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Ambient Monitoring Program

2013 Ambient Air Surveillance Report

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EXECUTIVE SUMMARY

The Ambient Monitoring Program of the Air Protection Branch of the Environmental Protection Division (EPD) has monitored air quality in the State of Georgia for more than forty years. During that time, the list of monitored compounds has grown to more than 200 pollutants and EPD has expanded the types of samplers used at monitoring sites across the state. This monitoring is performed to protect public health and environmental quality. The resulting data is used for a broad range of regulatory and research purposes, as well as to inform the public. This report is the summary of the monitoring data from 2013, and is an assessment of the data in conjunction with previous years' findings.

The Chemical Monitoring Activities, Photochemical Assessment Monitoring (PAMS), and Air Toxics Monitoring sections provide an in-depth discussion of the chemicals that are monitored and maps identify individual monitoring sites. These sections also contain discussions on general health effects, measurement techniques, and attainment designations for the criteria pollutants that are monitored. Additionally, these sections discuss trends and common sources for the monitored pollutants.

Six pollutants fall within the criteria pollutant list. These pollutants are carbon monoxide, sulfur dioxide, lead, ozone, nitrogen dioxide, and particulate matter (now regulated in two size categories). The ambient concentrations of these pollutants must meet a regulatory standard, which is health-based. Concentrations above the standard are considered unhealthy for sensitive groups.

Another set of compounds called air toxics are monitored throughout the state in the Air Toxics Network. The sources of these emitted compounds include vehicle emissions, stationary source emissions, and natural sources. These air toxic compounds do not have ambient air regulatory standards. However, a review of the monitoring results is screened for theoretical lifetime cancer risk and potential non-cancer health effects on a yearly basis. This analysis is presented in the Risk Assessment section of this report. Estimates of theoretical cancer risk posed by these compounds are primarily driven by a small number of chemicals in the metals, volatile organic compounds, and carbonyls groups of the air toxics. The estimates of theoretical lifetime cancer risk related to air toxic pollutants in the areas monitored across the state ranged from 1 in 10,000 to 1 in 1,000,000. The potential risk of non-cancer health effects from air toxic pollutants is estimated differently, and most chemicals fell well below the hazard quotient of 1.

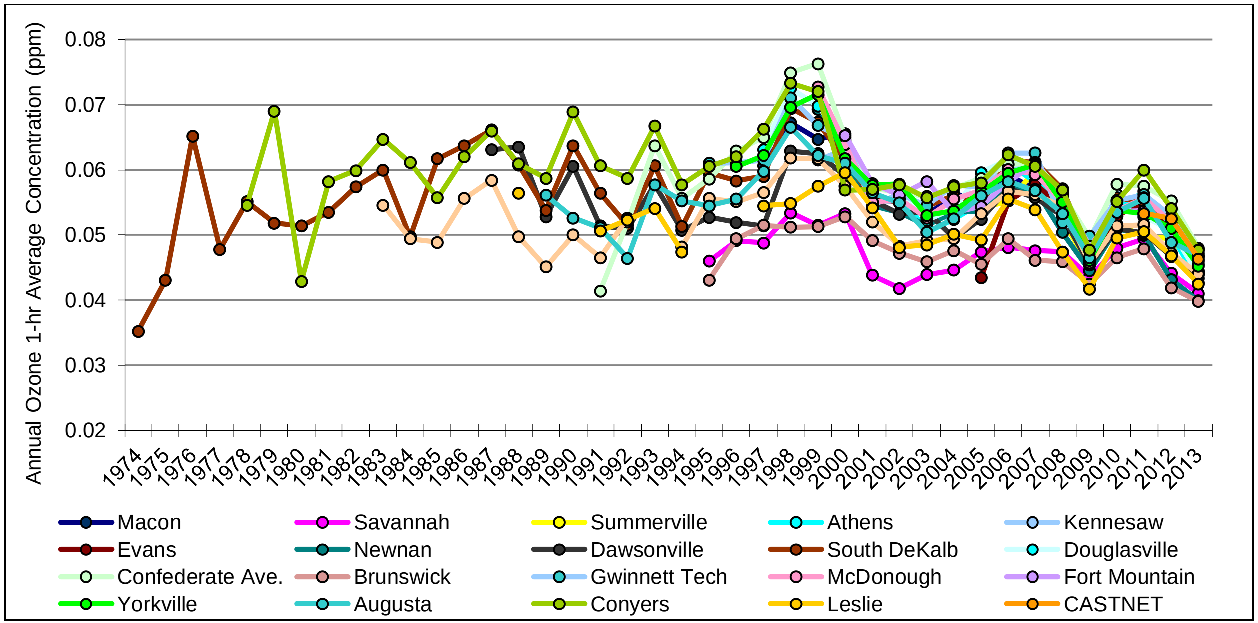
The Ambient Monitoring Program also operates an extensive network of meteorological stations. The Meteorological Report section discusses Georgia's climatology, based on the meteorological data captured at PAMS sites and statewide sites. The meteorological sites provide, at a minimum, wind speed and wind direction data. Some stations are very sophisticated and provide information on barometric pressure, relative humidity, solar radiation, temperature, and precipitation. A discussion of the Georgia ozone and $PM_{2.5}$ forecasting effort is also included in this section.

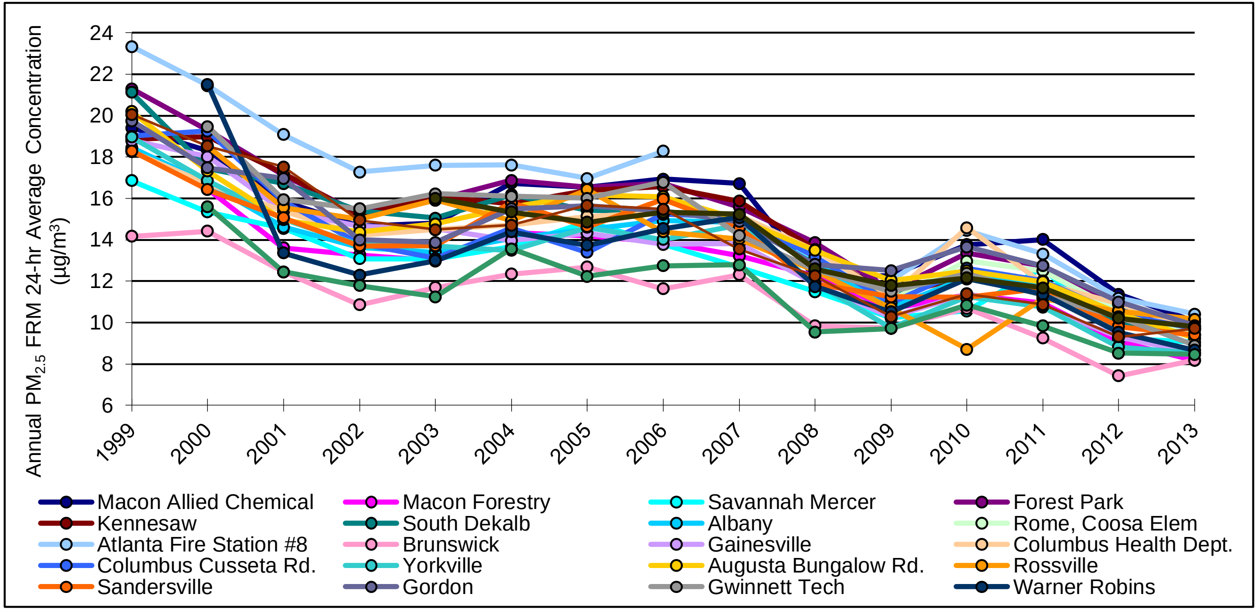
The Quality Assurance section shows the Ambient Monitoring Program's undertaking to produce quality data. The data has to be collected and measured in a certain manner to meet requirements that are set forth by the EPA. The requirements for each monitored pollutant are provided, including field and laboratory techniques, as well as the results of quality assurance audits.

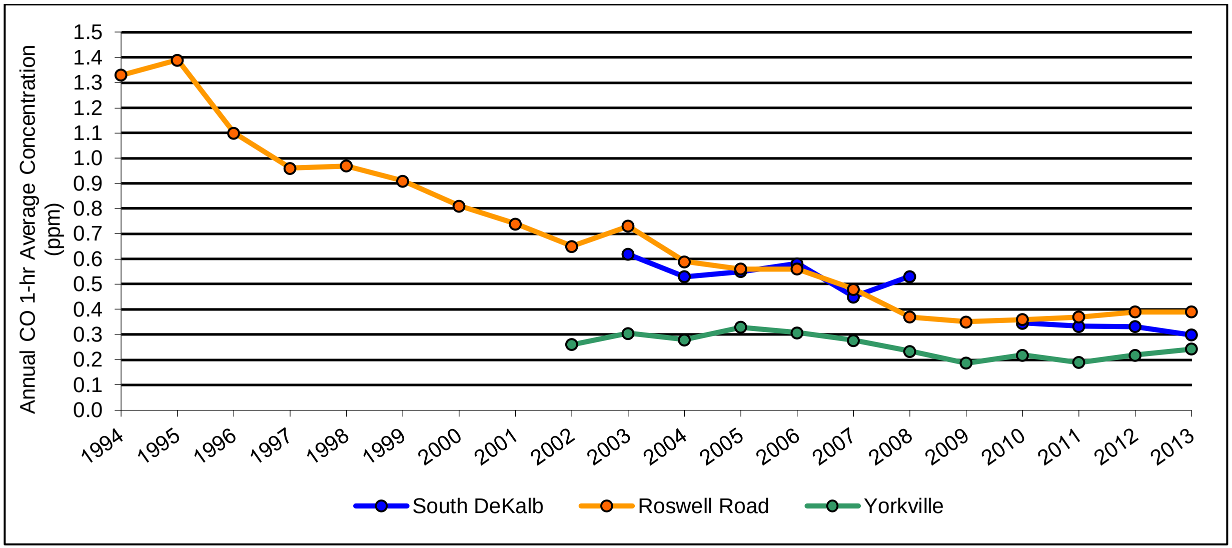
The Outreach and Education section provides information concerning the efforts of the Clean Air Campaign to change the commuting habits of residents of Atlanta. The voluntary program partners with the public and private sector to reduce vehicle congestion and aid in reducing vehicle emissions. This section includes a description of educational and news media outreach activities, and explains how the Air Quality Index (AQI) is used to offer the public an easy to use indicator of air quality.

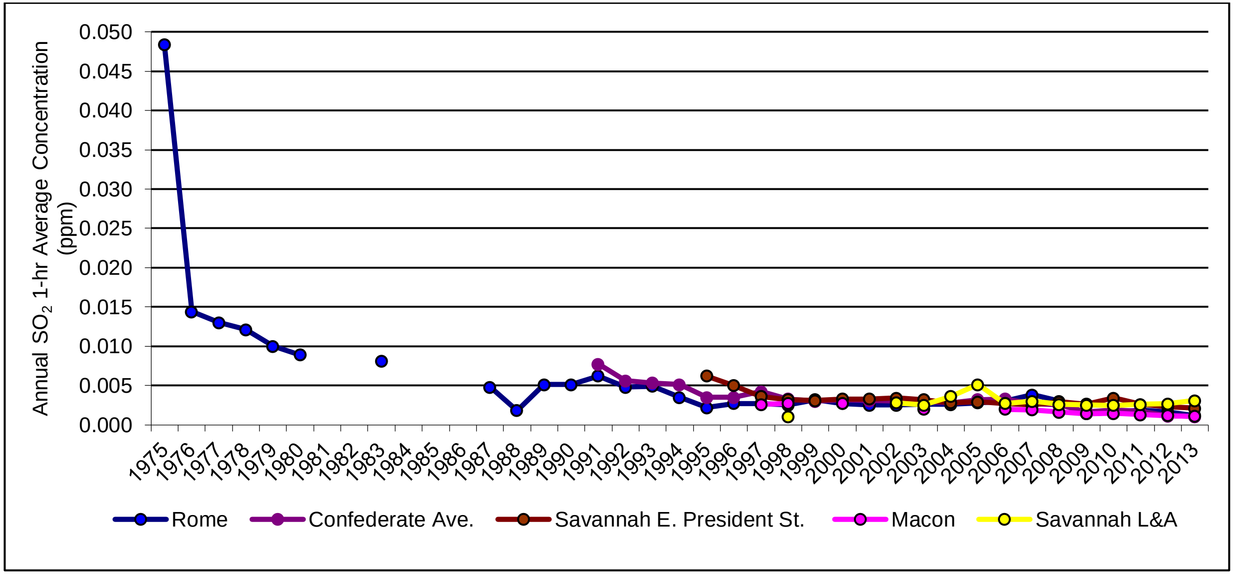
The appendices of this document contain summary tables for the pollutants measured during 2013. Included in the summary tables is information about the location of air pollutant detections, the number of samples collected, as well as average and maximum concentrations.

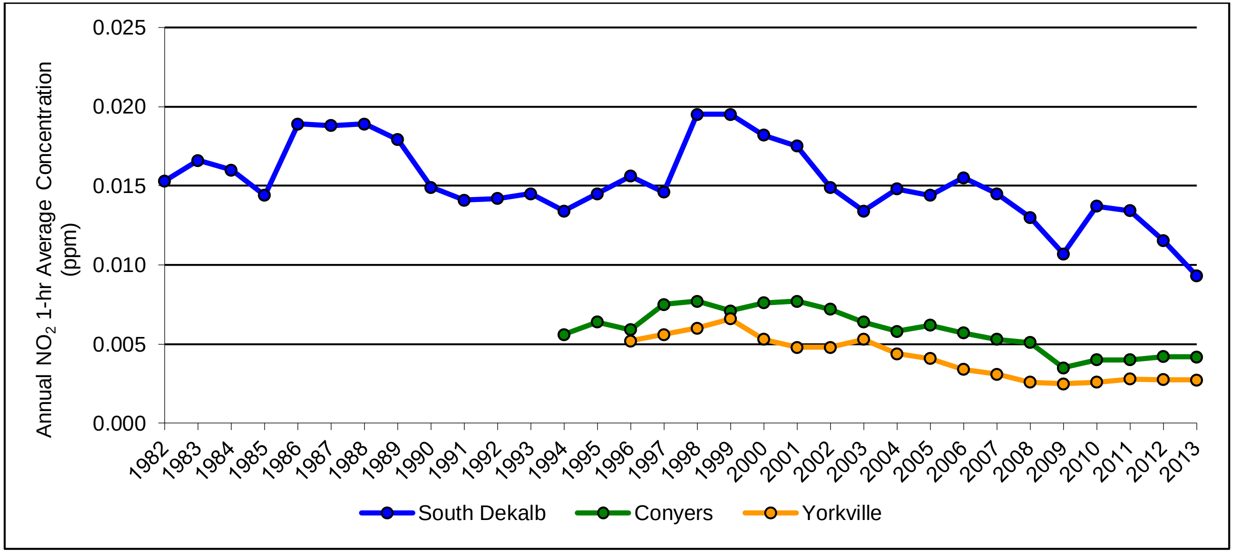
The following graphs depict the overall improvement of Georgia's air quality since the inception of Georgia EPD's Ambient Air Monitoring Program. As shown in these graphs, some pollutants seem to have more of a cyclic trend, but all have shown an overall decrease in air pollution concentrations since GA EPD began monitoring ambient air decades ago. Details are included in the following ambient air surveillance report.











Copies of this and previous annual reports are available in Adobe Acrobat format via the Ambient Monitoring Program website at http://www.air.dnr.state.ga.us/amp/. A limited number of print copies are available and may be requested at 404-363-7006. Real time air monitoring information for the criteria pollutants may be found at the above website by selecting the pollutant of concern. In addition, the website also provides links to the Clean Air Campaign and the air quality forecast.

GLOSSARY

Aerosols	A gaseous suspension of fine solid or liquid particles
AM	Annual Mean
APB	Air Protection Branch
AQCR	Air Quality Control Region
Anthropogenic	Resulting from human activity
ARITH MEAN	Arithmetic Mean
AQS	Air Quality System
By-product	Something produced in making something else; secondary result
BAM	Beta Attenuation Monitor
CAA	Clean Air Act
CFR	Code of Federal Regulations
CO	Carbon Monoxide
CV	Coefficient of Variation
DNR	Department of Natural Resources (state agency)
EPA	Environmental Protection Agency (federal agency)
EPD	Environmental Protection Division (state agency)
FRM	Federal Reference Method- the official measurement technique for a given pollutant
GEO MEAN	Geometric Mean
HAP	Hazardous Air Pollutant
HI	Hazard Index
HQ	Hazard Quotient
IUR	Inhalation Unit Risk
LOD	Limit of Detection
$\mu g/m^3$	Micrograms per cubic meter
m/s	Meters per second
MDL	Method Detection Limit
Mean	Average
MSA	Metropolitan Statistical Area, as defined by the U.S. Census Bureau
N_2	Nitrogen Gas
NAAQS	National Ambient Air Quality Standard
NAMS	National Ambient Monitoring Site
NATTS	National Air Toxics Trends Station
NEI	National Emission Inventory
NMHC	Non-Methane Hydrocarbons
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
NO_y	Reactive oxides of Nitrogen
NUM OBS	Number of Observations
NWS	National Weather Service
ODC	Ozone depleting Chemicals
O_3	Ozone
PAH	Polycyclic Aromatic Hydrocarbons
PAMS	Photochemical Assessment Monitoring Station
Pb	Lead
$PM_{2.5}$	Particles with an aerodynamic diameter of 2.5 microns or less
PM_{10}	Particles with an aerodynamic diameter of 10 microns or less
ppb	Parts per billion
ppbC	Parts per billion Carbon
ppm	Parts per million
Precursor	A substance from which another substance is formed
PUF	Polyurethane Foam
QTR	Calendar Quarter
Rawinsonde	A source of meteorological data for the upper atmosphere

RfC	Reference Concentration
Screening Value	Initial level of air toxic compounds used in risk assessment
SLAMS	State and Local Air Monitoring Site
SO_2	Sulfur Dioxide
SPMS	Special Purpose Monitoring Site
TEOM	Tapered Element Oscillating Microbalance
TNMOC	Total Non-Methane Organic Compounds
TRS	Total Reduced Sulfur
TSP	Total Suspended Particulates
UV	Ultraviolet
VOC	Volatile Organic Compound
w/m^2	Watts per square meter

INTRODUCTION

This report summarizes the air quality data collected by the State of Georgia during calendar year 2013. The Air Protection Branch is a subdivision of the state's Department of Natural Resources (DNR), Environmental Protection Division (EPD).

The United States Environmental Protection Agency (EPA) regulates air quality standards nationwide through authority granted by Congress in the Clean Air Act. The air quality monitoring that is required by the Clean Air Act is performed almost entirely by state and local governments. In Georgia, the Ambient Monitoring Program of the Air Protection Branch conducts this ambient air monitoring, both to satisfy Clean Air Act monitoring requirements and to exceed them in cases where additional monitoring proves beneficial to the citizens and industries of the state. Ambient monitoring is performed to facilitate the protection of public health, as well as to protect the natural environment. The data is collected and quality assured using equipment and techniques specified by EPA. Once the data is ready, it is submitted to EPA's national air quality database (AQS), where it is available to a broad community of data users.

Despite the technical nature of the information collected, every effort has been made to make the data relevant and useful to those who do not routinely study air quality data. To provide additional information for those who have interest in more detailed technical information, extensive appendices are included. Further information about air quality in Georgia and nationwide is available from EPA.

CHEMICAL MONITORING ACTIVITIES

This section contains a summary of the National Ambient Air Quality Standards (NAAQS) and the monitoring techniques used to measure ambient air quality for comparison with these standards.

The Clean Air Act (CAA) requires the EPA Administrator to identify pollutants that may endanger public health or welfare. The Administrator is required to issue air quality criteria that reflect current scientific knowledge, useful in indicating the type and extent of identifiable effects on public health or welfare that may be expected from the presence of such pollutants in ambient air. Under the CAA, the EPA Administrator establishes National Ambient Air Quality Standards (NAAQS) for each pollutant for which air quality criteria have been issued. The EPA is to set standards where “the attainment and maintenance are requisite to protect public health” with “an adequate margin of safety.” In 1971, the EPA established standards for five “criteria” pollutants as required by the Clean Air Act. The standards and pollutants have changed over time to keep up with improvements in scientific knowledge and now consist of six pollutants. These pollutants are carbon monoxide, sulfur dioxide, lead, ozone, nitrogen dioxide, and particulate matter (now regulated in two size categories). For the most current list of standards, please refer to EPA’s website (http://www.epa.gov/air/criteria.html). The following table displays 2013 criteria pollutants and standards.

Table 1. National ambient air quality standards

Pollutant [final rule cite]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead [73 FR 66964, Nov 12, 2008]		primary and secondary	Rolling 3 month average	0.15 $\mu g/m^3$ (1)	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]		primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		primary and secondary	Annual	53 ppb (2)	Annual Mean
Ozone [73 FR 16436, Mar 27, 2008]		primary and secondary	8-hour	0.075 ppm (3)	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution Dec 14, 2012	$PM_{2.5}$	primary	Annual	12 $\mu g/m^3$	annual mean, averaged over 3 years
		secondary	Annual	15 $\mu g/m^3$	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 $\mu g/m^3$	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide [75 FR 35520, Jun 22, 2010] [38 FR 25678, Sept 14, 1973]		primary	1-hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

(1) Final rule signed October 15, 2008. The 1978 lead standard (1.5 µg/m3 as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

(2) The official level of the annual NO2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.

(3) Final rule signed March 12, 2008. The 1997 ozone standard (0.08 ppm, annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years) and related implementation rules remain in place. In 1997, EPA revoked the 1-hour ozone standard (0.12 ppm, not to be exceeded more than once per year) in all areas, although some areas have continued obligations under that standard ("anti-backsliding"). The 1-hour ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1.

(4) Final rule signed June 2, 2010. The 1971 annual and 24-hour SO2 standards were revoked in that same rulemaking. However, these standards remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

(Source: http://www.epa.gov/air/criteria.html)

As shown in Table 1, there are two categories for ambient air quality standards, primary and secondary. Primary standards are intended to protect the most sensitive individuals in a population. These "sensitive" individuals include children, the elderly, and people with chronic illnesses. The secondary standards are designed to protect public welfare or the quality of life. This includes visibility protection, limiting economic damage, damage to wildlife, the climate, or man-made material. The varied averaging times are to address the health impacts of each pollutant. Short-term averages are to protect against acute effects. Long-term averages are to protect against chronic effects.

The Georgia ambient air monitoring network provides information on the measured concentrations of criteria and non-criteria pollutants at pre-selected locations. The 2013 Georgia Air Sampling Network consisted of 44 sites in 32 counties across the state. Table 2, on pages 5 and 6, is a list of sites in the monitoring network along with details of pollutants monitored and their locations. Monitoring occurs year-round, although some pollutants have various required monitoring periods. Ozone, with the exception of the South DeKalb and CASTNET sites, is sampled from March through October, and the continuous (hourly) Photochemical Assessment Monitoring Stations (PAMS) volatile organic compounds are sampled from June through August.

Figure 1 is a spatial display of the air monitoring locations in the state. Please note that not all pollutants are monitored at all sites. Maps of the monitoring locations for individual pollutants are provided in each pollutant's respective section in this report. For more details regarding the ambient air monitoring network, refer to Georgia EPD's Ambient Air Monitoring Plan found on EPD's website at http://www.air.dnr.state.ga.us/amp/.

The number of monitoring sites and their respective locations can vary from year to year. This variation depends on the availability of long-term space allocation, regulatory needs, and other factors such as the sufficiency of resources. Once a site is established, the most common goal for its use is to monitor for long-term trends. All official monitoring performed in support of the National Ambient Air Quality Standards (NAAQS) must use U.S. EPA-defined reference methods described in 40 CFR Part 53, Appendix A, or equivalent methods designated in accordance with Part 53 of that chapter. All data collected in the network undergoes an extensive quality assurance review and is then submitted to the Air Quality System (AQS) database that is maintained by the EPA.

In general, the basic ambient air monitoring objectives that govern the selection of sites are: 1) to measure the highest observable concentration; 2) to determine representative concentrations in areas of high population density; 3) to determine the impact of significant sources or source categories on ambient pollution levels; 4) to determine the general background concentration levels; and 5) to determine the concentration of a number of compounds which contribute to the formation of ground level ozone. Data collected from continuous monitors in Georgia's ambient air monitoring network are presented on EPD's website at http://www.air.dnr.state.ga.us/amp/. The data is updated hourly at 15 minutes past the hour. Specific annual summary data for 2013 are available in Appendix A.

Table 2. 2013 Georgia air monitoring network

SITE ID	COMMON NAME / CITY	COUNTY	O_3	CO	$PM_{2.5}$ FRM	$PM_{2.5}$ Cont.	$PM_{2.5}$ Spec.	NO	NOx	NO_2	NOy	SO_2	Pb	PM_{10}	PM_{10} Cont.	PAMS VOC	VOC	SVOC	Carb-onyls	Met	Aeth.	Cr6	Metals
Rome MSA																							
131150003	Coosa Elementary, Rome	Floyd			S	S	X					S											
Brunswick MSA																							
131270006	Risley Middle, Brunswick	Glynn	S		S															NR			
Valdosta MSA																							
131850003	Mason Elem., Valdosta	Lowndes			S	S																	
Warner Robins MSA																							
131530001	Air Force Base, Warner Robins	Houston			S	S																	
Dalton MSA																							
132130003	Fort Mountain, Chatsworth	Murray	S																	NR			
Albany MSA																							
130950007	Turner Elem., Albany	Dougherty			S	S																	
Gainesville MSA																							
131390003	Boys & Girls Club, Gainesville	Hall			S	S																	
Athens-Clark County MSA																							
130590002	College Station Rd., Athens	Clarke	S		S	S	X																
Macon MSA																							
130210007	Allied Chemical, Macon	Bibb			S		X																
130210012	GA Forestry Comm., Dry Branch	Bibb	S		S	S						S					NR	NR		NR			NR
Columbus Georgia- Alabama MSA																							
132150001	Health Dept., Columbus	Muscogee			S																		
132150008	Airport, Columbus	Muscogee	S		S	S																	
132150009	UPS, Columbus	Muscogee												S									
132150010	Fort Benning, Columbus	Muscogee												S									
132150011	Cusseta Elem., Columbus	Muscogee			S		X							S									
132151003	Crime Lab, Columbus	Muscogee																		NR			
Savannah MSA																							
130510021	E. President St., Savannah	Chatham	S									S					NR	NR	NR	NR			NR
130510091	Mercer Middle, Savannah	Chatham			S																		
130511002	L & A, Savannah	Chatham				S						S								NR			
Augusta Georgia-South Carolina MSA																							
130730001	Riverside Park, Evans	Columbia	S																	NR			
132450091	Bungalow Rd., Augusta	Richmond	S		S	S	X					S			S					NR			

SITE ID	COMMON NAME / CITY	COUNTY	O_3	CO	$PM_{2.5}$ FRM	$PM_{2.5}$ Cont.	$PM_{2.5}$ Spec.	NO	NOx	NO_2	NOy	SO_2	Pb	PM_{10} Cont.	PM_{10}	PAMS VOC	VOC	SVOC	Carb-onyls	Met	Aeth.	Cr6	Metals
Atlanta-Sandy Springs-Marietta MSA																							
130150003	Cartersville Lead, Cartersville	Bartow											S										
130630091	Georgia DOT, Forest Park	Clayton			S																		
130670003	National Guard, Kennesaw	Cobb	S		S																		
130770002	Univ. of West GA, Newnan	Coweta	S			S														NR			
130850001	GA Forestry, Dawsonville	Dawson	S														NR	NR	NR	NR			NR
130890002	South DeKalb, Decatur	DeKalb	S/P/C	S/P/C	S/C	S/C	T/C	S/P	S/P	S/P	S/P/C	C			C	P	N	N	P/N	P	N	N	N
130890003	DMRC, Decatur	DeKalb											S										
130893001	Idlewood Rd., Tucker	DeKalb																		NR			
130970004	W. Strickland St., Douglasville	Douglas	S																	NR			
131210039	Fire Station #8, Atlanta	Fulton			S									S									
131210055	Confederate Ave., Atlanta	Fulton	S			S						S								NR			
131210099	Roswell Road, Atlanta	Fulton		S																			
131350002	Gwinnett Tech, Lawrenceville	Gwinnett	S		S	S																	
131510002	County Extension, McDonough	Henry	S			S																	
132230003	King Farm, Yorkville	Paulding	S/P	S/P	S	S		S/P	S/P	S/P						P	NR	NR		P			NR
132319991	EPA CASTNET	Pike	A																				
132470001	Monastery, Conyers	Rockdale	S/P					S/P	S/P	S/P						P				P			
Chattanooga Tennessee-Georgia MSA																							
132950002	Maple Street, Rossville	Walker			S	S	X																
Not In An MSA																							
130550001	Fish Hatchery, Summerville	Chattooga	S																				
130690002	General Coffee SP, Douglas	Coffee					X										NR	NR					NR
132611001	Union High School, Leslie	Sumter	S																				
133030001	Health Dept., Sandersville	Washington			S																		
133190001	Police Dept., Gordon	Wilkinson			S																		

Monitoring Types: S=SLAMS; P=PAMS; C=NCore; X=Supplemental Speciation; T=STN; N=NATTS; NR=Non-Regulatory; A=CASTNET

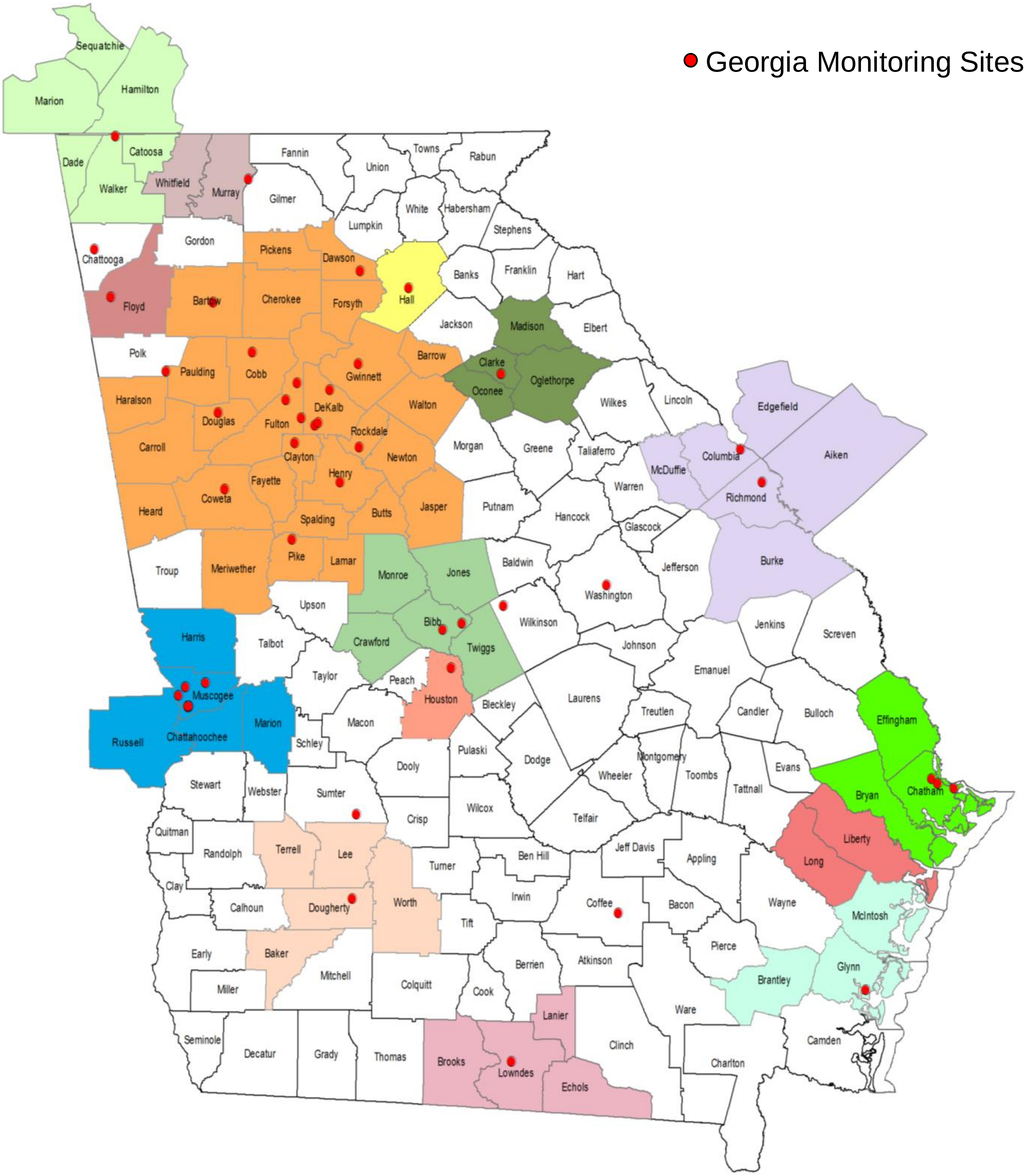


Figure 1. Georgia’s air monitoring sites, MSAs shown as solid colors

CARBON MONOXIDE (CO)

GENERAL INFORMATION

Carbon monoxide (CO) is an odorless, colorless, and poisonous gas that is a by-product of incomplete burning. In most large metropolitan areas, the primary source of CO pollution is engendered from automobile exhaust. The CO emissions from automobiles are responsible for approximately 51% of CO emissions nationwide. Other contributors of CO are fires, industrial processes, cigarettes, and other sources of incomplete burning in the indoor environment. Figure 2 and Figure 3 give a visual representation of the CO emissions in Georgia. These figures are taken from EPA's latest available records on air emission sources, based on 2011 data.

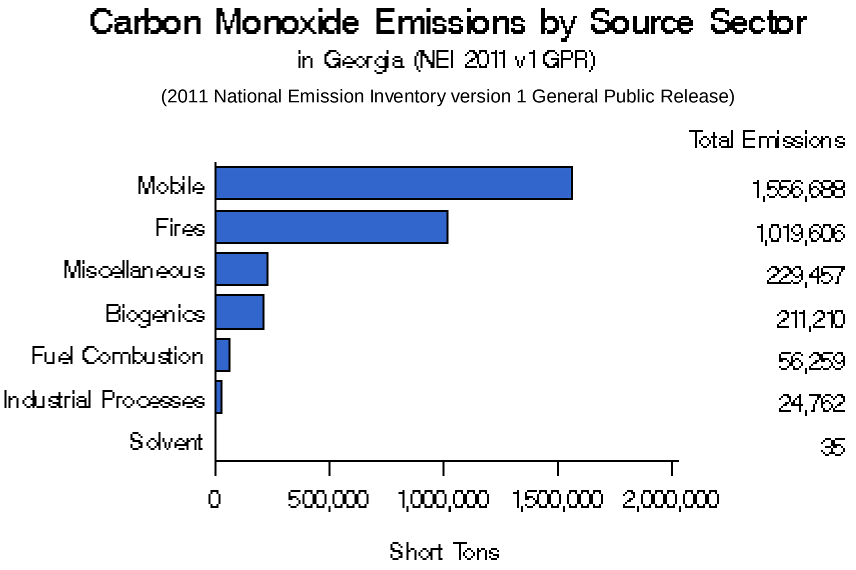


Figure 2. Common sources of carbon monoxide (CO) in Georgia, National Emission Inventory version 1 general public release

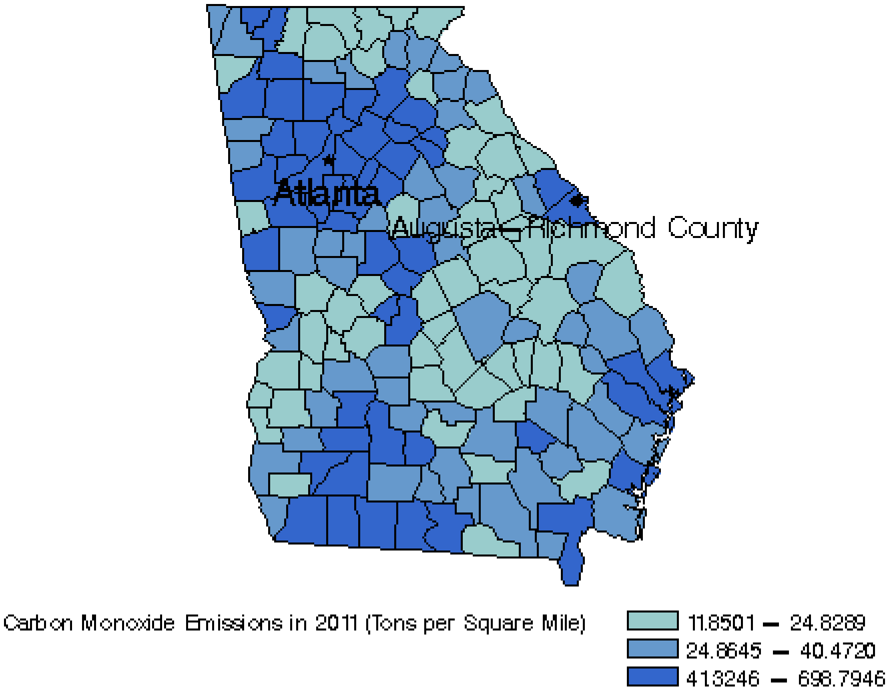


Figure 3. Spatial view of carbon monoxide (CO) emissions in Georgia

In colder months, a few factors come together that can cause concentrations of ambient CO to be found at higher levels than the rest of the year. During the winter months, cooler temperatures prevent complete combustion of fuels, causing an increase in CO emissions. This can especially affect fuel combustion in gas-powered automobiles, as friction is increased during cold engine operation. At the same time, winter is subjected to more frequent atmospheric inversion layers. In standard conditions, the troposphere contains temperatures that decrease with increasing altitude. An inversion layer can occur when a layer of warmer air traps cooler air near the surface, disrupting the descending temperature gradient of the troposphere and preventing the usual mixing that would occur in normal conditions. During this time, the increased CO emissions can be trapped by the cap that is formed by the inversion layer, locking in CO emissions near the earth’s surface.

The Clean Air Act (CAA) requires that Metropolitan Statistical Areas (MSAs) with a population greater than 500,000, as determined by the last census (2010), to have at least two CO State and Local Air Monitoring Stations (SLAMS). In Georgia, only the Atlanta-Sandy Springs-Marietta MSA meets the population requirement. Currently, Georgia’s CO sites are located at Roswell Road, Yorkville, and South DeKalb (Figure 4). The Roswell Road site was established to monitor for CO at a microscale level. The purpose of microscale measurements is to measure peak concentrations in major urban traffic areas. A microscale site monitors an air mass that covers a distance of several meters to about 100 meters. In addition, high sensitivity CO monitors are located at the Yorkville and South DeKalb sites. The purpose of these CO monitors is to aid in the detection of combustion and smoke plumes from power plants. Furthermore, the South DeKalb site is required to monitor CO as part of the National Core (NCore) Multi-pollutant Monitoring Network.

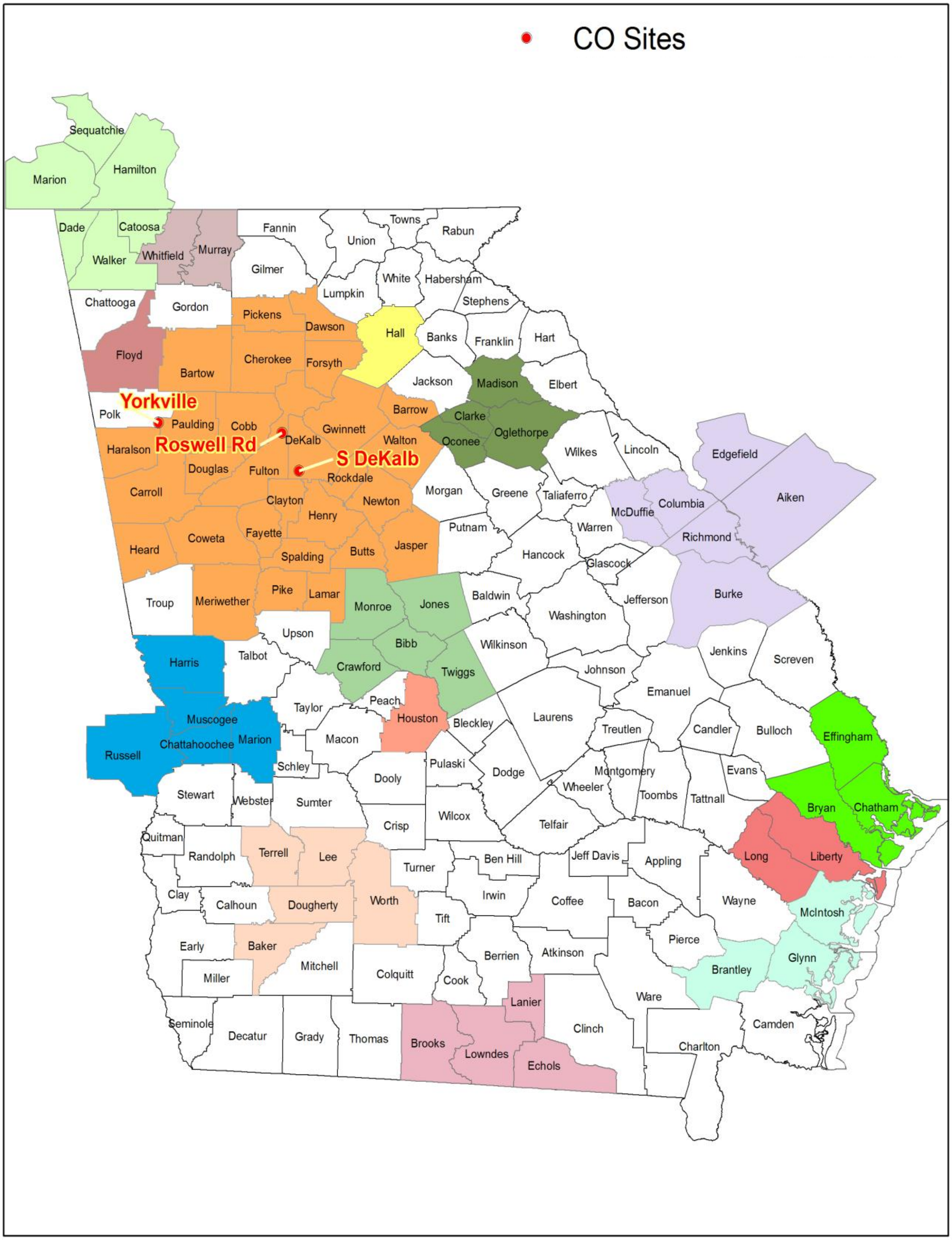


Figure 4. Georgia carbon monoxide monitoring sites, MSAs shown as solid colors

HEALTH IMPACTS

Once CO is inhaled, it enters the blood stream, where it binds chemically to hemoglobin. Hemoglobin is the component of blood that is responsible for carrying oxygen to the cells. When CO binds to hemoglobin, it reduces the ability of hemoglobin to do its job, and in turn reduces the amount of oxygen delivered throughout the body. The percentage of hemoglobin affected by CO depends on the amount of air inhaled, the concentration of CO in air, and the length of exposure.

Negative health effects of CO include weakening the contractions of the heart that reduces blood flow to various parts of the body. In a healthy person, this effect significantly reduces the ability to perform physical activities. In persons with chronic heart disease, this effect can threaten the overall quality of life, because their systems may be unable to compensate for the decrease in oxygen. CO pollution is also likely to cause such individuals to experience chest pain during activity. Adverse effects have also been observed in individuals with heart conditions who are exposed to CO pollution in heavy freeway traffic for one or more hours.

In addition, fetuses, young infants, pregnant women, elderly people, and individuals with anemia or emphysema are likely to be more susceptible to the effects of CO. For these individuals, the effects are more pronounced when exposure takes place at high altitude locations, where oxygen concentration is lower. CO can also affect mental functions, visual acuity, and the alertness of healthy individuals, even at relatively low concentrations.

MEASUREMENT TECHNIQUES

CO is monitored using an EPA-approved reference or equivalent method. The analyzers are self-contained and capable of measuring ambient CO on a continuous, real-time basis using the non-dispersive infrared analysis and gas filter correlation methods. CO is monitored using specialized analyzers based on the principle that CO absorbs infrared radiation. The sample is drawn through the sample bulkhead and the optical bench. Radiation from an infrared source is chopped and then passed through a gas filter alternating between CO and N_2. The radiation then passes through a narrow bandpass interference filter and enters the optical bench where absorption by the sample gas occurs. The infrared radiation then exits the optical bench and falls on an infrared detector. The N_2 side of the filter wheel produces a measure beam which can be absorbed by CO in the cell. The chopped detector signal is modulated by the alternation between the two gas filters with amplitude related to the concentration of CO in the sample cell. Thus, the gas filter correlation system responds specifically to CO. The CO concentration is then displayed on the front panel display and sent to the analog or digital output. The sampler is equipped with a microprocessor that enables digital measurement of CO, automatic compensation for changes in temperature and pressure, and internal diagnostics.

ATTAINMENT DESIGNATION

Data collected from the continuous monitors are used to determine compliance with the Clean Air Act (CAA) 8-hour and 1-hour standard for CO. The 8-hour standard requires that, for 8-hour averages, no concentration greater than 9 ppm may be observed more than once per year. For 1-hour averages, no concentration greater than 35 ppm may be observed more than once a year [76 FR 54294, August 31, 2011].

Figure 5 and Figure 6 show how Georgia’s CO compares to the two standards. Figure 5 shows a comparison to the 1-hour standard of 35 parts per million (ppm), and Figure 6 shows a comparison to the 8-hour standard of 9 ppm. Georgia’s CO values have dropped considerably since 1995 and are well below the standards. If the data shows that these criteria are met, then the area is considered to be in attainment of the standard. All of Georgia is in attainment of both the 8-hour and 1-hour standards for carbon monoxide.

For additional summary data on carbon monoxide see Appendix A.

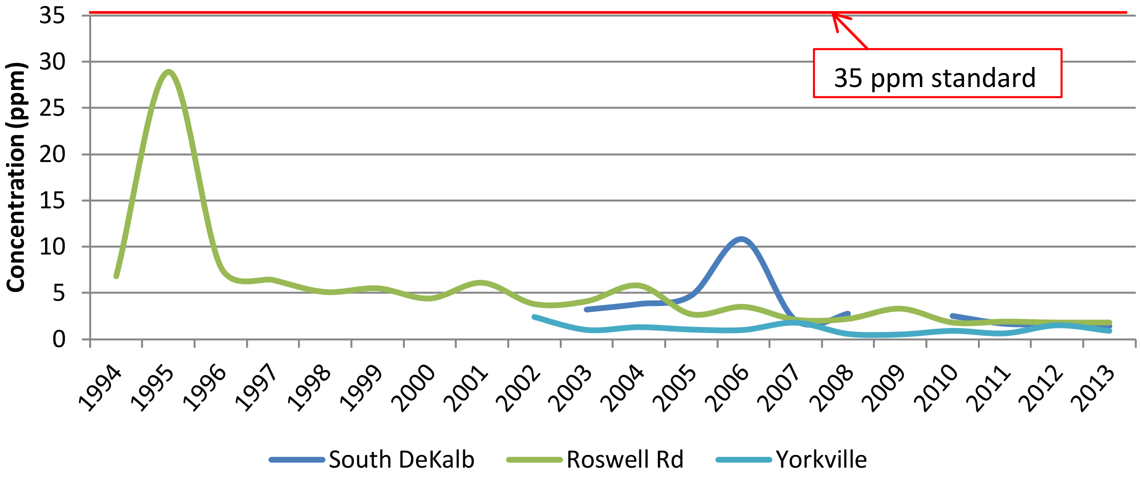


Figure 5. Carbon monoxide maximum annual 1-hour average compared to the 1-hour standard

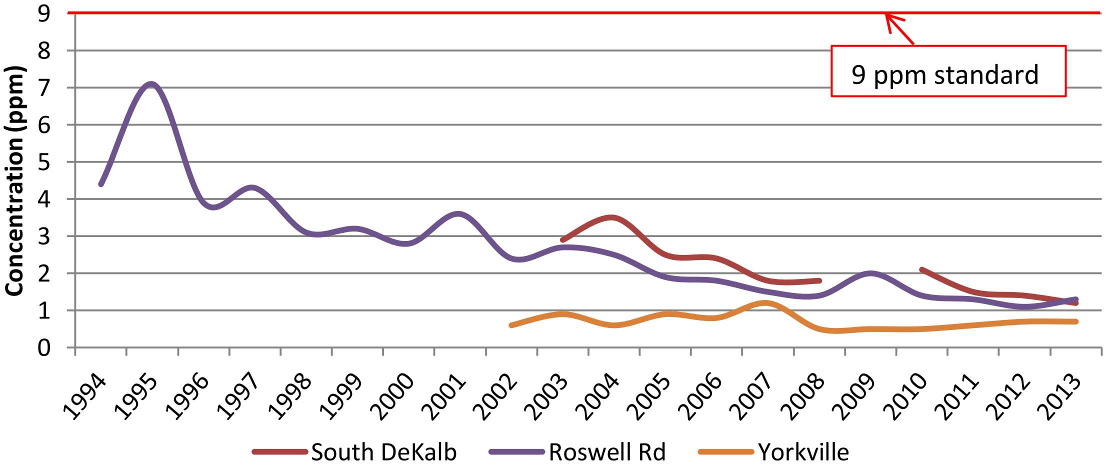


Figure 6. Carbon monoxide maximum annual 8-hour average compared to the 8-hour standard

OXIDES OF NITROGEN (NO, NO_2, NO_x and NO_y)

GENERAL INFORMATION

Oxides of nitrogen exist in various forms in the atmosphere (Table 3). The most common is nitric oxide (NO), but other forms such as nitrogen dioxide (NO_2), nitric acid (HNO_3) and dinitrogen pentoxide (N_2O_5) are also present. The bulk of these compounds in the atmosphere are produced from high temperature combustion and lightning. Nitrogen is a very stable molecule and is essentially inert unless subjected to extreme conditions. The oxides of nitrogen are less stable, however, and are key participants in atmospheric chemistry, converting back and forth between numerous states under different conditions. Many of these reactions involve the conversion of oxygen atoms between their atomic (O_2) and ozone (O_3) forms. As such, oxides of nitrogen are studied as precursors of (and alternately by-products of) ozone formation. With the many forms of oxides of nitrogen in the atmosphere, they are sometimes referred to using the generic terms NO_x or NO_y. Nitric acid (HNO_3) is the most oxidized form of nitrogen in the atmosphere. This species is water-soluble and is removed from the atmosphere in the form of acidic raindrops.

NO is changed to NO_2 in very rapid atmospheric reactions. During daylight hours, ultraviolet (UV) radiation from the sun breaks apart NO_2 into NO and free oxygen (O). The free oxygen atom (O) will attach itself to molecular oxygen (O_2) creating an ozone (O_3) molecule. This is the origin of the majority of ground level ozone. With the UV radiation breaking apart the NO_2 and N_2O_5, daytime levels are low. Then the concentrations rise rapidly overnight with the lack of UV radiation. When the sun rises again in the morning, the compounds are converted back to NO and ozone. Figure 7 is a representation of the typical diurnal pattern of NO_2. Refer to the ozone section and Figure 19 for a comparison of the ozone diurnal pattern.

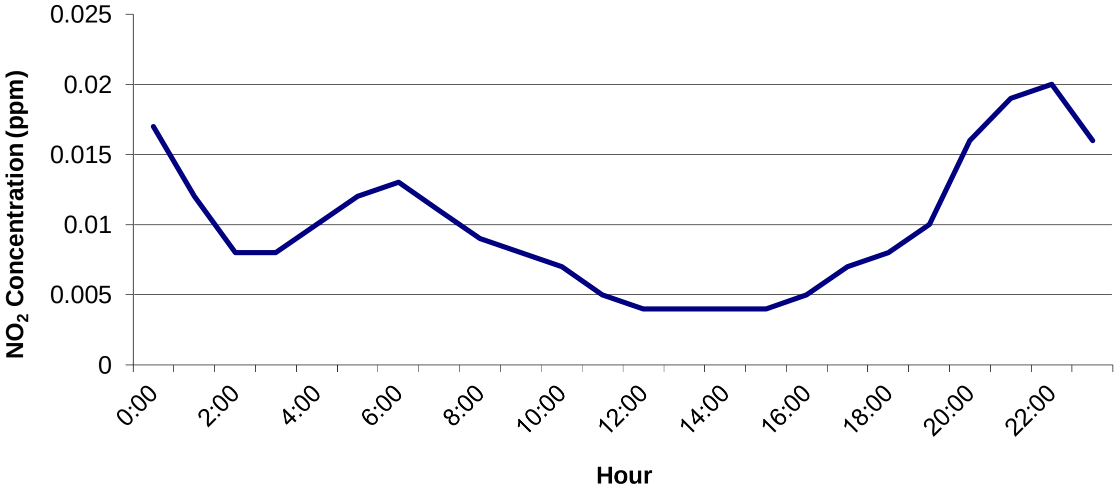


Figure 7. Typical diurnal pattern of nitrogen dioxide

Table 3. Common oxides of nitrogen species and terms

ABBREVIATION	FULL NAME	CREATION PROCESSES	ELIMINATION PROCESSES
NO	Nitrous Oxide	Result of ozone photochemistry High-temperature combustion	Reacts with ozone to form NO_2 and oxygen
NO_2	Nitrogen Dioxide	High-temperature combustion Reaction of NO and ozone	Reacts with oxygen in strong sun to form ozone plus NO “washes out” in rain
HNO_3	Nitric Acid	$NO_2 + H_2O$	“washes out” in rain
PAN	Peroxyacetyl Nitrate	Oxidation of hydrocarbons in sunlight	Slow devolution to NO_2
NO_x	Name for NO + NO_2		
NO_y	Name for all atmospheric oxides of nitrogen- mostly NO, NO_2, HNO_3, N_2O_5, and PAN		

Nitrogen dioxide (NO_2) is one of the important oxides of nitrogen. It is a light brown gas, and can be an important component of urban haze, depending upon local sources. Nitrogen oxides usually enter the air as the result of high-temperature combustion processes, such as those occurring in automobiles and industries (Figure 8). Home heaters, gas stoves, and non-road equipment also produce substantial amounts of NO_2. NO_2 is formed from the oxidation of nitric oxide (NO), which has a pungent odor at high concentrations and a bleach smell at lower concentrations. NO_2 is a precursor to ozone formation and can be oxidized to form nitric acid (HNO_3), one of the compounds that contribute to acid rain. Nitrate particles and NO_2 can block the transmission of light, reducing visibility. Figure 9 shows a spatial view of the varying concentrations of nitrogen oxides by county in Georgia during 2011. Figures 8 and 9 are taken from the latest emissions report from EPA, based on 2011 data.

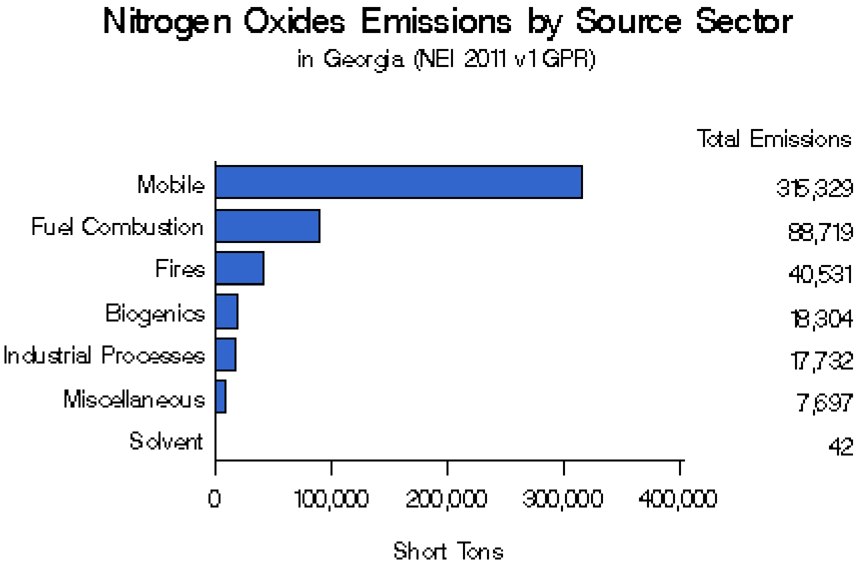


Figure 8. Common sources of nitrogen oxides in Georgia

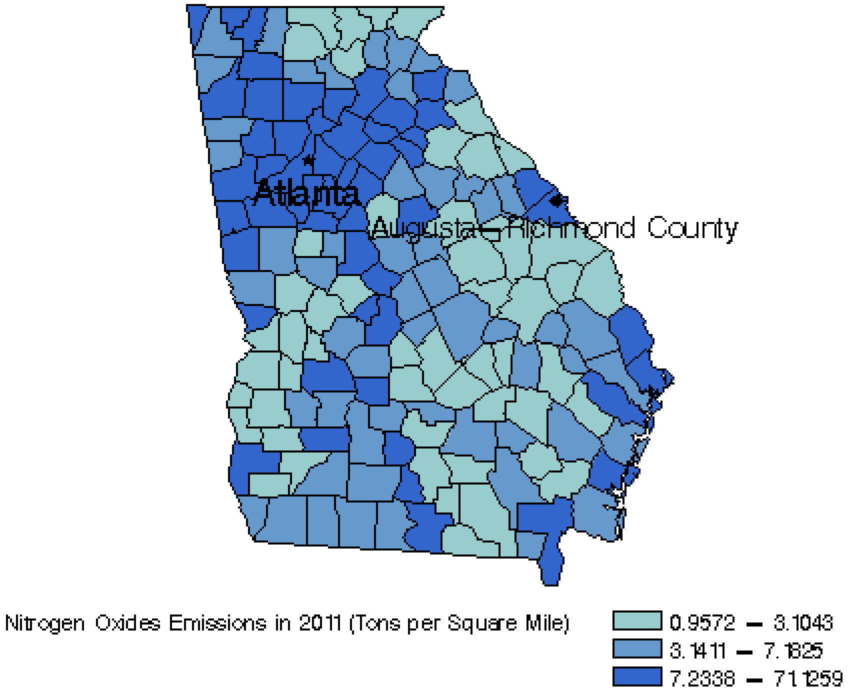


Figure 9. Spatial view of nitrogen oxides emissions in Georgia

Efforts are being taken to reduce the emissions of harmful nitrogen oxides. School bus retrofitting, truck stop electrification, and locomotive conversions are three alternative methods that are being used to reduce emissions. School bus retrofitting focuses on older school buses that are being fitted with an emission control device to reduce emitted NO_x. A specific type of retrofit known as selective catalytic reduction (SCR) reduces output by converting nitrogen oxides to molecular nitrogen and oxygen-rich exhaust streams. SCR systems are enhanced by using a low sulfur fuel. The amount of sulfur in diesel was recently reduced by 97 percent, creating low sulfur fuel. As sulfur tends to hamper exhaust-control devices, the introduction of low sulfur fuel has allowed retrofitting to be an effective means of reducing emissions.

Truck stop electrification (TRE) reduces idling by diesel powered commercial trucks. Truck drivers are typically required to rest 8 hours for every 10 hours of travel time. During this resting period, diesel engines are idled as a means to power their air conditioning and heating systems. TRE eliminates this diesel dependence by providing an electrical system that charges battery-powered appliances including air conditioning, heating, and other electronic devices. In addition, cool or warm air is pumped into the trucks via a hose hookup at the truck stops as another method of cutting down on idling and emissions. All of this reduces oxides of nitrogen that would be produced by unnecessary idling.

Locomotive conversions reduce emissions by replacing old single diesel engines used by switch locomotives with smaller, more efficient modular diesel engines. Switch locomotives, or switchers, assemble and disassemble trains at rail yards. When they are not in action, they idle on the rails until another train comes along. The new engines, known as "genset" and eventually Tier 4 engines, utilize two or more smaller engines that can combine to equal the strength of the older engines to pull the maximum load. They can function individually, or with less horsepower, to handle less demanding loads, while cutting down on the fuel needed to perform the task. These lower-emitting off-road diesel engines also feature an automatic engine start/stop technology to reduce idling when not in use.

HEALTH IMPACTS

Exposure to high levels of NO_2 for short durations (less than three hours) can lead to respiratory problems. Asthma sufferers, in particular, are sensitive to NO_2. This sensitivity was expressed in a study that examined changes in airway responsiveness of exercising asthmatics during exposure to relatively low levels of NO_2. Other studies also indicate a relationship between indoor NO_2 exposures and increased respiratory illness rates in young children, but definitive results are still lacking. In addition, many animal analyses suggest that NO_2 impairs respiratory defense mechanisms and increases susceptibility to infection. Several other observations also show that chronic exposure to relatively low NO_2 pollution levels may cause structural changes in the lungs of animals. These studies suggest that chronic exposure to NO_2 could lead to adverse health effects in humans, but specific levels and durations likely to cause such effects have not yet been determined.

MEASUREMENT TECHNIQUES

Oxides of nitrogen, particularly NO_2, are monitored using specialized analyzers that continuously measure the concentration of oxides of nitrogen in ambient air using the ozone-phase chemiluminescent method. Nitric oxide (NO) and ozone (O_3) react to produce a characteristic luminescence with an intensity, linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO_2 molecules decay to lower energy states. NO_2 must first be converted to NO before it can be measured using the chemiluminescent reaction. NO_2 is converted to NO by a molybdenum NO_2-to-NO converter, heated to about 325°C. The ambient air sample is drawn into the sample bulkhead. The sample flows through a particulate filter, a capillary, then to the mode solenoid valve. The solenoid valve routes the sample either straight to the reaction chamber (NO mode) or through the NO_2-to-NO converter and then to the reaction chamber (NO_x mode). Dry air enters the dry air bulkhead through a flow sensor, and then through a silent discharge ozonator. The ozonator generates the necessary ozone concentration needed for the chemiluminescent reaction. The ozone reacts with the NO in the ambient air to produce electronically excited NO_2 molecules. A photomultiplier tube housed in a thermoelectric cooler detects the NO_2 luminescence. The NO and NO_2 concentrations calculated in the NO and NO_x modes are stored in memory, and the difference between the concentrations are used to calculate the NO_2 concentration. The sampler outputs NO, NO_2, and NO_x concentrations on the front panel display and the analog or digital outputs. There are two major instrument designs. While they are closely related, they do not monitor the same species. NO_x analyzers measure NO, NO_2, and NO_x. NO_y analyzers measure NO and NO_y, but cannot measure NO_2. The NO_y analyzers are also specialized for measuring trace-level concentrations; as such, they cannot measure higher concentrations. Because of these instrument design tradeoffs, it is necessary to operate a network of both instrument types to get a complete picture of local conditions.

ATTAINMENT DESIGNATION

Of the oxides of nitrogen, only NO_2 is regulated under the NAAQS. Therefore, only the NOx type analyzers produce data directly relevant to the standard. NO_2 monitoring is required in urban areas with populations greater than 1,000,000. The Atlanta-Sandy Springs-Marietta MSA is the only urban area in Georgia that meets that population requirement. In 2013, the Atlanta-Sandy Springs-Marietta MSA had three NO_2 sites collecting data. They are located at the South DeKalb, Conyers, and Yorkville sites. The South DeKalb site is designated as the area-wide NO_2 monitoring site for the Atlanta-Sandy Springs-Marietta MSA. Figure 10 shows the complete oxides of nitrogen monitoring network, including NOx and NOy monitoring locations.

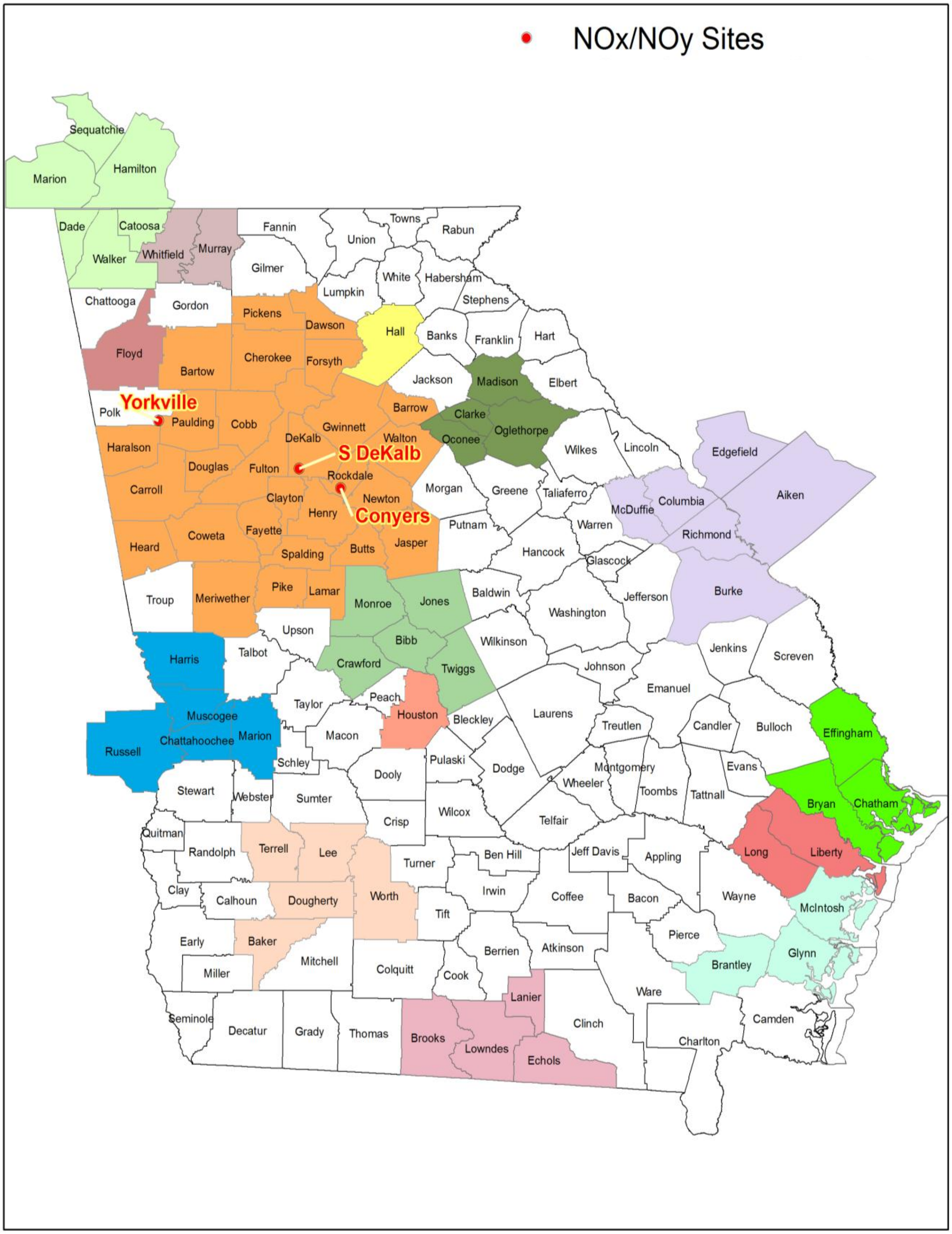


Figure 10. Georgia oxides of nitrogen monitoring sites, MSAs shown as solid colors

Data collected from these continuous monitors is used to determine compliance with the NAAQS primary and secondary annual standards for NO_2. These standards require that a site's annual average concentration not exceed 0.053 ppm (53 ppb). Figure 11 shows Georgia's annual average NO_2 concentrations from 2000 to 2013. Annual average concentrations are well below the standard of 53 ppb. In order to protect public health against adverse effects associated with short-term NO_2 exposure, on January 22, 2010, EPA strengthened the NO_2 standard to include a 1-hour form [Federal Register, Vol. 75, No. 26, page 6474, dated February 9, 2010]. This form of the standard is a three-year average of the 98^{th}% of the annual daily maximum 1-hour averages. The level for this standard is 100 parts per billion. For this standard, EPA is interested in monitoring near-road concentrations and the effects of traffic emissions. In 2014, GA EPD will have established one of a limited number of sites launched nationwide. To show how past and current NO_2 data would compare to this new standard, Figure 12 displays the three-year averages of the 98^{th}% of annual daily maximum 1-hour averages (1-hour design values), as available from 2000 to 2013. The 1-hour design values are well below the 100 ppb standard, and have consistently dropped since the 2000-2002 averages. The Atlanta-Sandy Springs-Marietta MSA is in attainment of both the annual and the 1-hour NO_2 standard. For additional summary data on this topic see Appendix A.

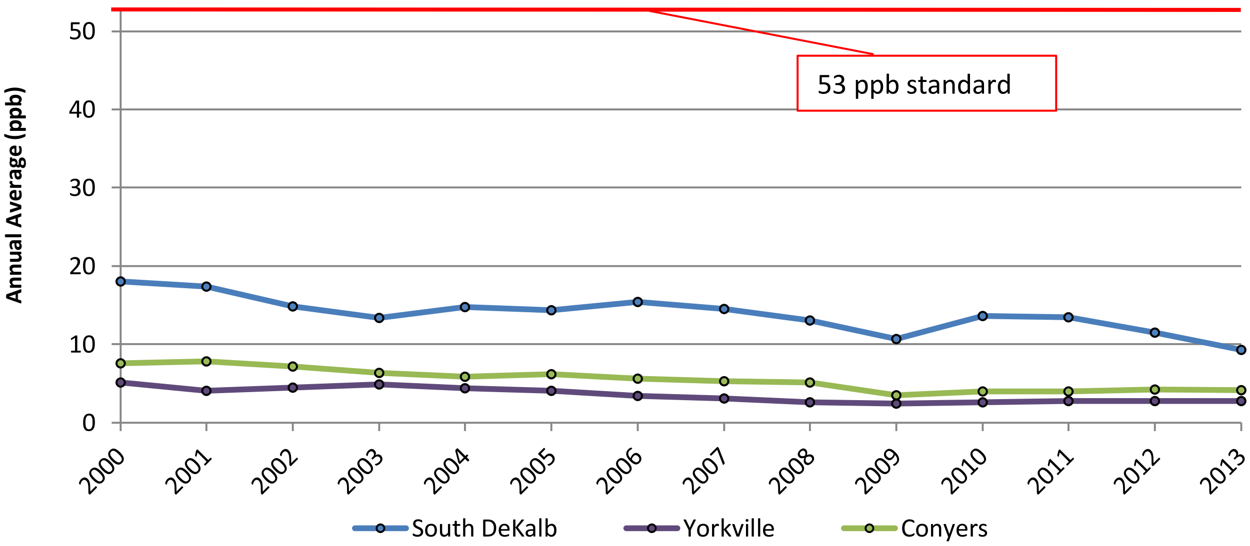


Figure 11. Nitrogen dioxide annual averages compared to the annual standard

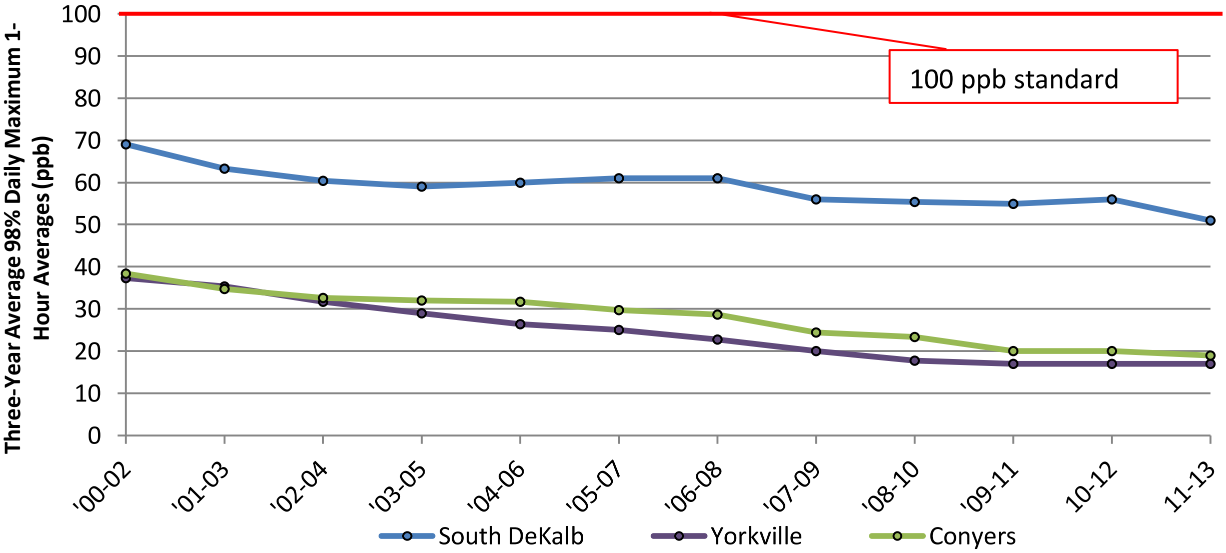


Figure 12. Nitrogen dioxide 1-hour design values compared to the 1-hour standard

Figure 13 is a visualization of decreasing NO_2 levels (higher levels shown with darker red) in the Atlanta area and the northern part of the state. This image was produced using data gathered by NASA's Aura satellite equipped with an Ozone Monitoring Instrument (OMI) (source: http://www.nasa.gov/content/goddard/new-nasa-images-highlight-us-air-quality-improvement/#.U7095vldXpX).

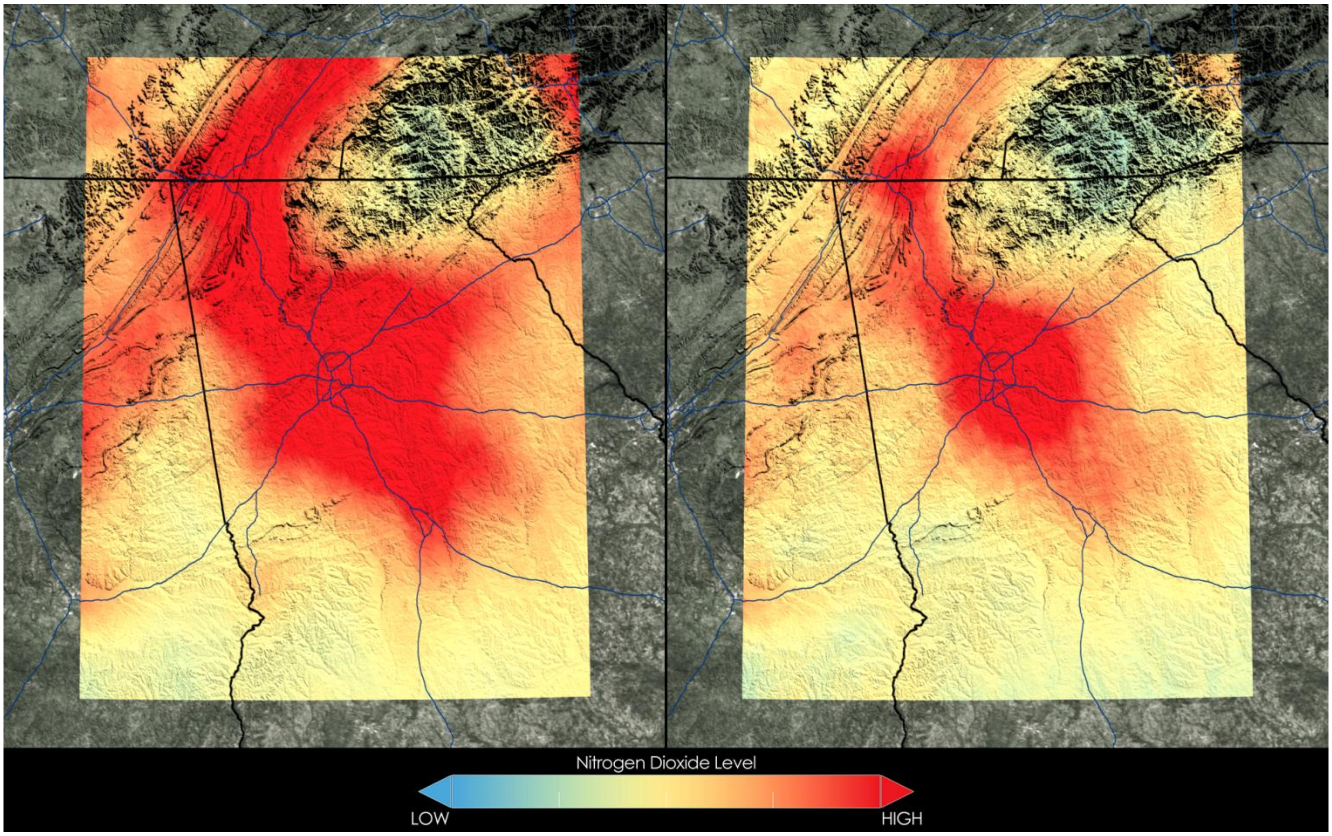


Figure 13. Satellite data show that Atlanta has seen a 42 percent decrease in nitrogen dioxide between the 2005-2007 (left) and 2009-2011 (right) periods.

