the co-located SPM monitoring devices that operated at Site 10 throughout the program. Because these two devices concurrently measured SO_2 concentrations, the expectation would be that the devices' measurements would be reasonably comparable. This comparison, however, was difficult to implement due to the magnitude of concentrations measured at Site 10. Specifically, more than 95% of the measurements from the instruments resulted in either non-detect observations or measurements marginally higher than the MDL (i.e., in the range of 4.0 to 4.6 ppbv). In this concentration range, measurements are known to be highly variable. In many cases, one instrument reported a valid concentration (typically near the detection limit), while the other reported a non-detect, greatly limiting the ability to compute precision estimates using RSD. To better assess the precision from the co-located measurements, the data set was restricted to only those instances in which both devices recorded valid concentrations above the detection limit. The average concentrations from the two co-located instruments for this subset of data—5.35 ppbv for the primary instrument and 4.10 ppbv for the secondary instrument—showed reasonable agreement (13.23% RSD).

Table 3-4. SO_2 Measurement Precision (Direct Challenge)

Sys. #	*Ref. Conc. (ppbv)*	*M-1*	*M-2*	*M-3*	*M-4*	*M-5*	*M-6*	*M-7*	*M-8*	*M-9*	*M-10*	*M-avg*	*M-stdev*	*RSD (%)*	*Difference (%)*
1	173	175	175	176	175	175	176	175	176	175	175	175.3	0.46	0.26	1.33
2		172	172	172	173	173	173	174	174	174	174	173.1	0.83	0.48	0.06
3		171	172	173	172	171	172	171	172	173	172	171.9	0.70	0.41	0.64
4		177	177	177	177	176	176	176	177	177	176	176.6	0.49	0.28	2.08
5		173	175	174	175	174	173	173	174	175	175	174.1	0.83	0.48	0.64
6		176	176	176	176	176	176	175	175	176	175	175.7	0.46	0.26	1.56
7		171	172	171	173	172	173	173	171	172	172	172	0.77	0.45	0.58
8		169	168	169	168	169	170	170	169	170	170	169.2	0.75	0.44	2.20
9		174	175	176	174	175	176	174	175	176	174	174.9	0.83	0.47	1.10
10		170	170	170	170	170	170	171	171	171	171	170.4	0.49	0.29	1.50
11		172	174	173	176	175	172	173	174	173	171	173.3	1.42	0.82	0.17
12		179	177	175	176	178	178	179	177	176	177	177.2	1.25	0.70	2.43
13		177	175	177	175	177	176	178	175	176	177	176.3	1.00	0.57	1.91
Pre-deployment average		173.5	173.7	173.8	173.8	173.9	173.9	174.0	173.8	174.2	173.8	173.8	0.79	0.45	1.24
1	163	166	166	165	163	166	163	165	166	166	164	165	1.18	0.72	1.23
2		161	161	161	162	161	162	163	161	161	161	161.4	0.66	0.41	0.98
3		160	161	163	161	163	162	160	162	163	161	161.6	1.11	0.69	0.86
4		166	167	168	168	168	166	167	168	167	168	167.3	0.78	0.47	2.64
5		163	163	165	163	166	164	163	163	165	164	163.9	1.04	0.64	0.55
6		165	165	165	166	166	167	166	166	165	165	165.6	0.66	0.40	1.60
7		160	160	161	160	161	159	161	162	163	160	160.7	1.10	0.68	1.41
8		159	160	162	160	159	162	163	161	160	159	160.5	1.36	0.85	1.53
9		164	164	164	165	164	164	165	163	164	164	164.1	0.54	0.33	0.67
10		159	160	160	161	161	160	160	161	162	160	160.4	0.80	0.50	1.60
11		163	162	163	164	163	162	161	162	163	163	162.6	0.80	0.49	0.25
12		168	169	168	169	168	167	169	169	168	167	168.2	0.75	0.44	3.19
13		168	169	167	166	168	167	169	169	166	166	167.5	1.20	0.72	2.76
Post-deployment average		163.2	163.6	164.0	163.7	164.2	163.5	164.0	164.1	164.1	163.2	163.8	0.92	0.56	1.48
Overall method average														0.51	1.36

Note: This table presents data for 13 different "systems" or SPM devices. Thirteen devices were deployed to the field, which included the devices that were installed at the ten monitoring locations (see Table 2-1), plus additional back-devices to be used in the event that some malfunctioned.

Measurement Accuracy

Given that the SPM devices do not carry a Reference Method designation from EPA, several different measures were employed to assess the devices' measurement accuracy. The following discussion describes the different ways that accuracy was assessed, with conclusions presented at the end of this section. As noted earlier, the SPM measurements did not meet the program's DQO for measurement accuracy.

Pre- and post-deployment accuracy checks:

As was done for measurement precision, pre- and post-deployment QC checks were conducted by challenging each of the SO_2 SPM instruments with a known concentration of SO_2 standard gas to evaluate measurement accuracy. During the challenges, each instrument completed ten concentration determinations (labeled in Table 3-4 as "M-1" through "M-10"). The average concentrations from the ten determinations were used to calculate instrument-specific and overall method-specific estimates of accuracy, expressed as the percent difference. As Table 3-4 shows, instrument specific measurement accuracy ranged from 0.06% to 2.43% difference for the pre-deployment QC checks, and from 0.25% to 3.19% difference for post-deployment QC checks, with an overall method accuracy difference of 1.36%. These gas challenges were performed in the controlled setting of an analytical laboratory.

Post-deployment comparative analysis:

Recognizing that the SPM is not designated by EPA as a reference or equivalent method for measuring SO_2, ATSDR conducted additional quality assurance activities to ensure that the SPM measurements are representative. It should be noted that ATSDR does not require that only reference or equivalent methods be used in these studies, because the purpose of an EI is not regulatory in nature (see Exposure Investigation Overview). Nonetheless, to better qualify the measurement performance of the SO_2 SPM instruments, a comparative analysis was conducted to assess the performance of two SO_2 SPM instruments used during the EI. In this analysis, measurements made by these two devices were compared to those made by an EPA equivalent reference method instrument (i.e., a Thermo Electron Corporation Model 43i SO_2 analyzer, ERM Designation EQSA-0486-060). In this test, laboratory personnel simultaneously challenged the ERM analyzer and the two SO_2 SPM instruments with zero gas (i.e., 0.0 ppbv) and three concentration levels of SO_2 (i.e., 20.2, 79.8, and 168.6 ppbv). As Table 3-5 depicts, the SPMs and the ERM instrument all measured SO_2 concentrations to a high degree of accuracy. This analysis was also performed in the controlled setting of an analytical laboratory.

Table 3-5. Instrument Response Comparison Data

Reference Concentration (ppbv)	*SPM 1 Response (ppbv)*	*Relative Difference (%)*	*SPM 2 Response (ppbv)*	*Relative Difference (%)*	*ERM Instrument Response (ppbv)*	*Relative Difference (%)*
0.0	0	0.0	0	0.0	0[1]	0.0[1]
168.6	165	2.2	167	1.0	169[2]	-0.2[2]
79.8	75	6.2	77	3.6	78	2.3
20.2	16	23.2	17	17.2	19	6.1
Overall relative difference (%)	10.5		7.2		2.7	
Linearity (R^2)	0.9997		0.9998		0.9999	

[1]ERM instrument zero adjusted
[2]ERM instrument span adjusted

Both instrument types presented higher potential for negative measurement bias as the applicable MDLs were approached. This observation suggested that the SO_2 SPM instruments during the EI may have possibly under-reported actual ambient concentrations, considering that most measurements were close to the lower end of the SPM instrument detection range.

Supplemental comparative SO_2 field measurement study:

Given the implications of the comparative study, further exploration was warranted to evaluate the performance of the SO_2 SPM instruments in a field setting. Accordingly, ATSDR conducted additional quality assurance measures. A follow-up field study was conducted in June/July 2009 to more fully evaluate the accuracy and precision of SPM SO_2 field measurements under a variety of instrument configurations and field conditions. The study was designed to determine relative differences in concentrations of SO_2 as measured by two types of monitoring devices: SPMs and monitors that have received EPA Equivalent Reference Method (ERM) status.

The study involved the simultaneous collection of a representative quantity of high quality field measurements data from a single location to allow the comparability of measurements between the SPM and ERM instrument technologies. All laboratory pre-test and post-recovery calibration checks and quality control checks of the SPMs met data quality objectives. All field procedures were conducted in strict accordance with study protocol requirements. The study revealed that the SPMs with the same wet configuration used in the Mirant PRGS EI field program performed poorly, with the SPMs consistently underreporting SO_2 concentrations by a considerable margin.

Detailed quantitative findings of this study are detailed in the report titled ATSDR Sulfur Dioxide Measurements Comparative Field Application Study (ATSDR, 2009).

Conclusion on SO_2 Measurement Accuracy:

In summary, pre- and post-deployment checks conducted in a laboratory setting suggested that the SPMs would meet the technical DQO for SO_2 measurement accuracy. Post-deployment comparison of SO_2 concentrations measured by SPMs to those measured by ERM monitors in a laboratory setting also indicated that the SPMs would meet the technical DQO, but also suggested a possible underreporting of SO_2 by the SPMs. These findings led to a more definitive study conducted under field conditions (instead of in the controlled setting of a laboratory). The extensive supplemental field measurement study documented considerable underreporting of SO_2 by the SPMs under field conditions. It is not clear why the SPM devices performed well in the laboratory and not in the field, but because of these findings, ATSDR has concluded that the SO_2 data collected during the Mirant PRGS EI may not be accurate and therefore should not be used to support its public health evaluation. In addition, since the EI SPM SO_2 results may not be accurate, the actual measurements collected during the program are not presented in this report.

Other Quality Control Activities

To assess performance of the SO_2 SPM instruments in the field, sampling personnel performed two additional QC activities: 1) optical performance checks and 2) sample flow rate checks.

- Optical performance checks were performed to ensure that the SPM instrument lamp and detector assembly was functioning within manufacturer specifications. In this optical check, a manufacturer-supplied test card is inserted into the optical path and the instrument response is recorded. When the lamp and detector assembly is performing properly, the instrument produces a response between 10 and 13 mA. Across the duration of the EI, three optical performance checks were performed on each SO_2 SPM instrument. For these checks, responses ranged from 11.1 mA to 11.6 mA, indicating that every instrument performed within manufacturer specifications (see Table 3-6).

Table 3-6. Field Optical Performance Check Data

Site ID	*Instrument Response*					
	Date	*mA*	*Date*	*mA*	*Date*	*mA*
1	06/08/07	11.4	06/29/07	11.3	07/22/07	11.4
2	06/08/07	11.1	06/29/07	11.1	07/22/07	11.2
3	06/10/07	11.2	06/29/07	11.1	07/22/07	11.1
4	06/08/07	11.4	06/29/07	11.4	07/22/07	11.3
5	06/08/07	11.4	06/29/07	11.3	07/22/07	11.3
6A	06/08/07	11.3	06/29/07	11.3	07/22/07	11.3
6B	06/08/07	11.2	06/29/07	11.1	07/22/07	11.2
7	06/08/07	11.3	06/29/07	11.2	07/22/07	11.5
8	06/09/07	11.6	06/29/07	11.6	07/22/07	11.6
9	06/08/07	11.3	06/29/07	11.3	07/22/07	11.2
10-primary	06/08/07	11.4	06/29/07	11.2	07/22/07	11.3
10-collocated	06/08/07	11.3	06/29/07	11.1	07/22/07	11.4

- Sample flow rate checks were performed to ensure that each SPM sampled air at rates within manufacturer specifications. During these checks, field personnel measured the flow rate with which the SPMs pulled ambient air into the instrument. The flow rate was measured using a primary flow measurement standard, in this case a 0–6 Lpm Buck Calibrator. Properly operating SPMs have flow rates of approximately 1 Lpm (+/- 20%). Across the duration of the EI, four sample flow rate checks were conducted on each SO_2 SPM instrument. For these checks, flow rates ranged from 0.81 Lpm to 1.17 Lpm, indicating that every instrument performed within manufacturer specifications (see Table 3-7).

Table 3-7. Sample Flow Rate Check Data

Site ID	*Date*	*Flow Rate (Lpm)*	*Date*	*Flow Rate (Lpm)*	*Date*	*Flow Rate (Lpm)*	*Date*	*Flow Rate (Lpm)*
1	5/30/07	1.13	6/23/07	1.09	7/11/07	1.05	7/21/07	1.09
2	5/30/07	1.16	6/23/07	1.10	7/11/07	1.13	7/21/07	1.17
3	5/30/07	0.93	6/23/07	0.97	7/11/07	1.01	7/21/07	0.99
4	5/30/07	0.81	6/23/07	0.81	7/11/07	0.83	7/21/07	0.85
5	5/30/07	1.09	6/23/07	1.11	7/11/07	1.01	7/21/07	0.98
6A	5/30/07	0.84	6/23/07	0.83	7/11/07	0.88	7/21/07	0.81
6B	5/30/07	0.96	6/23/07	1.01	7/11/07	0.94	7/21/07	1.03
7	5/30/07	1.13	6/23/07	1.09	7/11/07	1.16	7/21/07	1.17
8	5/30/07	0.88	6/23/07	0.93	7/11/07	0.94	7/21/07	0.88
9	5/30/07	0.87	6/23/07	0.90	7/11/07	0.93	7/21/07	0.96
10-primary	5/30/07	1.03	6/23/07	1.01	7/11/07	0.98	7/21/07	1.02
10-collocated	5/30/07	0.99	6/23/07	1.04	7/11/07	1.07	7/21/07	1.08

3.1.2.2 TSP/Trace Metals

Measurement Completeness

Measurement completeness for TSP/trace metals was 100% at all sites, with an overall completeness of 100% (see Table 3-8).

Table 3-8. TSP/Trace Metals Measurement Completeness

Site ID	*Total Possible Samples*	*Valid Measurements*	*Invalid Measurements*	*Completeness (%)*
Site 1	17	17	0	100
Site 6A	17	17	0	100
Site 8	17	17	0	100
Site 10	17	17	0	100
Overall	68	68	0	100

Measurement Precision

Eight TSP/trace metals samples, representing all four TSP monitoring sites across the duration of the EI, were selected to receive both primary and duplicate laboratory analyses. This approach provided two sets of measurements for each of the eight samples to allow calculation of

measurement precision. For each measurement pair, the concentration difference was calculated for the individual trace metals and a program-average RSD (%) was calculated for the individual trace metals. Overall, measurement precision data met the program DQO and ranged from 0.0% RSD for beryllium to 10.19% RSD for mercury (see Table 3-9).

Table 3-9. TSP/Trace Metals Measurement Precision

Pollutant	*Average Concentration Difference (ng/m^3)*	*Average RSD (%)*
Antimony	0.06	1.47
Arsenic	0.04	1.72
Beryllium	0.00	0.00
Cadmium	0.02	5.89
Chromium (total)	0.09	1.78
Cobalt	0.02	2.74
Lead	0.43	4.27
Manganese	0.48	2.22
Mercury	0.01	10.19
Nickel	0.13	2.57
Selenium	0.04	1.31

Measurement Accuracy

Measurement accuracy for TSP/trace metals was determined through the analysis of independently generated performance evaluation (PE) audit samples. ERG manages and operates the National Monitoring Programs for EPA; and one of these programs is the National Air Toxics Trends Stations (NATTS). For NATTS, ERG regularly performs analyses to determine the presence and concentration of trace metals from ambient air filter samples. TSP/trace metals analyses for ATSDR were performed in the same laboratory, by the same staff, using the same instrumentation, and following the same procedures as applied to the NATTS Program. Under NATTS, the ERG laboratory regularly receives PE audit samples from EPA to assess the accuracy of the analyses being performed. The most recent PE audit occurred on July 19, 2007, during the Mirant PRGS EI. Based on the results of this PE audit, TSP/trace metals measurement accuracy ranged from -24.0% difference for manganese to 17.2% difference for beryllium (see Table 3-10). These observations all fall within the measurement accuracy DQO established for the Mirant PRGS EI.[2]

[2] It is important to note that these observations are presented to demonstrate the high accuracy of ERG's laboratory analyses of TSP/metals samples based on an independent evaluation, with this particular audit conducted under an EPA program. Not every metal sampled for during the Mirant EI was considered in the EPA PE sample.

Table 3-10. TSP/Trace Metals Performance Evaluation Audit Data

Analyte	*Reported Value (µg/filter)*	*Assigned Value (µg/filter)*	*Difference (%)*
Antimony	0.766	0.930	-17.6
Arsenic	0.938	0.830	13.0
Beryllium	0.844	0.720	17.2
Cadmium	0.616	0.580	6.2
Lead	1.03	1.03	-0.0
Manganese	0.707	0.930	-24.0
Nickel	0.817	0.920	-11.2

Quality Control Activities

To ensure that TSP/trace metals measurements were representative of the ambient air being monitored, three unused (or blank) filters were analyzed to assess the potential for contamination. These blank filters were from the same batch of filters used to collect TSP/trace metals samples during the EI, and had traveled to the field and back to the laboratory in accordance with the procedures associated with the regular TSP/trace metals samples. According to EPA (1999), this method requires three types of blanks, where "a calibration blank establishes the analytical calibration curve, a laboratory reagent blank assesses possible contamination from the sample preparation procedure and spectral background, and a rinse blank flushes the instrument between samples to reduce memory interferences" (EPA 1999). As presented in Table 3-11, background concentrations were very low and consistent with the requirements of the monitoring method.

Table 3-11. TSP/Trace Metals Filter Blank Data

Target Metal	*Blank 1 (µg/filter)*	*Blank 2 (µg/filter)*	*Blank 3 (µg/filter)*
Antimony	0.02	0.01	0.01
Arsenic	0.02	0.01	0.01
Beryllium	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00
Chromium (total)	3.21	2.61	2.43
Cobalt	0.02	0.02	0.02
Lead	0.32	0.55	0.09
Manganese	0.33	0.18	0.18
Mercury	0.01	0.01	0.04
Nickel	1.00	0.69	0.57
Selenium	0.01	0.02	ND

Overall, the mass loadings of metals on the blank filters are consistent with the analytical laboratory's experience with applying this sampling and analytical method. The relatively higher average detections of some metals (e.g., chromium, nickel) most likely result from the presence of these constituents in the sampling filter media. As noted later in this report, the metal loadings of chromium, mercury, and nickel observed in the actual ambient air samples are comparable to the average metal loadings for these metals in the blanks. Accordingly, all measurement results in this program for chromium, mercury, and nickel should be viewed as estimated results.

3.1.2.3 Continuous Particulate ($PM_{2.5}$ and PM_{10})

Measurement Completeness

Measurement completeness for continuous particulate monitoring ranged from 95.27% for $PM_{2.5}$ to 99.97% for PM_{10}; both at Site 1, with an overall completeness of 98.45% (see Table 3-12).

Table 3-12. Continuous Particulate Measurement Completeness

Site ID	*Pollutant*	*Total Possible Measurements*	*Valid Measurements*	*Invalid Measurements*	*Completeness (%)*
Site 1	PM_{10}	6,451	6,449	2	99.97
Site 1	$PM_{2.5}$	6,454	6,149	305	95.27
Site 6A	$PM_{2.5}$	6,477	6,469	8	99.88
Site 8	$PM_{2.5}$	6,336	6,253	83	98.69
Overall		25,718	25,320	398	98.45

Quality Control Activities

All particulate monitoring devices were operated according to the manufacturer specifications. The primary quantifiable quality control measure was to assess sample flow rates prior to deployment and compare these to manufacturer specifications. The flow rate was measured using a primary flow measurement standard, in this case a 0-30 Lpm Buck Calibrator. According to the manufacturer, properly-operating instruments have flow rates of 16.7 liters per minute (+/- 2%). For these checks, as shown in Table 3-13, flow rates ranged from 16.4 to 16.7 liters per minute, indicating that every instrument performed within manufacturer specifications.

Table 3-13. Sample Flow Rate Check Data

Site ID	*Pollutant*	*Instrument Flow Rate Setting (Lpm)*	*Actual Measured Flow Rate (Lpm)*	*Difference (%)*
Site 1	$PM_{2.5}$	16.7	16.4	1.8
Site 1	PM_{10}	16.7	16.7	0.0
Site 6A	$PM_{2.5}$	16.7	16.4	1.8
Site 8	$PM_{2.5}$	16.7	16.5	1.2

3.1.2.4 Meteorological Parameters

Measurement Completeness

The following meteorological parameters were measured at two separate sites during the EI: temperature, relative humidity, wind speed, and wind direction. Throughout the duration of the EI, no malfunctions occurred with any of the sensors used to monitor these parameters, and data were only lost during brief periods required to download the data (i.e., approximately 10 minutes each week at each of the two sites). Measurement completeness for meteorological parameters monitoring was 99.97% at Site 1 and 99.98% at Site 10, with an overall completeness of 99.98% (see Table 3-14).

Table 3-14. Meteorological Parameters Measurement Completeness

Site ID	*Total Possible Measurements*	*Valid Measurements*	*Invalid Measurements**	*Completeness (%)*
Site 1†	62,985	62,967	18	99.97
Site 10†	63,376	63,363	13	99.98
Overall	126,361	126,330	31	99.98

***** For meteorological measurements, the term "invalid" in this table refers to measurements that could not be collected because the system was offline due to data downloading.

† Meteorological parameters were combined to measure completeness at each site.

4.0 Results

The following section discusses measurement results obtained during the Mirant PRGS EI monitoring conducted from June 8 to July 23, 2007. This section reviews measurements for SO_2, PM_{10}, $PM_{2.5}$, TSP, trace metals, and meteorological parameters. See Table 2-2 for the specific dates when each pollutant was collected at each site.

When available, ATSDR compared the measurement results to health-based comparison values (CVs) (see text box)—screening values that enable ATSDR to identify contaminants requiring further evaluation. To be protective of public health, screening values are generally based on contaminant concentrations *many times lower than levels at which no effects were observed* in experimental animals or human epidemiologic studies. Therefore, exposure to concentrations detected above CVs will not necessarily cause adverse health effects. ATSDR further evaluates concentrations detected above CVs on a case-by-case basis to identify any potential public health implications. Specifically for the Mirant PRGS EI, screening values consisted of ATSDR's minimal risk levels (MRLs) and EPA's NAAQS. More details on these screening values are presented below by pollutant. In a separate report, ATSDR will evaluate the public health significance of the concentrations measured during this EI.

> ATSDR defines a comparison value (CV) as a calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

4.1 SO_2

As described in Section 3.1.2.1, ATSDR has determined that the SO_2 monitoring data collected during the EI are of insufficient quality for characterizing human exposure. Subsequent field testing of the SO_2 SPM technology used during the Mirant PRGS EI revealed consistent underreporting of SO_2 compared with data measured using ERM technology. For this reason, quantitative SO_2 data measured during the EI are not presented in this report.

Limited inferences can be made from the SO_2 monitoring data collected during the EI, due to the evidence that the measurement devices understated actual ambient air concentrations. As expected, the measurements indicated that SO_2 concentrations varied with location and time of day, but quantitative evaluation of these spatial and temporal variations is not recommended given the apparent bias in the measurements. Moreover, while the EI recorded a small percentage of measurements greater than ATSDR's acute MRL for SO_2, such observations are also of questionable utility given the knowledge that the measured concentrations were likely considerably lower than the actual concentrations. However, even though the EI SPM SO_2 data was considered unsuitable to use for characterizing human exposures, other SO_2 datasets were available to ATSDR for this purpose (see Health Consultation Review of Ambient Air Data).