SULFUR DIOXIDE (SO_2)

GENERAL INFORMATION

Sulfur dioxide (SO_2) is a colorless reactive gas that is formed by burning sulfur-containing material, such as coal, or by processing sulfur-containing ores. Most SO_2 emissions in Georgia come from electric generation (Figure 14). SO_2 is odorless at low concentrations, but pungent at very high concentrations. It can be oxidized in the atmosphere into sulfuric acid. When locomotives, large ships, and non-road equipment burn sulfur-bearing fuel, or when ores that contain sulfur are processed, the sulfur is oxidized to form SO_2. SO_2 then can react with other pollutants to form aerosols. In liquid form, SO_2 may be found in clouds, fog, rain, aerosol particles, and in surface liquid films on these particles. Both SO_2 and NO_2 are precursors to the formation of acid rain that lead to acidic deposition. SO_2 is also a precursor for sulfate particles. Major sources of SO_2 are fossil fuel-burning power plants and industrial boilers. Figure 14 shows common SO_2 sources and Figure 15 shows SO_2 emissions by county in Georgia. These figures are based on 2011 data and are taken from the latest emissions report from EPA.

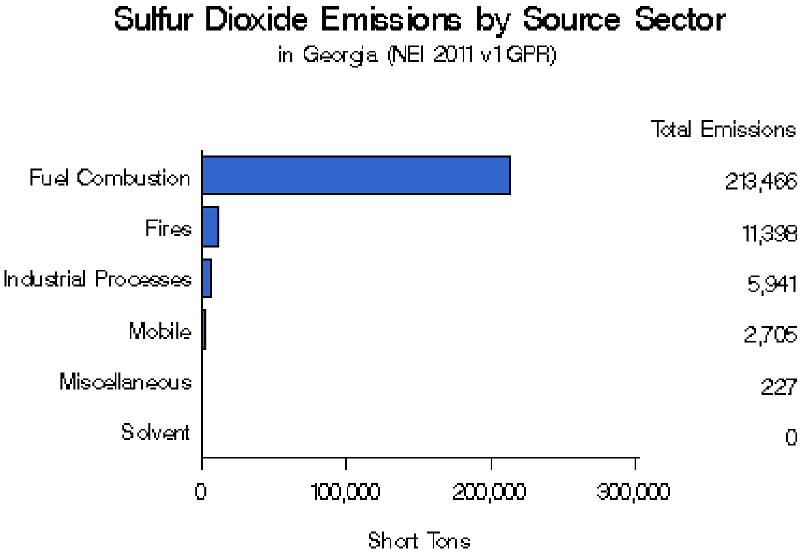


Figure 14. Common sources of sulfur dioxide (SO_2) in Georgia

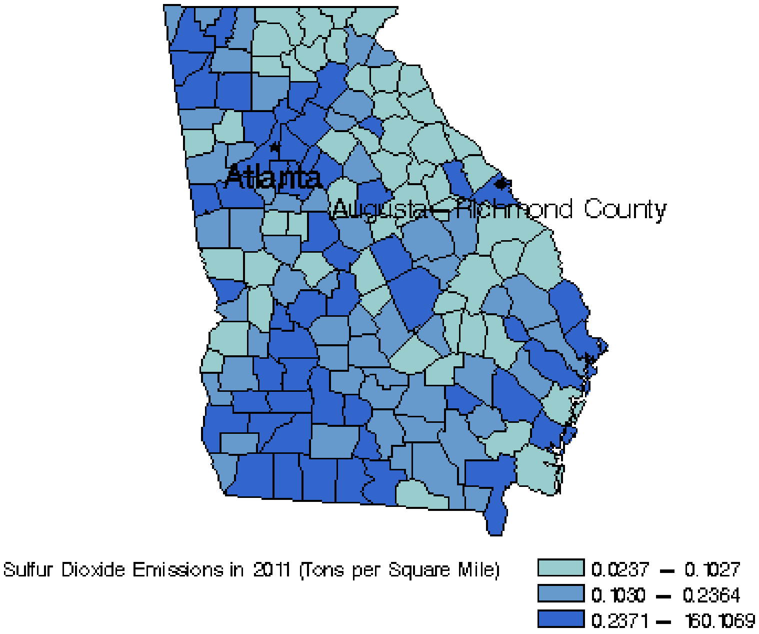


Figure 15. Spatial view of sulfur dioxide emissions in Georgia

On June 2, 2010, the SO_2 primary National Ambient Air Quality Standard (NAAQS) was strengthened in order to protect public health from high short-term concentrations. Three-year averages of the 99th% of annual daily maximum 1-hour averages are now compared to the standard of 75 ppb. Figure 16 shows how Georgia's SO_2 data compares to this 1-hour standard from 2000 to 2013. The highest SO_2 design value for 2011-2013 occurred at the Savannah L&A site (79 ppb).

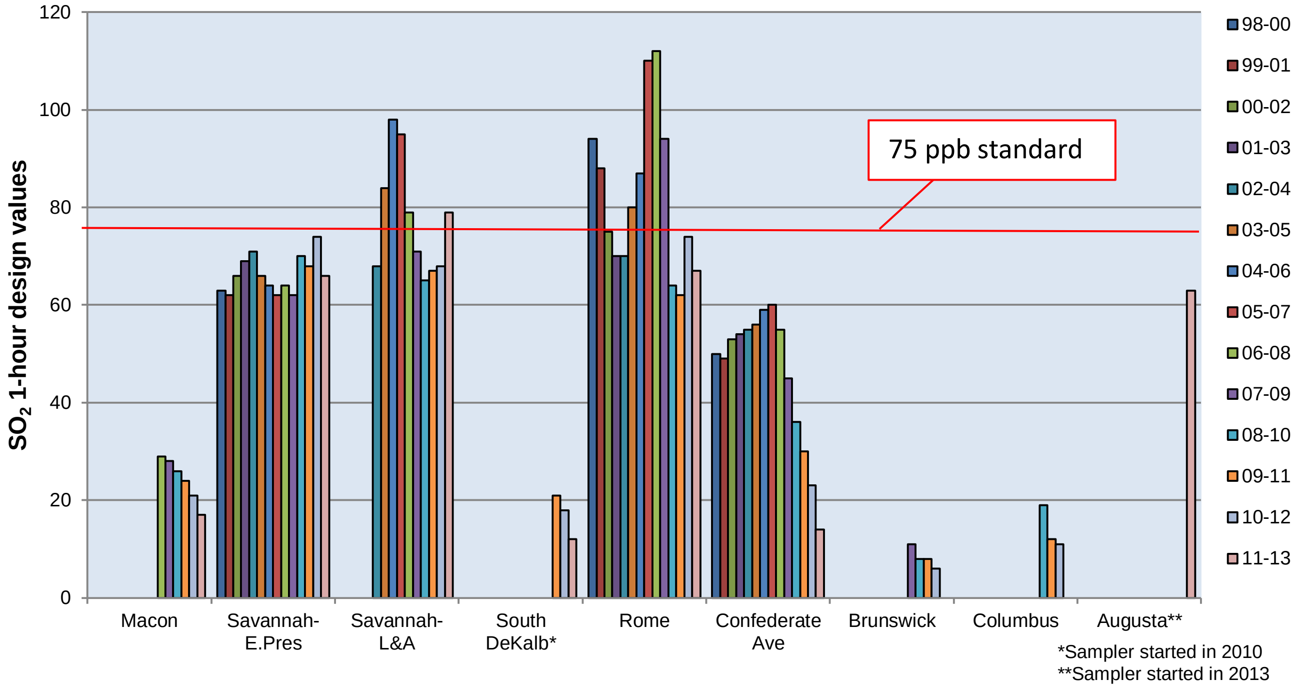


Figure 16. SO_2 three-year averages of the 99th% of annual daily max 1-hour averages

The statewide SO_2 design value averages have decreased 38% between 2000 and 2013 (Figure 17). The average of the SO_2 three-year averages peaked at 82 ppb for the 2005-2007 average and has decreased to 42.5 ppb in the current 2011-2013 average. This graph is showing the data from the varying number of SO_2 monitors that were collecting data each year.

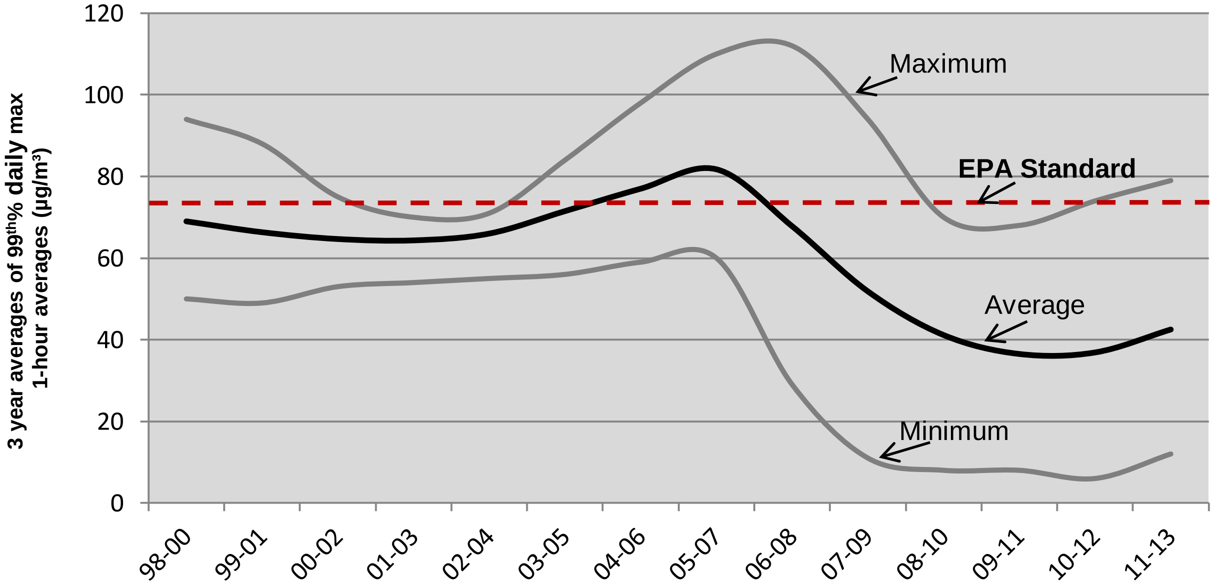


Figure 17. Statewide SO_2 1-hour design value maximums, averages, and minimums

HEALTH IMPACTS

Exposure to SO_2 can cause impairment of respiratory function, aggravation of existing respiratory disease (especially bronchitis), and a decrease in the ability of the lungs to clear foreign particles. It can also increase mortality, especially if elevated levels of particulate matter (PM) are present. Individuals with hyperactive airways, cardiovascular disease, and asthma are most sensitive to the effects of SO_2. In addition, elderly people and children are also likely to be sensitive to this air pollutant.

The effects of short-term peak exposures to SO_2 have been evaluated in controlled human exposure studies. These studies show that SO_2 generally increases airway resistance in the lungs, and can cause significant constriction of air passages in sensitive asthmatics. These impacts have been observed in subjects engaged in moderate to heavy exercise while exposed to relatively high peak concentrations. These changes in lung function are accompanied by perceptible symptoms such as wheezing, shortness of breath, and coughing in these sensitive groups.

The presence of particle pollution appears to aggravate the impact of SO_2 pollution. Several studies of chronic effects have found that people living in areas with high particulate matter and SO_2 levels have a higher incidence of respiratory illnesses and symptoms than people living in areas without such a combination of pollutants.

MEASUREMENT TECHNIQUES

Sulfur dioxide is measured in the ambient air using EPA-approved equivalent method instruments as defined in 40 CFR Part 53, Appendix A. Georgia's sulfur dioxide network consists of continuous instruments using a pulsed ultraviolet (UV) fluorescence technique. This monitoring technique is based on measuring the emitted fluorescence of SO_2 produced by its absorption of UV radiation. Pulsating UV light is focused through a narrow bandpass filter allowing only light wavelengths of 1,900 to 2,300 angstrom units (Å) to pass into the fluorescence chamber. SO_2 absorbs light in this region without any quenching by air or most other molecules found in polluted air. The SO_2 molecules are excited by UV light and emit a characteristic decay radiation. A second filter allows only this decay radiation to reach a photomultiplier tube. Electronic signal processing transforms the light energy impinging on the photomultiplier tube into a voltage which is directly proportional to the concentration of SO_2 in the sample stream being analyzed. The sampler outputs the SO_2 concentration to the front panel display and to an analog or digital output. Data gained from the continuous monitors are used to determine compliance with the NAAQS for SO_2. Figure 18 shows the locations of the Georgia SO_2 monitoring stations for 2013.

ATTAINMENT DESIGNATION

To determine if an SO_2 monitor is in attainment, the 1-hour daily maximum values and 3-hour averages are evaluated. The data collected has to be at least 75 percent complete in each calendar quarter. A 24-hour block average is considered valid if at least 75 percent of the hourly averages for that 24-hour period are available [61 FR 25579, May 22, 1996]. To be considered in attainment of the secondary standard, an SO_2 site must have no more than one 3-hour average exceeding 0.5 ppm (500 ppb) [38 FR 25678, September 14, 1973]. In addition, for the newer 1-hour primary standard, the three-year averages of the 99th% of annual daily maximum 1-hour averages should be less than 75 ppb [Federal Register, Vol. 75, No. 119, page 35520, dated June 22, 2010]. As of the publication of this document, EPA has not addressed Georgia's SO_2 attainment status of the 2010 standard. For more information on Georgia's SO_2 attainment status, see EPA's website, http://www.epa.gov/airquality/sulfurdioxide/designations/regs.html. For additional SO_2 summary data see Appendix A.

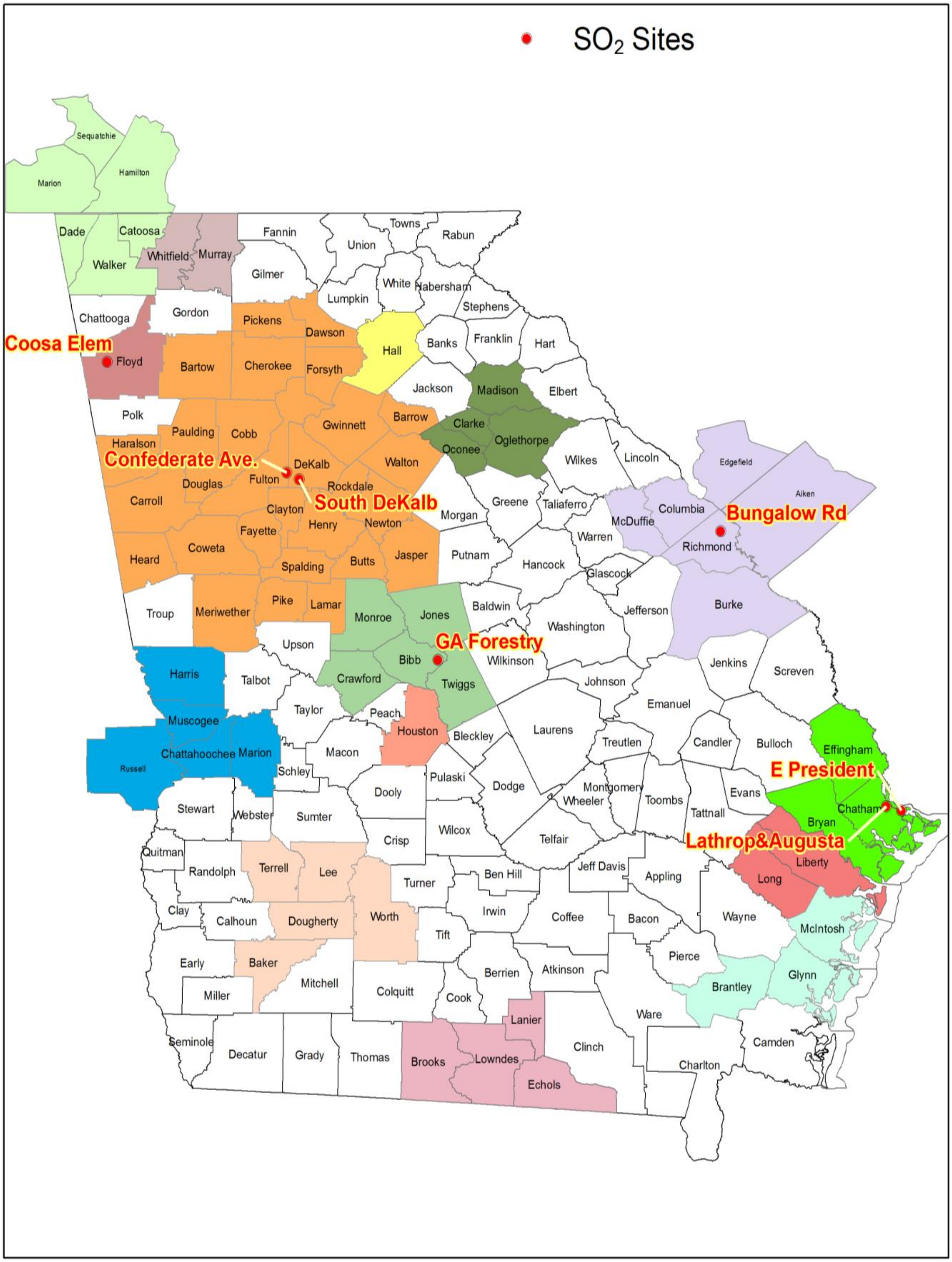


Figure 18. Georgia's sulfur dioxide monitoring sites, MSAs shown as solid colors

OZONE (O_3)

GENERAL INFORMATION

Ground level ozone formation occurs through a complex series of photochemical reactions that take place in the presence of strong sunlight. Since the reactions must take place in the presence of sunlight, ozone concentrations have a strong diurnal pattern (occurring daily and in daylight hours). Figure 19 shows this typical diurnal pattern of ozone concentration throughout the day.

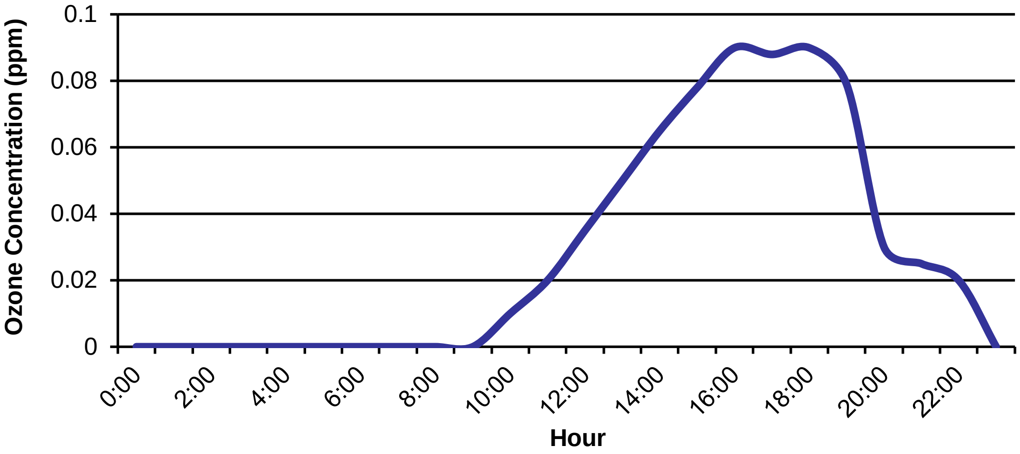
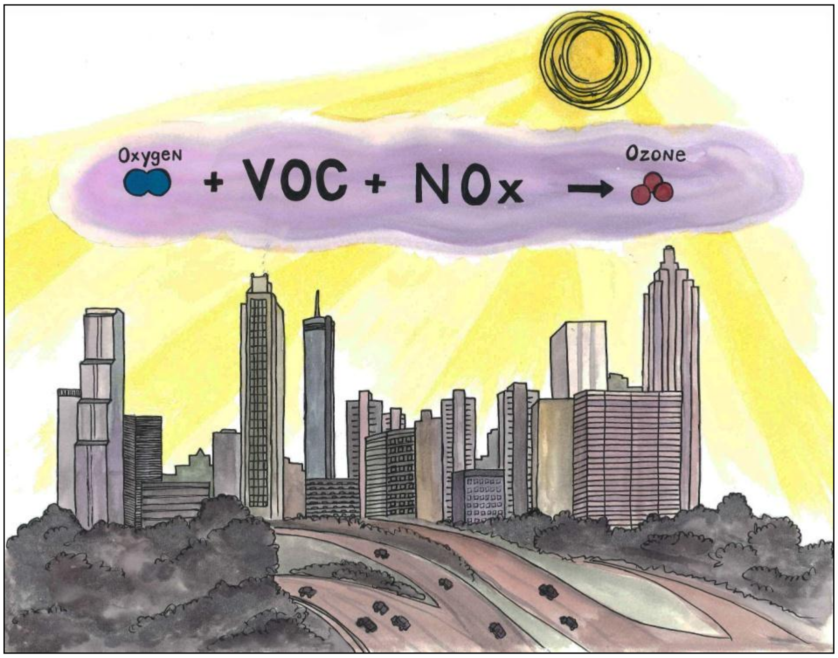


Figure 19. Typical urban 1-hour ozone diurnal pattern

For these photochemical reactions to take place, certain components, or precursors, must be available. The precursors[1] to ozone are oxides of nitrogen (NO_x) and photochemically reactive volatile organic compounds (VOCs) (Figure 20). Common sources of NO_x include combustion processes from vehicles and industrial processes. Examples of the reactive VOCs that contribute to ozone formation are: hydrocarbons found in automobile exhaust (benzene, propane, toluene); vapors from cleaning solvents (toluene); and biogenic emissions from plants (isoprene).



(Courtesy of Jamie Smith)

Figure 20. Ozone formation process

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[1] For a more complete discussion on ozone precursors see the NO_2 section and the PAMS section of this report.

Sources of VOCs in Georgia are shown in Figure 21 followed by a spatial view of VOC emissions across the state in Figure 22. In Georgia, biogenic emissions are the most common source of volatile organic compounds. These figures are taken from the latest emissions report from EPA, based on 2011 data.

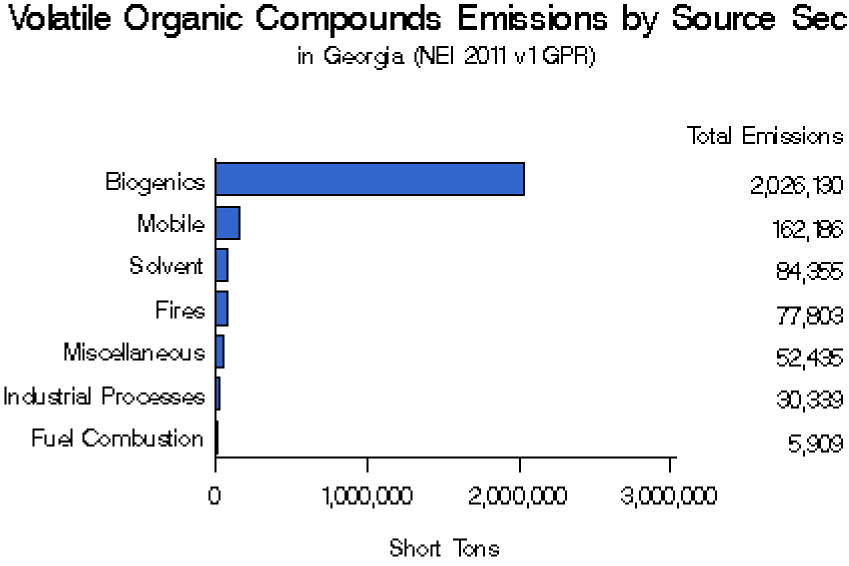


Figure 21. Common sources of VOCs in Georgia in 2011

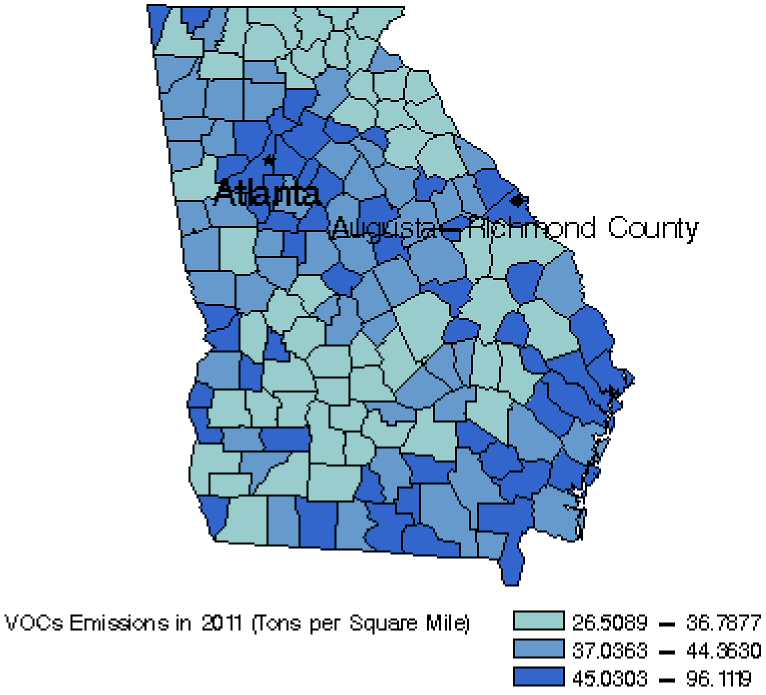


Figure 22. Spatial view of VOCs emissions in Georgia

Ozone is a colorless gas; however, when mixed with particles and other pollutants, such as NO_2, the atmospheric reaction forms a brownish, pungent mixture. This type of pollution first gained attention in the 1940's in Los Angeles as photochemical "smog" and has since been observed frequently in many other cities.

As stated previously, ozone is formed when its precursors come together in the presence of strong sunlight. The reaction only occurs when both precursors are present, and the reaction itself consumes the precursors as it produces ozone. The amount of ozone produced, assuming sufficient sunlight, is controlled by what is known as the "limiting reactant." This limiting reactant can be thought of in terms of household baking. One can only bake cookies until any one of the ingredients is gone. If the flour is gone, it does not matter how much milk and sugar there is; no more cookies can be made without more flour. In the same way, ozone production can only occur until the process has consumed all of any one of the required ingredients. As it turns out, natural background hydrocarbon levels are quite low in Los Angeles. Therefore, in that area, hydrocarbons are typically the reactant that limits how much ozone can be produced. The control measures that proved effective in reducing smog in the Los Angeles area involved reducing hydrocarbon emissions. These control measures and the science behind them have become relatively advanced because the Los Angeles ozone problem was so severe and developed so long ago. However, many of the fundamental lessons learned about smog formation in Los Angeles over many years of research have proven to not apply in the same way in Georgia.

At the start of air quality control implementation in Georgia, the assumption was that Georgia was also hydrocarbon limited. However, the initial control measures seemed ineffective in actually reducing ozone levels. In time, researchers discovered that vegetation naturally emits large quantities of hydrocarbons. The solution to ozone control in Georgia, then, would have to focus on a different limiting reactant. Since there will always be strong sunshine in the summer, and there will always be oxygen, the only effective way left to control ozone production is to reduce emissions of oxides of nitrogen.

Various strategies have been put into place to control hydrocarbons and oxides of nitrogen. With respect to reducing emissions from automobile engines, for example, the addition of relatively simple and inexpensive catalytic converters to existing engine design was a great leap forward in reducing hydrocarbon emissions, and has been used with great success since the early 1970's. In Atlanta, while catalytic converters and many other VOC controls have been put into place, control measures have also been implemented for the reduction of oxides of nitrogen, including selective catalytic reduction (SCR) on power plant generators.

A final difference between ozone and the other pollutants is that ozone is sometimes good. While ground level ozone is considered a hazardous pollutant, the ozone in the upper atmosphere, approximately 10-22 miles above the earth's surface, protects life on earth from the sun's harmful ultraviolet (UV) rays. This ozone is gradually being depleted due to man-made products called ozone depleting chemicals, including chlorofluorocarbons (CFCs), which when released naturally, migrate to the upper atmosphere. In the upper atmosphere, CFCs break down due to the intensity of the sun's UV rays, releasing chlorine and bromine atoms. These atoms react with the ozone and destroy it. Scientists say that one chlorine atom can destroy as many as 100,000 "good" ozone molecules. The destruction of this ozone may lead to more harmful ultraviolet rays reaching the earth's surface, causing increased skin cancer rates. This reduction in the protection provided by ozone in the upper atmosphere is usually referred to as the "ozone hole" and is most pronounced in polar regions.

With the exception of the South DeKalb site, ozone in Georgia, unlike other pollutants previously discussed, is only monitored during the "summer" months (March through October), according to EPA's 40 Code of Federal Regulations Part 58 monitoring requirements. The South DeKalb site began year-round monitoring as of November 2009. Many urban areas experience high levels of ground level ozone during the summer months. High ozone levels can also be seen in rural and mountainous areas. This is often caused by ozone and/or its precursors being transported by wind for many hundreds of miles.

As part of the Clean Air Status and Trends Network (CASTNET), EPA established a monitoring site in Georgia in 1988. The CASTNET site is part of a national air quality monitoring network put in place to assess long-term trends in atmospheric deposition and ecological effects of air pollutants. The CASTNET site is one of 85 regional sites across rural areas of the United States and Canada measuring nitrogen, sulfur, and ozone concentrations, and deposition of sulfur and nitrogen. Like the South DeKalb ozone monitor, the CASTNET ozone monitor also collects data year-round. As of 2011, the CASTNET ozone monitor met the Code of Federal Regulations (40 CFR), and met quality assurance and completeness criteria. Therefore, as of 2011, data collected by this monitor can be used for comparison to the NAAQS.

In 2013, the GA EPD monitored ground level ozone at 20 sites throughout the state and the EPA collected data at the CASTNET site (Figure 23).

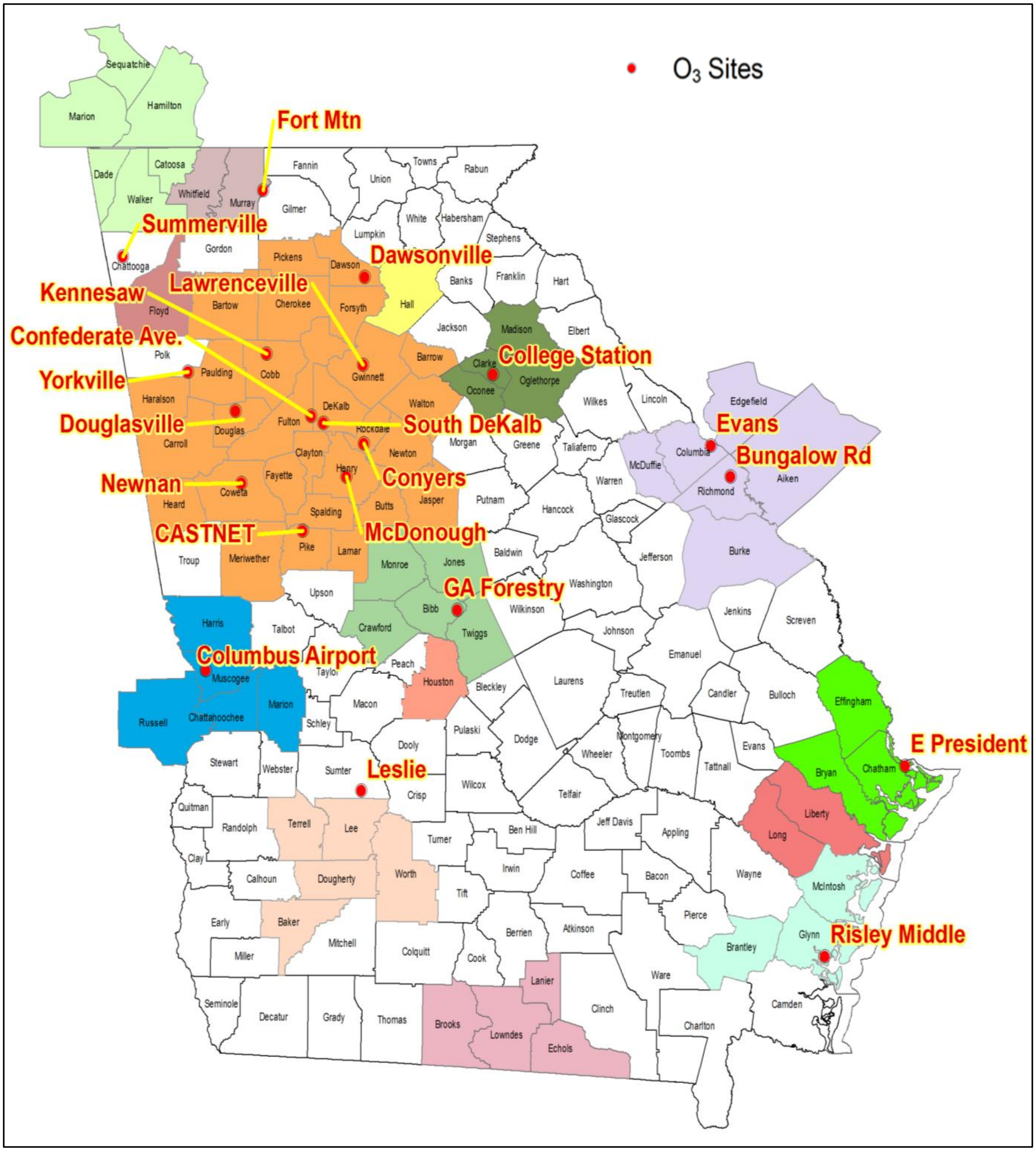


Figure 23. Georgia's ozone monitoring sites, MSAs shown as solid colors

HEALTH IMPACTS

Ozone and other photochemical oxidants such as peroxyacetyl nitrate (PAN) and aldehydes are associated with adverse health effects in humans. Peroxyacetyl nitrate and aldehydes cause irritation that is characteristic of photochemical pollution. Ozone has a greater impact on the respiratory system, where it irritates the mucous membranes of the nose, throat, and airways. Ninety percent of the ozone inhaled into the lungs is never exhaled. Symptoms associated with exposure include cough, chest pain, and throat irritation. Ozone can also increase susceptibility to respiratory infections. In addition, ozone impairs normal functioning of the lungs and reduces the ability to perform physical exercise. Recent studies also suggest that even at lower ozone concentrations some healthy individuals engaged in moderate exercise for six to eight hours may experience symptoms. All of these effects are more severe in individuals with sensitive respiratory systems, and studies show that moderate levels may impair the ability of individuals with asthma or respiratory disease to engage in normal daily activities.

The potential chronic effects of repeated exposure to ozone are of even greater concern. Laboratory studies show that people exposed over a six to eight hour period to relatively low ozone levels develop lung inflammation. Animal studies suggest that if exposures are repeated over a long period (e.g. months, years, lifetime), inflammation of this type may lead to permanent scarring of lung tissue, loss of lung function, and reduced lung elasticity.

MEASUREMENT TECHNIQUES

Georgia's ozone analyzers continuously measure the concentration of ozone in ambient air using the ultraviolet (UV) photometric method and are EPA-approved for regulatory air monitoring programs. The degree to which the UV light is absorbed is directly related to the ozone concentration. The ambient air is drawn into the sample bulkhead and is split into two gas streams. One gas stream flows through an ozone scrubber to become the reference gas. The reference gas then flows to the reference solenoid valve. The sample gas flows directly to the sample solenoid valve. The solenoid valves alternate the reference and sample gas streams between the two cells every 10 seconds. When cell A contains reference gas, cell B contains sample gas and vice versa. The UV light intensities of each cell are measured by detectors A and B. When the solenoid valves switch the reference and sample gas streams to opposite cells, the light intensities are ignored for several seconds to allow the cells to be flushed. The sampler calculates the ozone concentration for each cell and outputs the average concentration to both the front panel display and the analog or digital output. Data gained from the continuous monitors are used to determine compliance with the NAAQS for ozone.

ATTAINMENT DESIGNATION

Ozone monitoring has been in place in the Atlanta area since 1980. The 1980 network consisted of two monitors located in DeKalb and Rockdale Counties. Currently the Atlanta-Sandy Springs-Marietta MSA ozone network includes ten monitors located in ten counties.

In July 1997 the U.S. EPA issued an 8-hour ozone standard intended to eventually replace the older 1-hour standard. This 8-hour standard is attained when the average of the fourth highest concentration measured is equal to or below 0.08 ppm (up to 0.085 ppm with third digit truncated, or cut off) averaged over three years (see Table 1; 62 FR 38894, July 18, 1997). Areas that EPA designated attainment with the 1-hour standard were immediately exempt from that standard, and thereafter are subject to the 8-hour standard. In the summer of 2005, the metro Atlanta area was designated attainment with the 1-hour standard. As of the printing of this report, only the 8-hour ozone standard is applicable in Georgia. The data showed that the Atlanta area met the 1997 8-hour ozone standard, and GA EPD submitted a revised maintenance state implementation plan (SIP) to EPA for this standard. EPA approved GA EPD's SIP, and the Atlanta area was redesignated as in attainment of the 1997 8-hour standard of 0.085 ppm in December 2013.

On March 27, 2008 the ozone primary standard level was lowered to 0.075 ppm for the 8-hour averaging time, fourth maximum value, averaged over three years (Federal Register, Vol. 73, No. 60, page 16436). With the implementation of the 2008 ground-level ozone standard, the boundary of the Atlanta nonattainment area is defined as a 15-county area (Figure 24). Because the Atlanta area was defined with a 'marginal' designation compared to the 2008 ground-level ozone standard, a SIP is not required.

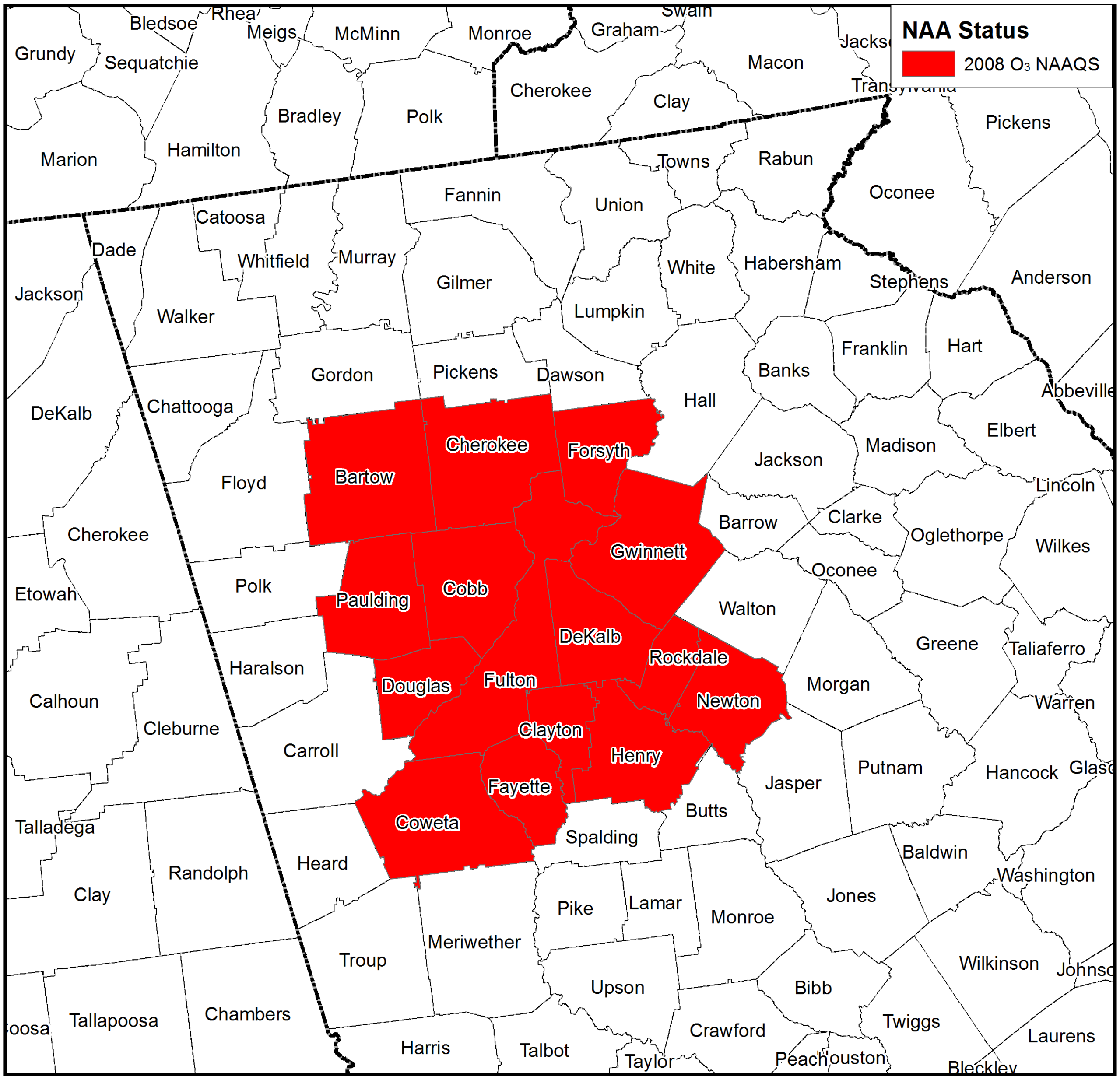


Figure 24. Georgia's 8-hour ozone nonattainment area map for the 2008 standard

A number of activities to aid in controlling the precursors to ozone formation have been implemented. A state implementation plan (SIP) has been developed to assist in ozone reduction. As new areas are declared in nonattainment, these control measures may be expanded to include them. One activity could include a vehicle inspection program. However, as the vehicle fleet gets younger, this is not as beneficial. Other activities include installing controls on stationary emission sources, and the establishment of a voluntary mobile emissions reduction program. An example of such a program in the Atlanta-Sandy Springs-Marietta MSA is called The Clean Air Campaign (CAC). Activities of The Clean Air Campaign include distributing daily ozone forecasts (as well as $PM_{2.5}$ forecasts produced by

EPD and Georgia Tech) during the ozone season to enable citizens in the sensitive group category, as well as industries, to alter activities on days that are forecasted to be conducive to ozone formation. This is also done for the Macon and Columbus metropolitan areas. In addition to the daily forecasts, citizens have access to forecast and monitoring data on an as needed basis by either calling 1-800-427-9605 or by accessing the Georgia DNR/EPD Ambient Air Monitoring website at http://www.air.dnr.state.ga.us/amp/index.php. For a more detailed discussion concerning the CAC, see the section in this report titled “Outreach and Education”.

Figure 25 shows the number of exceedance days per year in relation to the current 0.075 ppm 8-hour ozone standard (red line) and the old 0.085 ppm 8-hour ozone standard (blue line). This chart was produced by comparing measurement data against both ambient standards. This demonstrates the relative strictness of each standard and shows how the Atlanta-Sandy Springs-Marietta MSA’s air quality has changed over time. Despite a great deal of fluctuation, over the course of the past twenty-eight years, there has been a gradual reduction in the number of days exceeding either ozone standard. Trendlines for both standards show that the number of days that exceed the ozone standard has fallen by approximately one day each year over this time period. Even with the new, lower 8-hour ozone standard, the data shows a decrease in the number of days with ozone exceedances for the Atlanta-Sandy Springs-Marietta MSA. In 2013, the Atlanta-Sandy Springs-Marietta MSA area had a total of 3 days that violated the current (0.075 ppm) 8-hour standard.

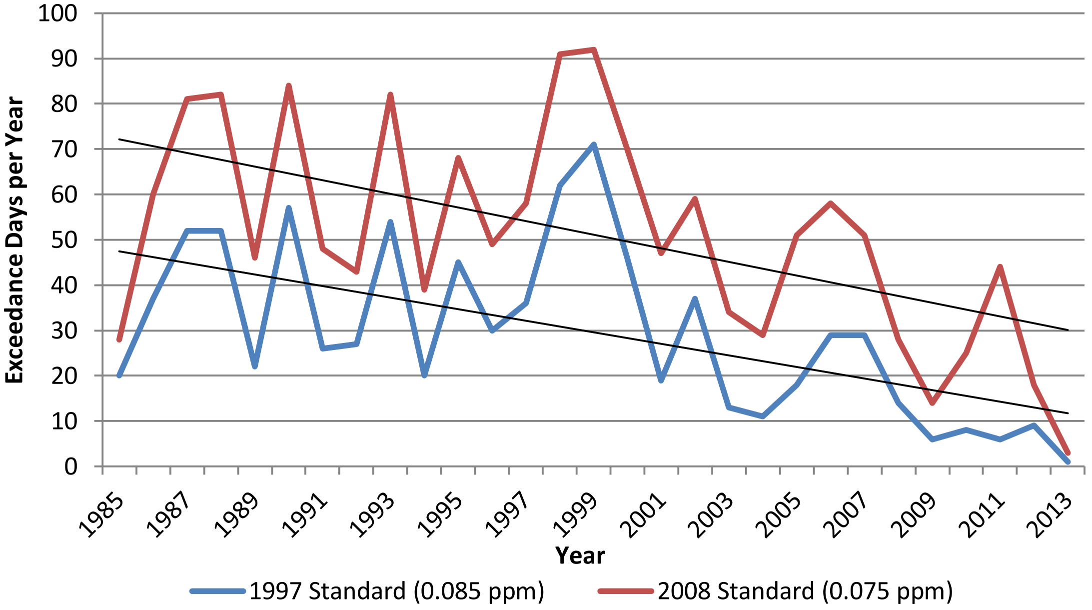
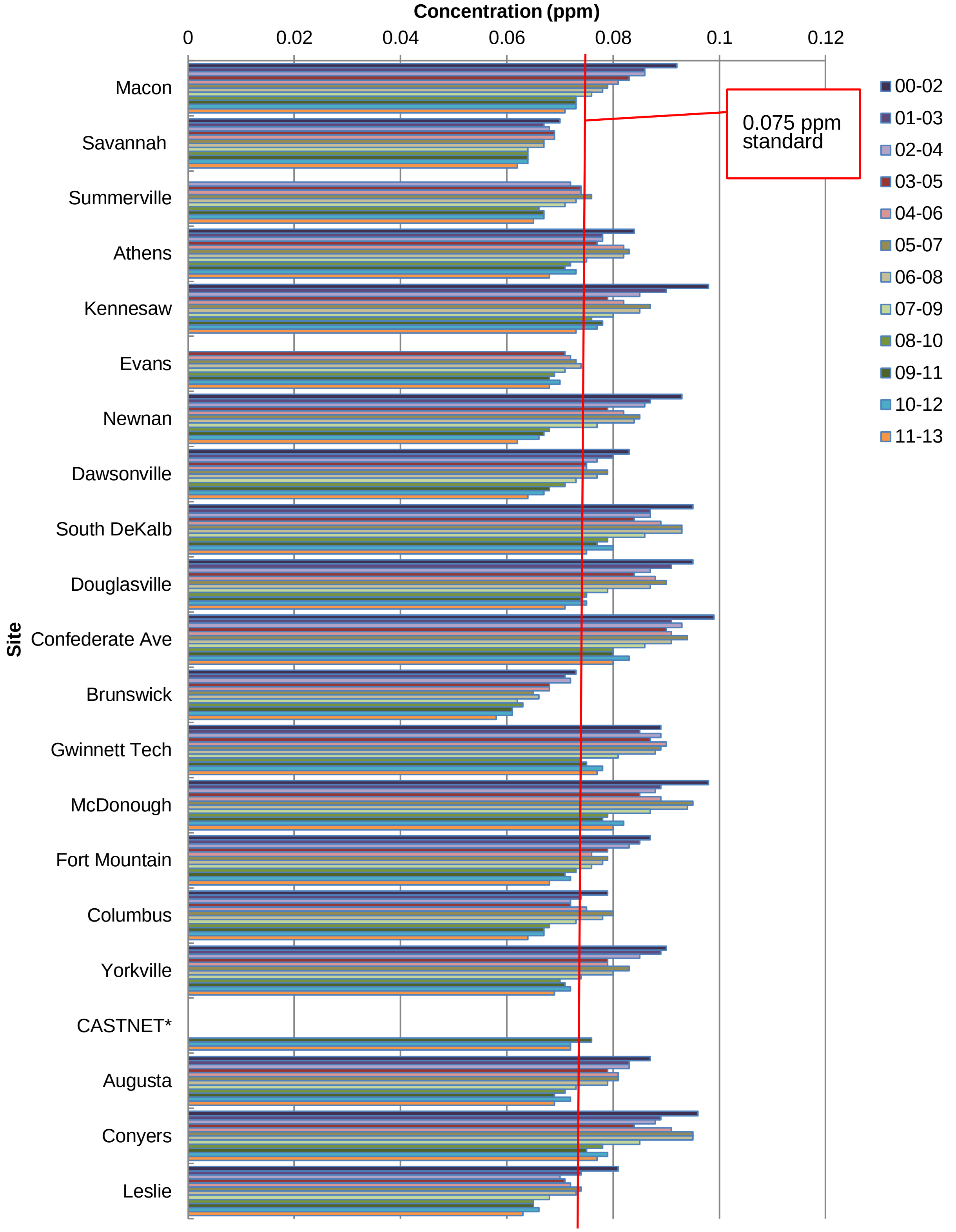


Figure 25. Number of ozone violation days per year in relation to the current (red line) and former (blue line) standards in the Atlanta-Sandy Springs-Marietta MSA.

For 2011-2013, five sites (all within the Atlanta-Sandy Springs-Marietta MSA) have ozone design values at or above the standard (Figure 26), these include South Dekalb, Confederate Avenue, Gwinnett Tech, McDonough, and Conyers.

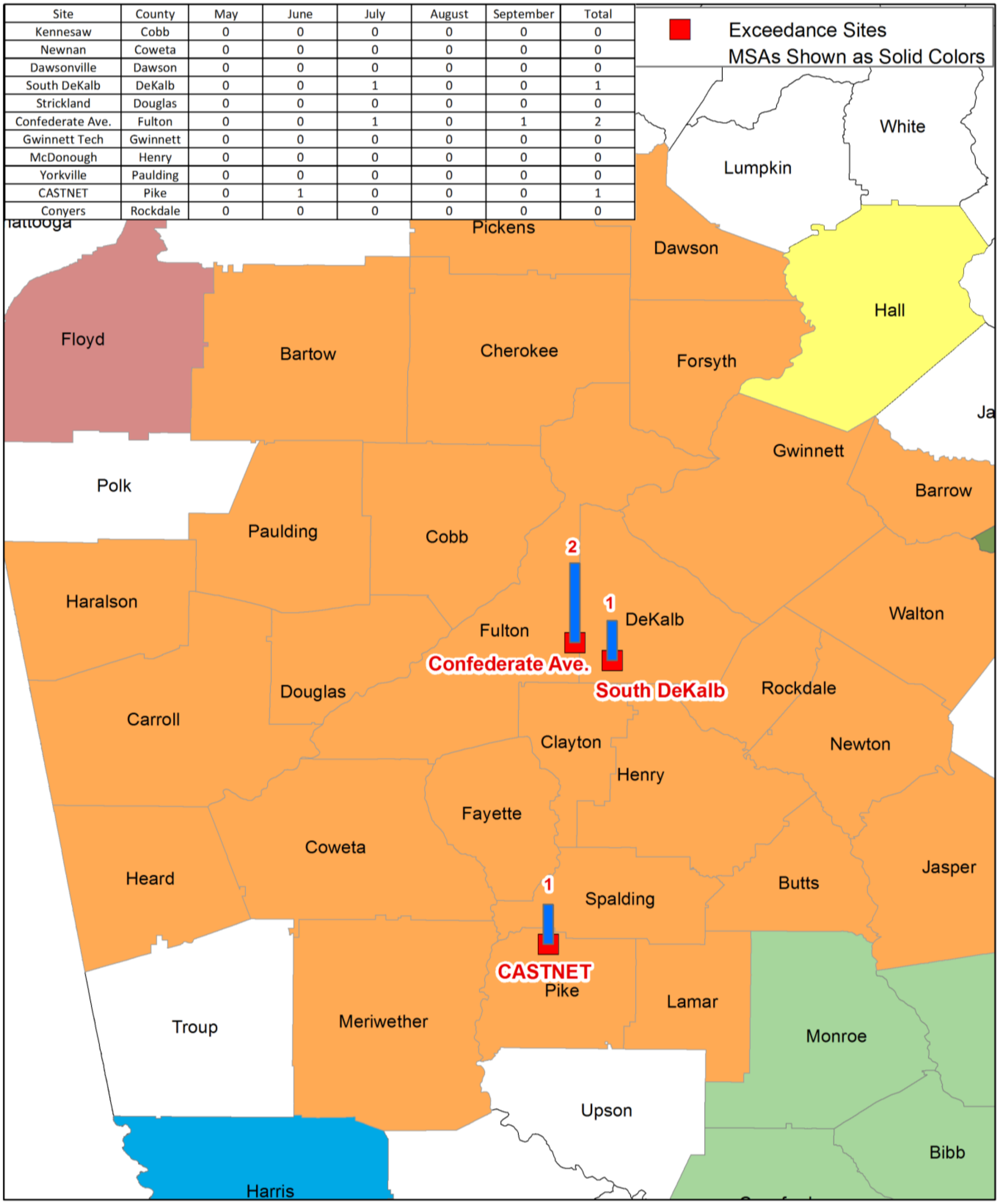


*Incomplete; 2011-2013

Figure 26. Ozone design values for GA EPD's ozone sites and EPA's CASTNET site.

The Atlanta-Sandy Springs-Marietta MSA ozone monitors which exceeded the 8-hour ozone standard (0.075 ppm) in 2013 are mapped along with a table of the monthly breakdown of the exceedances (Figure 27). Since the 8-hour increment is calculated as a running 8-hour timeframe, there are a number of averages each day. Of the eleven ozone sites collecting data in the Atlanta-Sandy Springs-Marietta MSA, three experienced exceedances in 2013. The Confederate Avenue site had two exceedance days, the South DeKalb site had one, and the CASTNET site had one for the 2013 ozone season.

For additional ozone summary data see Appendix A.



Site	County	May	June	July	August	September	Total
Kennesaw	Cobb	0	0	0	0	0	0
Newnan	Coweta	0	0	0	0	0	0
Dawsonville	Dawson	0	0	0	0	0	0
South DeKalb	DeKalb	0	0	1	0	0	1
Strickland	Douglas	0	0	0	0	0	0
Confederate Ave.	Fulton	0	0	1	0	1	2
Gwinnett Tech	Gwinnett	0	0	0	0	0	0
McDonough	Henry	0	0	0	0	0	0
Yorkville	Paulding	0	0	0	0	0	0
CASTNET	Pike	0	1	0	0	0	1
Conyers	Rockdale	0	0	0	0	0	0

Figure 27. The number of days each monitor had 8-hour averages above the 0.075 ppm ozone standard in the Atlanta-Sandy Springs-Marietta MSA, including a table of the monthly breakdown of exceedances.

Figure 28 was taken from the EPA document “Our Nation’s Air- Status and Trends through 2010”. It shows the fourth maximum reading for the 8-hour ozone readings across the United States. Georgia’s fourth maximum ozone readings in 2010 were in the 0.060-0.075 ppm (light blue) and 0.076-0.095 ppm (yellow) ranges.

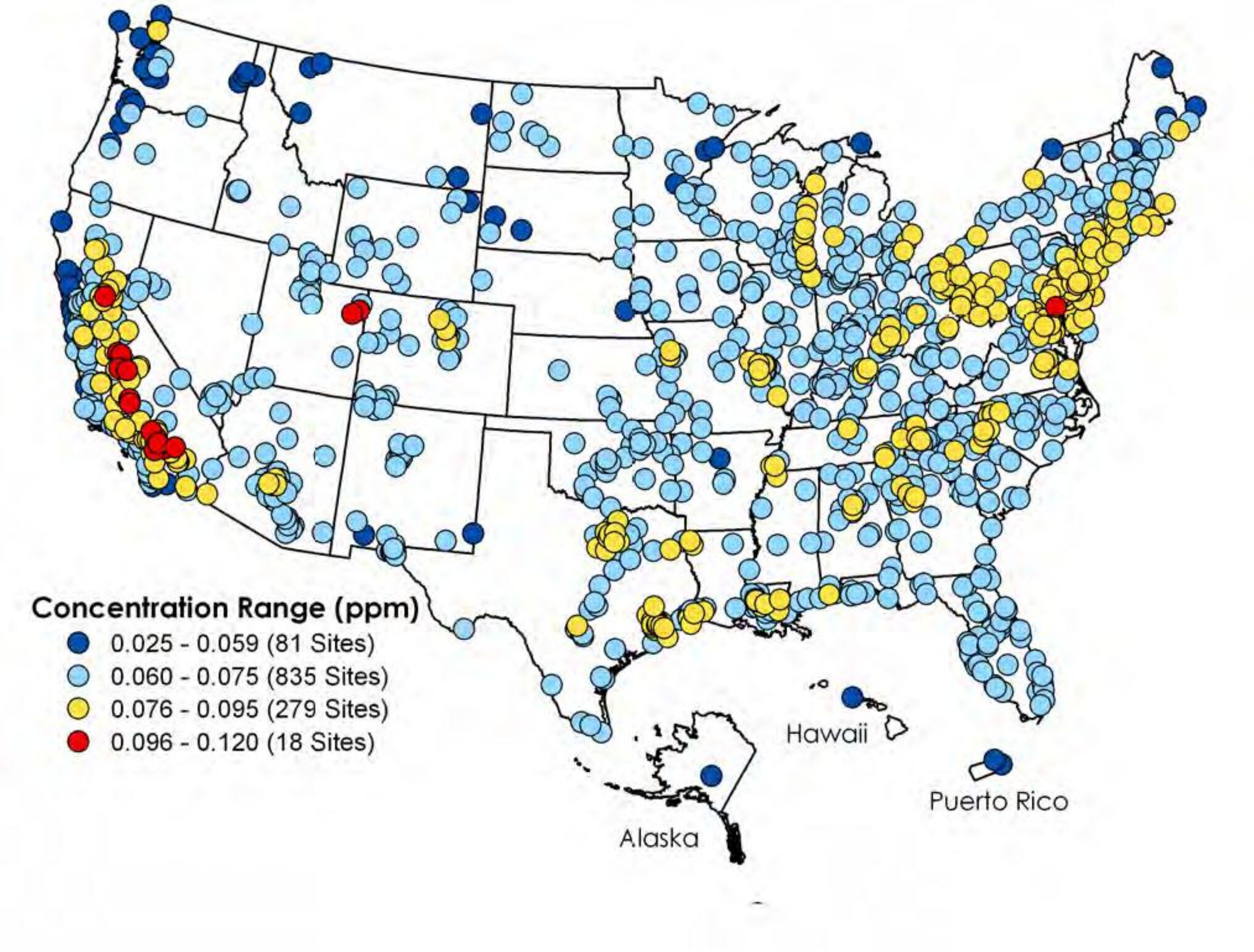


Figure 28. Ozone concentrations for the U.S. in 2010

LEAD (Pb)

GENERAL INFORMATION

In the past, the Clean Air Act required extensive lead monitoring in order to detect the high levels of airborne lead that resulted from the use of leaded gasoline. With the phase-out of leaded gasoline, lead concentrations had decreased to nearly detection level by the late 1980s**.** Since then, the concentrations have hovered just above detection level. Based on data from EPA's Air Emission Sources for 2011, Georgia's primary source of lead emissions comes from mobile sources (Figure 29). Other sources of lead emissions include industrial processes (metals processing, iron and steel production), combustion of solid waste, and lead-acid battery manufacturing. Figure 30 shows a spatial view of Georgia's lead emissions, also from EPA's Air Emission Sources, based on 2011 data.

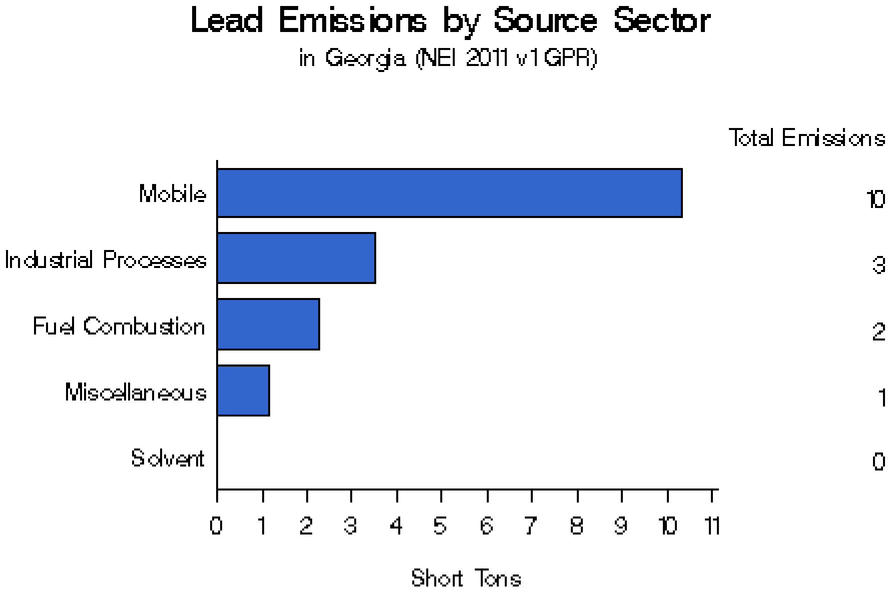


Figure 29. Common sources of lead in Georgia

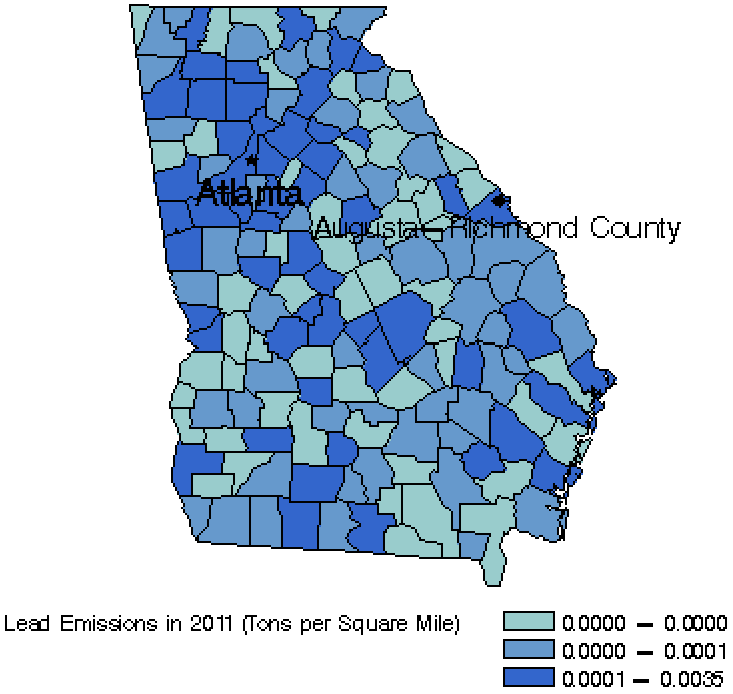


Figure 30. Spatial view of lead emissions in Georgia

At the beginning of 2009 there were two dedicated lead monitors remaining in Georgia for comparison to the NAAQS lead standard. One was in the Atlanta-Sandy Springs-Marietta MSA for monitoring long-term trends in ambient lead levels, and the other was located in the Columbus GA-AL MSA for industrial source monitoring (given the historical issues with lead pollution in the area). At the end of 2008, EPA strengthened the standard and monitoring requirements. In addition to lowering the standard, further monitors were to be placed in areas with demonstrated lead emissions of 1.0 or more tons per year and in urban areas with a population in excess of 500,000 (Federal Register, Vol. 73, No. 219, dated November 12, 2008). In response to this rule change, in December of 2009, GA EPD added a lead monitoring site in the Cartersville area in order to observe an additional pollutant source. Since this time (December 14, 2010), EPA has lowered the source-oriented lead emission levels to 0.5 tons per year (tpy), and changed the population based requirement to include the ‘NCore network’ (40CFR58, Docket #EPA-HQ-OAR-2006-0735). To monitor industrial facilities that emit greater than 0.5 tpy, GA EPD reopened two lead monitors in the Columbus GA-AL MSA in 2012 to determine proper siting in this area.

The current criteria lead monitoring network is shown in Figure 31. For summary data on criteria lead monitoring, see Appendix A. In addition to the criteria network sites, lead is also being monitored at sites throughout the state as a trace metal in the Georgia Air Toxics Monitoring Network, the National Air Toxics Trends Station (NATTS), and with $PM_{2.5}$ speciation samplers. In the Air Toxics Network, samples are taken from total suspended particles in the ambient air. The NATTS sampler is a PM_{10} sampler and collects particles up to 10 microns in size. With the $PM_{2.5}$ speciation samplers, particles are collected up to 2.5 microns in size. For additional summary data concerning lead collected as an Air Toxics trace metal see Appendix D.

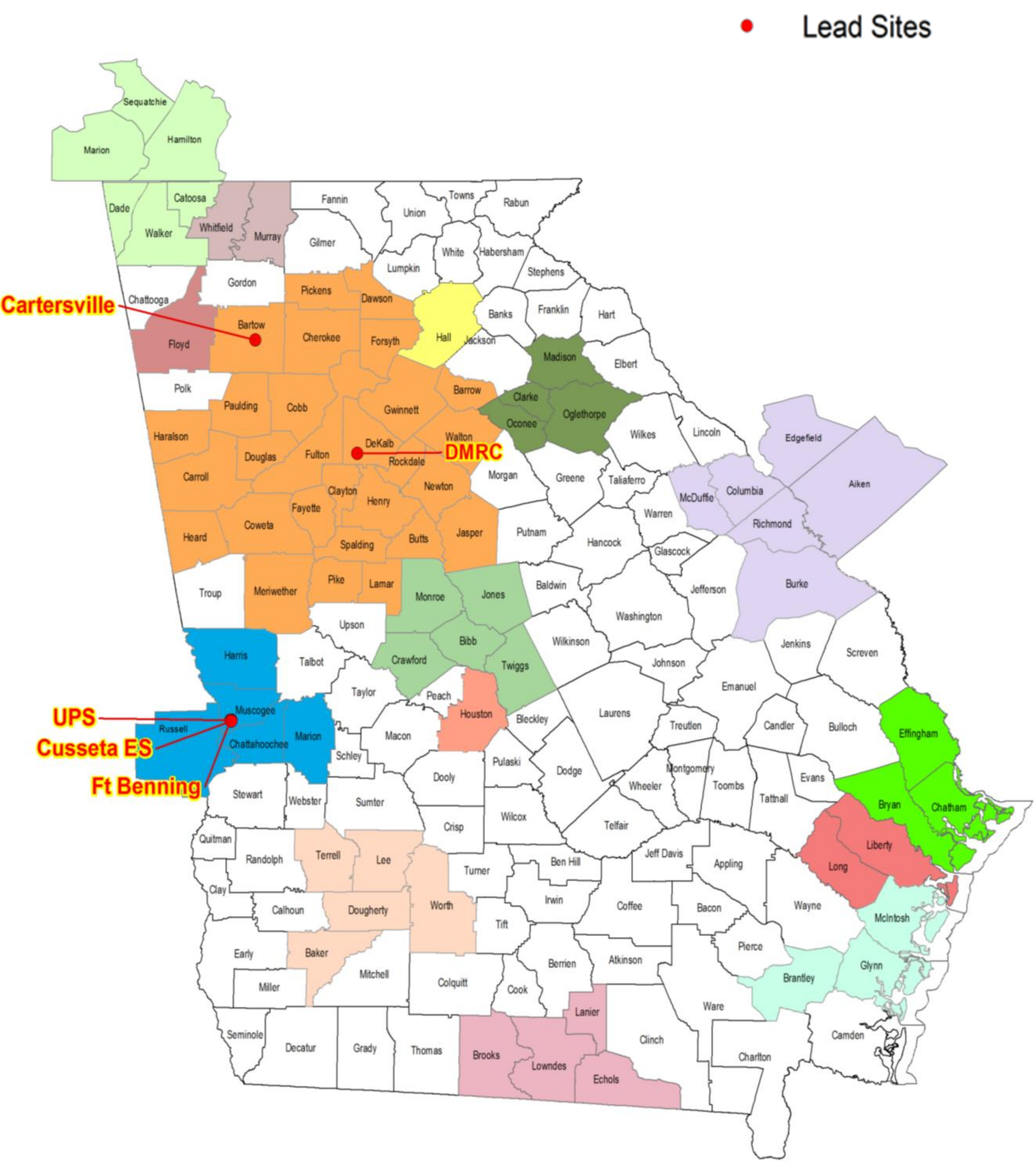


Figure 31. Georgia's lead monitoring sites, MSAs shown as solid colors

HEALTH IMPACTS

Exposure to lead occurs mainly through inhalation and ingestion of lead in food, water, soil, or dust. Lead particles can re-enter the environment through re-entrainment of dust from vehicle traffic, construction activities, and agricultural activities. It accumulates in the blood, bones, and soft tissues. Lead can adversely affect the kidneys, liver, nervous system, and other organs. Excessive exposure to lead may cause neurological impairments, such as seizures, mental retardation, and behavioral disorders. Even at low doses, lead exposure is associated with damage to the nervous systems of fetuses and young children, resulting in learning deficits and lowered IQ. Recent studies also show that lead may be a factor in high blood pressure and subsequent heart disease. Lead can also be deposited on the leaves of plants, presenting a hazard to grazing animals. Lead deposition in soil puts children at particular risk exposure since they commonly put hands, toys, and other items in their mouths, which may come in contact with lead-containing dust and dirt.

MEASUREMENT TECHNIQUES

Since lead is a particulate, the measurement for ambient air lead concentrations is performed using a manual method, unlike measurements for the gaseous pollutants discussed earlier (ozone, SO_2, NO_2 and CO). Samples are collected on 8" x 10" pre-weighed fiberglass filters with a high-volume total suspended particulate (TSP) sampler for 24 hours, collecting particles with diameters of 100 microns or less. High volumes of ambient air in the flow range of 40-60 cubic feet per minute are sampled at a constant rate during the sampling period. This produces a uniform distribution of particles deposited on the sample filter downstream of the sampler inlet. Samples collected with the TSP high volume sampler can be used to determine the average ambient TSP concentration over a sampling period followed by subsequent analysis to determine the identity and quantity of inorganic metals present in the TSP. The filter sample is shipped to a laboratory for analysis using inductively coupled plasma mass spectroscopy (commonly known as ICP-MS). Data gained from the criteria lead samplers are used to determine compliance with the National Ambient Air Quality Standards for lead.

In addition to the criteria lead network sites, lead is monitored as a trace metal in the Georgia Air Toxics Monitoring Network, the National Air Toxics Trends Station (NATTS), and with the $PM_{2.5}$ speciation samplers. Air Toxics Network samples are obtained with a High-Volume sampler collecting total suspended particles in the ambient air. NATTS lead is sampled using a PM_{10} sampler, and particles are sampled up to 10 microns in size. $PM_{2.5}$ speciation samplers collect particles up to 2.5 microns in size. All three of these sampling techniques also collect 24-hour samples on pre-weighed filters, ship samples to a laboratory for analysis, and are analyzed with ICP-MS.

ATTAINMENT DESIGNATION

Compliance with the national primary and secondary ambient air quality standards for lead and its compounds is determined based on the assumption that all lead is elemental lead. In order to comply with the primary and secondary standards, the concentration of lead in the air must have an arithmetic mean no higher than 0.15 micrograms per cubic meter averaged on a rolling 3-month basis (Federal Register, Vol. 73, No. 219, dated November 12, 2008). On October 15, 2008 this standard was changed from the original standard of 1.5 $\mu g/m^3$ averaged per calendar quarter that had been in place since October 5, 1978 (43 FR 46258). This new lead standard became effective on January 12, 2009 and was implemented by January 1, 2010. Then on December 14, 2010, EPA revised the requirements for measuring lead in the ambient air. The emission threshold for placing lead monitors near industrial facilities was lowered from 1.0 tons per year (tpy) to 0.5 tpy. In addition, EPA is requiring that lead monitors be placed at the NCore sites. The new lead monitors were required to be operational by December 27, 2011 [40CFR58, Docket No. EPA-HQ-OAR-2006-0735, 12/14/10]. GA EPD meets the requirement of monitoring lead at the South DeKalb NCore site, with the sampler located at the nearby DMRC site. To accommodate the changes to monitor industries with lead emissions greater than 0.5 tpy, GA EPD reopened two monitors in the Columbus GA-AL MSA in 2012 to determine proper location of this source-oriented monitor. In addition, GA EPD had previously established a source-oriented lead monitor in the Cartersville area.

Figure 32 shows how Georgia's lead data compares to the rolling three-month average standard for 2010 through 2013. The last of the three months used for each average is indicated on the graph. The two monitors that were reopened in the Columbus GA-AL MSA have shown higher readings compared to the other monitors in the Columbus GA-AL MSA or the Atlanta-Sandy Springs-Marietta

MSA. As more lead data is collected it will be observed to see if this trend continues. For additional summary data on this topic see Appendix A.

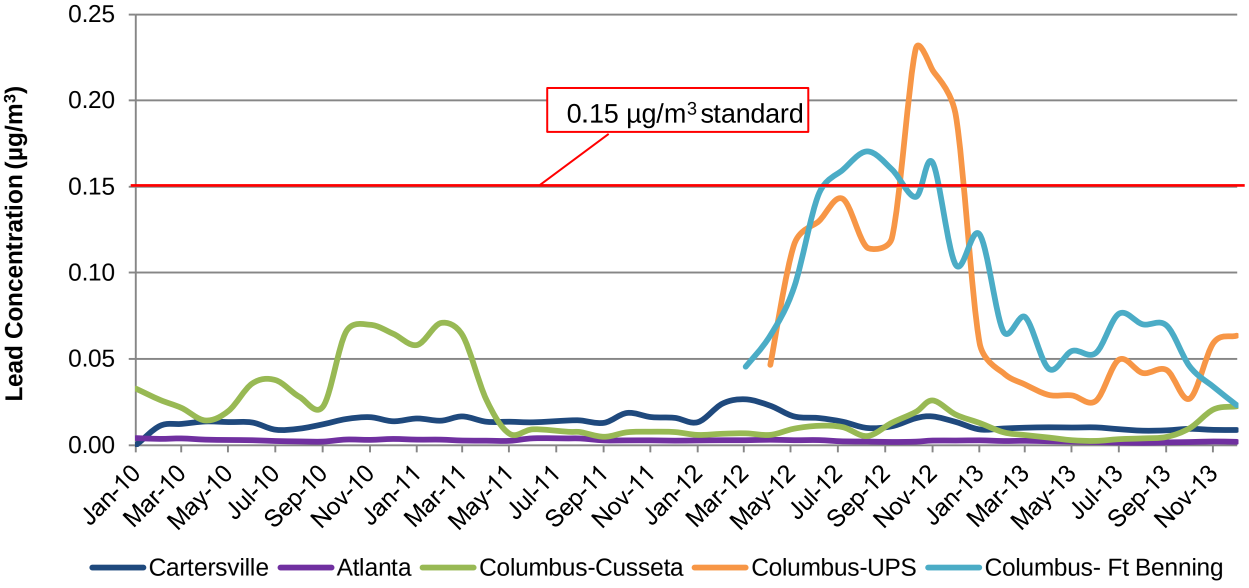


Figure 32. Georgia's lead design values, 2010-2013

Figure 33 was taken from EPA's document "Our Nation's Air Quality-Status and Trends through 2010" showing the maximum three-month lead averages across the United States. Georgia's three-month maximum lead averages in 2010 were in the lowest range, 0.00-0.07 ppm (dark blue).

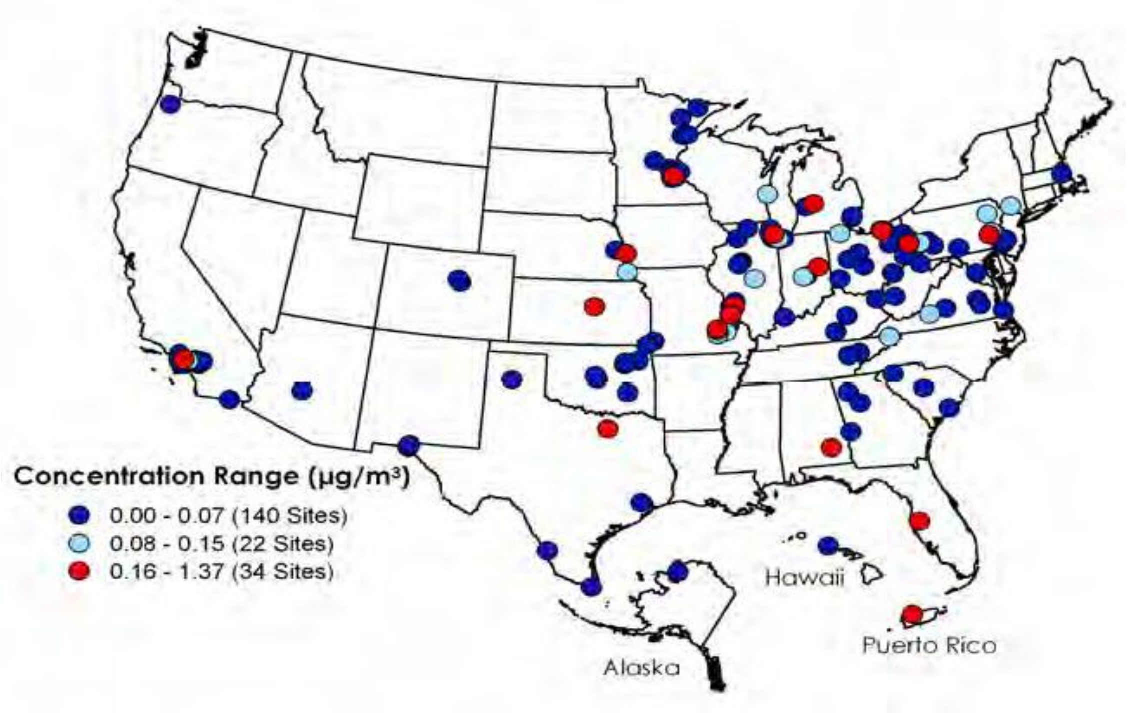


Figure 33: 2010 lead concentrations for the U.S. (maximum 3-month averages)

PARTICULATE MATTER

GENERAL INFORMATION

Particulate matter is a broad range of material that consists of solid particles, fine liquid droplets, or condensed liquids absorbed onto solid particles. Airborne particulates are not a single pollutant as discussed for the other criteria pollutants, but rather a mixture of many different air pollutants. Primary sources that emit particles include combustion, incineration, construction, mining, metals smelting, metal processing, and grinding. Other sources include motor vehicle exhaust, road dust, wind blown soil, forest fires, open burning of vegetation for land clearing or waste removal, ocean spray, and volcanic activity.

There are two ways (primary and secondary) that particulate matter is formed. Primary particulate is emitted directly from a source, like a vehicle's tailpipe or a factory's smokestack. However, a great deal of particulate matter is not directly emitted from such sources. In fact, the vast majority of primary air pollution is in the form of gases. Those gaseous air pollutants readily react in the atmosphere with oxygen and with each other. While many of those reactions produce other gases, they frequently produce particles. Particles formed through this process are known as secondary particulate matter. Examples of secondary particulates include:

- Atmospheric sulfate particles, formed from the oxidation of gaseous SO_2.
- Atmospheric nitrate particles, such as ammonium nitrate, formed from a complex series of reactions that transform gaseous NO_x.
- Atmospheric calcium nitrate or sodium nitrate particulates formed from a series of atmospheric reactions involving gaseous nitric acid (HNO_3) reacting with sodium chloride/calcium carbonate.

Since diesel combustion and vehicle exhaust are sources of particulate matter, efforts are being made to reduce these emissions by retrofitting diesel engines and making alternative diesel fuels available. Retrofitting is defined as the addition of an emission control device designed to remove emissions from an exhaust engine. Currently, school buses and diesel powered commercial trucks are being retrofitted for emission reduction. One method is a particulate trap, which essentially filters exhaust from the engine. In some cases, as the particulate accumulates in the filter, the particulate is oxidized or burned off in order to regenerate the filter and reuse it. Regeneration is achieved by various techniques that reduce the temperature necessary to oxidize accumulated particulate matter. Disposable filters are also used when the particulate matter cannot be cleaned by oxidation. For information about Georgia EPD's program, go to http://www.georgiaair.org/retrofit/index.htm.

In addition to retrofitting, alternative diesel fuels are available that emit less particulate matter, as well as other pollutants. Ultra-low sulfur diesel fuel is one fuel that emits less sulfur and particulate matter. Biodiesel fuel emits less particulate matter, carbon monoxide, hydrocarbons, and air toxics. Also, emulsified diesel emits less nitrogen oxides and particulate matter.

Particulate pollution may be categorized by size since there are different health impacts associated with the different sizes. The Georgia Ambient Air Monitoring Program currently monitors for three sizes of particles: PM_{10} (up to 10 microns in diameter), $PM_{2.5}$ (up to 2.5 microns in diameter) and PM_{coarse} (PM_{10} minus $PM_{2.5}$). All of these particles are very small in size. For example, Figure 35 shows how approximately ten PM_{10}

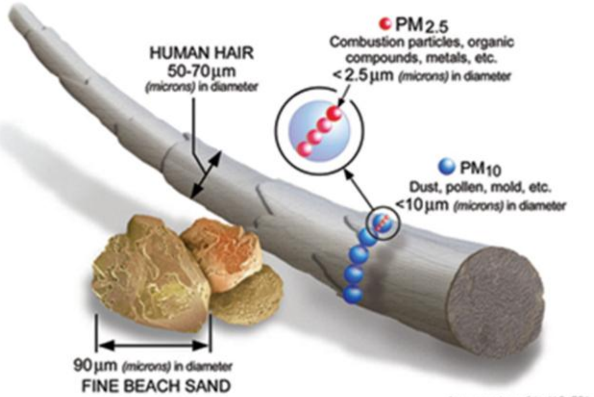


Image courtesy of the U.S. EPA

Figure 34. Comparison of particulate matter size to human hair

particles can fit on a cross section of a human hair, and approximately thirty $PM_{2.5}$ particles would fit on a cross section of a hair.

PM_{10}

Particulate matter (PM) less than or equal to 10 microns in diameter is defined as PM_{10}. These particles can be solid matter or liquid droplets from smoke, dust, fly ash, or condensing vapors that can be suspended in the air for long periods of time. PM_{10} represents part of a broad class of chemically diverse particles that range in size from molecular clusters of 0.005 microns in diameter to coarse particles of 10 microns in diameter (for comparison, an average human hair is 70-100 microns in diameter, as shown in the previous figure). PM results from all types of combustion. The carbon-based particles that result from incomplete burning of diesel fuel in buses, trucks, and cars are examples of major sources of PM_{10}. Another important combustion source is the burning of wood in stoves and fireplaces in residential settings. Also of concern are the sulfate and nitrate particles that are formed as a by-product of SO_2 and NO_2 emissions, primarily from fossil fuel-burning power plants and vehicular exhausts. Figure 35 shows Georgia's most important source of PM_{10} is dust, with over 470,000 short tons attributed to this source. Figure 36 shows a spatial view of the varying concentrations of PM_{10} by county in Georgia during 2011. Figure 35 and Figure 36 are taken from the latest emissions report from EPA based on 2011 data.

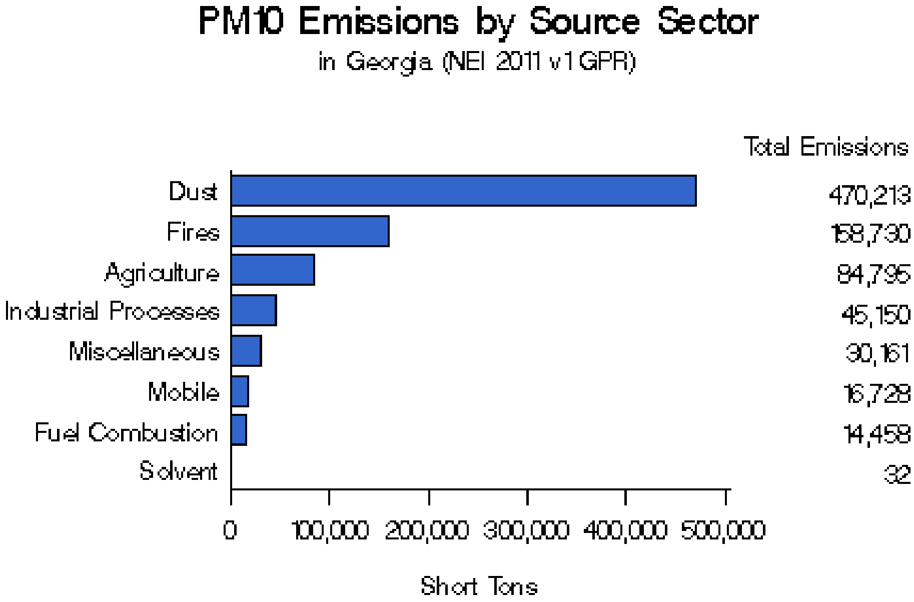


Figure 35. Common sources of PM_{10} in Georgia

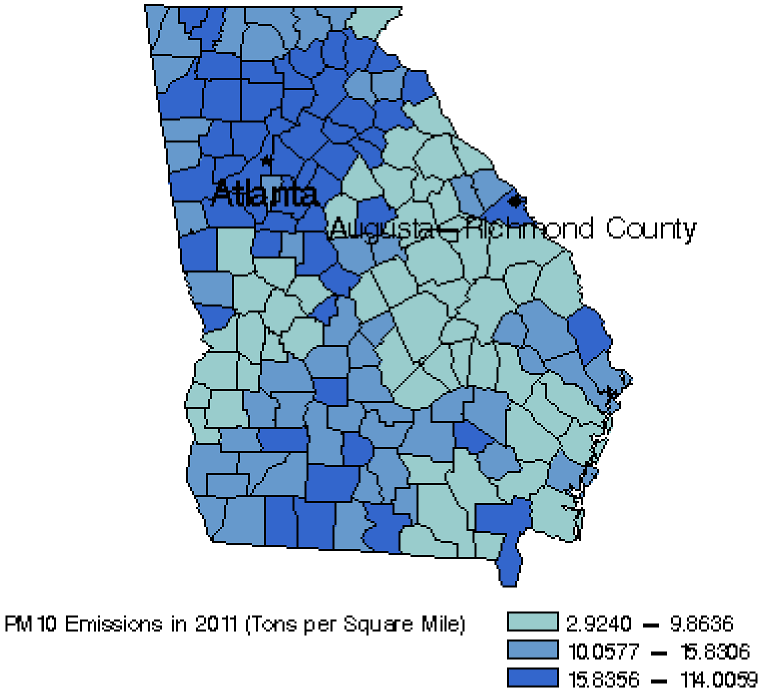


Figure 36. Spatial veiw of PM_{10} emissions in Georgia

HEALTH IMPACTS

The U.S. national ambient air quality standard was originally based on particles up to 25-45 microns in size, termed "total suspended particles" (TSP). In 1987, EPA replaced TSP with an indicator that includes only those particles smaller than 10 microns, termed PM_{10}. These smaller particles cause adverse health effects because of their ability to penetrate deeply into the lungs. The observed human health effects of PM include breathing and respiratory problems, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense system against inhaled materials and organisms, and damage to lung tissue. Groups that appear to be most sensitive to the effects of PM include individuals with chronic lung or cardiovascular disease, individuals with influenza, asthmatics, elderly people, and children.

MEASUREMENT TECHNIQUES

The Georgia PM_{10} monitoring network consists of two types of EPA-approved reference or equivalent monitors. Both types of monitors are used to determine attainment with the PM_{10} standard. The first type of monitor is an integrated low-volume sampler that collects samples for a 24-hour period. Ambient air is sampled through an impaction inlet device that only allows particles with 10 microns or less in diameter to reach the filter media. The flow rate is controlled by an electronic mass-flow controller, which uses a flow sensor installed below the filter holder to monitor the mass flow rate and control the speed of the motor accordingly. Filters are weighed in a laboratory before and after the sampling period. The change in the filter weight corresponds to the mass of PM_{10} particles collected. That mass, divided by the total volume of air sampled, corresponds to the mass concentration of the particles in the air.

The second type of PM_{10} monitor that Georgia EPD operates is a continuous monitor. The continuous monitor measures and records hourly particulate mass concentrations in ambient air. The monitor consists of three basic components; the central unit, the sampling pump and the sampling inlet hardware. In order to sample particles that are 10 microns or less, the inlet is designed to cut out particles larger than 10 microns in size. The monitor uses beta ray attenuation to calculate collected particle mass concentrations in units of micrograms per cubic meter (µg/m^3). A ^{14}C element (60 µCi +/- 15 µC) emits a constant source of low-energy electrons, also known as beta particles. The beta rays are attenuated as they collide with particles collected on a filter tape. The decrease in signal detected by the scintillation counter is inversely proportional to the mass loading on the filter tape. The pump turns on at the beginning of the hour and runs for 50 minutes. During the last 10 minutes of the hour, the pump turns off while the tape transport operates, final mass reading is collected, and self-tests are performed. PM_{10} concentrations are displayed on the front panel and sent to the analog or digital output.

For a map of the PM_{10} network, refer to Figure 37.

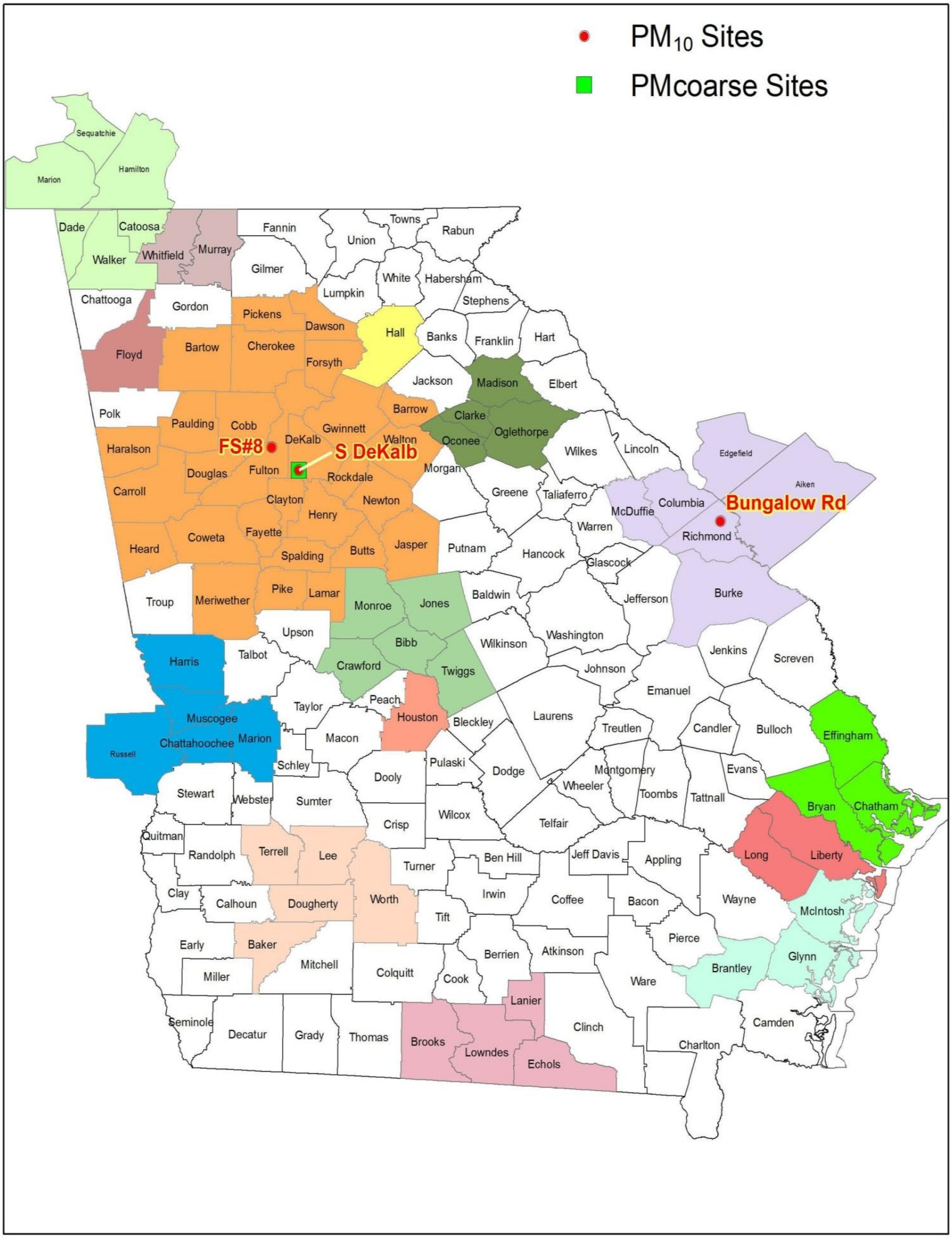


Figure 37. Georgia's PM_{10} monitoring site map, MSAs shown as solid colors

ATTAINMENT DESIGNATION

The primary and secondary standards for PM_{10} are the same. In order for an area to be considered in compliance with the PM_{10} standard, the 24-hour concentration of 150 micrograms per cubic meter should not be exceeded more than once per year on average over three years [52 FR 24663, July 1, 1987, as amended at 62 FR 38711, July 18, 1997; 65 FR 80779, Dec. 22, 2000].

Figure 38 shows how Georgia compares to the 24-hour standard for PM_{10}, which remains set at 150 µg/m^3. The standard allows one exceedance per year, averaged over a 3-year period; therefore, this chart shows the second highest 24-hour average for each site. GA EPD collected PM_{10} samples at three sites in 2013. Therefore, this graph reflects data from those three monitors. All three samplers collected data well below the standard.

For additional PM_{10} summary data, see Appendix A.

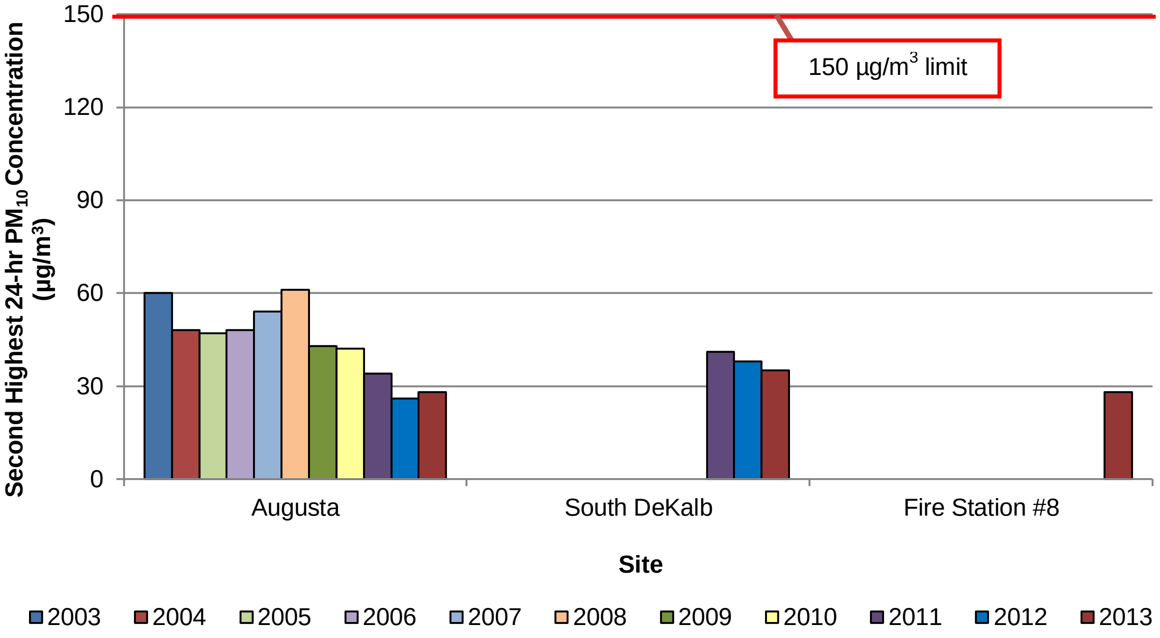


Figure 38. Georgia's second highest 24-hour PM_{10} concentrations

Figure 39 shows a map that was taken from the EPA document "Our Nation's Air-Status and Trends through 2010". It shows PM_{10} second maximum 24-hour concentrations across the United States for 2010. This gives a comparison of Georgia's PM_{10} data, related to the rest of the country. For Georgia, the second maximum 24-hour concentrations were in the lowest range of 2-54 µg/m^3 (dark blue).

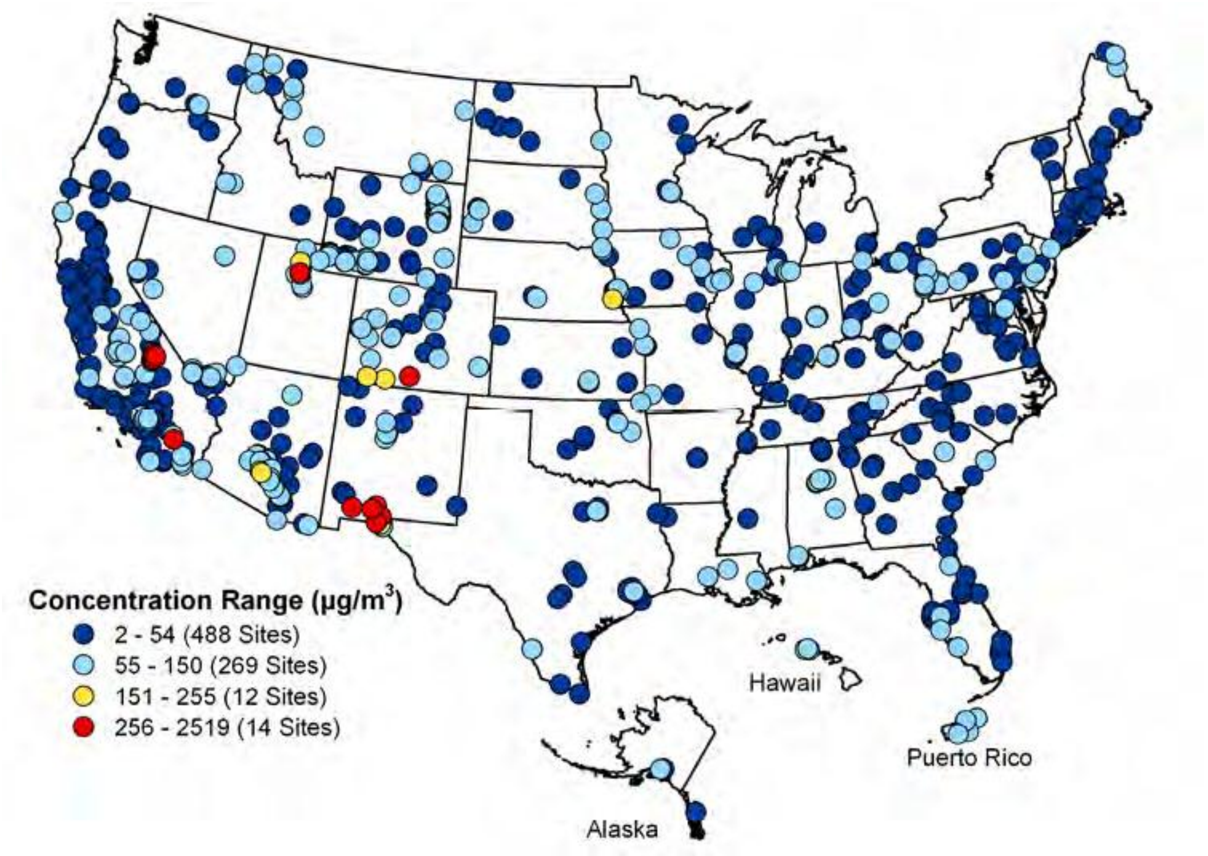


Figure 39. 2010 PM_{10} second maximum 24-hour concentrations

PM_{Coarse}

PM_{coarse}, or $PM_{10-2.5}$, is described as particulate matter (PM) less than 10 microns in diameter and greater than 2.5 microns in diameter. The composition of PM_{coarse} is predominantly crustal matter (from construction, demolition, mining, agricultural activities, sea spray, dust) and organic materials (from resuspension of biological material from soil surfaces and roads). However, composition and sources can vary greatly by region. Regional relative humidity can affect the level of water present within the particles and affect how much dissolved gases or reactive species enter the lungs. The amount of water within the PM_{coarse} material can also affect size and particle deposition characteristics.

As part of the NCore requirements, the South DeKalb site began PM_{coarse} sampling January 1, 2011. Figure 40 displays daily PM_{coarse} averages at the South DeKalb site from 2011 through 2013. During the three year span, PM_{coarse} daily average concentrations have been found primarily in the 5-15 µg/m³ range and have fallen by about 3 µg/m³ (shown by the black trend line). The peak PM_{coarse} daily average concentration occurred in April in 2011 and 2012 and in June in 2013. As data continues to be collected, it will be observed for possible trends or seasonal variations.

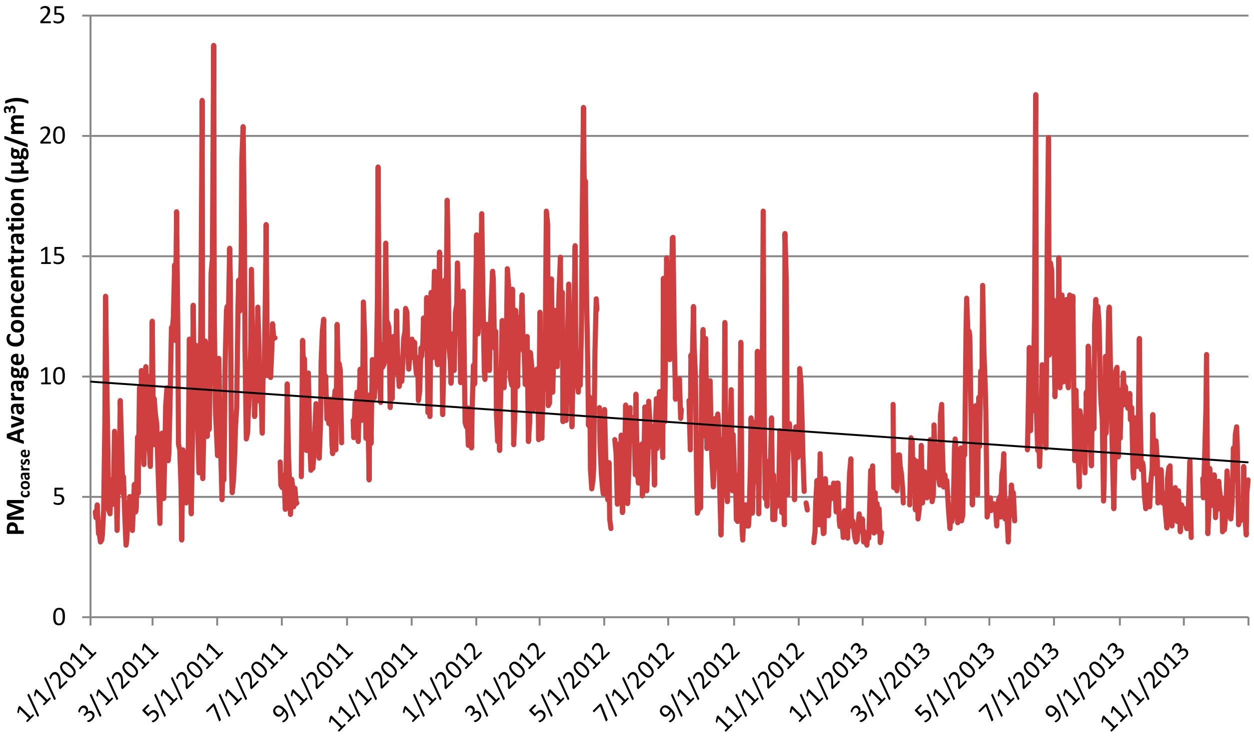


Figure 40. PM_{coarse} daily averages at the South DeKalb site, 2011-2013

HEALTH IMPACTS

At this point, there is a limited amount of available data on health effects of PM_{coarse} material. Studies have shown that short-term exposure to high levels of ambient PM_{coarse} is associated with decreased lung function, increased hospital admissions for respiratory systems and heart disease, and possible premature death. Efforts are being made to collect more information on sources, characteristics and toxicity levels of PM_{coarse} that will help with understanding potential health effects.

MEASUREMENT TECHNIQUES

Georgia EPD measures PM_{coarse} with two beta attenuation particle monitors networked together. Both units are identical except for the inlet size. The PM_{10} unit has an inlet that only allows particles of 10 microns or smaller in size, while the $PM_{2.5}$ unit has a Very Sharp Cut Cyclone (VSCC) inlet allowing only particles of 2.5 microns in size or smaller. At the beginning of each hourly measurement cycle, beta rays containing ^{14}C are emitted across clean filter tape, and then measured with a photomultiplier tube with a scintillator. Next, air is sampled through the clean spot on the filter tape. The particulate matter is collected on the tape, and the beta rays are measured across the dirty spot. The difference between the clean and dirty spots determines the concentration. A PM_{coarse} board and synchronization cable connects the two samplers. Each hour, the PM_{10} sampler measures the PM_{10} concentration, collects the $PM_{2.5}$ concentration from the $PM_{2.5}$ sampler, and calculates the $PM_{10-2.5}$ concentration.

ATTAINMENT DESIGNATION

Currently, there is no attainment standard for PM_{coarse}. PM_{coarse} measurements are performed to support the regulatory, analytical, and public health purposes of the program. While it is understood that these PM_{coarse} particles are harmful, the severity and type of health outcomes, rural versus urban area sources, and composition are not well understood. By collecting data about current concentrations, researchers can later compare Georgia EPD's data with health data to better understand the health effects.

For a map that includes the location of Georgia EPD's PM_{coarse} monitor, refer to Figure 37 in the previous section.

$PM_{2.5}$

The U.S. EPA defines 2.5 particulate matter as solid particles and liquid droplets present in the air that are less than or equal to 2.5 microns in diameter. These particles and droplets are invisible to the naked eye. However, collectively, they may appear as a fog-like haze or clouds and are often referred to as “fine” particles.

Fine particles are produced by various sources, including fires, industrial combustion, residential combustion, and vehicle exhaust (Figure 41 and Figure 42). However, fine particles are also formed when combustion gases are chemically transformed. Fine particles can soil and accelerate the deterioration of man-made materials. In addition, fine particles impair visibility and are an important contributor to haze, particularly in humid conditions. The visibility effect is roughly doubled at 85% relative humidity as compared to humidity under 60% (U.S. EPA, 2004a). Based on data from EPA’s Air Emission Sources for 2011, Georgia’s primary source of $PM_{2.5}$ emissions is fires, with over 136,000 tons attributed to this emission source. This information is displayed in Figure 41. Figure 42 shows a spatial view of Georgia’s $PM_{2.5}$ emissions, also from EPA’s Air Emission Sources, based on 2011 data.

Considerable effort is being undertaken to analyze the chemical composition of fine particles ($PM_{2.5}$) so that pollution control efforts can be focused in areas which create the greatest hazard reductions. Therefore, Georgia currently monitors 53 particle species including gold, sulfate, lead, arsenic, and silicon. This speciation data is discussed further in the $PM_{2.5}$ Speciation section.

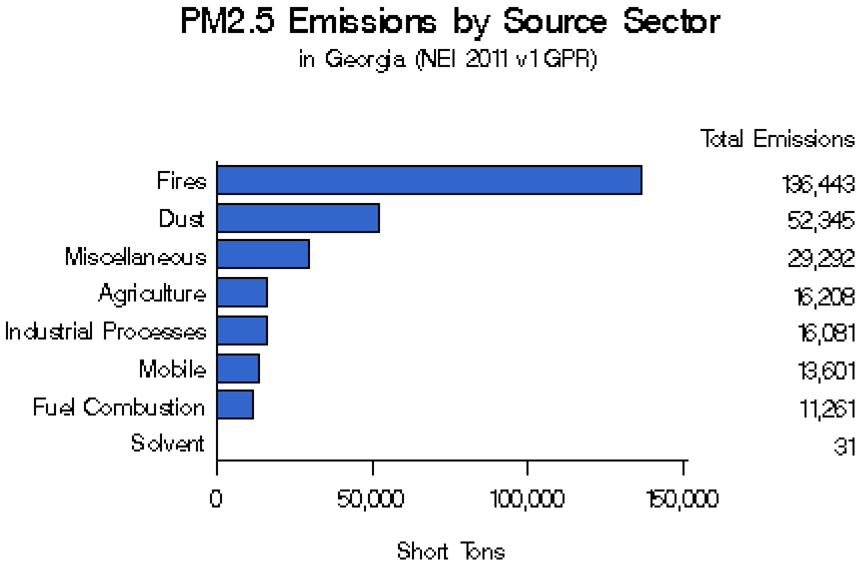


Figure 41. Common sources of $PM_{2.5}$ in Georgia

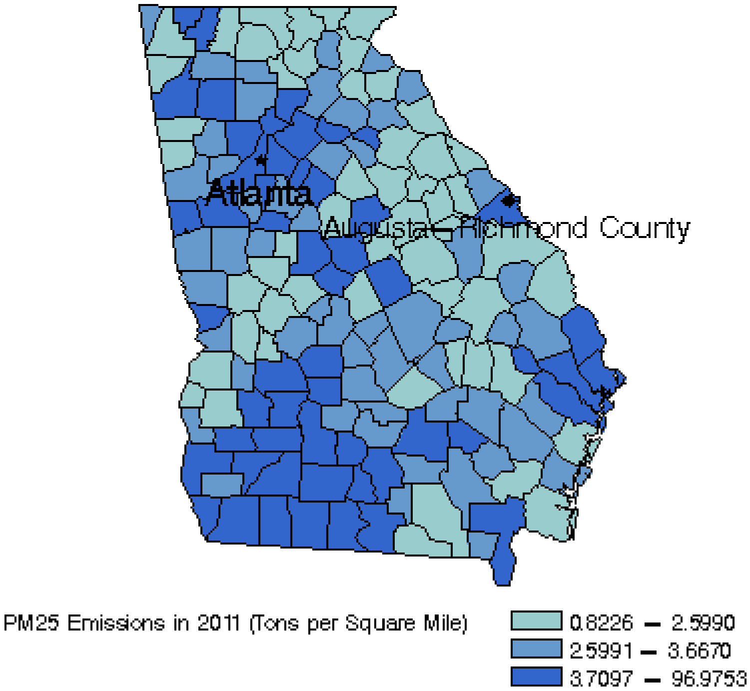


Figure 42. Spatial view of $PM_{2.5}$ emissions in Georgia

HEALTH IMPACTS

Fine particles can penetrate into the sensitive regions of the respiratory tract, which make them a health concern. Recently published community health studies indicate that significant respiratory and cardiovascular-related problems are associated with exposure to fine particle levels below the existing particulate matter standards. In addition, fine particles are likely to cause the most serious health effects, which include premature death, hospital admissions from respiratory causes, and increased respiratory problems. Long-term exposure to particulate matter may increase the rate of respiratory and cardiovascular illnesses and reduce the life span of an individual. Some data also suggests that fine particles can pass through lung tissues and enter the bloodstream. Therefore, children, the elderly, and individuals with cardiovascular disease or lung diseases such as emphysema and asthma are especially vulnerable.

MEASUREMENT TECHNIQUES

$PM_{2.5}$ mass concentrations are measured with two types of methods. These two techniques consist of an integrated method and a continuous method. At sites where mass $PM_{2.5}$ samples are taken on an integrated basis, the samples are measured using very similar techniques utilized for measuring PM_{10}. The official reference method requires that samples are collected on Teflon filters with a $PM_{2.5}$ sampler for 24 hours. A specialized particle size sorting device is used to filter the air, collecting only particles 2.5 microns in size and smaller. The filters are weighed in a laboratory before and after the sampling period. The change in the filter weight corresponds to the mass weight of $PM_{2.5}$ particles collected. That mass weight, divided by the total volume of air sampled, corresponds to the mass concentration of the particles in the air for that 24-hour period. The reference method filters are used for attainment determinations. However, due to the delay in collecting each filter, shipping it to the laboratory, and weighing, weeks may pass before the results are known. Although this method is very accurate, it is not useful for real-time determinations of $PM_{2.5}$ concentrations in ambient air.

At sites where the continuous method is utilized, Georgia EPD uses two types of instruments. One type GA EPD uses is the beta attenuation method. The continuous monitor measures and records hourly particulate mass concentrations in ambient air. The monitor consists of three basic components; the central unit, the sampling pump and the sampling inlet hardware. In order to sample particles that are 2.5 microns or less, the inlet is designed to cut out particles larger than 2.5 microns in size. The monitor uses beta ray attenuation to calculate collected particle mass concentrations in units of micrograms per cubic meter (µg/m^3). A ^{14}C element (60 µCi +/- 15 µC) emits a constant source of low-energy electrons, also known as beta particles. The beta rays are attenuated as they collide with particles collected on a filter tape. The decrease in signal detected by the scintillation counter is inversely proportional to the mass loading on the filter tape. The pump turns on at the beginning of the hour and runs for 50 minutes. During the last 10 minutes of the hour, the pump turns off while the tape transport operates, final mass readings are collected, and self-tests are performed. $PM_{2.5}$ concentrations are displayed on the front panel and sent to the analog or digital output. The sampling method for the BAM type of continuous $PM_{2.5}$ monitor was approved as Federal Equivalent Method (FEM) in Notices of the Federal Register/Vol.73, No.49 dated March 12, 2008 when used with a “Very Sharp Cut Cyclone”. When GA EPD operates the continuous BAM as an FEM with a “Very Sharp Cut Cyclone”, these samplers can be used for making attainment decisions relative to the NAAQS. Currently, Georgia EPD has two BAM samplers running as FEM samplers: one at the South DeKalb site (associated with the PM_{coarse} unit described above) as of January 1, 2011, and one at the Albany site as of January 1, 2013. These two samplers are the only continuous $PM_{2.5}$ samplers that can be used for attainment designations in Georgia.

At the other locations where Georgia EPD samples $PM_{2.5}$ on a continuous basis, the tapered element oscillating microbalance (TEOM) method is used. These monitors use an inline $PM_{2.5}$ cyclone for particle size selection and an inline Sample Equilibration System (SES), which uses a diffusion drying technique to minimize water vapor interference with the particle mass measurement. The instrument oscillates the sample filter on a microbalance continuously while particles are collected from ambient air. By measuring the change in the oscillation frequency, the change in filter mass can be determined. $PM_{2.5}$ concentrations are displayed on the front panel and sent to the analog or digital output. As configured in the Georgia ambient air monitoring network, these analyzers (TEOM) are not approved as reference or equivalent method, and the data collected from these samplers cannot be used for making attainment decisions relative to the NAAQS.

Both types of $PM_{2.5}$ continuous samplers are used to support the development of air quality models and forecasts, including the Air Quality Index (AQI), and provide the public with information about pollutant concentrations in real time. Continuous $PM_{2.5}$ data is reported every hour, at fifteen minutes after the end of each hour, on Georgia’s Ambient Air Monitoring web page located at http://www.air.dnr.state.ga.us/amp/index.php. The immediate availability of this data allows the public to make informed decisions regarding their outdoor activities. Figure 43 shows the location of Georgia’s $PM_{2.5}$ FRM monitors and Figure 44 shows the location of $PM_{2.5}$ continuous and speciation monitors.

Figure 43. Georgia’s $PM_{2.5}$ FRM monitoring sites, MSAs shown as solid colors

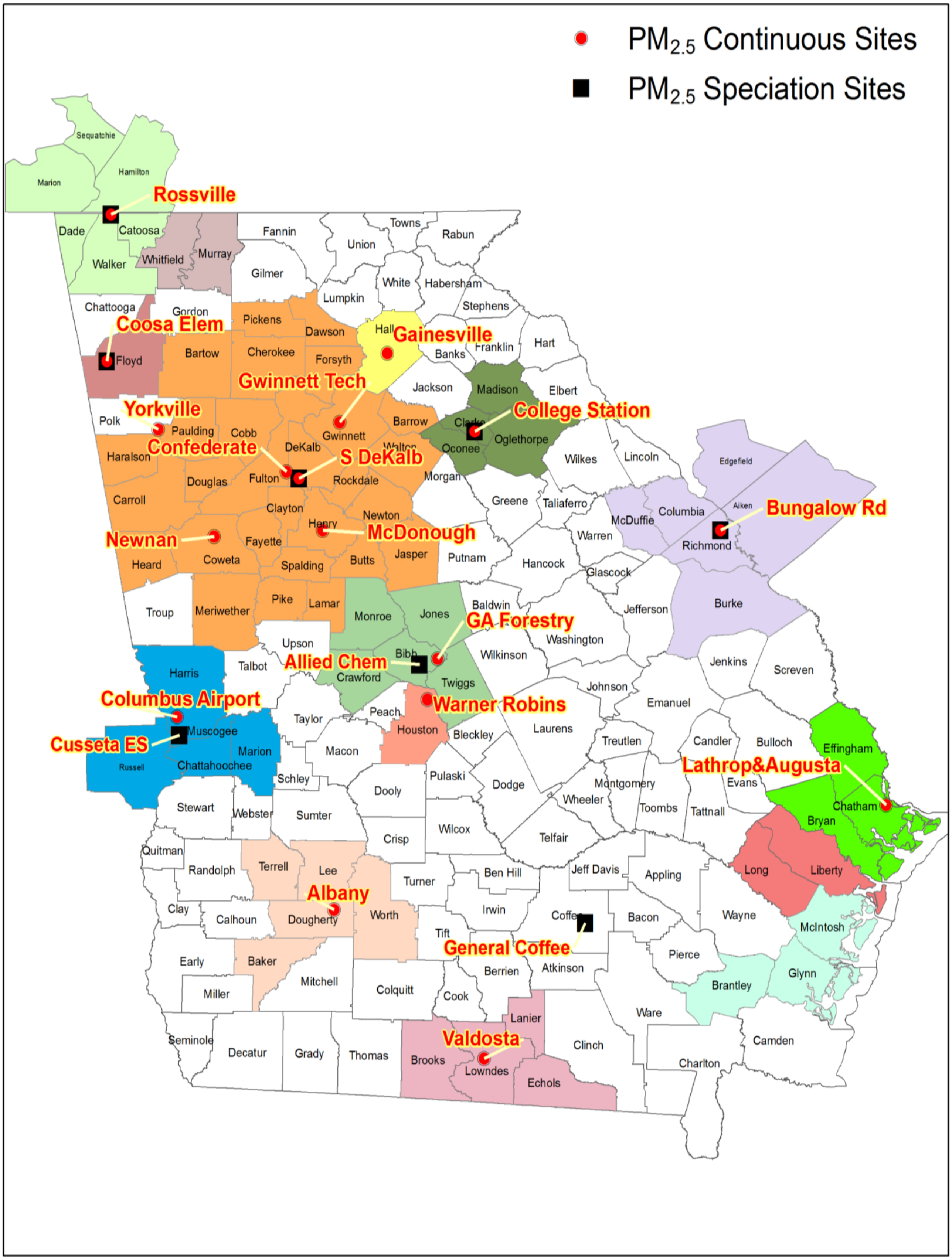
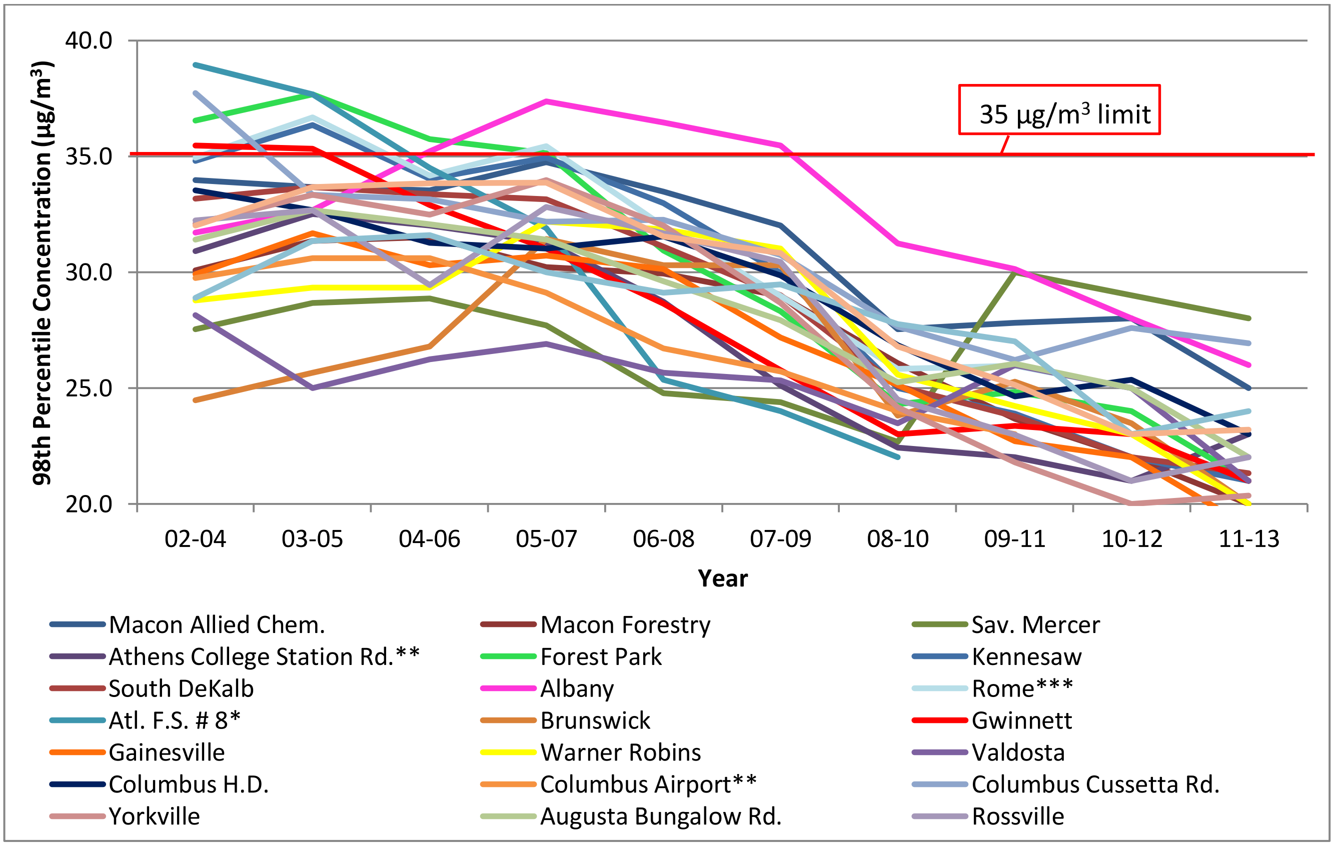


Figure 44. Georgia's $PM_{2.5}$ continuous and speciation monitoring sites, MSAs shown as solid colors

ATTAINMENT DESIGNATION

Since 1997, the national primary and secondary annual ambient air $PM_{2.5}$ standard had been 15.0 micrograms per cubic meter (µg/m^3) [Federal Register Vol. 62, No. 138, Page 38711, July 18, 1997]. As of December 14, 2012, EPA lowered this primary annual standard to 12.0 µg/m^3 [Federal Register Vol. 78, No. 10, Page 3086, January 15, 2013]. For an area to be in attainment of this standard, the three-year average of the annual average concentrations has to be less than or equal to 12.0 µg/m^3. The secondary annual standard remains at 15.0 µg/m^3. In addition, the 24-hour primary and secondary standard requires that the three-year average of the 98th percentile of the 24-hour concentrations be less than or equal to 35 micrograms per cubic meter [71 FR 61144, October 17, 2006]. All sample analyses used for determining compliance with the standards must use a reference method based on information present in 40 CFR 53 Appendix L, or an equivalent method as designated in accordance with Part 53.

Figure 45 shows the three-year averages of 98th percentile of $PM_{2.5}$ 24-hour data compared to the 24-hour standard of 35 µg/m^3. The 2007 data was affected by the Sweat Farm/Big Turnaround/Bugaboo Fire in the Okefenokee Swamp. To show the complete data set that was collected, the 2007 data includes the exceptional event data that was taken out for regulatory purposes. Therefore, in Figure 45 the three-year average calculations including the 2007 data are not a regulatory comparison to the 24-hour standard. In addition, another wildfire took place in the Okefenokee Swamp (Honey Prairie Fire) in the summer of 2011. A few of the sites were affected by this, and the upswing with 2011 data, especially at the Savannah-Mercer site (shown in green) is due to this. GA EPD has submitted exceptional event documentation to EPA to also have this data excluded for regulatory purposes. Overall, the 98th percentile of 24-hour average concentrations show a general downward trend and all of the 2011-2013 averages are well below the 24-hour standard.

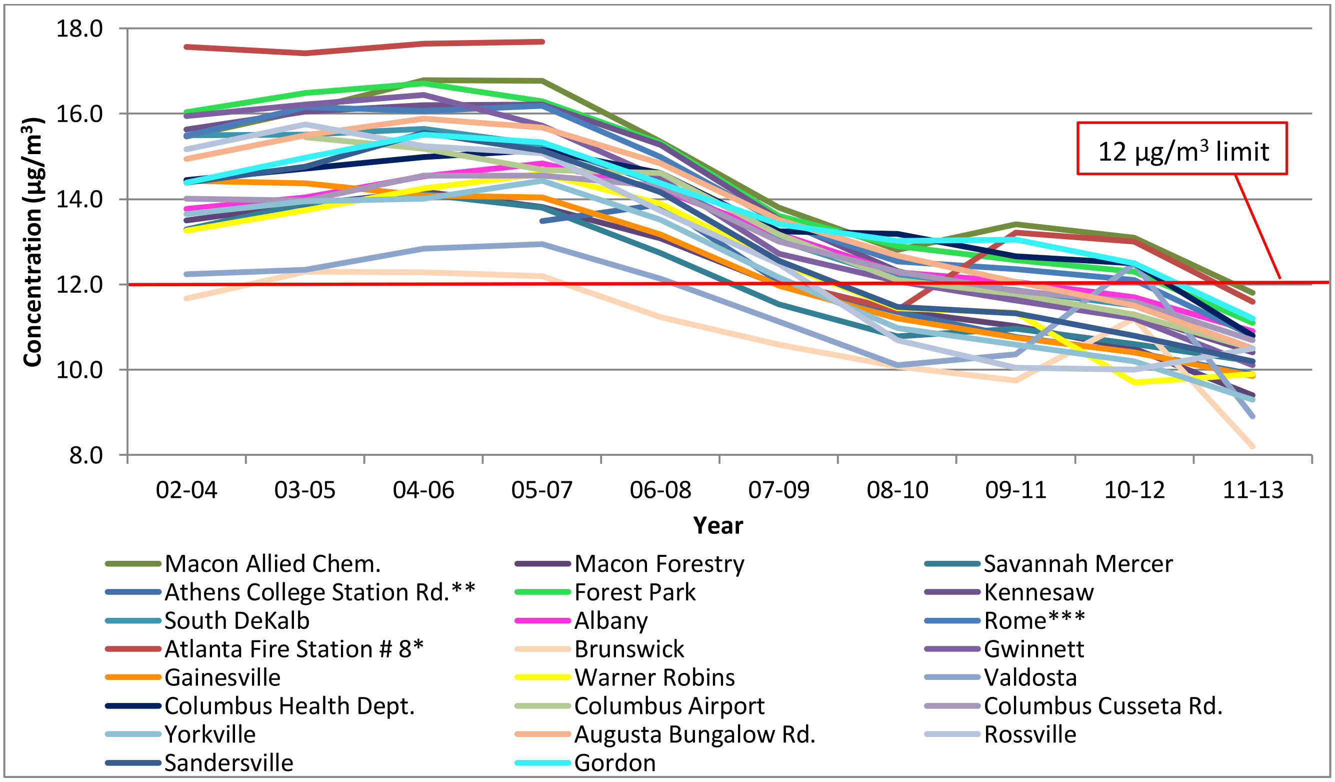


** Site was shut down from 9/06 to 12/08; averages not complete 3 years until 09-11*
*** Sites established in 2005; 04-06 and 05-07 averages incomplete*
**** Sites consolidated in 2009, data combined for Rome-Coosa Elem and Rome-Coosa High*

Figure 45. Comparison of the three-year averages of the 98th percentile of $PM_{2.5}$ 24-hour data to the 24-hour standard, includes all data from 2007 that was excluded for exceptional events

For the $PM_{2.5}$ 24-hour standard, the entire State of Georgia is classified as in attainment. The 24-hour standard is also based on three years of monitoring data, and this attainment status is based on the 2005-2007 data.

Figure 46 shows a comparison of three-year averages of annual $PM_{2.5}$ data to the annual standard of 12.0 µg/m^3. This graph also includes the $PM_{2.5}$ exceptional event data for 2007 to show the complete data set that was collected. Therefore, in Figure 46 the annual averages are not a regulatory comparison to the standard. There is an overall continual decreasing trend in the annual $PM_{2.5}$ data since the 2002-2004 design value year. For the 2011-2013 design values, the lowest was 8.2 µg/m^3 at the Brunswick site (shown in tan) and the highest was 11.8 µg/m^3 at the Macon-Allied site (shown in green). For additional $PM_{2.5}$ summary data, see Appendix A.



** Site was shut down 9/06 to 12/08; averages do not include three full years until 09-11*
*** Site established 2005; 04-06 and 05-07 averages incomplete*
******* *Sites consolidated in 2009, data combined for Rome-Coosa Elem and Rome-Coosa High*

Figure 46. Comparison of the $PM_{2.5}$ three-year annual averages to the annual standard, includes all data for 2007 that was excluded for exceptional events

The $PM_{2.5}$ annual standard attainment and nonattainment designations require three years of monitoring data. Therefore, Georgia's initial attainment status was not determined until late 2004. Based on the three years of data (2001-2003), EPA officially declared several areas of Georgia in nonattainment of the annual standard. Nonattainment areas included Walker and Catoosa counties, which are a part of the metro Chattanooga nonattainment area. All of Bibb County and portions of Monroe County were included in the Macon nonattainment area. Floyd County itself was declared a nonattainment area. Finally, the metro Atlanta nonattainment area was also declared. The boundaries of Georgia's four $PM_{2.5}$ annual standard nonattainment areas are shown in Figure 47. Currently, based on 2007-2009 data, all of Georgia is meeting the $PM_{2.5}$ annual standard. For attainment designations to be official, the maintenance state implementation plan (SIP) needs to be submitted and approved by EPA. GA EPD has submitted the maintenance SIP to EPA and was approved for the Floyd and Macon areas. Therefore the Floyd and Macon areas were redesignated as attainment of the 1997/2006 annual PM2.5 standard in September 2013. GA EPD is awaiting approval of the maintenance SIP for the Atlanta area and the Georgia portion of the Chattanooga area (Walker and Catoosa Counties).

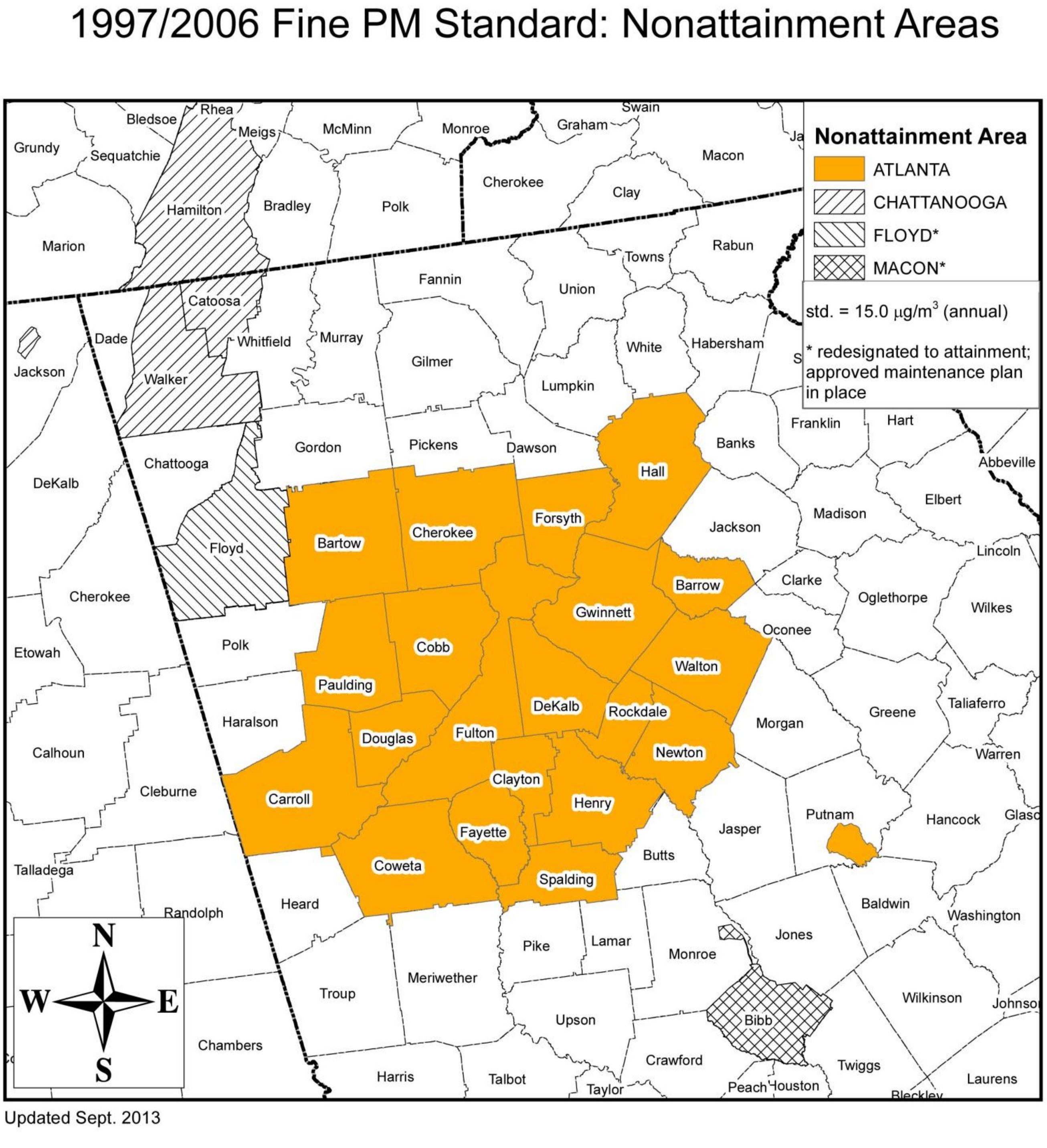


Figure 47. Map of Georgia's nonattainment areas for $PM_{2.5}$

Figure 48, taken from the EPA document "Our Nation's Air – Status and Trends through 2010", shows (a) $PM_{2.5}$ annual and (b) 24-hour concentrations across the United States. It appears that for Georgia, the annual average concentrations ranged from 3.1-12.0 μg/m^3 (dark blue) and 12.1-15.0 μg/m^3 (light blue). The 24-hour average concentrations ranged from 16-35 μg/m^3 (light blue) across the state.

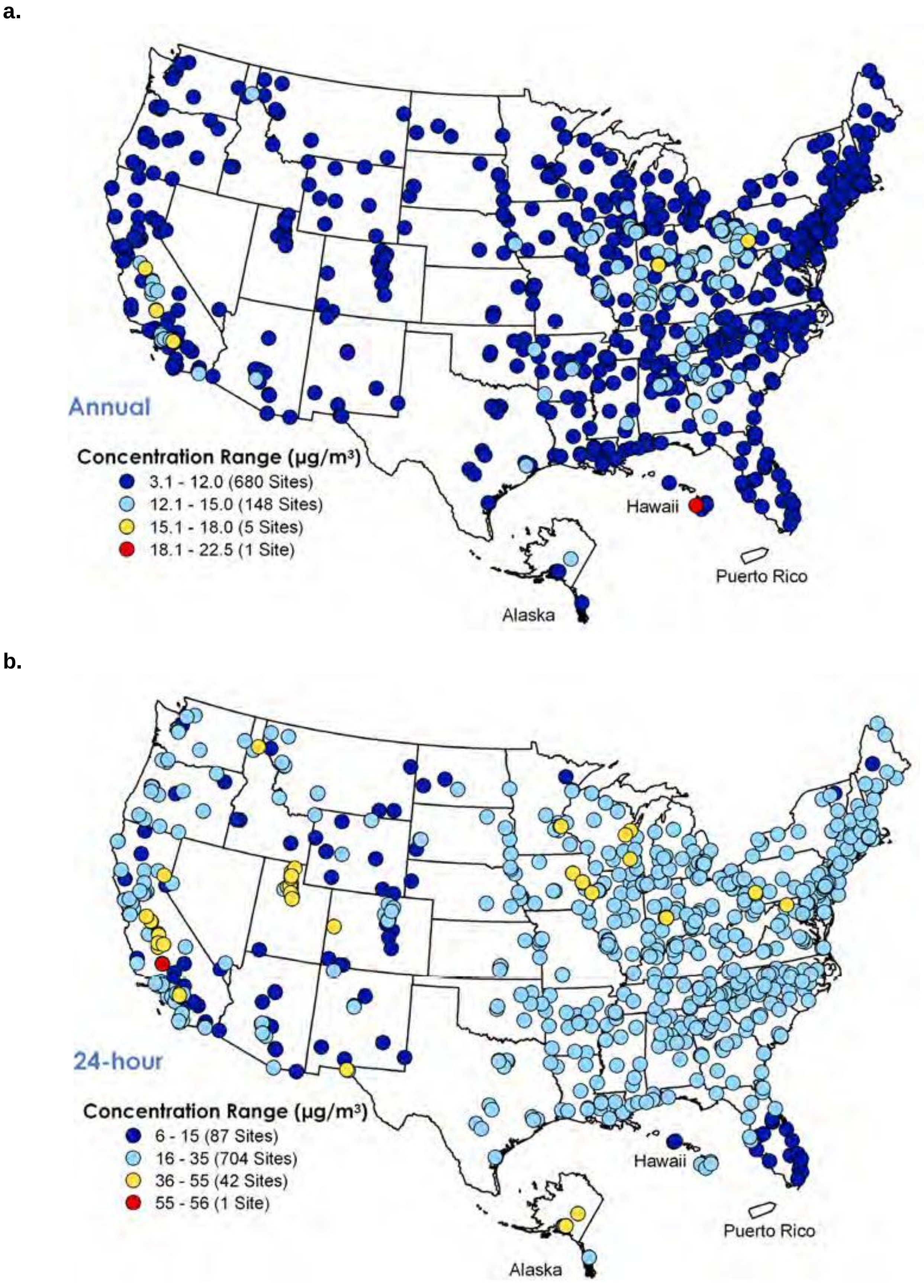


Figure 48. (a) $PM_{2.5}$ average annual concentrations and (b) average 24-hour concentrations across the United States

PM$_{2.5}$ SPECIATION

As required by the national PM$_{2.5}$ speciation program (40 CFR 58), EPD monitors the mass concentration of fine particulate matter (in micrograms per cubic meter of air) along with the chemical composition of those particles. Attempts to control the concentration of fine particulate matter are considered a national priority, and are reliant upon listings in the National Ambient Air Quality Standards. Therefore, regulations intended to reduce levels of fine particulate matter are now being implemented on a widespread basis. The desired reduction of fine particulate matter concentrations is expected to produce benefits in human health and assist in the improvement of visibility by reducing the presence of haze.

It is known that particulate matter has varying health effects depending on their size and chemical composition. The particles that compose fine particulate matter are not uniform. While they are all smaller than 2.5 microns in diameter, size does vary. Some fine particles are emitted into the air directly from engine exhaust, fossil fuel combustion, unpaved roads, and the tilling of fields; others are formed in the atmosphere through reactions between gaseous pollutants. Each individual particle, regardless of its source, has a distinct chemical composition. The overall composition of all particles that make up the fine particulate matter in a given volume of air may also vary, depending on local sources and a variety of other factors. Within the make-up of the particulate matter, some chemicals are more toxic than others. There has been some disagreement on whether the quantity or toxicity of fine particulate matter is most responsible for health concerns. This reinforces the need to monitor and analyze both the species of particulate matter and weight of the species.

Georgia currently monitors fifty-three species, which include gold, sulfate, lead, arsenic, and silicon. However, there are only approximately six chemicals that are detected frequently. Of these, sulfate and organic carbon are detected in the highest concentrations, with magnitudes of up to five to nine times greater than the other major species. Figure 49 illustrates the average concentrations of these six chemicals from 2003 to 2013. The chemical elements typical of the Earth’s crust are grouped together as “crustal”. All of the sites are shown for one bar, showing how each site makes up the total of each of the major constituents of the speciation data. Note that the Rossville site began collecting data in 2005; therefore, the blue bars are not included in the 2003 and 2004 data. With the exception of the 2007 data, which was affected by the Okefenokee Swamp wildfire, there is a general downward trend in the data. Below the figures is a listing of the most significant chemical constituents of fine particulate matter.

Refer to Figure 44 for a map of Georgia’s PM$_{2.5}$ Speciation monitors.

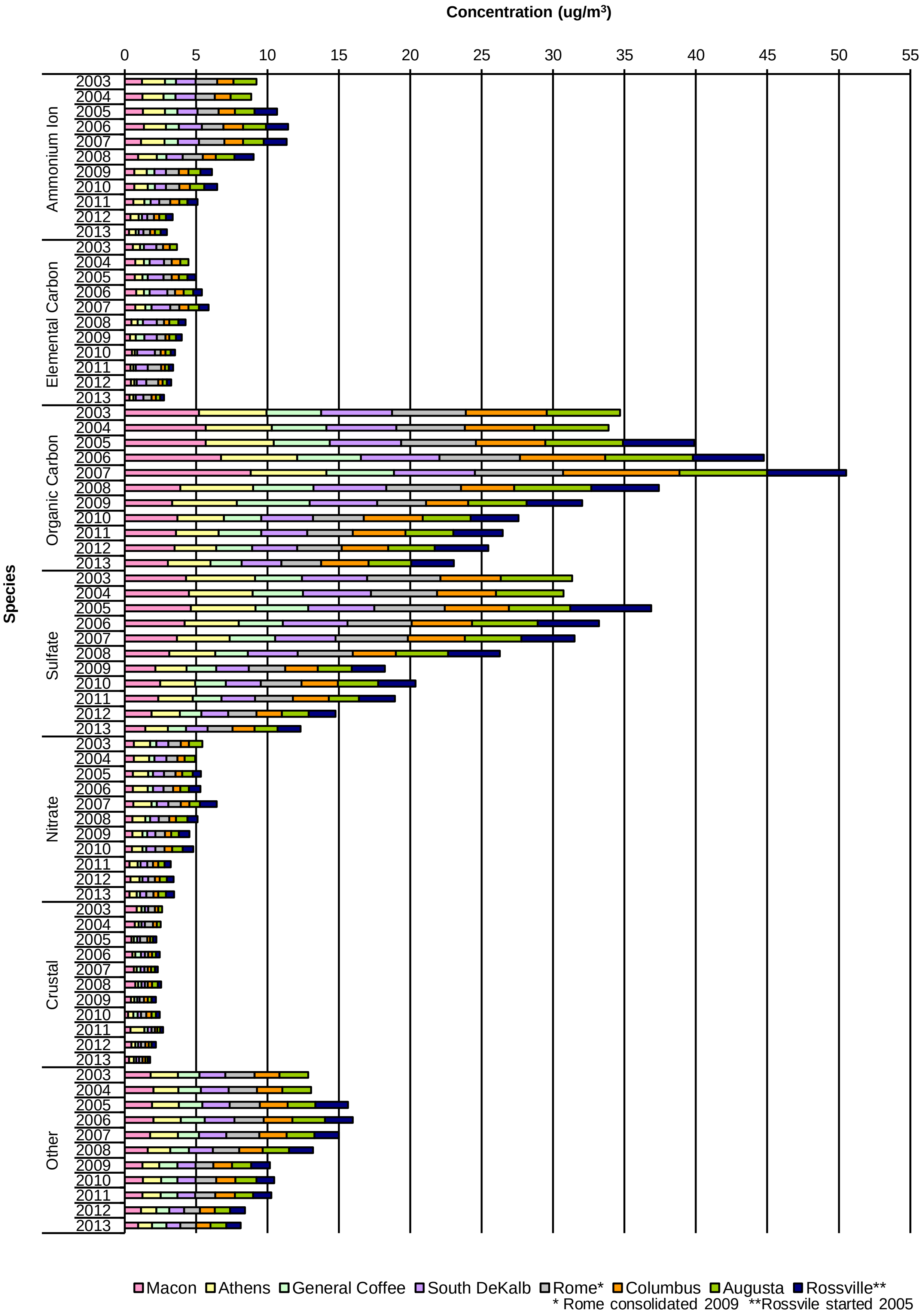


Figure 49. PM$_{2.5}$ speciation, by species

PREDOMINANT SPECIES FOUND IN PM2.5

Ammonium Ion: commonly released by fertilizer production, livestock production, coke production, and some large refrigeration systems. Ironically, it can be emitted by NO_x control systems installed on large fossil fuel combustion systems, which use ammonia or urea as a reactant.

Sulfate products: formed during the oxidation of SO_2 in the atmosphere. SO_2 is primarily produced by coal burning boilers.

Nitrate products: formed through a complex series of reactions that convert NO_x to nitrates. Vehicle emissions and fossil fuel burning produce NO_x.

Crustal products: components that are the result from the weathering of Earth's crust. They may include ocean salt and volcanic discharges. Crustal products include aluminum, calcium, iron, titanium, and silicon. These components are released by metals production, and can be resuspended in the atmosphere by mechanisms that stir up fine dust, such as mining, agricultural processes, and vehicle traffic.

Elemental carbon: carbon in the form of soot. Sources of elemental carbon include diesel engine emissions, wood-burning fireplaces, and forest fires.

Organic carbon: consist of hundreds of organic compounds that contain more than 20 carbon atoms. These particles may be released directly, but are also formed through a series of chemical reactions in the air, mostly as a result of the burning of fossil fuels and wood.

Data on the composition of fine particulate matter is a useful input to scientific models of air quality. Ultimately, it helps scientists and regulators track the progress and effectiveness of newly implemented pollution controls. The data also improves scientific understanding of the relationship between particle composition, visibility impairment, and adverse human health effects.

Figure 50 presents a different view of the above $PM_{2.5}$ speciation data to facilitate visualization of trends. Each site is shown with all species making up the composition of each bar. Each year is shown separately.

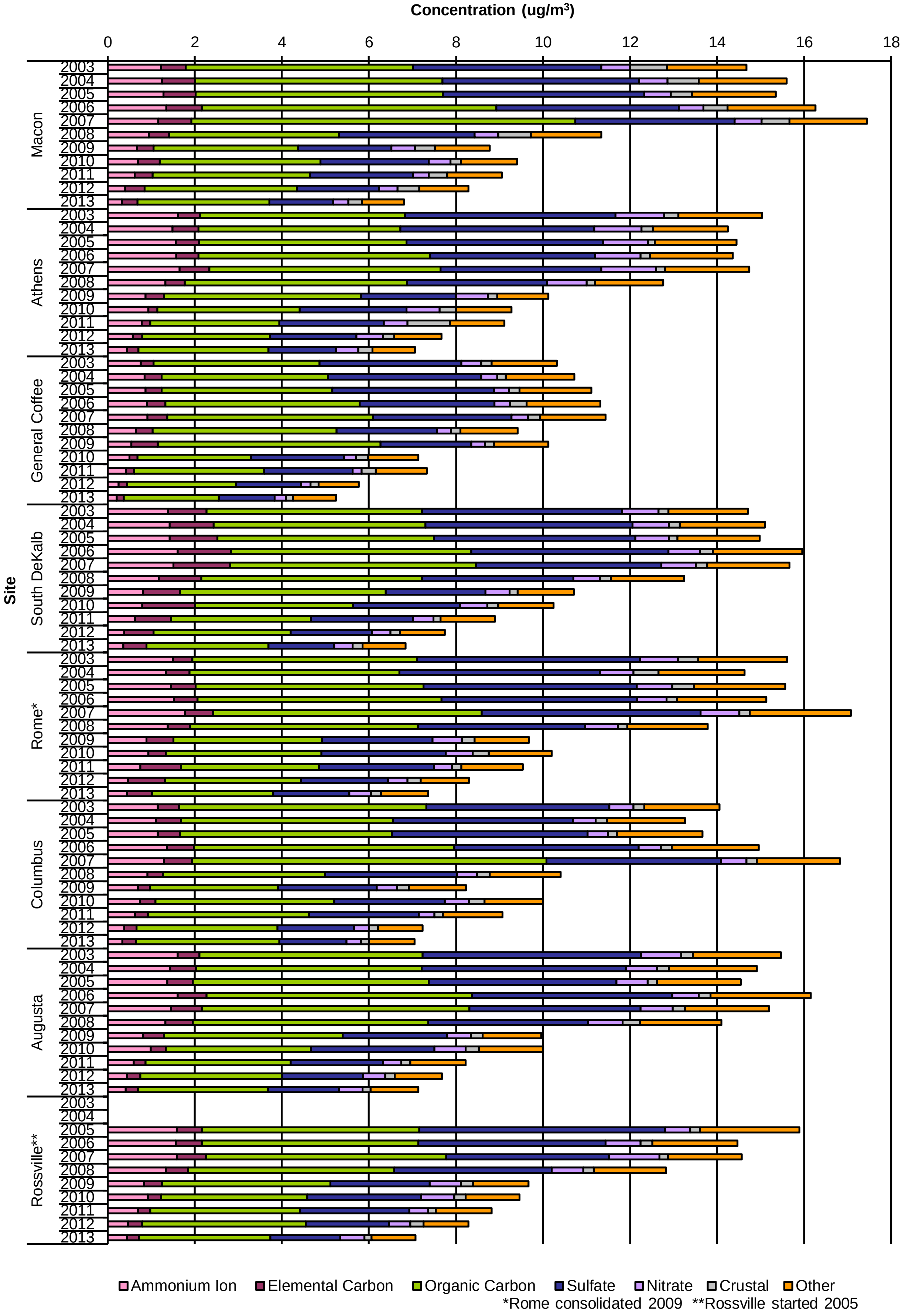


Figure 50. $PM_{2.5}$ speciation, by site

Figure 50 shows a general trend downward of the $PM_{2.5}$ speciated parameters, except in 2007 when the data was affected by the Sweat Farm/Big Turnaround/Bugaboo Fire in the Okefenokee Swamp, as discussed in the PM_{10} and $PM_{2.5}$ sections. The rural background site, General Coffee, continues to show the smallest total average concentration. In 2013, the General Coffee site showed an overall concentration of approximately 5.2 $\mu g/m^3$. The remaining sites had overall concentrations of 6.8 to 7.4 $\mu g/m^3$.

Ammonium ion concentrations (shown in pink) are relatively even statewide, with concentrations lowest at the General Coffee site. The concentrations ranged from 0.21 $\mu g/m^3$ at the General Coffee site to 0.45 $\mu g/m^3$ at the Athens and Rossville sites in 2013. Ammonium ion is the third largest single contributor to the total speciation make up.

The Rome area has the highest elemental carbon concentration, 0.57 $\mu g/m^3$, shown in burgundy. Cities with less heavy vehicle traffic generally have lower concentrations. The General Coffee site has the lowest elemental carbon concentration, with 0.16 $\mu g/m^3$ in 2013.

Organic carbon concentrations (shown in green) are relatively consistent throughout the state, usually consisting of about 3 $\mu g/m^3$ of the total speciation concentration. The General Coffee site collected a slightly lower concentration of 2.2 $\mu g/m^3$. Organic carbon concentrations are much higher than typical ammonium ion or elemental carbon concentrations, having one of the largest contributions (about 40%-50%) to the total $PM_{2.5}$ mass concentrations.

Sulfate (shown in dark blue) is also found in higher concentrations, with concentrations around 1.3-1.8 $\mu g/m^3$ in 2013. Concentrations are relatively consistent statewide, though somewhat lower in rural areas, and their relatively large observed mass means that they are also a major contributor to overall $PM_{2.5}$ mass concentrations.

Nitrate concentrations (shown in purple) are relatively small (0.26-0.56 $\mu g/m^3$ in 2013), usually contributing the fourth or fifth largest single component of the total five major constituents. Atmospheric forms of nitrate can be formed from the conversion of NO_x. Other forms of nitrate can be found in fertilizers, animal and human organic waste, medications, and used in welding.

Crustal matter concentrations (shown in gray) are generally one of the lowest speciation concentrations (0.16-0.34 $\mu g/m^3$ in 2013) and consistent in most areas. Rome and Macon have in some years recorded unexpectedly high crustal matter concentrations. This may be attributed to local industry, or possibly a sign of poor dust control at agricultural, construction, or mining operations in those areas.