4.2 PM_{10}

PM_{10} was continuously monitored during the EI (see Table 2-2) at one site, Site 1, an outdoor monitoring location. Concentrations were averaged over 10-minute periods, and program-

average and highest 24-hour average concentrations were obtained based on these 10-minute average concentrations. The highest 24-hour average PM_{10} concentration of 58.5 μg/m^3 at Site 1 was nearly 60% less than the 24-hour NAAQS of 150 μg/m^3. Accordingly, none of the 24-hour average PM_{10} concentrations exceeded the NAAQS. The program-average concentration of PM_{10} at Site 1 was 23.6 μg/m^3, but no air quality standard exists to enable a comparison.[3]

4.3 $PM_{2.5}$

During the EI, monitoring was conducted continuously over 10-minute averaging periods for $PM_{2.5}$. As shown in Table 4-1, monitoring occurred at three sites—Site 1, Site 6A, and Site 8—which were all outdoor monitoring locations. The highest 24-hour average $PM_{2.5}$ concentrations, calculated using the 10-minute average concentrations, were 44.4 μg/m^3 at Site 6A, 48.0 μg/m^3 at Site 1, and 55.8 μg/m^3 at Site 8. All of these highest 24-hour average concentrations exceeded the 24-hour NAAQS of 35 μg/m^3 for $PM_{2.5}$. These exceedances were infrequent, however, with 24-hour $PM_{2.5}$ concentrations detected above the NAAQS on only 5 days during the EI: 6/8/07 (Site 1), 6/19/07 (Sites 1, 6A, and 8), 6/28/07 (Sites 1 and 8), 7/9/07 (Sites 1 and 8), and 7/10/07 (Site 8).

Table 4-1. Summary of Ambient Air Monitoring of $PM_{2.5}$

Site	*Ambient Air Concentration (μg/m^3)*	
	Program-Average	*Highest 24-Hour Average*
Site 1	21.5	48.0
Site 6A	17.9	44.4
Site 8	18.4	55.8

Monitoring was conducted at Site 1 and Site 6A from 6/8/07 to 7/23/07, and at Site 8 from 6/9/07 to 7/23/07.
All measurements presented in this table are outdoor air samples.

Program-average concentrations of $PM_{2.5}$ were 17.9 μg/m^3 at Site 6A, 18.4 μg/m^3 at Site 8, and 21.5 μg/m^3 at Site 1. The program-average concentrations for all three sites exceeded the annual $PM_{2.5}$ NAAQS of 15 μg/m^3; however, the significance of this comparison is limited given that the EI program lasted just over 6 weeks, and the 15 μg/m^3 NAAQS is an annual standard.

4.4 TSP/Trace Metals

4.4.1 TSP

As detailed in Section 2.2.2, TSP samples were collected at four sites (i.e., Sites 1, 6A, 8, and 10) during the EI, with integrated outdoor air samples collected on a 24-hour basis (see Table 2-2 for the TSP sampling dates). The average ambient concentrations of TSP over the investigation period were 35.35 μg/m^3 at Site 1, 43.47 μg/m^3 at Site 6A, 36.46 μg/m^3 at Site 8, and 50.06 μg/m^3 at Site 10. No federal air quality standards or ATSDR comparison values are available for TSP. The health implications of exposure to these concentrations will be further evaluated and discussed in a separate ATSDR report.

[3] In 2006, EPA revoked its annual PM_{10} standard of 50 μg/m^3 due to a lack of scientific evidence proving a link between long-term exposure to coarse particle pollution and health effects (see www.epa.gov/air/criteria.html).

4.4.2 Trace Metals

As shown in Table 4-2 and Table 4-3, 11 trace metals were sampled at four monitoring locations (i.e., Sites 1, 6A, 8, 10), with integrated outdoor air samples collected on a 24-hour basis (see Table 2-2 for the time period that trace metals were collected at each site). These 24-hour integrated samples were used to calculate the program-average (Table 4-2) and highest 24-hour average (Table 4-3) concentrations at each of the four monitoring stations. In the case of duplicate samples, duplicate observations were averaged together to obtain one concentration for each monitoring date.

Table 4-2. Program-Average Concentrations of Trace Metals

Pollutant	*Program-Average Concentration (µg/m^3)*			
	Site 1	*Site 6A*	*Site 8*	*Site 10*
Antimony	0.0015	0.0019	0.0015	0.0025
Arsenic	0.00084	0.00080	0.00085	0.00088
Beryllium	0.000014	0.000014	0.000014	0.000016
Cadmium	0.00015	0.00014	0.00013	0.00022
Chromium (total)*	0.0023	0.0023	0.0022	0.0028
Cobalt	0.00019	0.00025	0.00020	0.00038
Lead	0.0050	0.0067	0.0046	0.0049
Manganese	0.0083	0.011	0.0089	0.014
Mercury*	0.000029	0.000021	0.000017	0.000018
Nickel*	0.0018	0.0017	0.0016	0.0029
Selenium	0.0012	0.0012	0.0013	0.0011

See Table 2-2 for the dates monitoring occurred.
At all four sampling stations listed, 17 valid samples were collected.
All measurements presented in this table are outdoor air samples.
On dates when duplicate samples were collected, the average of the two measurements was used when generating the summary statistics.
*Concentrations should be viewed as estimated results, due to the average amount of these metals identified in the field blanks (see Section 3.1.2.2).

Table 4-3. Highest 24-Hour Average Concentrations of Trace Metals

Pollutant	*Highest 24-Hour Average Concentration (µg/m³)*			
	Site 1	*Site 6A*	*Site 8*	*Site 10*
Antimony	0.0040	0.0039	0.0020	0.0053
Arsenic	0.0014	0.0014	0.0013	0.0017
Beryllium	0.000040	0.000030	0.000040	0.000040
Cadmium	0.00030	0.00030	0.00027	0.00091
Chromium (total)*	0.0032	0.0029	0.0029	0.0050
Cobalt	0.00035	0.00046	0.00034	0.00088
Lead	0.012	0.017	0.011	0.011
Manganese	0.012	0.020	0.013	0.029
Mercury*	0.000085	0.000040	0.000030	0.000030
Nickel*	0.0036	0.0038	0.0042	0.011
Selenium	0.0020	0.0021	0.0025	0.0017

See Table 2-2 for the dates monitoring occurred at each site.
At all four sampling stations listed, 17 valid samples were collected.
All measurements presented in this table are outdoor air samples.
On dates when duplicate samples were collected, the average of the two measurements was used when generating the summary statistics.
*Concentrations should be viewed as estimated results, due to the average amount of these metals identified in the field blanks (see Section 3.1.2.2).

As detailed below and shown in Table 4-2, maximum program-average concentrations for 8 of the 11 trace metals were detected at Site 10, while minimum program-average concentrations were most often found at Site 8. The range of program-average concentrations for each monitored metal is as follows[4]:

- Antimony: ranged from 0.0015 µg/m³ at Site 1 and Site 8 to 0.0025 µg/m³ at Site 10.
- Arsenic: ranged from 0.00080 µg/m³ at Site 6A to 0.00088 µg/m³ at Site 10.
- Beryllium: ranged from 0.000014 µg/m³ at Sites 1, 6A, and 8 to 0.000016 µg/m³ at Site 10.
- Cadmium: ranged from 0.00013 µg/m³ at Site 8 to 0.00022 µg/m³ at Site 10.
- Chromium (total): ranged from 0.0022 µg/m³ at Site 8 to 0.0028 µg/m³ at Site 10.
- Cobalt: ranged from 0.00019 µg/m³ at Site 1 to 0.00038 µg/m³ at Site 10.
- Lead: ranged from 0.0046 µg/m³ at Site 8 to 0.0067 µg/m³ at Site 6A.
- Manganese: ranged from 0.0083 µg/m³ at Site 1 to 0.014 µg/m³ at Site 10.
- Mercury: ranged from 0.000017 µg/m³ at Site 8 to 0.000029 µg/m³ at Site 1.
- Nickel: ranged from 0.0016 µg/m³ at Site 8 to 0.0029 µg/m³ at Site 10.
- Selenium: ranged from 0.0011 µg/m³ at Site 10 to 0.0013 µg/m³ at Site 8.

[4] As Section 3.1.2.2 notes, the measured concentrations of chromium (total), mercury, and nickel should be viewed as estimated results, due to the average amount of these metals identified in the field blanks.

Intermediate or chronic MRLs are available for chromium (hexavalent),[5] cobalt, manganese, mercury, and nickel; a NAAQS is available for lead. Table 4-4 presents the maximum program-average concentrations for these trace metals compared to their respective health-based comparison values. As Table 4-4 shows, all of these maximum program-average concentrations fall below their respective comparison values, ranging from 3 times less than the chronic MRL for manganese to nearly 7,000 times less than the chronic MRL for mercury.

Table 4-4. Program-Average Concentrations of Trace Metals with Comparison Values

Pollutant	*Site*	*Maximum Program-Average Concentration ($\mu g/m^3$)*	*Comparison Value ($\mu g/m^3$)*	*Type of Comparison Value*	*Is the Maximum Program-Average Concentration Above or Below the Comparison Value?*
Chromium (total)*	Site 10	0.0028	1	Intermediate MRL (chromium, hexavalent)[5]	Below (356 times less)
Cobalt	Site 10	0.00038	0.1	Chronic MRL	Below (262 times less)
Lead	Site 6A	0.0067	1.5	NAAQS	Below (223 times less)
Manganese	Site 10	0.014	0.04	Chronic MRL	Below (3 times less)
Mercury*	Site 1	0.000029	0.2	Chronic MRL	Below (6896 times less)
Nickel*	Site 10	0.0029	0.09	Chronic MRL	Below (30 times less)

*Concentrations should be viewed as estimated results, due to the average amount of these metals identified in the field blanks (see Section 3.1.2.2).

As detailed below and shown in Table 4-3, a similar trend was seen with the highest 24-hour average concentrations–namely, the highest levels observed occurred at Site 10 for 8 of the 11 trace metals considered in this EI. The range of highest 24-hour average concentrations for each monitored metal is as follows[6]:

- Antimony: ranged from 0.002 $\mu g/m^3$ at Site 8 to 0.0053 $\mu g/m^3$ at Site 10.
- Arsenic: ranged from 0.0013 $\mu g/m^3$ at Site 8 to 0.0017 $\mu g/m^3$ at Site 10.
- Beryllium: ranged from 0.00003 $\mu g/m^3$ at Site 6A and to 0.00004 $\mu g/m^3$ at Site 10.
- Cadmium: ranged from 0.00027 $\mu g/m^3$ at Site 8 to 0.00091 $\mu g/m^3$ at Site 10.
- Chromium (total): ranged from 0.0029 $\mu g/m^3$ at Site 6A and Site 8 to 0.005 $\mu g/m^3$ at Site 10.
- Cobalt: ranged from 0.00034 $\mu g/m^3$ at Site 8 to 0.00088 $\mu g/m^3$ at Site 10.
- Lead: ranged from 0.011 $\mu g/m^3$ at Site 8 and Site 10 to 0.017 $\mu g/m^3$ at Site 6A.
- Manganese: ranged from 0.012 $\mu g/m^3$ at Site 1 to 0.029 $\mu g/m^3$ at Site 10.
- Mercury: ranged from 0.00003 $\mu g/m^3$ at Site 8 and Site 10 to 0.000085 $\mu g/m^3$ at Site 1.
- Nickel: ranged from 0.0036 $\mu g/m^3$ at Site 1 to 0.011 $\mu g/m^3$ at Site 10.

[5] ATSDR has not developed a health-based comparison value for total chromium. Therefore, the MRL for hexavalent chromium was used to conduct an initial screen.

[6] As Section 3.1.2.2 notes, the measured concentrations of chromium (total), mercury, and nickel should be viewed as estimated results, due to the average amount of these metals identified in the field blanks.

- Selenium: ranged from 0.0017 μg/m^3 at Site 10 to 0.0025 μg/m^3 at Site 8.

No ATSDR acute CVs are available for comparison. In a separate report, ATSDR will evaluate the public health implications of short-term exposure to the highest 24-hour average concentrations identified during the EI.

4.5 Meteorological Parameters

As described in Section 2.2.5, two on-site systems (i.e., one at Site 1 and one at Site 10) collected continuous meteorological measurements. Site 1 and Site 10 used a measurement height of approximately 160 feet (48.8 meters) and 10–12 feet (3.0–3.7 meters) above ground level, respectively. Meteorological data were also obtained for a National Weather Service station, located 3 miles away from Mirant PRGS at the Ronald Reagan Washington National Airport in Washington, DC. Meteorological data from this station were obtained for the same time period as data were collected during the EI (i.e., June–July 2007), and compared to the measurements collected in the investigation area. This airport NWS station used a tower height of approximately 32.8 feet (10 meters) above ground level.

4.5.1 Wind Direction and Speed

Surface wind observations include two primary components: wind speed and wind direction. Wind speed is a scalar value, which was measured in meters per second (m/s). Wind direction describes the direction from which the wind is blowing and is measured in degrees, where 0E is from due north, 90E is from due east, 180E is from due south, and 270E is from due west.

Figures 4-1 and 4-2 summarize the wind speed and direction data for Sites 1 and 10, respectively, in a format known as a wind rose. These figures indicate that 51.87% and 39.58% of the wind observations were classified as calm for Site 1 and Site 10, respectively. They also show differences in prevailing wind directions, presumably due to the considerably different mast heights employed. For comparison and reference, Figure 4-3 shows a wind rose constructed using meteorological data obtained for the Ronald Reagan Washington National Airport NWS station for the same time period as the Mirant PRGS EI. As shown in the figure, the frequency of calm winds was 8.04% at the airport NWS during the investigation period.

Figure 4-1. Wind Rose for the Site 1 Meteorological Station

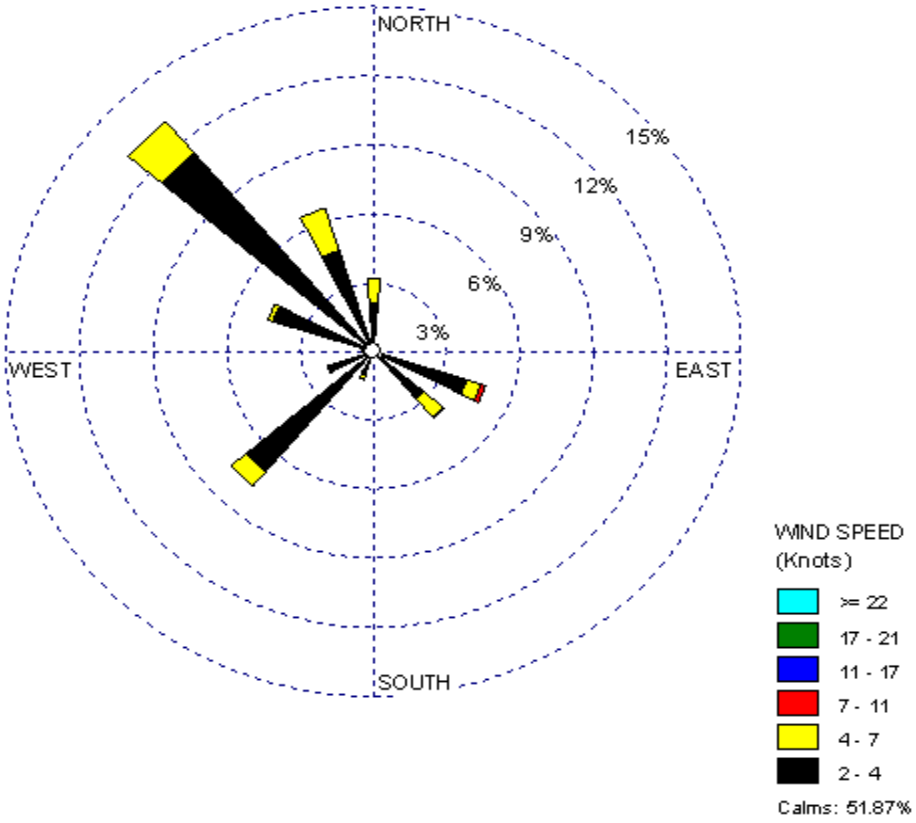


Figure 4-2. Wind Rose for the Site 10 Meteorological Station

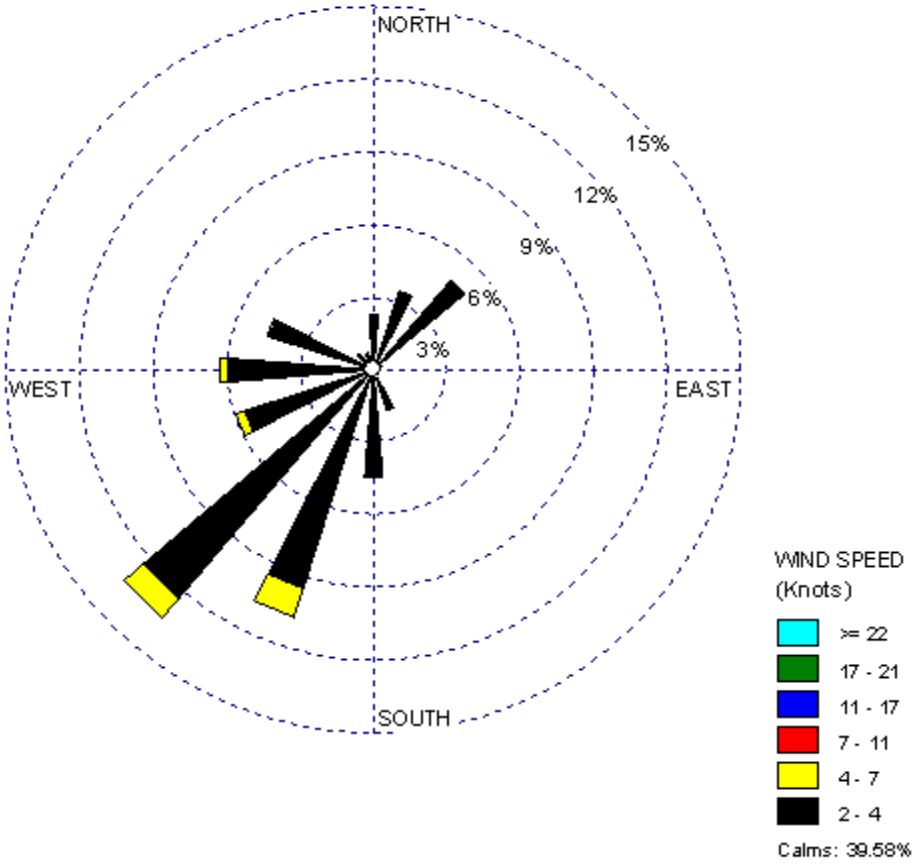
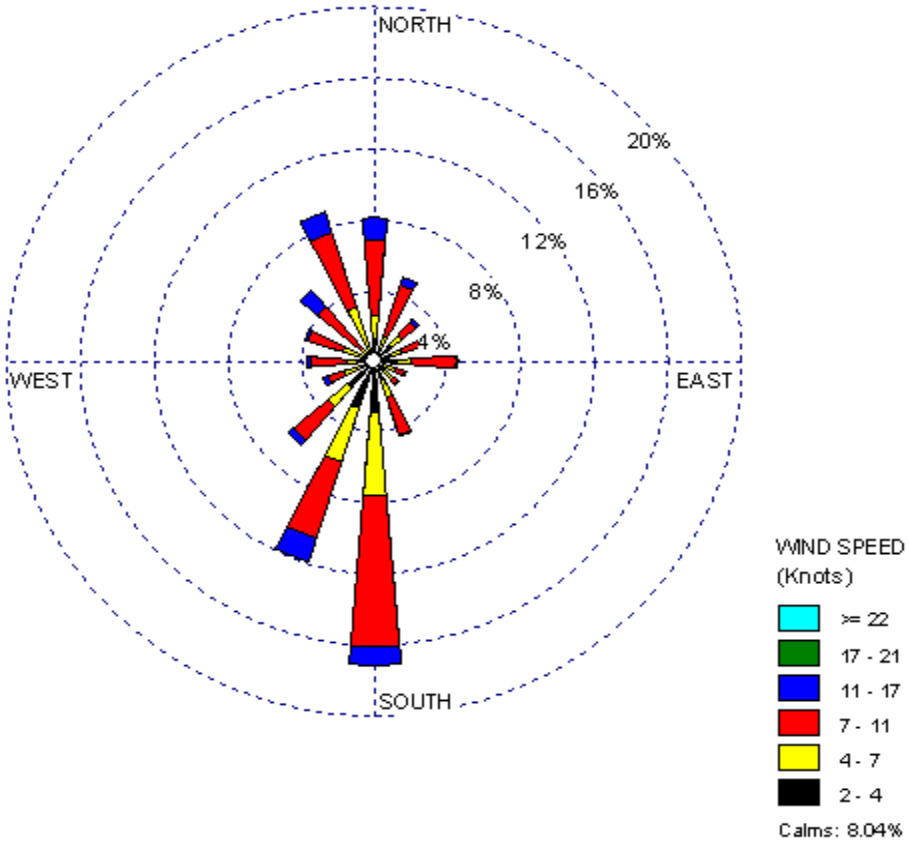


Figure 4-3. Wind Rose for the Ronald Reagan Washington National Airport NWS Station



4.5.2 Temperature

Table 4-5 summarizes temperature measurements for Site 1, Site 10, and the airport NWS station for the investigation period. Overall, the temperatures in the EI area match well with those reported at the Ronald Reagan Washington National Airport NWS station, with average temperatures at Site 1 (78.35°F) and Site 10 (78.40°F) within 1 degree of the airport station (77.22°F).

Table 4-5. Temperature Data Summary

Site	*Time Period*	*Minimum Temperature (°Fahrenheit)*	*Maximum Temperature (°Fahrenheit)*	*Average Temperature (°Fahrenheit)*	*Standard Deviation (°Fahrenheit)*
Site 1	Overall	59	98	78.35	7.52
Site 10	Overall	55.28	101.79	78.40	9.06
Ronald Reagan Washington National Airport NWS station*	Overall	60	97	77.22	7.46

*NWS measurements are based on hourly observations; Site 1 and Site 10 measurements are based on 1-minute average observations.

4.5.3 Humidity

Table 4-6 summarizes relative humidity measurements for Site 1, Site 10, and the airport NWS station for the investigation period. Overall, the minimum, maximum, and average relative humidity measurements for Site 1 and Site 10 matched well with those for the airport NWS station.

Table 4-6. Relative Humidity Data Summary

Site	*Time Period*	*Minimum Relative Humidity (%)*	*Maximum Relative Humidity (%)*	*Average Relative Humidity (%)*	*Standard Deviation (%)*
Site 1	Overall	22	96	57.86	17.58
Site 10	Overall	21.75	98.75	60.54	19.33
Ronald Reagan Washington National Airport NWS station*	Overall	22	97	59.37	17.39

*NWS measurements are based on hourly observations; Site 1 and Site 10 measurements are based on 1-minute average observations.

5.0 Conclusions

ATSDR, with assistance from ERG, conducted an exposure investigation to measure the levels of pollutants in residential communities near the Mirant Potomac River Generating Station. The EI consisted of a 6-week ambient air monitoring program conducted from June 8 to July 23, 2007, in Alexandria, VA. ATSDR considered the following pollutants because they are likely to be emitted from coal-fired electricity generating facilities and have measurable health endpoints: SO_2, PM_{10}, $PM_{2.5}$, and 11 trace metals (i.e., antimony, arsenic, beryllium, cadmium, total chromium, cobalt, lead, manganese, mercury, nickel, and selenium).