The section labeled ‘Other’ (shown in orange) is a make-up of all the rest of the compounds not included in the five major contributors or crustal make-up. This is a total of the remaining 43 compounds in the speciation sample. Concentrations ranged from 0.96 to 1.1 $\mu g/m^3$ in 2013.

For $PM_{2.5}$ speciation summary data see Appendix B.

Figure 51 shows the distribution of Georgia’s 2013 $PM_{2.5}$ annual speciation averages collected across the state. The regional similarities and differences of the $PM_{2.5}$ species composition become apparent from this analysis. All across the state, organic carbon (pink) and sulfate (peach) show the greatest contribution of the all the $PM_{2.5}$ species collected. The Rome and Atlanta sites have more contribution of elemental carbon, while the Macon site collects more of the crustal species. Ammonium ion (green) and nitrate (light green) also show relatively more contribution at the Athens site, compared to the other sites.

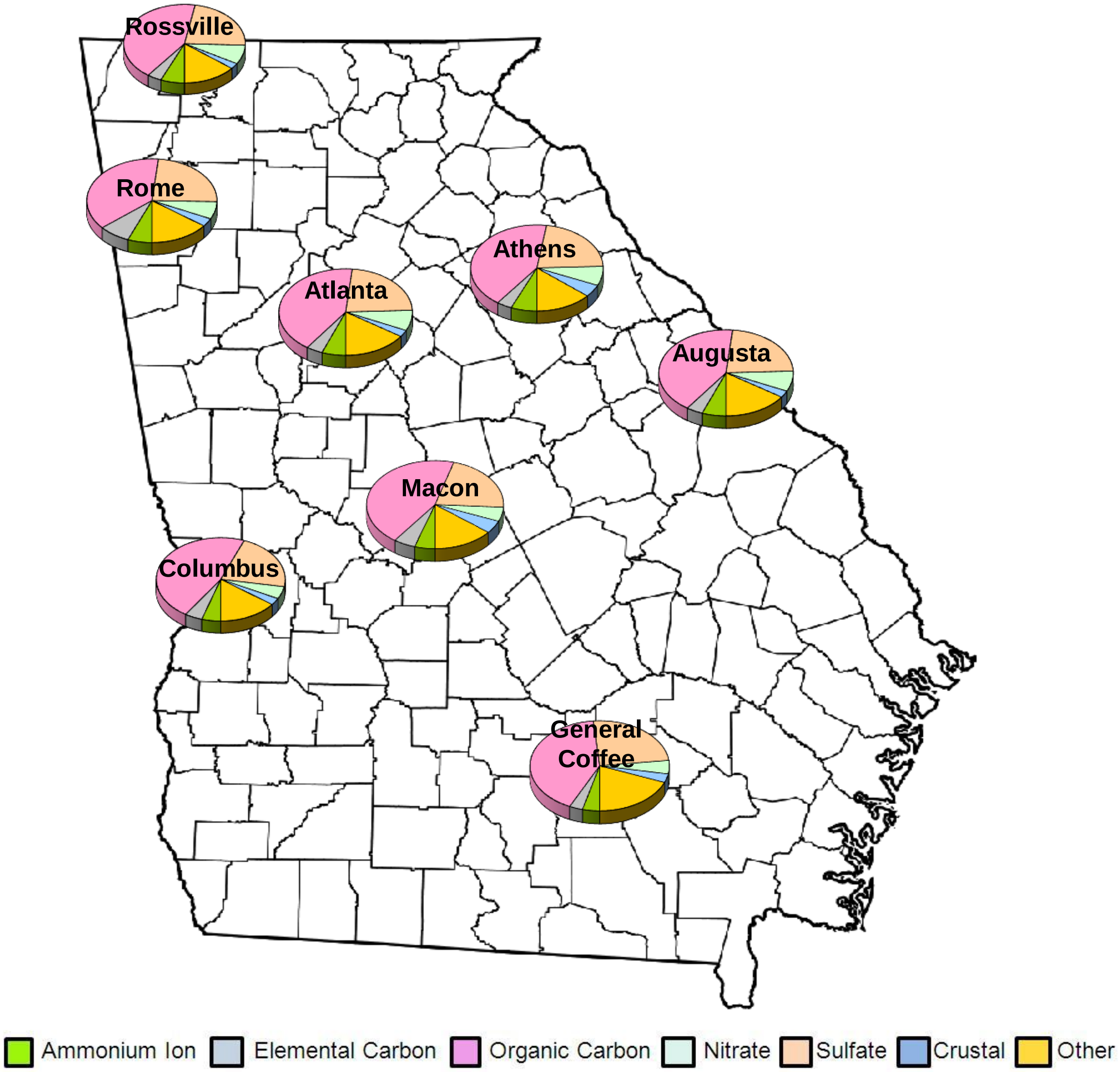


Figure 51. 2013 annual averages of $PM_{2.5}$ composition data in Georgia

MEASUREMENT TECHNIQUES

Particle speciation measurements require the use of a wide variety of sampling and analytical techniques, but all generally use filter media to collect the particles to be analyzed. Laboratory techniques currently in use are gravimetric (microweighing); X-ray fluorescence and particle-induced X-ray emission for trace elements; ion chromatography for anions and selected cations; controlled combustion for carbon; and gas chromatography/mass spectroscopy (GC/MS) for semi-volatile organic particles.

ATTAINMENT DESIGNATION

Particle speciation measurements are performed to support the regulatory, analytical, and public health purposes of the program. Currently, there are no ambient air quality standards regarding the speciation of particles.

PHOTOCHEMICAL ASSESSMENT MONITORING STATIONS (PAMS)

GENERAL INFORMATION

Ozone is the most prevalent photochemical oxidant and an important contributor to photochemical pollutants. The understanding of the chemical processes in ozone formation and the specific understanding of the atmospheric mixture in nonattainment areas nationwide are essential. To better understand the chemical processes and develop a strategy for solving those problems, EPA revised the ambient air quality surveillance regulations. In February 1993, Title 40, Part 58 of the Code of Federal Regulations (40 CFR Part 58) was developed to include provisions for enhanced monitoring of ozone, oxides of nitrogen, volatile organic compounds (VOCs), select carbonyl compounds, and the monitoring of meteorological parameters. These parameters would be monitored at Photochemical Assessment Monitoring Stations (PAMS). Stated in Title 40, Part 58 of the Code of Federal Regulation (40 CFR Part 58), the increased monitoring of ozone and its precursor concentrations allows for the characterization of precursor emissions within the area, transport of ozone and its precursors, and the photochemical processes leading to nonattainment. By expanding on the study of ozone formation, PAMS monitoring sites better serve as a means to study trends and spatial and diurnal variability.

As described in the Technical Assistance Document (TAD), PAMS monitoring was to be implemented in cities that were classified as serious, severe, or extreme for ozone nonattainment. The classifications were based on the number of exceedances of the ozone standard, and the severity of those exceedances. Nineteen areas nationwide were required to implement a PAMS network. In the Atlanta metropolitan area, a network of four sites was established beginning in 1993. The monitoring sites were selected depending on the pollutants monitored in relation to the prevailing winds in the area. The Yorkville site serves as a Type 1 site. It is a rural background site, upwind of the city, which aids in determining the role of transport of pollutants into the Atlanta area. The South DeKalb and Tucker sites were the primary and secondary wind directions for an urban core-type site, serving as Type 2 sites. These sites are expected to measure the highest precursor concentrations of NO_x and VOCs in the Atlanta area. The Conyers site is the downwind site where titration of the precursors has occurred and the ozone concentrations should be at their highest. The Conyers site serves as a Type 3 site. Until the end of 2006, this was the setup of the PAMS network. At the end of 2006, the Tucker site was shut down. From that point, South DeKalb has served as the urban core-type site. When the PAMS network was originally designed, there was a plan for a Type 4 site, which samples the air once it has returned to background levels far downwind from the metropolitan area. However, when the network was instituted, this type of site was not installed. The PAMS network as it was set up for the 2013 monitoring year is shown in Figure 52.

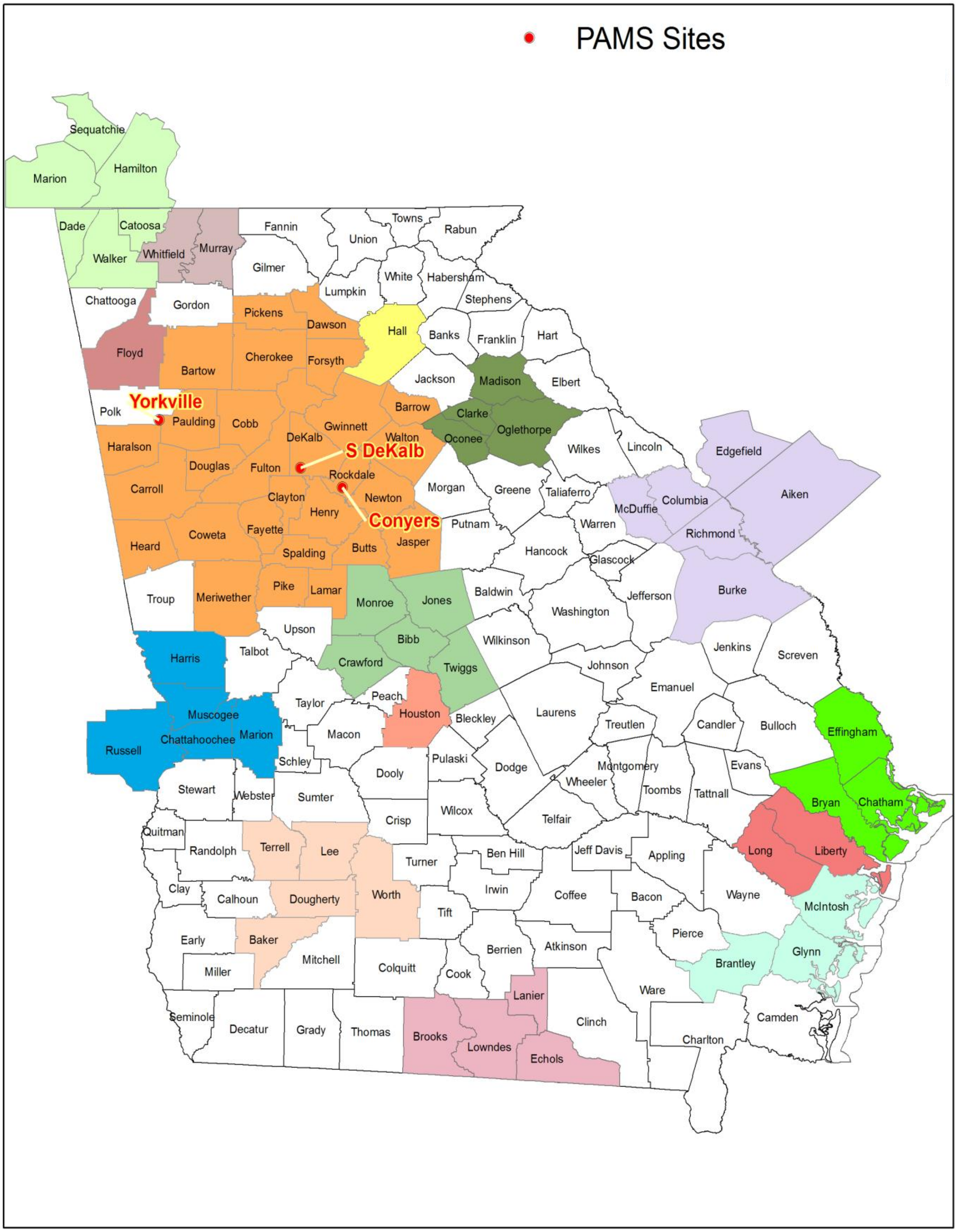


Figure 52. Georgia PAMS monitoring sites, MSAs shown as solid colors

Of the fifty-six PAMS compounds monitored, the same volatile organic compounds (VOCs) consistently show the highest average concentrations at all three sites. These compounds include isoprene, m/p xylene, toluene, propane, ethane, isopentane, n-butane and n-pentane. Propane, ethane, isopentane, n-butane, and n-pentane have a limited reactivity for ozone formation, and therefore are the most prevalent of the volatile organic compounds measured. However, when the characterization of the top compounds is based upon contributions to ozone formation potential, the list is slightly different.

Isoprene, the tracer for VOCs emissions from vegetation, is by far the largest contributor to ozone formation at every site. Isoprene is a 5 carbon organic compound naturally released in large quantities by conifer trees. These trees are very abundant in the Southeastern United States, contributing a significant portion to the overall carbon loading of the atmosphere in this region. Isoprene's chemical structure makes it a highly reactive substance with a short atmospheric lifetime and large ozone forming potential.

Figure 53 shows the seasonal occurrence of isoprene from 2003 to 2013. This figure represents a combination of the 6-day, 24-hour data shown as monthly averages over the eleven years from the three PAMS sites, and concentrations are given in parts per billion Carbon (ppbC). Evidence of isoprene's natural origin is shown in this figure, where the ambient concentration is essentially non-existent from November to May.

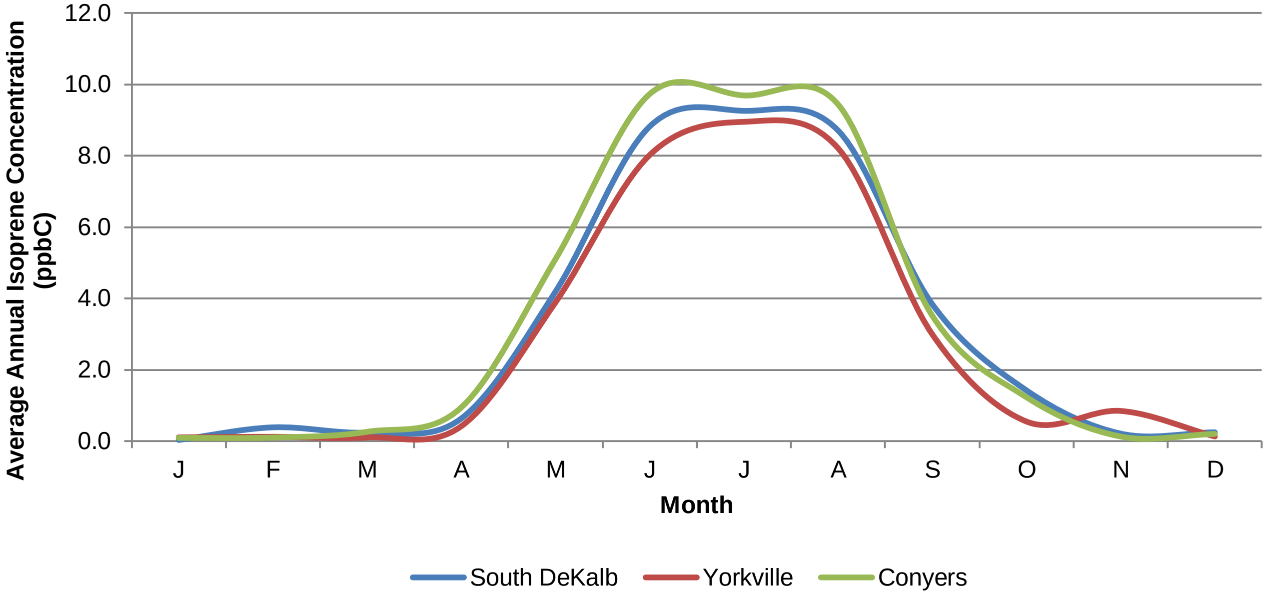


Figure 53. Average yearly profile of isoprene, 2003-2013

The anthropogenic compounds detected at all sites with the highest ozone formation potential were toluene, m/p xylene, propylene, ethylene, and isopentane. The sources for these five compounds are varied. All five compounds are emitted by mobile sources, with ethylene being an important tracer for vehicle emissions. Toluene (generally the most abundant species in urban air), m/p xylene, and isopentane are also emitted by solvent use and refinery activities. Toluene reaches the air from a variety of sources such as combustion of fossil fuels and evaporative emissions. This hydrocarbon is in motor vehicle fuel and is also used as a common solvent in many products such as paint. It has a substituted benzene ring possessing modest atmospheric reactivity. Figure 54 compares the seasonal occurrence of toluene with monthly averaged data from 2003 through 2013. Again, this figure is a combination of the 6-day, 24-hour data from the three PAMS sites, and concentrations are given in parts per billion Carbon (ppbC).

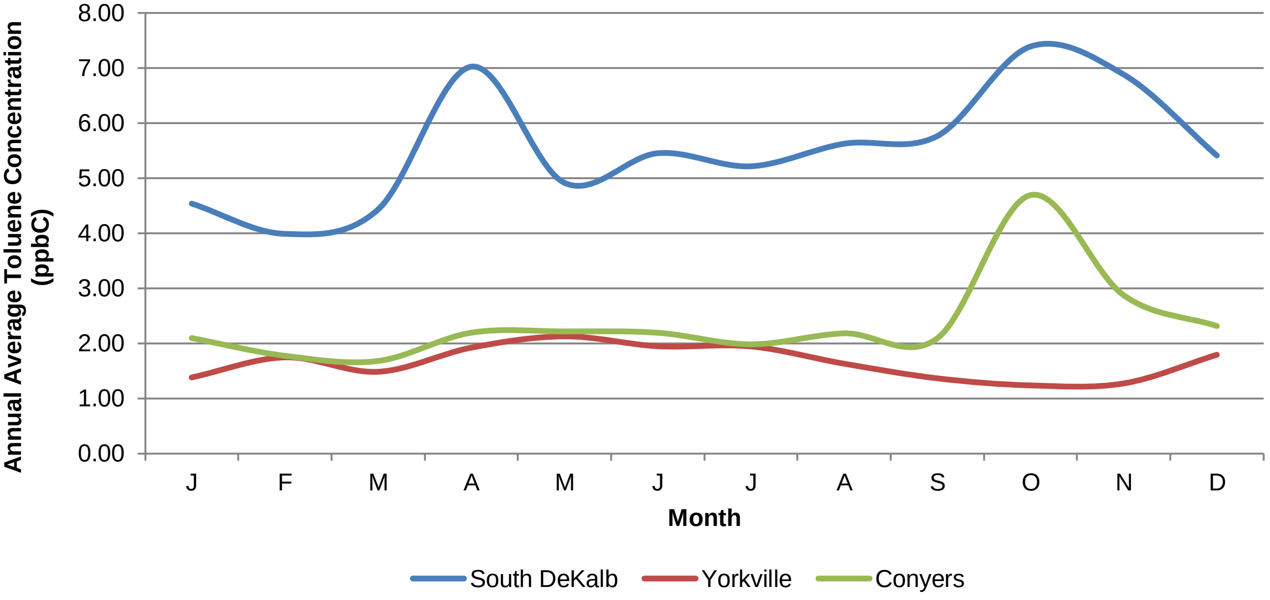


Figure 54. Toluene average annual occurrence, 2003-2013

As shown in Figure 54, the atmospheric levels of toluene are relatively constant throughout the year, suggesting a steady level of emissions year-round. Over the past eleven years, an occasional spike in concentration has occurred without evidence of a pattern. Overall, the PAMS site that is situated in the urban area (South DeKalb) has slightly higher levels of toluene, while the sites located on the outskirts of the Atlanta metropolitan area (Yorkville and Conyers) show lower levels of toluene.

Figure 55 plots the daily profiles of toluene and isoprene. This graph uses data gathered in the summer, and shows a constant background of toluene emissions with higher levels resulting from morning and evening rush hour traffic. The graph shows the typical diurnal, or daily, profile for a typical urban area. During morning hours, when the nocturnal inversion has not yet broken, emissions become trapped within the boundary layer, resulting in a temporary increase in atmospheric concentration. Nighttime toluene levels are constant from midnight to 5:00 am. From 6:00 am to 7:00 am, increased vehicular activity releasing emissions into an atmosphere with limited dispersing ability produces an increase in the ambient concentration. This behavior is typical of area source anthropogenic emissions with modest to long atmospheric lifetimes. Isoprene, on the other hand, exhibits very different behavior. At night, emission levels are at zero as photosynthesis ceases. At sunrise (about 6:00 am) concentrations begin to rise and continue to do so throughout the daylight hours. The vertical flux, or mass input per unit area, in the atmosphere of this substance is massive, being only slightly influenced by the enhanced mid-morning mixing. This effect can be seen at 9:00 am when a slight drop in concentration occurs followed by a quick resumption in rise.

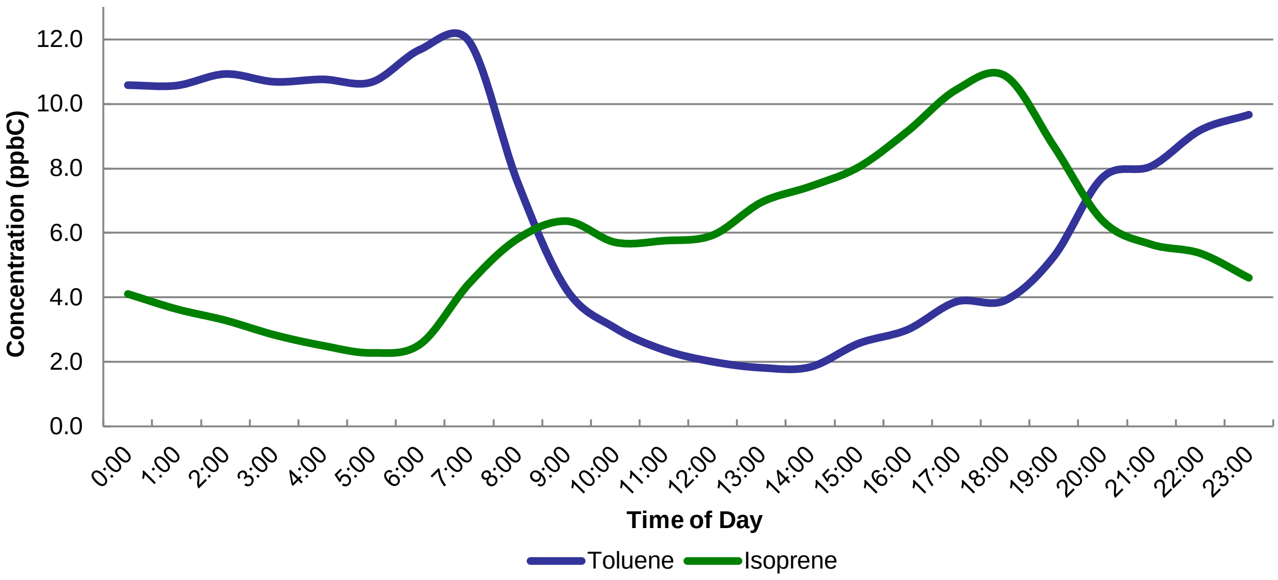


Figure 55. Typical urban daily profile of toluene & isoprene

CARBONYL COMPOUNDS

Carbonyl compounds define a large group of substances, which include acetaldehyde, acrolein, and formaldehyde. These compounds can act as precursors to ozone formation. Some of the sources of carbonyl compounds include vehicle exhaust and the combustion of wood. Depending on the amount inhaled, exposure to these compounds can cause irritation to the eyes, ears, nose, and throat, dizziness, and damage to the lungs. Each of the seven carbonyl compounds that Georgia EPD monitors is discussed further in the following paragraphs. The South DeKalb site is part of both the PAMS network and the National Air Toxics Trends Stations (NATTS) network, and collects samples every six days throughout the year, and every three hours throughout the summer. For a map of locations monitoring carbonyl compounds, see Figure 56.

Acrolein is primarily used as an intermediate in the manufacture of acrylic acid. It can be formed from the breakdown of certain organic pollutants in outdoor air, from forest fires and wildfires, as well as from vehicle exhaust. It is also found in cigarette smoke.

Acetaldehyde is mainly used as an intermediate in the production of other chemicals. Acetaldehyde is formed as a product of incomplete wood combustion (in fireplaces and woodstoves, forest fires, and wildfires), pulp and paper production, stationary internal combustion engines and turbines, vehicle exhaust, and wastewater processing.

Formaldehyde is used mainly to produce resins used in particleboard products and as an intermediate in the production of other chemicals. The major sources of emissions to the air are forest fires and wildfires, marshes, stationary internal combustion engines and turbines, pulp and paper plants, petroleum refineries, power plants, manufacturing facilities, incinerators, cigarette smoke, and vehicle exhaust.

Acetone is used industrially as a reactant with phenol to produce bisphenol A, which is an important component of polymers. It is used in nail polish removers, superglue removers, and as a drying agent. It is also used to dissolve plastic. Acetone is highly volatile and evaporates quickly. Inhalation of acetone can lead to liver damage.

Benzaldehyde is the simplest form of the aromatic aldehydes. It has an almond scent and is used in the food industry. It is also used as an industrial solvent, and is used in making pharmaceuticals, plastic additives, and aniline dyes. Liquid phase oxidation or chlorination of toluene can form benzaldehyde. In addition, benzaldehyde can be formed from a reaction between benzene and carbon monoxide. The combustion of gasoline, diesel fuel, wood burning, and incinerators emit benzaldehyde into the atmosphere.

Butyraldehyde is used in the manufacture of synthetic resins, solvents, and plasticizers. It is emitted into the air by combustion of gasoline, diesel fuel, and wood.

Propionaldehyde is a highly volatile compound that is produced or used in making propionic acid, plastics, rubber chemicals, alkyd resins, and is also used as a disinfectant and preservative. It is released into the atmosphere by combustion of gasoline, diesel fuel, wood, and polyethylene.

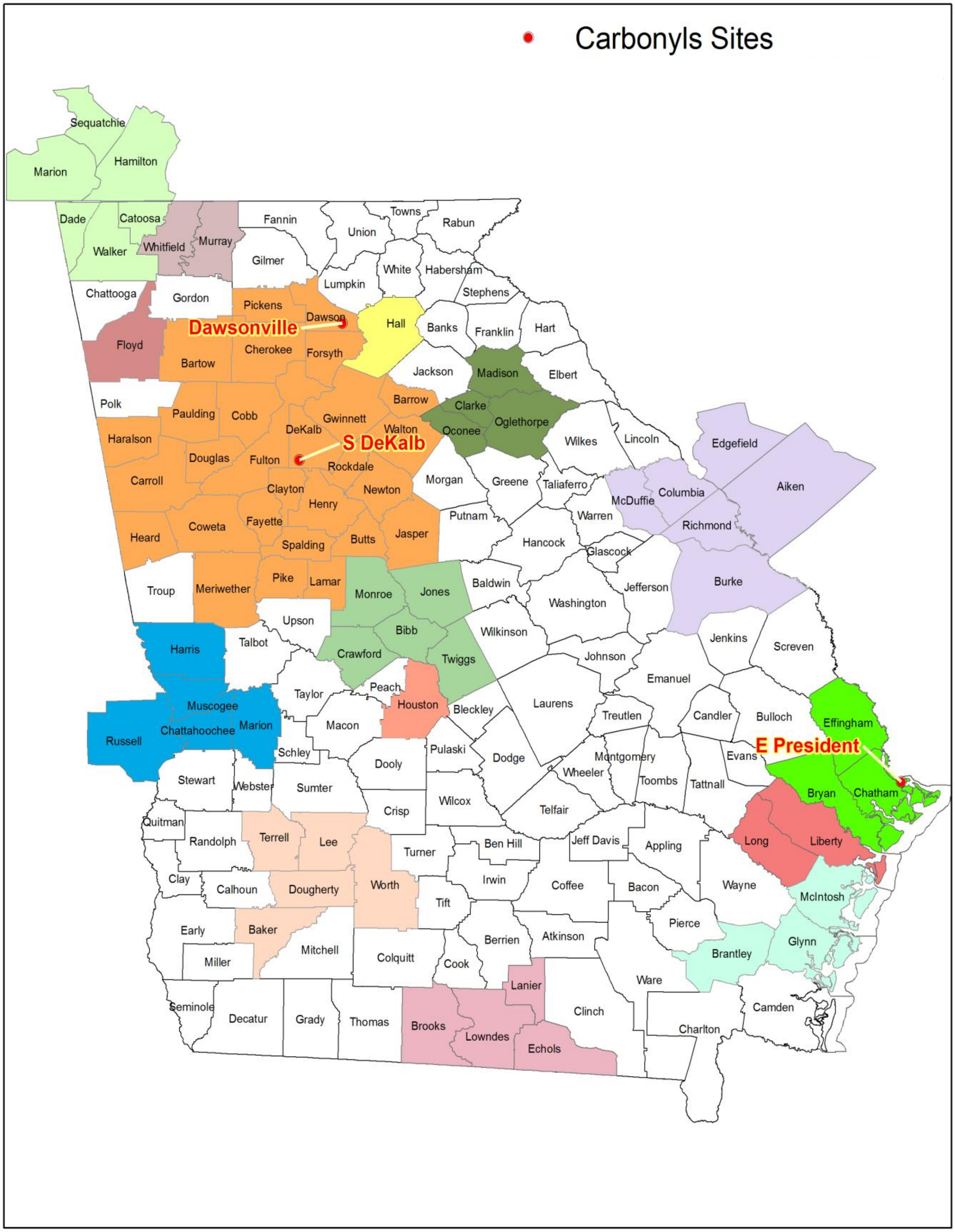


Figure 56. Georgia's carbonyls monitoring sites, MSAs shown as solid colors

As part of the PAMS network, the South DeKalb site collects 3-hour samples of carbonyls during the summer months (June - August). Samples are collected at hours 6:00, 9:00, 12:00, and 15:00, every three days. The average concentrations of all the 3-hour samples of carbonyls collected during those months for 2005 through 2013 have been combined for a given hour and are shown in Figure 57. The early morning ambient concentrations are generally lower for all constituents. Overall, most of the concentrations appear to peak at 12:00. There appears to be a cyclic trend, particularly for the compounds with higher concentrations, formaldehyde and acetone. Acetaldehyde, acetone, and formaldehyde continue to be the biggest contributors, and for the past three years the other three compounds (benzaldehyde, propionaldehyde, and butyraldehyde) have had no detections.

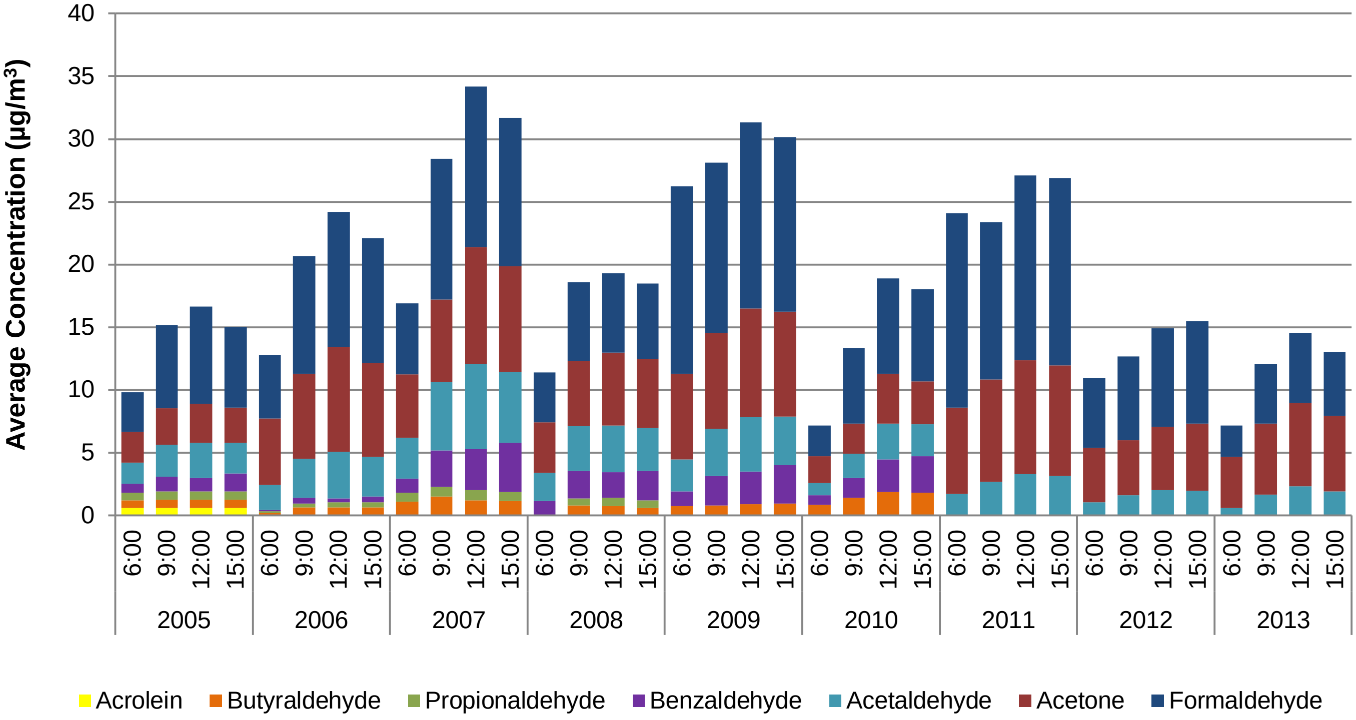


Figure 57. This stacked column chart shows the average concentration for each of the seven carbonyls at South DeKalb from June-August, 2005-2013.

The next two graphs address 24-hour samples of carbonyls data. Due to the differences in sampling method, analysis method, and the sites collecting acrolein data, acrolein is discussed separately in later paragraphs. Figure 58 shows the average concentration of the other six carbonyls and the detection percentage at each of the sampling sites. Detections are shown as a percentage of the overall samples taken since the South DeKalb site collects data every six days with the PAMS and NATTS networks, while the Savannah and Dawsonville sites collect data every twelve days with the Air Toxics Network (discussed in next section). A detection of any given pollutant is counted as any number that is above half the limit of detection. There are some notable changes in concentrations between 2005 and 2013. The Savannah site had a dramatic increase in 2010, but levels have dropped back down the past three years. The Dawsonville site had a visible increase in concentration in 2007 and 2010, but levels have come back down the past three years. The South DeKalb site has consistently had overall higher average concentrations. In 2013, percent detections ranged from 28% at the Savannah and Dawsonville sites, to 39% at the South DeKalb site.

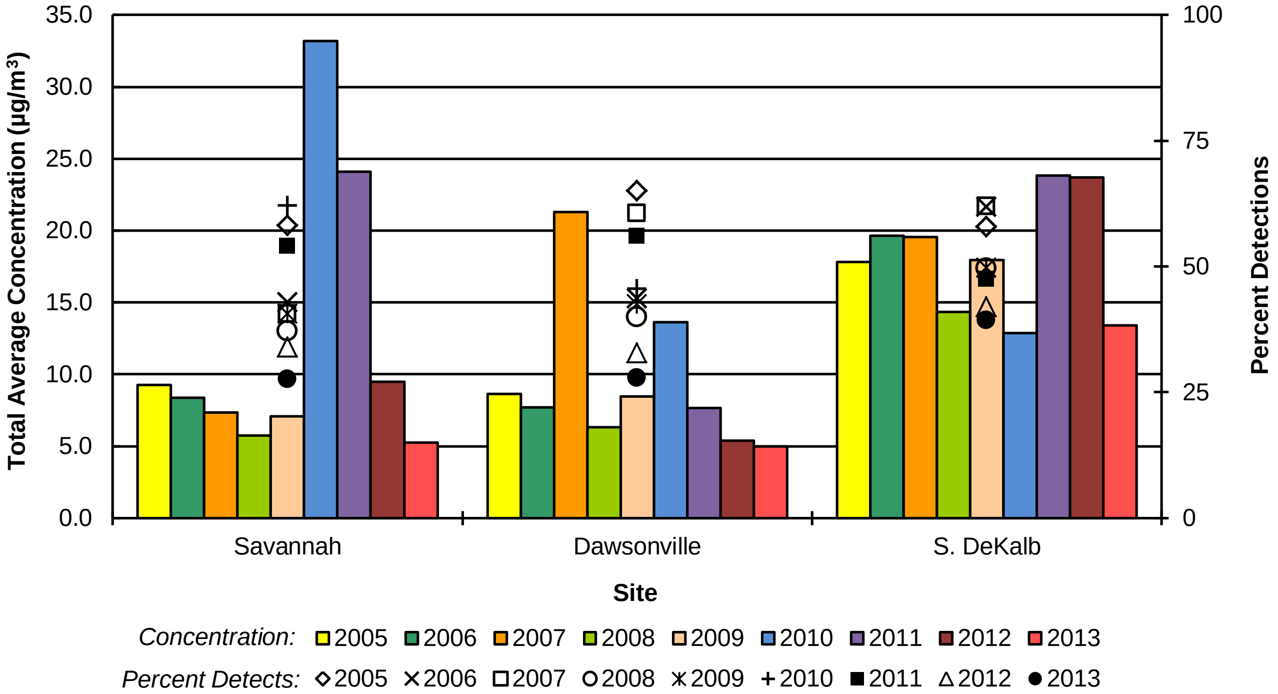


Figure 58. Average 24-hour carbonyl concentrations and number of detects, by site, 2005-2013

Figure 59 shows the statewide annual abundance of six species of carbonyls, based on percentage of detections and average concentration. A graph of the seventh carbonyl, acrolein, is shown separately as it is collected with the canister method and involves all the Air Toxics sites (Figure 60). A gradient is evident from this graph, with formaldehyde and acetone being the most abundant carbonyls. In general, it appears that there is a positive correlation with the number of detections and the average concentration. However, acetaldehyde does not follow this pattern, having a higher percentage of detections and lower concentrations. All the compounds showed an increase in total average concentrations in 2010, mainly attributed to the Savannah site (Figure 58). Overall, the average concentrations have declined over the past two years which is attributed to the general decrease in percent detections. The relative proportion of each compound to the others has remained the same throughout all nine years, with formaldehyde, acetone, and acetaldehyde remaining the principal contributors.

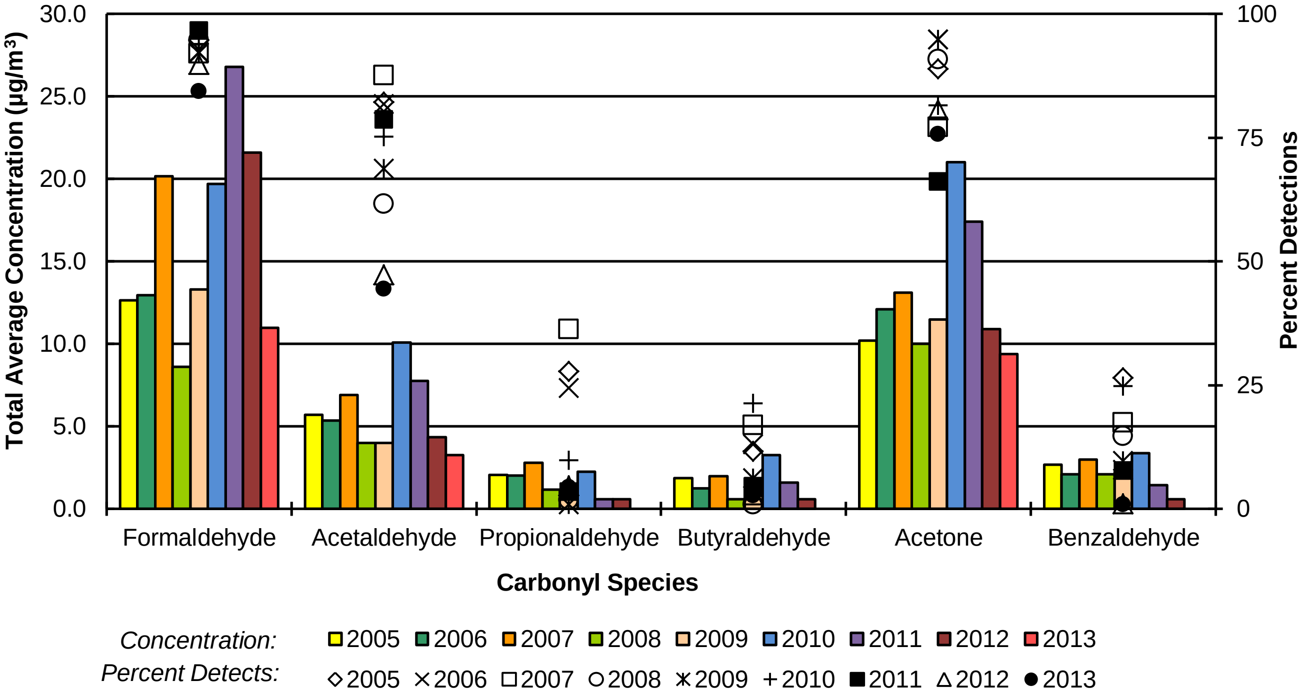


Figure 59. Average 24-hour carbonyl concentrations and number of detects, by species, 2005-2013

Acrolein may enter the environment as a result of combustion of trees and other plants, tobacco, gasoline, and oil. Additionally, it can be used as a pesticide for algae, weeds, bacteria, and mollusks (ATSDR, 2011). The potential for acrolein to cause health effects is not well understood. At very low concentrations, it is an eye and upper respiratory irritant. At very high concentrations it may produce more serious damage to the lining of the upper respiratory tract and lungs (ATSDR, 2011; U.S. EPA, 2003).

A new acrolein sampling and analysis method was developed by EPA and implemented in Georgia in July of 2007. The sampling method uses the volatile organic compounds (VOCs) canister collection method, and the analysis method uses gas chromatograph and mass spectroscopy (GC/MS). This change occurred due to EPA's findings during the School Air Toxics Monitoring Initiative. For more information on this study, please see EPA's website, http://www.epa.gov/ttnamti1/airtoxschool.html. Georgia EPD began using this new method for the National Air Toxics Trends Station (NATTS) at the South DeKalb site and other Air Toxics sites (discussed in the next section). In previous years, acrolein was sampled along with the six other carbonyls with a dinitrophenylhydrazine (DNPH) cartridge method and analyzed with high performance liquid chromatography (HPLC) at select sites across the state. The DNPH sampling and HPLC analysis method were used on the data that is displayed in the three previous carbonyls graphs. Before the new methods were used there were a total of four detections in 2005, zero in 2006, and one in 2007 in Georgia. With the canister collection, GC/MS analysis method, and the addition of Air Toxics sites, the number of acrolein detections drastically increased during the second half of 2007. All sites demonstrated more than 80% detection, and some had 100% detection (Figure 60) after the implementation of the new sampling and analysis methods.

Figure 60 shows relatively stable concentrations for all years with the exception of 2010 which had a sudden dramatic increase. Every site had at least twice the 2009 concentration. The Savannah site had the highest increase from 0.34 µg/m^3 in 2009 to 4.25 µg/m^3 in 2010. This was followed by an equally dramatic decrease in concentration in 2011, with levels remaining relatively stable since then.

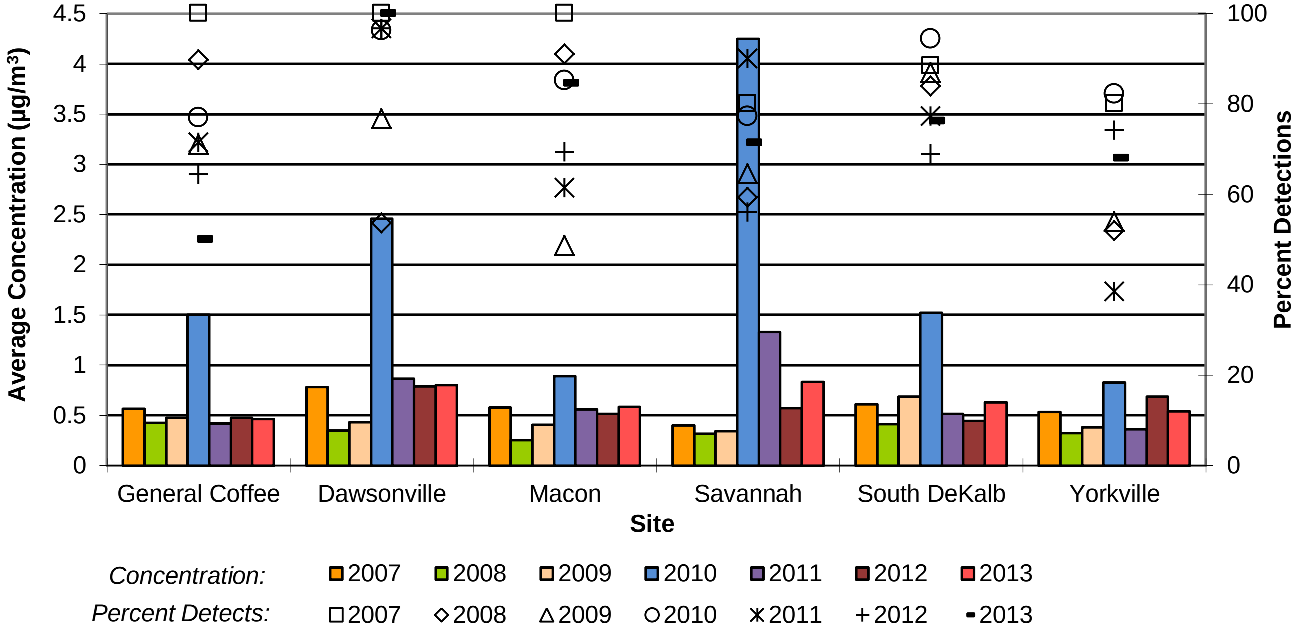


Figure 60. Acrolein concentrations and percent detections, 2007- 2013

MEASUREMENT TECHNIQUES

A number of methods are used to conduct the PAMS hydrocarbon portion of the analyses. Throughout the year, 24-hour integrated volatile organic compounds samples are taken every sixth day at the PAMS sites (Conyers, South DeKalb, and Yorkville) and analyzed in the GA EPD laboratory for 56 hydrocarbon compounds. A SUMMA® polished canister is evacuated to a near-perfect vacuum and attached to a sampler with a pump controlled by a timer. The canister is filled to greater than 10 psig. Then, the canister is analyzed using a gas chromatograph with mass spectroscopy detection (GC/MS).

Additionally, from June through August, hydrocarbon samples are analyzed hourly at the PAMS sites (Conyers, South DeKalb, and Yorkville) using a gas chromatography unit with a Flame Ionization Detector (FID). The gas chromatograph produces analyses of the ambient air for the same 56 hydrocarbons.

The carbonyls are sampled with two types of methods. One method includes an absorbent cartridge filled with dinitrophenylhydrazine (DNPH) coated silica that is attached to a pump to allow approximately 180 L of air to be sampled. The cartridge is analyzed using High Performance Liquid Chromatography. Twenty-four hour integrated samples are collected throughout the year, every 12 days at the Air Toxics sites (Dawsonville and Savannah) and every 6 days at the NATTS site (South DeKalb). Also, during June, July, and August, four integrated three-hour carbonyl samples are taken every third day at the NATTS site (South DeKalb). All analyses are conducted at the GA EPD laboratory. Another collection method is the canister sampler that is used for sampling volatile organic compounds (described above); acrolein is analyzed using this method. Specific annual summaries for the 2013 PAMS data may be found in Appendix C.

ATTAINMENT DESIGNATION

There are no specific ambient air standards for the hydrocarbon and aldehyde species measured. PAMS measurements are performed to support the regulatory, analytical, and public health purposes of the ambient air monitoring program. By performing these measurements, GA EPD can better understand the characterization of precursor emissions within the area, transport of ozone and its precursors, and the photochemical processes leading to nonattainment. In addition, by studying local atmospheric chemistry, it improves the ability to control the formation of secondary pollutants like ozone and particulate matter. By making such data available, scientists can study air quality and how it relates to human health. This data can serve to guide policymakers toward making decisions that protect public health.

AIR TOXICS MONITORING

GENERAL INFORMATION

Air toxic pollutants, or hazardous air pollutants (HAPs), are a group of air pollutants that have a wide variety of sources. Air toxic compounds are released from mobile sources (such as vehicles), stationary industrial sources, small area sources, indoor sources (such as cleaning materials), and other environmental sources (such as volcanoes and wildfires). The lifetime, transportation, and make-up of these pollutants are affected by both weather (rain and wind) and landscape (mountains and valleys). They can be transported far away from the original source, or be caught in rain and brought down to waterways or land. In addition, some HAPs that are no longer used, but were commonly used in the past, can still be found in the environment today.

All of these air toxic pollutants can potentially have negative health and environmental effects. Negative effects on human health range from headaches, nausea, and dizziness to cancer, birth defects, problems breathing, and other serious illnesses. These effects can vary depending on frequency of exposure, length of exposure time, health of the person that is exposed, along with the toxicity of the compound. People can be exposed to HAPs by breathing contaminated air, consuming food or water contaminated by air pollutants, or touching contaminated water or soil. These air pollutants also affect the environment. Wildlife experience symptoms similar to those in humans. Pollutants accumulate in the food chain. Many air pollutants can also be absorbed into waterways and have toxic effects on aquatic wildlife. Some of the substances tend to have only one critical effect, while others may have several. Some of the effects may occur after a short exposure and others appear after long-term exposure, or many years after being exposed. Exposure is not only through direct inhalation of the pollutant, but also through the consumption of organisms (such as fish) that have absorbed the pollutant.

In order for GA EPD to expand the understanding of the quality of Georgia's air regarding ambient concentrations of hazardous air pollutants, GA EPD began state-sponsored monitoring activities. HAPs monitoring efforts were undertaken to provide a more complete picture of the state's air quality. In 1994, GA EPD conducted an intensive air quality study in Savannah (GADNR, 1996a). Following the study, in 1996, GA EPD conducted an additional study in Glynn County as part of a multimedia event with EPA (GADNR, 1996b). These studies provided detailed pictures of the air quality in local communities, but were not long-term studies and could not provide information on seasonal variation or trends. A reassessment of the air toxic monitoring program occurred, and in 1996 GA EPD embarked on establishing a statewide hazardous air pollutant-monitoring network. The network was not designed to monitor any one particular industry, but to provide information concerning trends, seasonal variations, and rural versus urban ambient concentrations of air toxics. In order to evaluate the rural air quality, two background sites were proposed: one in North Georgia and one in South Georgia. The majority of the other sites were located in areas with documented emissions to the atmosphere of HAPs exceeding one million (1,000,000) pounds per year as indicated by the 1991 Toxic Release Inventory (GADNR, 1993).

After six years, the 2002 Air Toxics Network (ATN) consisted of fourteen sites statewide, including a collocated (where two sets of monitors sample side by side) site at Utoy Creek, which monitored for a common set of toxic compounds. From the list of 187 HAPs compounds identified by EPA, toxic compounds included metals, volatile organic compounds, and semi-volatile organic compounds. In addition, three of the ATN sites (Brunswick, Dawsonville, and Savannah) monitored carbonyl compounds (discussed in the previous section).

In 2003, a National Air Toxics Trends site was added to the network at the South DeKalb site, bringing the total to fifteen air toxics sites. The National Air Toxics Trends Station (NATTS) network was established in 2003 and is intended for long-term operation for the purpose of discerning national trends. The NATTS Network consists of 27 sites nationwide, 20 urban and 7 rural. The South DeKalb site monitors the same compounds as other air toxics sites, as well as hexavalent chromium, black carbon, and carbonyls (already being monitored with PAMS network).

With the inception of the NATTS network, there was an effort to standardize detection limits for all air toxic monitoring and evaluate air toxics data at a level that would reflect potential cancer risk. Therefore, in 2004, the laboratory methodology was changed for the Air Toxics Network compounds, which lowered detection and reporting limits. This enabled analysis of a broader range of data. Instead of only seeing the higher numbers that were detected and using those numbers for average concentrations, now both sides of the spectrum show a truer average for each chemical. Also, including the lower concentrations for each chemical allows for a better understanding of what levels can cause chronic health problems and potential cancer risk. Seeing only the higher levels of concentration (spikes) only yields data useful for identifying acute health effects. However, with the lower concentration levels included in the data, there can be further assessment of potential chronic health effects and potential cancer risk. In addition, all possible effects of the analyzed chemicals can be viewed, with lower limits included in the data.

In 2008, nine of the 15 Air Toxics samplers (including the collocated Utoy Creek site mentioned above) were discontinued due to budgetary constraints and lack of available personnel. The NATTS site and the remaining five sites in the Air Toxics Network are reflected in the following subsections and included in the following maps of the current network. The following section discusses air toxic compounds, possible sources, monitoring techniques, 2013 findings, and a comparison of 2013 data to previous years.

METALS

The metals subcategory includes antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, nickel, selenium, and zinc.

Antimony is used as a hardener in lead for storage batteries, in matches, as an alloy in internal combustion engines, and in linotype printing machines. Antimony compounds are used in making materials flame-retardant, and in making glass, ceramic enamels, and paints. Forms of the antimony metal are also used in medicines, and can be found in gasoline and diesel exhaust.

Arsenic occurs naturally at trace levels in soil and water. Most people are not exposed to arsenic through air pollution, but it can be found in food. The arsenic found in air comes mainly from the burning of coal or fuel oil, from metal smelters or iron foundries, and from the burning of waste.

Beryllium is a lightweight and rigid metal and used in watch springs, computer equipment, and is used in the production of beryllium-copper as an alloying agent. This strong alloy is used to conduct heat and electricity in spot welding, electrical contacts, and high-speed aircrafts. Until 1949, beryllium was used in fluorescent lighting until it was determined to have caused berylliosis, a disease that primarily affects the respiratory system and skin. Beryllium in ambient air is mainly a result of the burning of coal or fuel oil.

Cadmium emissions, like beryllium and arsenic, occur mainly from the burning of fossil fuels such as coal or oil. The incineration of municipal waste and the operation of zinc, lead, or copper smelters also release cadmium in the air. For nonsmokers, food is generally the largest source of cadmium exposure.

Chromium sources include the combustion of coal and oil, electroplating, vehicle exhaust, iron and steel plants, and metal smelters. The emissions from these sources are a combination of elemental chromium and compounds including chromium ions. The most toxic form is hexavalent chromium.

Cobalt is used as a pigment (blue and green coloring agent), as a drying agent for paints, inks and varnishes, and as a catalyst for the petroleum and chemical industries. It is used as an alloy for parts in turbine aircraft engines, corrosion-resistant alloys, magnets, battery electrodes, and steel-belted tires. Cobalt also has a medicinal use as a radioactive metal in radiotherapy. It is also found in gasoline and diesel exhaust. Cobalt is actually necessary to many forms of life, when ingested through the digestive tract, in small amounts, as a micronutrient. It is a central component of vitamin B-12. As with most micronutrients, however, human activity can cause it to accumulate in unnatural locations or in unnatural concentrations. In those cases, it may be harmful and is considered a pollutant.

Lead is used in the manufacturing of batteries. The largest source of lead in the atmosphere used to be from the combustion of leaded gasoline. With the elimination of lead from gasoline, lead levels in the air have decreased considerably. Other sources of lead emissions include combustion of solid waste, coal, oils, emissions from iron and steel production, and lead smelters. Exposure to lead can also occur from food and soil. Children are at particular risk to lead exposure, because they commonly put hands, toys, and other items in their mouths that may come in contact with lead-containing dust and dirt. Lead-based paints were commonly used for many years. Flaking paint, paint chips, and weathered paint powder may be a major source of lead exposure, particularly for children.

Manganese is a naturally occurring substance found in many types of rock and soil. It is ubiquitous in the environment and found in low levels in water, air, soil, and food. Manganese can also be released into the air by combustion of coal, oil, wood, and the operation of iron and steel production plants.

Nickel is found in the air as a result of oil and coal combustion, residential heating, nickel metal refining, lead smelting, sewage sludge incineration, manufacturing facilities, mobile sources, and other sources.

Selenium is a by-product of mining and smelting sulfide ores, such as silver, copper, and pyrite. It is found in soils, and can also be released by burning coal. Selenium has photovoltaic and photoconductive properties and is therefore used in photocells and solar panels. It is used as a pigment (red coloring agent) in enamels and glass, and also as a toner in photographs and in photocopying. Selenium is found in gasoline and diesel exhaust. It is also a micronutrient, needed at very low levels for the health of all living creatures. However, it is normally absorbed through the digestive tract, and not desirable in the air.

Zinc is found in gasoline and diesel exhaust. It is used to prevent corrosion of galvanized steel. It is also used in die-casting, and as part of battery containers. Zinc has been used as the primary metal for producing the U.S. penny since 1982. Zinc compounds are used to make white pigment, sunscreen, deodorant, calamine lotions, and pigments for glow-in-the-dark items. It is also used in the rubber industry. Like selenium, zinc is also a micronutrient that is needed for the health of living beings when consumed through the digestive system. When found in the air, though, it may be considered a pollutant.

For a map of the current metals monitoring locations, see Figure 61.

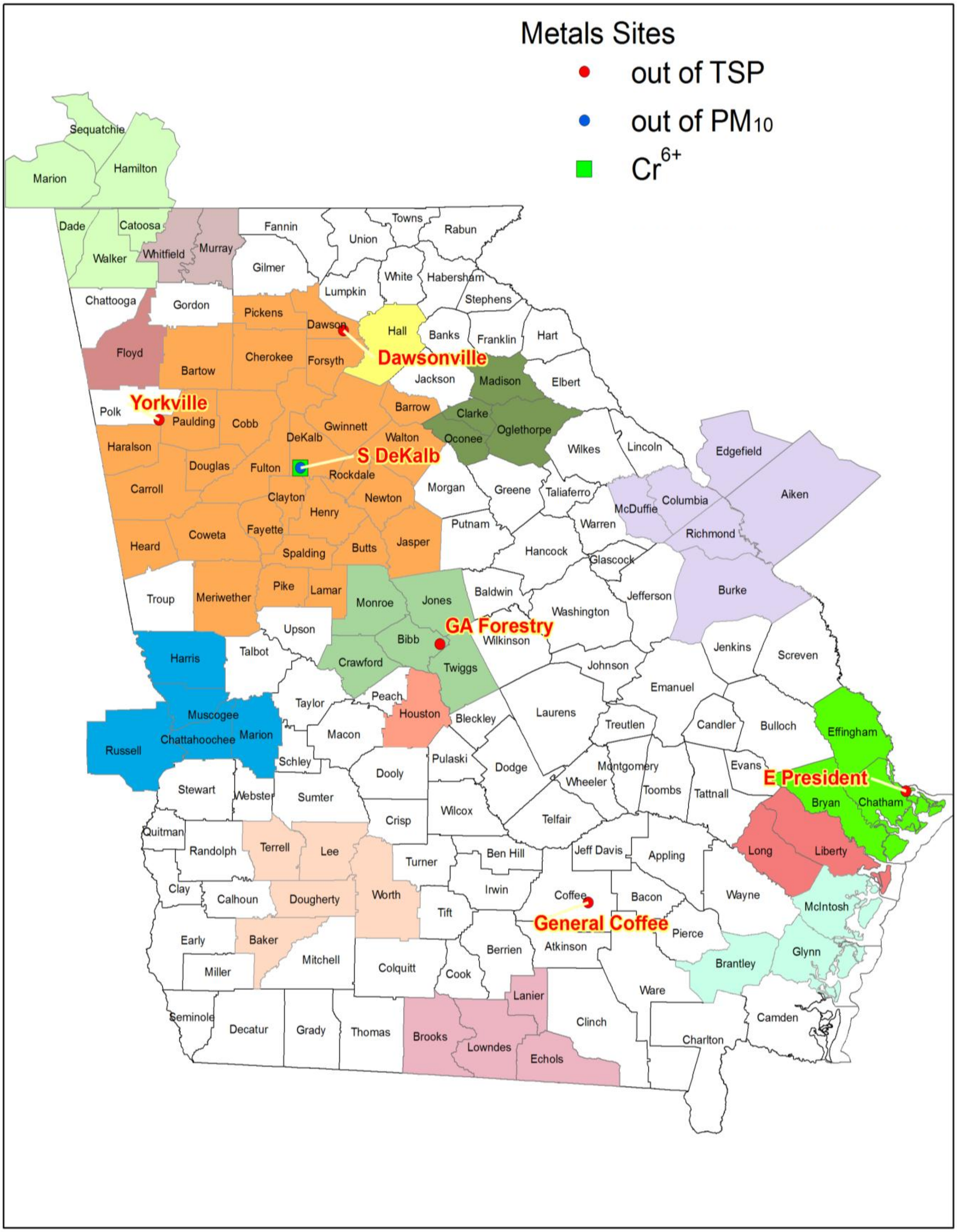


Figure 61. Metals monitoring site map, MSAs shown as solid colors

Figure 62 shows the percentage of the 11 metal species detected out of the total number of samples collected at each site for the years 2005 through 2013. Following EPA's guidance, a detection of any given pollutant is counted as any number that is above half the limit of detection. It is important to note that the South DeKalb metals sampler is designed to take the sample from the smaller PM_{10} fraction of the air as part of the NATTS network, while the other samplers in the Air Toxics Network collect samples from all the total suspended particles. Lower limits of detection (LOD) were introduced in September of 2004; therefore to be consistent, the data represented in these figures starts with 2005 data. There have been only nine full years of data collected at the lower limits, therefore true trends may not be discernible at this time. In Figure 62, the distribution of metals at various locations across the state can be clearly examined, as well as any changes to pollutant levels in the past nine years. The distribution across these six sites is relatively similar. For all sites, the percent detections remain around 70% to 90% of the total samples collected. Variability across sampling locations is modest, considering the vast geographic distribution of the sites, and climatological and anthropogenic influences from local urban development.

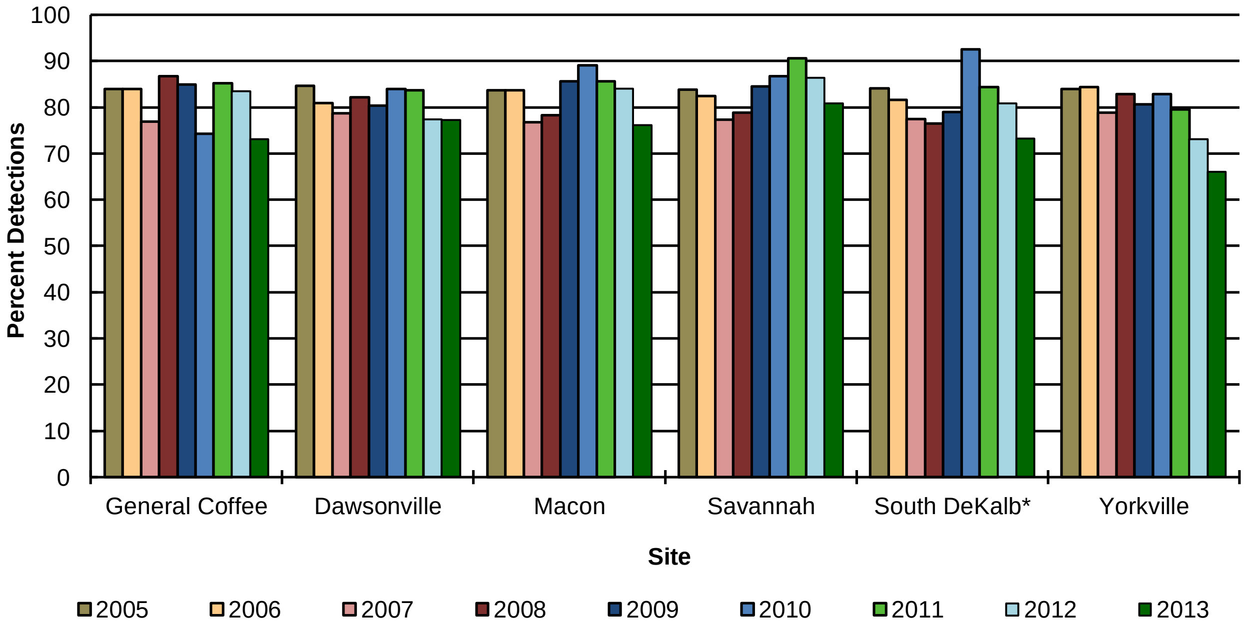


Figure 62. Percent of metals detections by site, 2005-2013

Figure 63 tracks the annual percent detection of each monitored metal species along with its annual average concentration for all the Air Toxics sites. This figure shows that most metals had several detections, with many up to 100% detection rate in some years, however, the overall concentrations remained low. This indicates that each detection contributed little to the overall concentration, with the exception of zinc. Its detection rate was similar to other metals (e.g. lead, manganese, and nickel) but it had the highest average concentration for all years shown. This would indicate that each zinc detection was associated with a higher concentration relative to the other metals. Some metals including zinc, nickel, antimony, lead, chromium, and cadmium have been associated with emissions from tires and brake linings. The use of vehicles on Georgia's roads could be a reason for higher levels associated with some of these metals. With the concentrations of zinc being much higher than the other metals, zinc is explored further in Figure 64, which examines the concentrations of zinc by site.

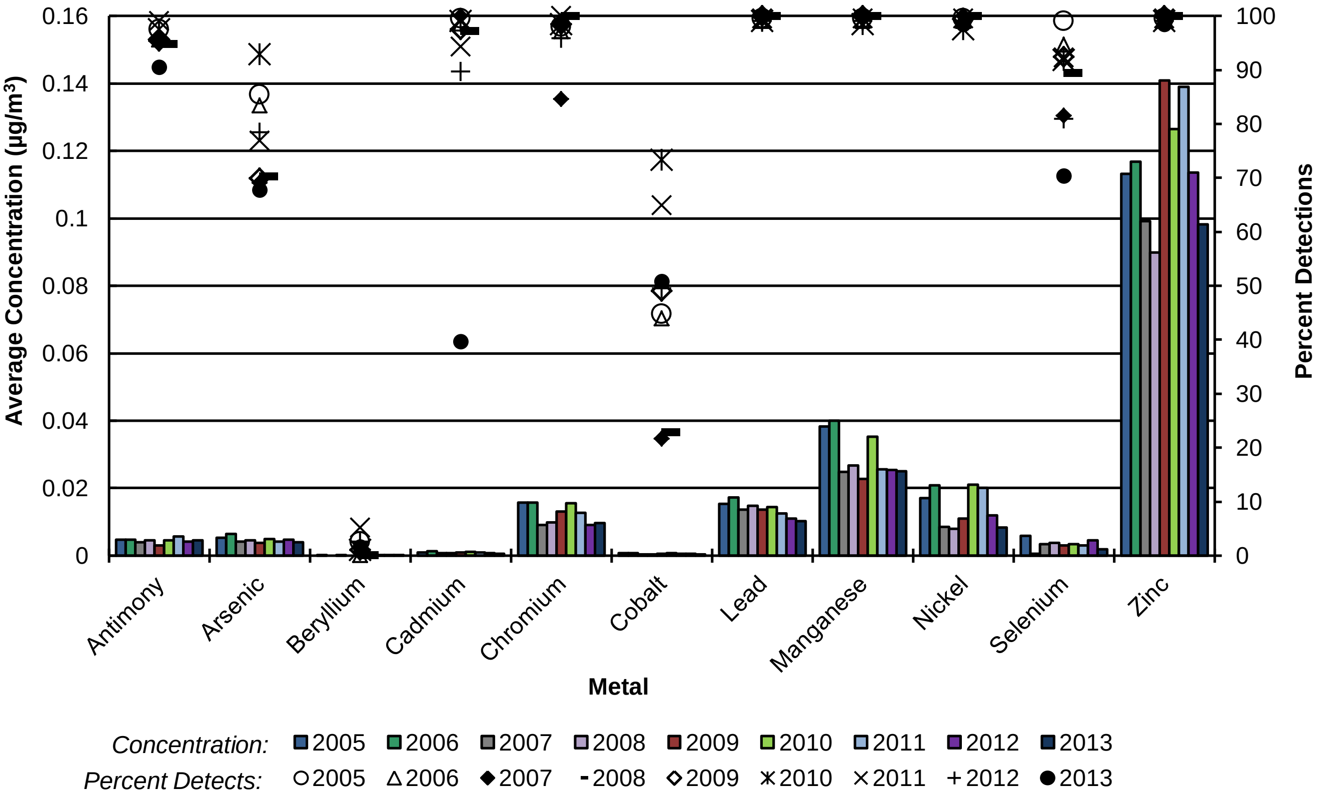


Figure 63. Average concentration and percent detections of metals, by species, 2005-2013

Figure 64 investigates the total average concentrations of zinc, divided by site, more closely for 2005 through 2013. It is important to note that zinc does not have a health based screening value (see Risk Assessment section for more details) that is considered harmful to humans. In addition, zinc is not one of the 187 hazardous air pollutants; however, it is reported here for completeness.

With a few exceptions, most sites have had a consistent level of zinc throughout the nine years of data. As noted earlier, the South DeKalb metals sampler is designed to take the sample from the smaller PM_{10} fraction of particles in the air, while the other samplers collect samples from all the total suspended particles. The lower levels at the South DeKalb site, in comparison, could be due to the larger particles (larger than PM_{10} size) being restricted by the sampler, indicating that some of the zinc sample could be lost in the larger, restricted fraction of particles. An obvious change over the nine years of data is the Macon site's 2009 average zinc concentration, which more than doubled from the 2008 average concentration. This data was investigated further; however, results were inconclusive as to the cause of the Macon site's higher values in 2009. The changes in zinc levels at the Macon site could be due to changes in local industry. Zinc can be released into the environment from mining, metal processing, steel production, burning coal, and burning certain wastes. In 2010, the average zinc concentration for the Macon site decreased by about half again, resulting in a level near that of 2008. There was a slight upward trend at the General Coffee and Savannah sites through 2011. However, after 2011, there has been a general downward trend of zinc concentrations at all the sites.

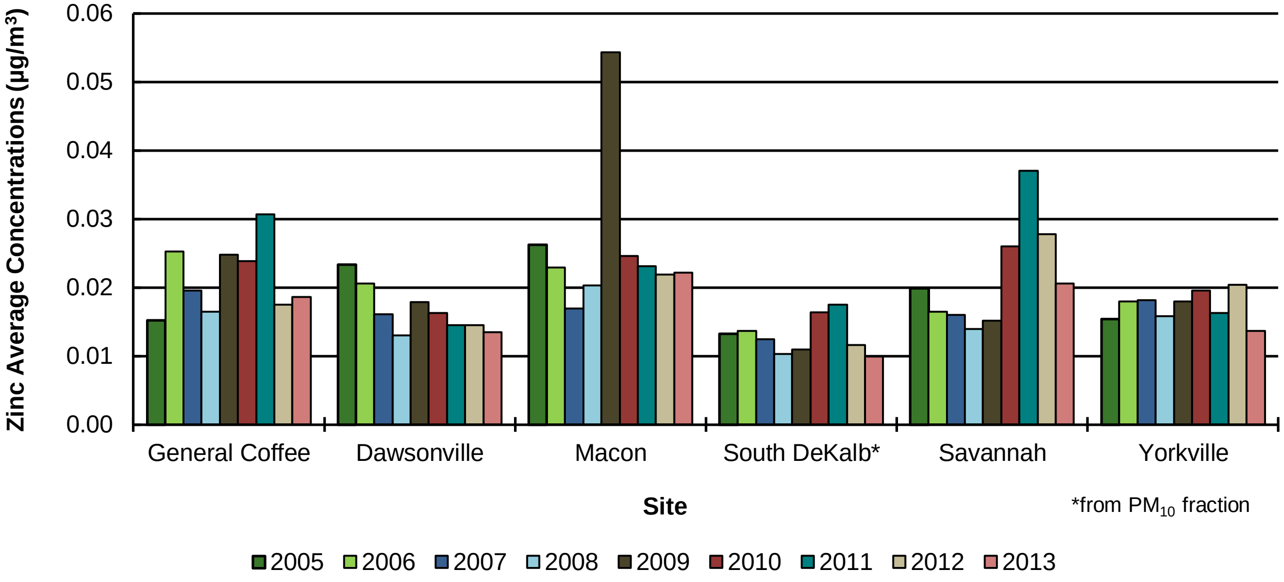
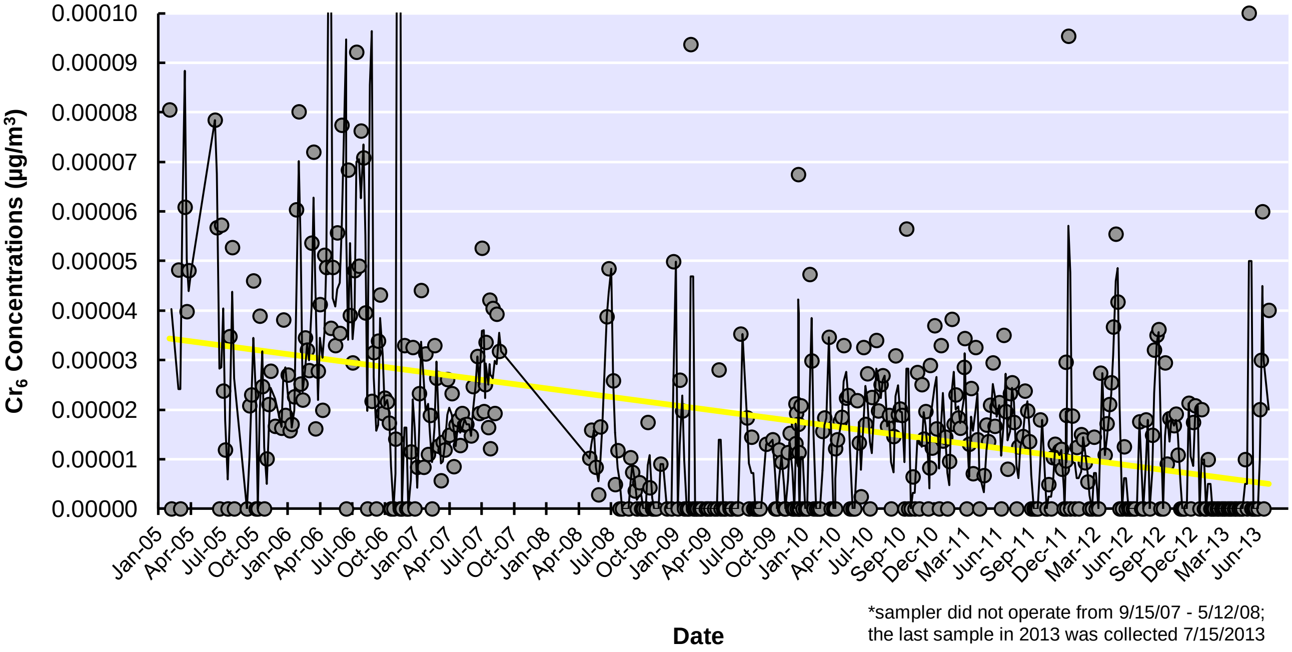


Figure 64. Average concentration comparison of zinc by site, 2005-2013

HEXAVALENT CHROMIUM (Cr_6)

Hexavalent chromium (chromium in its +6 oxidation state) in the environment is almost always related to human activity. Hexavalent chromium can be released into the atmosphere through the production of stainless steel, chrome plating, coating processes, and painting. It is also found in vehicle engines. The presence of chromium compounds is common at hazardous waste sites. From locations such as these, exposure of populations residing or working nearby can occur through inhalation of air containing particulates or mists of chromium compounds. These particles can also find their way into drinking water if soluble forms of chromium leach into groundwater. Human exposure can also occur through skin contact with soil at hazardous waste sites. Hexavalent chromium is absorbed most readily through the lungs or digestive tract. Other forms of the metal, such as chromium in the +3 oxidation state, occur naturally in the environment and are not as efficient at entering the body. In general, hexavalent chromium compounds are more toxic than other chromium compounds. The toxicity of hexavalent chromium is in part due to the generation of free radicals formed when biological systems reduce hexavalent chromium to the +3 oxidation state. Effects in humans exposed occupationally to high levels of chromium or its compounds, primarily hexavalent chromium, by inhalation may include nasal septum ulceration and perforation, and other irritating respiratory effects. Cardiovascular effects, gastrointestinal and hematological effects, liver and kidney effects, and increased risks of death from lung cancer may also result from such exposure. In addition to the respiratory effects, exposure to chromium compounds can be associated with allergic responses (e.g., asthma and dermatitis) in sensitized individuals. Hexavalent chromium dioxide is a tetravalent chromium compound with limited industrial application. It is used to make magnetic tape, as a catalyst in chemical reactions, and in ceramics. Because of its limited industrial uses, the potential for human exposure is less for chromium dioxide than for the more industrially important hexavalent chromium and chromium +3 compounds.

This is the ninth year hexavalent chromium has been monitored at the South DeKalb site, as part of the NATTS network. The data for 2005 through 2013 is presented in Figure 65. The sampler did not operate the last quarter of 2007 through part of May 2008; therefore, a gap in the data is shown. Observed concentrations range over an order of magnitude, from 0.00001 to 0.0003 µg/m^3 (micrograms per cubic meter). To observe the lower data points, the maximum concentration shown on the graph is 0.00010 µg/m^3. The observed concentrations are represented with the points, the black line represents a moving average across the data set, and the yellow line represents the overall linear trend in the dataset. It appears that from 2005 through 2007 the hexavalent chromium concentrations were sporadic and included some higher values. Then from 2008 through 2013, the concentrations seem more consistent and lower. The highest data point of 0.3 ng/m^3 was observed in 2006, while the highest data points from 2008 through 2013 were 0.1 ng/m^3. GA EPD discontinued this sampler in 2013; the last sample was collected on July 15, 2013.



*sampler did not operate from 9/15/07 - 5/12/08;
the last sample in 2013 was collected 7/15/2013

Figure 65. Hexavalent chromium concentrations at South DeKalb with moving average (black line) and trendline (yellow line)

VOLATILE ORGANIC COMPOUNDS (TO-14/15)

Volatile organic compounds (VOCs) make up a group of chemicals from various industrial, stationary, and mobile sources. VOCs reach the atmosphere by way of evaporative emissions as well as incomplete combustion processes. Chlorinated compounds are very stable in the atmosphere, with lifetimes of several years. Dichlorodifluoromethane, a chlorinated compound, was the refrigerant of choice for automotive cooling. This material has not been manufactured since the mid-1990s (cars now use R-134a), yet dichlorodifluoromethane remains prevalent in the environment. Chloromethane is a volatile industrial solvent. Toluene is a major component of paints, solvents and is also present in gasoline. Benzene is found in vehicle emissions, evaporation from gasoline service stations, emissions from the burning of coal and oil, and in industrial solvents. Carbon tetrachloride and the Freons are generally used as refrigerants, industrial solvents, and as fire suppressants (though generally known as Halon in that application). The atmospheric reactivity of aromatic compounds is relatively high, with lifetimes in the weeks to months range.

Figure 66 shows the statewide detection distribution of air toxic (TO-15) type volatile organic compounds (VOCs) from 2005 to 2013 across the state's Air Toxics Network. The detection of any given pollutant is counted as any number that is above half the limit of detection. The South DeKalb site has samples collected every six days; therefore, all of the site's detections are shown as a percentage of samples taken. The distribution is relatively even across the state, although the sites are located in different geographic regions, and have different local influences. The percentage of detections has remained relatively low throughout the nine years shown here. Out of all the VOCs samples taken, the percent detections have consistently been about 8% to 15%.

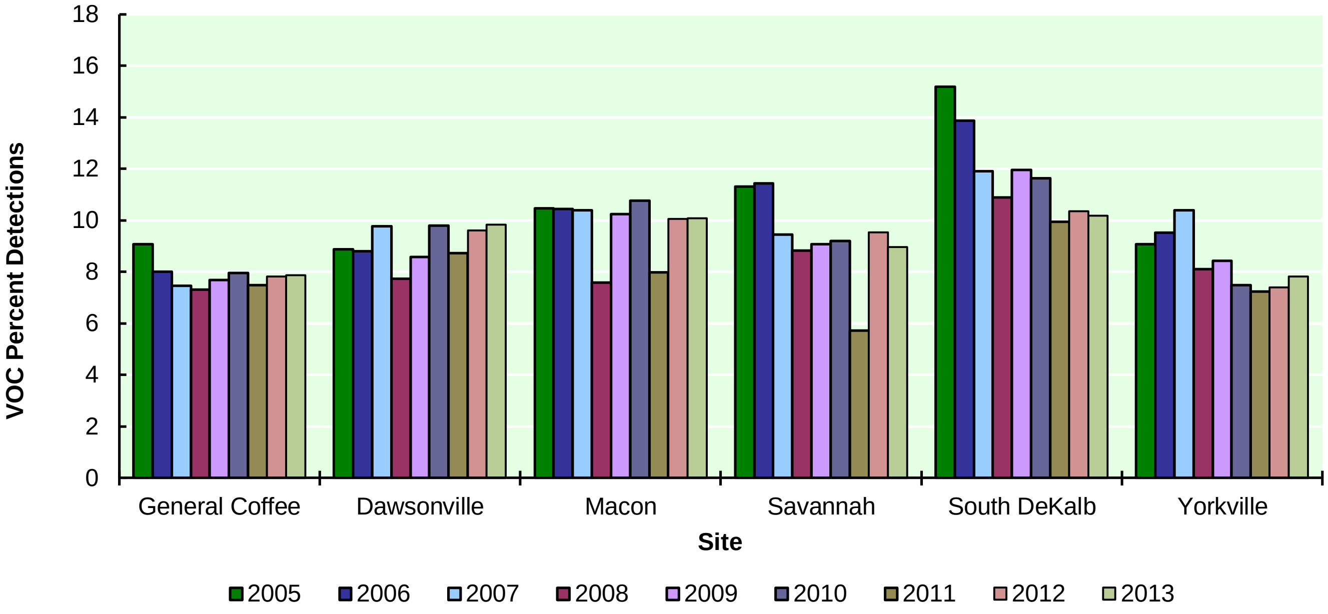


Figure 66. Percent detected total volatile organic compounds per site, 2005-2013

Figure 67 compares the relationship between the concentrations observed and percent detections above detection limit, showing the top ten compounds of the VOCs group that were detected for 2005 through 2013. Although there are 42 species in this analyte group, only a relatively smaller subset is typically detected with any regularity. The percentage of detections was derived using any detection that was above half of the method detection limit. To obtain the average concentration for compounds with a minimum of one detection, the half method detection limit for that compound was substituted for any number lower than that compound's half method detection limit. Chloromethane and trichlorofluoromethane consistently had the same pattern of the highest detection rates, but the total average concentrations were frequently the second and third highest over the nine years. This would indicate that the concentrations of chloromethane and trichlorofluoromethane are relatively average per each consistent detection. Conversely, dichlorodifluoromethane had one of the highest levels of concentration and one of the highest detection rates consistently for the nine years of data. This would indicate that for each detection, the dichlorodifluoromethane concentration had a consistently heavier weight. Although there have been some noticeable fluctuations with benzene and cyclohexane, the proportions of the VOCs have remained relatively consistent throughout the years.

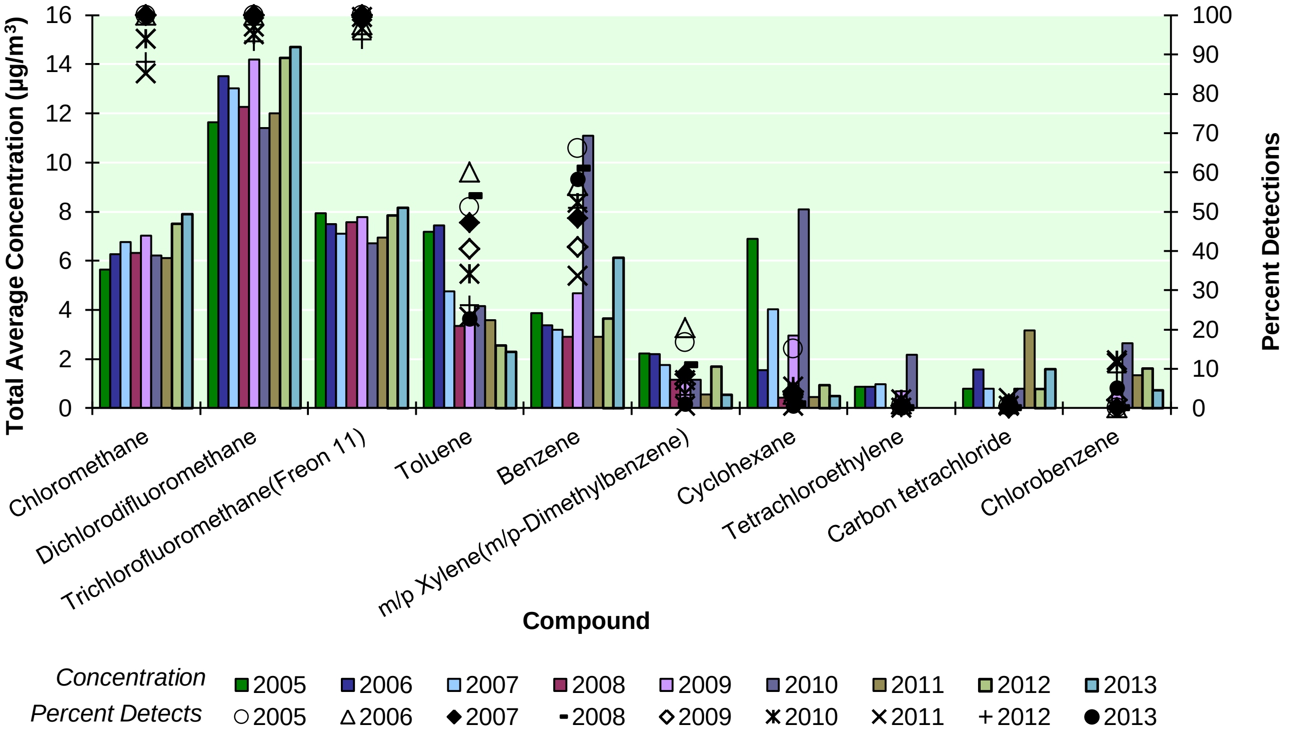


Figure 67. Average concentration and percent detection of common volatile organic compounds (TO-15), 2005–2013

Figure 68 shows the total volatile organic compound concentration, or loading, at each site for 2005 through 2013. This “total loading” measurement is produced by adding all the detected concentrations of all VOCs, even those below half of the detection limit as discussed earlier. It is intended as a surrogate measure showing general trends in overall VOC concentrations. When considering Figure 68, it is important to note that the South DeKalb site would appear elevated since this site has a larger number of scheduled samplings than the rest of the sites in the network. Samples are collected on a 6-day schedule at the South DeKalb site, as part of the NATTS network, as opposed to every twelve days at the other Air Toxics sites. It is important to note that the Macon site was shut down for most of 2008 (shown in maroon) due to damage to the site, causing that value to appear much lower than the other Air Toxics sites. In 2010, the Macon site had a significant increase in total concentration. These higher concentrations seem to be attributed primarily to cyclohexane, dichloromethane, and benzene samples. Then in 2011, the Macon site had a dramatic decrease, to levels below those of 2009, while the other sites’ total concentrations remained relatively stable. Since then, there has been little fluctuation at each site.

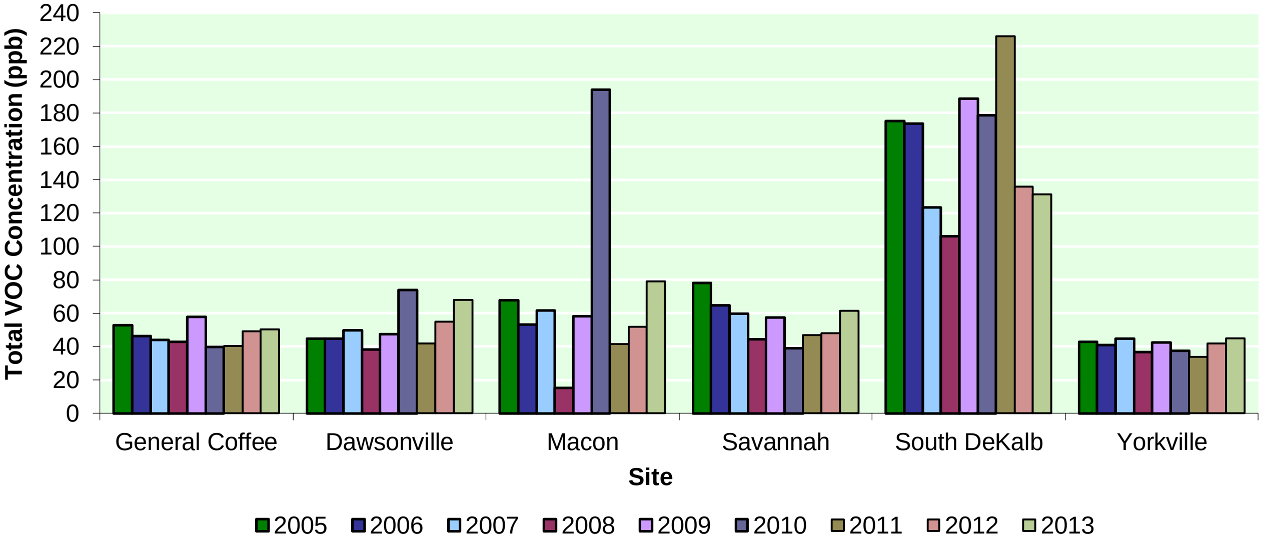


Figure 68. Total volatile organic compound loading for each site, 2005-2013

For a map of volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOC) monitoring locations see Figure 69.

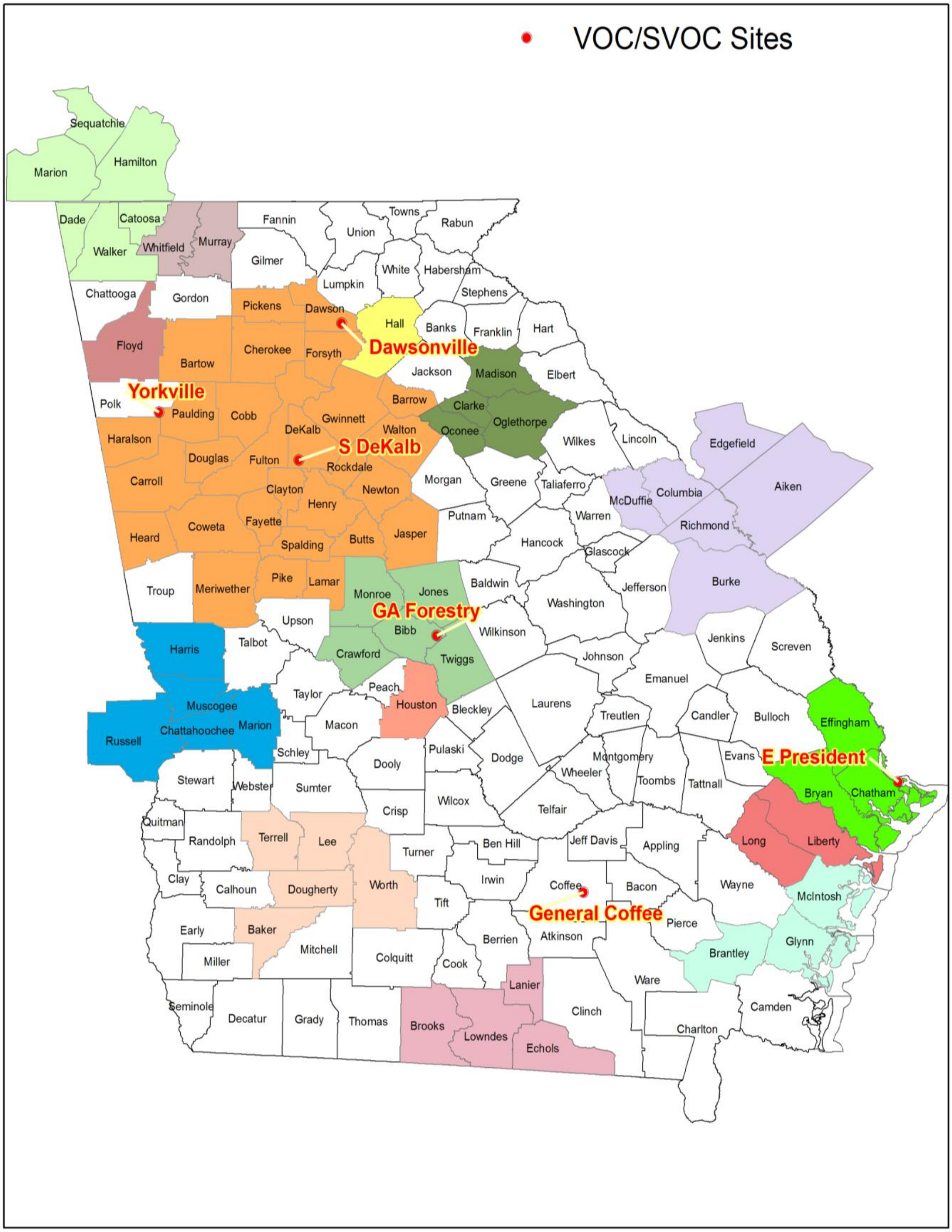


Figure 69. VOC and SVOC monitoring site map, MSAs shown as solid colors

SEMI-VOLATILE ORGANIC COMPOUNDS

Polycyclic aromatic hydrocarbons (PAHs), also called semi-volatile organic compounds (SVOCs) are chemical compounds that consist of fused, six-carbon aromatic rings. They are formed by incomplete combustion of carbon-containing fuels such as wood, coal, diesel fuel, fat or tobacco. Over 100 different chemicals are comprised within this designation. Many of them are known or suspected carcinogens. Some environmental facts about this class of compounds are listed below.

- PAHs enter the air mostly as releases from volcanoes, forest fires, burning coal, and automobile exhaust.
- PAHs can occur in air attached to dust particles.
- Some PAH particles can readily evaporate into the air from soil or surface waters.
- PAHs can break down by reacting with sunlight and other chemicals in the air over a period of days to weeks.
- PAHs can enter water through discharges from industrial and wastewater treatment plants.
- Most PAHs do not dissolve easily in water. They stick to solid particles and settle to the bottoms of lakes or rivers.
- Microorganisms can break down PAHs in the soil or water after a period of weeks to months.
- In soils, PAHs are most likely to stick tightly to particles. Certain PAHs can seep through soil to contaminate groundwater.
- PAH content of plants and animals may be much higher than the PAH content of the soil or water in which they live.

For a map of SVOC monitoring locations see Figure 69.

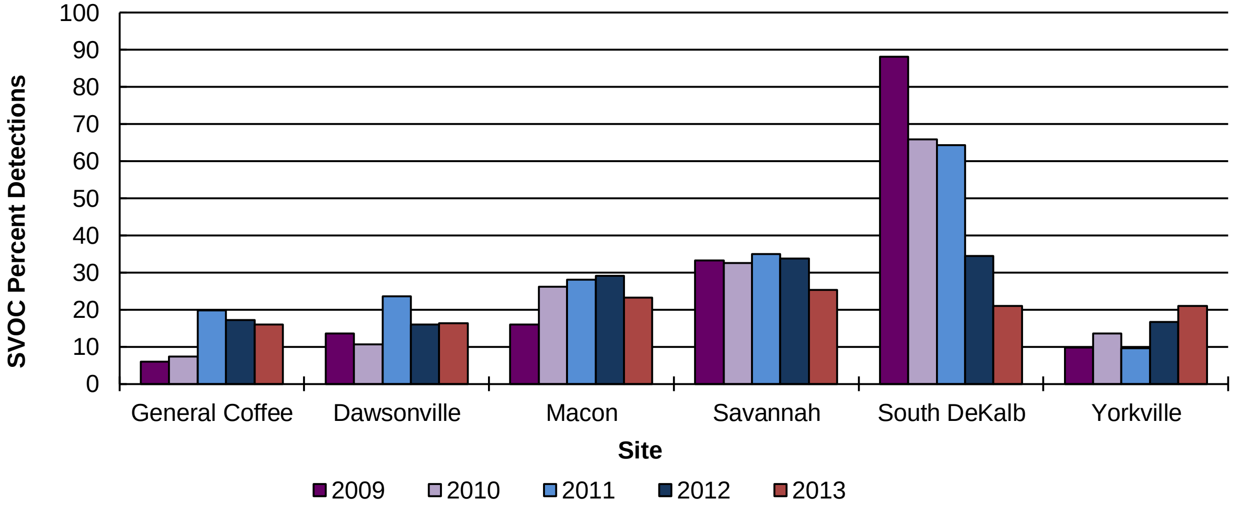


Figure 70. Percent detections of semi-volatile organic compounds per site, 2009-2013

Figure 70 displays the percentage of detections (according to site) from the fourth quarter of 2009 through 2013 for all semi-volatile organic compounds combined in the Air Toxics Network, as well as the South DeKalb (NATTS) site. Prior to the fourth quarter of 2009, the semi-VOCs data collected within the Air Toxics Network was analyzed by the GA EPD laboratory with a gas chromatograph with Electron Capture Detector, while the semi-VOCs data collected within the NATTS network were analyzed with a gas chromatograph by an EPA contract laboratory. Then, in the fourth quarter of 2009, the GA EPD laboratory began analyzing the Air Toxics Network data with a gas chromatograph, the same method used to analyze data from the South DeKalb site. This caused an increase in detection rate for the five sites in the Air Toxics Network. Traditionally, there were only a few compounds that would have any detections, and most compounds would have no detections. Since the change in laboratory analysis method, the detection rates have ranged from about 6% to 35%, for the five sites in the Air Toxics Network. Even though the same laboratory analysis method is used for this analysis, the South DeKalb data has shown some significantly higher percentages, up to 88% detection rate. As of July 2012, the GA EPD laboratory began analyzing the semi-VOCs collected at the South DeKalb site as well. Detections were counted as any number that was above half of the method detection limit. As data is collected in the future, the relationship between these sites will continue to be tracked. In addition, the data will be observed for possible continuing increase in detections with the gas chromatograph laboratory analysis method.

Figure 71 shows the percentage of detections compared to the total average concentration for the seventeen semi-volatile organic compounds that all six sites have in common from fourth quarter 2009 through 2013. The percentage detections were derived using any detection that was above half of the method detection limit. To obtain the average concentration for compounds with at least one detection, the half method detection limit for that compound was substituted for any number lower than that compound's half method detection limit. As discussed above, until 2009, the percentage of detections and average concentrations were very low. Before the laboratory analysis method change for the Air Toxics Network data, the percent detections were below 10% and the average concentrations were below 0.01 µg/m^3. With the laboratory analysis change in the last quarter of 2009, there were significant increases in detections and concentrations for some compounds. Since the analysis method is the same, the following graph combines the Air Toxics Network data and the NATTS data. The largest semi-VOC contributor in both total average concentration and percent detections is naphthalene. The concentrations of naphthalene range from about 0.09 µg/m^3 to 0.21 µg/m^3, and percent detections are around 92 to 99%. These concentrations are approximately four to nine-fold higher than the next highest concentrations of around 0.015 to 0.033 µg/m^3 for phenanthrene. Phenanthrene's total detections have been in the 80% to 95% range, indicating that there were several small concentrations detected, as compared to having higher concentrations for each detection of naphthalene. Over half of the compounds continue to have low average concentrations and percent detections below 50%. Polycyclic aromatic hydrocarbons such as these are found in the air from the burning of coal, oil, gas, and garbage, and are found in dyes, cigarette smoke, coal tar, plastics, and pesticides. They have been found to bother the skin and mucous membranes and have even been linked to cancer.

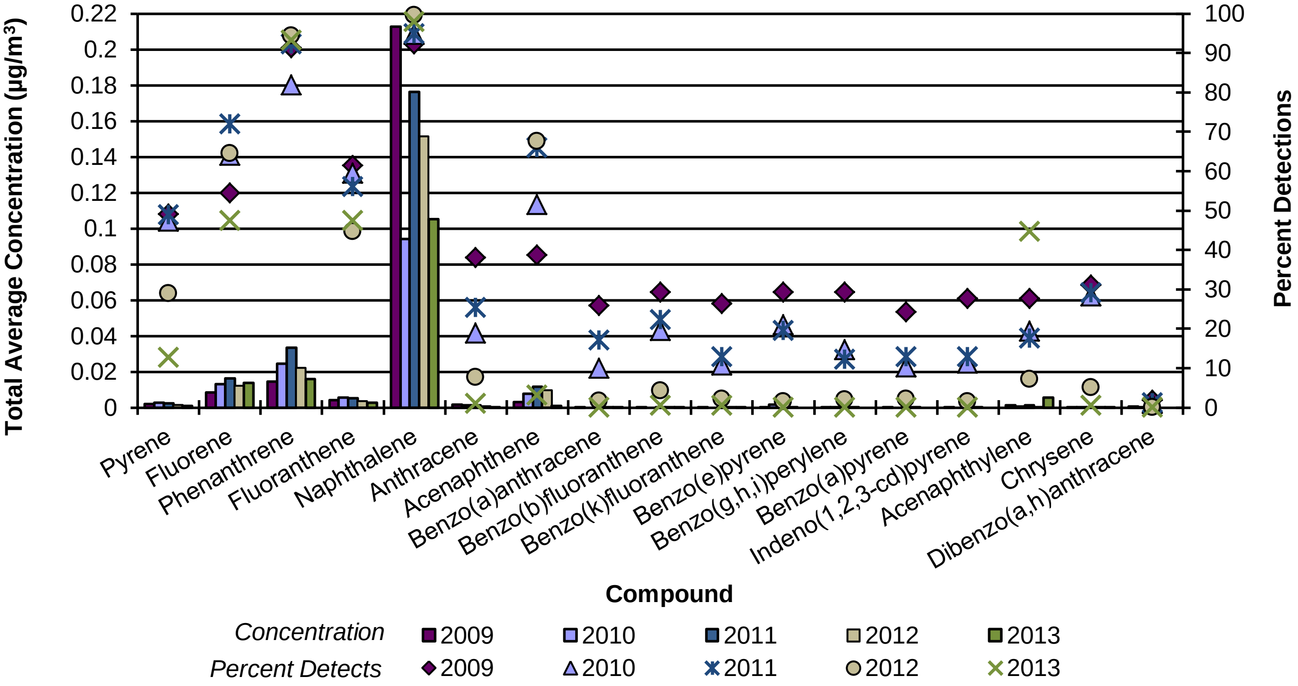


Figure 71. Total average concentration and percentage detections of semi-volatile organic compounds by compound, 2005-2013

MONITORING TECHNIQUES

In 2013 air toxics samples were collected from a total of six sites, including a NATTS site, and two background (rural) sites.

The compounds sampled at the ATN sites are shown in Appendix D. The list was derived from the 187 compounds EPA has designated as Hazardous Air Pollutants (HAPS). Many of the HAPS do not have standardized ambient air sampling and analytical methods. In order to collect the compounds of interest for the Georgia network, three types of samplers are used at all locations: the HIVOL, PUF, and canister. In addition, carbonyls were monitored at two of the ATN sites, as well as one NATTS/PAMS site, in 2013.

This equipment samples for metals, semi-volatile organic compounds, and volatile organic compounds once every twelve days following a pre-established schedule that corresponds to a nationwide sampling schedule. The South DeKalb site collects samples every six days, as part of the National Air Toxics Trends (NATTS) network. On the run day, the sampler runs midnight to midnight and takes a 24-hour integrated sample.

The HIVOL sampler used for sampling metals is a timed sampler. The sampler is calibrated to collect 1300 to 2000 liters of air per minute. Particulate material is trapped on an 8.5” x 11” quartz fiber filter. The particulates include dust, pollen, diesel fuel by-products, particulate metal, etc. The filters are pre-weighed at a remote laboratory prior to use and weighed again after sampling. The filters are subjected to a chemical digestion process and are analyzed on an inductively coupled plasma spectrometer.

The PUF (polyurethane foam) sampler used for sampling semi-volatile organic compounds (SVOCs) is a timed sampler. The sampler is calibrated to collect 198 to 242 liters (L) of air per minute. A multi-layer cartridge is prepared which collects both the particulate fraction and the volatile fraction of this group of compounds. The plug, filter and absorbent are extracted at a remote laboratory and analyzed using a gas chromatograph.

The canister sampler used for sampling volatile organic compounds (VOCs) is a timed sampler. A SUMMA® polished canister is evacuated to a near-perfect vacuum and attached to a sampler with a pump controlled by a timer. The canister is filled to greater than 10 psig. The canister is analyzed using a gas chromatograph with mass spectroscopy detection (GC/MS).

The carbonyls are sampled with two types of methods. One type is an absorbent cartridge filled with dinitrophenylhydrazine (DNPH) coated silica that is attached to a pump to allow approximately 180 L of air to be sampled. The cartridge is analyzed using High Performance Liquid Chromatography (HPLC). A 24-hour integrated carbonyl sample is taken every six days throughout the year. The other method used for collecting carbonyls is the cansiter sampler that is used for sampling volatile organic compounds. Acrolein is a carbonyl compound that is collected using the canister method, described above, and analyzed with the GC/MS method.

As part of the National Air Toxics Trends network, the above listed compounds, as well as hexavalent chromium and black carbon are monitored at the South DeKalb site. In addition, metals are monitored on a PM_{10} sampler at the South DeKalb site.

The hexavalent chromium sampler used for sampling Cr+6 is a timed sampler. Samples are collected at a flow rate of 15 liters of air per minute using a 37 mm diameter substrate of bicarbonate impregnated cellulose. The filter is controlled by an auto cover which remains closed until sampling, and fully exposes the filter when the sampler is running. The sample is analyzed using the modified California Air Resources Board (CARB) SOP 039. The filters are extracted in deionized water via sonication, which is analzyed by ion chromatography. Cr+6 is separated through a column, forming a complex with diphenylcarbohydrazide. Dianex Peaknet chromatography software is used to determine the peak analysis.

The aethalometer is a continuous sampler used for sampling black and organic carbon. Operating at 60 watts / 110V AC, the aethalometer uses quartz tape to perform an optical analysis to determine the concentration of carbon particles passing through an air stream. The analysis is conducted using spectrophotometry, measuring the wavelength of the light energy absorbed and plotting the results on the site computer.

The PM_{10} sampler used for sampling toxic metal particles less than or equal to 10 microns in diameter is a timed sampler. Collecting 1020 to 1240 liters of air per minute, the sampler uses a 8.5” x 11” quartz glass fiber filter to trap particulate matter. The sample is analyzed using inductively coupled plasma mass spectrometry (ICP-MS). In ICP-MS, an argon gas is used to atomize and ionize the elements in a sample. The resulting ions are used to identify the isotopes of the elements and a mass spectrum is used to identify the element proportional to a specific peak formed from an isotope.

ATTAINMENT DESIGNATION

Currently, there are no attainment standards for the air toxics compounds, with the exception of lead, which has its designation as a criteria pollutant. Air toxics measurements are performed to support the regulatory, analytical, and public health purposes of the program. While it is understood that these compounds are toxic, it is not well understood what airborne concentrations of each compound may be harmful. By collecting data about their current concentrations, researchers can later compare GA EPD’s data with health data to determine what levels of each compound may be safe.

METEOROLOGICAL REPORT

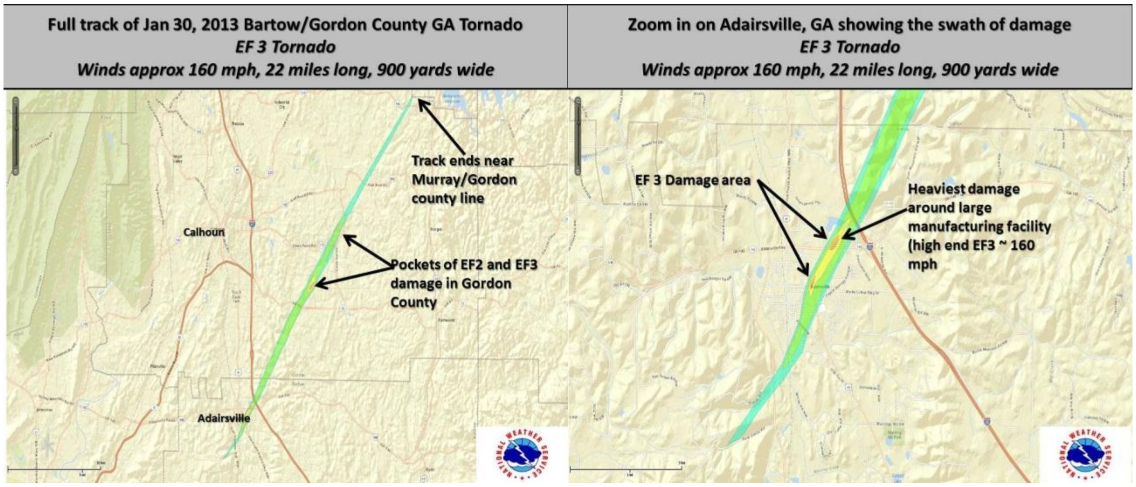
STATE CLIMATOLOGY AND METEOROLOGICAL SUMMARY OF 2013

The climate of north and central Georgia, which includes the metropolitan areas of Atlanta, Columbus and Macon, involves summers of warm, humid weather, and variable temperatures during the winter months. The climate across Northern Georgia is largely a function of terrain. Average amounts of rainfall reach between 45-50 inches, with September and October averaging as the driest months and the wettest being March.

The beginning months of 2013 consisted of a very “active” upper level pattern, which included fairly significant swings in temperature and precipitation across the Southeast. The positioning of the subtropical jet allowed ample amounts of Gulf of Mexico moisture to stream across the area, which aided in continuous periods of heavy rainfall occurring over the same locations for an extended period of time. Also on occasions, a dip in the jet allowed for brief intrusions of colder air into the state. Intrusions like this were evident on such days as January 25th, where the National Weather Service (NWS - Peachtree City) reported ice accumulations in areas of North Georgia. January struck a warm note as areas across the state observed above normal mean temperatures for the month. Atlanta set a record high temperature of 76°F on January 12th, breaking the old record of 75°F set in 1890. Macon also set a record high temperature on the 12th of 78°F, beating the old record of 77°F set in 1916. Columbus set several high temperature records during the period of the 12th–14th of January, reaching a maximum of 78°F on the 14th. The January temperature records continued across the state with Augusta also reaching several record highs. Augusta Regional Bush Field topped out at 81°F on the 12th, surpassing the previous record of 78°F set in 1916.

A large portion of the state received below normal rainfall during the month of January. A record low rainfall for the month was set at Augusta Regional Bush Field at 0.60 inches. This beat the old record of 0.75 inches last reached in 1981. The precipitation gradient across the state ranged from a deficit of 2-4 inches for much of Central and Southern Georgia to a surplus of 6-8 inches in parts of North Georgia. A slow moving cold front combined with significant moisture from both the Pacific and the Gulf of Mexico to create a heavy rainfall event mainly across Northwest GA during the week of January 14-18th.

The month of January ended on a stormy note as a supercell thunderstorm moved across northwest Bartow and central Gordon counties on the 30th. The NWS in Peachtree City determined an EF3 tornado, beginning southwest of Adairsville, GA and tracking 22 miles northeast, caused significant damage in Bartow and Gordon counties. The image below from the NWS shows the track of the tornado.



Full track of Jan 30, 2013 Bartow/Gordon County GA Tornado
EF 3 Tornado
Winds approx 160 mph, 22 miles long, 900 yards wide

Track ends near Murray/Gordon county line

Pockets of EF2 and EF3 damage in Gordon County

Zoom in on Adairsville, GA showing the swath of damage
EF 3 Tornado
Winds approx 160 mph, 22 miles long, 900 yards wide

EF 3 Damage area

Heaviest damage around large manufacturing facility (high end EF3 ~ 160 mph

Figure 72. Path of tornado in Bartow and Gordon counties, January 30, 2013

February was characterized by periods of heavy rainfall from storm systems moving through in the progressive upper level pattern. Continuous heavy rainfall for extended periods allowed for areas like Savannah to have its wettest February on record out of 143 years of data, with 9.75 inches. This was +6.83 inches for the month. Macon and Columbus also saw their wettest February on record, while Augusta was 4th wettest and Atlanta was 15th. Alma, in Southeast GA, recorded 9.54 inches of rainfall during the month which broke the old monthly record of 9.27 inches set in 1986. Several record daily maximum records were also set across the state on February 11th as a heavy band of precipitation moved through. The beneficial rainfall in February resulted in major drought improvement across Georgia. For the first time since August 2010, according to the Drought Monitor, the region was free of extreme drought.

The beginning of spring across the state was characterized by a colder than average March and continual improvement in long-term drought conditions. March was colder than the average winter temperature in some locations, as was the case in Atlanta. The average monthly temperature of 49.1°F for March in Atlanta was slightly lower than the average temperature of 49.2°F for the months of December to February of this year. March of 2013 was also 15.4°F colder in Atlanta than March of 2012, which averaged 64.5°F. Similar conditions occurred across much of the state, with temperatures near several coastal areas of Southeast Georgia averaging 5-7°F below normal. Record low temperatures of 27°F and 30°F were set on the 28th of the month in Athens and Macon, respectively. A record low of 38°F was also set in Brunswick on the 26th of the month, breaking the old record of 39°F, set in 1979. One primary cause of the cool temperatures was the Arctic Oscillation which had been extremely negative. Precipitation was slightly below-to-near normal across the state in March. Several frontal systems and associated rainfall brought some relief to the drought-stricken areas of North and Central Georgia. A cold front that pushed through on March 5th also brought with it nickel-sized hail in Fannin County and an EF-1 tornado in Glascock County, according to the NWS.

April reflected more near normal temperatures, with the continuing wet pattern allowing for removal of D1 and D0 drought areas in central and eastern sections of the state at the beginning of the month. More locally heavy rainfall eased moderate drought and long-term dryness across the state by the end of the month.

The month of May was characterized by cooler than normal temperatures and above normal rainfall in north, central and southeast parts of the state. Abnormally dry conditions remained in Southwest Georgia throughout the month. An ample supply of Gulf of Mexico and Atlantic moisture and a low pressure system led to a widespread rain event at the beginning of the month from the 4th to the 6th, with flooding across areas of north and central Georgia. Atlanta experienced a record daily maximum rainfall of 1.85 inches on the 4th, breaking the old record of 1.79 inches set in 1917. Alma and Brunswick received record daily maximum rainfall of 1.46 and 2.24 inches on the 5th, respectively, associated with the same low pressure system. According to the NWS, approximately 40 stream gage locations across north and central Georgia exceeded flood stage during that rain event, as the ground was already well saturated beforehand. Another round of strong convection moved through on the 19th and 20th of the month. Rainfall estimates showed 4 to 5 inches were received on the 19th in parts of Northeast Georgia.

May also experienced a cool trend with an average temperature of 68.6°F for the entire state, which was 2.6°F below normal. This was the 12th coldest May out of 119 years of data. Macon had its 4th coolest average temperature on record at 68.4°F, -3.5°F below the normal monthly temperature of 71.9°F. Atlanta and Columbus both reached low maximum temperature records on the 6th of the month, while Macon and Augusta tied and reached low temperature records on the 14th at 42°F and 40°F, respectively. Macon also set a record low of 49°F on the 25th.

The mean weather pattern for June featured a high pressure ridge over the western states with troughing prevailing for the east. An active storm track, centered north of Georgia, brought a series of disturbances through the state keeping June rather wet and unsettled. This pattern allowed for several days of moderate to heavy rainfall with many climate sites recording their wettest or near wettest June on record. Mean temperatures were generally near normal at most locations, with maximum temperatures slightly below average due to frequent cloud cover and rainfall. A notable severe weather episode affected portions of the north on the 13th producing widespread damaging wind along with two relatively uncommon June tornadoes. Climate impacts were wide-reaching, with saturated soils leading to crop damage and downed trees in many areas.

Above normal rainfall was experienced in nearly all portions of the state, with the exception of the extreme northwest, southwest, and along the coast. Particularly wet areas included portions of the east-central and southeast where many locations received well over 12 inches for the month of June. The greatest monthly totals observed included 18.5 inches at the co-operative observing site 4 miles northeast of Waycross and 18.36 inches in Kite. In contrast, relatively drier locations included Ringgold and LaGrange with 3.52 inches. A heavy thunderstorm in the Atlanta area dropped 4.14 inches at Hartsfield-Jackson International Airport on the 5th, setting both daily and monthly records for the greatest rainfall total for the 5th and for any single day in June. Augusta and Macon had their wettest June on record with 10.78 inches and 12.23 inches respectively. Temperatures across the state did not vary drastically from normal during June with mean temperatures at or above normal across portions of the northwest and south and at or below normal for the remainder of the state. With wet and cloudy conditions prevailing, many climate sites recorded slightly below average maximum temperatures and slightly above average minimum temperatures. This produced means that were near normal for the month. One exception was at Savannah, where the mean was +2.8°F above normal for the month.

A noteworthy severe weather event affected portions of North Georgia on the 13th of June, producing widespread damaging winds and two tornadoes. Particularly hard hit were portions of Cherokee, eastern Cobb, northern Fulton, and northern DeKalb counties. Two tornadoes, producing damage consistent with an EF-1 rating, were documented in Cherokee, Cobb, and northern Fulton counties.

July was marked by much wetter than normal rainfall conditions which led to slightly cooler than average temperatures across much of Georgia. A persistent Bermuda High pressure over the Atlantic, coupled with weak low pressure systems in the Gulf of Mexico, pulled moist air from the Gulf northward across Georgia. Heavy rainfall characterized the beginning of the month with the abundance of Gulf and tropical moisture. A stationary front to the west during the first week of July allowed significant moisture to be funneled into Alabama, Georgia and Tennessee. Rainfall totals across areas of Northeast Georgia were substantial, as was flooding in many areas from this event. One such flash flooding event occurred near and south of Gainesville, GA on the 8th, with radar-derived totals showing rainfall amounts exceeding 3-4 inches in approximately one hour. Local storm reports in Franklin County reported a mudslide and debris flow across portions of Highway 29 in Royston. The major climate sites of Atlanta, Athens, Columbus, and Macon observed above average precipitation totals of 8.48 inches, 9.19 inches, 8.81 inches and 6.99 inches, respectively, for the month of July. The average precipitation for the entire state during July was 9.10 inches, +3.53 inches above normal. The troughness and rainfall also provided cooler temperatures with a mean temperature for the entire state of 78.2°F. It was the coldest July since 1994 and ranked 11th coldest overall out of 119 years of record. Even during a relatively cool month, Metro Atlanta recorded one of few ozone exceedances this summer on July 30th, reaching Code Red.

The mean August weather pattern featured a mid-level high pressure ridge over the central states and anomalously strong troughness over New England. An active storm track, centered north of the state, kept Georgia's weather rather unsettled during the month. This wet and frequently cool pattern resulted in below normal temperatures and above normal precipitation for most areas. Heavy rainfall in the southwest and north central portions of the state allowed several cooperative observing sites to record their wettest August on record. Below normal temperatures were experienced in nearly all areas with the exception of the extreme southeast. Monthly means ranged from 3-4°F below normal for the north and east central to 1-2°F above normal in the Southeast. A warm spell occurred from the

9th-13th with daily maximum temperatures rising into the mid to upper 90s in central and southern areas. The month's warmest reading of 99°F occurred twice during this period at Valdosta and on the 15th at the cooperative observing site in Rocky Ford. Much cooler weather prevailed from the 15th-18th with many areas experiencing daily maximum temperatures of 10-20°F below normal. New daily low maximum temperature records were set during this period at Athens, Atlanta, Augusta, and Macon. Record low temperatures were also set or tied at Athens, Atlanta, and Columbus. After a slight warm up during the 21st-23rd, a dry continental air mass brought much cooler daily minimum temperatures from the 25th-27th. The month's coldest reading of 53°F occurred at the cooperative observing site near Clayton on the 26th.

Most areas saw above normal rainfall during the month of August, with the exception of a few isolated locations. Surpluses ranged from over 6-8 inches in the southwest and north central to 2 inches in the extreme southeast. Isolated deficits of up to 4 inches were noted southeast of Waycross. A particularly wet period occurred from the 14th-19th in association with a stationary front. On the 14th Columbus set new records for maximum daily rainfall both for the 14th and for any day in August with 5.73 inches. This was also the second highest total for any calendar day, falling just short of the record 5.74 inches set on April 1, 1984. Alma also set a new record daily maximum on the 16th with 2.20 inches; breaking a record of 1.94 inches set in 1971. Macon recorded its second wettest August on record with 10.20 inches, while Columbus observed its fourth wettest August with 8.63 inches. A tornado occurred in Heard County on the 18th, producing damage consistent with an EF-1 rating. This tornado traveled four tenths of a mile and caused roof damage to one mobile home. Numerous trees were snapped along its path. Many areas experienced localized flash flooding during the month. Gilmer County was particularly hard hit, with swift water rescues and infrastructure damage occurring on the 1st. Another round of heavy rain brought additional flooding and damage to the county on the 7th.

Many areas saw below normal rainfall during the month of September, with the exception of portions of the northwest and south central. Surpluses in these areas ranged from 1 to 1.5 inches, with isolated 2 inch amounts. Deficits across the remainder of the state averaged 1 to 2 inches, with isolated 3 to 4 inch areas. Among the drier locations were the Northeast Georgia Mountains, the fall line region, and along the coast. The month started on a wet note across the north, with scattered thunderstorms on the 1st, followed by heavier and more widespread rainfall on the 2nd and 3rd. A daily rainfall total of 3.36 inches was observed near Villa Rica during this event on the 2nd, with this being the second greatest 24-hour total reported in the state during September. The focus for heavier rainfall gradually shifted into South Georgia through the 8th as a cold front drifted southward. After a relatively dry period from the 9th through 12th, a cold front brought renewed convection and rainfall to the north on the 13th, with generally lighter amounts across the central and south through the 16th. Isolated heavier rainfall amounts were reported in Wilcox (17th) and Camden (18th) counties before the front finally exited the state on the 19th. A notable wet period affected portions of the state from the 21st through the 26th as an initially progressive front became stationary across the south. The month closed on a quiet note, with generally dry conditions from the 27th through the 30th.

Average temperatures were near normal across much of the state for September, with slightly above normal temps in cities such as Atlanta and Columbus. The average temperature in Atlanta was 74.4°F (0.9°F above normal). The average in Columbus was a bit warmer at 77.9°F (1.3°F above normal). The Augusta area began the month with warmer temperatures before settling into a cooler pattern by the end of the month. The average temperature at Augusta Regional Bush Field was 74.5°F or 0.1°F below the normal of 74.6°F. The highest maximum temperatures across the state were in Valdosta and Waycross, which reached 99°F and 97°F, respectively.

October was characterized by warmer than normal temperatures and below normal rainfall. Climatologically, the fall season is one of the driest periods for the region. Atlanta, Columbus, Macon and Athens were among major climate sites that recorded -0.84, -2.13, -2.17, and -2.28 inches below normal rainfall, respectively. The total precipitation at Augusta Regional Bush Field was 0.36 inches or

2.91 inches below the normal of 3.27 inches. It was the 16th driest October on record at Augusta. The Warrenton Cooperative Observing site had no rainfall for the entire month, which set a record for its driest month on record. A brief heavy rainfall event occurred at the beginning of the month, as a cold front moved across the region on the 7th and 8th. Radar estimated that over 4 inches of rain fell along the McIntosh/Liberty county line on the 7th. Nearby CoCoRaHS observers reported one to nearly two inches of rain during the same period. Abnormally dry conditions spread across portions of eastern and southeast Georgia towards the end of the month, earning a designation of D0 by the U.S. Drought Monitor. This designation typically indicates short-term dryness, slowing planting, and growth of crops or pastures.

Temperatures across the state in October were near to slightly above normal for most areas, and departures ranged from two degrees above normal across portions of the west central to one degree below normal over portions of the southeast and north central. A warm spell occurred from the 4th through the 7th with temperatures in central and southern sections reaching well into the 80s and lower 90s. The Valdosta Regional Airport recorded a maximum temperature of 92°F on the 4th, which was the warmest daily maximum observed in the state during the month. Slightly cooler conditions prevailed from the 8th through the 11th following a frontal passage, with moderating temperatures through the 13th. A series of cold fronts brought colder conditions from the 17th through the 27th, with freezes observed at several locations in the north and central areas. The season's first freeze was reported on the 20th at the Blairsville Cooperative Observing site, while the month's coldest daily minimum of 25°F occurred at LaFayette (on the 25th) and Toccoa (26th). Temperatures following this cold spell began a slow moderating trend which continued for the remainder of the month.

The mean weather pattern for November featured a high pressure ridge over the eastern Pacific with troughing prevailing over eastern Canada and New England. An active upper level flow pattern brought a series of weather disturbances through the state keeping the month rather cool and unsettled. Mean temperatures were below normal statewide, with the coldest readings in the north. Cold-air outbreaks on the 13th and 28th brought record low temperatures to some locations. Mean temperatures across the state were below normal, with departures ranging from less than one degree below normal in the southeast to over five degrees below normal in the northwest. Temperature departures at the first order climate sites ranged from -4.0°F at Athens to -0.5°F at Savannah.

The month of November began on a mild note temperature-wise, with mean temperatures from the 1st through 7th in the lower 50s (north) to lower 60s (far southeast). Slight cooling occurred on the 8th after the passage of a weak cold front, with temperatures moderating through the 11th. A strong cold front impacted the area on the 12th, with cold temperatures statewide on the 13th and 14th. Several cooperative observing sites in northern Georgia recorded daily minimum temperatures in the teens during this period. Among the coldest readings were 13°F at LaFayette (on the 14th), and 14°F at Blairsville (13th). This is the earliest date on which LaFayette has recorded a temperature this low (the previous earliest date was 11/15/40 with 11°F and 11/15/69 with 13°F). Atlanta's Hartsfield-Jackson International Airport also recorded its first freeze of the season on the 13th with 28°. This date coincides with the historical average first freeze date for Atlanta.

After a brief warm spell on the 17th and 18th of November, temperatures again cooled following the passage of a cold front on the 19th. Further cooling continued through the 25th as a modified area of arctic high pressure settled into the region. Following the passage of a strong upper level trough and associated surface wave on the 26th and 27th, high pressure again built into the region with good radiational cooling allowing for record cold temperatures at a few climate sites. Augusta and Macon set new record low temperatures on the 28th with 21°F, breaking their existing low temperature records of 22°F, set in 1903 (Macon) and 1938 (Augusta). The Elberton cooperative observing site also recorded a low of 13°F on the 29th.

November continued the pattern of below normal rainfall across much of the state. Rainfall ranged between 1 to 3 inches in a large swath of western and central Georgia, which is 25-50% of normal.

Atlanta and Columbus both fell over 2 inches below normal for the month, receiving 1.87 inches and 1.79 inches, respectively. Rainfall totals across southeast Georgia were generally above normal for the month, primarily due to a storm system that moved through on the 26th-27th. Alma set a daily rainfall record of 2.60 inches on the 26th, which also was the maximum daily precipitation total for the month. St. Simons Island also set a daily rainfall record of 1.19 inches on the 26th, which broke the old record of 0.70 inches set in 1976. The greatest daily rainfall total for the entire state was 4.63 inches at the Pearson CoCoRaHS site on the 27th. The highest monthly rainfall total of 9.73 inches was recorded at the Elijay site in North Georgia. By the end of November, Elijay was a little over an inch shy of breaking its wettest year on record, which was 1967, when 84.69 inches of precipitation fell that year. White County in northern Georgia was also well above average for year-to-date rainfall with 85.47 inches by the end of November. That total was +23.58 inches above normal and +44.15 inches above rainfall amounts this same time last year.

The mean circulation pattern in December featured pronounced ridging over the eastern north Pacific and western North America, with troughing prevalent from eastern Canada into the central United States. An active storm track combined with an absence of cold-air intrusions kept the state relatively warm and wet throughout the month. Monthly average temperatures were above normal statewide, with the greatest departures found along the upper coast. Savannah had a mean temperature of 57.3°F, which is 5.6°F above normal for December. Several daily temperature records were set during warm spells on the 5th-6th and 21st-22nd, with monthly maximum temperature records set at Augusta and tied at Savannah with 83°F.

Precipitation was variable across the state in December. Coastal sections remained driest, with departures of around one inch below normal. Conversely, portions of the west central and north received plentiful rainfall with departures exceeding four (to locally six) inches above the mean. Athens received 7.62 inches (3.89 inches above normal), Atlanta had 7.80 inches (+3.90 inches), Augusta had 6.90 inches (+3.51 inches), Columbus had 8.87 inches (+4.60 inches), Macon had 9.04 inches (+5.00 inches), and Savannah had 2.38 inches (+0.57 inches). Noteworthy precipitation events occurred on the 23rd and 29th, resulting in widespread stream and isolated stem river flooding primarily in northern and central portions of the state.

SUMMARY OF METEOROLOGICAL MEASUREMENTS FOR 2013

A complete suite of meteorological instrumentation is used to characterize meteorological conditions around metropolitan Atlanta. The basic surface meteorological parameters were measured at the Photochemical Assessment Monitoring Sites (PAMS). The PAMS sites are Conyers, South DeKalb, Tucker, and Yorkville. The South DeKalb site is also a National Core Multi-pollutant site (NCore) and a National Air Toxics Trends Station (NATTS) site as well. The Tucker site primarily records meteorological data for possible future modeling or comparative purposes. The Tucker site was discontinued in May 2013. All PAMS sensors measure hourly-averaged scalar wind speed and vector-averaged wind direction at the 10-meter level, and hourly-averaged surface temperature, relative humidity and barometric pressure at the 2-meter level. Several sites include instruments to record precipitation, global solar radiation and total ultraviolet radiation. The standard deviation of the wind direction is also computed at the South DeKalb (NCore, NATTS) site. A ceilometer was installed at South DeKalb to monitor the evolution of the atmospheric boundary layer and the growth of the mixing height. A map of the GA EPD meteorological network, as well as specific instruments at each site, is detailed in the figure and chart below.

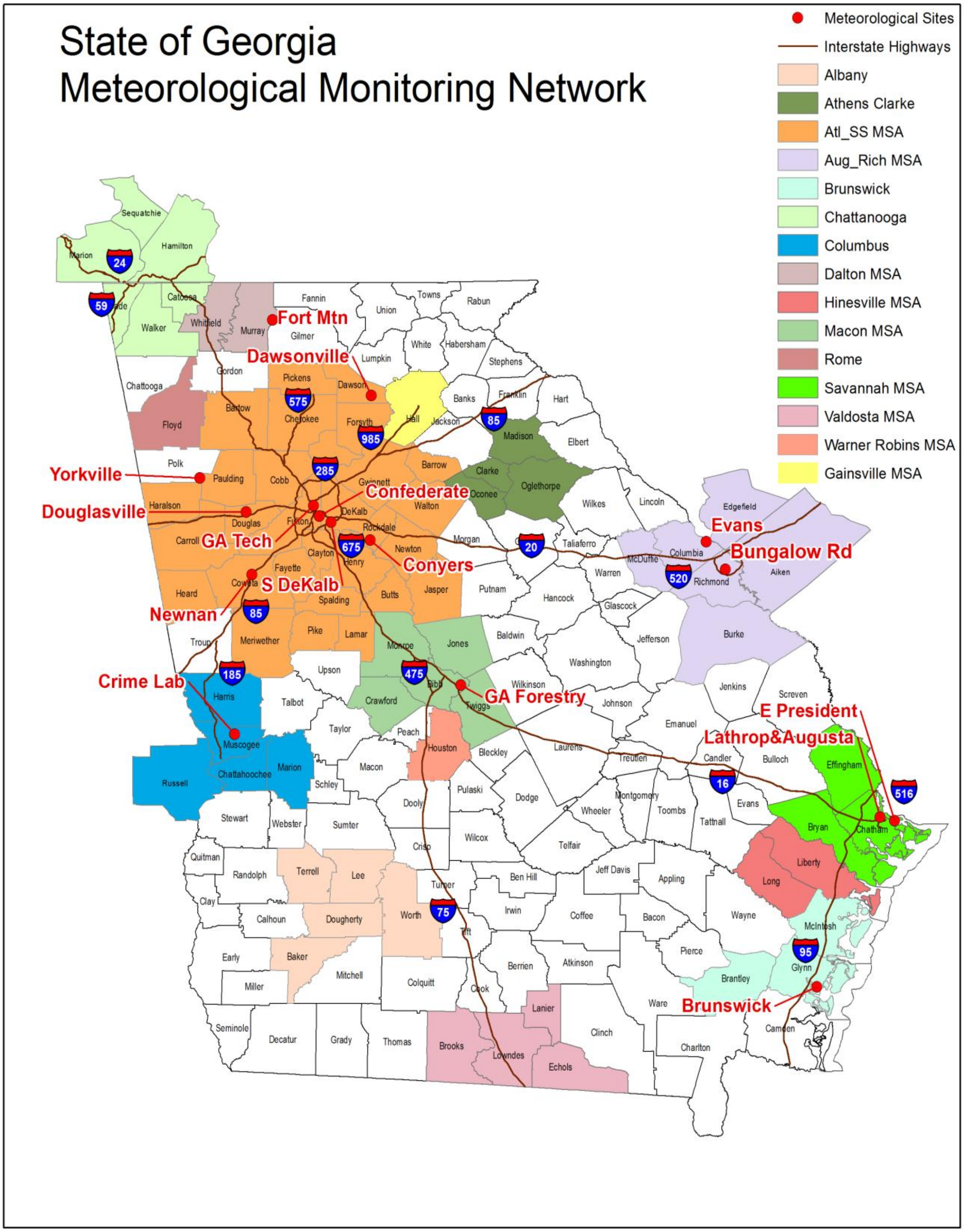


Figure 73. Meteorological Site Map

Table 4. List of equipment at each meteorological site

PARAMETER	COMPANY	INSTRUMENT	MODEL	LOCATION																LEGEND	
				1C	1E	1G	1H	1I	1K	1U	2B	2D	2E	2F	2K	2N	2U	3D	4K	1C	Augusta
WSP/WDR	R.M. Young	Ultrasonic Anemometer	81000	X	X	X		X	X		X	X		X	X			X	X	1E	Brunswick
	R.M. Young	Ultrasonic Anemometer	85000				X						X			X	X			1G	Col Cr Lab
	R.M. Young	Wind Monitor A.Q.	05305VM							X										1H	Confed Ave
ATP10/ELEV	R.M. Young	Ultrasonic Anemometer	81000	X	X	X		X	X		X	X			X				X	1I	Conyers
ATP2/RH	R.M. Young	TEMP/RH Probe	41375VC	X		X				X		X				X	X			1K	Dawsonville
	R.M. Young	TEMP/RH SENSOR, DEG C	41382VC					X			X									1U	S DeKalb
BP	R.M. Young	Barometric Pressure Sensor	61201	X				X				X								2B	Sav Pres
	R.M. Young	Barometric Pressure Sensor	61302V			X				X	X									2D	Yorkville
PRECIP	Novalynx	Tipping Bucket Rain Gauge	260-2501	X		X		X		X		X								2E	Macon SE
S/R	Eppley Lab	Standard Precision Pyronometer	SPP					X				X								2F	Douglasville
TUVR	Eppley Lab	Total Ultraviolet Radiometer	TUVR					X				X								2K	Newnan
Data Logger	ESC	Data System Controller	8832	X	X		X	X	X	X	X	X	X	X	X	X	X		X	2N	Fort Mt
	ESC	Data System Controller	8816			X														2U	Evans
Towers	Aluma Tower Inc.	Crank-Up Tower	T-135	X	X	X	X	X		X	X	X	X	X	X			X	X	3D	NR-GAT
	Aluma Tower Inc.	Fold-Over Tower	FOT-10						X							X	X			4K	Sav L&A

OZONE AND $PM_{2.5}$ FORECASTING AND DATA ANALYSIS

Each day a team of meteorologists from Georgia Department of Natural Resources, Environmental Protection Division (EPD) and Georgia Tech scientists meet at 1:30 EST to issue an air quality forecast for the Atlanta, Macon, and Columbus metropolitan areas. The air quality forecast is then relayed to the Clean Air Campaign and EPA, which disseminate the forecast to important national outlets, such as National Weather Service (NWS), USA Today, and The Weather Channel. The forecasts are determined based upon several meteorological factors, such as the synoptic regime, surface and upper air meteorology, satellite imagery, as well as the ambient concentration of pollutant. Multiple 2D and 3D forecasting models generated by Georgia Tech are utilized in addition to NWS synoptic forecasting models. These synoptic models consist of the North American Model (NAM/WRF), the Global Forecasting System (GFS), the European, and the Canadian models to name a few.

In 2013 there were three ozone violations in the Metropolitan Atlanta area (*see Meteorological Appendix A below*). During much of the summer of 2013, Georgia experienced extensive troughness. The Bermuda/Azores High pressure system was positioned over the Atlantic as such that most of the state was positioned on the western flank of the ridge. This kept good return flow from the Gulf of Mexico in place with moist and unstable conditions, typical of El Nino-Southern Oscillation (ENSO) neutral conditions. There were very few days during the summer where the mid-level and surface ridge axes were directly positioned over North GA. Thus, moist and unstable conditions persisted with somewhat elevated dew points from Gulf moisture advection on several days. The first ozone violation occurred on June 14th (78 parts per billion by volume for 8-hour average) at EPA's Pike County site monitor. This violation was primarily due to dry downslope flow from the northwest, following a frontal passage earlier during the day (*see Meteorological Appendix B below*). Post-frontal conditions such as these during the summer typically can cause sites south and southeast of Metro Atlanta to have elevated levels of ozone, as long as wind speeds are not too high. The second violation did not occur until much later in the season on July 30th.

The violation that occurred on July 30th was mainly due to a ridge of high pressure that set up across North GA as a weak stationary front gradually stalled across South GA. Surface winds were light and variable with some possible local recirculation around the Metro Atlanta area. There was a small dry stable pocket that developed across North GA around the Metro Atlanta area due to subsidence from the ridge of high pressure. That violation seemed to be a good example of local production because it occurred around the Metro Atlanta area at the Confederate Avenue and South DeKalb sites.

The ozone violation that occurred at Confederate Avenue on September 5th was mainly due to brief ridging and a ridge axis across the area with a weak decaying front positioned just south of Metro Atlanta. The presence of an upper level ridge building to the west, combined with the exit of an upper level east coast trough, helped promote subsidence over the area. This could be verified by Peachtree City rawinsonde data and good dry downslope flow across North Georgia. Also evident from the 12Z September 5th sounding was a strong surface inversion, indicative of limited vertical mixing.

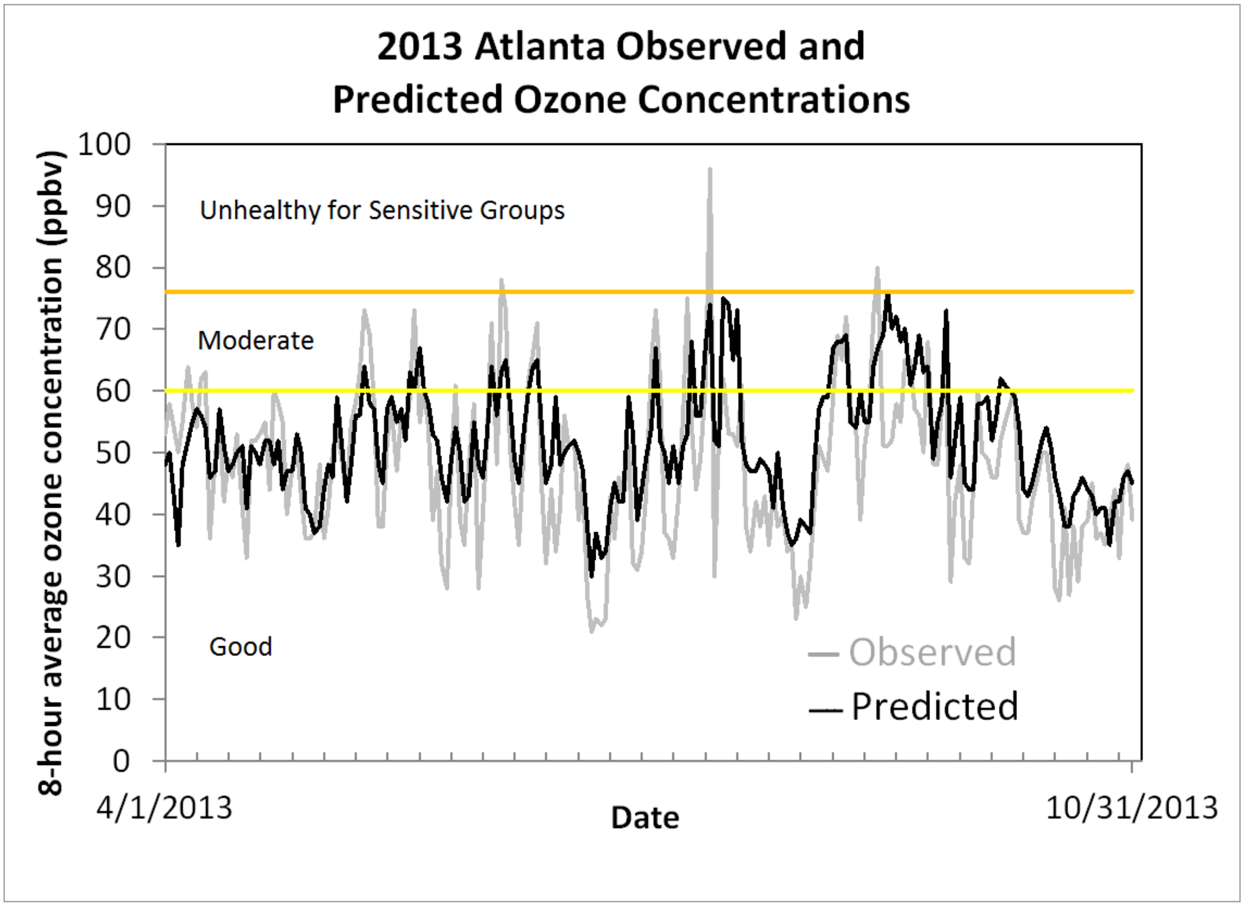
Statistical characteristics of daily team forecasting during the 2013 air quality forecasting season are given below for the cities of Atlanta, Columbus and Macon. The statistics are based on team daily predicted and final daily observed continuous ozone and $PM_{2.5}$ data (daily peak 8-hr average and daily 24-hr average, respectively).

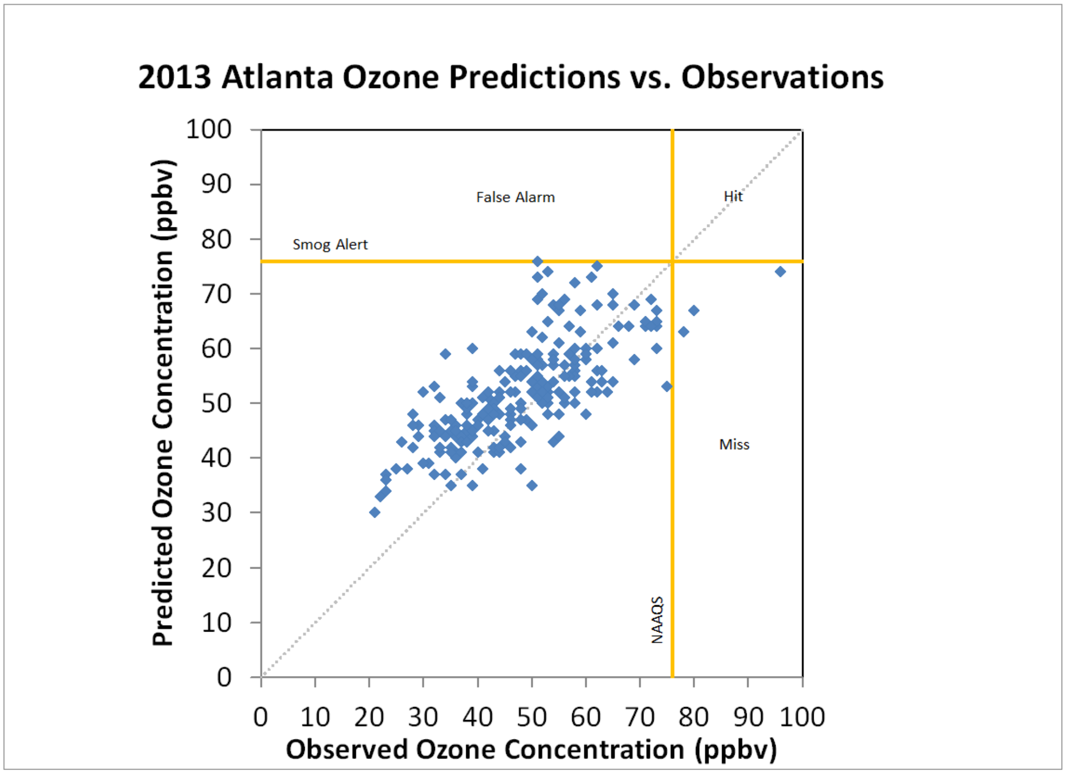
Meteorological Appendix A

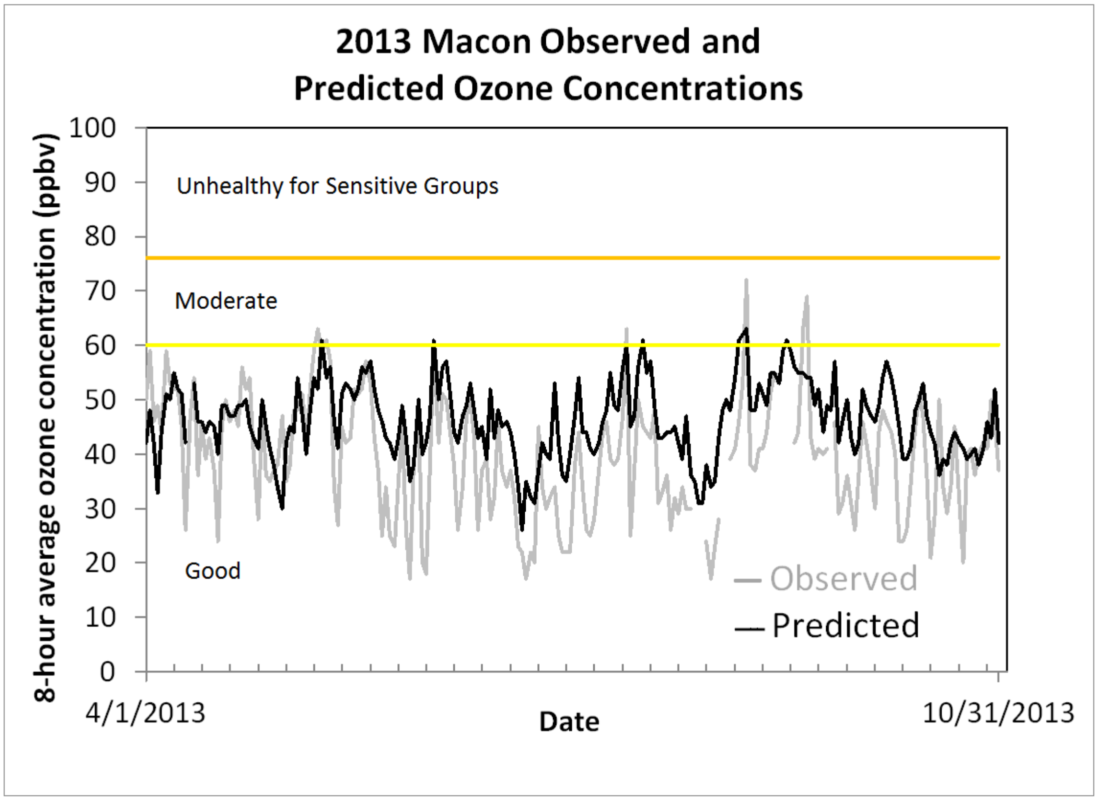
Observed Air Quality:

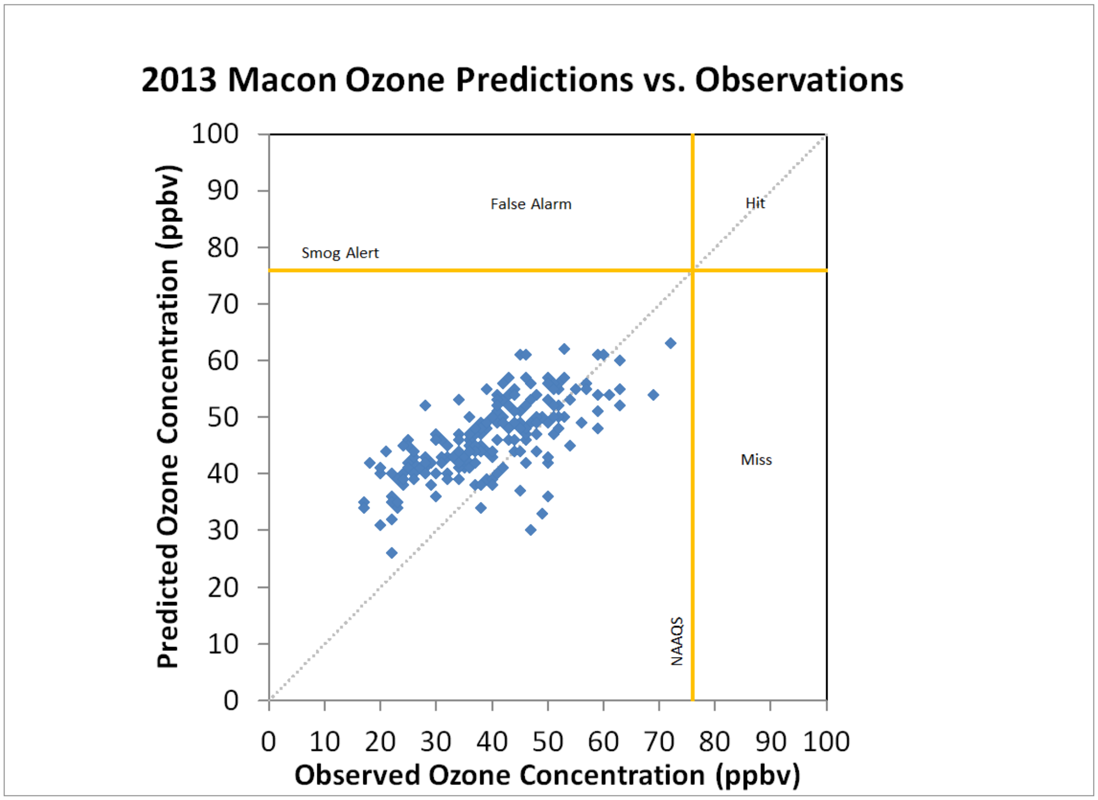
Metro Area and Pollutant	Total # of days in record	Observed # of days in AQI category			
		Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy
Atlanta Ozone	214	179	32	2	1
Macon Ozone	204	197	7	0	0
Atlanta $PM_{2.5}$	335	174	161	0	0
Columbus $PM_{2.5}$	299	237	62	0	0

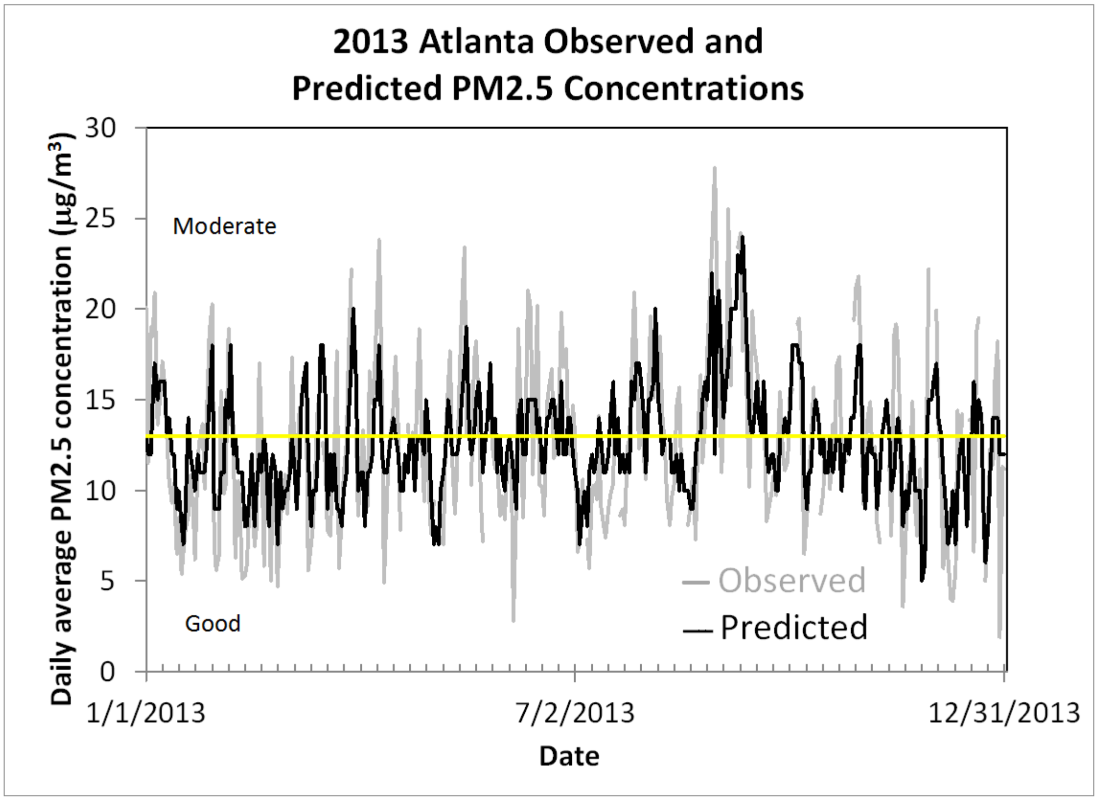
Observed and Predicted Air Quality:

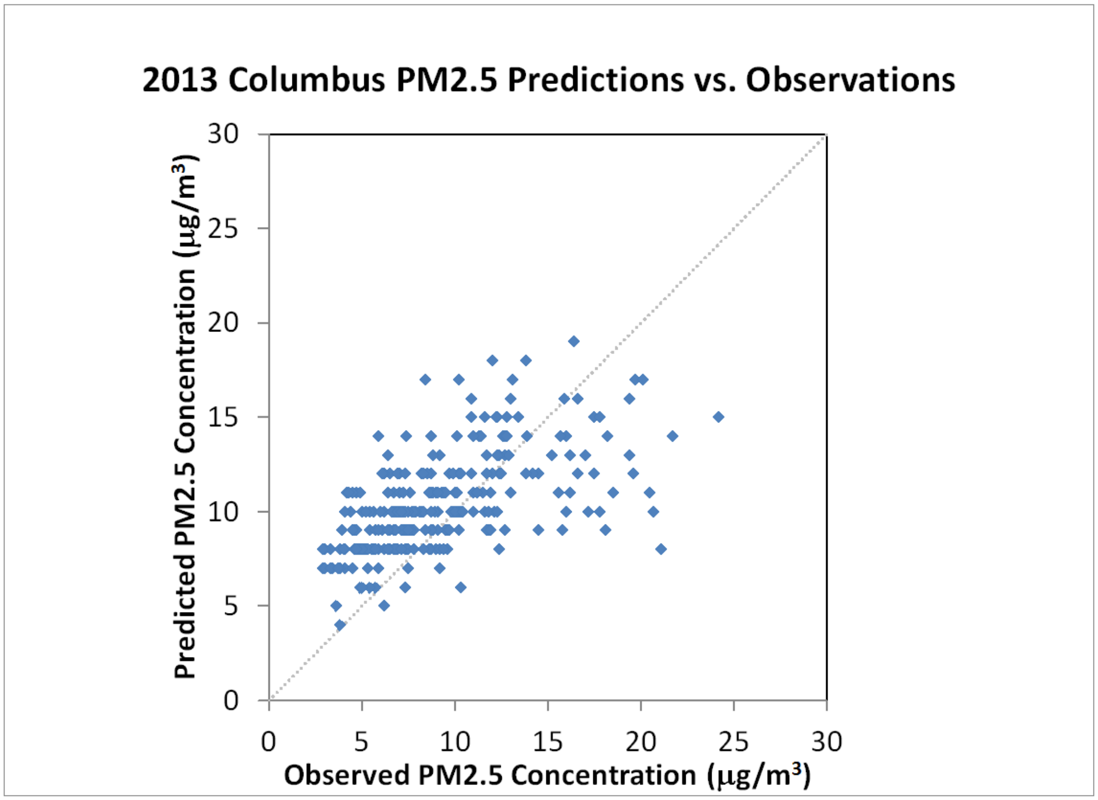


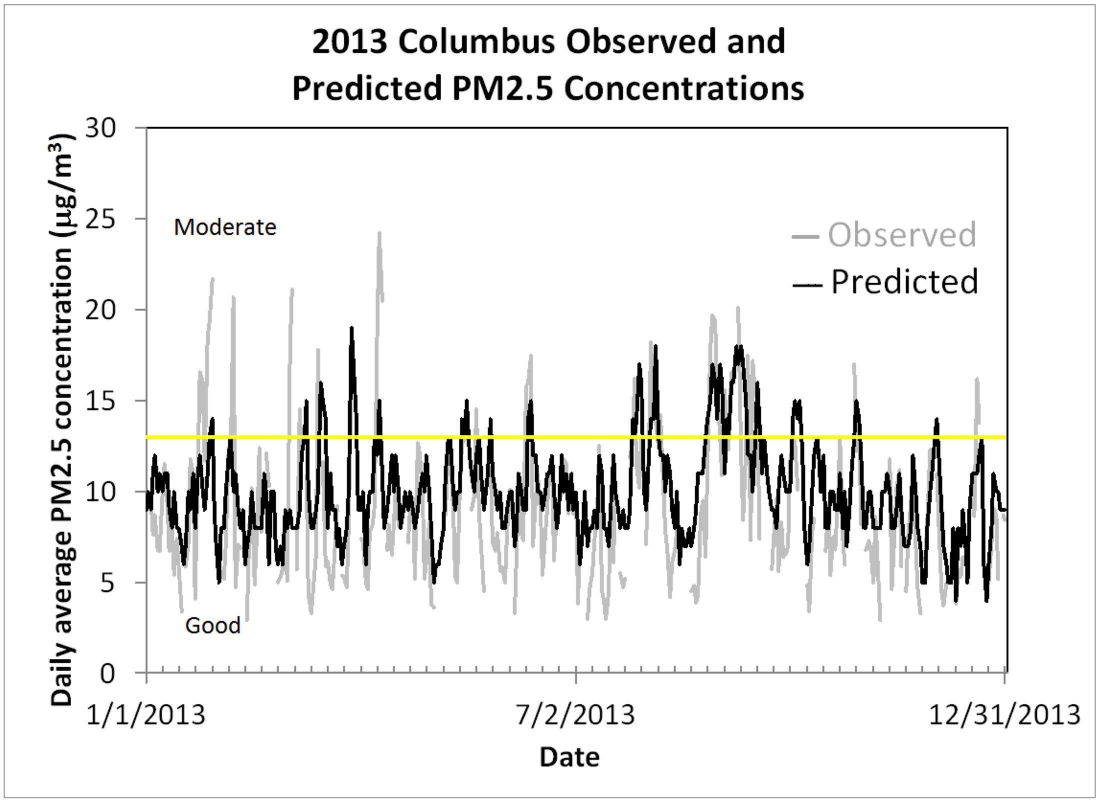

2013 Atlanta Ozone Predictions vs. Observations
Predicted Ozone Concentration (ppbv)
Observed Ozone Concentration (ppbv)
0
10
20
30
40
50
60
70
80
90
100
False Alarm
Hit
Smog Alert
Miss
NAAQS

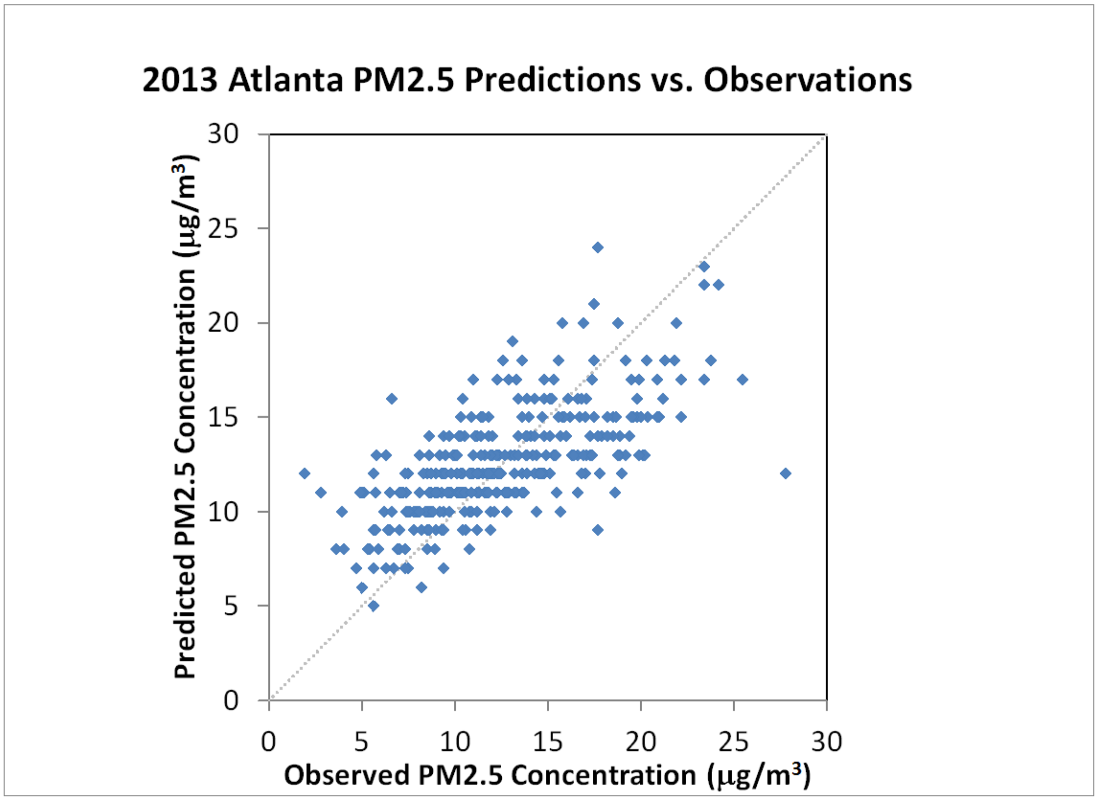

2013 Macon Observed and Predicted Ozone Concentrations
8-hour average ozone concentration (ppbv)
0
10
20
30
40
50
60
70
80
90
100
Unhealthy for Sensitive Groups
Moderate
Good
Observed
Predicted
4/1/2013
Date
10/31/2013


2013 Macon Ozone Predictions vs. Observations
Predicted Ozone Concentration (ppbv)
Observed Ozone Concentration (ppbv)
0
10
20
30
40
50
60
70
80
90
100
False Alarm
Hit
Smog Alert
Miss
NAAQS


2013 Atlanta Observed and Predicted PM2.5 Concentrations
Daily average PM2.5 concentration (µg/m³)
0
5
10
15
20
25
30
Moderate
Good
Observed
Predicted
1/1/2013
7/2/2013
12/31/2013
Date


2013 Columbus PM2.5 Predictions vs. Observations
Predicted PM2.5 Concentration (µg/m³)
Observed PM2.5 Concentration (µg/m³)
0
5
10
15
20
25
30


2013 Columbus Observed and Predicted PM2.5 Concentrations
Daily average PM2.5 concentration (µg/m³)
Moderate
Good
Observed
Predicted
0
5
10
15
20
25
30
1/1/2013
7/2/2013
12/31/2013
Date



(Data compiled by Dr. Michael Chang of Georgia Tech)

Predicted Air Quality:

	Hits	Misses	False Alarms	Bias	Gross Error	Correlation (-1 to +1)	% Accurate 2 categories	% Accurate 5 categories
Atlanta Ozone	0	3	1	4.1 ppbv	7.4 ppbv	0.74	98	86
Macon Ozone	0	0	0	6.9 ppbv	9.7 ppbv	0.55	100	86
Atlanta PM$_{2.5}$	0	0	0	0.2 µg/m^3	2.6 µg/m^3	0.68	100	80
Columbus PM$_{2.5}$	0	0	0	1.1 µg/m^3	3.5 µg/m^3	0.51	100	90

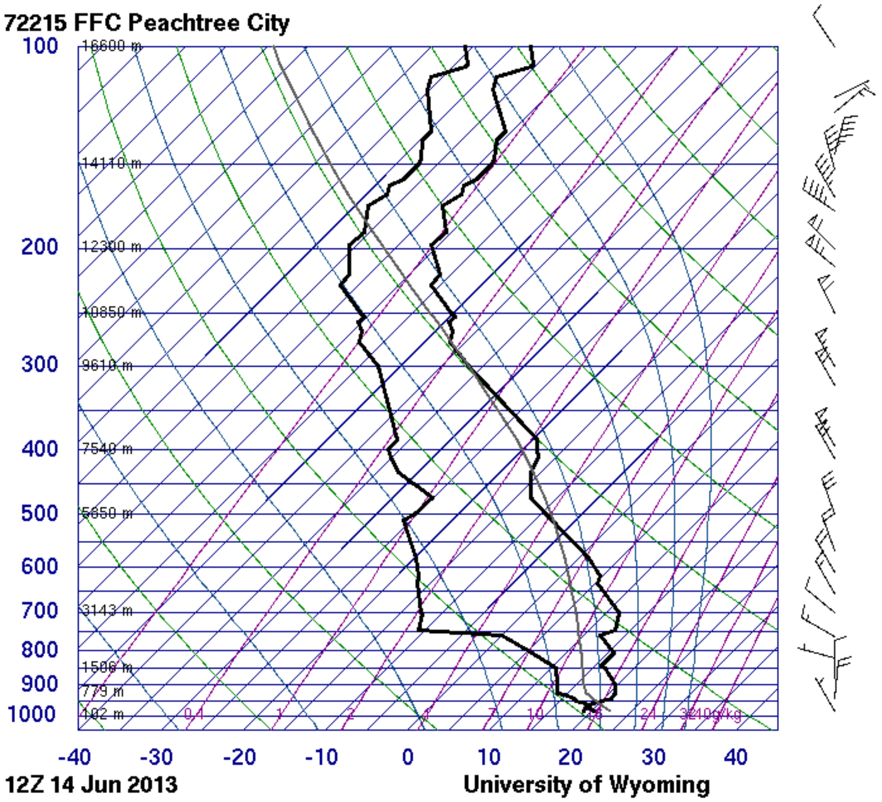
Statistics Clarification

- Hits are the number of days on which an observed exceedance of the daily NAAQS was correctly predicted.
- Misses are the number of days on which an observed exceedance of the daily NAAQS was not predicted
- False Alarms are the number of days on which an exceedance of the daily NAAQS was predicted, but was not later observed.
- Bias is the average tendency to over-predict (positive bias) or under-predict (negative bias) the observed pollutant concentration.

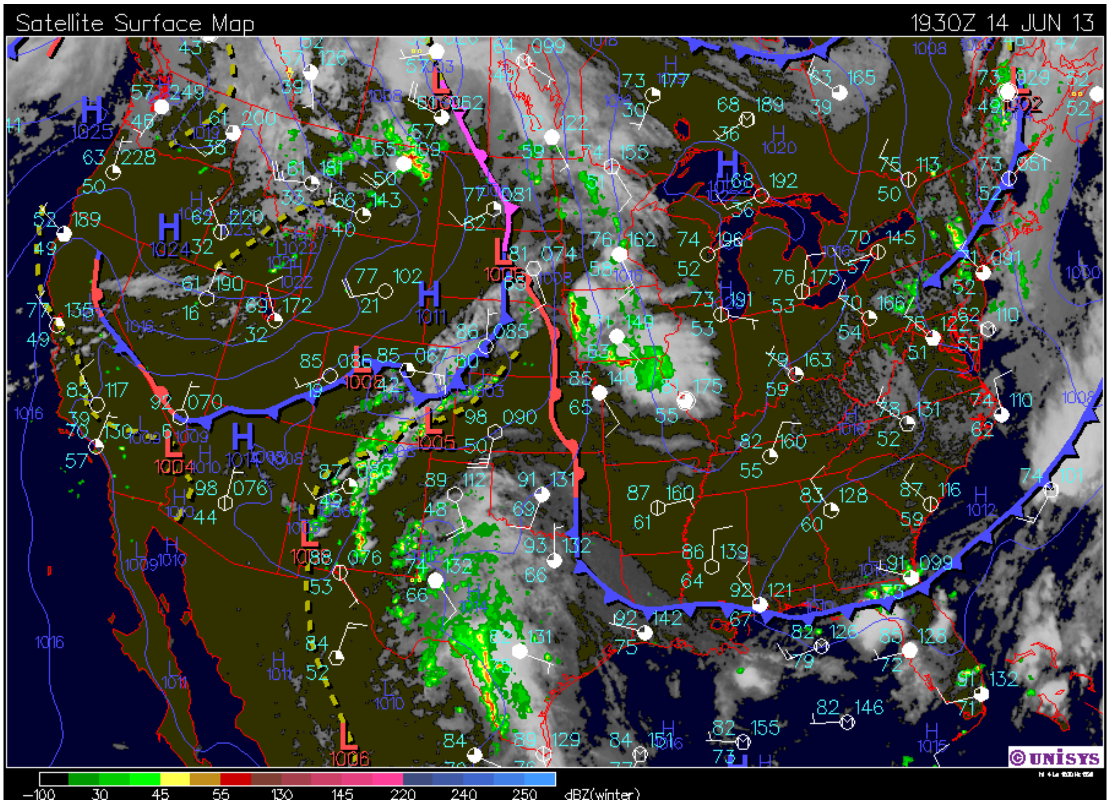
- Gross Error is the average absolute error of the predictions relative to the observations.
- Correlation is a measure of the ability to predict the relative change in observed concentrations. Higher positive correlation implies that the predictions are accurately anticipating changes in the observed concentrations.
- % Accurate 2 categories is the percentage of days when the forecast prediction correctly matched the observation for the “no smog alert” / “smog alert” condition (i.e. 2 categories)
- % Accurate 5 categories is the percentage of days when the forecast prediction correctly matched the observation for five categories of the Air Quality Index (Good, Moderate, Unhealthy for Sensitive Groups, Unhealthy, and Very Unhealthy).

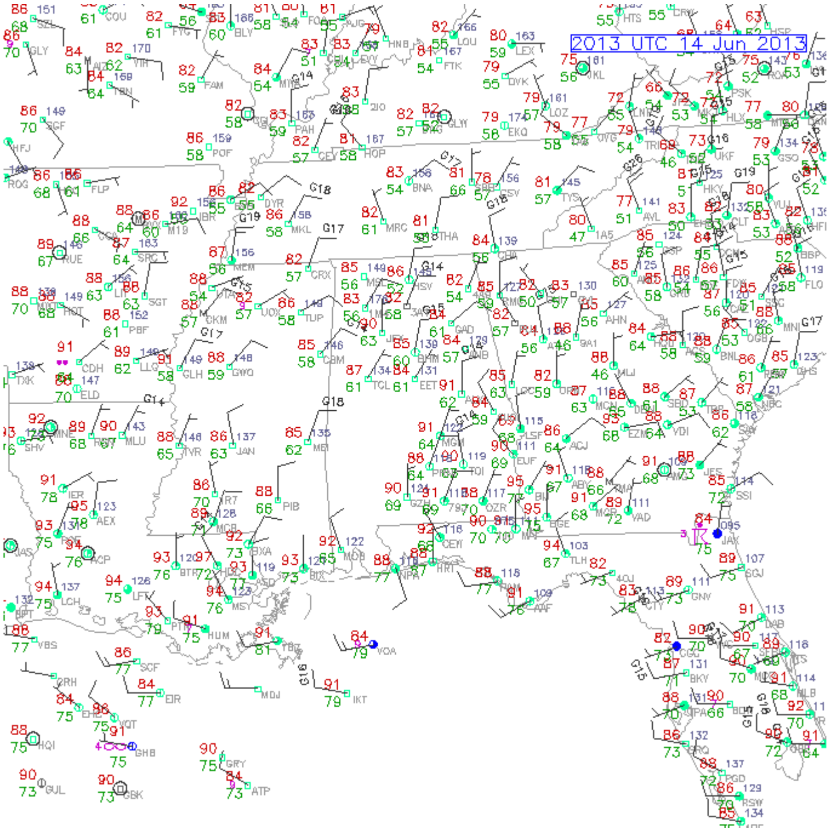
Meteorological Appendix B

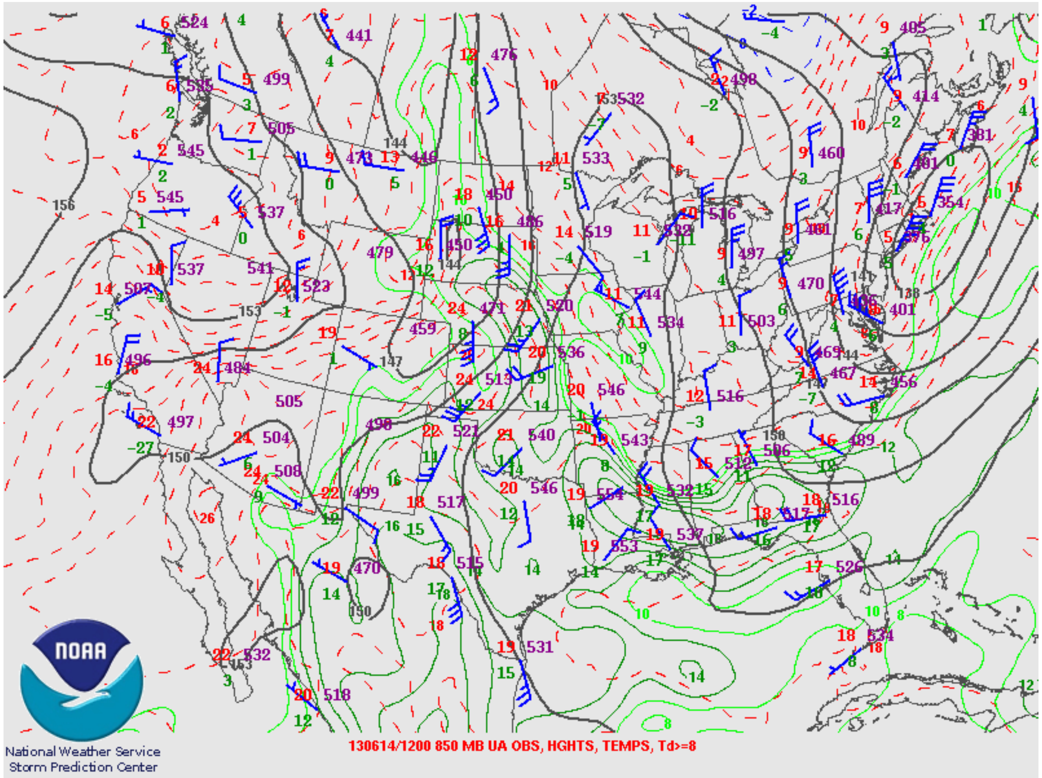
June 14, 2013 violation



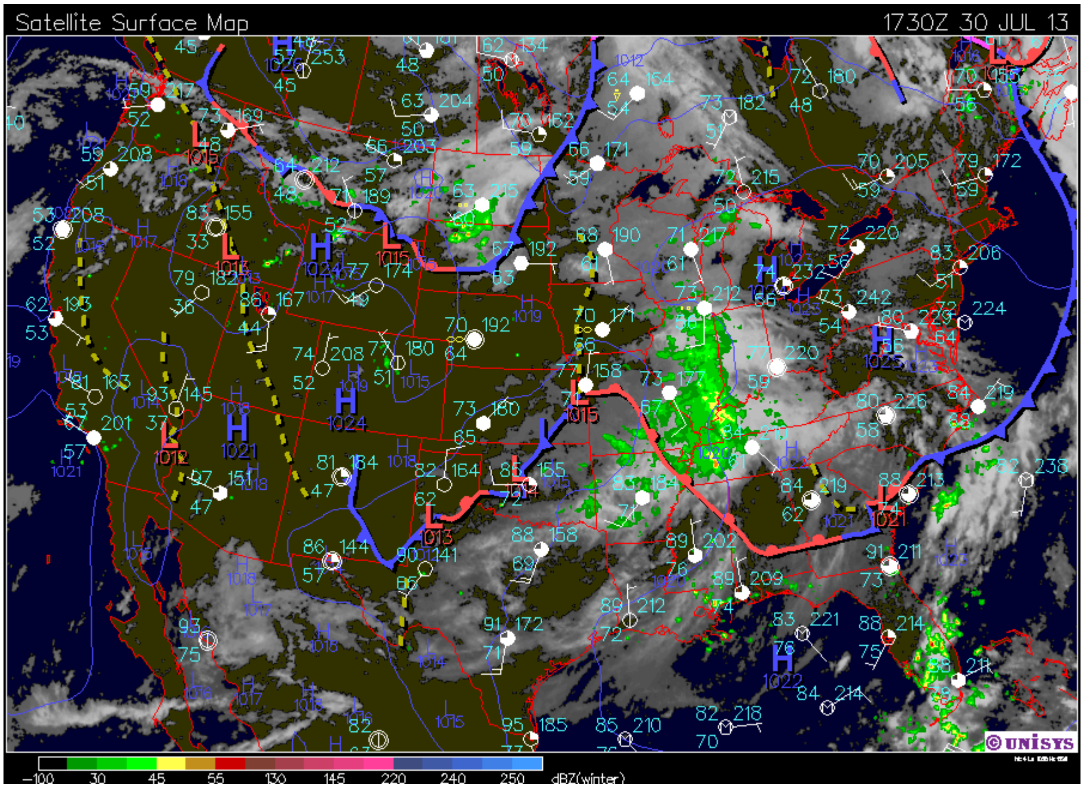
SLAT	33.36
SLON	-84.56
SELV	244.0
SHOW	1.00
LIFT	-0.59
LFTV	-1.07
SWET	165.1
KINX	12.50
CTOT	19.90
VTOT	25.90
TOTL	45.80
CAPE	49.52
CAPV	73.24
CINS	-551.
CINV	-425.
EQLV	274.7
EQTV	274.4
LFCT	513.1
LFCV	526.2
BRCH	12.76
BRCV	18.87
LCLT	290.1
LCLP	921.9
MLTH	296.9
MLMR	13.40
THCK	5748.
PWAT	28.40

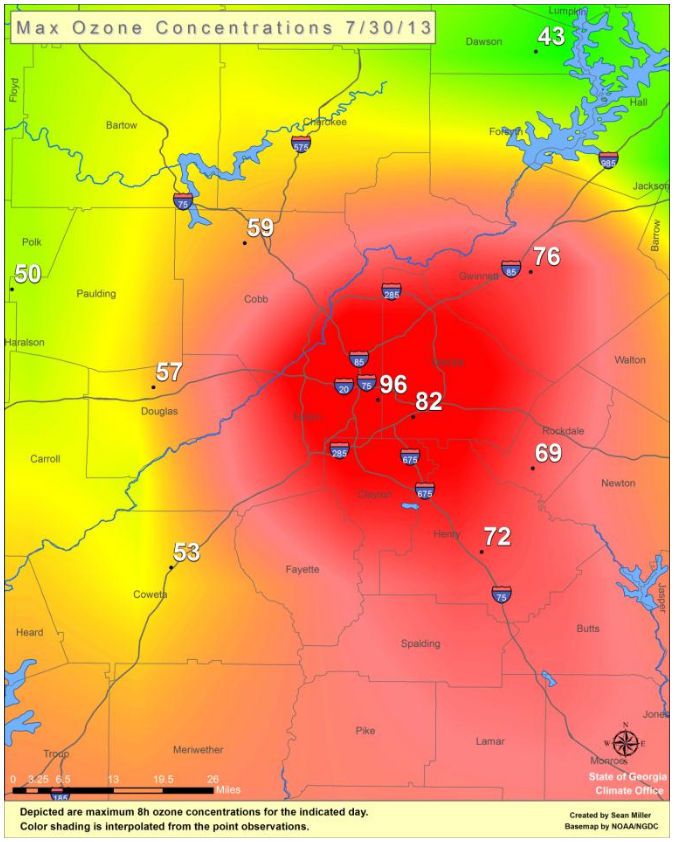

Satellite Surface Map
1930Z 14 JUN 13
©UNISYS
dBZ(winter)


2013 UTC 14 Jun 2013



July 30, 2013 violation:

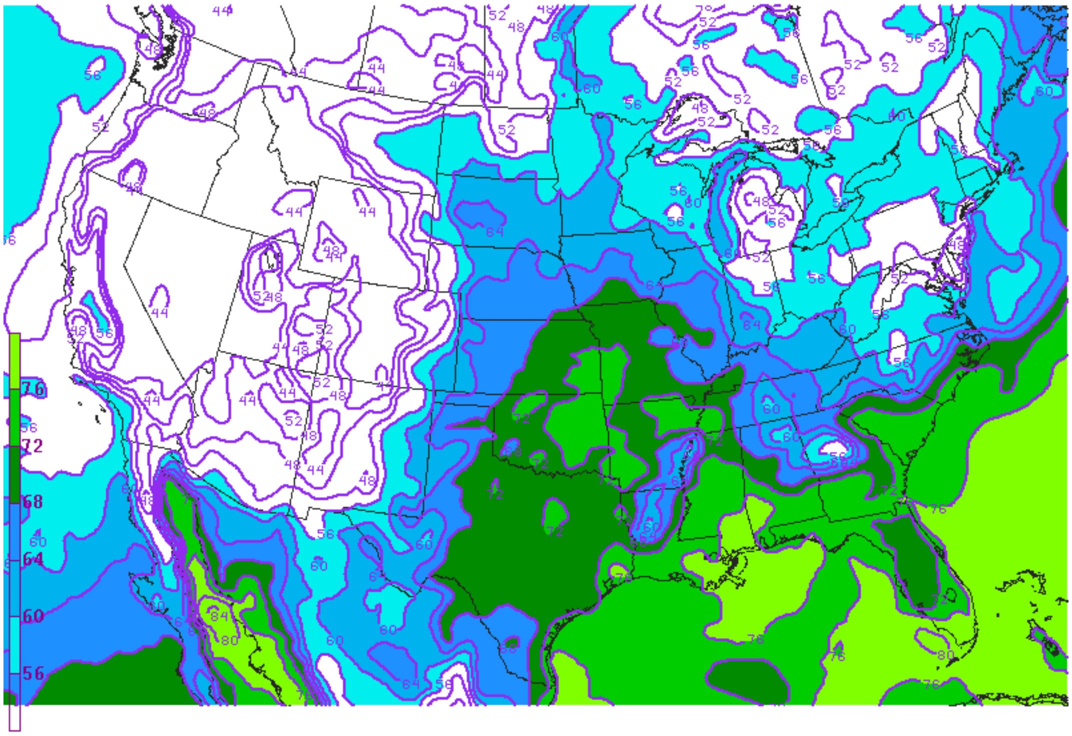


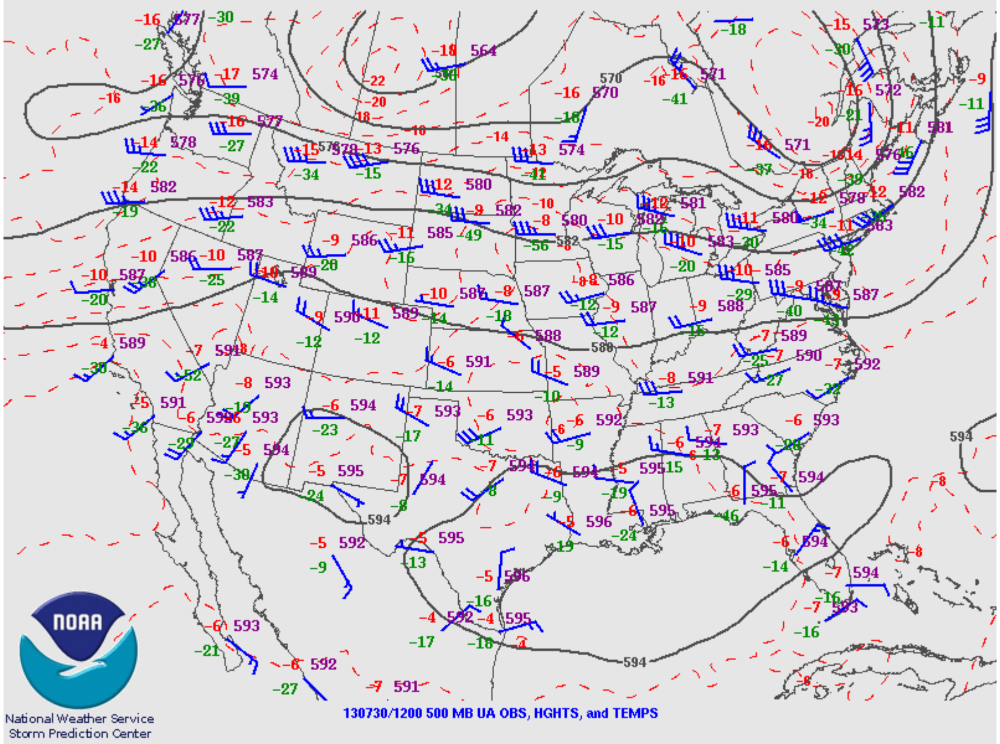


Max Ozone Concentrations 7/30/13

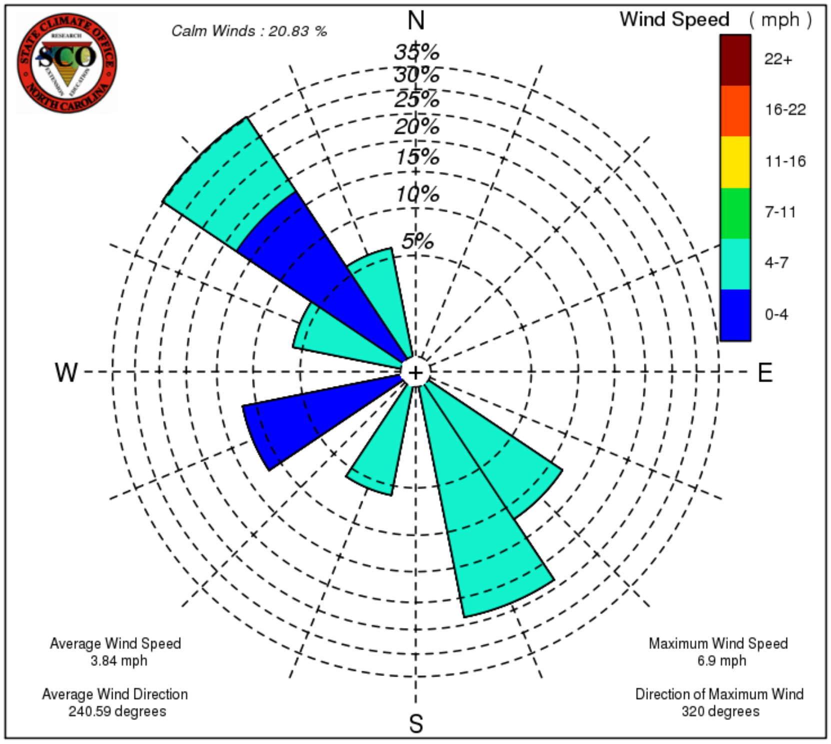
Depicted are maximum 8h ozone concentrations for the indicated day.
Color shading is interpolated from the point observations.

Created by Sean Miller
Basemap by NOAA/NGDC

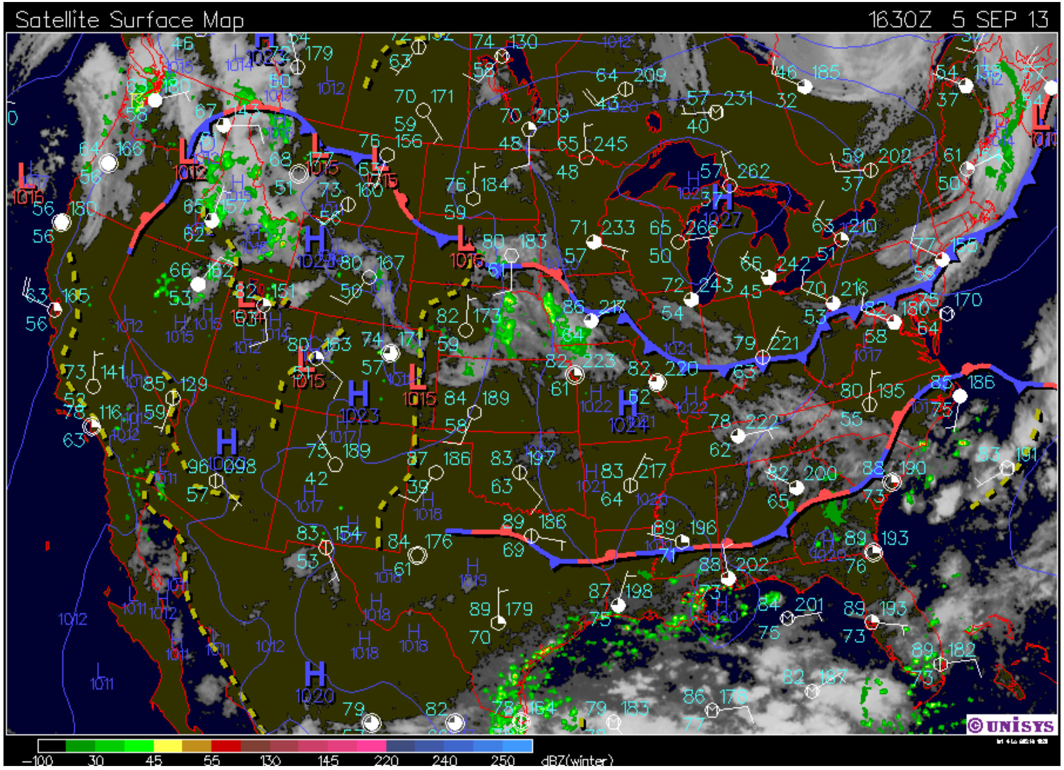




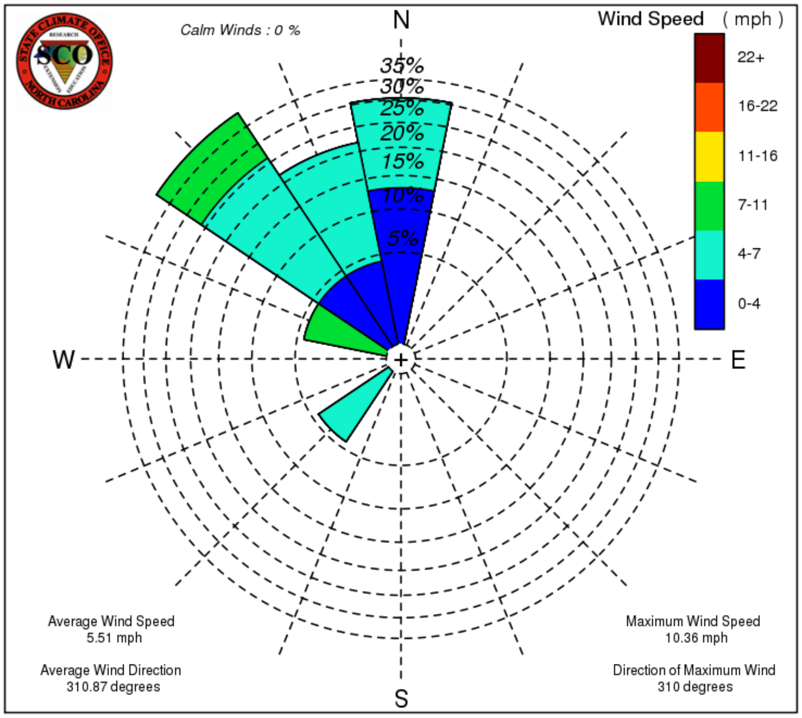
Wind Rose for Hartsfield Atlanta Airport (KATL)
Jul. 30, 2013 to Jul. 30, 2013

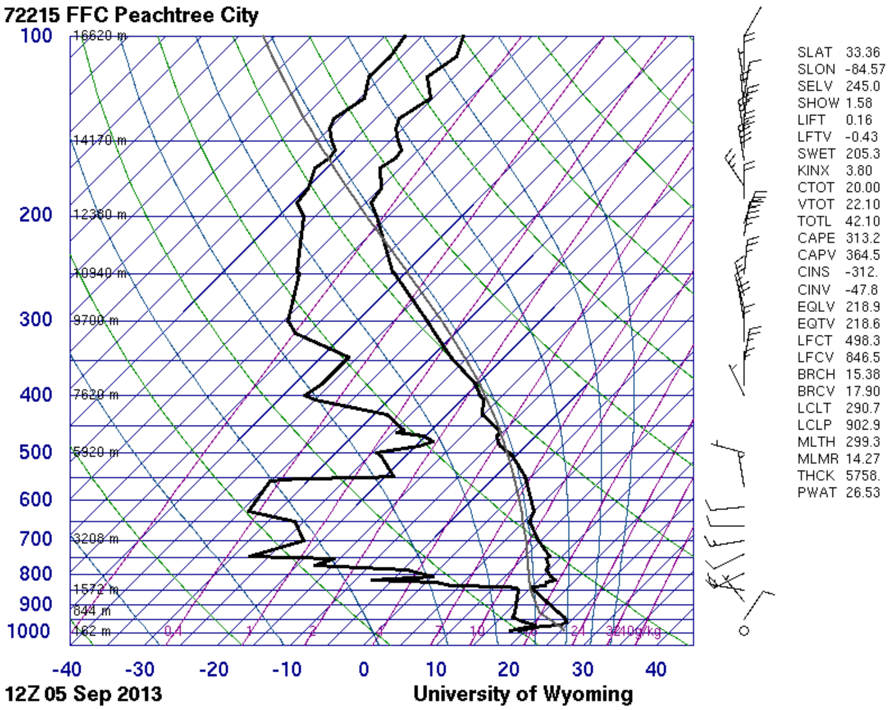


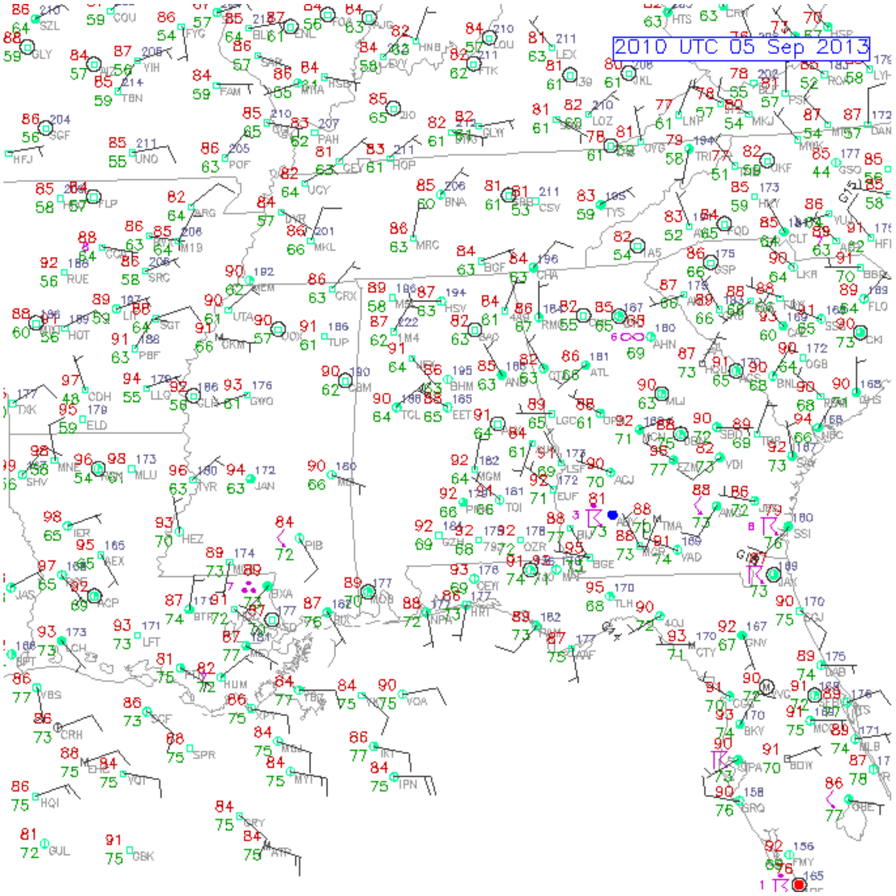
September 5, 2013 violation:

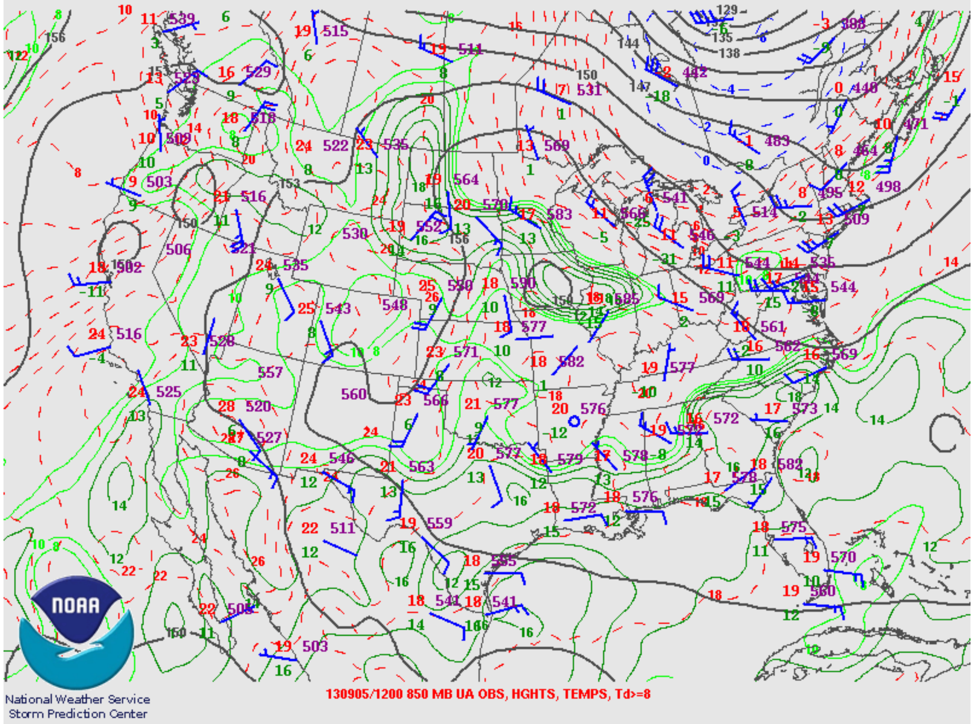


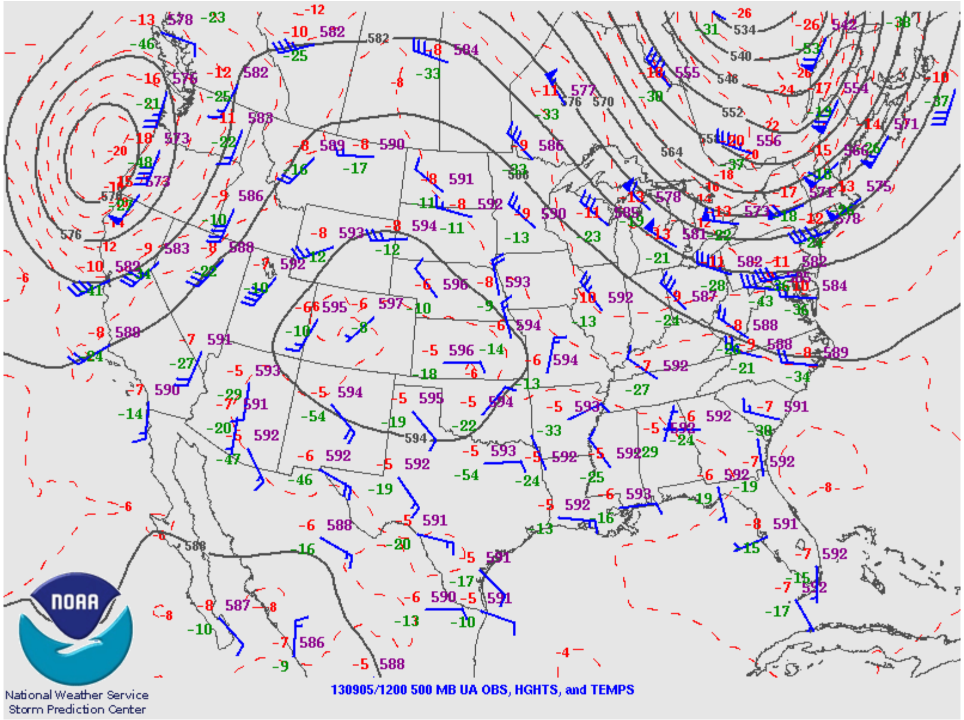
Wind Rose for Hartsfield Atlanta Airport (KATL)
Sep. 5, 2013 to Sep. 5, 2013




72215 FFC Peachtree City
100
200
300
400
500
600
700
800
900
1000
16620 m
14170 m
12360 m
10940 m
9700 m
7620 m
5920 m
3208 m
1572 m
844 m
162 m
-40
-30
-20
-10
0
10
20
30
40
SLAT 33.36
SLON -84.57
SELV 245.0
SHOW 1.58
LIFT 0.16
LFTV -0.43
SWET 205.3
KINX 3.80
CTOT 20.00
VTOT 22.10
TOTL 42.10
CAPE 313.2
CAPV 364.5
CINS -312.
CINV -47.8
EQLV 218.9
EQTV 218.6
LFCT 498.3
LFCV 846.5
BRCH 15.38
BRCV 17.90
LCLT 290.7
LCLP 902.9
MLTH 299.3
MLMR 14.27
THCK 5758.
PWAT 26.53
12Z 05 Sep 2013
University of Wyoming


2010 UTC 05 Sep 2013


National Weather Service
Storm Prediction Center
NOAA
130905/1200 850 MB UA OBS, HGHTS, TEMPS, Td>=8


National Weather Service
Storm Prediction Center
NOAA
130905/1200 500 MB UA OBS, HGHTS, and TEMPS

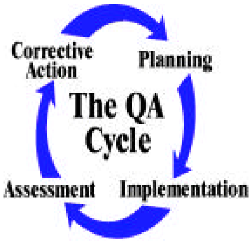
QUALITY ASSURANCE

The purpose of this report is to provide ambient air quality users and the general public, with a summary of the quality of the 2013 ambient air monitoring data in quantifiable terms. It presents an overview of various quality assurance and quality control activities. The tables included in this report provide summary data for ambient air monitoring stations in the statewide network.

The Georgia Air Protection Branch mission is to promote and protect public health, welfare, and ecological resources through effective and efficient reduction of air pollutants while recognizing and considering the effects on the economy of the state. The Ambient Air Monitoring Program provides a key element of that mission through collecting and reporting quality information on a large number of pollutants and for a vast air monitoring network. The Ambient Air Monitoring Program, directed by federal law, conducts various monitoring projects in support of the Georgia Department of Natural Resources (GA DNR), Georgia Environmental Protection Division (GA EPD), and the United States Environmental Protection Agency (U.S. EPA). The monitoring projects include gaseous criteria and non-criteria pollutants, particulate matter, air toxics, non-methane hydrocarbons, and meteorological parameters. Data from these monitoring sources provide the means to determine the nature of the pollution problem and assess the effectiveness of the control measures and programs.

It is the goal of the Ambient Monitoring Program to provide accurate, relevant, and timely measurements of air pollutants and their precursors associated with the corresponding meteorological data to support Georgia’s Air Protection Branch for the protection of environment and public health. The Quality Assurance Unit conducts various quality assurance activities to ensure that data collected comply with procedures and regulations set forth by the U.S. EPA and can be considered good quality data and data for record.

What is quality assurance? Quality assurance is an integrated system of management activities that involves planning, implementing, assessing, and assuring data quality through a process, item, or service that meets users needs for quality, completeness, representativeness and usefulness. Known data quality enables users to make judgment about compliance with quality standards, air quality trends and health effects based on sound data with a known level of confidence. The objective of quality assurance is to provide accurate and precise data, minimize data loss due to malfunctions, and to assess the validity of the air monitoring data to provide representative and comparable data of known precision and accuracy.



Quality assurance (QA) is composed of two activities: quality control and quality assessment. Quality control (QC) is composed of a set of internal tasks performed routinely at the instrument level that ensures accurate and precise measured ambient air quality data. Quality control tasks address sample collection, handling, analysis, and reporting. Examples include calibrations, routine service checks, chain-of-custody documentation, duplicate analysis, development and maintenance of standard operating procedures, and routine preparation of quality control reports.

Quality assessment is a set of external, quantitative tasks that provide certainty that the quality control system is satisfactory and that the stated quantitative programmatic objectives for air quality data are indeed met. Staff independent of those generating data perform these external tasks. Tasks include conducting regular performance audits, on-site system audits, inter-laboratory comparisons, and periodic evaluations of internal quality control data. Performance audits ascertain whether the samplers are operating within the specified limits as stated in the Standard Operating Procedures (SOPs). Table 5 illustrates the types of performance audits currently performed by the QA Unit in 2013. Field and laboratory performance audits are the most common. System audits are performed on an as-needed basis or by request. Whole air sample comparisons are conducted for the toxic air contaminants and non-methane hydrocarbons.

Table 5. Audits performed for each air monitoring program in 2013

Air Monitoring Program	Field Performance Audit	Laboratory Performance Audit	System Audit	Whole Air Audit
Gaseous Pollutants	X	X	X	
Particulate Matter	X	X	X	
Air Toxic Contaminants	X	X		X
Non-Methane Hydrocarbons	X	X	X	X
Meteorology	X		X	

QUALITY CONTROL AND QUALITY ASSESSMENT

The Quality Assurance Unit supports all ambient air monitoring programs undertaken by Georgia EPD, which in 2013 includes gaseous pollutants, particulate pollutants, air toxics contaminants, non-methane hydrocarbons and meteorological sensors run by the Ambient Monitoring Program. In 2013, 44 air monitoring sites operated in Georgia (see Table 2 on pages 5-6 for details). Appendix E of this document provides information about the air monitoring network (i.e., sampling schedules, number of instruments, collection/analysis method, etc.). The air quality monitors collect data in both real-time and on a time integrated basis. The data is used to define the nature, extent, and trends of air quality in the state; to support programs required by state and federal laws; and to track progress in attaining air quality standards. The precision and accuracy necessary depends on how the data will be used. Data that must meet specific requirements (i.e., criteria pollutants) are referred to as *controlled data sets*. Criteria for the accuracy, precision, completeness, and sensitivity of the measurement in controlled data sets must be met and documented. The process by which one determines the quality of data needed to meet the monitoring objective is sometimes referred to as the Data Quality Objectives Process. Data quality indicators associated with measurement uncertainty include:

Precision: A measurement of mutual agreement among individual measurements of the same property usually under prescribed similar conditions, expressed generally in terms of the standard deviation.

Bias: The systematic or persistent distortion of a measurement process, which causes errors in one direction.

Accuracy: The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (imprecision) and systematic error (bias) components that are due to sampling and analytical operations.

Completeness: A measure of the amount of valid data obtained from a measurement system compared to the amount that is expected to be obtained under correct, normal conditions.

Detectability: The low critical range value of a characteristic that a method specific procedure can reliably discern.

Data without formal data quality objectives (i.e., GA EPD's air toxics network) are called *descriptive data sets*. The data quality measurements are made as accurately as possible in consideration of how the data are being used. Quantified quality assessment results describe the measurement variability in standard terminology, but no effort is made to confine the data set to values within a predetermined quality limit.

The Georgia Air Sampling Network's (GASN) Quality Assurance Program is outlined in a five-volume *Quality Assurance Manual*. The volumes, listed below, guide the operation of the quality assurance programs used by the GASN.

Sampling Cone

Volume I: Quality Assurance Plan
Volume II: Standard Operating Procedures for Air Quality Monitoring
Volume III: Laboratory Standard Operating Procedures
Volume IV: Monitoring Methods for the State Ambient Air Quality standards
Volume V: Audit Procedures for Air Quality Monitoring

Volume I lists the data quality objectives and describes quality control and quality assessment activities used to ensure that the data quality objectives are met.

GASEOUS POLLUTANTS

Ambient concentrations of carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2) are continuously monitored by an automated network of stations run by the Georgia Ambient Air Monitoring Program. Exposure to these pollutants may cause adverse health effects such as: respiratory impairment, fatigue, permanent lung damage, and increased susceptibility to infection in the general population. Gaseous criteria and non-criteria pollutant data are a controlled data set and are subject to meeting mandatory regulations.

Accuracy: Annually, EPA conducts field through-the-probe (TTP) performance audits for gaseous pollutants to verify the system accuracy of the automated methods and to ensure the integrity of the sampling system. Accuracy is represented as an average percent difference. The average percent difference is the combined differences from the certified value of all the individual audit points. The upper and lower probability limits represent the expected accuracy of 95 percent of all the single analyzer's individual percent differences for all audit test levels at a single site. Bias is the systematic or persistent distortion of a measurement process, which causes errors in one direction. Overall, the responses of the individual analyzers indicate that as a whole, the network is providing accurate data. Ninety-five percent of the gaseous pollutant instruments audited in 2013 were found to be operating within the Georgia Ambient Air Monitoring control limits (±15%). The tables below summarize the 2013 performance audit results for each gaseous pollutant.

Precision: On a weekly basis, site operators confirm the linear response of the instrument by performing zero, precision and span checks. The zero precision check confirms the instrument's ability to maintain a stable reading. The span precision check confirms the instrument's ability to respond to a known concentration of gas. The degree of variability in each of these weekly measurements is computed as the precision of that instrument's measurements.

Annually, the Quality Assurance Unit conducts a precision data analysis as an overall indicator of data quality. The analysis addresses three parameters: precision data submission, precision data validity, and a combination of the two referred to as data usability rates. The precision performance goal for all three parameters is 85%. The submission rate is the number of precision points submitted for a pollutant divided by the expected number of bi-weekly submissions. Data validity is the percent difference of the actual and indicated values of each precision check. These differences should not exceed ±15% for gaseous analyzers. Usable data rates are determined by multiplying the data submission and data validity rates that indicate the completeness of verifiable air quality data on the official database. The tables below show the Georgia annual Data Quality Assessment summary for the gaseous pollutants (NO, NO_2, NO_X, CO, SO_2, O_3).

Table 6. NO data quality assessment

NO Yearly Data Quality Assessment Summary												
Site Code	**Site Name**	**No. of Obs.**	**Precision CV (%)**	**Absolute Bias Estimate (%)**	**Validation of Bias**			**Annual Performance Evaluation Bias**				**Completeness (%)**
					Avg (%)	**95% LPL (%)**	**95% UPL (%)**	**No. of Obs.**	**Avg (%)**	**95% LPL (%)**	**95% UPL (%)**	
13-089-0002	Decatur - S. DeKalb	54	1.88	4.94	-4.54	-7.79	-1.35	8	4.20	-5.31	13.72	96%
13-223-0003	Yorkville - King's Farm	66	3.29	5.27	-4.45	-10.30	1.12	8	-4.56	-5.99	-3.12	97%
13-247-0001	Conyers - Monastery	57	2.26	2.43	-1.47	-5.45	2.32	8	2.83	1.69	3.97	97%
Georgia Ambient Air Monitoring Program		**177**	**2.53**	**4.25**	**-3.52**	**-8.01**	**0.97**	**24**	**0.82**	**-4.77**	**6.42**	**96%**
95% LPL: 95% Lower Probability Limit			**95% UPL: 95% Upper Probability Limit**									

Table 7. NO_2 data quality assessment

NO_2 Yearly Data Quality Assessment Summary												
Site Code	**Site Name**	**No. of Obs.**	**Precision CV (%)**	**Absolute Bias Estimate (%)**	**Validation of Bias**			**Annual Performance Evaluation Bias**				**Completeness (%)**
					Avg (%)	**95% LPL (%)**	**95% UPL (%)**	**No. of Obs.**	**Avg (%)**	**95% LPL (%)**	**95% UPL (%)**	
13-089-0002	Decatur - S. DeKalb	54	2.28	2.27	-1.41	-5.30	2.48	12	-0.56	-12.48	4.23	97%
13-223-0003	Yorkville - King's Farm	63	4.77	3.77	-0.29	-8.78	7.72	8	2.36	-0.63	5.34	95%
13-247-0001	Conyers - Monastery	57	2.44	2.01	0.64	-3.55	4.82	4	0.00	-10.36	5.59	97%
Georgia Ambient Air Monitoring Program		174	3.23	2.73	-0.33	-6.26	5.59	24	0.50	-6.90	7.91	96%
95% LPL: 95% Lower Probability Limit			**95% UPL: 95% Upper Probability Limit**									

Table 8. NO_X data quality assessment

NO_x Yearly Data Quality Assessment Summary												
Site Code	**Site Name**	**No. of Obs.**	**Precision CV (%)**	**Absolute Bias Estimate (%)**	**Validation of Bias**			**Annual Performance Evaluation Bias**				**Completeness (%)**
					Avg (%)	**95% LPL (%)**	**95% UPL (%)**	**No. of Obs.**	**Avg (%)**	**95% LPL (%)**	**95% UPL (%)**	
13-089-0002	Decatur - S. DeKalb	54	1.97	2.37	-1.81	-5.19	1.56	12	-9.53	-11.30	3.03	96%
13-223-0003	Yorkville - King's Farm	66	3.27	3.66	-2.55	-8.32	3.02	8	-4.39	-5.56	-3.22	95%
13-247-0001	Conyers - Monastery	57	1.90	1.57	-0.05	-3.32	3.21	4	0.00	-3.03	-0.05	97%
Georgia Ambient Air Monitoring Program		177	2.43	2.59	-1.52	-5.90	2.86	24	-6.23	-11.49	-0.97	96%
95% LPL: 95% Lower Probability Limit			**95% UPL: 95% Upper Probability Limit**									

Table 9. CO data quality assessment

CO Yearly Data Quality Assessment Summary												
Site Code	Site Name	No. of Obs.	Precision CV (%)	Absolute Bias Estimate (%)	Validation of Bias			Annual Performance Evaluation Bias				Completeness (%)
					Avg (%)	95% LPL (%)	95% UPL (%)	No. of Obs.	Avg (%)	95% LPL (%)	95% UPL (%)	
13-089-0002	Decatur - S. DeKalb	62	1.64	2.19	-1.78	0.00	1.09	12	-3.37	-11.42	4.67	98
13-223-0003	Yorkville - King's Farm	60	2.01	2.99	-1.95	-6.01	0.90	3	-10.30	-0.85	0.85	98
13-247-0001	Conyers - Monastery	57	2.12	2.00	-1.08	-4.96	2.30	6	-0.63	-1.84	0.57	97
Georgia Ambient Air Monitoring Program		179	1.82	2.58	-1.86	-5.12	1.39	21	-3.40	-10.81	4.01	97.7
95% LPL: 95% Lower Probability Limit			**95% UPL: 95% Upper Probability Limit**									

Table 10. SO_2 data quality assessment

SO_2 Yearly Data Quality Assessment Summary												
Site Code	Site Name	No. of Obs.	Precision CV (%)	Absolute Bias Estimate (%)	Validation of Bias			Annual Performance Evaluation Bias				Completeness (%)
					Avg (%)	95% LPL (%)	95% UPL (%)	No. of Obs.	Avg (%)	95% LPL (%)	95% UPL (%)	
13-021-0012	Macon - Forestry	56	1.36	3.26	-2.99	-5.31	-0.66	8	-2.08	-2.49	1.21	98
13-051-0021	Savannah - East President St.	57	1.92	3.20	-2.76	-6.08	0.50	4	-3.39	-12.97	6.19	99
13-051-1002	Savannah - L & A	56	1.89	2.74	-2.35	-5.59	0.90	4	-4.96	-18.18	8.26	98
13-215-0008	Augusta-Bungalow	54	2.20	1.73	0.35	-3.42	4.11	4	-2.68	-7.19	1.84	95
13-115-0003	Rome - Coosa Elementary	60	2.08	2.65	-2.21	-5.68	1.49	8	-0.31	-15.86	15.24	92
13-121-0055	Atlanta - Confederate Ave.	54	2.41	2.52	1.51	-2.61	5.64	4	-4.34	-21.69	13.01	98
13-089-0002	Atlanta-South DeKalb	59	1.92	1.56	-0.22	-3.51	3.09	8	-2.80	-5.12	-0.48	98
Georgia Ambient Air Monitoring Program		396	1.97	2.52	-1.26	-4.68	2.15	40	-1.82	-12.09	8.45	96.9
95% LPL: 95% Lower Probability Limit			**95% UPL: 95% Upper Probability Limit**									

Table 11. O_3 data quality assessment

O_3 Yearly Data Quality Assessment Summary												
Site Code	Site Name	No. of Obs.	Precision Estimate CV (%)	Absolute Bias Estimate (%)	Validation of Bias			Annual Performance Evaluation Bias				Completeness (%)
					Avg (%)	95% LPL (%)	95% UPL (%)	No. of Obs.	Avg (%)	95% LPL (%)	95% UPL (%)	
13-021-0012	Macon - Forestry	37	1.29	1.23	-0.85	-2.98	1.29	4	-0.67	-3.38	2.03	99
13-051-0021	Savannah - East President St.	39	2.12	2.17	1.31	-1.99	5.06	4	1.75	-4.84	8.34	99
13-055-0001	Summerville - DNR Fish Hatchery	34	1.79	3.04	-2.61	-5.55	0.33	4	0.17	-2.30	2.65	99
13-059-0002	Athens - Fire Station 7	33	1.11	0.74	-0.36	-2.19	1.46	4	-0.09	-1.73	1.54	99
13-067-0003	Kennesaw - Georgia National Guard	33	1.00	2.00	-1.76	-3.38	-0.13	4	0.17	-6.10	6.45	98
13-073-0001	Evans - Riverside Park	34	2.17	1.79	0.19	-3.37	3.76	4	-1.00	-2.32	0.32	96
13-077-0002	Newnan - University of West Georgia	35	2.48	2.87	2.06	-2.02	6.13	4	0.96	-3.90	5.82	98
13-085-0001	Dawsonville - Georgia Forestry	34	1.55	1.09	0.42	-2.12	2.95	4	1.76	-0.35	3.88	99
13-089-0002	Decatur - South DeKalb	56	3.12	2.74	-2.65	-6.81	3.87	4	0.26	-2.85	3.37	99
13-097-0004	Douglasville - West Strickland Street	35	2.45	2.63	-1.89	-5.91	2.14	4	2.60	1.83	3.37	98
13-121-0055	Atlanta - Confederate Ave.	38	5.52	4.24	0.56	-8.60	9.72	4	-1.91	-9.90	6.07	99
13-127-0006	Brunswick - Risley School	36	1.52	1.03	0.28	-2.23	2.78	4	9.51	6.92	12.10	99
13-135-0002	Lawrenceville - Gwinnett Tech	35	3.08	2.75	-1.48	-6.55	3.59	4	1.03	-1.26	3.31	98
13-151-0002	McDonough - County Extension Office	39	3.09	2.52	0.45	-4.98	5.29	4	1.93	-1.84	5.70	99
13-213-0003	Chatsworth - Fort Mountain	35	2.38	1.88	-0.45	-4.37	3.47	4	4.98	4.33	5.63	99
13-215-0008	Columbus - Airport	37	0.66	1.99	-1.84	-2.92	-0.75	4	-2.35	-5.00	0.30	99
13-223-0003	Yorkville - King's Farm	34	2.38	2.18	1.10	-2.80	5.00	4	-1.48	-4.80	1.84	98
13-245-0091	Augusta - Bungalow Rd.	40	3.63	2.90	-0.31	-6.01	6.10	4	9.10	4.17	14.03	96
13-247-0001	Conyers - Monastery	37	1.09	4.00	-3.78	-5.55	-1.95	4	-1.83	-9.26	5.61	99
13-261-1001	Leslie - Union High School	35	1.79	1.31	-0.17	-3.12	2.78	4	-1.25	-2.61	0.11	99
Georgia Ambient Air Monitoring Program		736	2.26	2.29	-0.64	-4.82	3.55	80	1.18	-2.87	5.24	98.5
95% LPL: 95% Lower Probability Limit		**95% UPL: 95% Upper Probability Limit**										

PARTICULATE MATTER

Particulate matter is a mixture of substances that include elements such as carbon, metals, nitrates, organic compounds and sulfates; complex mixtures such as diesel exhaust and soil. Particles with an aerodynamic diameter of 10 microns or smaller pose an increased health risk because they can deposit deep in the lung and contain substances that are particularly harmful to human health. Respirable particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$) increase the chance of respiratory disease, lung damage, cancer, and premature death.

Particulate matter monitoring is conducted using both manual and continuous type samplers. Manual samplers are operated on a six-day sampling schedule for PM_{10}, and a similar, or more frequent schedule, for $PM_{2.5}$. The Georgia Ambient Monitoring particulate program also includes total suspended particulates (TSP), sulfate, mass and lead monitoring. Particulate matter is a controlled data set, and as such is subject to formal data quality objectives and federal and state regulations.

Accuracy (field): The accuracy of particulate samplers is determined by comparing the instrument's flow rate to a certified variable orifice (PM_{10} and TSP), or a calibrated mass flow meter (TEOM, BAM, and $PM_{2.5}$ samplers) that is certified against a National Institute of Standards and Technology (NIST) traceable flow device or calibrator. Since an accurate measurement of particulate matter is dependent upon flow rate, the Ambient Monitoring Program conducts semi-annual flow rate audits at each site. The average percent difference between the sampler flow rates and the audit flow rates represents the combined differences from the certified value of all the individual audit points for each sampler. The upper and lower probability limits represent the expected flow rate accuracy for 95 percent of all the single analyzer's individual percent differences for all audit test levels at a single site.

Overall, the 2013 flow audit results indicate that the flow rates of samplers in the network are almost all within bounds. Approximately ninety-eight percent of the instruments audited in 2013 operated within the Georgia Ambient Monitoring Program's control limits. The 2013 $PM_{2.5}$ yearly data quality assessment summary of integrated and analyzation using federal reference method, the $PM_{2.5}$ yearly data quality assessment summary semi-continuous measurements, and the PM_{10} yearly data quality assessment summary of 24-hour integrated measurements and semi-continuous measurements are shown in the tables below.

Table 12. PM$_{2.5}$ data quality assessment for FRM samplers

PM$_{2.5}$ Yearly Data Quality Assessment Summary of Integrated Sampling and Analyzation Using Federal Reference Method												
Site Code	**Site Name**	**Collocated (µg/m^3)**		**One-Point Flow Rate Check (L/min)**				**Semi-Annual Flow Check (L/min) (Bias %)**				**Completeness (%)**
		No. of Obs.	**Precision Estimate CV (%)**	**No. of Obs.**	**Avg (%)**	**Absolute Bias (%)**	**Signed Bias (%)**	**No. of Obs.**	**Avg (%)**	**95% LPL (%)**	**95% UPL (%)**	
13-021-0007	Macon - Allied Chemical	24	14.89	12	0.13	0.90	+/-0.9	4	0.65	-2.01	3.30	93%
13-021-0012	Macon - Macon SE	NA	NA	12	0.06	1.43	+/-1.43	2	-1.57	-7.77	4.62	94%
13-051-0091	Savannah - Mercer Jr. High School	NA	NA	11	0.20	0.62	+/-0.62	2	0.09	-0.99	1.17	87%
13-059-0002	Athens - Fire Station 7	NA	NA	12	1.12	1.50	+1.5	2	-1.01	-2.31	0.30	82%
13-063-0091	Forest Park - D.O.T.	NA	NA	11	1.85	2.31	+2.31	2	-1.17	-1.92	-0.42	95%
13-067-0003	Kennesaw - National Guard	NA	NA	11	0.82	1.16	+1.16	2	-0.27	-0.35	-0.19	96%
13-089-0002	Decatur - South DeKalb	28	7.78	12	-1.11	1.40	-1.4	2	-0.66	-1.15	-0.16	96%
13-095-0007	Albany - Turner Elem. School	256	5.58	12	-0.02	1.74	+/-1.74	4	1.62	-1.90	5.14	94%
13-115-0003	Rome - Coosa High School	NA	NA	13	0.86	1.17	+1.17	2	0.97	-0.89	2.83	89%
13-127-0006	Brunswick - Risley Middle Sch.	NA	NA	13	-0.15	0.38	-0.38	2	0.97	-0.89	2.83	79%
13-135-0002	Lawrenceville - Gwinnett Tech	NA	NA	12	0.55	1.78	+/-1.78	2	-0.80	-0.89	-0.72	95%
13-139-0003	Gainesville - Fair St. Elem. Sch.	NA	NA	12	-0.25	0.69	+/-0.69	2	-0.41	-2.06	1.23	89%
13-153-0001	Warner Robins - Warner Robins	NA	NA	12	0.53	1.53	+/-1.53	2	1.74	0.80	2.68	97%
13-185-0003	Valdosta - S. L. Mason School	NA	NA	12	0.09	0.55	+/-0.55	2	1.77	0.91	2.63	87%
13-215-0001	Columbus - Health Department	NA	NA	12	0.59	1.33	+/-1.33	2	-1.50	-2.23	-0.78	98%
13-215-0008	Columbus - Airport	NA	NA	12	0.02	1.02	+/-1.02	2	-1.45	-1.85	-1.04	92%
13-215-0011	Columbus - Cussetta Rd. Sch.	NA	NA	12	-0.30	1.22	+/-1.22	2	-2.05	-2.69	-1.42	95%
13-223-0003	Yorkville - King's Farm	NA	NA	11	0.71	1.34	+1.34	2	-0.45	-0.69	-0.20	91%
13-245-0091	Augusta - Bungalow Rd. Sch.	NA	NA	12	0.81	1.39	+1.39	2	1.61	1.18	2.04	91%
13-295-0002	Rossville - Health Department	NA	NA	13	0.54	1.21	+/-1.21	2	-1.59	-3.20	0.02	78%
13-303-0001	Sandersville - Health Department	NA	NA	13	0.61	1.29	+1.29	2	0.85	0.17	1.52	90%
13-319-0001	Gordon - Police Dept	NA	NA	12	0.59	1.79	+/-1.79	2	-0.31	-3.86	3.24	86%
Georgia Ambient Air Monitoring Program		52	22.67	276	0.33	1.23		50	-0.03	-3.08	2.76	91%
95% LPL: 95% Lower Probability Limit						**95% UPL: 95% Upper Probability Limit**						

Table 13. $PM_{2.5}$ data quality assessment for semi-continuous samplers

$PM_{2.5}$ Yearly Data Quality Assessment Summary of Semi-Continuous Measurements										
Site Code	**Site Name**	**One-Point Flow Rate Check (L/min)**				**Semi-Annual Flow Check (L/min) (Bias %)**				**Completeness (%)**
		No. of Obs.	**Avg (%)**	**Absolute Bias (%)**	**Signed Bias (%)**	**No. of Obs.**	**Avg (%)**	**95% LPL (%)**	**95% UPL (%)**	
13-021-0012	Macon - Macon SE	12	1.12	1.48	+1.48	3	1.50	0.59	2.41	90%
13-051-1002	Savannah - W. Lathrop & Augusta Ave.	11	2.58	3.43	+3.43	2	1.90	0.00	3.80	87%
13-059-0002	Athens - Fire Station 7	12	-0.81	1.38	+/-1.38	3	-0.63	-2.45	1.19	82%
13-077-0002	Newnan - University of West Georgia	14	1.59	1.86	+1.86	2	0.79	0.62	0.95	95%
13-089-0002	Decatur - South DeKalb	14	0.19	0.91	+/-0.91	3	-0.13	-5.22	4.96	97%
13-121-0055	Atlanta - Confederate Ave.	11	1.24	1.56	+1.56	2	0.97	0.12	1.81	93%
13-135-0002	Lawrenceville - Gwinnett Tech	12	-0.77	0.87	-0.87	2	-0.74	-0.83	-0.66	95%
13-151-0002	McDonough - County Extension Office	12	4.54	4.86	+4.86	2	4.41	3.78	5.05	87%
13-215-0008	Columbus - Airport	13	-1.62	1.80	-1.8	2	-1.42	-1.58	-1.26	92%
13-223-0003	Yorkville - King's Farm	12	-0.71	1.24	-1.24	2	0.48	-0.69	1.66	91%
13-245-0091	Augusta - Bungalow Rd. Sch.	12	-2.80	3.65	-3.65	3	-3.48	-4.06	-2.89	91%
Georgia Ambient Air Monitoring Program		135	0.39	2.07		26	0.18	-4.04	4.39	90%
95% LPL: 95% Lower Probability Limit			**95% UPL: 95% Upper Probability Limit**							

Table 14. PM_{10} data quality assessment of 24-hour integrated and semi-continuous samplers

PM_{10} Yearly Data Quality Assessment Summary of 24-Hour Integrated and Semi-Continuous Measurements												
Site Code	**Site Name**	**Collocated ($\mu g/m^3$)**		**One-Point Flow Rate Check (L/min)**				**Semi-Annual Flow Check (L/min)**				**Completeness (%)**
		No. of Obs.	**Precision Estimate CV (%)**	**No. of Obs.**	**Avg (%)**	**Absolute Bias (%)**	**Signed Bias (%)**	**No. of Obs.**	**Avg (%)**	**95% LPL (%)**	**95% UPL (%)**	
13-245-0091	Augusta - Bungalow Rd. Elem. School	21	33.77	12	0.46	1.36	+/-1.36	4	1.03	0.04	2.02	89%
13-121-0039	Atlanta Fire Station #8	NA	NA	14	2.11	2.83	+2.83	2	1.89	-3.19	6.98	93%
13-089-0002	Atlanta South DeKalb	NA	NA	11	-0.52	1.45	+/-1.45	2	-1.61	-4.74	1.53	92%
Georgia Ambient Air Monitoring Program		21	33.77	37	0.80	1.94		8	0.59	-1.38	2.90	92%
NA: Not Applicable												
95% LPL: 95% Lower Probability Limit			**95% UPL: 95% Upper Probability Limit**									

Precision (field): Precision data for non-continuous particulate samplers is obtained through collocated sampling whereby two identical samplers are operated side-by-side and the same laboratory conducts filter analyses. Collocated samplers are located at selected sites and are intended to represent overall network precision. Validity of the data is based on the percent difference of the mass concentrations of the two samplers. In 2013 collocated $PM_{2.5}$ samplers were operated at Decatur-South DeKalb, Albany-Turner Elementary School, and Macon-Allied. Collocated PM_{10} samplers were operated at Augusta-Bungalow Road Elementary School site, and collocated TSP-Lead samplers were operated at Atlanta-DMRC site.