The Mirant PRGS EI was developed to address eight DQOs designed for the data generated during the monitoring program. The EI DQOs, presented in Table 5-1, were met with the exception of the DQO for SO_2 measurement accuracy. Consequently, the SO_2 data set collected during the EI was determined to be of insufficient quality and is not presented in this report. However, data sets for other parameters (i.e., particulate matter, metals, meteorology) were found to be of a known and high quality and suitable for use in ATSDR's public health assessment process.

Table 5-1. Operational and Technical DQOs for the Mirant PRGS EI

Element	*Objective*
Where to conduct monitoring (siting)	All sites located in close proximity to the potentially impacted population, in accordance with the grid ring approach.
When to conduct monitoring (duration)	Daily from 0000 to 2359 hours across 6 continuous weeks.
Frequency of monitoring (measurement intervals)	Continuous for SO_2, $PM_{2.5}$, PM_{10}, and meteorological parameters to allow assessment of short duration excursions and calculations of hourly and daily average concentrations. Episodic for TSP/trace metals samples collection on a pre-determined schedule that characterized all days of the week across the duration of the EI.

Measurement completeness	80% data capture or greater
Element	***Objective***
SO_2 measurement precision	+/- 20% relative standard deviation (RSD)
SO_2 measurement accuracy	+/- 15% difference
Trace metals measurement precision	+/- 20% RSD
Trace metals measurement accuracy	+/- 25% difference

5.1 Overview of Findings

Technical conclusions and observations are presented below by pollutant.

5.1.1 SO_2

SO_2 was continuously monitored at all ten monitoring locations. However, ATSDR has concluded that the SO_2 measurements collected during the EI using SPM instrumentation most likely are not accurate.

The SPMs were tested rigorously prior to field applications and shown to generate highly precise and accurate data in the controlled setting of a laboratory. Though SPM equipment gave every indication to be functioning properly in the field, ATDSR has concluded that the equipment configuration used during the EI is likely underreporting SO_2 concentrations under field conditions. This conclusion is based on the results of an extensive field study conducted subsequent to the EI. The study, designed to test the accuracy and precision of SPM SO2 measurements under different SPM instrument configurations and field conditions, revealed consistent and significant underreporting of SO_2 when compared to SO_2 measured concurrently by instruments with EPA ERM status.

5.1.2 PM_{10}

Continuous outdoor PM_{10} monitoring occurred at Site 1, with concentrations averaged over 10-minute periods. The highest 24-hour average PM_{10} concentration—58.5 $\mu g/m^3$—was nearly 60% less than the 24-hour NAAQS of 150 $\mu g/m^3$. The program-average concentration of PM_{10} at Site 1 was 23.6 $\mu g/m^3$, but no ATSDR comparison value or EPA air quality standard is available for screening purposes.

5.1.3 $PM_{2.5}$

Continuous outdoor $PM_{2.5}$ monitoring occurred at three locations: Sites 1, 6A, and 8. The highest 24-hour average $PM_{2.5}$ concentrations—44.4 $\mu g/m^3$ at Site 6A, 48.0 $\mu g/m^3$ at Site 1, and 55.8 $\mu g/m^3$ at Site 8—all exceeded the 24-hour NAAQS of 35 $\mu g/m^3$. Exceedances were infrequent, however, with 24-hour average $PM_{2.5}$ concentrations only observed above EPA's 24-hour NAAQS on the following five dates: 6/8/07, 6/19/07, 6/28/07, 7/9/07, and 7/10/07. Program-average concentrations of $PM_{2.5}$ were 17.9 $\mu g/m^3$ at Site 6A, 18.4 $\mu g/m^3$ at Site 8, and 21.5 $\mu g/m^3$ at Site 1, all of which exceeded the annual NAAQS of 15 $\mu g/m^3$. However, this comparison is not entirely appropriate, given that the monitoring program occurred over 6 weeks and the NAAQS (i.e., 15 $\mu g/m^3$) is an annual standard.

5.1.4 TSP/Trace Metals

5.1.4.1 TSP

Twenty-four-hour integrated TSP samples were collected at four sites: 1, 6A, 8, and 10. The average ambient TSP concentrations during the EI period were 35.35 μg/m^3 at Site 1, 43.47 μg/m^3 at Site 6A, 36.46 μg/m^3 at Site 8, and 50.06 μg/m^3 at Site 10. No federal air quality standards or ATSDR comparison values are available for TSP. The health implications of exposure to these concentrations will be further evaluated and discussed in a separate ATSDR report.

5.1.4.2 Trace Metals

At four monitoring locations, 24-hour integrated particulate samples were collected and analyzed for 11 trace metals. Maximum program-average concentrations for 8 of the 11 trace metals were detected at Site 10, while minimum program-average concentrations were most often found at Site 8. The range of program-average concentrations varied by metal[7]:

- Antimony: 0.0015 μg/m^3 (Site 1 and Site 8) to 0.0025 μg/m^3 (Site 10)
- Arsenic: 0.00080 μg/m^3 (Site 6) to 0.00088 μg/m^3 (Site 10)
- Beryllium: 0.000014 μg/m^3 (Sites 1, 6, and 8) to 0.000016 μg/m^3 (Site 10)
- Cadmium: 0.00013 μg/m^3 (Site 8) to 0.00022 μg/m^3 (Site 10)
- Chromium (total): 0.0022 μg/m^3 (Site 8) to 0.0028 μg/m^3 (Site 10)
- Cobalt: 0.00019 μg/m^3 (Site 1) to 0.00038 μg/m^3 (Site 10)
- Lead: 0.0046 μg/m^3 (Site 8) to 0.0067 μg/m^3 (Site 6)
- Manganese: 0.0083 μg/m^3 (Site 1) to 0.014 μg/m^3 (Site 10)
- Mercury: 0.000017 μg/m^3 (Site 8) to 0.000029 μg/m^3 (Site 1)
- Nickel: 0.0016 μg/m^3 (Site 8) to 0.0029 μg/m^3 (Site 10)
- Selenium: 0.0011 μg/m^3 (Site 10) to 0.0013 μg/m^3 (Site 8)

ATSDR has developed intermediate or chronic MRLs for chromium (hexavalent), cobalt, manganese, mercury, and nickel; and EPA has published a NAAQS for lead. All of the maximum program-average concentrations fell below their respective comparison values, with trace metals ranging from 3 times (manganese) to nearly 7,000 times (mercury) less than these comparison values.

Similarly, the maximum highest 24-hour average concentrations for 8 of the 11 trace metals were detected at Site 10, while the minimum concentrations were most often found at Site 8. The range of highest 24-hour average concentrations is presented below.[8]

[7] As Section 3.1.2.2 notes, the measured concentrations of chromium (total), mercury, and nickel should be viewed as estimated results, due to the average amount of these metals identified in the field blanks.
[8] As Section 3.1.2.2 notes, the measured concentrations of chromium (total), mercury, and nickel should be viewed as estimated results, due to the average amount of these metals identified in the field blanks.

- Antimony: 0.002 μg/m^3 (Site 8) to 0.0053 μg/m^3 (Site 10)
- Arsenic: 0.0013 μg/m^3 (Site 8) to 0.0017 μg/m^3 (Site 10)
- Beryllium: 0.00003 μg/m^3 (Site 6) to 0.00004 μg/m^3 (Site 10)
- Cadmium: 0.00027 μg/m^3 (Site 8) to 0.00091 μg/m^3 (Site 10)
- Chromium (total): 0.0029 μg/m^3 (Site 6 and Site 8) to 0.005 μg/m^3 (Site 10)
- Cobalt: 0.00034 μg/m^3 (Site 8) to 0.00088 μg/m^3 (Site 10)
- Lead: 0.011 μg/m^3 (Site 8 and Site 10) to 0.017 μg/m^3 (Site 6)
- Manganese: 0.012 μg/m^3 (Site 1) to 0.029 μg/m^3 (Site 10)
- Mercury: 0.00003 μg/m^3 (Site 8 and Site 10) to 0.000085 μg/m^3 (Site 1)
- Nickel: 0.0036 μg/m^3 (Site 1) to 0.011 μg/m^3 (Site 10)
- Selenium: 0.0017 μg/m^3 (Site 10) to 0.0025 μg/m^3 (Site 8)

No ATSDR acute CVs are available for comparison. In a separate report, ATSDR evaluated the public health implications of short-term exposure to the highest 24-hour average concentrations identified during the EI (see Health Consultation Review of Ambient Air Data).

5.1.5 Meteorological Parameters

Two on-site systems (i.e., one at Site 1 and one at Site 10) were established to collect continuous meteorological measurements. In addition, a National Weather Service station collected data during the EI at the Ronald Reagan Washington National Airport. Temperature and humidity data were highly consistent across these three stations. On the other hand, wind speed data collected at Sites 1 and 10 were lower than those collected at the NWS station, and wind direction data varied across the sites, most likely reflecting differences in siting of measurement devices.

5.2 Data Gaps and Use Limitations

ATSDR acknowledges that all scientific investigations, such as this Mirant PRGS EI, have limitations. These include:

- Electricity generating facilities release a wide range of pollutants. While this EI focused on the pollutants believed to be of greatest health concern, not every pollutant emitted from the Mirant PRGS facility was monitored.

- Monitoring was conducted at fixed, stationary monitoring locations; however, people move around, and do not remain in one place all day long. Therefore, the monitoring data collected at the fixed locations are not directly equivalent to actual exposures that may have occurred, particularly for longer averaging periods (i.e., 24-hour averages and longer).

- The monitoring data collected during this program represent air quality conditions during June and July 2007, and may not represent conditions during other times of the year. That

being said, ATSDR intentionally conducted the EI during June and July because these months were believed to represent a peak exposure time frame, due to electricity demand, people spending more time outside during the summer, and other factors.

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Appendix E. Sulfur Dioxide Health Evaluation

Appendix E. Sulfur Dioxide Health Evaluation.

ATSDR's preliminary assessment of air dispersion modeling data suggested concern for peak (5-minute) sulfur dioxide (SO_2) exposures (Appendix B)[1]. This appendix describes how ATSDR addressed potential exposures to SO_2 identified in the Mirant Potomac River Generating Station (PRGS) 5-minute data.

ATSDR addresses health issues in public health assessments using both quantitative and qualitative methods. For SO_2, the qualitative strength of evidence approach will serve a primary role in deciding the public health significance of SO_2 levels. The strength of evidence approach requires (1) a thorough review of the scientific literature for health effects from acute and chronic exposures, (2) an evaluation of the potential for sensitive groups to be exposed, (3) the evaluation of site-specific exposure scenarios, and (4) the evaluation of co-exposures to other air pollutants.

While health guidelines describe levels believed to be safe from exposure to a specific chemical on a population basis, they do not describe the likelihood of adverse health effects for exposures above that value. As part of ATSDR's strength of evidence evaluation, we evaluate the likelihood of harmful effects occurring should a health guideline be exceeded. The site-specific evaluation will consider sensitive populations, co-exposures to other contaminants, and the location, frequency, duration and time-of-day the exposures occur.

ATSDR evaluated exposures to SO_2 using the following criteria:

Screening Assessment

ATSDR screened data to select all SO_2 detections above 10 ppb, ATSDR's acute minimal risk level (MRL) [2]. Acute exposures <10 ppb SO_2 are not likely to cause adverse health effects. The MRL is a screening level below which exposure is believed to be without adverse (non-cancerous) health effects to all populations, including sensitive groups. The MRL is not a threshold for health effects, but exposures to concentrations above the MRL will be evaluated further using the strength of evidence approach and site-specific factors.

Health Effects Assessment

ATSDR evaluated potential health effects in the health consultation by considering the locations of concentrations of SO_2 of concern, the time-of-day, the frequency and duration of SO_2 peaks of concern, and co-exposure to other contaminants. The following identifies the SO_2 concentration ranges and associated ATSDR level of concern.

>10 – 400 ppb SO_2.

ATSDR recognizes the variability in asthmatic response and uncertainty associated with adopting any single SO_2 concentration as a level of concern.

Exposures to 10 - 400 ppb SO_2 appears to be the range of most uncertainty as to whether an effect will occur and whether that effect should be considered adverse. ATSDR will use the Mirant 5-minute data to conduct a site-specific assessment in order to characterize the likelihood of health effects occurring in this range.

Exposures in this range may be considered a public health hazard depending on the frequency and duration of exposure, co-exposures to other contaminants, and exposure of potentially more sensitive populations, such as children and individuals with pre-existing respiratory disease. Exposures in this range will be evaluated using a site-specific strength of evidence approach.

Peak exposures (5 -minutes) above 10 ppb SO_2 to 400 ppb SO_2 are described as a dose-response continuum (Table E-1) where higher concentrations in this range are more likely to cause a response in a greater number of sensitive individuals than lower concentrations in this range. Clinical exposures in this range resulted in a response in healthy mild-to-moderate asthmatic adults and adolescents who were exercising (at an increased ventilation rate). Severe asthmatics, unhealthy individuals, and children were not included in these studies. These populations may be more sensitive than the populations that were included in the clinical studies. The lowest effect level reported in human clinical studies was 100 ppb SO_2 via mouthpiece exposure (oral breathing) which bypasses the protective effect of the nasal mucosa [3, 4]. The lowest level reported for effects in free-breathing or oronasal breathing subjects occurred about 200-250 ppb SO_2 [5, 6]. An estimated 5 - 30 % of asthmatics are believed to be sensitive to exposures between 200 and 300 ppb SO_2 and experience moderate or greater decrements in lung function (greater than or equal to a 100% increase in sRaw (airway resistance) and/or greater than or equal to a 15% decrease in Forced Expiratory Volume in 1 second, or FEV1) [7]. Further, an estimated 20 – 35 % of exercising asthmatics experience moderate or greater lung function decrements at SO_2 concentrations 400 – 500 ppb [7].

Acute effects reported in exercising adult and adolescent asthmatics exposed to <400 ppb SO_2 (5 minutes) are considered less serious than those exposed to > 400 ppb SO_2 (exposures <500 ppb do not usually require the individual to cease the activity, do not usually require medication, and do not usually require the individual to seek medical attention). Effects up to 250 ppb SO_2 are equivalent to reported effects of asthmatic responses to exercise alone [8]. Effects such as bronchoconstriction may not be perceived by the exposed individuals at the lower end of this range and symptoms (coughing, wheezing, dyspnea) begin to appear > 400 ppb SO_2.

Exposures of 10 ppb to 400 ppb SO_2 (5 minutes) may be considered of variable *public health concern*, depending on the intensity, frequency and duration of SO_2 exposure. Although about 200 ppb is the lower level of mild to moderate asthmatics experiencing effects while at increased ventilation rates in clinical studies, these studies did not include potentially more susceptible individuals and

were performed at laboratory conditions of controlled humidity and temperature, whereas actual exposures may occur at colder and dryer conditions which have been reported to result in an increased response [9, 10]. The Environmental Protection Agency (EPA) examined potential 5-minute health benchmark values in the 100 – 400 ppb range in the second draft of the Risk and Exposure Assessment to Support the Review of the SO_2 Primary National Ambient Air Quality Standards [11]. In addition, the frequency and duration of exposures may increase the risk for longer-term health effects leading to respiratory or cardiac disease. For example, increased frequency and duration of exposure to SO_2 leading to a 24-hour average concentration of 140 ppb SO_2, the EPA National Ambient Air Quality Standard (NAAQS), or an annual average of 30 ppb SO_2 (EPA annual average NAAQS) may be considered a *public health hazard to all populations.* In epidemiological studies, SO_2-related respiratory effects were consistently reported at lower concentrations than the clinical studies observed and in areas where the maximum ambient 24-hour average SO_2 concentration was below the current 24-hour average NAAQS level of 140 ppb.

A decrease in heart rate variability has been reported in asthmatic adults exposed to 200 ppb SO_2 for 60 minutes [12]. The significance of these short-term effects to chronic cardiac endpoints is still being investigated but such exposures suggest the need for public health concern.

>400-1000 ppb SO_2

Exposures >600 ppb and less than 1000 ppb SO_2 (5 minutes) may cause adverse health effects in an estimated 35 - 60 % of exercising asthmatics and an unknown portion of other sensitive populations [7]. Effects in exercising adult or adolescent asthmatics exposed to this concentration range may include more serious health effects which necessitate (1) stopping the exercise, (2) taking medication, or (3) seeking medical attention. Exposures in this concentration range may be considered a *public health hazard to sensitive populations at elevated ventilation rates.*

>1000 ppb SO_2

Exposures to >1000 ppb SO_2 (5 minutes) are considered an *acute public health hazard to all populations.*

Sensitive populations

The following populations are considered sensitive or potentially sensitive to SO_2 exposures in that the response to SO_2 may be more severe or occur at a lower threshold than the general population.

Asthmatics

Many asthmatics are very sensitive to SO_2 exposure [13]. The referenced SO_2 exposure ranges above are based on exposure to exercising asthmatic adults and adolescents.

Children

Children may be at increased risk from exposure to ambient air contaminants with respect to both toxicology and exposure. It is not clear that children are more toxicologically sensitive to SO_2 but may be more vulnerable because of increased exposure. While physiologically-based pharmacokinetic modeling has suggested that children may be more vulnerable in the pulmonary region to fine particulate matter, it also suggests that children's airways may not be more sensitive than adults to reactive gases such as SO_2 [14].

Factors that may contribute to enhanced lung deposition in children include higher ventilation rates, less contribution from nasal breathing, less efficient uptake of particles in the nasal airways, and greater deposition efficiency of particle and some vapor phase chemicals in the lower respiratory tract. A child breathes faster compared to an adult, which may result in increased uptake [15]. Children spend 3 times as much time outdoors as adults and engage in 3 times as much time playing sports and other vigorous activities [16]. Based on these parameters, children are more likely to be exposed to more outdoor air pollution than adults. Epidemiological evidence suggests that air pollution effects (lung function decrements) in children may not be fully reversible, even if the exposure stops, although SO_2 was not a major contaminant in these studies [17].

Other SO_2 sensitive or vulnerable populations

Other sensitive populations may include obese individuals, individuals have chronic pro-inflammatory state like diabetics, older adults (65+ years), and individuals with pre-existing respiratory and cardiopulmonary disease [18]. Vulnerable individuals are those who spend time outdoors at increased exertion levels and may include children, outdoor workers, and individuals who play sports or exercise outdoors.

Adverse health effects.

What constitutes an adverse health effect has long been debated [19]. Whether a less serious observed effect to SO_2 exposures in the 100 – 400 ppb range is considered an adverse health effect is still the subject of uncertainty. Some scientists consider a biological effect as an adverse effect only if the effect is medically significant in that the subject must take medication, seeks medical treatment (hospital or medical practitioner visit), or must stop the activity in which the subject was engaged. Other scientists consider a biological effect to be adverse if the exposure reduces the reserve function of the lung, reducing the subject's ability to withstand additional insults.

ATSDR recognizes the variability in asthmatic response and uncertainty associated with adopting any single health comparison value. ATSDR has described the reported range of health effects from the scientific literature in the range of most uncertainty, 10 – 400 ppb SO_2. ATSDR needs to make a site-specific assessment in order to characterize the likelihood of health effects occurring in this range. A site-specific evaluation would consider the location of

SO_2 concentrations, the frequency, duration, time-of-day and day-of-week, and co-exposures to other contaminants.

Severity and incidence of respiratory symptoms has been shown to increase with increasing concentrations between 200 and 600 ppb SO_2 in free-breathing exercising asthmatic adults following peak exposures (5-10 minutes). Statistically significant increases in symptoms (chest tightness, coughing, or wheezing) are observed at concentrations > or = 400 ppb SO_2.

Exposure to concentrations at or above 200 ppb SO_2 is considered by ATSDR to potentially result in a diminished capacity to respond to exposures to other agents in sensitive individuals at elevated ventilation rates. The diminished capacity results from a moderate or greater decrement in lung function (i.e. increases in sRaw > or = 100% or decrease in FEV1 > or = 15% in 5-30% of exercising asthmatics at 200-300 ppb SO_2 with 5-10 minute exposures). This diminished capacity from the decrement in lung function is considered an ***adverse health effect***. This adverse health effect may be considered a ***public health hazard to sensitive populations at elevated ventilation rates*** depending on the potential impact of site-specific frequency and duration of exposure as well as the temporal and spatial considerations and co-exposure potential. In addition, exposure must occur to a sensitive individual while at an elevated ventilation rate.

Exposure to concentrations at or above 400 ppb SO_2 may result in the increasing potential for the development of symptoms (chest tightness, coughing, and wheezing) in sensitive populations at elevated ventilation rates. SO_2 induces moderate or greater decrements in lung function (described above) in 20-60 % of asthmatics at 400 – 1000 ppb SO_2 with 5-10 minute exposures.

Exposure to concentrations at or above 600 ppb SO_2 is considered a ***public health hazard to sensitive populations at elevated ventilation rates*** because of the increasing potential that medical intervention may be appropriate.

These conclusions are based on clinical investigations reported in peer-reviewed scientific literature. These clinical investigations are based on responses in typically mild to moderate healthy adult asthmatics at elevated ventilation rates in controlled temperature and humidity environments. Due to ethical considerations, investigations do not usually involve severe asthmatics, children, or unhealthy individuals. These and other potentially sensitive or vulnerable individuals (obese individuals, individuals with pro-inflammatory state like diabetics, adults greater than 65 years, and individuals with pre-existing respiratory and cardiopulmonary disease) may be at risk for effects at lower SO_2 concentrations or more severe effects at equivalent concentrations. In addition, sensitive populations may experience an exacerbation of effects from exposure to dry, cold air or co-exposure to other agents such as particulate matter or ozone. Therefore, adverse health effects could occur to the more vulnerable or sensitive individuals at levels below 200 ppb SO_2. While clinical investigations have not addressed free-

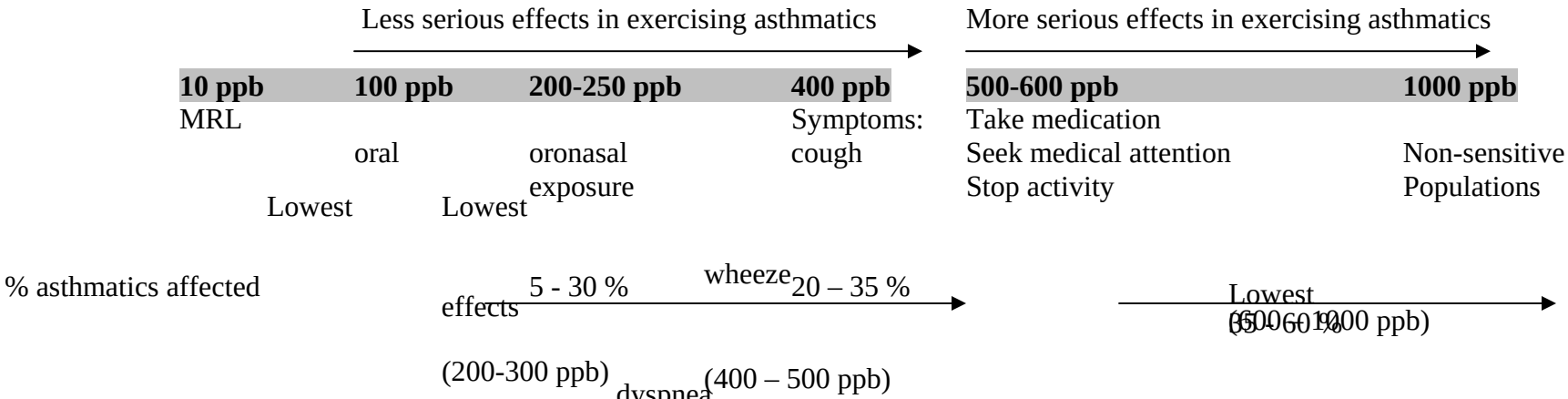
breathing levels below 200 ppb, mouthpiece investigations have reports effects at 100 ppb.

Epidemiological studies have provided consistent evidence of an association between ambient SO_2 exposures and increased respiratory symptoms in children, particularly those with asthma or chronic respiratory symptoms. Multicity studies have observed these associations at a median range of 17 to 37 ppb (75^{th} percentile: -25 to 50) across cities for 3-hr average SO_2 and 2.2 to 7.4 ppb (90^{th} percentile: 4.4 to 14.2) for 24-hr average SO_2 [20].

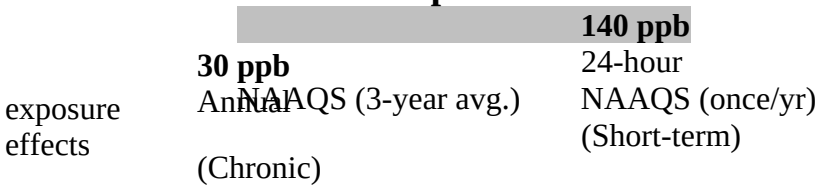
Table E-1. Sulfur Dioxide Concentrations of Interest

Peak exposures

Respiratory effects in clinical studies. Peak exposures < 15 minutes.



Chronic and short-term exposures[1]



[1]EPA is proposing the replacement of the annual average and 24-hour average NAAQS with a 1-hour average NAAQS [21].

Health Guideline Values

The following are health-based guidelines for sulfur dioxide.

Short-term health-based criteria (based on human clinical studies)		
ATSDR Acute MRL screening level (10 min)		10 ppb
UK/N Ireland	(15 minutes)	100 ppb
	(60 minutes)[1]	135 ppb
WHO 2005 Guidelines [2]	(10 minutes)	190 ppb
CA EPA[1]	(60 minutes)	250 ppb
Chronic health-based criteria (based on epidemiological studies)		
EPA[3] (24-hour NAAQS)		140 ppb
Northern Ireland (24 hour)[4]		48 ppb
CA EPA[2] (24-hour)		40 ppb
WHO 2005 Guidelines (24-hour)		8 ppb
EPA (Annual Average NAAQS)		30 ppb

1 not to be exceeded more than 24 times/calendar year
2 not to be exceeded value
3 not to be exceeded more than once per year
4 not to be exceeded more than 3 times/calendar year

EPA acute exposure guideline levels (AEGLs) for sulfur dioxide. AEGLs are intended to apply to once-in-a-lifetime exposures to the general population including infants and children, and other individuals who may be sensitive and susceptible.

AEGL1 (10 minutes – 4 hours)	200 ppb
AEGL2 (10 minutes – 4 hours)	750 ppb

AEGL 1 – general population and susceptible individuals could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. Effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL 2 – general population and susceptible individuals could experience irreversible or other serious, long-lasting adverse health effects or impaired ability to escape.

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Appendix F. Trona Report (Virginia Department of Health)

Health Effects Associated with Exposure to Trona
A Review of the Biomedical Literature

Virginia Department of Health
Office of Epidemiology
Office of Environmental Health
June 2007

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Virginia Department of Environmental Quality (VDEQ) requested that the Virginia Department of Health (VDH) provide a summary report on the possible health effects of trona (sodium sesquicarbonate). The following report discusses the application of trona in flue gas desulfurization, provides a toxicological assessment of trona, examines the available biomedical literature on trona in order to assess any adverse health effects, and identifies research gaps about potential health effects of trona.

In occupational studies reviewed, we can document that trona dust is an alkaline (caustic) substance that can have an irritant effect on respiratory airways, mucous membranes, eyes, and skin. Excessive levels of airborne dust may irritate the mucous membranes and upper respiratory tract. Aside from the irritant effects described, no chronic loss of lung function is attributed to trona in the studies examined and interventions to reduce dust levels improved respiratory and/or skin-related symptoms. As a food substance, refined trona is commonly added to animal feed and double-refined trona is designated by the Food and Drug Administration as a safe product when used in the appropriate context.

There are no published epidemiologic studies of populations living near power plants where trona is used for air pollution control, nor studies examining the health effects as a result of exposure to trona dust among the general population or among special populations that may be at increased susceptibility to airborne irritants. The absence of evidence of adverse health effects in the general population is not the same as evidence that adverse health effects in the general population are absent. Nevertheless, current information available only suggests that trona dust is a transient irritant, especially in the occupational setting.

Further work is needed to assess any impacts trona would have on health and air quality; research gaps to fill include better understanding: (1) the amount of trona dust or trona-related by-products released into air emissions by power plants, if any; (2) the long-term health effects associated with exposure to trona dust; (3) circumstances that increase trona dust levels in ambient air; and (4) the threshold values for occupational and public exposure where risk of

trona's irritant effects are minimized. VDH will continue to assist in addressing public health concerns related to trona utilization in the future.

INTRODUCTION

Mirant Corporation's Potomac River Generating Station (PRGS), located in Alexandria, Virginia, serves the District of Columbia and surrounding states using generating units that burn coal to generate electricity.[1] In an effort to curb the amount of air pollutants created when coal is combusted, PRGS began testing the use of a dry sorbent injection process in the winter of 2005. During the injection process, powdered trona is reacted with the flue gas stream to remove sulfur oxides; most of the solid by-products created are then captured for disposal. Residents in the area surrounding the power station have expressed concerns about the potential environmental and health effects from exposure to by-products emitted from the coal-burning units as well as trona dust that may be released into the air as a result of trona's use in air pollution control measures. The once sparsely populated area in which the power plant originally opened in 1949 is now a densely populated community with the power station at its epicenter.

The Virginia Department of Environmental Quality (VDEQ) requested that the Virginia Department of Health (VDH) provide a summary report on the possible health effects of trona. The following report provides a general overview of trona and its use at PRGS in flue gas desulfurization, in addition to a summary of the toxicologic and health information available on trona. There is limited information reported on the health effects of trona.

TRONA - GENERAL BACKGROUND

Trona is an evaporite mineral also known as sodium sesquicarbonate. Chemically, trona is a hydrated sodium carbonate-sodium bicarbonate compound [$NA_2CO_3 \cdot NAHCO_3 \cdot 2H_2O$]. Unrefined trona ore can contain natural impurities, including clay, silica, and other insoluble material. The types of natural impurities found in the ore will vary and are dependent on how and where the ore was formed. The trona ore is mechanically refined – crushed, screened, and dried – prior to commercial use. Mechanically refined trona is primarily utilized by power plants in air pollution control applications. Trona helps remove sulfur oxides (SO_2 and SO_3), hydrogen sulfide (H_2S), hydrochloric acid (HCl), and hydrofluoric acid (HF) from flue gas emissions.[2]

Coarse trona is commercially used in animal feed products to aid in animal digestion, in cement production to control sulfur emissions, and in other commercial applications. Trona ore also serves as source for soda ash (or sodium carbonate) production when the ore is dissolved to remove impurities and re-crystallized to form soda ash. Soda ash is commercially used in glass manufacturing, chemical products, food additives, detergents, paper mill industries, water treatment, and flue gas desulfurization.[3]

U.S. deposits of trona ore are primarily mined from Wyoming and California, but sources of trona are also located in Colorado, Michigan, Nevada, New Mexico, Utah, and Washington.[4] Industrial use of natural trona as a sorbent in air pollution control measures first began in the mid-1980s.

TRONA IN AIR POLLUTION CONTROL

Coal combustion results in the formation of acid gases, such as sulfur dioxide, among other air pollutants. The environmental and health effects linked to sulfur dioxide are well documented. In order to reduce and control acid gases emitted during coal-burning processes, trona is used as an acid neutralizer and sorbent to remove pollutants from flue stack emissions. As air emission standards have tightened for coal-burning power plants, the use of trona in air pollution control strategies has steadily increased.

PRGS employs a dry sorbent injection process that involves pressurized injection of powdered trona (trona dust) into a duct containing flue gasses. When trona is heated above 275^{o}F, it is calcined to sodium carbonate and becomes a reactive reagent that can achieve a range of efficiencies in acid neutralization. The heated trona provides a large, reactive surface area for sulfur oxide gases to bond, creating solid sodium salt by-products that can then be removed from the exhaust stream and collected for disposal. Trona also reacts with other acid gases [hydrogen sulfide (H_2S), hydrochloric acid (HCl), and hydrofluoric acid (HF)], if present; the solid by-products can be similarly removed and disposed. The reaction of trona with acids also creates carbon dioxide gas and water vapor.

The use of dry sorbent injection systems do have advantages over other flue gas desulfurization systems, including lower capital costs to retrofit the system to existing plant operations, and less corrosive by-products relative to wet-scrubber systems. Additionally, sodium-based sorbents, such as trona, in dry injection systems have been shown to have high removal efficiencies over a wide range of temperatures.[5, 6]

The control of waste by-products relies on the capability and efficiency of electrostatic precipitators (ESP) to capture the dry particulate waste. One concern expressed by the City of Alexandria is the ability of the ESP to effectively handle the large quantities of waste products produced during operations. Large amounts of trona are added to the system to remove sulfur dioxide; the trade-off for reducing sulfur dioxide gas emissions is to create substantial increases in ash loading relative to burning coal alone. If the quantities of trona used overwhelm the ESP, increased levels of particulate matter could be released into the air. However, trona has been shown to reduce sulfur dioxide gas levels and particulate matter emissions. Mirant reports that during trial injection tests conducted at PRGS, substantial sulfur dioxide removal could be achieved while maintaining particulate emissions and opacity performance within limits.[7]

To date, estimates of the quantity of trona dust escaping flue stacks or being released during the transportation/unloading stages have not been reported by regulatory agencies. No information exists in the literature related to potential human health effects due to exposure to trona during or following these pressure injection treatments at power plants. Although the use of trona to remove sulfur oxides from air emissions should reduce particulate matter in air emissions, it is possible that trona and its by-products may inadvertently be released as particulate matter.

TRONA CHEMISTRY & EXAMPLE BY-PRODUCTS [8]

Trona Decomposition

(heat calcines trona into sodium carbonate at temperatures above 275°F)

$Na_2CO_3 \cdot NaHCO_3 \cdot 2\ H_2O \rightarrow Na_2CO_3 + NaHCO_3 + 2\ H_2O$

Trona → Sodium Carbonate + Sodium Bicarbonate + Water

$NaHCO_3 \rightarrow \frac{1}{2}\ CO_2 + \frac{1}{2}\ H_2O + \frac{1}{2}\ Na_2CO_3$

Sodium Bicarbonate → Carbon Dioxide + Water + Sodium Carbonate

Trona Reactions with HCl and SO_2 flue gas pollutants

$Na_2CO_3 \cdot NaHCO_3 \cdot 2\ H_2O + HCl \rightarrow 3\ NaCl + 4\ CO_2 + 2\ H_2O$

Trona + Hydrochloric Acid → Salt + Carbon Dioxide + Water

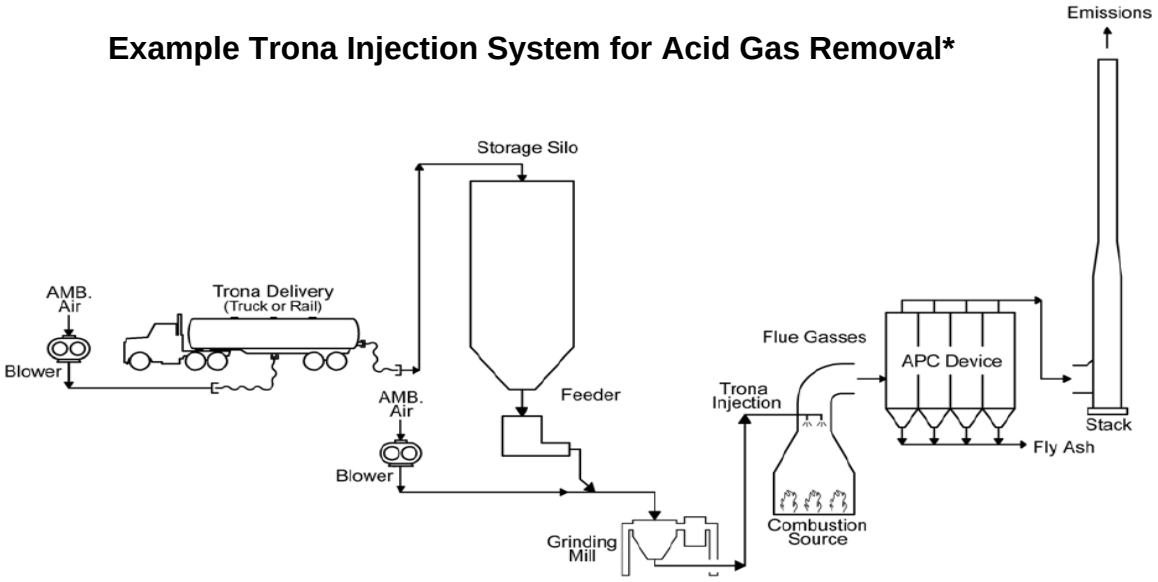
$2(Na_2CO_3 \cdot NaHCO_3 \cdot 2\ H_2O) + 3\ SO_2 \rightarrow 3\ Na_2SO_3 + 4\ CO_2 + 5\ H_2O$

Trona + Sulfur Dioxide → Sodium Sulphite + Carbon Dioxide + Water

$3\ Na_2SO_3 + O_2 \rightarrow 3\ Na_2SO_4$

Sodium Sulphite + Oxygen → Sodium Sulphate

Example Trona Injection System for Acid Gas Removal*



*Maziuk, John. 10 March 2005. Trona Injection Above 700 to Remove Sulfur Oxides from Flue Gas. Solvay Chemicals Presentation. http://www.solvaychemicals.us/static/wma/pdf/6/8/5/2/Trona_Injection.pdf.

HEALTH EFFECTS - EPIDEMIOLOGIC AND CLINICAL STUDIES

There are few studies examining the human health effects of trona. A literature search revealed two occupational studies on trona dust exposure. A third occupational study examined port workers exposed to sodium carbonate, a compound derived from trona. Following exposure-response principles, we anticipate that any health effects associated with trona will more readily be observed in occupational settings due to the increased likelihood of airborne or dermal contact with the substance. Examining occupational exposures to varying levels of trona dust may provide insight on the effects of trona to human health.

Trona Miners and Millers

In 1981, epidemiologic and clinical studies of trona ore miners and millers in Wyoming described the respiratory and dermatologic health effects associated with trona dust exposure.[9, 10] The studies were conducted following a union group request to the National Institute for Occupational Safety and Health (NIOSH) for a health hazard evaluation. The evaluation involved a structured interview, a standardized questionnaire about respiratory and dermatological effects, a lung function test, and a skin patch test for sensitivity. Prior to this evaluation, NIOSH had completed a lung function survey among a subset of the same workers in 1976.[11]

Respiratory Effects

NIOSH examined the impact of occupational exposures to trona dust on respiratory function. The study involved 142 underground miners and 88 surface workers who volunteered to participate in a cross-sectional study that included a questionnaire about respiratory symptoms, pre- and post- work shift lung function evaluation, and a five-year follow-up. Exposure determinations included total work-years, self-reported categorical exposure (high, medium, low) to different types of dust, and an exposure-index based on a mean score of all dust exposures. Area and personal exposure dust samples were also collected for total and respirable dust levels. Outcomes of interest included various pulmonary function measures, including forced expiratory volume at 1 second (FEV_1), and reported respiratory symptoms.

A significant fall in FEV_1 was found among non-smokers and surface workers in the shift study comparing pre- and post-shift FEV_1 values; the decrease in FEV_1 among the highest exposure group approached statistical significance. Processing stages that involve higher levels of trona dust (i.e., crushing, roasting, calcining, and filtering) appeared to have an acute effect on lung function, regardless of smoking habit. Some correlations between dust exposure and decreased FEV_1 were found among smokers, in relation to age and possibly work-years. The five-year follow-up did not reveal any chronic loss of lung function, which investigators hypothesized could be related to dust control improvements, decreases in smoking, and high worker turnover, among other factors.

Personal exposure dust samples (eight-hour, time-weighted average) ranged from 0.6 to 99 mg/m^3 for total dust and 0.1 to 11 mg/m^3 for respirable dust. The average total dust levels were 32 mg/m^3 for underground workers and 27 mg/m^3 for surface workers; the average respirable dust levels were 2.2 and 1.4 mg/m^3, respectively. Although some areas had high levels of total trona dust, the respirable fraction was much lower, accounting for only about 5% to 7% of the total dust. Free silica in the dust samples was not detectable.

Chronic cough and phlegm production was reported in 23% of the participants; both symptoms were more common among smokers than nonsmokers. Thirty-three percent of the workers complained of dyspnea (breathing difficulty) when hurrying on level ground or walking up a slight hill. There were significant exposure-response associations between reported upper respiratory symptoms (nasal and throat irritation) and trona dust exposure. Nasal drainage was reported among 48% of the respondents, and symptoms of eye and nose irritations occurred in nearly 60% of workers. Upper respiratory irritation commonly reported among workers coincided with air sampling data indicating dust particles of larger size.

Dermatologic Effects

A companion study examined the dermatologic effects of trona dust exposure. Exposure measures were determined as noted above, and outcome measures of interest included a list of skin irritations – redness, itching, scaling, skin sores, and dry, cracked skin.

Each of the 230 study participants (i.e., 142 underground miners and 88 surface workers) was interviewed to assess dermatologic signs and symptoms both before and after beginning work in the trona industry; participants were also given a skin examination by a physician. Skin patch tests were conducted on 67 of the study participants; 10% solutions of raw trona, sodium carbonate, and a saline control were applied on the upper arm. Additionally, all employees (n=1300) were given a self-administered questionnaire inquiring about health problems related to trona.

Among the group of 230 study participants, the incidence of skin signs and symptoms was from 2 to 15 times greater after beginning work in the trona industry. There was an exposure-response relationship between skin irritations and dust exposure among participants working in underground mines, but not for surface workers who reported higher rates of skin symptoms relative to underground miners. Skin irritations on exposed areas of the arms, hands, and legs were commonly reported. Twenty-five percent of the workers examined showed signs of inflammation to the mouth, nose, pharynx and eyes. One-half of the workers showing signs of mucous membrane inflammation also had conjunctivitis. Patch tests with the 10% aqueous solutions of raw trona and sodium carbonate were negative, which suggested the dermatitis occurring among workers was due to irritation, not allergy.

The self administered questionnaire provided to all employees was returned by 50% (648/1300). Of those that responded, 47% (305/648) reported a physical ailment caused or exacerbated by occupational exposure to trona dust. Sixty nine percent of those reporting ailments caused by trona dust cited skin irritations. Personal hygiene, protective clothing, dust control, and barrier creams were recommended interventions for curbing the occupational-related dermatitis.

Study Limitations

The studies have a number of limitations, which include:

- low participation rates [24% (142/600) of the underground miners and 44% (88/200) of the surface workers] and voluntary self-selection into the study. This may have created an unrepresentative sample of the population of concern.

- short employment duration (average length 10 years). The effects of trona exposure over a longer period of time are unknown. Additionally, those reporting low exposure tended to be older, to have worked longer in the industry, and may have been transferred to lower exposure duties over time. This may have lessened the exposure-response relationships under study.
- lack of an unexposed comparison group, which makes it difficult to assess and interpret exposure-response rates for respiratory and dermal measures.
- exposure to other dust, such as sodium carbonate. Although the dust may have predominantly been trona, it is difficult to know whether the health effects observed are attributable to trona versus sodium carbonate exposure.

Sodium Carbonate Port Workers

Clinical examinations of shipping workers exposed to high levels of sodium carbonate, or soda ash, showed many workers developed skin conditions (e.g., ulcers, erosion, and eczema), soda ash burns, and inflamed mucous membranes of the nose, pharynx and eyes. [12] Dust levels over 300 mg/m^3 in the ship holds and freight cars were reported. When interventions were employed to reduce dust levels by tenfold, 2/3 of the skin conditions were eliminated and upper respiratory tract symptoms were reduced by 1/3.

Additional Studies

Other studies examining the human health effects of trona focus on the use of trona as a food additive.[12-14] In parts of Tanzania, local sources of high-fluoride content trona is used as a food tenderizer and implicated as a major source of dental fluorosis in those communities. However, the source and application of high fluoride trona used in these communities are outside the scope of our discussion and will not be examined.

From the relevant studies reviewed, we can document that trona dust is a caustic substance that can have an irritant effect. Direct contact with trona dust causes irritation of the eyes and continuous or prolonged contact may cause skin irritation (red, dry, cracked skin). Excessive levels of airborne dust may irritate the mucous membranes and upper respiratory tract. Aside

from the irritant effects described, no chronic loss of lung function was noted and interventions to reduce dust levels improved respiratory and/or skin-related symptoms.

All effects in the studies examined have been reported among those occupationally exposed to high levels of dust, either acutely or over prolonged periods of time. There are no published epidemiologic studies of populations living near power plants where trona is used for air pollution control.

HEALTH EFFECTS - TOXICOLOGICAL SUMMARY

There are no animal toxicity studies of in-vitro toxicity for trona. Several studies do reference the use of trona in animal feed to help buffer the acidity in the rumen and duodenum[16] of farm animals, such as cattle and dairy cows. Trona helps to enhance the digestibility of grain diets in cattle[17] and increase milk production in dairy cows.[18]

Toxicological information for trona often reference toxicity data for sodium carbonate, a compound related to trona.[19] Laboratory studies involving rodents exposed to sodium carbonate indicate that the acute oral toxicity[i] in rats is 4,090 mg/kg (milligrams of substance per kilogram of animal weight), and the acute inhalation toxicity[ii] in rats is 2,300 mg/m^3 over a 2-hour period. Dermal exposure to sodium carbonate produces mild irritation at levels in excess of 2,000 mg/kg in rabbits. In rabbits, trona is a severe eye irritant at 50 mg. This parallels the acute effects reported with trona overexposure in humans which causes severe irritation of the eyes, and can lead to corneal opacities. Dusts and mists may be irritating to the skin, mucous membranes and upper respiratory tract and ingestion may cause nausea, vomiting, stomachache, and diarrhea. Chronic, excessive exposure or contact with trona may produce “soda ulcers” on the skin and perforation of the nasal septum.

Trona is not considered to be a probable or suspected human carcinogen. However, trona ore may contain trace amounts of silica (crystalline quartz). Silica[iii] is a suspected carcinogen that

[i] LD_{50} - lethal dose that will kill 50% of the experimental animals
[ii] LC_{50} – lethal concentration that will kill 50% of the experimental animals
[iii] ACGIH set their TLV for silica at 0.025 mg/m^3 for an 8-hour time weighted average. The OSHA PEL for crystalline silica is [(10 mg/m^3)/(%Silica +2)].

has been shown to cause silicosis (a lung disease) in humans when present in concentrations greater than 1%. Material safety data sheets (MSDS) on natural trona (unprocessed) indicate the presence of silica at less than 2%;[20] commercially processed trona used by Mirant (Solvay T-200®) indicates the presence of silica at less than 0.4%.[21]

REGULATIONS AND ADVISORIES

Food Safety

Double-refined trona ore (i.e., purified sodium sesquicarbonate) is "generally recognized as safe" (GRAS) by the Food and Drug Administration for use as a food ingredient within the context of good manufacturing practices.[22] Health-related literature on trona primarily focuses the use of processed trona, such as refined trona, sodium carbonate and sodium bicarbonate, as pH control agents in animal feed, human food products, and in various chemical industries.