Particulate samplers (collocated PM_{10} and TSP) must have mass concentrations greater than or equal to 20 $\mu g/m^3$ to be used in data validity calculations. The difference between the mass concentrations must be no greater than 5 $\mu g/m^3$. If the mass concentrations are greater than 80 $\mu g/m^3$, the difference must be within ±7% of each other. TSP (lead) samplers must have both mass concentrations greater than or equal to 0.15 $\mu g/m^3$ to be used in data validity calculations. For collocated $PM_{2.5}$ samplers, data *probability limits* validity is based on the sampler's coefficient of variation, which cannot exceed 10%. Both sample masses must also be greater than 6 $\mu g/m^3$.

Precision for continuous $PM_{2.5}$ monitors is based on the comparison of the sampler's/analyzer's indicated and actual flow rates. The differences between the flow rates must be within ±15.

Accuracy (lab): Annual performance audits for PM_{10} and $PM_{2.5}$ mass analysis programs include an on-site check and assessment of the filter weighing balance, relative humidity and temperature sensors, and their documentation. The performance audits conducted in 2013 found that the Ambient Monitoring Program was operating in accordance with U.S. EPA guidelines and that the data were of good quality and should be considered data-for-record.

Precision (lab): Laboratories perform various quality control tasks to ensure that quality data are produced. Tasks include duplicate weighing on exposed and unexposed filters, replicate analysis on every tenth filter, and a calibration of the balance before each weighing session. Upon receipt of particulate matter filters from the field, laboratory staff has up to 30 days to analyze the PM_{10} and $PM_{2.5}$ samples. Filters are visually inspected for pinholes, loose material, poor workmanship, discoloration, non-uniformity, and irregularities, and are equilibrated in a controlled environment for a minimum of 24 hours prior to the filters being weighed. If room conditions are not within the established U.S. EPA control limits, weighing is done only after the proper environment is re-established and maintained for 24 hours.

In 2013, there were no occurrences in which the Georgia's Ambient Monitoring laboratory balance room was outside of control limits. The analytical precision results indicate that the Ambient Monitoring Program is providing precise particulate matter data. The tables below show the unexposed and exposed filter replicate results for the Air Protection Branch's (APB) laboratory in 2013.

Table 15. Summary of unexposed filter mass replicates

QC Checks for Pre-weighed Filters	PM_{10}	$PM_{2.5}$
Total # of sample analyzed	100	5169
Total # of replicates	6	581
Total % replicated	6%	11.24%
Total # out-of-range	0	0

Source: Laboratory Section, Quality Control Report

Table 16. Summary of exposed filter mass replicates

QC Checks for Post-weighed Filters	PM_{10}	$PM_{2.5}$
Total # of samples analyzed	90	4147
Total # of replicates	3	426
Total % replicated	3.33%	10.27%
Total # out-of-range	0	0

Source: Laboratory Section, Quality Control Report

AIR TOXICS

In 1996, the Air Protection Branch established an Air Toxics Network in major urban areas of the state to determine the average annual concentrations of air toxics. The program was established to assess the effectiveness of control measures in reducing air toxics exposures. Compounds identified as air toxics vaporize at ambient temperatures, play a critical role in the formation of ozone, and have adverse chronic and acute health effects. Sources of air toxics include motor vehicle exhaust, waste burning, gasoline marketing, industrial and consumer products, pesticides, industrial processes, degreasing operations, pharmaceutical manufacturing, and dry cleaning operations. Under the current air toxic sampling schedule, ambient air is collected in a stainless steel canister, on a quartz filter, and on a multi-layer cartridge every 12 days over a 24-hour sampling period at each of the network stations. Toxic particulate samples are collected and analyzed for air toxic contaminants to support the Georgia Air Toxic Network. By using a low-flow multi-channel sampler capable of sampling onto filters or cartridges, ambient air is collected and analyzed for carbonyls, polycyclic aromatic hydrocarbons (PAH) compounds (also called semi-volatile organic compounds or semi-VOCs), volatile organic compounds (VOCs), and toxic metals. The quality of the air toxic data set is governed by a series of quality assurance activities, including audits. The laboratory and monitoring staff are made aware of any exceedance found during an audit, and every effort is made to ensure that the data collected is as accurate as possible.

Flow audits of the toxic metal, VOCs, semi-VOCs and carbonyl samplers are conducted annually at each site to ensure the accuracy of measuring these compounds. Flow rates are a determining factor in calculating concentration and are included as part of the Quality Assurance Program. Although toxics data are a descriptive data set, completeness is issued based on the operating parameters of the sampler. Corrections are made to the samplers if an audit finds the sampler to be outside the Air Toxic Program control limits.

Precision (field and lab): As part of the Air Toxic Program laboratory analyses, internal QC techniques such as blanks, control samples, and duplicate samples are applied to ensure the precision of the analytical methods and that the toxics data are within statistical control.

Stainless steel canisters used to collect ambient air samples are also checked for contamination. Canisters are analyzed for aromatic and halogenated hydrocarbons. One canister per batch of eight is assayed to ensure individual compound measurements fall below the limit of detection. In the event a compound exceeds canister cleanliness criteria, the canister and all other canisters represented in the batch are re-cleaned until compounds meet the cleanliness criteria. In addition, Xontech 910A air samplers are checked for cleanliness. Failed air collection media are re-cleaned and re-tested until they pass Xontech 910A cleanliness criteria.

Accuracy (field): The accuracy of air toxic samples is determined by comparing the instrument's flow rate to a certified variable orifice, or a calibrated mass flow meter, that is certified against a National Institute of Standards and Technology (NIST) traceable flow device or calibrator. Since an accurate measurement of air toxics data is dependent upon flow rate, the Ambient Monitoring Program conducts annual flow rate audits at each site. The percent difference between the sampler flow rates and the audit flow rates is computed for each air toxics sampler.

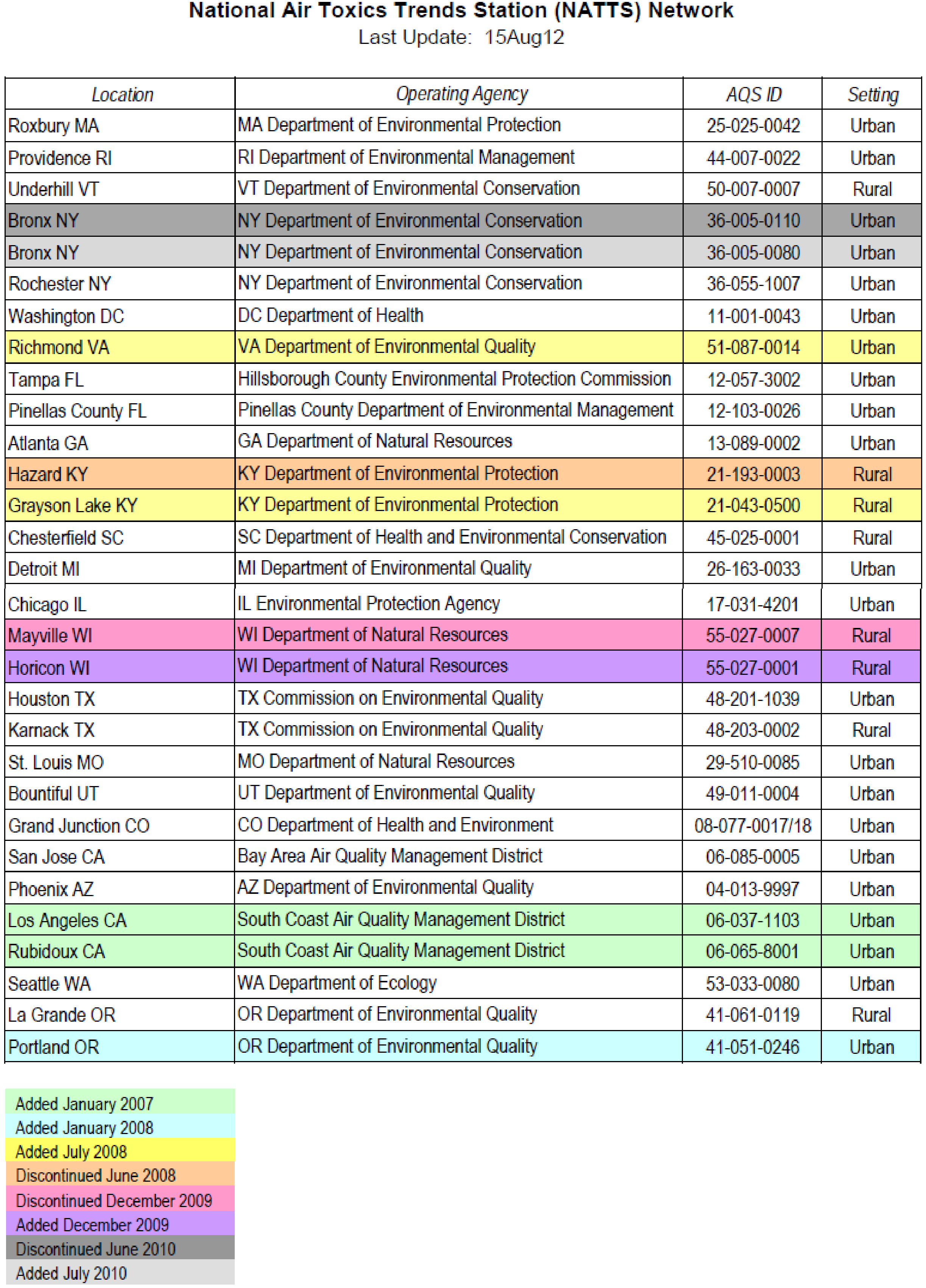
NATTS

There are currently 189 hazardous air pollutants (HAPs), or air toxics, with emissions regulated under the Clean Air Act (CAA). These compounds have been associated with a wide variety of adverse human health and ecological effects, including cancer, neurological effects, reproductive effects, and developmental effects. According to the Government Performance Results Act (GPRA), the U.S. Environmental Protection Agency (U.S. EPA) is committed to reducing air toxics emissions by 75 percent from 1993 levels in order to significantly reduce Americans' risk of cancer and of other serious health effects caused by airborne toxic chemicals. Early efforts toward this end have focused on emissions reductions through the assessment of technical feasibility. However, as new assessment tools are developed, more attention is being placed on the goal of risk reduction associated with exposure to air toxics.

To meet the GPRA goals, the National Air Toxics Trends Station (NATTS) network has been established, consisting of 27 stations nationwide, with one in Georgia. Having data of sufficient quality is paramount for a network such as the NATTS. As such, Georgia has closely followed the Quality System (QS) for the NATTS, established by U.S. EPA, two aspects of which are Technical Systems Audits (TSAs) and Instrument Performance Audits (IPAs) of each network station and its affiliated sample analysis laboratory. Another integral part of the QS is the quarterly analysis of performance evaluation (PE) samples. Furthermore, the sampling and analytical techniques selected to collect and quantify the air toxics of concern must demonstrate acceptable analytical and overall sampling precision, as well as suitable overall method detection limits that are compatible with expected ambient air toxics concentrations.

There are 27 sites nationwide in the NATTS network. Georgia joined the network with one site established in Decatur at the South DeKalb Monitoring Station. The location of all sites, whether the site is located in an urban or rural area, the unique AQS identification code (site code), and current status for all the sites are given in Table 17. The list was taken from the U.S. EPA website, http://www.epa.gov/ttnamti1/natts.html.

Table 17. Current list of NATTS sites with AQS site codes



National Air Toxics Trends Station (NATTS) Network

Last Update: 15Aug12

Location	*Operating Agency*	*AQS ID*	*Setting*
Roxbury MA	MA Department of Environmental Protection	25-025-0042	Urban
Providence RI	RI Department of Environmental Management	44-007-0022	Urban
Underhill VT	VT Department of Environmental Conservation	50-007-0007	Rural
Bronx NY	NY Department of Environmental Conservation	36-005-0110	Urban
Bronx NY	NY Department of Environmental Conservation	36-005-0080	Urban
Rochester NY	NY Department of Environmental Conservation	36-055-1007	Urban
Washington DC	DC Department of Health	11-001-0043	Urban
Richmond VA	VA Department of Environmental Quality	51-087-0014	Urban
Tampa FL	Hillsborough County Environmental Protection Commission	12-057-3002	Urban
Pinellas County FL	Pinellas County Department of Environmental Management	12-103-0026	Urban
Atlanta GA	GA Department of Natural Resources	13-089-0002	Urban
Hazard KY	KY Department of Environmental Protection	21-193-0003	Rural
Grayson Lake KY	KY Department of Environmental Protection	21-043-0500	Rural
Chesterfield SC	SC Department of Health and Environmental Conservation	45-025-0001	Rural
Detroit MI	MI Department of Environmental Quality	26-163-0033	Urban
Chicago IL	IL Environmental Protection Agency	17-031-4201	Urban
Mayville WI	WI Department of Natural Resources	55-027-0007	Rural
Horicon WI	WI Department of Natural Resources	55-027-0001	Rural
Houston TX	TX Commission on Environmental Quality	48-201-1039	Urban
Karnack TX	TX Commission on Environmental Quality	48-203-0002	Rural
St. Louis MO	MO Department of Natural Resources	29-510-0085	Urban
Bountiful UT	UT Department of Environmental Quality	49-011-0004	Urban
Grand Junction CO	CO Department of Health and Environment	08-077-0017/18	Urban
San Jose CA	Bay Area Air Quality Management District	06-085-0005	Urban
Phoenix AZ	AZ Department of Environmental Quality	04-013-9997	Urban
Los Angeles CA	South Coast Air Quality Management District	06-037-1103	Urban
Rubidoux CA	South Coast Air Quality Management District	06-065-8001	Urban
Seattle WA	WA Department of Ecology	53-033-0080	Urban
La Grande OR	OR Department of Environmental Quality	41-061-0119	Rural
Portland OR	OR Department of Environmental Quality	41-051-0246	Urban

Added January 2007
Added January 2008
Added July 2008
Discontinued June 2008
Discontinued December 2009
Added December 2009
Discontinued June 2010
Added July 2010

(Source: http://www.epa.gov/ttnamti1/natts.html)

Several Measurement Quality Objectives (MQOs) have been established for the NATTS network in order to ensure that only data of the highest quality are collected by the NATTS network, and to meet the NATTS Data Quality Objective (DQO): “to be able to detect a 15 percent difference (trend) between two consecutive 3-year annual mean concentrations within acceptable levels of decision error” (U.S. EPA, 1994b). Initially, the four compounds of primary importance to the NATTS program were benzene, 1,3-butadiene, formaldehyde, and PM_{10} arsenic. The Data Quality Objective MQOs for these four compounds are summarized in Table 18 below.

Table 18. Measurement quality objectives for the NATTS program

Compound	Completeness	Precision (Coefficient of Variation)	Laboratory Bias	Method Detection Limit (MDL)
Benzene	> 85 %	< 15 %	< 25 %	0.044 µg/m^3
1,3-Butadiene	> 85 %	< 15 %	< 25 %	0.020 µg/m^3
Formaldehyde	> 85 %	< 15 %	< 25 %	0.014 µg/m^3
Arsenic	> 85 %	< 15 %	< 25 %	0.046 ng/m^3

Other compounds have been added to the list of compounds, including hexavalent chromium, acrolein, and polycyclic aromatic hydrocarbons (PAHs). GA EPD collects data to monitor for these compounds as part of the NATTS program, as well as organic carbon, additional carbonyls, and additional volatile organic compounds.

The MQOs require that: (1) sampling occurs every sixth day and is successful 85 percent of the time; (2) precision as measured by the coefficient of variation (CV) be controlled to less than 15 percent; and (3) that laboratory (measurement) bias be less than 25 percent. Data acquired to assess compliance with the above stated MQOs are derived from a variety of sources. These sources are given in Table 19.

Table 19. MQO data sources for the Georgia NAATS program

Criteria	Data Source	MQO Limit
Completeness	Air Quality System (AQS)	< 15 %
Precision	AQS and Proficiency Testing	< 15 %
Bias - Laboratory	Proficiency Testing	< 25 %
Bias - Field	Audits of Sampler Flowrates	< 10 %
MDL	Laboratories	0.046 ng/m^3 to 0.044 µg/m^3

The Air Quality System (AQS) database contains raw data that is used to assess data completeness, and to estimate precision from results of replicate analyses and collocated sampling. In addition, results from the analysis of proficiency testing samples allow one to calculate laboratory precision and bias.

Completeness (of NATTS Data): The AQS database was accessed and the raw data records analyzed for 23 compounds having the AQS codes given in Table 20 on the next page. The completeness of the 2013 AQS dataset was assessed for four compounds: benzene, 1,3-butadiene, formaldehyde, and arsenic. The results are shown in Table 21, on the next page. The percent completeness ranged from 85% to 90.6%, with sampling occurring every sixth day. Primary and collocated data are differentiated in AQS by use of parameter occurrence codes (POCs).

Table 20. 23 Selected HAPs and their AQS parameter codes

Compound Name	AQS Code
Benzene	45201
1,3-Butadiene	43218
Carbon Tetrachloride	43804
Chloroform	43803
1,2-Dibromoethane	43843
1,2-Dichloropropane	43829
1,2-Dichloroethane	43815
Dichloromethane	43802
1,1,2,2-Tetrachloroethane	43818
Tetrachloroethylene	43817
Trichloroethylene	43824
Vinyl Chloride	43860
Cis-1,3-Dichloropropene	43831
Trans-1,3-Dichloropropene	43830
Formaldehyde	43502
Acetaldehyde	43503
Arsenic	82103
Beryllium	82105
Cadmium	82110
Lead	82128
Manganese	82132
Mercury	82142
Nickel	82136

Table 21. Percent completeness of Georgia's 2013 AQS data, selected compounds

	Completeness of Compound by AQS Number and by Name			
	45201	**43218**	**43502**	**82103**
Site	**benzene**	**1,3-butadiene**	**formaldehyde**	**arsenic**
Decatur, GA	97%	100%	92%	82%

PHOTOCHEMICAL ASSESSMENT MONITORING

In 1996, the Air Protection Branch began a routine seasonal sampling program to gather information about non-methane hydrocarbon (NMHC) species that were precursors to ozone formation in high ozone areas. In 1994, federal regulations required states to establish photochemical assessment monitoring stations (PAMS) as part of their State Implementation Plan (SIP) for monitoring networks in areas designated as serious or higher for ozone. Monitoring is to continue until the ozone standard is reached. The PAMS program is intended to supplement ozone monitoring and add detailed sampling for its precursors. PAMS sites collect data on real-time total NMHC, PAMS speciated VOCs, carbonyls, and various meteorological parameters at ground level and aloft. As this is a descriptive data set, there are currently no mandatory data quality objectives or regulations for the data. However, efforts are made to ensure that accurate data are collected and that the analyzers are operating within PAMS audit standards.

Accuracy (field and lab): Laboratory performance audits are conducted annually to assess the laboratory's ability to measure ambient levels of hydrocarbons. Through-the-probe *sampler* performance audits are conducted semi-annually at each monitoring site to assess the integrity of the sampling, analysis, and transport system. The 2013 PAMS speciated VOCs yearly data quality assessment summary for the three PAMS sites on the tables below show that most results were within the PAMS' control limits of ±20%.

Table 22. PAMS speciated VOCs yearly data quality assessment for South DeKalb

PAMS Speciated VOCs Yearly Data Quality Assessment Summary for Decatur - South DeKalb Site												
Parameter Code	**Parameter Name**	**2-Comp. Std. Weekly Check**			**Validation of Bias**			**Annual Perform, Evaluation Bias**				**Completeness (%)**
		No. of Obs.	**Precision Estimate CV (%)**	**Absolute Bias Estimate (%)**	**Avg (%)**	**95% LPL (%)**	**95% UPL (%)**	**No. of Obs.**	**Avg (%)**	**95% LPL (%)**	**95% UPL (%)**	
43202	Ethane[+]	NA	NA	NA	NA	NA	NA	6	6.01	-7.19	19.20	97%
43204	Propane[*]	26	22.39	15.35	17.67	-26.51	44.74	6	2.70	-13.01	18.40	97%
43214	Isobutane[+]	NA	NA	NA	NA	NA	NA	6	-8.66	-15.31	-2.00	97%
43216	Trans-2-Butene[+]	NA	NA	NA	NA	NA	NA	6	-34.00	-86.01	18.00	97%
43220	N-Pentane[+]	NA	NA	NA	NA	NA	NA	6	-17.01	-33.66	-0.37	97%
43285	2-Methylpentane[+]	NA	NA	NA	NA	NA	NA	6	-32.29	-83.16	18.59	97%
43243	Isoprene[+]	NA	NA	NA	NA	NA	NA	6	-58.44	-108.51	-8.37	97%
43231	N-Hexane[+]	NA	NA	NA	NA	NA	NA	6	-0.64	-63.83	62.56	97%
45201	Benzene[*]	26	35.17	23.54	21.88	-47.83	64.09	6	-0.44	-29.67	28.78	97%
43232	N-Heptane[+]	NA	NA	NA	NA	NA	NA	6	-23.13	-109.94	63.67	97%
45202	Toluene[+]	NA	NA	NA	NA	NA	NA	6	-36.45	-107.25	34.34	97%
45203	Ethylbenzene[+]	NA	NA	NA	NA	NA	NA	6	-38.72	-103.82	26.38	97%
43238	N-Decane[+]	NA	NA	NA	NA	NA	NA	6	-38.61	-49.34	-27.88	97%
45225	1,2,3-Trimethylbenzene[+]	NA	NA	NA	NA	NA	NA	6	-46.52	-67.81	-25.23	97%
95% LPL: 95% Lower Probability Limit					95% UPL: 95% Upper Probability Limit							
* NIST traceable												
+ Only NIST traceable by weight												

Table 23. PAMS speciated VOCs yearly data quality assessment for Conyers

PAMS Speciated VOCs Yearly Data Quality Assessment Summary for Conyers - Monastery Site												
Parameter Code	Parameter Name	2-Comp. Std. Weekly Check			Validation of Bias			Annual Perform, Evaluation Bias				Completeness (%)
		No. of Obs.	Precision Estimate CV (%)	Absolute Bias Estimate (%)	Avg (%)	95% LPL (%)	95% UPL (%)	No. of Obs.	Avg (%)	95% LPL (%)	95% UPL (%)	
43202	Ethane[+]	NA	NA	NA	NA	NA	NA	6	-7.41	-13.53	-1.29	95%
43204	Propane[*]	31	15.85	14.33	-8.46	-34.68	16.79	6	-13.17	-19.32	-7.01	95%
43214	Isobutane[+]	NA	NA	NA	NA	NA	NA	6	-21.78	-27.08	-16.48	95%
43216	Trans-2-Butene[+]	NA	NA	NA	NA	NA	NA	6	-25.50	-30.21	-20.80	95%
43220	N-Pentane[+]	NA	NA	NA	NA	NA	NA	6	-26.32	-34.24	-18.39	95%
43285	2-Methylpentane[+]	NA	NA	NA	NA	NA	NA	6	-66.04	-69.70	-62.38	95%
43243	Isoprene[+]	NA	NA	NA	NA	NA	NA	6	-60.82	-73.62	-48.01	95%
43231	N-Hexane[+]	NA	NA	NA	NA	NA	NA	6	-31.39	-89.84	27.06	95%
45201	Benzene[*]	31	16.8	22.87	-15.97	-45.91	8.66	6	-13.46	-21.83	-5.08	95%
43232	N-Heptane[+]	NA	NA	NA	NA	NA	NA	6	-16.99	-29.13	-4.86	95%
45202	Toluene[+]	NA	NA	NA	NA	NA	NA	6	-23.65	-35.18	-12.11	95%
45203	Ethylbenzene[+]	NA	NA	NA	NA	NA	NA	6	-32.26	-46.51	-18.01	95%
43238	N-Decane[+]	NA	NA	NA	NA	NA	NA	6	-26.01	-35.78	-16.24	95%
45225	1,2,3-Trimethylbenzene[+]	NA	NA	NA	NA	NA	NA	6	-46.49	-63.30	-29.68	95%
95% LPL: 95% Lower Probability Limit				95% UPL: 95% Upper Probability Limit								
* NIST traceable												
+ Only NIST traceable by weight												

Table 24. PAMS speciated VOCs yearly data quality assessment for Yorkville

PAMS Speciated VOCs Yearly Data Quality Assessment Summary for Yorkville – King's Farm Site

Parameter Code	Parameter Name	2-Comp. Std. Weekly Check			Validation of Bias			Annual Perform, Evaluation Bias				Completeness (%)
		No. of Obs.	Precision Estimate CV (%)	Absolute Bias Estimate (%)	Avg (%)	95% LPL (%)	95% UPL (%)	No. of Obs.	Avg (%)	95% LPL (%)	95% UPL (%)	
43202	Ethane[+]	NA	NA	NA	NA	NA	NA	6	5.69	-3.77	15.15	77%
43204	Propane[*]	26	7.88	6.02	0.99	-13.11	11.97	6	-0.63	-11.20	9.93	77%
43214	Isobutane[+]	NA	NA	NA	NA	NA	NA	6	-2.88	-8.19	2.42	77%
43216	Trans-2-Butene[+]	NA	NA	NA	NA	NA	NA	6	-16.20	-45.16	12.76	77%
43220	N-Pentane[+]	NA	NA	NA	NA	NA	NA	6	-17.72	-44.74	9.29	77%
43285	2-Methylpentane[+]	NA	NA	NA	NA	NA	NA	6	-5.93	-11.45	-0.41	77%
43243	Isoprene[+]	NA	NA	NA	NA	NA	NA	6	-35.09	-43.00	-27.17	77%
43231	N-Hexane[+]	NA	NA	NA	NA	NA	NA	6	13.14	-7.02	33.30	77%
45201	Benzene[*]	26	12.2	10.01	4.43	-16.51	22.3	6	-2.33	-10.38	5.73	77%
43232	N-Heptane[+]	NA	NA	NA	NA	NA	NA	6	8.59	-4.54	21.72	77%
45202	Toluene[+]	NA	NA	NA	NA	NA	NA	6	-5.85	-24.21	12.51	77%
45203	Ethylbenzene[+]	NA	NA	NA	NA	NA	NA	6	1.83	-22.87	26.53	77%
43238	N-Decane[+]	NA	NA	NA	NA	NA	NA	6	-34.01	-60.97	-7.04	77%
45225	1,2,3-Trimethylbenzene[+]	NA	NA	NA	NA	NA	NA	6	-29.72	-48.36	-11.07	77%

95% LPL: 95% Lower Probability Limit

95% UPL: 95% Upper Probability Limit

* NIST traceable

+ Only NIST traceable by weight

Table 25. PAMS speciated VOCs yearly data quality assessment for Ambient Monitoring Program Summary

PAMS Speciated VOCs Yearly Data Quality Assessment for GA EPD Ambient Air Monitoring Program Summary												
Parameter Code	**Parameter Name**	**2-Comp. Std. Weekly Check**			**Validation of Bias**			**Annual Perform, Evaluation Bias**				**Completeness (%)**
		No. of Obs.	**Precision Estimate CV (%)**	**Absolute Bias Estimate (%)**	**Avg (%)**	**95% LPL (%)**	**95% UPL (%)**	**No. of Obs.**	**Avg (%)**	**95% LPL (%)**	**95% UPL (%)**	
43202	Ethane[+]	NA	NA	NA	NA	NA	NA	18	1.43	-8.59	11.44	89%
43204	Propane[*]	83	15.40	12.05	2.69	-23.66	29.03	18	-3.70	-15.19	7.79	89%
43214	Isobutane[+]	NA	NA	NA	NA	NA	NA	18	-11.11	-16.89	-5.32	89%
43216	Trans-2-Butene[+]	NA	NA	NA	NA	NA	NA	18	-25.24	-59.71	9.24	89%
43220	N-Pentane[+]	NA	NA	NA	NA	NA	NA	18	-20.35	-39.23	-1.47	89%
43285	2-Methylpentane[+]	NA	NA	NA	NA	NA	NA	18	-34.75	-64.37	-5.13	89%
43243	Isoprene[+]	NA	NA	NA	NA	NA	NA	18	-51.45	-81.64	-21.26	89%
43231	N-Hexane[+]	NA	NA	NA	NA	NA	NA	18	-6.30	-57.34	44.75	89%
45201	Benzene[*]	83	21.11	19.05	2.28	-34.81	39.36	18	-5.41	-23.57	12.75	89%
43232	N-Heptane[+]	NA	NA	NA	NA	NA	NA	18	-10.51	-61.68	40.66	89%
45202	Toluene[+]	NA	NA	NA	NA	NA	NA	18	-21.98	-64.73	20.76	89%
45203	Ethylbenzene[+]	NA	NA	NA	NA	NA	NA	18	-23.05	-64.08	17.98	89%
43238	N-Decane[+]	NA	NA	NA	NA	NA	NA	18	-32.88	-50.55	-15.20	89%
45225	1,2,3-Trimethylbenzene[+]	NA	NA	NA	NA	NA	NA	18	-40.91	-59.91	-21.90	89%
95% LPL: 95% Lower Probability Limit				95% UPL: 95% Upper Probability Limit								
* NIST traceable												
+ Only NIST traceable by weight												

METEOROLOGY

The Ambient Monitoring Program monitors meteorological parameters such as wind speed, wind direction, ambient temperature, relative humidity, barometric pressure, total ultra violet radiation, precipitation and total solar radiation. Real-time meteorological data are generated to characterize meteorological processes such as transport and diffusion, and to make air quality forecasts and burn day decisions. The data are also used for control strategy modeling, case study analysis, and urban airshed modeling. A state/local meteorology subcommittee of the Air Monitoring Technical Advisory Commission (AMTAC) agreed to define the level of acceptability for meteorological data as those used by the U.S. EPA for both the Prevention of Significant Deterioration (PSD) and Photochemical Assessment Monitoring Stations (PAMS) programs. The Quality Assurance Unit audits to those levels.

The data variability collected by this element of the monitoring program is generally described as meeting or not meeting the PSD requirements. Station operators are notified if an exceedance is found during an audit, and every effort is made to ensure that the data meets the audit standards. The wind speed, wind direction, ambient temperature and relative humidity data sets are controlled data sets, and subject to meeting PAMS objectives. Since the inception of the meteorological audit program, the data quality has improved significantly.

Accuracy (field): The accuracy of meteorological sensors is checked by annual performance audits. Table 26 summarizes the 2013 data quality assessment results. The average difference (average degree difference with respect to ambient temperature) represents the combined differences from the certified value of all the individual audit points for each sensor. The upper and lower probability limits represent the expected accuracy of 95 percent of all the single sensor's individual percent differences for all audit test levels at a single site.

Table 26. Meteorological measurements accuracy results

Meteorological Measurements Yearly Data Quality Assessment Summary for GA EPD Ambient Air Monitoring Program (as a PQAO)							
Parameter Code	**Parameter Name**	**Annual Audit (Bias %)**					**Completeness (%)**
		No. of Obs.	**No. of Site**	**Avg (%)**	**95% LPL (%)**	**95% UPL (%)**	
61101	Wind Speed	16	16	0.44	-1.18	2.07	99%
61102	Wind Direction	16	16	3.90	-9.69	17.50	99%
62101	Ambient Temperature	9	7	-0.90	-6.64	4.84	97%
64101	Barometric Pressure	7	6	-0.01	-0.18	0.17	96%
62201	Relative Humidity	9	8	0.29	-3.31	3.90	96%
95% LPL: 95% Lower Probability Limit				95% UPL: 95% Upper Probability Limit			
PQAO: Primary Quality Assurance Organization							

QUALITY CONTROL REPORTS

Quality Control (QC) reports are summaries of the quality control activities conducted by the laboratory to support accurate and precise measurements. These activities include: blanks, duplicates, controls, spiked samples, limits of detection, calibrations, and audit results.

STANDARDS LABORATORY

The U.S. EPA Region IV Standards Laboratory yearly performs technical support and certification services for Georgia's ozone primary standard. Flow rate transfer standards and certification of compressed gas cylinders are sent to the manufacturers for re-certification to ensure that all are traceable to standards of the NIST. A calibration establishes a correction factor to adjust or correct the output of an instrument; a certification establishes traceability of a transfer standard to a NIST-traceable standard; and verification establishes comparability of a standard to a NIST-traceable standard of equal rank.

LABORATORY AND FIELD STANDARD OPERATING PROCEDURE

Standard Operating Procedures (SOPs) are guidance documents for the operation of quality assurance programs used by the Georgia Ambient Monitoring Program. The SOPs are intended for field operators and supervisors; laboratory, data processing and engineering personnel; and program managers responsible for implementing, designing, and coordinating air quality monitoring projects. Each SOP has a specific method that must be followed to produce data-for-record. The SOPs are developed and published to ensure that, regardless of the person performing the operation, the results will be consistent.

SITING EVALUATIONS

To generate accurate and representative data, ambient monitoring stations should meet specific siting requirements and conditions. It is assumed that the stations meet the siting criteria in place at the time initial operation began. The siting requirements of the AMP Quality Assurance Manual Volume II; 40 CFR 58, Appendix E; U.S. EPA's Quality Assurance Handbook Volume IV: U.S. EPA's Prevention of

Significant Deterioration (PSD); and U.S. EPA's PAMS guidelines present siting criteria to ensure the collection of accurate and representative data. The siting criterion for each pollutant varies depending on the pollutant's properties, monitoring objective and intended spatial scale. The U.S. EPA's siting criteria are stated as either "must meet" or "should meet". According to 40 CFR 58, Appendix E, the "must meet" requirements are necessary for high quality data. Any exception from the "must meet" requirements must be formally approved through the Appendix E waiver provision. The "should meet" criteria establish a goal for data consistency. Siting criteria are requirements for locating and establishing stations and samplers to meet selected monitoring objectives, and to help ensure that the data from each site are collected uniformly. There are four main monitoring objectives: to determine highest concentrations expected to occur in the area covered by the network; to determine representative concentrations in areas of high population density; to determine the impact on ambient pollution levels of significant sources or source categories; and to determine general background concentration levels. Typical siting designations are: micro, middle, neighborhood, urban, and regional. These designations represent the size of the area surrounding the monitoring site which experiences relatively uniform pollutant concentrations. Typical considerations for each of these site designations are, for example, the terrain, climate, population, existing emission sources, and distances from trees and roadways. The Quality Assurance Unit conducts siting evaluations annually. Physical measurements and observations include probe/sensor height above ground level, distance from trees, type of ground cover, residence time, obstructions to air flow, and distance to local sources. These measurements and observations are taken to determine compliance with 40 CFR Part 58, Appendix E requirements.

RISK ASSESSMENT

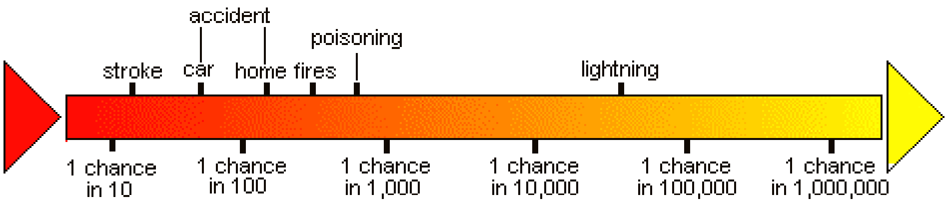
INTRODUCTION

In 2013, Georgia EPD collected air toxic samples from five Air Toxics Network (ATN) sites (including two rural background sites) and one National Air Toxics Trends Station (NATTS) site. The following risk assessment reflects data collected at these six locations. Compounds sampled at these sites are shown in Table 27. The list was derived from the 189 compounds EPA has designated as Hazardous Air Pollutants (HAPS). Many of the HAPS do not have standardized ambient air sampling and analytical methods. In order to collect the compounds of interest for the Georgia network, at least three types of samplers are used at all locations: HIVOL, PUF, and canister. In addition, a carbonyls sampler was located at the Dawsonville, Savannah, and South DeKalb sites in 2013. This equipment samples for metals, semi-volatile organic compounds, volatile organic compounds, and carbonyls once every twelve days following a pre-established schedule that corresponds to a nationwide sampling schedule. On the twelfth day the sampler runs midnight to midnight and takes a 24-hour composite sample. An exception to this sampling schedule is the South DeKalb site, which samples every six days as part of the National Air Toxics Trends Station (NATTS) and Photochemical Assessment Monitoring Stations (PAMS) networks. In addition, during June, July, and August, the South DeKalb site collects four integrated three-hour carbonyls samples every third day as part of the PAMS and NATTS networks.

Some of the chemicals monitored in the ATN are also monitored at sites in the PAMS network. The monitoring schedule and some analysis methods are different at the PAMS sites and ATN sites. To account for this, several of the compounds from the PAMS sites were evaluated and compared to concentrations measured at nearby ATN sites for this report.

To put into perspective the risks from environmental hazards as risk analysts will describe them, the continuum below presents risk statistics for some familiar events. Risk analysts describe cancer risks numerically in scientific notation, for example 1 x 10[-5], 1 x 10^{-5} or 1.00E-05, which means that there is one chance in 100,000 of an event occurring. It is important to note that these risk statistics are population averages, while risk analysts usually estimate risk to the maximum exposed individual. Additionally, it should be noted that these risk values are considered additional risk. That is, risk above and beyond the normal background risk from exposure in everyday life.

Putting Risks in Perspective



RESULTS AND INTERPRETATION

The air toxics data [volatile organic compounds (VOCs), semi-volatile organic compounds, and metals] collected during 2013 from the Air Toxics Network was evaluated to assess the potential for health concerns. Carbonyls data were assessed separately from the other air toxics, with the exception of acrolein, because those chemicals were only monitored at two of the ATN sites and one of the PAMS locations.

The initial evaluation consisted of a comparison of the monitored results to "health based" screening values. These values were calculated using procedures recommended in EPA's latest guidance on risk assessment for air toxics, 'A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Data Sets' (U.S. EPA, 2006). Briefly, EPA's prioritized chronic dose-response values for both noncancerous (reference concentrations, RfC) and cancer (inhalation unit risks, IUR) were used to generate screening air concentrations. To screen for noncancerous effects, the reference concentration was used as a starting point. However, to account for possible exposure to multiple contaminants, the screening air concentration was obtained by dividing the RfC by 10. Screening values for the cancer endpoint were determined by calculating air concentrations equivalent to a risk level of one in one million. Most screening values utilized in this assessment are listed in Appendix A of the previously mentioned guidance document (U.S. EPA, 2006) and updated "Table 1. Prioritized Chronic Dose-Response Values for Screening Risk Assessments (5/09/2014)" (U.S. EPA, 2014). These screening values and the chemicals monitored are displayed in Table 27. For a limited number of chemicals, other resources such as toxicity values from the Regional Screening Table (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm) were used to calculate conservative screening values. These compounds are indicated with an asterisk. When available, both the names derived from the International Union of Chemistry (IUC) and the common names are given. It is important to emphasize that the screening values were calculated in a very conservative manner. Assumptions were made that accounted for the potential for continuous exposure to air toxics for 24 hours per day for 70 years. The conservative screening process was utilized so that the chance of underestimating the potential for health impacts would be minimized, as chemicals were excluded from further quantitative analysis.

Because results for many of the chemicals assessed were routinely below detection limits of the analytical methods available, the initial review of the data was based on an assessment of the number of chemicals detected and the frequency with which they were detected. The process included determining how often (if at all) a chemical was detected (present), if it was present above detection limits, and if those concentrations were above screening values of concern.

Table 27. Compounds monitored and screening values used in initial assessment

Chemical	Screen Value (µg/m^3)	Chemical	Screen Value (µg/m^3)
Metals			
Antimony	0.02	Cobalt	0.01
Arsenic	0.00023	Lead	0.15
Beryllium	0.00042	Manganese	0.005
Cadmium	0.00056	Nickel	0.0021
Chromium	0.000083	Selenium	2
Chromium VI	0.000083	Zinc	N/A
Semi-Volatiles			
Acenaphthene	0.3	Cyclopenta(cd)pyrene	N/A
Acenaphthylene	0.3	Dibenzo(a,h)anthracene	0.00083
Anthracene	0.3	Fluoranthene	0.3
Benzo(a)anthracene	0.0091	Fluorene	0.3
Benzo(b)fluoranthene	0.0091	Indeno(1,2,3-c,d)pyrene	0.0091
Benzo(k)fluoranthene	0.0091	Naphthalene	0.029
Benzo(g,h,i)perylene	0.3	Phenanthrene	0.3
Benzo(a)pyrene	0.00091	Perylene	N/A
Benzo(e)pyrene	0.3	Pyrene	0.3
Chrysene	0.091		
Volatile Organic Compounds			
Benzene	0.13	1,3 and 1,4-Dimethylbenzene (m/p-Xylene)	10
Benzenecarbonal (Benzaldehyde)	N/A	Ethanal (Acetaldehyde)	0.45
Benzyl chloride	0.02	Ethylbenzene	0.4
Bromomethane (Methyl bromide)	0.5	Ethenylbenzene (Styrene)	100
1,3-Butadiene	0.03	Benzene,1-ethenyl-4-methyl (p-Ethyltoluene)	N/A
Butanal (Butyraldehyde)	N/A	Freon 113	N/A
Chlorobenzene (Phenyl chloride)	100	Hexachloro-1,3-Butadiene(Hexachlorobutadiene)	0.045
Chloroethane (Ethyl chloride)	1000	n-Hexane	70
Chloroethene (Vinyl chloride)	0.11	Methanal (Formaldehyde)	0.0769
Chloromethane (Methyl chloride)	9.0	Methylbenzene/Phenylmethane (Toluene)	40
Cyclohexane	6300*	Propanal (Propionaldehyde)	0.8
1,2-Dibromoethane (Ethylene dibromide)	0.002	2-Propanone (Acetone)	32000*
1,2-Dichlorobenzene	20*	Propenal (Acrolein)	0.002
1,3-Dichlorobenzene	N/A	1,1,2,2-Tetrachloroethane	0.017
1,4-Dichlorobenzene	0.091	Tetrachloroethene (Perchloroethylene)	3.846
Dichlorodifluoromethane (Freon 12)	100*	Tetrachlormethane (Carbon tetrachloride)	0.17
1,1-Dichloroethane (Ethylidene chloride)	0.63	1,2,4-Trichlorobenzene	20
cis-1,2-Dichloroethene	N/A	1,2,3-Trimethylbenzene	5.2*
1,1-Dichloroethene (1,1-Dichloroethylene)	210*	1,2,4-Trimethylbenzene	7.3*
Dichloromethane (Methylene chloride)	100	1,3,5-Trimethylbenzene	N/A
1,2-Dichloropropane (Propylene dichloride)	0.1*	1,1,1-Trichloroethane (Methyl chloroform)	5000
cis-1,3-Dichloropropene	N/A	1,1,2-Trichloroethane	0.063
trans-1,3-Dichloropropene	N/A	Trichloroethene (Trichloroethylene)	0.244
1,1-Dichloro-1,2,2,2-tetrafluoroethane(Freon114)	N/A	Trichlorofluoromethane (Freon 11)	730*
1,2-Dimethylbenzene (o-Xylene)	10	Trichloromethane (Chloroform)	9.8

*From Regional Screening Table (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)

Table 28 summarizes the total number of chemicals monitored at each site (excluding all carbonyls except acrolein), the number of chemicals detected, and the number of chemicals detected above the health based screening values for 2013. Seventy-one chemicals were monitored at all the Air Toxics sites, except the South DeKalb site, where 74 air toxic chemicals were monitored. In 2013, 36 of the 71 sampled compounds were not detected at the sites, and an additional 11 compounds had 2 or fewer sites with detections. The number of chemicals that were detected at concentrations above the screening levels was even less, with a mean value of 6. Of the three categories of chemicals measured at all sites (VOC, semi-VOC, metals), most of the chemicals that were detected above screening values belonged to the metals group.

Table 28. Summary of chemicals analyzed in 2013

Location	County	Number of Compounds Monitored	Number of Compounds Detected	Number of Compounds Greater than Screening Value
Dawsonville	Dawson	71*	27	5
General Coffee	Coffee	71	24	6
Macon	Bibb	71	28	7
Savannah	Chatham	71*	24	5
South DeKalb	DeKalb	74*	20	6
Yorkville	Paulding	71	27	6

* 6 additional carbonyls were monitored at these locations but not included in this analysis, compounds that exceeded their screening value are summarized in Table 33

Table 29 shows the average concentration and detection frequency of the chemicals that were detected above screening values at each Air Toxics site in 2013. The number of detects were counted as any number that was above half the method detection limit. The average was computed using the sample concentration when it was above half the method detection limit and substituting half the method detection limit if the sample concentration was below this limit.

Table 29. Site-specific detection frequency and mean concentration for chemicals that exceeded their screening values in 2013

Location	**Chemical**	**Mean (µg/m^3)**	**Detection Frequency**
Dawsonville	Arsenic	6.8×10^{-4}	20/28
	Chromium	1.6×10^{-3}	27/28
	Benzene	8.0×10^{-1}	30/30
	Acrolein	8.0×10^{-1}	30/30
	Carbon tetrachloride	7.9×10^{-1}	1/30
General Coffee	Arsenic	8.4×10^{-4}	19/27
	Chromium	1.4×10^{-3}	27/27
	Benzene	4.2×10^{-1}	8/26
	Acrolein	4.6×10^{-1}	13/26
Macon	Arsenic	6.2×10^{-4}	19/29
	Chromium	1.7×10^{-3}	29/29
	Benzene	3.5	18/26
	Acrolein	5.8×10^{-1}	22/26
	Manganese	6.2×10^{-3}	29/29
Savannah	Arsenic	7.3×10^{-4}	19/29
	Chromium	2.0×10^{-3}	29/29
	Benzene	4.6×10^{-1}	13/28
	Acrolein	8.3×10^{-1}	20/28
	Manganese	5.8×10^{-3}	29/29
South DeKalb	Arsenic	6.1×10^{-4}	20/27
	Chromium	1.6×10^{-3}	27/28
	Benzene	5.6×10^{-1}	37/59
	Acrolein	6.3×10^{-1}	45/59
	Naphthalene	5.1×10^{-2}	50/51
	Carbon tetrachloride	7.9×10^{-1}	2/59
Yorkville	Arsenic	5.0×10^{-4}	13/26
	Chromium	1.9×10^{-3}	25/26
	Benzene	4.3×10^{-1}	7/25
	Acrolein	5.4×10^{-1}	17/25

Formula For Calculating Risk Using IUR For Carcinogens

$$Risk = IUR*Conc$$

Formula For Calculating Hazard Quotient Using RfC For Noncarcinogens

$$HQ = \frac{Conc}{RfC}$$

Equation Parameters

Risk Theoretical lifetime cancer risk (unitless probability)
HQ Hazard quotient (unitless ratio)
Conc Measured ambient air concentration in $\mu g/m^3$
IUR Inhalation unit risk ($1/(\mu g/m^3)$)
RfC Reference concentration ($\mu g/m^3$)

Figure 74. Formulas for calculating theoretical cancer risk and hazard quotient

Figure 74 shows the formulas used to calculate cancer risk and non-cancer hazard for chemicals that were carried beyond the screening process into the quantitative assessment.

Table 30 shows the theoretical cancer risk and non-cancer hazard that would result from an individual breathing air containing the detected chemicals at the estimated concentrations daily for seventy years, or a full lifetime. These cancer risk and hazard quotient estimates are likely conservative because they were calculated assuming continuous exposure to outdoor air at breathing rates typical of moderate exertion. Real risk cannot be calculated, but may be substantially lower. Lifetime cancer risks for the limited number of chemicals exceeding screening values (and excluding that from carbonyls) exceeded 1×10^{-6} or one in one million, a value generally deemed as insignificant. However, lifetime cancer risks for these chemicals did not exceed 5×10^{-5} or five in one-hundred-thousand. This value is generally taken as a crude upper limit for “allowable” risk in many regulatory contexts.

Individual hazard quotients (HQs) are ratios that relate daily exposure concentrations, or dose, to a concentration or an amount thought to be without appreciable risks of causing deleterious non-cancer effects in sensitive individuals as well as the general population. HQ values less than 1.0 indicate the air “dose” is less than the amount required to cause toxic effects other than cancer.

In July of 2007, Georgia EPD changed the analysis method for acrolein. The sampling method changed from a dinitrophenylhydrazine (DNPH) cartridge with high performance liquid chromatography (HPLC) analysis to the VOCs canister collection with gas chromatograph with mass spectroscopy (GC/MS) analysis. This change occurred due to EPA’s findings during the School Air Toxics Monitoring Initiative. For more information on this study, please see EPA’s website, http://www.epa.gov/ttnamti1/airtoxschool.html. With this GC/MS analysis method, there were several more detections of acrolein than have been seen in previous years, with the HPLC cartridge method. These results are shown along with the other hazard quotients for the Air Toxics sites. The HQ numbers for acrolein are significantly higher than for the other air toxic compounds. This may be due to methodological changes. Potential reasons for differences are still being investigated.

Table 30. Cancer risk and hazard quotient by location for chemicals that exceeded their screening value in 2013

Location	Chemical	Cancer Risk	Hazard Quotient
Dawsonville	Acrolein		40
	Arsenic	3×10^{-6}	0.05
	Chromium	2×10^{-5}	0.02
	Benzene	6×10^{-6}	0.03
	Carbon tetrachloride	5×10^{-6}	0.01
General Coffee	Acrolein		23
	Arsenic	4×10^{-6}	0.06
	Chromium	2×10^{-5}	0.01
	Benzene	3×10^{-6}	0.01
Macon	Acrolein		29
	Arsenic	3×10^{-6}	0.04
	Chromium	2×10^{-5}	0.02
	Benzene	3×10^{-5}	0.1
	Manganese		0.1
Savannah	Acrolein		42
	Arsenic	3×10^{-6}	0.05
	Chromium	2×10^{-5}	0.02
	Benzene	4×10^{-6}	0.02
	Manganese		0.1
South DeKalb	Acrolein		32
	Arsenic	3×10^{-6}	0.04
	Chromium	2×10^{-5}	0.02
	Benzene	4×10^{-6}	0.02
	Naphthalene	2×10^{-6}	0.02
	Carbon tetrachloride	5×10^{-6}	0.01
Yorkville	Acrolein		27
	Arsenic	2×10^{-6}	0.03
	Chromium	2×10^{-5}	0.02
	Benzene	3×10^{-6}	0.01

For screening purposes, it is generally considered appropriate to treat the potential for effects in an additive manner and to sum cancer risk and hazard quotients, respectively. For example, if cancer risk for two separate chemicals were 1 x 10^{-4} and 2 x 10^{-4}, then the sum or aggregate cancer risk would equal 3 x 10^{-4}. Likewise, if cancer risk for two separate chemicals were 1 x 10^{-4} and 1 x 10^{-5}, then total cancer risk for the two would equal 1.1 x 10^{-4}, or rounded to 1 x 10^{-4}. Similarly, if hazard quotients were 0.6 and 0.5 for two different chemicals, it would indicate that each chemical alone is not likely to result in detrimental effects. However, summing the two would yield a hazard index (HI) of 1.1 or rounded to 1. Comparing this value to the threshold value of 1.0, this HI suggests at least the potential for detrimental effects from the combination of the two chemicals. Table 31 shows total or aggregate theoretical cancer risk and hazard indices (added hazard quotients) for the chemicals (VOCs, semi-VOCS, and metals) carried through the quantitative assessment.

In 2013, the aggregate theoretical cancer risk (excluding carbonyls) for all Air Toxics sites was 2 x 10^{-4}, with risks ranging from 2 x 10^{-5} to 5 x 10^{-5}. The HIs ranged from 0.1 to 0.3 without acrolein data and from 23 to 42 with acrolein data.

Table 31. Aggregate cancer risk and hazard indices with and without acrolein data for all Air Toxics sites in 2013. Carbonyls data were excluded.

Location	**Cancer Risk**	**Hazard Index without Acrolein**	**Hazard Index with Acrolein**
Dawsonville	3 x 10^{-5}	0.1	40
General Coffee	2 x 10^{-5}	0.1	23
Macon	5 x 10^{-5}	0.3	29
Savannah	3 x 10^{-5}	0.2	42
South DeKalb	3 x 10^{-5}	0.1	32
Yorkville	3 x 10^{-5}	0.1	27

Figure 75 summarizes the information in Table 31 and also shows the previous six years of hazard indices and cancer risk for comparison. With the GC/MS analysis used for the acrolein compound, the hazard indices significantly increased starting with the 2007 data. Before this method change, the highest hazard index generally seen with the Air Toxics data was 0.5. In 2007, the lowest hazard index was 20, at the Savannah site, and the highest was 39, at the Dawsonville site. In 2008 and 2009, the hazard indices were lower overall, with values ranging from 12 at the Macon site to 34 at the South DeKalb site. Then in 2010, there was a dramatic increase at all the sites, with the highest hazard index reading of 213 at the Savannah site. Subsequently, in 2011, the hazard indices decreased drastically, with the lowest value of 18 at the Yorkville site, and the highest value of 66 at the General Coffee site. In 2012 and 2013, hazard index values remained generally low. The lowest hazard index value recorded in 2013 was at the General Coffee site (23) and the highest at the Savannah site (42). The aggregate theoretical cancer risks have remained relatively consistent through the seven years, with values ranging from 2 x 10^{-5} to 7 x 10^{-5}.

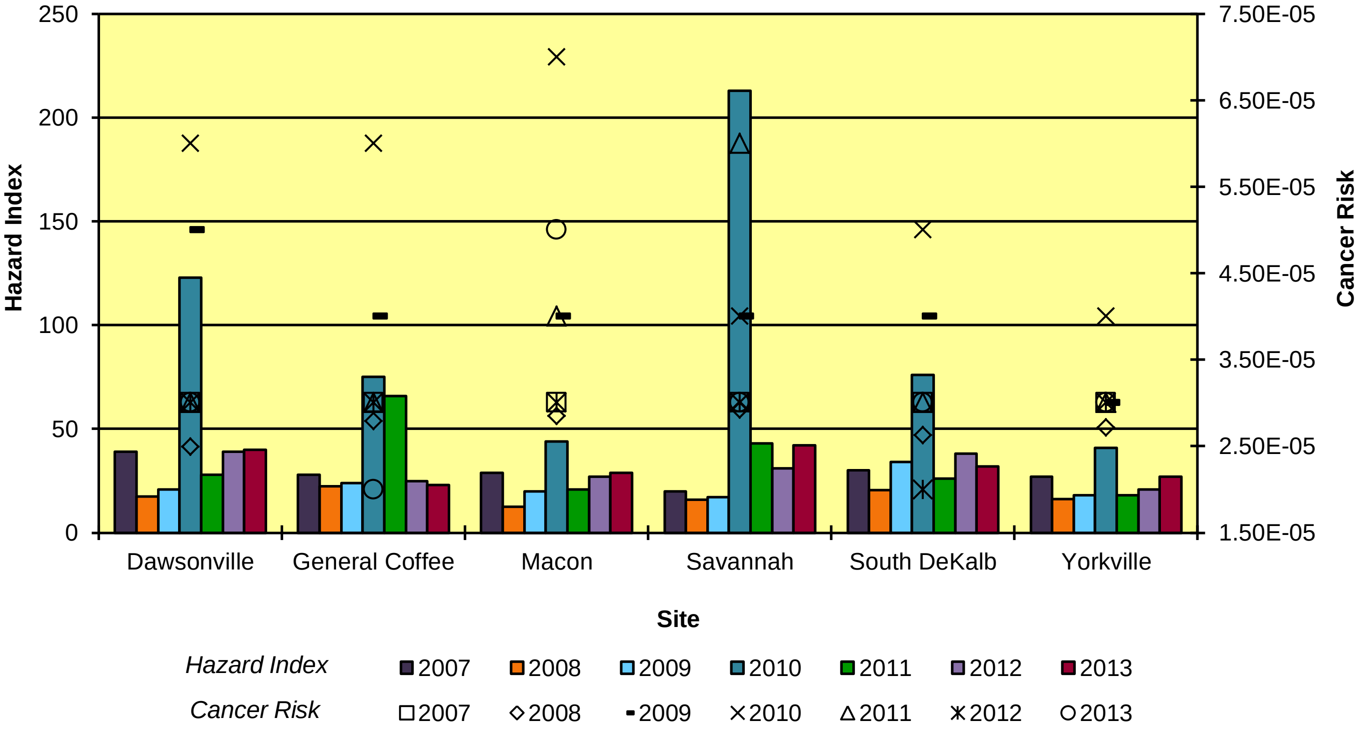


Figure 75. Aggregate cancer risk and hazard index by site for 2007-2013, excluding carbonyls

A few of the compounds collected from the PAMS network were evaluated in conjunction with the Air Toxics data. The PAMS network is a federally mandated network required to monitor for ozone precursors in those areas classified as serious, severe, or extreme for ozone nonattainment. Fifty-six chemicals are monitored on six-day intervals at these sites. In Georgia, the PAMS sites are located in Conyers, South DeKalb, and Yorkville. Of the 56 chemicals monitored at these sites, many are ozone precursors and have not had a screening value developed for determining the toxicity of those compounds. Therefore, for this study, only eleven chemicals were assessed for their potential to have detrimental effects on human health if present in ambient air. Those eleven chemicals were benzene, cyclohexane, ethylbenzene, n-hexane, 1,2,3-trimethylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, styrene, toluene, m/p-xylenes, and o-xylene.

Of these eleven, only benzene, 1,2,4-trimehtylbenzene, and ethylbenzene were found in concentrations above their screening values. Table 32 shows the detection frequency, first and second maximum sample concentrations, averages, hazard quotients (HQ) and cancer risk (CR) for these chemicals. Benzene produced theoretical cancer risks ranging from 1 x 10^{-5} to 3 x 10^{-5} and hazard quotients ranging from 0.06 to 0.1. 1,2,4-trimethylbenzene had a hazard quotient range of 0.4 to 1. Ethylbenzene only exceeded its screening value at the South DeKalb site, and had a HQ of 0.0008 and theoretical cancer risk of 2 x 10^{-6}.

Table 32. Detection frequency, 1st and 2nd maximums, mean, hazard quotients, and cancer risks for VOCs from the PAMs network which exceeded their screening levels in 2013.

Location	Chemical	Detection Frequency	1st Max (µg/m^3)	2nd Max (µg/m^3)	Mean (µg/m^3)	HQ	CR
South DeKalb	Benzene	57/59	7.35	7.35	3.32	0.1	3 x 10^{-5}
	1,2,4-Trimethylbenzene	51/59	147.48	147.48	37.12	1	
	Ethylbenzene	25/59	3.50	3.50	0.78	0.0008	2 x 10^{-6}
Conyers	Benzene	56/58	4.47	4.47	2.46	0.08	2 x 10^{-5}
	1,2,4-Trimethylbenzene	41/58	45.72	35.89	14.55	0.4	
Yorkville	Benzene	43/47	4.15	3.51	1.92	0.06	1 x 10^{-5}
	1,2,4-Trimethylbenzene	38/47	270.39	172.07	44.15	1	

With the exclusion of acrolein, the carbonyls (acetaldehyde, acetone, benzaldehyde, butyraldehyde, formaldehyde, and propionaldehyde) were measured at only two of the ATN sites (Savannah and Dawsonville) and one PAMS/NATTS site (South DeKalb) in 2013. For that reason, their results are displayed separately from the rest of the data. Detection frequency, average (mean) concentration in micrograms per cubic meter (µg/m^3), cancer risk, and non-cancer HQs for the carbonyls are shown in Table 33. This table also shows the sum of the cancer risk and hazard quotients, which are the aggregate cancer risk and hazard index (HI), per site. Of the six carbonyls sampled, acetaldehyde and formaldehyde were detected above the screening value in 2013. All the sites monitoring for acetaldehyde and formaldehyde detected these compounds with a relatively high detection frequency. Formaldehyde was detected 77% to 95% of the time (Dawsonville and South DeKalb, respectively). Acetaldehyde was detected 13% to 66% of the time (Dawsonville and South DeKalb, respectively). Formaldehyde's theoretical cancer risks ranged from 2 x 10^{-5} to 1 x 10^{-4} with hazard quotients ranging from 0.2 to 0.7. Acetaldehyde had relatively low theoretical cancer risks, ranging from 1 x 10^{-6} to 4 x 10^{-6}, and relatively low hazard quotients, ranging from 0.1 to 0.2.

Table 33. Detection frequency, average concentration, cancer risk, hazard quotient, and the aggregate cancer risk and hazard index for carbonyls, 2013

Location	Chemical	Detection Frequency	Mean (µg/m^3)	Cancer Risk	Hazard Quotient
Dawsonville	Acetaldehyde	4/30	0.66	1 x 10^{-6}	0.07
	Formaldehyde	23/30	1.62	2 x 10^{-5}	0.2
	SUM			2 x 10^{-5}	0.3
Savannah	Acetaldehyde	5/29	0.73	2 x 10^{-6}	0.08
	Formaldehyde	26/29	2.03	3 x 10^{-5}	0.2
	SUM			3 x 10^{-5}	0.6
South DeKalb	Acetaldehyde	37/56	1.86	4 x 10^{-6}	0.2
	Formaldehyde	53/56	7.35	1 x 10^{-4}	0.7
	SUM			1 x 10^{-4}	1.9

SUMMARY AND DISCUSSION

In 2013, there were 71 air toxics compounds monitored at 6 sites across the state, with the exception of the South DeKalb site that monitored 74 air toxic compounds. Of these compounds monitored, 36 were not detected and 11 compounds were detected at two sites or less. 43% of the compounds detected above the screening value were in the metals category, 43% were in the volatile organic compounds category, and 14% were in the semi-volatile organic compounds category. There was an average of 6 compounds per site that were above the screening value.

Of the volatile organic compounds, benzene and carbon tetrachloride exceeded their screening values and so were evaluated in the quantitative assessment (Table 29 and Table 30) (acrolein is discussed along with the carbonyls, as it was previously detected with the carbonyls). Benzene was found above the screening value at all six Air Toxics sites. Average benzene concentrations at the Air Toxics sites ranged from 0.4 to 3.5 µg/m^3. These concentrations correspond to the predicted theoretical lifetime cancer risk ranging from 3 x 10^{-6} to 3 x 10^{-5}. All three PAMS sites detected benzene above the screening value as well. Average concentrations of benzene measured in the PAMS network ranged from 1.9 to 3.3 µg/m^3. These concentrations correspond to predicted theoretical lifetime cancer risks in the range of 1 x 10^{-5} to 3 x 10^{-5} for the PAMS sites. Major sources of benzene to the environment include automobile service stations, exhaust from motor vehicles, and industrial emissions (ATSDR, 1997a). Most data relating effects of long-term exposure to benzene are from studies of workers employed in industries that make or use benzene, where people were exposed to amounts hundreds or thousands of times greater than those reported herein. Under these circumstances of high exposure, benzene can cause problems in the blood, including anemia, excessive bleeding, and harm to the immune system. Exposure to large amounts of benzene for long periods of time may also cause cancer of the blood-forming organs, or leukemia (ATSDR, 1997a). The potential for these types of health effects from exposure to low levels of benzene, as reported in this study, are not well understood. Benzene has been determined to be a known carcinogen (U.S. EPA, 2000) and was evaluated as such in this study.

Carbon tetrachloride (CCl_4) was found above the screening value at the Dawsonville and South DeKalb sites, with a concentration of 0.8 $\mu g/m^3$ for both sites (Table 29). There was one detection out of thirty samples for Dawsonville and 2 of 59 for South DeKalb, a detection frequency of 3% for both. Theoretical lifetime cancer risk for carbon tetrachloride, calculated from the mean concentration, was 5×10^{-6} with a non-cancer hazard quotient of 0.01 for both sites. In the past, carbon tetrachloride was used to produce refrigeration fluids, as propellants for aerosol cans, as a pesticide, in fire extinguishers, as a spot cleaner, and as a degreasing agent (ATSDR, 2005a). Because of concerns regarding carbon tetrachloride's toxicity, these uses have been stopped or severely restricted. Large exposures to carbon tetrachloride can damage the liver, kidneys, and nervous system. U.S. EPA has classified carbon tetrachloride as a probable human carcinogen (U.S. EPA, 1991a).

Naphthalene was the only compound in the semi-volatile organic group found above the screening value (Table 29). It was detected at the South DeKalb site in 50 out of 51 samples, or 98% detection frequency. The theoretical lifetime cancer risk for the South DeKalb site was 2×10^{-6}, with a non-cancer hazard quotient of 0.02 (Table 30). Naphthalene is found in moth repellents, petroleum, coal, and is used in making polyvinyl chloride (PVC) plastics. Exposure to large amounts can cause hemolytic anemia (ATSDR, 2005e).

Three metals, manganese, arsenic, and chromium, were evaluated in the quantitative assessment (Table 29 and Table 30). Manganese was detected above the screening value for two of the six Air Toxics sites, Macon and Savannah. Manganese is a trace element, and small amounts are needed to support good health. However, exposure to very large amounts through inhalation can result in neurological effects (ATSDR, 2000a). Manganese was evaluated as a neurotoxin, but did not contribute significantly in the quantitative assessment with a HQ of 0.1 at both sites. This HQ suggests that there is little potential for neurological effects from ambient air concentrations of manganese.

Arsenic was found above the screening value at all six Air Toxics sites (Table 29). Arsenic occurs naturally in soil and rocks, and was used extensively in the past as a pesticide on cotton fields and in orchards (ATSDR, 2005b). However, the majority of arsenic found in the atmosphere comes from the burning of coal and oil, incineration, and smelting operations. Arsenic has been recognized as a human poison since ancient times. Inhalation of large quantities of some forms of arsenic may cause irritation of the throat and upper respiratory tract. Long-term exposure either by inhalation or ingestion may result in a unique pattern of skin changes, and circulatory and peripheral nervous disorders (ATSDR, 2005b). Inhalation of some forms of arsenic may also cause cancer, so arsenic was evaluated as a carcinogen in this assessment. The detection frequency ranged from 50% to 74% at the Yorkville and South DeKalb sites, respectively. Theoretical lifetime cancer risks ranged from 2×10^{-6} to 4×10^{-6}, and HQs ranged from 0.03 to 0.06.

Total chromium was detected at all six Air Toxics sites and displayed a high detection frequency, ranging from 96% to 100%. The theoretical cancer risk for all six sites was 2×10^{-5} (Table 30). Chromium is a naturally occurring element and is common in low amounts in foodstuffs (ATSDR, 2000b). Natural processes such as wind generating dust and even volcanoes may release chromium into the atmosphere. However, many human activities such as coal and oil combustion, electroplating, smelting, and iron and steel production also release it into the atmosphere.

The chemistry of chromium is complex. It may occur in different forms or oxidation states in the environment, having very different degrees of toxicity. Chromium+3 is the form that often predominates in the natural environment, and is also an essential element required for good nutrition.

Hexavalent chromium (chromium+6) is the most toxic form of chromium and is often related to releases from industrial activities (ATSDR, 2000b). Inhaling large amounts of chromium+6 may cause upper respiratory track irritation, and chromium+6 has also been shown to be a carcinogen, causing increases in the risk of lung cancer (ATSDR, 2000b).

Studies have shown that in ambient air, even near industrial sites, chromium+6 is usually only a small portion of total chromium, with measured concentrations for chromium+6 accounting for a range of values from 1 to 25% of total chromium (ATSDR, 2000b). As part of the NATTS network, sampling for chromium+6 takes place at the South DeKalb site. When the 2013 concentration of chromium+6 is compared to the total chromium concentration, it shows that the chromium+6 is 0.6% of the total chromium accounted for at the South DeKalb site. However, the concentrations of chromium+6 detected were below the screening value and were not evaluated further as a potential cancer risk. The South DeKalb site is located within and representative of an urban area. Since the chromium+6 concentrations were below the screening value for the South DeKalb site, this could indicate that chromium+6 levels are low throughout the network. The other sites that measure for chromium, measure for the total form. Therefore, the measurements used in this study were for the total form, and distinctions cannot be made as to how much of the different states of chromium are present at the other Air Toxics sites. In the interest of conservativeness, chromium was evaluated with the most stringent toxicity index, as chromium+6, even though the chromium metal measured was not in this most toxic form. Data collected on the ratio of chromium+6 to total chromium (ATSDR, 2000b) indicates that this process may appreciably overestimate risk. Further work is needed to better understand chemical forms of chromium in Georgia’s air, and determine if chromium is an important contributor to risk.

Carbonyls were monitored at three sites in Georgia in 2013 (Table 33). Two sites, Dawsonville and Savannah are ATN sites, while the other site, South DeKalb, is in the PAMS/NATTS network. Three carbonyls, formaldehyde, acetaldehyde, and acrolein, were detected above their screening levels and included in the quantitative assessment.

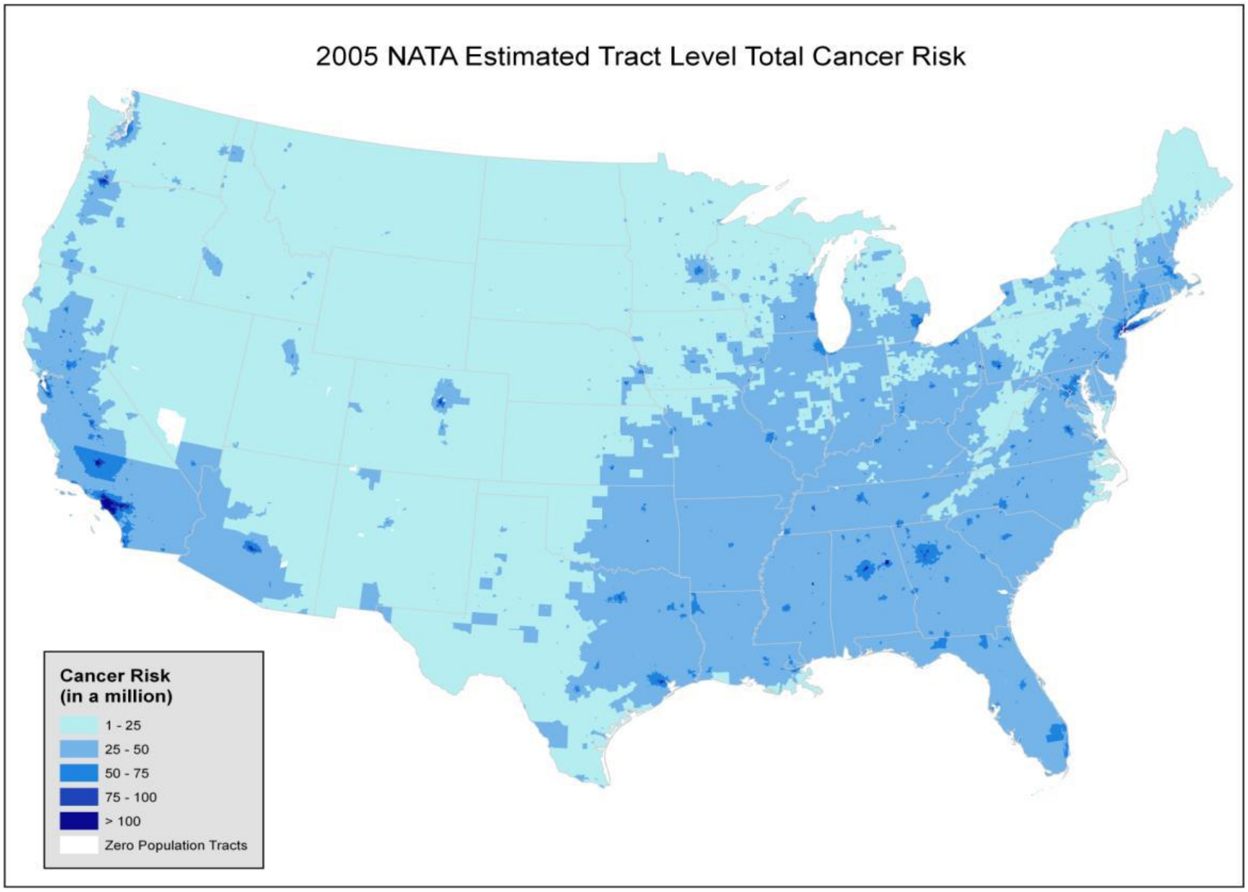
Formaldehyde, the simplest of the aldehydes, is produced by natural processes, and from the fertilizer, paper, and manufactured wood products industries (ATSDR, 1999). It is also found in vehicle emissions. Formaldehyde is a health concern because of its respiratory irritancy and as a possible carcinogen. It may cause irritation of the eye, nose, throat, and skin, and has the potential under certain exposure scenarios to cause cancers of the nose and throat (ATSDR, 1999). Acetaldehyde, like formaldehyde, is also a concern as an upper respiratory irritant, and because of its potential to cause nasal tumors in animal studies. However, research has shown it to be significantly less potent than formaldehyde. Acetaldehyde, as an intermediate product of plant respiration and a product of incomplete combustion, is ubiquitous in the environment. (U.S. EPA, 1987; U.S. EPA 1991b). Recent studies of acetaldehyde background levels have found average background concentrations at 0.16 µg/m^3 in remote areas of North America (McCarthy, Hafner, & Montzka, 2006).

Formaldehyde and acetaldehyde were detected at all three locations where carbonyls were assessed (Table 33). The highest average concentrations of both formaldehyde and acetaldehyde were found at the South DeKalb site, 7.35 µg/m^3 and 1.86 µg/m^3, respectively. As discussed above, 0.16 µg/m^3 of the acetaldehyde average concentration could be attributed to the background concentration. The theoretical cancer risk for formaldehyde ranged from 2 x 10^{-5} to 1 x 10^{-4} and the hazard quotients ranged from 0.2 to 0.7. Acetaldehyde theoretical cancer risk ranged from 1 x 10^{-6} to 4 x 10^{-6} and the hazard quotients ranged from 0.1 to 0.2.

Due to EPA research to improve acrolein sampling and analysis, GA EPD began collecting acrolein with the other VOCs in a canister and analyzing it using a GC/MS method. This method was started in July of 2007, drastically changing the number of detections that were found across the state. In previous years, acrolein was analyzed along with the carbonyls, at select sites. With the GC/MS and canister method, this allowed acrolein to be sampled at all of the air toxics sites. In 2013, it was detected at all the sites, with a detection frequency ranging from 50% to 100% (Table 29). Acrolein was evaluated as a potential non-carcinogen, and the hazard quotients ranged from 23 to 42 (Table 30). The average concentrations ranged from 0.46 µg/m^3 to 0.83 µg/m^3 with the highest average occurring at the Savannah site. Acrolein may enter the environment as a result of combustion of trees and other plants, tobacco, gasoline, and oil. Additionally, it can be used as a pesticide for algae, weeds, bacteria, and mollusks (ATSDR, 2011). The potential for acrolein to cause health effects is not well understood. At very low concentrations, it is an upper respiratory irritant. At very high concentrations it may produce more serious damage to the lining of the upper respiratory tract and lungs (ATSDR, 2011; U.S. EPA, 2003).