Occupational Exposure

The American Conference of Governmental Industrial Hygienists (ACGIH) has not established a specific Threshold Limit Value (TLV) for trona.[iv] Federal guidelines treat trona as particulate matter not otherwise regulated; OSHA lists the Permissible Exposure Limit (PEL) for particulates not otherwise regulated at 5 mg/m^3 (milligrams of substance per cubic meter of air) for the respirable fraction, and 15 mg/m^3 for total dust over an 8-hour time-weighted average.

Air Quality

There are no specific regulations for trona set by the U.S. Environmental Protection Agency (EPA). However, EPA does set air emission standards for coarse particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$) in the National Ambient Air Quality Standards (NAAQS).

The 2006 NAAQS for coarse particulate matter, PM_{10}, is limited to 150 $\mu g/m^3$ for a 24-hour exposure period, not to be exceeded more than once per year on average over a three-year period. For fine particulate matter, $PM_{2.5}$, the annual exposure standard is limited to 15 ug/m^3 and the 24-hour average is limited to 35 $\mu g/m^3$, averaged over three years.[23]

[iv] ACGIH proposed in 1999 a TLV of 0.5mg/m^3 for respirable trona, but subsequently abandoned this effort.

Waste Disposal

Trona discarded or disposed of as purchased it is not listed hazardous waste according to U.S. Federal Resource Conservation and Recovery Act (RCRA) regulations (40 CFR 261). As a non-hazardous waste, the material may be disposed of in a landfill in accordance with local and state government regulations.

CURRENT EVALUATIONS

At the request of the Alexandria Health Department, the Agency for Toxic Substances and Disease Registry (ATSDR) reviewed existing air quality and environmental data related to the operations at PRGS to assess any potential health hazards to nearby residents. In a January 2007 response letter, ATSDR discussed the uncertainty of the available air dispersal models that estimate SO_2 exposures and the need to collect additional monitoring data, including monitoring data to evaluate model estimates; data on the intensity, duration, and frequency of emissions; and data on indoor/outdoor contaminant ratios.[24]

Mirant began collecting monitoring data in June of 2006 for a Model Evaluation Study that will include a comparison between modeling and monitoring data for PRGS. The data will help to assess the accuracy of the modeled concentrations. Additionally, ATSDR has proposed conducting an exposure investigation to better assess the potential human exposure to airborne concentrations of sulfur dioxide, particulate matter, and selected metals. The proposed investigation would measure ambient and limited indoor air for contaminants and is designed to fill data gaps in evaluating community exposure pathways. Although not trona-specific, the investigation would help provide further information to determine if health hazards exist (from sulfur dioxide, particulate matter, and selected metals) in areas not currently monitored. Additionally, the Alexandria Health Department (AHD) developed a complaint form for residents living within a one-mile radius of the power station. Residents are encouraged to report health events believed to be related to the operation of the plant. AHD will review the collected data to determine if further studies are warranted.[25]

ASSESSMENT AND DISCUSSION

There is limited medical, toxicological, and public health literature on the direct health effects attributable to trona dust. Occupational exposures provide evidence that trona, at some threshold level, is an irritant to skin, the upper respiratory tract, and mucous membranes. However, no specific occupational exposure limits have been developed for trona either by ACGIH or OSHA. Additionally, there are no studies examining the health effects resulting from exposure to trona dust among the general population or in special populations that may be at increased susceptibility to airborne irritants. The absence of evidence of adverse health effects in the general population is not the same as evidence that adverse health effects in the general population are absent. Nevertheless, current information available only suggests that trona dust is a transient irritant, especially in the occupational setting.

More research and ambient air monitoring data are needed to assess exposure levels and better understand fully whether or not trona has any significant, negative, short- or long-term human health effects. There are no studies of the human health impacts of trona used in the context of air pollution control and flue gas de-sulfurization processes. Further work is needed to assess any impacts trona would have on health and air quality; research gaps to fill include better understanding: (1) the amount of trona dust or trona-related by-products released into air emissions from power plants, if any; (2) the long-term health effects associated with exposure to trona dust; (3) circumstances that increase trona dust levels in ambient air; and (4) the threshold values for occupational and public exposure where risk of trona's irritant effects are minimized. VDH will continue to assist in addressing public health concerns related to trona utilization in the future.

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Appendix G. Statistical Analyses.

Appendix G. Statistical Analyses.

Mirant Sulfur Dioxide Environmental Data.

Tables G-1 – G-2 present descriptive statistics for Mirant 5-minute sulfur dioxide environmental data (April 2007 – July 2008). **Data obtained from Mirant Corp., September 2008.**

Mirant 5-Minute Sulfur Dioxide Peak:Mean Ratios.

Table G-3 presents the statistical analysis of hourly peak:mean ratios of Mirant 5-minute sulfur dioxide environmental data (April 2007 – July 2008). **Data obtained from Mirant Corp., September 2008.**

Meteorological Data.

Tables G-4 – G-8. Statistical data analysis among three meteorological stations (Reagan Washington National Airport and ATSDR EI meteorological stations at Site 1 and Site 10) for wind direction. **Data obtained from Reagan Washington National Airport and ATSDR Exposure Investigation and Site Assessment Branch).**

Table G-9 – G-14. Statistical Analysis of Meteorological Sites for Wind Speed.

Mirant Environmental Data

Table G-1. Mirant 5-Minute Sulfur Dioxide Concentration by Month.

Mirant 5-minute SO_2Concentration (ppb) by Month																
Station	**Apr07**	**May07**	**June07**	**July07**	**Aug07**	**Sept07**	**Oct07**	**Nov07**	**Dec07**	**Jan08**	**Feb08**	**Mar08**	**Apr08**	**May08**	**Jun08**	**Jul08**
MTc																
#>10	257	1316	721	793	1143	1377	1054	942	826	2052	1650	1702	633	652	1258	1832
#>100	5	80	11	9	7	11	3	0	18	1	8	32	12	19	72	162
#>200	0	10	0	0	0	0	0	0	6	0	0	1	0	2	13	26
#>300	0	5	0	0	0	0	0	0	1	0	0	0	0	0	3	1
#>400	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#>500	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MTs																
#>10	87	1013	545	569	652	966	727	795	652	1618	120	49	393	529	721	1028
#>100	0	30	7	28	0	6	2	2	21	0			7	5	62	115
#>200	0	0	0	0	0	0	0	0	3	0			0	1	20	17
#>300	0	0	0	0	0	0	0	0	0	0			0	0	4	2
#>400	0	0	0	0	0	0	0	0	0	0			0	0	2	0
#>500	0	0	0	0	0	0	0	0	0	0			0	0	1	0
SEFL																
#>10	733	817	821	664	989	1221	1313	2149	1813	3440	2625	1872	549	861	524	713
#>100	140	38	95	3	2	8	8	22	4	30	35	49	7	16	4	0
#>200	24	3	21	0	0	0	0	0	0	0	0	0	0	0	1	0
#>300	5	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
#>400	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NEFL																
#>10	593	473	209	155	337	222	218	281	457	591	529	563	50	192	91	63
#>100	44	0	21	0	0	0	0	0	0	0	0	0	0	0	0	3
#>200	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
#>300	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N Dang																
#>10	36	608	242	389	509	633	745	718	606	1798	1428	987	344	436	401	683
#>100	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
SW HI																
#>10	177	579	246	455	764	1026	1189	1652	1235	2223	2191	1478	808	330	345	477
#>100	5	7	0	0	0	0	1	0	0	0	0	0	0	2	0	1

Maximum SO_2 Concentrations by Month by Station																
Station	**Apr07**	**May07**	**June07**	**July07**	**Aug07**	**Sept07**	**Oct07**	**Nov07**	**Dec07**	**Jan08**	**Feb08**	**Mar08**	**Apr08**	**May08**	**Jun08**	
MTc	203	507	183	200	142	180	114	83	419	113	140	220	168	204	356	
MTs	84	178	219	238	82	128	123	139	233	79	27*	24*	173	271	522	
SEFL	402	258	377	121	146	151	189	164	173	181	195	195	141	141	255	
NEFL	326	73	223	28	45	32	92	42	55	78	77	40	23	63	36	
NDang	24	86	7	44*	45	71	81	62	61	50	42	113	69	103	81	
SE HI	189	135	51	71	63	71	107	61	64	37	71	71	84	115	44	140

Table G-2. Descriptive statistics for Mirant 5-minute sulfur dioxide data by station collected April ~6, 2007* through July 31, 2008.

Descriptive statistics for Mirant 5-minute data by station for all data (μ/m^3)						
Description	**Marina Towers Central**	**Marina Towers South**	**North Dangerfield Island**	**Northeast Fence Line**	**Southeast Fence Line**	**Southwest Holiday Inn**
Number of readings	134,075	120,141	132,208	131,041	126,659	129,422
Minimum	0.0	0.0	0.0	2.6	0.0	2.6
Percentiles						
10th	5.2	2.6	3.9	5.2	6.5	3.9
25th	9.2	3.9	6.5	6.5	7.9	7.9
Median (50$^{th)}$	13.1	7.9	9.2	9.2	13.1	11.8
75th	18.3	13.1	14.4	13.1	19.6	18.3
90th	30.1	23.6	23.6	18.3	35.4	27.5
99th	137.6	100.9	60.3	49.8	174.2	62.9
Maximum	1327.0	1368.9	296.1	852.8	1053.2	493.9
Mean	18.7	12.8	12.7	11.4	20.7	15.1
Standard Deviation	31.0	26.1	11.7	13.4	33.8	13.3
Mode	10.5	2.6	7.9	7.9	7.9	10.5

*Startup date for each station – MTWRc (April 6, 14:10), MTWRs (April 6, 14:10), ND (April 6, 10:15), NE (April 11, 8:10), SE (April 9, 10:45), SW (April 13, 9:20)

Mirant 5-Minute Peak:Mean Ratios

Table G-3. Statistical Analysis of Hourly Peak:Mean Ratios of Mirant 5-minute Data.
Descriptive statistics for Mirant 5-minute data – hourly peak to mean ratio calculations by station for all data collected for the whole period- i.e., April ~6, 2007* through July 31, 2008.

	MTWRc	MTWRs	ND	NE	SE	SW
Number of readings	11,507	10,307	11,327	11,218	10,865	11,094
($\mu g/m^3$)						
Minimum	1.0	1.0	1.0	1.0	1.0	1.0
Percentiles						
10^{th}	1.03	1.0	1.03	1.04	1.03	1.03
25^{th}	1.08	1.06	1.08	1.08	1.08	1.07
Median (50^{th})	1.16	1.19	1.15	1.14	1.14	1.13
75^{th}	1.36	1.44	1.28	1.23	1.33	1.26
90^{th}	1.98	2.11	1.56	1.45	2.05	1.54
99th	4.24	4.54	3.08	2.85	4.38	3.50
Maximum	9.40	9.49	7.04	9.49	9.52	9.09
Mean	1.38	1.43	1.26	1.24	1.39	1.27
Standard Deviation	0.65	0.71	0.39	0.36	0.66	0.45
Mode	1.0	1.0	1.0	1.12	1.08	1.0

*Startup date for each station – MTWRc (April 6, 14:10), MTWRs (April 6, 14:10), ND (April 6, 10:15), NE (April 11, 8:10), SE (April 9, 10:45), SW (April 13, 9:20)

Meteorological Data

Table G-4 – G-8. Statistical data analysis among three meteorological stations (Reagan, Site 1, Site 10) for wind direction.

In order to control for date and time, only readings matched across monitoring sites for exact date and time were used for analysis and included hourly readings from June 9^{th} through July 21, 2007. The Reagan monitoring site collected data hourly at xx:52. Sites 1 and 10 collected data by the minute. Total: N=1,049 date/times.

Of note, site Reagan had 33 missing values; 1016 readings per site were used for analysis. Results indicate that wind direction is significantly different among the three monitoring sites, Chi-square test of independence: 717.9 with 16 df, p=0.0001. All pairwise comparisons between monitoring sites were likewise significantly different.

Degree definitions for wind direction categories:

N: 337.5 - < 22.5
NE: 22.5 - < 67.5
E: 67.5 - < 113.5
SE: 113.5 - < 158.5
S: 158.5 - < 203.5
SW: 203.5 - < 247.5
W: 247.5 - < 292.5
NW: 292.5 - < 337.5

Table G-4. Comparison of Wind Directions by Monitoring Site; June 9, 2007 through July 21, 2007.

	Site 1	Site 10	Reagan
N (337.5-<22.5)	125 (12%)	62 (6%)	156 (15%)
NE (22.5-<67.5)	32 (3%)	118 (12%)	61 (6%)
E (67.5-<113.5)	34 (4%)	18 (2%)	61 (6%)
SE (113.5-<158.5)	74 (7%)	41 (4%)	39 (4%)
S (158.5-<203.5)	39 (4%)	131 (13%)	275 (27%)
SW (203.5-<247.5)	124 (12%)	281 (28%)	137 (13%)
W (247.5-<292.5)	100 (10%)	198 (19%)	86 (8%)
NW (292.5-<337.5)	164 (16%)	50 (5%)	115 (11%)
Calm (wind speed=0)	324 (32%)	117 (11%)	86 (8%)

Table G-5. Comparison of Wind Directions by Monitoring Site; June 9, 2007 through July 21, 2007 by time of day: 7 am through 11 am.

	Site 1	Site 10	Reagan
N (337.5-<22.5)	30 (15%)	24 (12%)	43 (22%)
NE (22.5-<67.5)	5 (2%)	33 (17%)	29 (15%)
E (67.5-<113.5)	6 (3%)	4 (2%)	13 (6%)
SE (113.5-<158.5)	19 (10%)	11 (5%)	4 (2%)
S (158.5-<203.5)	8 (4%)	28 (14%)	53 (27%)
SW (203.5-<247.5)	17 (8%)	49 (25%)	12 (6%)
W (247.5-<292.5)	16 (8%)	31 (16%)	10 (5%)
NW (292.5-<337.5)	38 (19%)	18 (9%)	22 (11%)
Calm (wind speed=0)	60 (30%)	1 (<1%)	13 (6%)

199 readings per site were used for analysis. Results indicate that wind direction is significantly different among the three monitoring sites, Chi-square test of independence: 207.2 with 16 df, p=0.0001. All pairwise comparisons between monitoring sites were likewise significantly different.

Table G-6. Comparison of Wind Directions by Monitoring Site; June 9, 2007 through July 21, 2007 by time of day: Midnight through 6 am.

	Site 1	Site 10	Reagan
N (337.5-<22.5)	35 (11%)	12 (4%)	55 (18%)
NE (22.5-<67.5)	8 (3%)	20 (6%)	19 (6%)
E (67.5-<113.5)	5 (2%)	2 (1%)	13 (4%)
SE (113.5-<158.5)	6 (2%)	7 (2%)	6 (2%)
S (158.5-<203.5)	9 (3%)	26 (8%)	70 (23%)
SW (203.5-<247.5)	36 (12%)	66 (22%)	52 (17%)
W (247.5-<292.5)	23 (10%)	69 (23%)	15 (5%)
NW (292.5-<337.5)	39 (13%)	11 (4%)	36 (12%)
Calm (wind speed=0)	145 (47%)	93 (30%)	40 (13%)

306 readings per site were used for analysis. Results indicate that wind direction is significantly different among the three monitoring sites, Chi-square test of independence: 231.7 with 16 df, p=0.0001. All pairwise comparisons between monitoring sites were likewise significantly different.

Table G-7. Comparison of Wind Directions by Monitoring Site; June 9, 2007 through July 21, 2007 by time of day: Noon through 7 pm.

	Site 1	Site 10	Reagan
N (337.5-<22.5)	48 (14%)	23 (7%)	43 (13%)
NE (22.5-<67.5)	16 (5%)	50 (15%)	12 (4%)
E (67.5-<113.5)	10 (3%)	9 (3%)	25 (7%)
SE (113.5-<158.5)	36 (11%)	16 (5%)	19 (6%)
S (158.5-<203.5)	18 (5%)	57 (17%)	104 (31%)
SW (203.5-<247.5)	38 (11%)	113 (34%)	40 (12%)
W (247.5-<292.5)	43 (13%)	52 (15%)	41 (12%)
NW (292.5-<337.5)	65 (19%)	16 (5%)	37 (11%)
Calm (wind speed=0)	62 (18%)	0	15 (4%)

336 readings per site were used for analysis. Results indicate that wind direction is significantly different among the three monitoring sites, Chi-square test of independence: 296.8 with 16 df, p=0.0001. All pairwise comparisons between monitoring sites were likewise significantly different.

Table G-8. Comparison of Wind Directions by Monitoring Site; June 9, 2007 through July 21, 2007 by time of day: 8 pm through 11 pm.

	Site 1	Site 10	Reagan
N (337.5-<22.5)	12 (7%)	3 (2%)	15 (9%)
NE (22.5-<67.5)	3 (2%)	15 (9%)	1 (<1%)
E (67.5-<113.5)	13 (7%)	3 (2%)	10 (6%)
SE (113.5-<158.5)	13 (7%)	7 (4%)	10 (6%)
S (158.5-<203.5)	4 (2%)	20 (11%)	48 (27%)
SW (203.5-<247.5)	33 (19%)	53 (30%)	33 (19%)
W (247.5-<292.5)	18 (10%)	46 (26%)	20 (11%)
NW (292.5-<337.5)	22 (13%)	5 (3%)	20 (11%)
Calm (wind speed=0)	57 (33%)	23 (13%)	18 (10%)

175 readings per site were used for analysis. Results indicate that wind direction is significantly different among the three monitoring sites, Chi-square test of independence: 137.8 with 16 df, p=0.0001. All pairwise comparisons between monitoring sites were likewise significantly different.

Table G-9 – G-14. Statistical Analysis of Meteorological Sites for Wind Speed.

Table G-9. Descriptive Statistics for Wind Speed by Monitoring Site; June 9, 2007 through July 21, 2007. Only readings matched across monitoring sites for exact date and time were used for analysis and included hourly readings from June 9th through July 21, 2007. The Reagan monitoring site collected data hourly at xx:52. Sites 1 and 10 collected data by the minute (1,049 data/times matched; 33 had missing wind direction at the Reagan site: N=1016 for analysis).

	Site 1	Site 10	Reagan
Number of readings	1016	1016	1016
(m/s)[1]			
Minimum	0	0	0
Percentiles			
10th	0	0	1
25th	0	1	2
Median (50th)	1	1	4
75th	2	2	4
90th	3	2	6
99th	4	4	8
Maximum	5	5	9
Mean[2**]	1.21	1.14	3.39
Std Deviation	1.13	0.88	1.84
Mode	1	1	4

[1] Wind speed was recorded as m/s at Site 1 in whole numbers; m/s at Site 10 in numbers with 2 decimals; in mph at Reagan and converted to m/s by a factor of 0.44704 (Site 10 and Reagan values were rounded to whole numbers to compare to Site 1).
[2] Analysis of Variance indicates that wind direction is significantly different among the three monitoring sites, and post-ANOVA analysis show that Sites 1 and 10 are not significantly different from each other; however, both are significantly different from Reagan. P=0.05.

Table G-10. Comparison of Wind Speed Categories by Monitoring Site; June 9, 2007 through July 21, 2007.

Wind Speed	Site 1	Site 10	Reagan
0	324 (32%)	117 (11%)	86 (8%)
1-<4 m/s	653 (64%)	896 (88%)	539 (53%)
4-<7 m/s	39 (4%)	3 (<1%)	353 (35%)
7-<11 m/s	0	0	38 (4%)

Results indicate that wind speed is significantly different among the three monitoring sites, Chi-square test of independence: 925.2 with 6 df, p=0.0001. All pairwise comparisons between monitoring sites were likewise significantly different.

Table G-11. Comparison of Wind Speed Categories by Monitoring Site; June 9, 2007 through July 21, 2007 by time of day: 7 am through 11 am (n=199 per site).

	Site 1	Site 10	Reagan
0	60 (30%)	1 (<1%)	13 (7%)
1-<4 m/s	136 (68%)	197 (99%)	99 (50%)
4-<7 m/s	3 (1%)	1 (<1%)	83 (42%)
7-<11 m/s	0	0	4 (2%)

Results indicate that wind speed is significantly different among the three monitoring sites, Chi-square test of independence: 271.7 with 6 df, p=0.0001. All pairwise comparisons between monitoring sites were likewise significantly different.

Table G-12. Comparison of Wind Speed Categories by Monitoring Site; June 9, 2007 through July 21, 2007 by time of day: Midnight through 6 am (n=306 per site).

	Site 1	Site 10	Reagan
0	145 (47%)	93 (30%)	40 (13%)
1-<4 m/s	158 (52%)	213 (70%)	197 (64%)
4-<7 m/s	3 (1%)	0	64 (21%)
7-<11 m/s	0	0	5 (2%)

Results indicate that wind speed is significantly different among the three monitoring sites, Chi-square test of independence: 194.7 with 6 df, p=0.0001. All pairwise comparisons between monitoring sites were likewise significantly different.

Table G-13. Comparison of Wind Speed Categories by Monitoring Site; June 9, 2007 through July 21, 2007 by time of day: Noon through 7 pm (n=336 per site).

	Site 1	Site 10	Reagan
0	62 (18%)	0	15 (4%)
1-<4 m/s	246 (73%)	334 (99%)	128 (38%)
4-<7 m/s	28 (8%)	2(1%)	168 (50%)
7-<11 m/s	0	0	25 (7%)

Results indicate that wind speed is significantly different among the three monitoring sites, Chi-square test of independence: 463.6 with 6 df, p=0.0001. All pairwise comparisons between monitoring sites were likewise significantly different.

Table G-14. Comparison of Wind Speed Categories by Monitoring Site; June 9, 2007 through July 21, 2007 by time of day: 8 pm through 11 pm (n=175 per site).

	Site 1	Site 10	Reagan
0	57 (33%)	23 (13%)	18 (10%)
1-<4 m/s	113 (65%)	152 (87%)	115 (66%)
4-<7 m/s	5 (3%)	0	38 (22%)
7-<11 m/s	0	0	4 (2%)

Results indicate that wind speed is significantly different among the three monitoring sites, Chi-square test of independence: 102.7 with 6 df, p=0.0001. All pairwise comparisons between monitoring sites were likewise significantly different.

Appendix H. Peer Review Comments and ATSDR Responses

PEER REVIEW COMMENT FORM

Review of Ambient Air Monitoring Data

Mirant Potomac River Generating Station

PUBLIC HEALTH CONSULTATION

November 2009

GUIDE TO REVIEWERS:

The objective of peer review conducted by the Office of Science is to ensure the highest quality of science for NCEH/ATSDR studies and results of research; therefore, your comments should be provided with this goal in mind. Unlike other peer review processes in which you may have participated, the questions to be addressed for NCEH/ATSDR are broadly based so that each reviewer may have a wide latitude in providing his/her comments. Any remarks you wish to make that have not been specifically covered by the General Questions Section may be included under question # 2 in the Additional Questions Section. Please note that your unaltered comments will be sent to the investigator for a response. You should receive a copy of the response to the peer review comments when they are available.

GENERAL QUESTIONS:

1. **Does the public health consultation adequately describe the nature and extent of contamination?**

Reviewer #1 Comment

The public health consultation describes the results of the monitoring campaign that was conducted in relation to the Mirant Potomac River Generating Station. The Mirant Station is a source of emissions with regional and local impact; I suggest a more explicit discussion of this point. The community's understanding of the monitoring results might be helped if similar data were provided for one or more community sites that monitor pollution largely driven by regional pollution sources and meteorology.

ATSDR Response

ATSDR agrees with this comment and has added a paragraph to the "Site Description and History" section that more explicitly acknowledges that Mirant's emissions both affect local air pollution levels and contribute to regional air quality issues. This paragraph also acknowledges contributions from other sources. Many of these concepts are revisited in the existing section on "Environmental Setting (General Air Quality)." ATSDR has also added text in the section on "Sulfur Dioxide" that compares the sulfur dioxide concentrations measured at VDEQ's Alexandria monitoring station to ambient air concentrations measured at the agency's nine other monitors. The section on particulate matter already included text indicating the $PM_{2.5}$ concentrations that have recently been measured in populated areas in northern Virginia.

2. **Does the public health consultation adequately describe the existence of potential pathways of human exposure?**

Reviewer #1 Comment
The pathway of concern is inhalation; that is made clear by the presentation. Exposure at potentially hazardous levels to S02 requires that a susceptible individual be in a microenvironment where a peak is taking place; this point merits further emphasis. The discussion of exposure would also be more informative with additional consideration of the likely impact of plant emissions on indoor concentrations, particularly for those residents in buildings adjacent to the Mirant Station. Indoor monitoring was mentioned in the May, 2007 *Exposure Investigation* but was apparently not carried out.

ATSDR Response
The comment notes that the draft Health Consultation made no mention of potential indoor air exposures since useful indoor air monitoring data are not available to assess this pathway for sulfur dioxide. However, we can assume that indoor air concentrations of sulfur dioxide would not be expected to exceed the peak outdoor concentrations measured by the monitoring network (unless residents have a significant indoor source, which seems unlikely). Therefore, the conclusions for outdoor exposures are assumed to apply to indoor exposures. The likelihood of individuals experiencing health effects due to indoor exposures seems low, unless sensitive individuals are exercising at indoor locations within ½-mile of Mirant and with windows open. A text box has been added to the "Public Health Implications" section regarding this issue.

3. **Are all relevant environmental, toxicological, and radiological data (i.e., hazard identification, exposure assessment) being appropriately used?**

Reviewer #1 Comment
Since this report was written, the Environmental Protection Agency has released its proposal for a 1-hr S02 National Ambient Air Quality Standard. The Health Consultation should be updated by mentioning this proposal and the proposed range.

ATSDR Response
EPA has recently proposed revoking the sulfur dioxide NAAQS for 24-hour and annual average and replacing these with a 1-hour NAAQS. ATSDR has added this language at appropriate places in the document (pp 13, 16, and 23).

4. **Does the public health consultation accurately and clearly communicate the health threat posed by the site?**

Reviewer #1 Comment
Yes, the health threat is appropriately and accurately communicated.

ATSDR Response: No response is required.

5. **Are the conclusions and recommendations appropriate in view of the site's condition as described in the public health consultation?**

Reviewer #1 Comment

The conclusions are generally reasonable. With regard to the recommendations for Conclusion 1, can greater detail be given with regard to the approach to be followed by ATSDR and the Alexandria Health Department to inform the public. The challenges in following through may not be sufficiently acknowledged. I am similarly concerned about the recommendation with regard to health education under Conclusion 3.

ATSDR Response

ATSDR has added the following recommendation to the document:
ATSDR will develop health education material with information about potential locations and times that sulfur dioxide may be present at levels of public health concern for susceptible populations. Public outreach and education will include an open house, community fact sheet, educational information on the ATSDR website, and meetings with local community groups. In addition, ATSDR will ask the local public health department to provide a link to the ATSDR website for educational material.

6. **Are there any other comments about the public health consultation that you would like to make**?

Reviewer #1 Comment

Note throughout: "particulate" is an adjective and not a noun, as used in places. Page 9, second paragraph, second sentence: PM_{10} is not "larger particles", but includes the coarse fraction in addition to $PM_{2.5.}$ The elemental analysis, unfortunately, was done on TSP. There needs to be a careful description of how mass measurements made on TSP relate to PM2.S, the current PM indicator and far better related to lung dose.

ATSDR Response

The document has been edited for "particulate" as suggested.

As the comment implies, ambient air concentrations of metals found in TSP do in fact differ from ambient air concentrations of metals in $PM_{2.5}$. ATSDR's exposure investigation was designed to provide an initial evaluation of airborne metals. This initial work characterized worst case exposure concentrations, which would be the amount of metals found in TSP. The evaluations in the Public Health Assessment consider the metals concentrations in TSP. This approach likely overstates exposures, because some of TSP is not respirable. Two sentences were added to the section describing the TSP sampling to explain that the measured concentrations likely overstate the respirable levels.

7. **Are there any other comments?**

ADDITIONAL QUESTIONS:

1. Are there any comments on ATSDR's peer review process?

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GENERAL QUESTIONS:

1. Does the public health consultation adequately describe the nature and extent of contamination?

Reviewer #2 Comment

Yes. Given the scope of the evaluation in terms of time frame, pollutants, and exposure scenarios, the consultation was appropriate.

2. Does the public health consultation adequately describe the existence of potential pathways of human exposure?

Reviewer #2 Comment

Yes. There are obvious difficulties in fully quantifying all the pathways in question, but the overall description is appropriate for the scope of the study and for the conclusions reached.

ATSDR Response: No change is required.

3. Are all relevant environmental, toxicological, and radiological data (i.e., hazard identification, exposure assessment) being appropriately used?

Reviewer #2 Comment

Yes. A major challenge to these studies is that new information from general research may become available in the future. The long term consequences of this site make it imperative to keep all of these data available for any future studies.

ATSDR Response: No change is required.

4. Does the public health consultation accurately and clearly communicate the health threat posed by the site?

Reviewer #2 Comment

Yes. This is a challenging consultation, because it involves exposures to mixtures, major decisions on regulatory and technological controls, and health education on some complex issues. Even with the careful and thoughtful language in this consultation, there may be a need for long-term follow-up to assure ongoing accurate communication.

ATSDR Response

ATSDR is planning the following activities to facilitate ongoing communication and has added this statement as a recommendation: ATSDR will develop health education material with information about potential locations and times that sulfur dioxide may be present at levels of public health concern for susceptible populations. Public outreach and education will include an open house, community fact sheet, educational information on the ATSDR website, and meetings with local community groups. In addition, ATSDR will ask the local public health department to provide a link to the ATSDR website for educational material.

5. Are the conclusions and recommendations appropriate in view of the site's condition as described in the public health consultation?

Reviewer #2 Comment

Yes.

6. Are there any other comments about the public health consultation that you would like to make?

Reviewer #2 Comment

No.

7. Are there any other comments?

Reviewer #2 Comment

It has been fascinating for me to follow this study, and I commend the very fine work of this team for the ATSDR. I have been paying closer attention of late to regulatory recommendations when there is uncertainty in a rapidly developing area of research, particularly when the technical and economic solutions are long term in nature. In other words, this may be an especially important case study for future ATSDR policies and procedures.

ADDITIONAL QUESTIONS:

1. **Are there any comments on ATSDR's peer review process?**

Reviewer #2 Comment

No.

PEER REVIEW COMMENT FORM

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GENERAL QUESTIONS:

1. **Does the public health consultation adequately describe the nature and extent of contamination?**

Reviewer #3 Comments

The concentrations of S02 were adequately characterized near Mirant PRGS, but not at distances greater than 0.25 miles. Were 5 minute average concentrations not recorded from the VDEQ monitor in Alexandria? If that is the case and since the data from the ATSDR monitors are not being used, the Mirant monitors at sites ND and SW are then the furthest away from the facility reporting peak S02 concentrations. Clearly, the 5 minute average concentrations are lower at those two sites than the sites closer to Mirant PRGS, however, peak concentrations above 100 ppb have been observed at these locations. Can estimates from the dispersion models be used to provide some information on potential peak concentrations at distances beyond 0.5 miles from the facility?

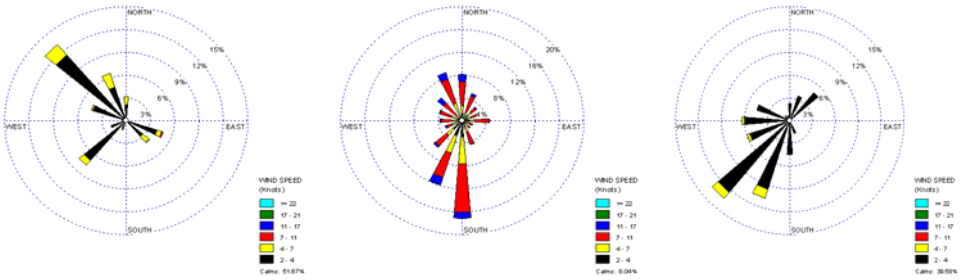
In table 3, presenting percentage of S02 measurements greater than a range of concentrations is confusing. Does % greater than 10-100 ppb mean greater than 10 ppb, greater than 100 ppb, or something else? I assume the numbers do not represent the detections greater than 100 ppb based on what is presented in figure 6, but this should be clarified in table 3.

For PM2.5, the focus of the consultation is clearly on long-term exposures. On page 26 under the section heading *Public Health Implications* it reads, "Characterization of short-term exposures around Mirant PRGS is insufficient but long-term exposures suggest a cause for concern." The basis for this conclusion is not adequately explained in the previous sections. I would suggest including additional information in table 4 on the distribution of 24 hour average concentrations, and not just the overall average and maximum 24 hour averages.

ATSDR Response

5-minute SO_2 concentrations were not available from the VDEQ monitor in Alexandria. Data from annual average air dispersion modeling was evaluated in ATSDR's preliminary assessment (Appendix B). Appendix A contains the results of historical and current air dispersion modeling as well as ATSDR's modeling of 1-hour maximums. While we have confidence in the annual average modeling, short-term air dispersion modeling did not accurately or consistently predict monitoring results around Mirant using Reagan National Airport meteorology (Appendix A). A Modeling Evaluation Study was conducted at Mirant using predictive meteorology, modeling and monitoring, as well as actual meteorology (the day after). This study was performed for over a year and did not accurately predict SO_2 peaks. Data from two local meteorological stations set up by ATSDR did not agree with Reagan meteorological data or with each other with regard to wind direction, wind speed, and the percentage calms, suggesting the potential for complex meteorology around Mirant (Appendix G). The following wind rose illustrates these differences.

Wind Rose for the ATSDR Site 1, Reagan Washington National Airport, and ATSDR Site 10 Meteorological Station; June 9, 2007 through July 21, 2007.



Site 1 **Reagan** **Site 10**

Table 3 has been clarified as indicated by the comment.

Exposure to particulate matter was not a focus of ATSDR's assessment as determined in the preliminary evaluation (Appendix B). $PM_{2.5}$ samples were collected by ATSDR at three locations at which SO_2 was also collected around Mirant for six weeks. ATSDR collected samples to investigate whether $PM_{2.5}$ concentrations were elevated at the same time SO_2 concentrations were elevated at the same monitoring locations, suggesting a potential local influence by Mirant. Elevations in $PM_{2.5}$ did not correspond with elevations in SO_2 at the same monitor locations. Beyond comparison with SO_2, ATSDR considered the limited data as insufficient to characterize 24-hour $PM_{2.5}$ exposures in the area around Mirant, as limited results were consistent with NAAQS data for the same

time period. Long-term SO_2 exposures are well-characterized by VDEQ monitors located in northern Virginia and Arlington since 1999.

ATSDR revised Table 4 to include more detailed summary statistics (arithmetic mean, median, 90^{th} percentile, and maximum) for the 24-hour average $PM_{2.5}$ concentrations.

2. **Does the public health consultation adequately describe the existence of potential pathways of human exposure?**

Reviewer #3 Comments
For the most part, yes, the potential pathways of human exposure are adequately described. From my response to question 1, I think it would be informative to more fully describe the distribution of 24 hour average PM concentrations near the Mirant PRGS, acknowledging that data for PM were only collected for 6 weeks. For S02, I disagree somewhat with exposure to concentrations of health concern being characterized as "rare." On page 17 it is stated that, "...5-minute peaks greater than 200 ppb were observed an average of twice per week." I don't think this is a trivial number of potential exposures, particularly since both the Marina Towers and, maybe more importantly, the Mt. Vernon Trail are located within 0.25 miles of the Mirant PRGS. I also would argue that exposures to concentrations of 200 ppb, and possibly even 100 ppb could pose a concern to human health (see response to question 3).

ATSDR Response
Information on the distribution of $PM_{2.5}$ concentrations has been added to Table 4 of the Health Consultation. Further discussion was provided under Question 1.

ATSDR was describing the qualitative exposure frequency and has removed the qualitative descriptors and replaced with quantitative descriptions.

3. Are all relevant environmental, toxicological, and radiological data (i.e., hazard identification, exposure assessment) being appropriately used?

Reviewer #3 Comments
The health effects of peak exposures to S02 have been identified from studies of controlled human exposures, which is appropriate. These studies of free-breathing mild and moderate asthmatics clearly show an increase in both the magnitude of respiratory effects (bronchoconstriction and respiratory symptoms), as well as the fraction of asthmatic subjects affected with increasing S02 exposure concentrations between 200 and 600 ppb. Contrary to what is included in the consultation, respiratory symptoms have been observed in a limited number of studies conducted using exposure concentrations < 400 ppb (Linn et al., 1983; U.S. EPA, 2008). Referring to 200 ppb as the “lower range of oronasal effects" is misleading. In fact, the effect of S02 has not been evaluated in free-breathing asthmatics at concentrations below 200 ppb. I would have the same comment related to identifying 100 ppb as the LOAEL. I suppose this is technically true, but to my knowledge, no controlled human exposure studies have been conducted using exposure concentrations < 100 ppb.

A very important point here is that the subjects participating in these studies had mild or moderate asthma, and were not representative of severe asthmatics. In some of the studies

conducted by Linn et al. at Rancho Los Amigos, there was a group of subjects referred to as “moderate/severe asthmatics." However, these individuals were able to withhold medication usage for a given period of time prior to exposure, and none were dependent on corticosteroids. These individuals would clearly not be considered today to be “severe" asthmatics. In the discussion of exposures to concentrations < 200 ppb on page 22, it states, “Effects from exposures to less than 200 ppb are unlikely but have occurred to very sensitive individuals using a mouthpiece in clinical studies (Sheppard et al., 1981)”. Referring to the subjects in the Sheppard et al. (1981) study as “very sensitive" under the Public Health Implications section is misleading. There were two subjects in that particular study who were more responsive than others *in that study.* However, they were not selected out of the population due to their sensitivity to S02 or their severity of asthma. It is important to note that mild asthmatics (those less likely to own or use a rescue inhaler) may still experience significant bronchoconstriction following exposure to S02. There is a discussion of the potential for sensitive individuals to experience effects at lower S02 concentrations on top of page 23. However, I think this should be discussed in greater detail and be introduced earlier in the document.

It is concluded in the Public Health Implications section for S02 that “Potential effects [of exposure] are estimated to be mild and transient." This may be true for many asthmatics exposed at lower concentrations, however, for more sensitive asthmatics and with increasing exposure concentration, such exposures pose a more significant health risk. Page 23 includes a sentence on the interpretation of asymptomatic decrements in lung function. The 2009 U.S. EPA Exposure and Risk Assessment supporting the S02 NAAQS concludes that an S02-induced shift in the distribution of lung function among a population of asthmatics should be considered an adverse effect of exposure, even if exposure by itself does not result in respiratory symptoms. This is justified by considering those asthmatics who may have diminished reserve lung function from another agent, such as a viral infection.

There is a large body of epidemiologic evidence, which is not discussed, demonstrating associations between S02 concentration and respiratory symptoms as well as emergency department visits and hospital admissions for respiratory causes. I assume these have been excluded because the focus of the consultation is effects of peak S02 exposures. I will point out that although these studies typically use 24 hour average concentrations, it is thought that the observed associations could be driven by short term peaks within the 24 hour period.

Short-term exposures to PM are clearly linked to both cardiovascular and respiratory morbidity, but this is not discussed in the consultation. The rationale for excluding a discussion of potential health effects of short-term exposure to PM from Mirant PRGS should be stated explicitly.

ATSDR Response

Several of the comments to more than one question involve the same or similar subject matter. ATSDR is addressing these in the following paragraphs.

While respiratory symptoms have been reported at less than 400 ppb SO_2 in some asthmatics in limited studies, these limited reports have not been statistically significant. Stronger evidence with some statistically significant increases in respiratory symptoms has occurred at greater than 400 ppb SO_2 (EPA ISA 2008). ATSDR has added

"reported" to the following excerpt, "200 ppb as the lower range of reported oronasal effects", and "statistically significant" to the following excerpt "Lower range of statistically significant symptom expression". ATSDR's LOAEL refers to values reported in the peer-reviewed scientific literature.

ATSDR clarified the use of sensitive and mild to moderate asthmatics in the document. Note that, in general, ATSDR wishes to continue to use "sensitive" individuals to emphasize the application to not only asthmatics but other populations who may be sensitive to sulfur dioxide. We have modified the language when referencing a specific study.

ATSDR moved the discussion of the participants in clinical investigations and exposure to more sensitive individuals to the front of the Public Health Implications section under Sulfur Dioxide.

ATSDR agrees that effects from SO_2 exposure resulting in a diminished lung function would be considered an adverse effect, because the exposed individual would be at greater risk if affected by another respiratory agent (discussed in more detail in Appendix E). Whether this exposure, resulting in an adverse effect, would be termed a public health hazard for a particular site would depend on site specific characteristics such as temporal and spatial distribution which may influence the frequency and duration of exposures and coexposure to other substances.

Thus, ATSDR's site-specific approach is to consider exposures resulting in symptoms as an obvious public health hazard, while exposures below this level may or may not be a hazard depending on the spatial and temporal distribution as well as the frequency and duration of the estimated exposures.

Therefore, ATSDR agrees that exposures that diminish capacity should be considered adverse effects but differentiates exposures resulting in effects such as symptoms as public health hazards. Exposures that diminish capacity may be considered public health hazards if warranted by information at the specific site. These and other issues are discussed in Appendix E of the Health Consultation where ATSDR addresses the range of SO_2 exposures as a dose-response continuum, sensitive populations, and adverse health effects.

ATSDR agrees that there is a large body of epidemiological evidence linking SO_2 exposures and adverse health effects. ATSDR did not include discussions on the epidemiological evidence of sulfur dioxide exposure because of the focus on peak exposures. We felt that the stronger clinical evidence was sufficient. In addition, short-term exposure to PM is also not discussed since we have insufficient data to characterize short-term PM exposure and PM was not the focus of the investigation. ATSDR discussed

long-term exposure to PM as we had sufficient data to make public health conclusions. We did not provide a discussion of Mirant's contribution to potential PM health effects because Mirant's contribution is minor compared to the total PM observed (see further discussion below in ATSDR Response in #4). The short-term monitoring also did not suggest excessive short-term PM peaks. We did not focus on Mirant PM emissions because we wished to focus on the more significant public health problem.

4. **Does the public health consultation accurately and clearly communicate the health threat posed by the site?**

Reviewer #3 Comments

For the average person, including relatively healthy asthmatics exposed to S02 from Mirant, I would say yes, the health threat posed by the site is accurately and clearly communicated. However, as outlined in my response to question 3, the potential increase in health risk posed by exposure to S02 among more "sensitive" asthmatics should be discussed in greater detail and introduced earlier in the document. It is also important to note that while peak concentrations of 5 minutes are important to evaluate, even shorter exposures (2-3 minutes) to S02 have been shown to result in bronchoconstriction and respiratory symptoms (U.S. EPA, 2008).

The health threat posed by the site from elevated PM concentration is not as clearly communicated, and is more difficult to evaluate given the high concentrations of pM2.5 in the surrounding areas, as well as the limited monitoring data. The discussion and conclusions regarding exposure to PM2.5 are related to elevated concentrations in the area, and do not specifically address the contributions from Mirant PRGS.

ATSDR Response

While shorter exposures (2-3 minutes) to higher concentrations (500 ppb) have resulted in effects in mouthpiece exposures, the body of studies is limited. ATSDR focused on 5-minute exposures to avoid confusion by adhering to the convention adopted by EPA in its sulfur dioxide reviews..

Air dispersion modeling of Mirant emissions by Mirant, EPA, and others suggested that the ground-level particulate matter concentrations associated with Mirant's emissions are considerably lower than the regional background levels observed in the northern Virginia metropolitan areas. Specifically, in a publication by a researcher from the Harvard School of Public Health (Levy et al., 2004), air emissions from Mirant are estimated to contribute 0.2-0.6 µg/m^3 to ground-level $PM_{2.5}$ concentrations in Alexandria; in contrast, the same study notes that outdoor $PM_{2.5}$ air concentrations in this area are typically in the range of 13 to 15 µg/m^3. Therefore, ATSDR's conclusion reflects, as the comment suggests, the elevated concentrations of $PM_{2.5}$ in northern Virginia, and not the specific incremental impacts associated with Mirant's emissions. The conclusions have been revised slightly to clarify this point.

5. Are the conclusions and recommendations appropriate in view of the site's condition

as described in the public health consultation?

Reviewer #3 Comments
I disagree somewhat with the following statement under conclusions regarding S02 exposures: "At lower sulfur dioxide concentrations (200 ppb to 400 ppb), sensitive individuals at elevated ventilation rates may experience effects (e.g., mild constriction of bronchial passages) without symptoms." As presented in my response to question 3, respiratory symptoms have been observed following exposure to concentrations between 200 and 400 ppb. I would also suggest that this group not be referred to as "sensitive individuals" but rather "mild and moderate asthmatics." I would also suggest that something be added in the conclusions on the potential for increased response, or response at lower concentrations in more severe asthmatics.

The conclusions regarding PM2.5 do not specifically address risks posed from Mirant PRGS, but rather discuss the elevated PM2.5 concentrations in northern Virginia in general. If specific conclusions regarding PM2.5 from the Mirant site cannot be made explicitly, this should be discussed in the conclusion.

ATSDR Response
ATSDR has changed the reference from sensitive individuals to mild and moderate asthmatic.
See response in #4for discussion of specific PM conclusions.

6. Are there any other comments about the public health consultation that you would like to make?

Reviewer #3 Comments
With the stack reconfiguration (stack merging), it would seem that there could be an increase in concentrations of S02 at distances further from the facility. Has this been modeled?

The discussion on near roadway exposures should provide information on N02, CO and PM in addition to what is included on hazardous air pollutants.

It is not clear how “general population" is being defined in the consultation.

ATSDR Response

ATSDR agrees that the stack merger may increase SO_2 at more distant locations. Mirant is now permitted by the Virginia Department of Environmental Quality (VDEQ). Air dispersion modeling was conducted on SO_2 emissions (not PM emissions) in support of the stack merger, but ATSDR has not evaluated these data.

ATSDR agrees with this comment and has added text in the “Near Roadway Exposures” section to acknowledge that mobile sources emit these pollutants, in addition to the air toxics previously identified in the Health Consultation.

ATSDR usage of general population includes the members of the population not

expressing an increased susceptibility to the health effects of an environmental exposure to sulfur dioxide (The American Lung Association.2001.Urban Air Pollution and Health Inequities: A Workshop Report. Environmental Health Perspectives 109(S3):357-373). This has been added to the document to clarify.

7. Are there any other comments?

Reviewer #3 Comment
Overall, it is a very informative, thorough and well written document.

REFERENCES (submitted by reviewer#3):

Linn WS, Venet TG, Shamoo DA, Valencia LM, Anzar UT, Spier CE and Hackney JD. (1983). Respiratory effects of sulfur dioxide in heavily exercising asthmatics: a dose-response study. Am Rev Respir Dis, 127, 278-283.

Sheppard D, Saisho A, Nadel JA and Boushey HA. (1981). Exercise Increases Sulfur Dioxide-induced Bronchoconstriction in Asthmatic Subjects. Am Rev Respir Dis 123: 486-491

EPA. (2008). Integrated science assessment for sulfur oxides -health criteria (No. EPA/ 600 / R-08 / 047F). Research Triangle Park, NC: National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency.

U.S. EPA. (2009). Risk and exposure assessment to support the review of the S02 primary national ambient air quality standards: Final report (No. EPA-452/R-09-007). Research Triangle Park, NC: Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency.

ADDITIONAL QUESTIONS:

PEER REVIEW COMMENT FORM

1. Are there any comments on ATSDR's peer review process?

Appendix I. Public Comments and the ATSDR Response to Public Comments.

Section A includes all public comments. Public comments were received from the following;

> The City of Alexandria, the Utility Air Regulatory Group (UARG), and the Environmental Protection Agency (EPA).

Section B includes the ATSDR response to public comments.

A. Public Comments

City of Alexandria
301 King Street, City Hall, Suite 2300
Alexandria, Virginia 22314

August 12, 2010

Agency for Toxic Substances and Disease Registry
Attention: Rolanda Morrison
Re: Mirant Potomac River Generating Station site
ATSDR Records Center
4770 Buford Highway, NE (MS F-09)
Atlanta, GA 30341

Re: ATSDR's Health Consultation, Public Comment Version, Review of Ambient Air Monitoring Data, Mirant Potomac River Generating Station (PRGS), Alexandria, Virginia, July 12, 2010

Dear Ms. Morrison:

As co-chairs of the City of Alexandria's Mirant Community Monitoring Group (MCMG), we would like to thank the Agency for Toxic Substances and Disease Registry (ATSDR) for the opportunity to comment on the above mentioned report.

We appreciate the thoroughness of the scientific approach and analysis of the monitoring data that ATSDR employed in reaching its conclusions and recommendations. Its main conclusion basically points to the continuing need to reduce the ambient five-minute SO_2 as well as the $PM_{2.5}$ level near the PRGS site to further reduce public health impacts from this power plant.

The goals of the City/Mirant Agreement are consistent with ATSDR's recommendations. In fact, in accordance with the City/Mirant Agreement, the City is currently working with Mirant on a project to further reduce stack and fugitive fine particulate ($PM_{2.5}$) emissions. The City/Mirant Agreement also requires a more stringent short-term SO_2 emissions limit of 0.3 lb per million Btu (24-hour average) compared to 0.4-0.45 lb per million Btu for the years 2006-2007 preceding the agreement (i.e., 25-33% reduction). The ATSDR report corroborates well with the approach that the City has been taking to lessen the environmental impacts of this power plant, but, the information in the ATSDR report would have been more relevant and useful to the community had it been issued sooner.

We understand that Mirant has agreed to provide ATSDR with five-minute SO_2 data from February 2009 until May 2010, i.e., after the implementation of stack merge project. We request that ATSDR include in the final report, an analysis of this data including QA/QC procedures used in collecting this data.

We would like to thank Lora Werner and her project team for their effort in generating this report and holding the information meeting to answer questions from concerned residents. In addition, we appreciate ATSDR's willingness to meet with MCMG members and other concerned stakeholders in smaller groups prior to public meetings.

Sincerely,

Redella S. (Del) Pepper
Councilwoman and Co-chair of MCMG
City of Alexandria

Paul C. Smedberg
Councilman and Co-chair of MCMG
City of Alexandria

C: Honorable Mayor and Alexandria City Council
James Hartmann, City Manager
Mark Jinks, Deputy City Manager
Richard Baier, Director, T&ES
Stephen Haering, Director, Alexandria Health Department
William Skrabak, Director, T&ES Office of Environmental Quality
MCMG Members

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August 12, 2010

Agency for Toxic Substances and Disease Registry
ATTN: Records Center
1600 Clifton Road, NE (Mail Stop (F-09)
Atlanta GA 30333

Re: Health Consultation: Review of Ambient Air Monitoring Data
Mirant Potomac River Generating Station

To Whom It May Concern:

This letter provides comments by the Utility Air Regulatory Group ("UARG") on the Health Consultation: Review of Ambient Air Monitoring Data Mirant Potomac River Generating Station (ATSDR, July 12, 2010, Public Comment Version) ("Health Consultation"). UARG is a voluntary, nonprofit group of individual electric generating companies and industry trade associations. UARG's purpose is to participate on behalf of its members collectively in rulemakings by the Environmental Protection Agency ("EPA") and other Clean Air Act ("CAA" or "Act") proceedings that affect the interests of electric generators, and in related litigation. Since 1977, UARG has participated in virtually all key rulemakings, related litigation, and other arenas of policy development under the Act that affect electric generating companies. UARG participated extensively in proceedings by EPA that led to that agency's recent final decision on the primary national ambient air quality standard ("NAAQS") for sulfur dioxide ("SO_2"), a decision cited in the Health Consultation. UARG offers the following comments on the Health Consultation based on its participation in that rulemaking and in other rulemakings that concern health effects that are allegedly related to emissions from coal-fired power plants such as the Potomac River Generating Station that is the subject of the Health Consultation.

The Health Consultation concludes, "Breathing air around Mirant PRGS contaminated with sulfur dioxide for short periods (5 minutes) could harm the health of sensitive person (e.g., persons with asthma) functioning at elevated ventilation rates, ..." Health Consultation at 2. At least some of the information on which the Health Consultation relies to support this conclusion is dated. Appendix E to the Health Consultation -- the Sulfur Dioxide Health Evaluation -- for example, references a 1994 EPA staff report assessing the scientific and technical information on sulfur dioxide effects, although EPA completed a more recent

assessment of the relevant science in connection with its recent review of the SO_2 NAAQS. With regard to that review, the Health Consultation refers to a draft of a risk assessment and EPA's proposal to modify the NAAQS, but not to the final rule adopting a 1-hour NAAQS of 75 parts per billion ("ppb"). 75 Fed. Reg. 35520 (June 22, 2010). It is EPA's judgment that this 75 ppb standard will protect the public health (including the health of sensitive subpopulations such as asthmatics) with an adequate margin of safety. *Id.* at 35548. This standard specifically protects against 5-minute exposures of health concern. *Id.* at 35538. Although the Health Consultation does not provide hourly SO_2 monitoring data from which compliance of the new NAAQS in the vicinity of the plant can be judged, information provided by EPA when it adopted that standard shows no exceedance in Alexandria, Virginia, the vicinity of the Potomac River Generating Station. *See* Design Values (1-Hour) by County for Sulfur Dioxide (available at *http://www.epa.gov/air/sulfurdioxide/pdfs/20100602table0709.pdf*) (Attachment 1 to these Comments). Thus, no concern about health effects of associated with exposures to SO_2 around the Potomac River Generating Station is warranted.

In fact, both the Health Consultation and EPA overstate the evidence of health risk to asthmatics exposed briefly to low SO_2 concentrations during exercise. As UARG explained in commenting on EPA's proposal for a 1-hour SO_2 NAAQS in the range of 50 to 100 ppb, the clinical studies do not support a conclusion that even exercising asthmatics require protection from brief SO_2 exposures of less than 600 ppb. Comments of the Utility Air Regulatory Group on EPA's Proposed Rule on the Primary National Ambient Air Quality Standard for Sulfur Dioxide 14-15 (Feb. 8, 2010) (Attachment 2). The scientific evidence does not reflect statistically significant findings of important changes in performance on pulmonary function tests in combination with respiratory symptoms in exercising asthmatics attributable to SO_2 exposures below this level. Nor is that evidence consistent with concerns that individuals who suffer from more severe asthma will have larger responses to SO_2 than the subjects of the studies.

In addition, UARG notes that the Health Consultation expresses concern about exposures to $PM_{2.5}$ in the vicinity of the Mirant plant. Health Consultation at 3. Although the Health Consultation acknowledges that these $PM_{2.5}$ levels "are similar to levels measured in multiple locations throughout northern Virginia, *id.*, it nevertheless suggests reducing particulate matter emissions from the plant. Given the regional nature of the $PM_{2.5}$ concentrations, however, this is unlikely to reduce significantly risks from $PM_{2.5}$ near the plant..

Finally, UARG notes that the Health Consultation concludes that reducing particulate matter exposures will also reduce arsenic and chromium exposures in the vicinity of the Potomac River Generating Station. *Id.* at 4. As the Health Consultation recognizes, levels of arsenic

and chromium near the plant "were consistent with those routinely observed in suburban and urban locations nationwide and likely reflected contributions from many emissions sources." *Id.* Essentially, then, the risks from these metals around the Potomac River plant are not elevated.[1] Any contribution by the Plant to risks posed by these metals would be negligible.

Sincerely,

Lucinda Minton Langworthy
Counsel to the Utility Air Regulatory Group

Attachments

[1] Risks associated with chromium in the plant's vicinity are, in fact, likely significantly overstated given the contamination of the filter blanks for the ambient measurements in the vicinity of the plant. *See* Health Consultation at 34-35.

US Environmental Protection Agency

Comments on ATSDR's Health Consultation; Review of Ambient Monitoring Data from the Mirant Potomac River Generating Station in Alexandria, VA (July 12, 2010).

SO_2 comments:

- Air quality analyses were performed showing that SO_2 concentrations did not exceed the then existing 24-hour and annual SO_2 NAAQS (during the timeframe examined). However, it was also noted throughout the document that EPA proposed setting a new 1-hour SO_2 standard between 50 and 100 ppb to provide increased public health protection against short-term (5-minute to 24-hour) SO_2 concentrations (e.g., see p. 17). Given that a 99th percentile 1-hour daily maximum standard has now been set at 75 ppb (see 75 FR 35520), it would be beneficial if these air quality analyses were repeated in relation to this new 99th percentile 1-hour daily maximum standard. It is possible that these analyses could change the conclusions/recommendations described in this document.

- Multiple pages indicate (e.g., p. 26) that following 5-minute SO_2 exposures in the range of *200- 400* ppb, asthmatics could experience bronchoconstriction, which is estimated to be mild and transient *without symptoms*. This is not entirely correct. We note that based on individual level data from controlled human exposure studies, an estimated 5 -30% of exposed exercising asthmatics experience *moderate or greater* bronchoconstriction following 5-minute exposures in the range of *200 -300 ppb*. Moreover, at 400 ppb there is evidence of bronchoconstriction *and* respiratory symptoms from clinical studies (see Integrated Science Assessment for Sulfur Oxides- Health Criteria, see p. 5-11).

- P. 5 notes that high 5-minute SO_2 levels were confined to populated areas within 0.25 miles of the facility. Thus, it would also be beneficial to have an estimate of the population within 0.25 miles of the facility.

- P. 21 suggests that asthmatics at elevated ventilation rates need to be exposed for approximately 5 or more minutes to SO_2 concentrations of concern in order to experience health effects (p. 21). We note that SO_2-induced bronchoconstriction has been shown to occur in as little as 2 minutes following SO_2 exposure (see Integrated Science Assessment for Sulfur Oxides- Health Criteria, p. 3-6)

- P. 25 states that clinical investigations have not been performed in severe asthmatics, children, or those with pre-existing respiratory disease. In this statement, "those with pre-existing respirator disease" should be deleted since studies have been performed in mild and moderate asthmatics as well as in individuals with Chronic Obstructive Pulmonary Disorder (COPD). Also, while young children have not been included in free-breathing clinical studies, we note that adolescents were included in some clinical mouthpiece studies (see Integrated Science Assessment for Sulfur Oxides- Health Criteria, p. 3-9

- P. 26 states that at 5-minute SO_2 levels > 500 ppb, sensitive persons may use medication, seek medical treatment or stop physical activity. This statement is not limited to SO_2 concentrations > 500 ppb. It is very possible that SO_2 sensitive individuals would do these things following 5-minute exposures < 500 ppb.

- The document references the second draft of the SO_2 Risk and Exposure Assessment to Support the Review of the SO_2 NAAQS. Citations should be checked against the finalized SO_2 Risk and Exposure Assessment which is available at: http://www.epa.gov/ttn/naaqs/standards/so2/s_so2_cr_rea.html

- Appendix E (p. 3) states that "exposures to <500 ppb SO_2 appears to be the range of most uncertainty as to whether an effect will occur and whether that effect should be considered adverse." Adversity of effects is also discussed on p.5 of Appendix E. In the SO_2 NAAQS Proposal and Final Rule (75 FR 35520), EPA considered 5-minute exposures ≥ 400 ppb as clearly being adverse to the health of asthmatics since exposures in this range can result in moderate or greater decrements in lung function in the presence of respiratory symptoms. In addition, based on American Thoracic Society Guidelines, Clean Air Scientific Advisory Committee advice, and conclusions in previous NAAQS reviews, EPA also considered the health effects associated with 5-minute SO_2 exposures in the range of 200 -300 ppb to be adverse to the health of asthmatics (see 75 FR 35520).

PM Comments:

- The document references the first draft Integrated Science Assessment for PM (USEPA 2008c). The ISA, finalized in Dec 2009, should be referenced in the draft report. It is available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=216546.

    - The health studies briefly summarized on p. 30 do not reflect the most currently available evidence including extended analyses of the ACS and Harvard Six Cities studies as well as important new studies that are currently available.

    - In addition to a more substantive body of scientific evidence for mortality and cardiovascular and respiratory effects, the ISA concludes that there is suggestive evidence between long-term $PM_{2.5}$ exposures and reproductive/developmental effects as well as cancer, mutagenicity, and genotoxicity. This evidence is not reflected in the draft report.

    - Populations susceptible to PM exposures include not just infants but the broader lifestage of childhood. In addition, as identified in the ISA, evidence is now

available that supports the identification of persons with lower socioecomonic status (SES) as a susceptible population.

- The conclusion that the available monitoring data points to a regional rather than local air quality issue is not clearly supported by the data presented. Similarly, the statement that $PM_{2.5}$ concentrations in the immediate vicinity of Mirant may be "slightly higher" than the regional values typically measured in northern VA are not supported by the data presented. In addition, the rationale supporting that statement that "characterization of short-term exposures around Mirant PRGS is insufficient, but long-term exposures suggest a cause for concern" is not clear.

    - While recognizing that monitoring data are presented for a 6-week time period only, Table 4 summarizes substantially higher $PM_{2.5}$ concentrations at the ATSDR and Mirant monitoring sites in relation to an annual average concentration for the VDEQ site. It would be more reasonable to consider VDAQ measured data for the same time period (June 8-July 23, 2007) to better understand the spatial heterogeneity in ambient $PM_{2.5}$ in this area.

    - Also, it is unclear why the summary of statistics in Table 4 presents 90th percentile data for the 24-hour measured concentrations rather than the 98th percentile to match the form of the current 24-hour $PM_{2.5}$ standard. Recognizing the limitations of having only 6-weeks' worth of measured data, as noted on p. 28, 4 days during the monitoring period exceeded the level of the current 24-hour $PM_{2.5}$ standard, providing some support for considering whether or there is a potential for short-term exposures of concern.

B. ATSDR Response to Public Comments.

Section B includes ATSDR's response to comments received during the public comment period. Often comments were a part of a correspondence which contained information in addition to comments on the Public Health Consultation. In these cases, an excerpt from the correspondence is included in this section to identify the specific comment that is being addressed. Each of the correspondence is provided in Section A. Correspondence was received from the city of Alexandria, the Utility Air Regulatory Group and the Environmental Protection Agency.

City of Alexandria comments: **(**see complete letter in Section A**). "**We understand that Mirant has agreed to provide ATSDR with five-minute SO_2 data from February 2009 until May 2010, i.e., after the implementation of the stack merge project. We request that ATSDR include in the final report, an analysis of this data including QA/QC procedures used in collecting this data."

> **ATSDR response:** *ATSDR applauds the efforts of the City of Alexandria, the Mirant Community Monitoring Group, and the Alexandria Health Department in pursuit of improved air quality around Mirant PRGS. These efforts have resulted in reduced air contamination in the area and a reduction in potential exposures.*
>
> *ATSDR has received post stack monitoring data from Mirant and has reported results of the evaluation of these data below. Related to these data, ATSDR has also requested QA/QC information from Mirant. To date, we have not received the QA/QC procedures.*

Mirant 5-Minute Sulfur Dioxide Monitoring Data and Generating Output.

Pre and post stack merge 5-minute sulfur dioxide (SO_2) monitoring data and generating output data were obtained from the Virginia Department of Environmental Quality (VDEQ) for the Mirant Potomac River Generating Station (PRGS). The pre stack merge generating output data covered the period January 26, 2007 through August 2, 2007 while the pre stack merge SO_2 monitoring data were obtained from April 2007 through July 2008 (previously analyzed). The post stack merge generating output data covered the period June 2009 through May 2010 while the post stack merge SO_2 monitoring data were obtained for February 2009 through May 2010. The SO_2 data from the Mirant monitoring network are described below in Table 1.

Three monitoring locations were used during both the pre- and post-stack merge data monitoring periods. We reviewed data for the locations to compare the levels reported. During the pre stack merge period at the same 5-minute SO_2 monitoring locations, there were less than 0.04% SO_2 detections greater than 200 ppb, less than 0.3 % detections greater than 100 ppb, and the remainder of the detections were all less than 10 ppb. During the post stack merge period, there were no SO_2 detections greater than 200 ppb, less than 0.001% detections greater than 100 ppb, and the remainder of the detections were all less than 10 ppb.

Mirant generating output during the pre stack merge time frame of January 26, 2007 through August 2, 2007 averaged 5653 Megawatts (MW) per day for 127 days reported during this time frame. Mirant generating output during the post merge time frame of June 26, 2009 through May 20, 2010 averaged 1931 MW per day for the 323 days reported. These data suggest Mirant generating output was 66% lower during the post merge time frame compared to the pre merge time frame. We do not know if these data are representative of other time frames.

Table 1. Mirant 5-Minute SO_2 Monitoring Data Summary

Mirant 5-Minute SO_2 Monitoring Data Summary Post Stack Merge Period 2/09-5/10 (Pre Stack Merge Period 4/07 – 7/08)		
Detections	Valid 5-minute Samples	Percentage of Total 5-Minute Samples
Total 5-Minute Detections	351,199 (380,875)	
Detections > 10 ppb	15,359 (49,776)	4% Post (13% Pre)
Detections > 100 ppb	5 (1196)	<0.001% Post (0.3 % Pre)
Detections > 200 ppb	0 (148)	0 % Post (<0.04 % Pre)
Detections > 400 ppb	0 (6)	0% Post (<0.0002% Pre)

Post stack merge data represent a reduction in 5-minute SO_2 concentrations from pre stack merge SO_2 data at the three remaining of the original six Mirant monitoring stations. ATSDR does not have information suggesting these three monitoring stations are the most appropriate for post stack merge configurations. It is also not known if data collected during these time frames are representative of other time frames. For example, Mirant PRGS generating output was 66% lower during the post stack merge time frame compared to the limited pre stack merge time frame provided by VDEQ. In addition, the pre and post timeframes are not for the same seasonal periods.

Utility Air Regulatory Group (UARG) comments: (see complete letter in Section A)

UARG comment, 2nd paragraph, page I-5: "Thus, no concern about health effects [of] associated with exposures to SO2 around the Potomac River Generating Station is warranted."

> **ATSDR response:** *ATSDR does not agree with the author's comment. EPA's data showing no SO_2 exceedances were based on 3-year average of the 99th percentile of the daily maximum 1-hour average at a location more distant from Mirant PRGS than data from monitors used in the ATSDR analysis. The data from the Mirant monitors and the VDEQ NAAQS monitor in Alexandria for the same time period is presented in Figure 7 (Average hourly Mirant and VDEQ SO_2 data and Mirant PRGS operations output by hour for June and July, 2007) of the Health Consultation. ATSDR's conclusions were based on actual monitoring of ambient air near Mirant PRGS, which recorded 5-minute concentrations of public health concern. An hourly average of 75 ppb SO_2 could theoretically have a 5-minute peak of 900 ppb and still be in compliance with an hourly*

standard of 75 ppb average, which is based on the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area. ATSDR based health concerns on actual 5-minute sulfur dioxide data provided by Mirant PRGS, which reported excursions above 200 ppb more than three times a week.

To compare with EPA's new 1-hour standard criteria, ATSDR computed peak:mean ratios for the Mirant dataset which were included in the Health Consultation (Appendix G, Table G-3. Statistical Analysis of Hourly Peak:Mean Ratios of Mirant 5-minute Data). Note that the maximum 99th percentile peak:mean ratio was 4.54, resulting in a 5-minute concentration estimate of 340 ppb, based on a 99th percentile 75 ppb 1-hour average and assuming the data were based on 3 years. This level would be a level of concern for sensitive populations, depending on the frequency of exposure. Therefore, concern about health effects associated with exposures to SO_2 around the PRGS is warranted.

UARG comment, 3rd paragraph, page I-6: "As UARG explained in commenting on EPA's proposal for a 1-hour SO_2 NAAQS in the range of 50 to 100 ppb, the clinical studies do not support a conclusion that even exercising asthmatics require protection from brief SO_2 exposures of less than 600 ppb."

ATSDR response: *ATSDR does not agree with the author's comments. Statistically significant findings of changes in performance attributable to SO_2 exposures in combination with respiratory symptoms are reported at levels 400 ppb and above (EPA REA, July 2009, p. 55), not 600 ppb. Statistically significant findings of changes in performance, but without respiratory symptoms, attributable to SO_2 exposures are reported at levels 200 ppb and above. Further, ATSDR agrees with EPA which has adopted the principles recommended by the American Thoracic Society (ATS. 2000. What constitutes an adverse effect of air pollution? Am J Respir Cirt Care Med 161:665-673) concerning diminished capacity as an adverse health effect from exposure to air pollution.*

UARG comment, 3rd paragraph, page I-6: "The scientific evidence does not reflect statistically significant finding of important changes in performance on pulmonary function test in combination with respiratory symptoms in exercising asthmatics attributable to SO_2 exposures below this level. Nor is that evidence consistent with concerns that individuals who suffer from more severe asthma will have larger responses to SO_2 than the subjects of the studies."

ATSDR response: *ATSDR disagrees with the author's comments. Not all asthmatics have equal sensitivity to* SO_2. *While severe asthmatics have not usually been tested in clinical investigations (for ethical considerations), clinical studies involving mild to moderate asthmatics demonstrate an increase in severity of response and/or an increase in the proportion of subjects affected with increasing SO_2 exposure (EPA ISA 2008, Summary of Evidence on the Effect of Peak Exposure on Respiratory Health).*

UARG comment, 4th paragraph, page I-6: "Although the Health Consultation acknowledges that these $PM_{2.5}$ levels 'are similar to levels measured in multiple locations throughout northern Virginia', *id*., it nevertheless suggests reducing particulate matter emissions from the plant. Given the regional nature of the $PM_{2.5}$ concentrations, however, this is unlikely to reduce significantly risk from $PM_{2.5}$ near the plant."

> **ATSDR response:** *ATSDR agrees that, given the regional nature of the $PM_{2.5}$ concentrations, reducing $PM_{2.5}$ contributions from Mirant PRGS are unlikely to significantly reduce risks from $PM_{2.5}$ near the plant. However, a reduction in the combined exposure to SO_2 and $PM_{2.5}$ near the plant could be of significant benefit and reducing particulate emissions could result in lower cancer risks from chromium and arsenic concentrations measured in particulate matter near Mirant PRGS. ATSDR's recommendation specifically referenced the previously-negotiated settlement agreement between Mirant and the City of Alexandria to reduce and monitor particulate matter emissions. In addition, ATSDR addressed mixtures exposures in Conclusion 5, noting that reductions in $PM_{2.5}$ would reduce the likelihood of multiple contaminant exposures.*

UARG comment, 5th paragraph, page I-6**:** "As the Health Consultation recognizes levels of arsenic and chromium near the plant 'were consistent with those routinely observed in suburban and urban locations nationwide and likely reflected contributions from many emissions sources'. *Id*. Essentially, then, the risks from these metals around Potomac River plant are not elevated[1]. Any contribution by the Plant to risks posed by these metals would be negligible.

[1] Risks associated with chromium in the plant's vicinity are, in fact, likely significantly overstated given the contamination of the filter blanks for the ambient measurements in the vicinity of the plant. See Health Consultation at 34-35."

> **ATSDR response:** *ATSDR disagrees somewhat with the author's comments. The cancer risks described by ATSDR are increased risks above the background cancer rate. The risks are elevated, even if other areas have a similar elevation in risk from exposure to chromium and arsenic. ATSDR agrees that the stated risk may overestimate risk from the environment as the filter blanks also contained chromium. However, if the average chromium in the blanks were subtracted from the total chromium, the cancer risk from chromium would still be elevated.*

Environmental Protection Agency (EPA) comments: (See comments in Section A).

Sulfur Dioxide Comments

EPA comment, first bullet, page I-8:

Air quality analyses were performed showing that SO_2 concentrations did not exceed the then existing 24-hour and annual SO_2 NAAQS (during the timeframe examined). However, it was also noted throughout the document that EPA proposed setting a new 1-hour SO_2 standard between 50 and 100 ppb to provide increased public health protection against short-term (5-minute to 24-hour) SO_2 concentrations (e.g., see p. 17). Given that a 99th percentile 1-hour daily maximum standard has now been set at 75 ppb (see 75 FR 35520), it would be beneficial if these air quality analyses were repeated in relation to this new 99th percentile 1-hour daily maximum standard. It is possible that these analyses could change the conclusions/recommendations described in this document.

> **ATSDR response:** *ATSDR considers it unlikely that the conclusions/recommendation described in the Health Consultation would change if based on EPA's 1-hour standard of 75 ppb. EPA's standard was based in large part on 5-minute exposures during clinical investigations. ATSDR's conclusions and recommendations are based on the same exposures during 5-minute clinical investigations. EPA's standard is a regulatory value while ATSDR describes the health effects expected from described exposures.*
>
> *ATSDR agrees it would be interesting to compare results based on the new standard, but that obviously cannot be accomplished with this limited dataset since the standard is based on a 3-year average of the 99th percentile of the daily maximum 1-hour-average. ATSDR conducted an analysis of the peak:mean ratios of Mirant's 5-minute SO_2 data Appendix G, Table G-3. Statistical Analysis of Hourly Peak:Mean Ratios of Mirant 5-minute Data). The maximum 99th percentile peak:mean ratio was 4.54. Based on EPA's 3-year average of the 99th percentile value of 75 ppb and assuming the collected data were representative of 3 years, the 99th percentile of 4.54 would result in an estimated 5-minute value of 340 ppb. The degree of hazard would depend on the frequency of exposure to this value in sensitive populations because the concentration level could cause adverse health effects in some portion of the sensitive population (EPA, ISA 2008).*

EPA comment, second bullet, page I-8:

Multiple pages indicate (e.g., p. 26) that following 5-minute SO_2 exposures in the range of *200-400* ppb, asthmatics could experience bronchoconstriction, which is estimated to be mild and transient *without symptoms*. This is not entirely correct. We note that based on individual level data from controlled human exposure studies, an estimated 5 -30% of exposed exercising asthmatics experience *moderate or greater* bronchoconstriction following 5-minute exposures in the range of *200 -300 ppb*. Moreover, at 400 ppb there is evidence of bronchoconstriction *and* respiratory symptoms from clinical studies (see Integrated Science Assessment for Sulfur Oxides- Health Criteria, see p. 5-11).

> **ATSDR response:** *ATSDR does not entirely agree with EPA's statements. ATSDR refers to exposure at 400 ppb as the lower range of statistically significant symptom expression (Figure 4, page 19). ATSDR is aware of symptoms reported below 400 ppb, but they were not statistically significant. From the EPA Risk and Exposure Assessment to Support the*

Review of the SO_2 Primary National Ambient Air Quality Standards, July 2009, p.55: "The lower end of the range considers the factors mentioned above, while the upper end of the range recognizes that 400 ppb represents the lowest concentration at which statistically significant decrements in lung function are seen in conjunction with statistically significant respiratory symptoms."

EPA comment, third bullet, page I-8:

P. 5 notes that high 5-minute SO_2 levels were confined to populated areas within 0.25 miles of the facility. Thus, it would also be beneficial to have an estimate of the population within 0.25 miles of the facility.

ATSDR response: *ATSDR agrees. While the population could be roughly estimated from the population reported from the 2000 Census (Figure 1, page 19), it may have been helpful to document the population in the 0.25 mile area with new data. We requested this analysis but were told the data on this level would not be available until April 2011.*

EPA comment, fourth bullet, page I-8:

P. 21 suggests that asthmatics at elevated ventilation rates need to be exposed for approximately 5 or more minutes to SO_2 concentrations of concern in order to experience health effects (p. 21). We note that SO_2-induced bronchoconstriction has been shown to occur in as little as 2 minutes following SO_2 exposure (see Integrated Science Assessment for Sulfur Oxides- Health Criteria, p. 3-6)

ATSDR response: *ATSDR agrees that bronchoconstriction has occurred in some asthmatics with exposures to SO_2 in less than 5 minutes. While shorter exposures (2-3 minutes) to higher concentrations (500 ppb) have resulted in effects in mouthpiece exposures, the body of studies is limited and ATSDR was describing exposures relevant to the site-specific conditions for the public to avoid confusion.*

EPA comment, fifth bullet, page I-8:

P. 25 states that clinical investigations have not been performed in severe asthmatics, children, or those with pre-existing respiratory disease. In this statement, "those with pre-existing respirator disease" should be deleted since studies have been performed in mild and moderate asthmatics as well as in individuals with Chronic Obstructive Pulmonary Disorder (COPD). Also, while young children have not been included in free-breathing clinical studies, we note that adolescents were included in some clinical mouthpiece studies (see Integrated Science Assessment for Sulfur Oxides- Health Criteria, p. 3-9).

ATSDR response: *ATSDR agrees. The statement has been altered as suggested.*

EPA comment, first bullet, page I-9:

P. 26 states that at 5-minute SO_2 levels > 500 ppb, sensitive persons may use medication, seek medical treatment or stop physical activity. This statement is not limited to SO_2 concentrations > 500 ppb. It is very possible that SO_2 sensitive individuals would do these things following 5-minute exposures < 500 ppb.

ATSDR response: *ATSDR agrees. The statement has been clarified to state "exposure to sensitive persons may more often result in medication…."*

EPA comment, second bullet, page I-9:

The document references the second draft of the SO_2 Risk and Exposure Assessment to Support the Review of the SO_2 NAAQS. Citations should be checked against the finalized SO_2 Risk and Exposure Assessment which is available at:
http://www.epa.gov/ttn/naaqs/standards/so2/s_so2_cr_rea.html

ATSDR response: *ATSDR has made any necessary changes as appropriate for which it was aware from the draft to final version of the Integrated Science Assessment.*

EPA comment, third bullet, page I-9:

Appendix E (p. 3) states that "exposures to <500 ppb SO_2 appears to be the range of most uncertainty as to whether an effect will occur and whether that effect should be considered adverse." Adversity of effects is also discussed on p.5 of Appendix E. In the SO_2 NAAQS Proposal and Final Rule (75 FR 35520), EPA considered 5-minute exposures ≥ 400 ppb as clearly being adverse to the health of asthmatics since exposures in this range can result in moderate or greater decrements in lung function in the presence of respiratory symptoms. In addition, based on American Thoracic Society Guidelines, Clean Air Scientific Advisory Committee advice, and conclusions in previous NAAQS reviews, EPA also considered the health effects associated with 5-minute SO_2 exposures in the range of 200 -300 ppb to be adverse to the health of asthmatics (see 75 FR 35520).

ATSDR response: *ATSDR agrees with the comment and has further clarified statements in Appendix E by changing the range of uncertainty value from 500 to 400 ppb.*

Particulate Matter (PM) Comments

ATSDR general response: *ATSDR's initial response to concerns identified by the Alexandria Health Department (Appendix B. Letter to Alexandria Health Department), identified short-term exposure to SO_2 in sensitive populations as the exposure of concern. Exposure to particulate matter was not identified as an exposure of concern from Mirant PRGS emissions, based on air dispersion modeling conducted by EPA and Mirant PRGS. ATSDR conducted particulate matter monitoring during the Exposure Investigation to determine if evidence existed for elevations in particulate matter co-eluting with*

elevations of SO_2 by observing temporal and spatial patterns, which might suggest Mirant PRGS as the source of PM emissions. ATSDR did not find this to be the case.

Therefore, because the focus of the Health Consultation was short-term exposure to SO_2, ATSDR did not conduct a detailed assessment of particulate matter. ATSDR included particulate matter data collected or evaluated and offered conclusions as to the public health significance of these data. ATSDR considered short-term exposures to particulate matter to be indeterminate because of the limited data collected (six weeks), the seasonal variation in particulate matter in Virginia, and the limited public health conclusions that could be determined about site-specific short-term (24-hour) $PM_{2.5}$ exposures in relation to expected adverse health effects. The EI was not designed to provide determinate data for PM exposures. Conclusions concerning long-term PM exposures were provided as prudent public health information from data observed but not collected by ATSDR.

That said, ATSDR has addressed specific comments not addressed by the preceding general response on particulate matter, as follows:

EPA comment, first comment, first bullet, page I-9

The health studies briefly summarized on p. 30 do not reflect the most currently available evidence including extended analyses of the ACS and Harvard Six Cities studies as well as important new studies that are currently available.

ATSDR response: *ATSDR agrees that the summary on page 30 does not reflect a comprehensive summary of all currently available evidence. However, we have presented sufficient and adequate evidence to support the conclusion by ATSDR that public health concern is warranted for adverse health effects from long-term exposure to $PM_{2.5}$. ATSDR believes that the WHO summary is particularly relevant to the public for comparison with long-term exposure levels; therefore, we used the WHO summary although additional evidence now exists.*

EPA comment, first comment, second bullet, page I-9.

In addition to a more substantive body of scientific evidence for mortality and cardiovascular and respiratory effects, the ISA concludes that there is suggestive evidence between long-term $PM_{2.5}$ exposures and reproductive/developmental effects as well as cancer, mutagenicity, and genotoxicity. This evidence is not reflected in the draft report.

ATSDR response: *ATSDR agrees that additional information is available on PM, but as noted above, ATSDR considers the current content of the Health Consultation sufficient to relay the intended message. Note that ATSDR did not discuss the details of the adverse health effects of exposure to $PM_{2.5}$, since it was not the focus of the document.*

EPA comment, first comment, third bullet, page I-9.

Populations susceptible to PM exposures include not just infants but the broader lifestage of childhood. In addition, as identified in the ISA, evidence is now available that supports the identification of persons with lower socioeconomic status (SES) as a susceptible population.

> **ATSDR response:** *ATSDR addresses children's health in Children's Health Considerations, page 38 of the Health Consultation. "Lower socioeconomic status" was added to the list of sensitive populations on page 29 of the Health Consultation.*

EPA comment, second comment, page I-10.

The conclusion that the available monitoring data points to a regional rather than local air quality issue is not clearly supported by the data presented. Similarly, the statement that $PM_{2.5}$ concentrations in the immediate vicinity of Mirant may be "slightly higher" than the regional values typically measured in northern VA are not supported by the data presented. In addition, the rationale supporting that statement that "characterization of short-term exposures around Mirant PRGS is insufficient, but long-term exposures suggest a cause for concern" is not clear.

> **ATSDR response:** *The conclusions about regional and local air quality are based on and supported by a number of sources including EPA, VDEQ, and the Mid-Atlantic Regional Air Management Association (MARAMA. 2005. A guide to Mid-Atlantic regional air quality). Short-term exposures were addressed in General Comments.*

EPA comment, second comment, first bullet, page I-10.

While recognizing that monitoring data are presented for a 6-week time period only, Table 4 summarizes substantially higher $PM_{2.5}$ concentrations at the ATSDR and Mirant monitoring sites in relation to an annual average concentration for the VDEQ site. It would be more reasonable to consider VDAQ measured data for the same time period (June 8-July 23, 2007) to better understand the spatial heterogeneity in ambient $PM_{2.5}$ in this area.

> **ATSDR response:** *The Mirant and ATSDR monitors in Table 4 are located at different elevations and sites. Measured concentrations during the time period (six weeks) are not directly comparable to the VDEQ NAAQS monitor, located in Arlington, VA, because EPA's NAAQS standard is based on annual average concentrations measured over a 3-year time frame. Information that Mirant's $PM_{2.5}$ contribution was less than 5% to the area's air quality did not suggest the need for gathering additional data on spatial heterogeneity in the area. Again, the focus of ATSDR's evaluation was on short-term SO_2 exposures and not on particulate matter.*

EPA comment, second comment, second bullet, page I-10.

Also, it is unclear why the summary of statistics in Table 4 presents 90th percentile data for the 24-hour measured concentrations rather than the 98th percentile to match the form of the current 24-hour $PM_{2.5}$ standard. Recognizing the limitations of having only 6 weeks' worth of measured data, as noted on p. 28, 4 days during the monitoring period exceeded the level of the current 24-hour $PM_{2.5}$ standard, providing some support for considering whether or there is a potential for short-term exposures of concern.

> **ATSDR response:** *ATSDR's intent was to provide information about 24-hour data collected by ATSDR, Mirant, and VDEQ, not to compare with EPA's 24-hour NAAQS. ATSDR does not consider the 24-hour monitoring to be sufficient to make a health call. ATSDR collected 5-minute samples and compiled results into a 24-hour average for comparative information with monitors operated by Mirant and VDEQ.*

Appendix J. Fact Sheet.

ATSDR Review of Environmental Air Data in Alexandria, Virginia near the Mirant Potomac River Generating Station

Introduction

In 2006, the Alexandria Department of Health asked the Agency for Toxic Substances and Disease Registry (ATSDR) to review available environmental air data and determine possible health effects on people in the community near the Mirant Potomac River Generating Station (PRGS), now GenOn Energy, Inc. In 2010, ATSDR released a health consultation for public comment. In 2011, ATSDR released its final health consultation, which addresses the public comments and includes additional data. This fact sheet summarizes what ATSDR found and the steps it took.

Summary of Conclusions

The main findings of the final report include:

- Breathing air contaminated with sulfur dioxide near the site was not expected to harm the health of the general population.
- Sulfur dioxide levels could have been high enough to cause temporary health effects in some sensitive groups, such as people with asthma. These levels occurred infrequently.
- Levels of fine particulate matter ($PM_{2.5}$) were elevated, similar to levels throughout northern Virginia. $PM_{2.5}$ is a regional concern; it is not specific to Alexandria. Studies show that long-term exposure to elevated levels of $PM_{2.5}$ could be associated with adverse health effects.
- Arsenic and chromium were found in air particulate matter at levels that could cause slight health risks. Levels observed were consistent with those routinely observed in suburban and urban locations nationwide.

2011 report additions

In February 2009, Mirant completed a stack merge project. The purpose of this project was to allow greater dispersion of contaminants before they reached the ground, thus reducing ground-level air pollution in areas nearest the Mirant PRGS.

- The City of Alexandria and other stakeholders asked ATSDR to look at the post-stack merge sulfur dioxide data. ATSDR analyzed the Mirant monitoring data from February 2009 through May 2010 and included this information in the final health consultation.
- These additional results did not change the conclusions and recommendations published in the public comment version of the health consultation.

Reducing Exposure

You can protect your health by taking the following actions:

- Stay informed about air pollution alerts in your area by going to http://alexandriava.gov/link/redir.pxe?www.deq.virginia.gov/airquality/
- Stay indoors and close windows on unhealthy days
- Avoid prolonged outdoor exertion near high traffic areas

Conclusions and Recommendations

Sulfur Dioxide

Sulfur dioxide is a pungent, colorless gas.
Sulfur dioxide is a common pollutant in the atmosphere.

Conclusions

Breathing air contaminated with sulfur dioxide around the Mirant PRGS is not expected to harm the health of the general population; however, sensitive populations may be affected.

Sensitive people are those who may experience greater health effects from exposure to sulfur dioxide. They include:

- adults aged 65 and older
- people with asthma
- persons with chronic lung disease such as bronchitis and emphysema
- persons with existing heart disease or diabetes and
- children

Peak (5-minute) Sulfur Dioxide Levels:

Peak exposures (five minute periods when sulfur dioxide is the highest) could harm the health of sensitive persons, such as those with asthma, when they breathe deeply during activities such as exercising, working outdoors, gardening, or climbing steps.

Sensitive persons may experience lung symptoms if they are exposed to peak sulfur dioxide concentrations greater than 400 parts per billion (ppb) when breathing deeply, such as while exercising. These levels have been very infrequent, limited to areas within ¼-mile of Mirant PRGS, and generally have occurred between noon and 5 pm.

Lung symptoms may include coughing, wheezing, or chest tightness, and are likely reversible. Even at high breathing rates, sensitive persons may not experience symptoms when concentrations are less than 400 ppb sulfur dioxide.

At lower sulfur dioxide concentrations (less than 400 ppb), sensitive persons may experience adverse health effects that are not strong enough to cause lung symptoms, but may reduce the ability to experience additional exposure without causing symptoms. Persons not sensitive to sulfur dioxide will not be affected at these concentrations.

Recommendations

The Virginia Department of Environmental Quality should continue efforts to reduce peak sulfur dioxide emissions from the Mirant PRGS.

Particulate Matter

Particulate matter, or particles in the air, is a mixture of very small particles and liquid droplets. It is generally made up of a mixture of substances which include dust, smoke, metals, soil, soot, diesel exhaust particles, organic and inorganic chemicals and other particles. The composition of particulate matter will vary depending on the source. Particulate matter is a common pollutant in the atmosphere. Fine particles are 2.5 microns or less in diameter and are called $PM_{2.5}$. A micron is 1 millionth of a meter.

Conclusions

- The $PM_{2.5}$ levels observed in the local Alexandria area are similar to levels measured in many locations throughout northern Virginia. Thus $PM_{2.5}$ levels in the Alexandria area are in fact a regional concern. A range of factors contributes to this, including Mirant PRGS emissions.
- ATSDR compared reported levels of $PM_{2.5}$ in ambient air with epidemiological studies of people exposed to similar outdoor air conditions. The studies concluded that people may experience some adverse health effects if, average concentrations over several years were in the range of those reported in or near Alexandria.
- Long term (months to years) elevations of particulate matter in the region may affect persons with heart or respiratory disease. Short term (24 hour average) exposure may worsen existing lung and heart conditions.

Recommendations

ATSDR recommends VDEQ and the City of Alexandria continue to reduce particulate matter emissions in the City of Alexandria and the State of Virginia. This includes steps to reduce and monitor particulate matter emissions as specified in the City of Alexandria–Mirant PRGS settlement agreement.

Multiple Chemicals

Conclusions

ATSDR cannot determine if exposure to sulfur dioxide and $PM_{2..5}$ together will harm people's health more than exposure to sulfur dioxide or $PM_{2.5}$ alone.

Recommendations

ATSDR recommends state and local agencies continue their efforts to reduce exposure to sulfur dioxide peaks and particulate matter. These reductions are expected to reduce the likelihood of harmful effects from multiple contaminant exposures.

Select Metals

Conclusions

Measured levels of metals found in the air near Mirant PRGS were generally lower than previously estimated by air models. With two exceptions, every metal measured in the air samples was below levels of potential health concern.

Arsenic and chromium were found at levels that could present a slight to low increase in the estimated risk for developing cancer in the population. However, the arsenic and chromium levels observed were consistent with those routinely observed in suburban and urban locations nationwide. They likely reflect contributions from many emissions sources.

Recommendations

ATSDR recommends reducing particulate matter exposures. This should also reduce exposure to arsenic and chromium.

ATSDR Activities

Reviewed Modeling Data

In January 2006, the City of Alexandria's health department asked ATSDR to review the existing air modeling data for Mirant PRGS emissions. Based on this review, ATSDR expressed public health concern for potential exposures to 5-

minute peak concentrations of sulfur dioxide in sensitive individuals. These findings were provided to the Alexandria Health Department in January 2007.

Monitored Short-term Air Exposures

To address the concern for potential exposures to 5-minute peaks, in summer 2007, ATSDR set up air monitoring stations in areas where people live and work around Mirant PRGS. ATSDR monitored for sulfur dioxide, particulate matter, and selected metals.

Data Evaluation

ATSDR monitors used new technology for measuring sulfur dioxide in 2007, and they did not perform to the manufacturing specifications. Therefore, the agency used ATSDR monitors to only evaluate data for particulate matter and metals data at this site. The City negotiated with Mirant to obtain the facility's more comprehensive set of sulfur dioxide monitoring data from 2007-2008 as part of their settlement agreement in 2008. The City provided these data to ATSDR. ATSDR included both the Mirant and Virginia Department of Environmental Quality data for sulfur dioxide and particulate matter in this evaluation.

Evaluation Time Period

ATSDR evaluated sulfur dioxide air monitoring data from April 2007- July 2008, before the Mirant PRGS stack merge in February 2009. ATSDR evaluated post stack merge sulfur dioxide data through May 2010. The information is included in Appendix I of the final health consultation released in 2011

Peer Review

ATSDR sent a draft of its report for external peer review. Peer review means the report was reviewed by science experts external to ATSDR who have no conflict of interest with this project. These experts independently review the report and provide written comments to ATSDR. External peer review ensures that the evaluation performed in the report was done using the best science given the nature of the available information.

The final report includes information about the peer review process, the questions posed to the peer reviewers, their comments (verbatim), and ATSDR's responses to their comments.

Public Comment Review

ATSDR released a draft report for public comment in July 2010. ATSDR received written comments during the public comment period from the City of Alexandria, the U.S. Environmental Protection Agency, and the Utility Air Regulatory Group. These comments and ATSDR's response to the comments are contained in the final health consultation. In response to public comments, ATSDR evaluated post stack merge sulfur dioxide data. These additional results did not change the conclusions and recommendations published in the public comment version of the report and summarized in the final health consultation.

ATSDR is a Federal public health agency located in Atlanta, GA. Our mission is to provide communities with information they can use to protect their health. ATSDR often assists state and local health departments with environmental public health issues. ATSDR is an advisory agency. ATSDR staff conducts public health activities to provide regulatory authorities such as the Environmental Protection Agency (EPA) and health departments with information needed to guide their decision-making.