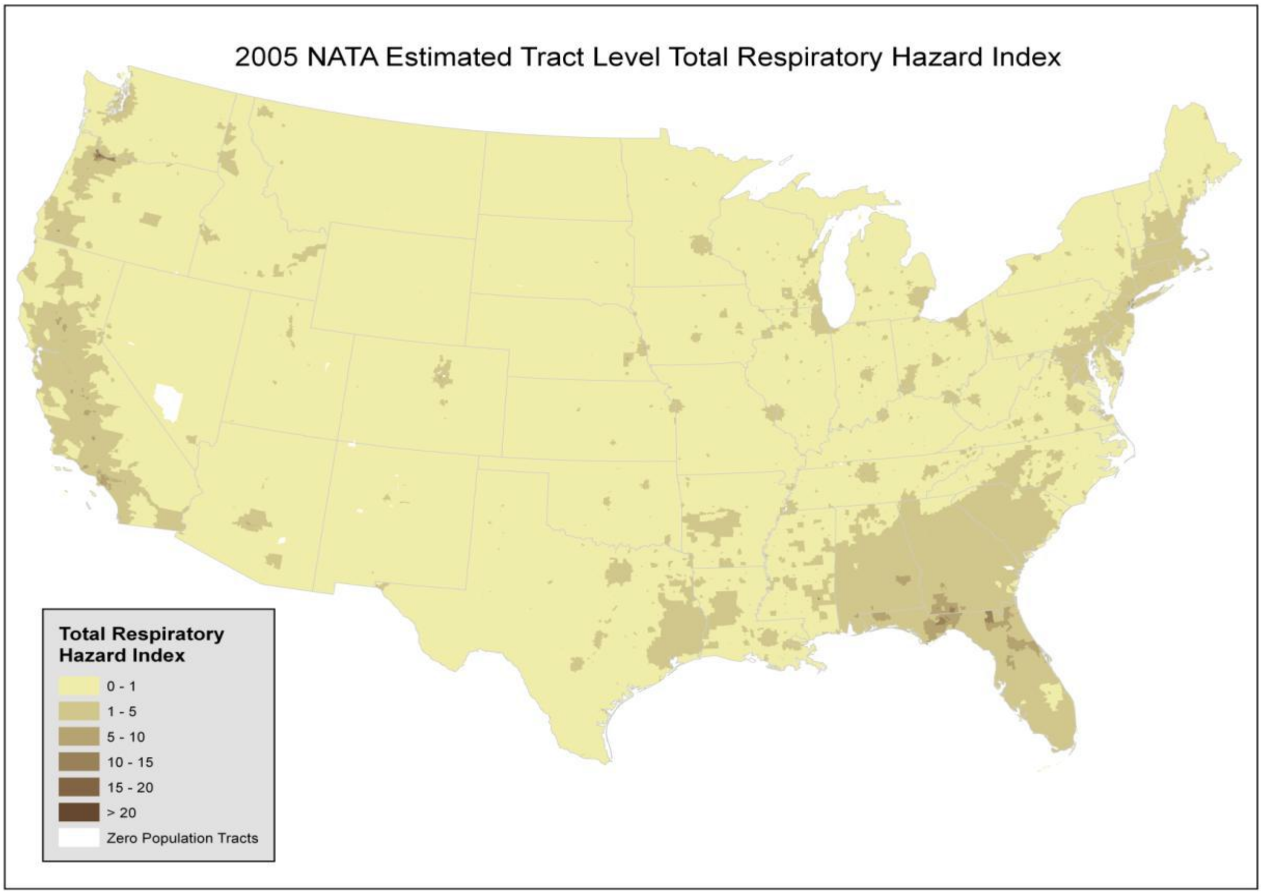
Of the PAMS compounds assessed, benzene and 1,2,4-trimethylbenzene were the only compounds detected above the screening value at all sites, while ethylbenzene was only detected above the screening value at the South DeKalb site (Table 32). When evaluated as a theoretical cancer risk, the levels of benzene ranged from 1 x 10^{-5} at the Yorkville site to 3 x 10^{-5} at the South DeKalb site, with hazard quotients ranging from 0.06 to 0.1, also at the Yorkville and South DeKalb sites respectively. As stated earlier, major sources of benzene to the environment include automobile service stations, exhaust from motor vehicles, and industrial emissions (ATSDR, 1997a). 1,2,4-Trimethylbenzene occurs naturally in coal tar and petroleum crude oil. It is a component of gasoline, and has other uses in industry as an intermediate in the production of dyes, drugs, and coatings. Exposure to very large amounts of 1,2,4-trimethylbenzene may cause skin and respiratory irritancy and nervous system depression, fatigue, headache, and drowsiness. However, risks resulting from exposure to low ambient concentrations of 1,2,4-trimethylbenzene have not been studied extensively (U.S. EPA, 1994a). 1,2,4-trimethylbenzene was evaluated as a non-carcinogen with potential to cause central nervous system and irritant effects (U.S. EPA, 2004b). 1,2,4-trimethylbenzene hazard quotients ranged from 0.4 at the Conyers site to 1 at both the Yorkville and South DeKalb sites. The theoretical cancer risk of ethylbenzene at South DeKalb was 2 x 10^{-6} and the hazard quotient was 0.0008. Ethylbenzene is a colorless liquid found in many products including inks, pesticides, and paints and naturally occurs in coal tar and petroleum. Breathing high levels may cause dizziness and throat and eye irritation. Breathing relatively low levels for several days to weeks has been found to cause hearing damage in animals while breathing relatively low levels for several months to years caused kidney damage (ATSDR, 2010).

Figure 76 and Figure 77 show the most recent official National Air Toxics Assessment (NATA) based on 2005 air toxics emissions inventory. The estimated total cancer risk levels and estimated total respiratory hazard index are given per tract across the United States. The maps indicate that the estimated tract level total cancer risk and estimated tract level total respiratory hazard index, respectively, are higher in more populated areas and along transportation corridors.



(http://www.epa.gov/ttn/atw/nata2005/05pdf/sum_results.pdf)

Figure 76. Estimated tract-level cancer risk from the 2005 national air toxics assessment



(http://www.epa.gov/ttn/atw/nata2005/05pdf/sum_results.pdf)

Figure 77. Estimated tract-level total respiratory hazard index from the 2005 national air toxics assessment

As stated previously, the estimates of risk presented herein are likely overestimates due to conservative assumptions used in this exercise. Conservative assumptions were used to estimate the potential for possible exposures (high inhalation rates and long term exposure) and toxicity values. In the absence of good exposure information, this practice is warranted to decrease the potential for underestimating risk.

The results presented herein suggest that the majority of calculated risk is due to a small number of chemicals. The risk values presented in this report should not be interpreted as indicators of true or “real” risk, but for relative comparisons of a chemical’s contribution to aggregate risk, or for comparisons of risk between locations within the monitoring network or in other areas of the country.

OUTREACH AND EDUCATION

Maintaining effective public outreach and education is important to the Ambient Monitoring Program's mission. The Ambient Monitoring Program (AMP) seeks to address the air quality issues that are most vital to the citizens of Georgia by identifying the pollutants that represent the greatest risks, continually monitoring the pollutants, and then communicating the monitoring results directly to the public. The goal is to provide an understanding of the presence of air pollution throughout the state, and to educate the public on the steps they can take to improve air quality and protect health. AMP accomplishes this goal by issuing smog alerts and providing information about the Air Quality Index (AQI), maintaining a partnership with the Clean Air Campaign, and conducting other outreach strategies aimed at keeping the public up to date on air quality issues.

What is the Clean Air Campaign®?

The Clean Air Campaign® (CAC) is a not-for-profit organization that works to reduce traffic congestion and improve air quality in the metro Atlanta nonattainment area through a variety of voluntary programs and services, including free employer assistance, incentive programs, public information and children's education.

The Clean Air Campaign and its partners offer assistance to more than 1,600 employers to design and implement commute options programs that make business sense; protect public health; offer targeted incentives to commuters and employers; and work with elementary, middle and high schools to protect children from harmful pollution and empower children to take a positive role in reducing traffic and cleaning the air.

In addition to addressing commuters' driving habits, CAC utilizes the AQI to relay air quality information to metro Atlanta residents by providing Smog Alert notifications.

The Air Quality Index

The Air Quality Index (AQI) is a national air standard rating system developed by the U.S. Environmental Protection Agency. The AQI is used statewide to provide the public, on a daily basis, with an analysis of air pollution levels and possible related health risks. Generally, an index scale of 0 to 500 is used to assess the quality of air, and these numbers are synchronized with a corresponding descriptor word such as: Good, Moderate, Unhealthy for Sensitive Groups, Unhealthy, and Very Unhealthy. To protect public health the EPA has set an AQI value of 100 to correspond to the NAAQS for the following criteria pollutants: Ozone (O_3), Sulfur Dioxide (SO_2), Carbon Monoxide (CO), Particulate Matter 10 (PM_{10}), Particulate Matter 2.5 ($PM_{2.5}$), and Nitrogen Dioxide (NO_2). The AQI for a reporting region equates to the highest rating recorded for any pollutant within that region. Therefore, the larger the AQI value, the greater level of air pollution present, and the greater expectation of potential health concerns. However, this system only addresses air pollution in terms of acute health effects over time periods of 24 hours or less and does not provide an indication of chronic pollution exposure over months or years.

Figure 78 shows how the recorded concentrations correspond to the AQI values, descriptors and health advisories. Each day the AQI values for Athens, Atlanta, Augusta, Columbus, Macon, North Georgia Mountains, and Savannah are available to the public through GA EPD's website http://www.air.dnr.state.ga.us/amp/. Table 34 shows a summary of the 2013 AQI values for these sites as well as all sites that collect criteria data in Georgia.

Maximum Pollutant Concentration									
$PM_{2.5}$	PM_{10}	SO_2	O_3	O_3	CO	NO_2			
(24hr) µg/m^3	(24hr) µg/m^3	(1hr)* ppm	(8hr)^ ppm	(1hr) ppm	(8hr) ppm	(1hr) ppm	**AQI Value**	**Descriptor**	**EPA Health Advisory**
0.0 – 12.0	0 – 54	0 – 0.035	0.000– 0.059	None	0.0 – 4.4	0 – 0.053	0 to 50	**Good (green)**	Air quality is considered satisfactory, and air pollution poses little or no risk.
12.1 – 35.4	55 – 154	0.036 – 0.075	0.060 – 0.075	None	4.5 – 9.4	0.054- 0.100	51 to 100	**Moderate (yellow)**	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to the condition of the air may experience respiratory symptoms.
35.5 – 55.4	155 – 254	0.076 – 0.185	0.076 – 0.095	0.125 – 0.164	9.5 – 12.4	0.101- 0.360	101 to 150	**Unhealthy for Sensitive Groups (orange)**	Members of sensitive groups (people with lung or heart disease) are at greater risk from exposure to particle pollution. Those with lung disease are at risk from exposure to ozone. The general public is not likely to be affected in this range.
55.5 – 150.4	255 – 354	0.186 – 0.304*	0.096 – 0.115	0.165 – 0.204	12.5 – 15.4	0.361- 0.64	151 to 200	**Unhealthy (red)**	Everyone may begin to experience health effects in this range. Members of sensitive groups may experience more serious health effects.
150.5 – 250.4	355 – 424	0.305 – 0.604*	0.116 – 0.374	0.205 – 0.404	15.5 – 30.4	0.65 – 1.24	201 to 300	**Very Unhealthy (purple)**	AQI values in this range trigger a health alert. Everyone may experience more serious health effects. When the AQI is in this range because of ozone, most people should restrict their outdoor exertion to morning or late evening hours to avoid high ozone exposures.
250.5 – 350.4	425 – 504	0.605 – 0.804*	None^	0.405 – 0.504	30.5 – 40.4	1.25 – 1.64	301 to 400	**Hazardous (maroon)**	AQI values over 300 trigger health warnings of emergency conditions. The entire population is more likely to be affected.
350.5 – 500	505 – 604	0.805 – 1.004*	None^	0.505 – 0.604	40.5 – 50.4	1.65 – 2.04	401 to 500		

Figure 78. The AQI, *AQI values of 200 or greater are calculated with 24-hr SO_2 concentrations, ^AQI values of 301 or greater are calculated with 1-hr O_3 concentrations.

Table 34. 2013 AQI summary data, most days had an AQI value in the ‘Good’ (0-50) category for all the sites.
***AQI numbers above 100 may not be equivalent to a violation of the standard*

Air Quality Index Summary by CBSA						
Number of Days						
Pollutants Monitored in 2013	**Good (0-50)**	**Moderate (51-100)**	**Unhealthy for Sensitive Groups (101-150)****	**Unhealthy (151-200)****	**Very Unhealthy (201-300)****	**Hazardous (>300)****
Albany						
$PM_{2.5}$	232	127	5	-	-	-
Americus						
O_3	240	5	-	-	-	-
Athens-Clark County						
O_3, $PM_{2.5}$	272	93	-	-	-	-
Atlanta-Sandy Springs-Marietta						
O_3, NO_2, $PM_{2.5}$, CO, SO_2, PM_{10}	175	187	2	1	-	-
Augusta-Richmond County, GA-SC						
O_3, $PM_{2.5}$, PM_{10}	251	112	2	-	-	-
Brunswick						
O_3, $PM_{2.5}$	286	26	-	-	-	-
Chattanooga, TN-GA						
O_3, $PM_{2.5}$	240	123	-	-	-	-
Columbus GA-AL						
O_3, $PM_{2.5}$	279	85	1	-	-	-
Dalton						
O_3	255	7	-	-	-	-
General Coffee						
$PM_{2.5}$	49	7	-	-	-	-
Gainesville						
$PM_{2.5}$	215	127	-	-	-	-
Macon						
O_3, SO_2, $PM_{2.5}$	260	105	-	-	-	-
Rome						
SO_2, $PM_{2.5}$	166	198	1	-	-	-
Savannah						
O_3, SO_2, $PM_{2.5}$	249	106	10	-	-	-
Summerville						
O_3	242	3	-	-	-	-
Valdosta						
$PM_{2.5}$	286	74	3	-	-	-
Warner Robins						
$PM_{2.5}$	251	100	-	-	-	-

(Source: http://www.epa.gov/airquality/airdata/ad_rep_aqi.html)

Figure 79 shows the number of days that the AQI value was above 100 for each metropolitan statistical area (MSA) in Georgia where an AQI value is produced. The data was generated starting in 1972 and is shown through 2013. To be consistent, the most current standards were applied throughout the historical dataset. As one would expect, the Atlanta-Sandy Springs-Marietta MSA (shown in orange below) has historically had the highest number of days with the AQI above 100. The pattern materializing across the forty-two year timeframe seems to be cyclic. However, the number of days above 100 for the Atlanta-Sandy Springs-Marietta MSA decreased dramatically from 1999 to 2004 and from 2006 to 2009. The number dropped from 95 days in 1999 to 33 days in 2004 and from 63 days in 2006 to 15 days in 2009. More recently, the Atlanta-Sandy Springs-Marietta MSA's number of days with AQI above 100 decreased from 44 days in 2011 to 19 days in 2012, and then 3 in 2013. The Savannah MSA site had 10 days with AQI above 100 in 2013. The remaining MSA sites had five or fewer days with the AQI above 100 in 2013. The majority of sites did not have any days with AQI above 100 in 2013.

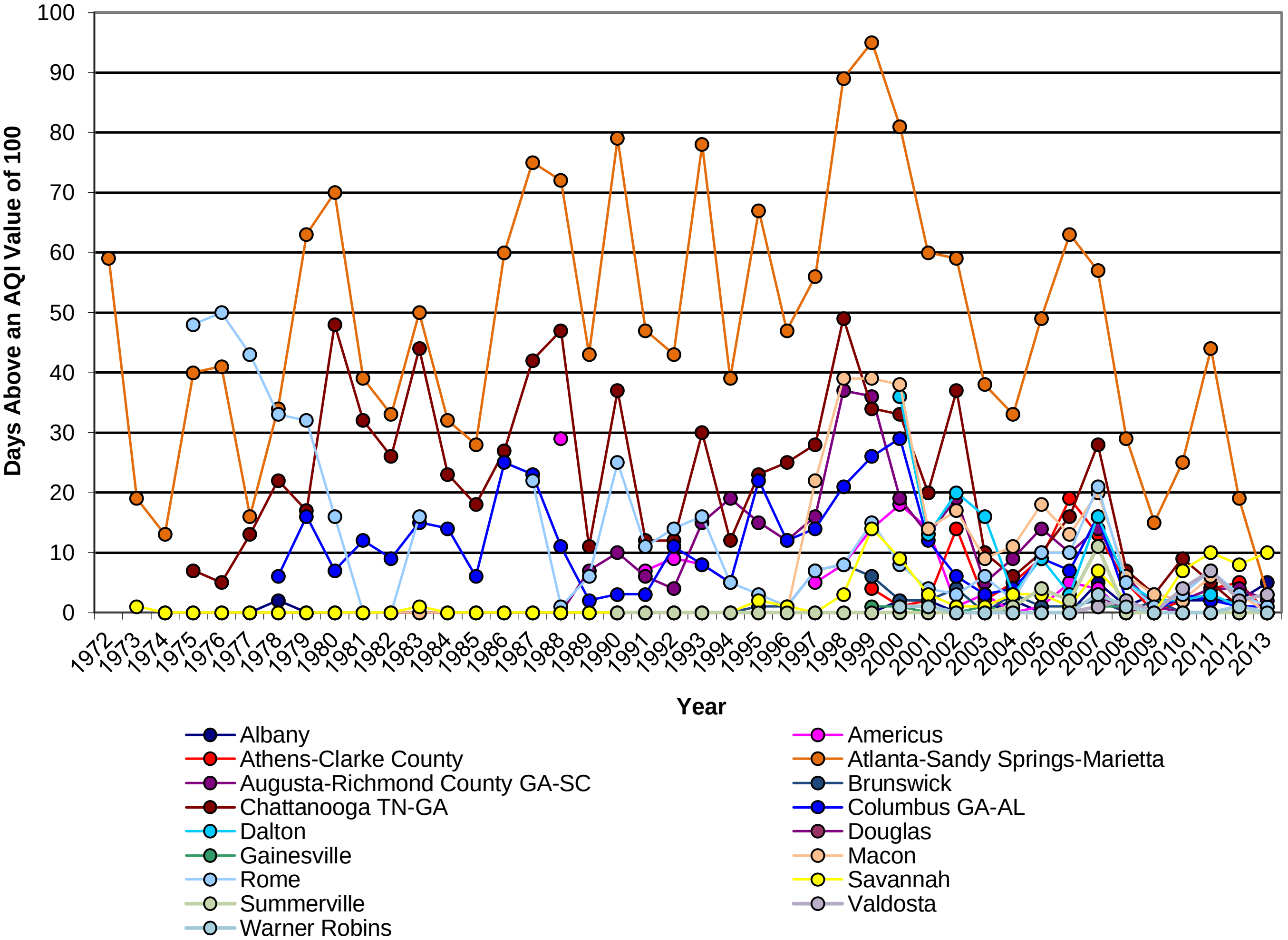


Figure 79. The number of days each MSA had an AQI value above 100

Figure 80 displays in more detail the 2013 AQI values for the Atlanta-Sandy Springs-Marietta MSA. There were two days with an AQI value between 100 and 150, and one day with an AQI above 150, all occurring between June and September. Ozone is a major driver of an elevated AQI and can be higher in the summer months due to increased sunlight. Higher ozone and $PM_{2.5}$ concentrations are the primary sources of AQI values in the "Unhealthy for Sensitive Groups" category in the Atlanta-Sandy Springs-Marietta MSA.

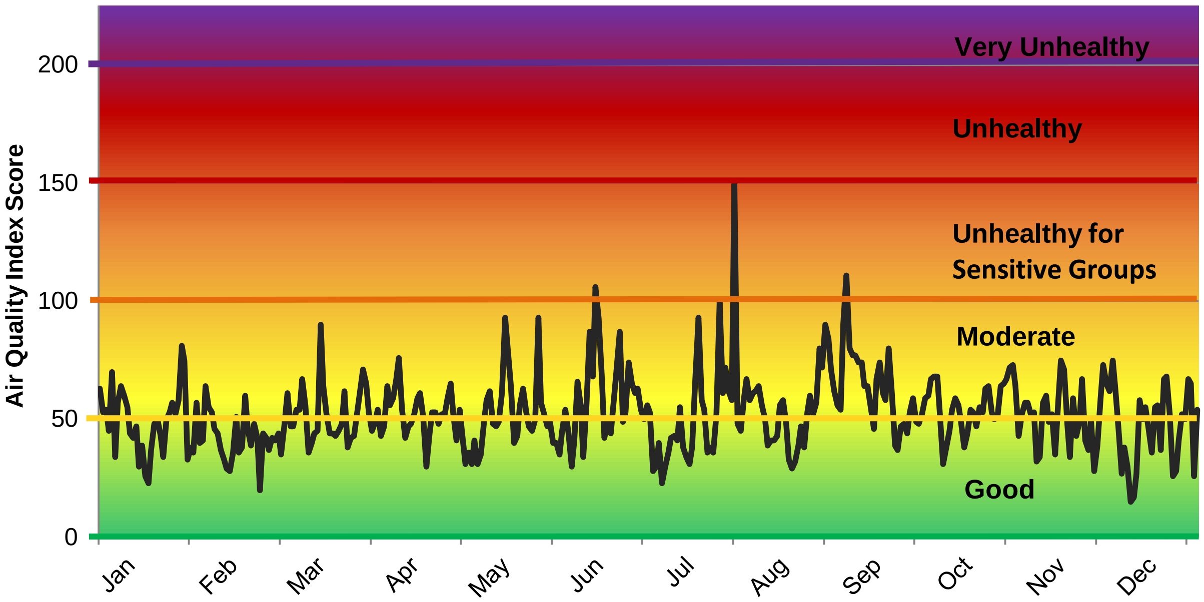
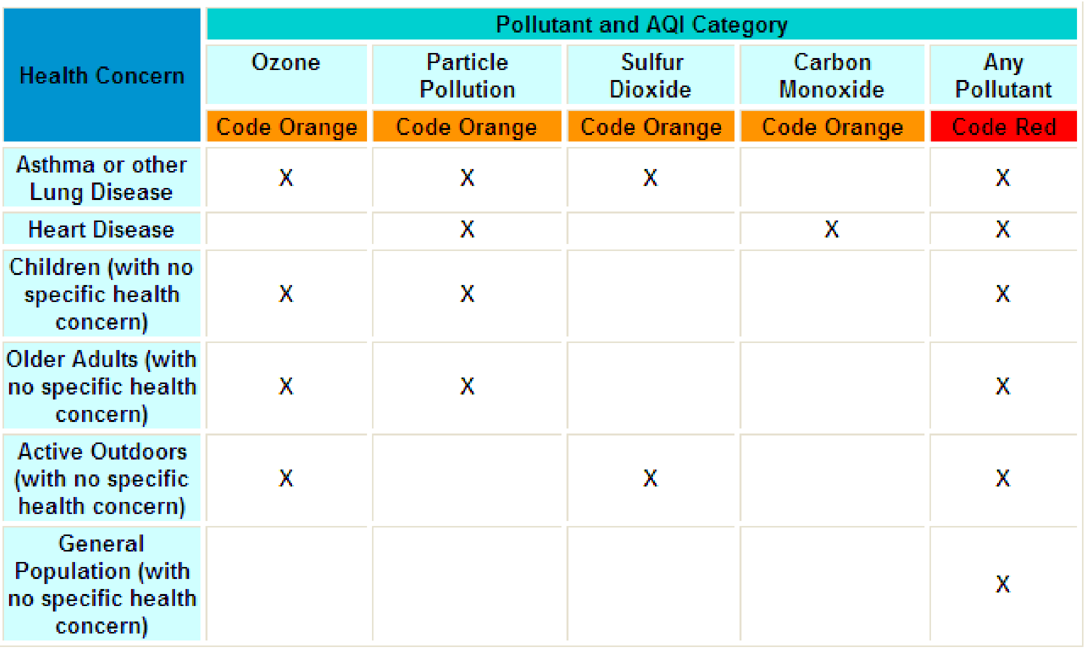


Figure 80. 2013 AQI Values for the Atlanta-Sandy Springs-Marietta MSA

When pollution levels are higher causing the AQI values to be above 100, members of sensitive groups, such as children, older adults or people with lung disease, may experience health effects. The general public is more likely to be affected when AQI values are greater than 150. Table 35 can be used as a guide to outline the health concerns of each group of sensitive populations that can be affected when the AQI is Code Orange or Code Red. This table also shows which pollutant(s) affects each sensitive population. It is used as an illustration, with the understanding that some individuals can be more sensitive than others.

Table 35. The health concerns of sensitive populations when AQI values exceed 100 (Code Orange) and the general population when the AQI values exceed 150 (Code Red) and which pollutants affect each population



Health Concern	Pollutant and AQI Category				
	Ozone	Particle Pollution	Sulfur Dioxide	Carbon Monoxide	Any Pollutant
	Code Orange	Code Orange	Code Orange	Code Orange	Code Red
Asthma or other Lung Disease	X	X	X		X
Heart Disease		X		X	X
Children (with no specific health concern)	X	X			X
Older Adults (with no specific health concern)	X	X			X
Active Outdoors (with no specific health concern)	X		X		X
General Population (with no specific health concern)					X

Source: http://www.epa.gov/aircompare/index.htm

Figure 81 shows the number of days each MSA had an AQI value exceeding 100 and which pollutant was the primary driver (critical pollutant) of that AQI value. Combining the data shown in Figure 81 with Table 35, we can infer which sensitive groups would be most affected on days with an AQI value >100 based on the critical pollutant for that day. For example, Savannah had 10 days with an AQI score >100 and the critical pollutant was SO_2, so we can infer using Table 35 that those with asthma or other lung disease and active individuals would have been most likely to experience health effects during those 10 days.

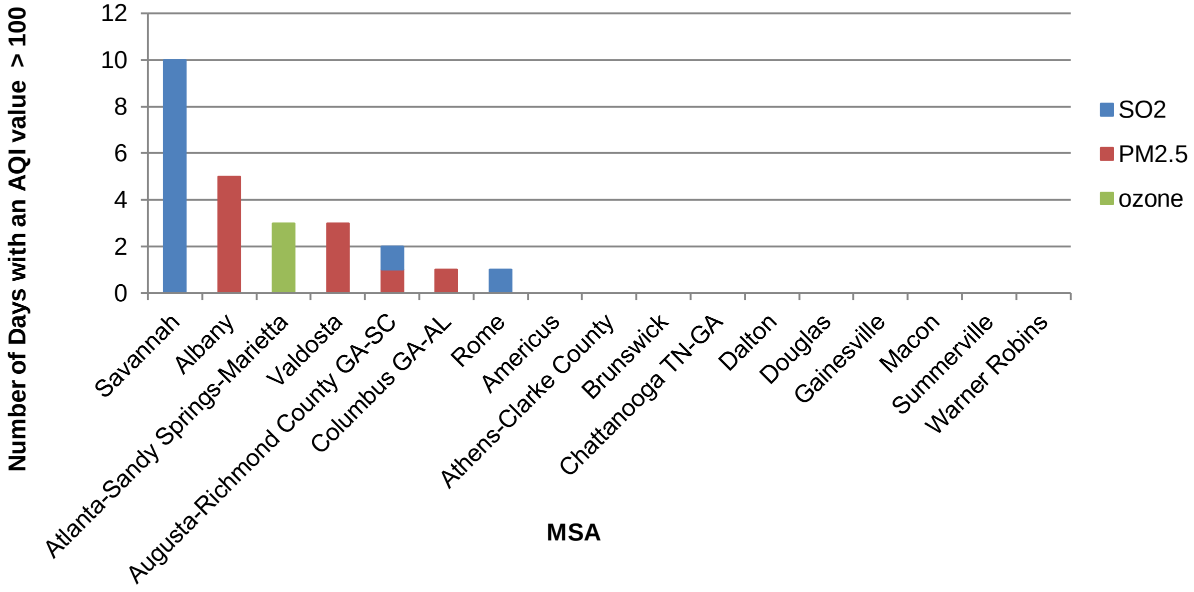


Figure 81. The number of days each MSA had an AQI value exceeding 100 in 2013 and which pollutant was the critical pollutant for those days

How does Georgia's Ambient Monitoring Program (AMP) Cooperate with The Clean Air Campaign® (CAC)?

The Ambient Monitoring Program is responsible for measuring air pollutant levels in metro Atlanta and throughout the state. Equipment at fourteen continuous monitoring stations across metro Atlanta is used for these measurements of particulate matter (PM), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and ozone (O_3). This data is reported hourly on a website which is maintained and updated by the Ambient Monitoring Program. Based on these levels, AMP calculates the Air Quality Index (AQI), which represents overall air quality in a way that is quick and easy for the general public to understand. The Ambient Monitoring Program's website is linked to a website maintained by CAC. The AQI is then displayed on The Clean Air Campaign's website. The CAC also distributes AQI information to people who have signed up to receive daily air quality forecasts via e-mail. When a smog alert is forecasted, an automated fax blast informs all local media as well. Through these connections, thousands of metro Atlanta citizens and businesses keep abreast of current air quality conditions. The Ambient Monitoring Program also encourages the public to access the CAC's website and learn about voluntary measures that are available locally to improve air quality.

MEDIA OUTREACH

The Ambient Monitoring Program continuously contacts citizens as well as the news media through phone calls, website updates and media interviews. At many times throughout the year, the demand for a story puts AMP in the spotlight. The Program Manager and staff of the Ambient Monitoring Program make themselves available to television and newspaper reporters, thus educating the public about the AQI, statewide air monitors, and the Clean Air Campaign.

OTHER OUTREACH OPPORTUNITIES

Meteorologists

Forecasters from the Ambient Monitoring Program issue air quality forecasts on a daily basis. In addition, forecasters answer questions for the news media and calls from the public. For more information regarding the work done by the Ambient Monitoring Program's meteorologists, refer to the Meteorological Section of this report.

Elementary and Middle Schools

Educating school children and incorporating air quality information into the classroom-learning environment is also an outreach strategy for the Ambient Monitoring Program. AMP staff visit Georgia classrooms to discuss air quality, forecasting, and monitoring. Each program presented by the AMP is designed to supplement grade-specific curricula. Learning opportunities include meteorological lessons and forecasting techniques, among other relevant topics.

In many situations, these lessons involve hands-on activities and mini-field trips to the monitoring sites. High School students simulate forecasting conditions and use scientific methods to create their own forecasts. AMP staff also participate in Career Days at both elementary and high schools to promote environmental and meteorological careers.

Colleges and Universities

The Ambient Monitoring Program works with colleges and universities in several capacities. Utilizing a more technical, advanced approach, AMP has participated in several college-level seminars, providing scientific expertise on the subject of meteorology and forecasting. Through this close contact with university staff, AMP staff have co-authored scientific papers in peer-reviewed scientific journals. AMP staff provide technical data to professors as well as students, thus incorporating real-time data into college courses and projects. Additionally, AMP works with Georgia Institute of Technology in a joint forecasting effort.

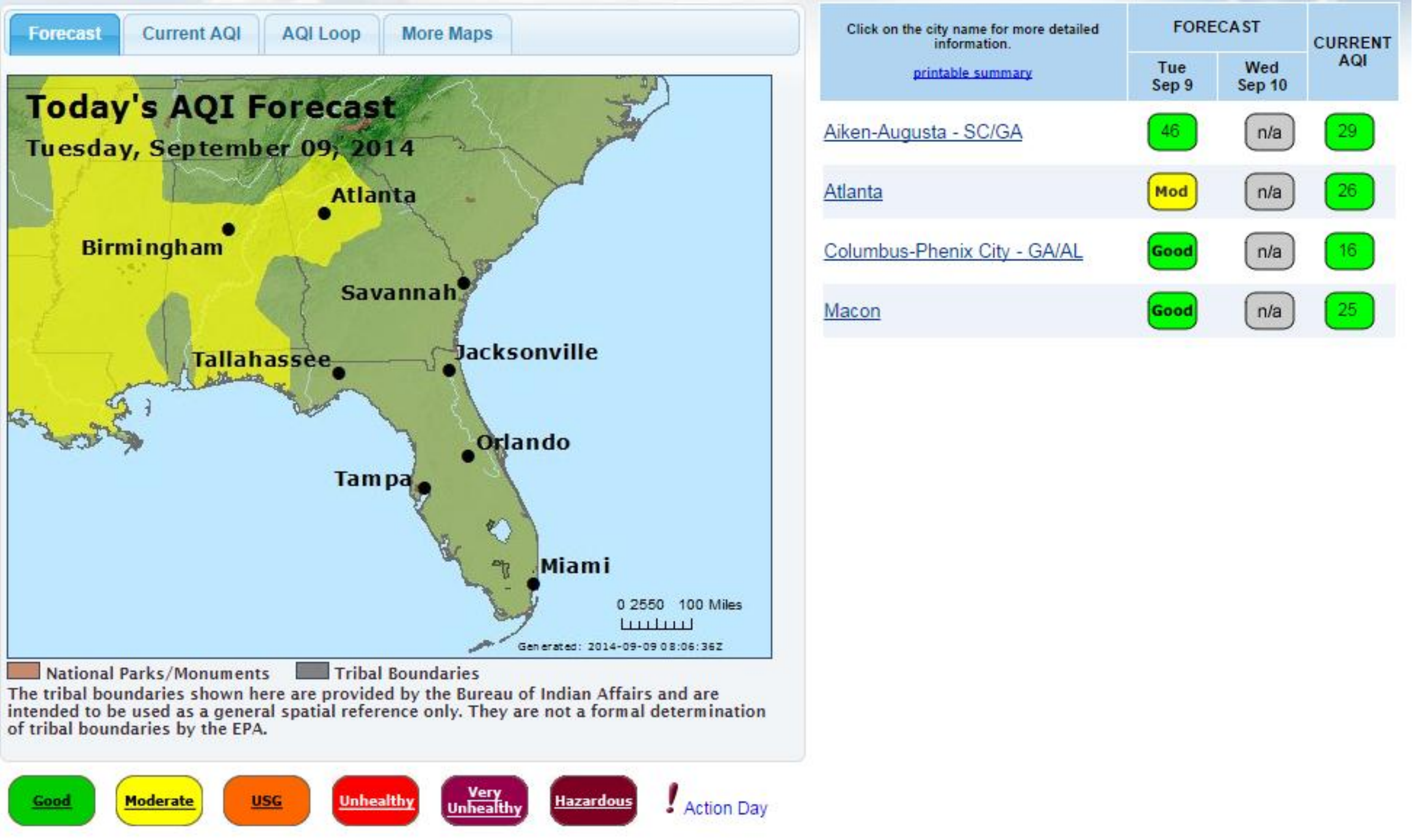
AMP also hosts an annual Air Quality Seminar and Air Monitoring Station fieldtrip for college interns in the Centers for Disease Control and Prevention's (CDC) Environmental Health Summer Intern Program, thereby reaching top college students from all over the country.

Monitoring Data Requests

AMP also regularly receives requests for specific, detailed monitoring data from members of the research community and the broader public. Completely fulfilling the needs of these data users often requires not just data, but also providing guidance on how the data can be interpreted and what the limitations of the data set may be. AMP welcomes these opportunities to serve the public and the research community, and to ensure that the data collected is put to its fullest and most advantageous use in protecting the health and welfare of Georgia's citizens and the state's natural environment.

EPA AIRNOW Website

Georgia supplies ozone and particulate matter data to the U.S. EPA every hour for pollution mapping activities. AIRNOW is a cooperative effort between EPA, states, and local air pollution control agencies to provide near real-time information on ground level ozone and $PM_{2.5}$ concentrations. EPA uses the data to produce maps that display ozone and $PM_{2.5}$ contours covering the Midwest, New England, Mid-Atlantic, Southeastern, South central and Pacific coastal regions of the country. Color-coded, animated concentration gradient AQI maps are created that show daily ozone and $PM_{2.5}$ formation and transport at various spatial scales. The information is available on the EPA's AIRNOW website at: http://www.airnow.gov/. See Figure 82 for a sample map.



The tribal boundaries shown here are provided by the Bureau of Indian Affairs and are intended to be used as a general spatial reference only. They are not a formal determination of tribal boundaries by the EPA.

Click on the city name for more detailed information. printable summary	FORECAST		CURRENT AQI
	Tue Sep 9	Wed Sep 10	
Aiken-Augusta - SC/GA	46	n/a	29
Atlanta	Mod	n/a	26
Columbus-Phenix City - GA/AL	Good	n/a	16
Macon	Good	n/a	25

Figure 82. Sample AIRNOW ozone concentration map

The AIRNOW Data Management Center (DMC) regularly evaluates the performance of monitoring agencies that participate in the AIRNOW project based on three criteria:

1. Percent of hourly data files received
2. Average arrival time (earlier in the hour is better)
3. Percent completeness of the data within the submission files

There is a three-tier system (top, middle, and lower) set up to evaluate each agency based on these performance criteria. An agency is placed in a tier based on how it performs these three criteria, with respect to all participating agencies.

GA EPD Website and Call-In System

The Ambient Monitoring Program also provides a public-access website with Georgia-specific current and historical air quality data, often more promptly and with more detail than what is available at the AIRNOW website. AMP's website provides hourly information about current pollutant concentrations from Georgia's continuous and semi-continuous monitoring equipment, and is updated with each hour's data only 15 minutes after the hour ends. The site also offers downloads of bulk data, and electronic copies of archived Annual Reports such as this one, on a self-serve basis to facilitate research projects and satisfy public interest on these topics. Finally, the Ambient Monitoring Program also maintains an automated dial-in system that provides current air quality information for those who may not have ready access to the internet. These resources are listed below.

Ambient Monitoring Program Website:
http://www.air.dnr.state.ga.us/amp
Call-In System:
(800) 427-9605 (statewide)
(404) 362-4909 (metro Atlanta free calling zone)

Appendix A: Additional Criteria Pollutant Data

Carbon Monoxide (CO)

Units: parts per million

Site ID	City	County	Site Name	Hours Measured	Max 1 - Hour		Obs. ≥ 35	Max 8 - Hour		Obs. ≥ 9
					1st	2nd		1st	2nd	
130890002	Atlanta	DeKalb	South DeKalb	8472	1.407	1.308	0	1.2	1.2	0
131210099	Atlanta	Fulton	Roswell Road	8619	1.8	1.7	0	1.3	1.2	0
132230003	Yorkville	Paulding	Yorkville	8606	0.9	0.7	0	0.7	0.6	0

Nitrogen Dioxide (NO_2)

Units: parts per billion

Site ID	City	County	Site Name	Hours Measured	98th %	Max 1-Hour		Annual Arithmetic Mean
						1st	2nd	
130890002	Decatur	DeKalb	South DeKalb	8427	42.9	55.9	51.6	9.33
132230003	Yorkville	Paulding	Yorkville	8358	18.2	23.7	22.1	2.73
132470001	Conyers	Rockdale	Monastery	8501	19.9	22.7	22.3	4.19

Nitric Oxide (NO)

Units: parts per billion

Site ID	City	County	Site Name	Hours Measured	Max 1-Hour		Annual Arithmetic Mean
					1st	2nd	
130890002	Decatur	DeKalb	South DeKalb	8427	361.7	329.1	12.72
132230003	Yorkville	Paulding	Yorkville	8358	14.2	8.9	1.23
132470001	Conyers	Rockdale	Monastery	8501	54.7	47.6	1.68

Oxides of Nitrogen (NOx)

Units: parts per billion

Site ID	City	County	Site Name	Hours Measured	Max 1-Hour		Annual Arithmetic Mean
					1st	2nd	
130890002	Decatur	DeKalb	South DeKalb	8427	387.3	353.4	21.55
132230003	Yorkville	Paulding	Yorkville	8358	23.7	23.7	2.86
132470001	Conyers	Rockdale	Monastery	8501	69.8	62.7	4.97

Reactive Oxides of Nitrogen (NOy)

Units: parts per billion

Site ID	City	County	Site Name	Hours Measured	Max 1-Hour		Annual Arithmetic Mean
					1st	2nd	
130890002	Decatur	DeKalb	South DeKalb	8330	201.0	201.0	21.14

** The NO_y instrument is specialized for measurement of trace concentrations, so its range is only 0-200 ppb. Actual 1st Max appears to have exceeded the instrument's measurement range. Since all ambient concentrations exceeding the instrument's range are recorded as 200 instead of the actual (higher) value, the reported annual arithmetic mean may be biased slightly downward from the true concentration.

Sulfur Dioxide (SO_2)

24-Hour, 3-Hour, 1-Hour Maximum Observations, 99th Percentile 1-hour, and Maximum 5-minute

Units: parts per billion

Site ID	City	County	Site Name	Hours Measured	Max 24 - Hour		Max 1-Hour		99th Pctl 1- Hr	Maximum 5-Minute Average	Annual Arithmetic Mean
					1st	2nd	1st	2nd			
130210012	Macon	Bibb	Georgia Forestry Comm.	8600	4.6	2.5	28.3	13.3	10.7	37.9	1.09
130510021	Savannah	Chatham	East President St.	8656	19.4	18.9	96.0	71.0	56.5	151.4	2.10
130511002	Savannah	Chatham	W. Lathrop & Augusta Ave.	8594	30.2	28.4	142.1	117.5	92.7	261.8	3.07
130890002	Decatur	DeKalb	South DeKalb	8306	1.7	1.6	14.4	6.8	6.3	34.8	0.33
131150003	Rome	Floyd	Coosa Elem. School	8024	13.3	3.4	87.7	39.6	28.0	136.6	1.17
131210055	Atlanta	Fulton	Confederate Ave.	8597	2.0	1.8	14.9	10.4	8.9	21.3	1.04
132450091	Augusta	Richmond	Bungalow Rd.	8000	9.4	9.3	83.0	68.9	62.9	203.6	1.66

Ozone (O_3)

1-Hour Averages

Units: parts per million

Site ID	City	County	Site Name	Days Measured	1st Max	2nd Max
130210012	Macon	Bibb	GA Forestry Comm.	245	0.082	0.078
130510021	Savannah	Chatham	E. President Street	244	0.080	0.079
130550001	Summerville	Chattooga	DNR Fish Hatchery	244	0.073	0.072
130590002	Athens	Clarke	College Station Rd.	245	0.077	0.074
130670003	Kennesaw	Cobb	Georgia National Guard	242	0.081	0.079
130730001	Evans	Columbia	Riverside Park	237	0.073	0.073
130770002	Newnan	Coweta	Univ. of West Georgia	241	0.069	0.066
130850001	Dawsonville	Dawson	GA Forestry Comm.	245	0.076	0.071
130890002	Decatur	DeKalb	South DeKalb	245	0.097	0.079
130970004	Douglasville	Douglas	W. Strickland St.	241	0.078	0.076
131210055	Atlanta	Fulton	Confederate Ave.	242	0.114	0.096
131270006	Brunswick	Glynn	Risley Middle School	245	0.074	0.066
131350002	Lawrenceville	Gwinnett	Gwinnett Tech.	245	0.088	0.084
131510002	McDonough	Henry	County Extension Office	238	0.094	0.093
132130003	Chatsworth	Murray	Fort Mountain	242	0.073	0.072
132150008	Columbus	Muscogee	Columbus Airport	245	0.077	0.071
132230003	Yorkville	Paulding	Yorkville	240	0.076	0.074
132319991	Williamson	Pike	CASTNET	218	0.096	0.071
132450091	Augusta	Richmond	Bungalow Road Elementary School	236	0.085	0.075
132470001	Conyers	Rockdale	Conyers Monastery	244	0.090	0.087
132611001	Leslie	Sumter	Leslie Community Center	245	0.069	0.067

Ozone (O_3)

8-Hour Averages

Units: parts per million

Site ID	City	County	Site Name	Days Measured	1st Max	2nd Max	3rd Max	4th Max	Number of Days ≥ 0.075
130210012	Macon	Bibb	GA Forestry Comm.	245	0.072	0.069	0.065	0.064	0
130510021	Savannah	Chatham	E. President Street	244	0.067	0.066	0.059	0.059	0
130550001	Summerville	Chattooga	DNR Fish Hatchery	244	0.063	0.061	0.061	0.059	0
130590002	Athens	Clarke	College Station Road	245	0.067	0.065	0.061	0.060	0
130670003	Kennesaw	Cobb	Georgia National Guard	240	0.073	0.073	0.068	0.067	0
130730001	Evans	Columbia	Riverside Park	235	0.068	0.065	0.064	0.061	0
130770002	Newnan	Coweta	Univ. of West Georgia	241	0.059	0.055	0.054	0.053	0
130850001	Dawsonville	Dawson	GA Forestry Comm.	245	0.072	0.064	0.064	0.063	0
130890002	Decatur	DeKalb	South DeKalb	245	0.082	0.067	0.063	0.062	1
130970004	Douglasville	Douglas	W. Strickland St.	241	0.071	0.069	0.069	0.063	0
131210055	Atlanta	Fulton	Confederate Ave.	242	0.096	0.080	0.075	0.069	2
131270006	Brunswick	Glynn	Risley Middle School	245	0.064	0.064	0.058	0.057	0
131350002	Lawrenceville	Gwinnett	Gwinnett Tech.	245	0.074	0.069	0.069	0.069	0
131510002	McDonough	Henry	County Extension Office	237	0.072	0.072	0.071	0.070	0
132130003	Chatsworth	Murray	Fort Mountain	242	0.068	0.063	0.062	0.062	0
132150008	Columbus	Muscogee	Columbus Airport	245	0.068	0.062	0.060	0.060	0
132230003	Yorkville	Paulding	Yorkville	240	0.068	0.066	0.065	0.062	0
132319991	Williamson	Pike	CASTNET	213	0.078	0.069	0.066	0.064	1
132450091	Augusta	Richmond	Bungalow Road Elementary School	234	0.070	0.070	0.067	0.063	0
132470001	Conyers	Rockdale	Conyers Monastery	244	0.073	0.073	0.072	0.071	0
132611001	Leslie	Sumter	Community Center	245	0.064	0.063	0.061	0.060	0

4th max used in 3-year average, therefore if number above 0.075 is more than 4 per site, it is shown in bold.

Lead (Pb)

3-Month Rolling Averages Using Federal Equivalent Method

Units: micrograms per cubic meter

Site ID	130150003	130890003	132150009	132150010	132150011
City	Cartersville	Atlanta	Columbus	Columbus	Columbus
County	Bartow	DeKalb	Muscogee	Muscogee	Muscogee
Site Name	Cartersville	DMRC	UPS	Fort Benning	Cusseta School
Number of Obs.	62	61	61	62	60
Nov 2012-Jan 2013	0.0091	0.0027	0.0591	0.1222	0.0128
Dec 2012-Feb 2013	0.0096	0.0023	0.0417	0.0659	0.0074
Jan 2013-Mar 2013	0.0101	0.0025	0.0351	0.0743	0.0058
Feb 2013-Apr 2013	0.0103	0.0022	0.0291	0.0442	0.0043
Mar 2013-May 2013	0.0102	0.0020	0.0288	0.0546	0.0028
Apr 2013-Jun 2013	0.0102	0.0017	0.0256	0.0535	0.0024
May 2013-Jul 2013	0.0092	0.0015	0.0495	0.0762	0.0034
Jun 2013-Aug 2013	0.0083	0.0013	0.0418	0.0701	0.0039
Jul 2013-Sep 2013	0.0085	0.0015	0.0435	0.0693	0.0047
Aug 2013-Oct 2013	0.0094	0.0017	0.0269	0.0456	0.0098
Sep 2013-Nov 2013	0.0088	0.0021	0.0594	0.0337	0.0207
Oct 2013-Dec 2013	0.0087	0.0019	0.0635	0.0231	0.0225
# of Values ≥ 0.15	0	0	0	0	0

Fine Particulate Matter ($PM_{2.5}$)

98th% and Annual Arithmetic Mean
Integrated Sampling (midnight to midnight) Using Federal Reference Method

Units: micrograms per cubic meter

Site ID	City	County	Site Name	Days Meas-ured	98th Percen-tile	Values Exceeding Applicable Daily Standard	Annual Arith-metic Mean
130210007	Macon	Bibb	Allied Chemical	338	20.5	0	10.03
130210012	Macon	Bibb	GA Forestry Comm.	115	18.3	0	8.16
130510091	Savannah	Chatham	Mercer School	106	17.8	0	9.04
130590002	Athens	Clarke	College Station Rd.	100	28.0	0	9.71
130630091	Forest Park	Clayton	Georgia DOT	116	18.1	0	9.70
130670003	Kennesaw	Cobb	GA National Guard	347	19.5	0	9.63
130890002	Decatur	DeKalb	South DeKalb	350	19.0	0	9.40
130950007	Albany	Dougherty	Turner Elem. School	339	25.7	1	9.83
131150003	Rome	Floyd	Coosa Elementary	318	18.7	0	9.37
131210039	Atlanta	Fulton	Fire Station #8	110	20.4	0	10.42
131270006	Brunswick	Glynn	Risley Middle School	96	18.7	0	8.20

Fine Particulate Matter ($PM_{2.5}$) (continued)

98^{th}% and Annual Arithmetic Mean
Integrated Sampling (midnight to midnight) Using Federal Reference Method

Units: micrograms per cubic meter

Site ID	City	County	Site Name	Days Measured	98th Percentile	Values Exceeding Applicable Daily Standard	Annual Arithmetic Mean
131350002	Lawrenceville	Gwinnett	Gwinnett Tech	116	18.3	0	8.88
131390003	Gainesville	Hall	Fair St. Elem.	108	16.9	0	8.51
131530001	Warner Robins	Houston	Robins AFB	118	18.3	0	8.67
131850003	Valdosta	Lowndes	S.L. Mason Elem.	106	19.1	0	8.54
132150001	Columbus	Muscogee	Health Dept.	120	20.0	0	9.66
132150008	Columbus	Muscogee	Columbus Airport	84	22.0	0	9.94
132150011	Columbus	Muscogee	Cusseta Rd. School	116	26.8	0	9.72
132230003	Yorkville	Paulding	Yorkville	111	19.1	0	8.53
132450091	Augusta	Richmond	Bungalow Rd. School	111	17.7	0	9.24
132950002	Rossville	Walker	Health Dept.	95	22.9	0	10.05
133030001	Sandersville	Washington	Health Dept.	110	21.8	0	9.40
133190001	Gordon	Wilkinson	Police Dept.	105	21.6	0	9.83

Fine Particulate Matter ($PM_{2.5}$)

Hourly Averages of Semi-Continuous Measurements

Units: micrograms per cubic meter

Site ID	City	County	Site Name	Hours Meas-ured	1st Max	2nd Max	Annual Arith-metic Mean
130210012	Macon	Bibb	GA Forestry Comm.	8640	48.6	44.2	7.49
130511002	Savannah	Chatham	Lathrop & Augusta Avenues	8364	84.2	75.5	8.69
130590002	Athens	Clarke	College Station Rd.	8681	165.8	148.0	9.04
130770002	Newnan	Coweta	Univ. of West Georgia	8622	40.0	39.4	8.16
130890002	Decatur	DeKalb	South DeKalb	7340	39.0	39.0	11.90
130950007	Albany	Dougherty	Turner Elem	8233	205.0	169.0	11.68
131150003	Rome	Floyd	Coosa Elem	8465	138.0	61.0	13.23
131210055	Atlanta	Fulton	Confederate Avenue	8535	70.4	46.0	8.68
131350002	Lawrenceville	Gwinnett	Gwinnett Tech	8706	126.9	111.7	8.40
131390003	Gainesville	Hall	Gainesville	8225	212.0	121.0	10.52
131510002	McDonough	Henry	County Extension Office	8489	66.6	60.4	8.53
131530001	Warner Robins	Houston	Warner Robins	8208	88.0	66.0	9.97
131850003	Valdosta	Lowndes	Valdosta	8676	115.0	96.0	9.80
132150008	Columbus	Muscogee	Columbus Airport	8680	85.6	81.9	8.41
132230003	Yorkville	Paulding	Yorkville	8527	53.3	46.0	10.80
132450091	Augusta	Richmond	Bungalow Rd. School	8596	120.0	119.4	8.81
132950002	Rossville	Walker	Health Department	8658	177.0	86.0	10.17

Except for the South DeKalb and Albany monitors, these semi-continuous methods for measuring $PM_{2.5}$ are not approved for use in making attainment determinations.

Particulate Matter (PM_{10})

24-Hour Integrated Measurements

Units: micrograms per cubic meter

Site ID	City	County	Site Name	Days Measured	1st Max	Number Values ≥150	Annual Arith-metic Mean
131210039	Atlanta	Fulton	Fire Station #8	57	39	0	14.9
132450091	Augusta	Richmond	Bungalow Rd. Elem. School	54	37	0	14.8

Particulate Matter (PM_{10})

Hourly Averages of Semi-Continuous Measurements

Units: micrograms per cubic meter

Site ID	City	County	Site Name	Hours Measured	1st Max	Annual Arithmetic Mean
130890002	Decatur	DeKalb	South DeKalb	8078	116	18.1

Coarse Particulate Matter ($PM_{10-2.5}$)

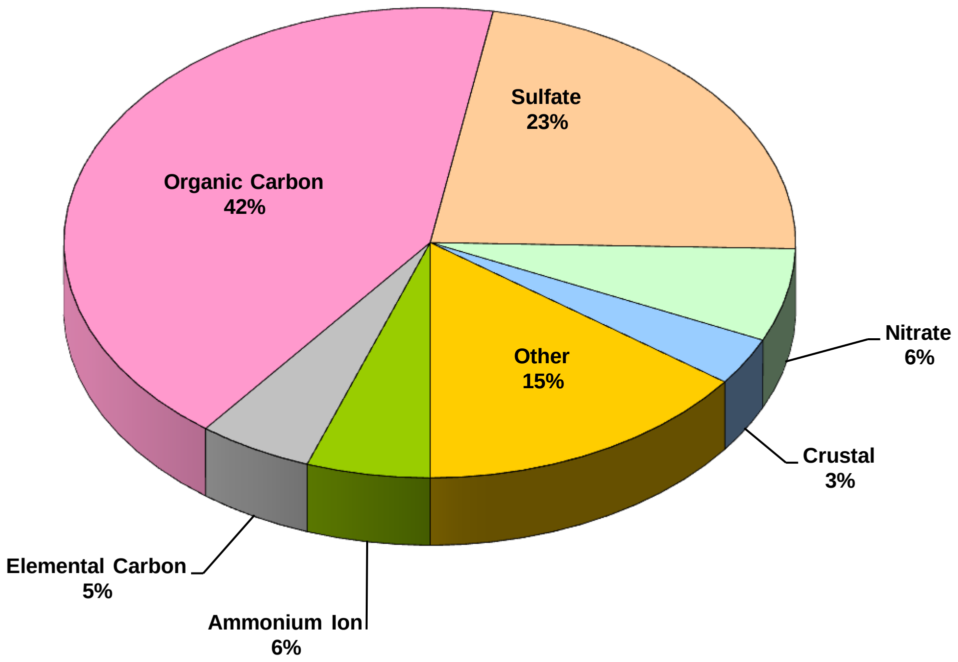
Hourly Averages of Semi-Continuous Measurements

Units: micrograms per cubic meter

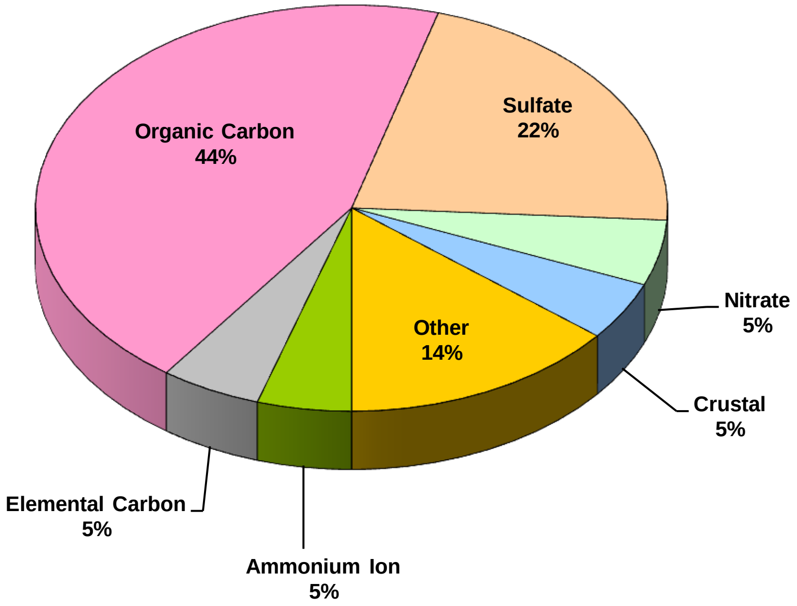
Site ID	City	County	Site Name	Hours Measured	1st Max	Annual Arithmetic Mean
130890002	Decatur	DeKalb	South DeKalb	7738	103.0	6.94

Appendix B: Additional $PM_{2.5}$ Particle Speciation Data

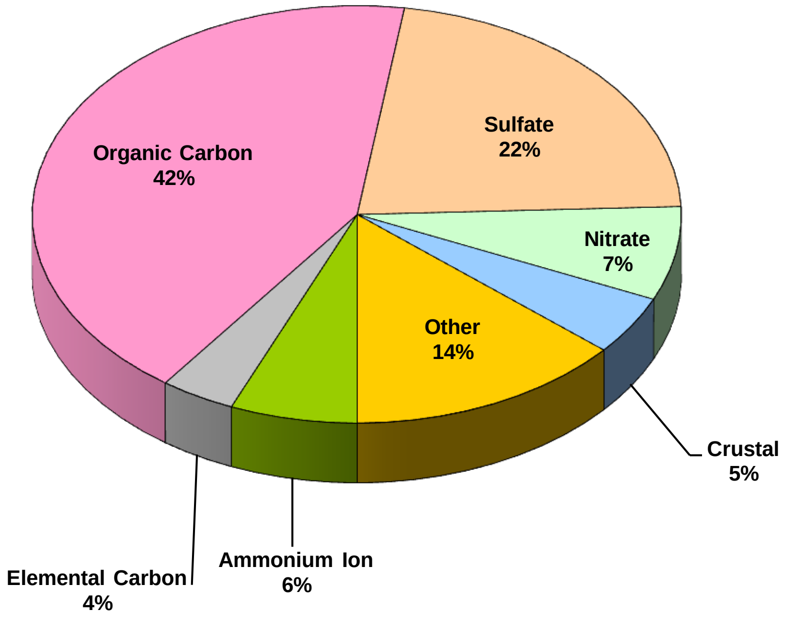
Particle Speciation- 2013 Statewide Average

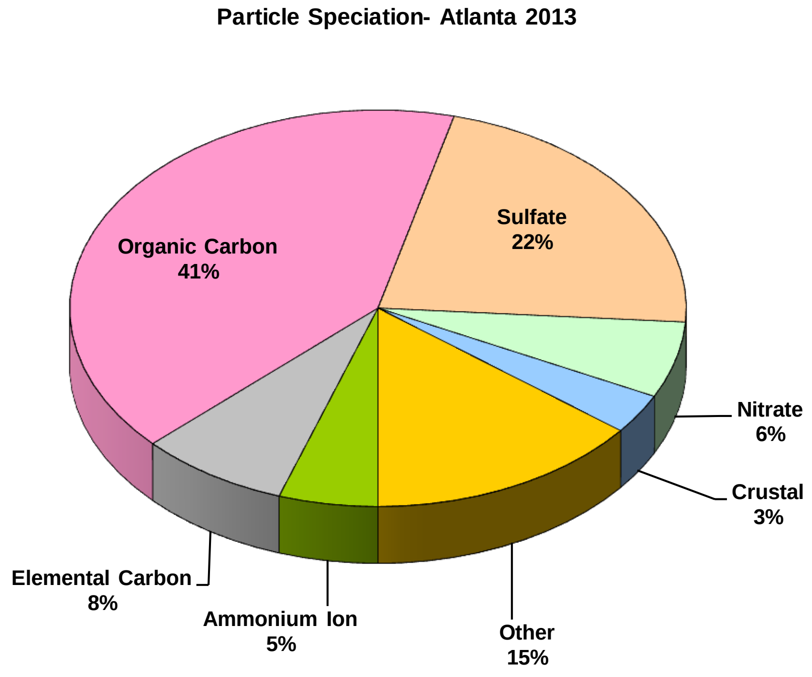


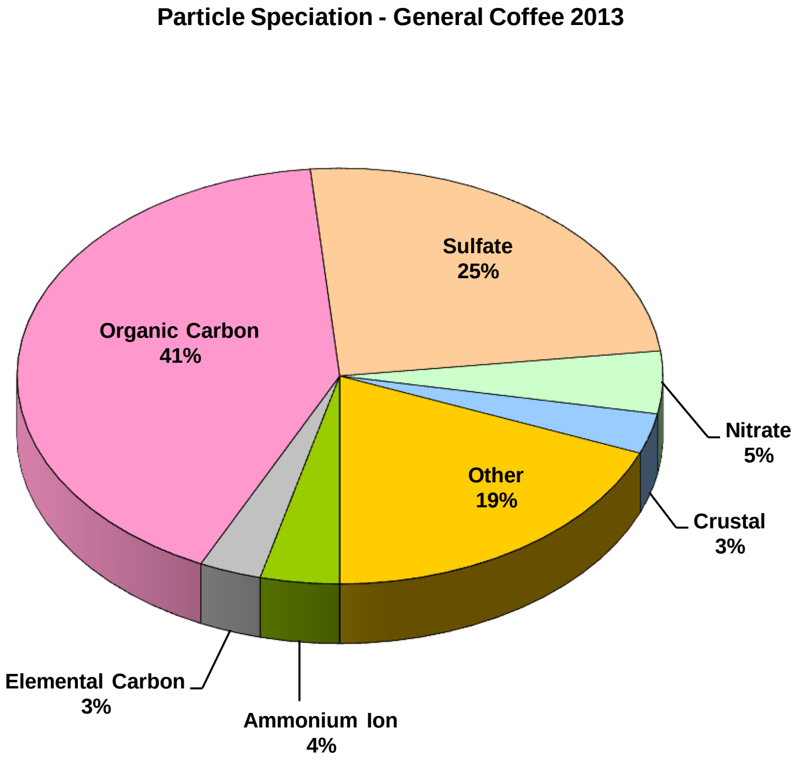
Particle Speciation - Macon 2013



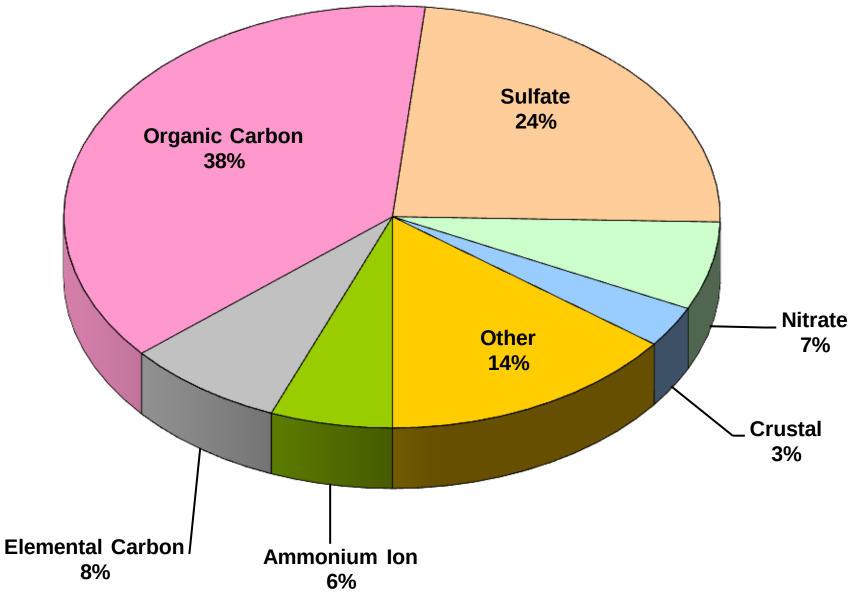
Particle Speciation - Athens 2013



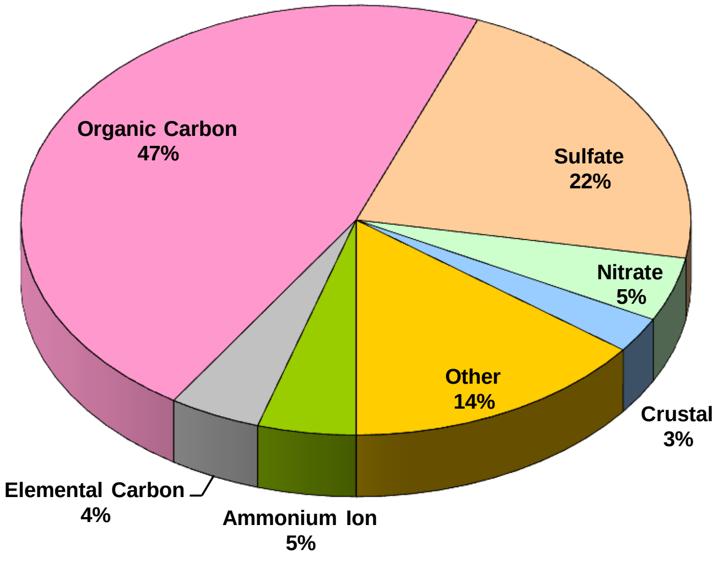

Particle Speciation- Atlanta 2013
Organic Carbon 41%
Sulfate 22%
Nitrate 6%
Crustal 3%
Other 15%
Ammonium Ion 5%
Elemental Carbon 8%

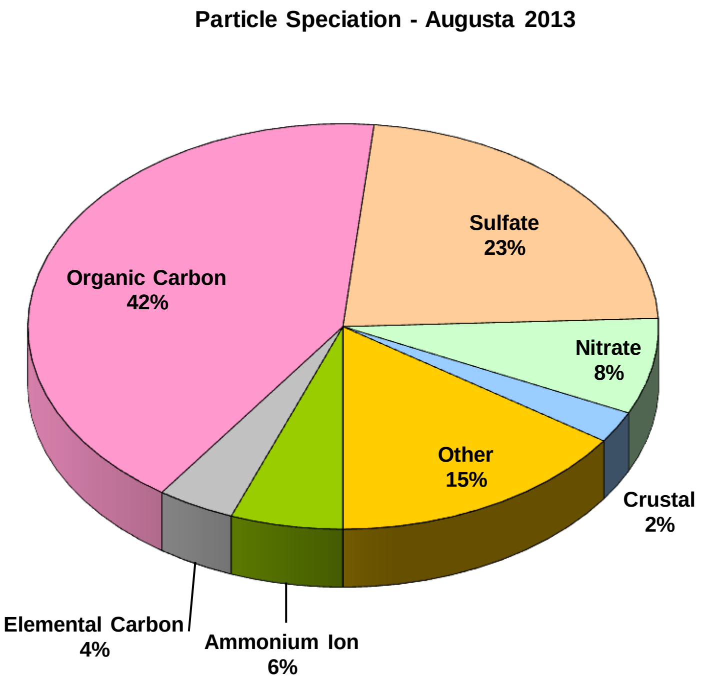

Particle Speciation - General Coffee 2013
Organic Carbon 41%
Sulfate 25%
Nitrate 5%
Crustal 3%
Other 19%
Ammonium Ion 4%
Elemental Carbon 3%

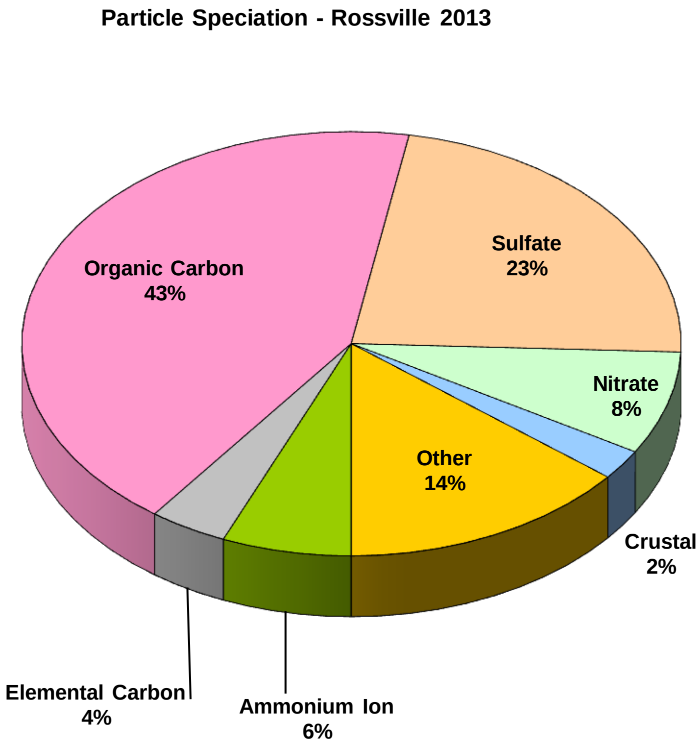
Particle Speciation - Rome 2013



Particle Speciation - Columbus 2013




Particle Speciation - Augusta 2013
Sulfate
23%
Organic Carbon
42%
Nitrate
8%
Other
15%
Crustal
2%
Elemental Carbon
4%
Ammonium Ion
6%


Particle Speciation - Rossville 2013
Organic Carbon
43%
Sulfate
23%
Nitrate
8%
Other
14%
Crustal
2%
Elemental Carbon
4%
Ammonium Ion
6%

Appendix C: Additional PAMS Data

PAMS Continuous Hydrocarbon Data (June-August 2013)

(concentrations in parts per billion Carbon (ppbC))

Name	Site	#Samples	Avg.	1st Max	2nd Max
PAMSHC	S. DeKalb	1724	36.78	214.1	213.4
	Conyers	1854	16.02	360.0	165.4
	Yorkville	1322	18.48	96.6	71.9
TNMOC	S. DeKalb	1724	43.88	255.5	248.1
	Conyers	1854	25.08	450.1	404.9
	Yorkville	1322	22.50	196.3	87.9
Ethane	S. DeKalb	1721	3.311	39.75	18.72
	Conyers	671	2.314	6.71	6.64
	Yorkville	1321	2.646	7.74	7.73
Ethylene	S. DeKalb	1721	1.271	20.33	19.95
	Conyers	694	0.566	13.16	4.46
	Yorkville	1321	0.172	1.92	1.32
Propane	S. DeKalb	1721	2.956	19.56	17.65
	Conyers	1287	2.352	13.61	9.14
	Yorkville	1321	2.401	19.13	17.51
Propylene	S. DeKalb	1721	0.841	10.62	8.82
	Conyers	1848	0.267	4.56	1.73
	Yorkville	1321	0.194	1.16	1.03
Acetylene	S. DeKalb	1721	0.56	14.1	12.2
	Conyers	1848	0.32	10.7	4.2
	Yorkville	1321	0.28	3.0	2.9
n-Butane	S. DeKalb	1721	1.591	11.02	10.38
	Conyers	1848	0.431	46.47	7.64
	Yorkville	1321	0.571	2.71	2.57
Isobutane	S. DeKalb	1721	0.788	6.21	5.33
	Conyers	1848	0.223	78.56	43.57
	Yorkville	1321	0.222	2.14	1.23
trans-2-Butene	S. DeKalb	1721	0.024	0.72	0.60
	Conyers	1849	0.005	0.32	0.01
	Yorkville	1321	0.005	0.62	0.01
cis-2-Butene	S. DeKalb	1721	0.050	3.09	2.60
	Conyers	1849	0.012	1.51	0.75
	Yorkville	1321	0.081	43.23	4.42
n-Pentane	S. DeKalb	1721	2.161	17.36	17.10
	Conyers	1849	1.042	14.18	9.96
	Yorkville	1321	0.349	3.25	3.10
Isopentane	S. DeKalb	1721	2.907	23.77	19.04
	Conyers	1849	1.891	19.10	18.54
	Yorkville	1321	0.680	6.53	6.03
1-Pentene	S. DeKalb	1721	0.054	1.81	1.23
	Conyers	1849	0.006	0.88	0.72
	Yorkville	1321	0.007	0.83	0.62

PAMS Continuous Hydrocarbon Data (June-August 2013)(continued)

(concentrations in ppbC)

Name	Site	#Samples	Avg.	1st Max	2nd Max
trans-2-Pentene	S. DeKalb	1721	0.072	1.72	1.22
	Conyers	1849	0.047	1.55	1.01
	Yorkville	1321	0.051	40.54	1.44
cis-2-Pentene	S. DeKalb	1721	0.022	0.87	0.53
	Conyers	1849	0.006	0.68	0.58
	Yorkville	1321	0.007	2.29	0.68
3-Methylpentane	S. DeKalb	1721	0.417	4.25	3.89
	Conyers	1849	0.022	5.08	4.35
	Yorkville	1321	0.067	1.83	1.15
n-Hexane	S. DeKalb	1720	0.065	18.00	2.90
	Conyers	1496	0.197	19.49	11.75
	Yorkville	1322	0.155	6.37	3.39
n-Heptane	S. DeKalb	1720	0.281	4.04	3.57
	Conyers	1851	0.053	4.10	3.95
	Yorkville	1322	0.020	1.23	0.76
n-Octane	S. DeKalb	1720	0.103	6.25	1.96
	Conyers	1851	0.091	1.69	1.47
	Yorkville	1322	0.025	5.83	2.01
n-Nonane	S. DeKalb	1720	0.086	20.09	13.23
	Conyers	1851	0.007	0.53	0.48
	Yorkville	1322	0.011	1.40	0.64
n-Decane	S. DeKalb	1511	0.093	2.76	2.72
	Conyers	1851	0.035	3.65	3.31
	Yorkville	1322	0.018	3.26	1.02
Cyclopentane	S. DeKalb	1721	0.088	2.32	1.25
	Conyers	1849	0.006	0.69	0.69
	Yorkville	1321	0.219	2.01	1.80
Isoprene	S. DeKalb	1721	5.371	20.63	20.06
	Conyers	1849	3.054	21.73	21.66
	Yorkville	1321	6.213	54.48	48.51
2,2-Dimethylbutane	S. DeKalb	1721	0.043	0.88	0.70
	Conyers	1849	0.009	0.62	0.48
	Yorkville	1321	0.007	0.90	0.32
2,4-Dimethylpentane	S. DeKalb	1720	0.148	1.78	1.73
	Conyers	1851	0.011	2.63	2.24
	Yorkville	1322	0.006	1.16	0.01
Cyclohexane	S. DeKalb	1720	0.103	2.01	1.23
	Conyers	1851	0.011	1.55	1.01
	Yorkville	1322	0.009	1.09	0.36
3-Methylhexane	S. DeKalb	1720	0.463	5.12	5.06
	Conyers	1851	0.155	9.55	8.05
	Yorkville	1322	0.078	1.74	0.95
2,2,4-Trimethylpentane	S. DeKalb	1720	0.829	7.60	7.00
	Conyers	1851	0.275	9.36	7.78
	Yorkville	1322	0.222	4.77	2.73

PAMS Continuous Hydrocarbon Data (June-August 2013)(continued)

(concentrations in ppbC)

Name	Site	#Samples	Avg.	1st Max	2nd Max
2,3,4-Trimethylpentane	S. DeKalb	1720	0.228	2.51	2.30
	Conyers	1851	0.031	3.97	2.44
	Yorkville	1322	0.022	1.72	0.87
3-Methylheptane	S. DeKalb	1720	0.084	4.35	2.78
	Conyers	1850	0.008	2.21	1.39
	Yorkville	1322	0.015	0.78	0.52
Methylcyclohexane	S. DeKalb	1720	0.167	2.57	1.93
	Conyers	1851	0.055	2.96	2.20
	Yorkville	1322	0.015	0.90	0.48
Methylcyclopentane	S. DeKalb	1720	0.336	3.14	3.00
	Conyers	1851	0.033	4.63	3.01
	Yorkville	1322	0.008	0.74	0.32
2-Methylhexane	S. DeKalb	1720	0.349	3.74	3.73
	Conyers	1851	0.036	5.86	4.20
	Yorkville	1322	0.027	2.06	1.07
1-Butene	S. DeKalb	1721	0.225	2.12	1.60
	Conyers	1849	0.009	0.52	0.50
	Yorkville	1321	0.006	0.77	0.25
2,3-Dimethylbutane	S. DeKalb	1721	0.131	7.21	1.81
	Conyers	1849	0.010	4.77	1.00
	Yorkville	1321	0.014	1.00	0.56
2-Methylpentane	S. DeKalb	1721	0.572	6.17	5.46
	Conyers	1849	0.027	4.08	3.24
	Yorkville	1321	0.175	2.73	1.72
2,3-Dimethylpentane	S. DeKalb	1720	0.224	3.04	2.81
	Conyers	1850	0.020	4.81	3.50
	Yorkville	1322	0.008	1.55	0.36
n-Undecane	S. DeKalb	1510	0.112	2.42	2.25
	Conyers	1851	0.035	1.02	1.00
	Yorkville	1322	0.043	5.55	3.79
2-Methylheptane	S. DeKalb	1720	0.029	2.26	0.88
	Conyers	1850	0.011	2.93	1.63
	Yorkville	1322	0.008	0.69	0.45
m & p Xylenes	S. DeKalb	1720	1.121	9.98	9.16
	Conyers	1851	0.197	9.33	8.76
	Yorkville	1322	0.198	3.29	2.20
Benzene	S. DeKalb	1720	0.625	7.79	6.41
	Conyers	1851	0.392	5.65	5.49
	Yorkville	1322	0.062	1.99	0.98
Toluene	S. DeKalb	1720	2.651	34.60	20.24
	Conyers	1850	0.963	19.73	17.20
	Yorkville	1322	0.633	22.49	8.73
Ethylbenzene	S. DeKalb	1720	0.276	2.64	2.26
	Conyers	1851	0.053	3.20	3.10
	Yorkville	1322	0.022	1.40	0.61

PAMS Continuous Hydrocarbon Data (June-August 2013)(continued)

(concentrations in ppbC)

Name	Site	#Samples	Avg.	1st Max	2nd Max
o-Xylene	S. DeKalb	1720	0.438	3.92	3.71
	Conyers	1851	0.041	3.61	2.15
	Yorkville	1322	0.013	1.12	0.65
1,3,5-Trimethylbenzene	S. DeKalb	1511	0.098	1.99	1.86
	Conyers	1851	0.017	1.84	1.28
	Yorkville	1322	0.018	1.91	0.90
1,2,4-Trimethylbenzene	S. DeKalb	1511	0.470	6.49	4.22
	Conyers	1851	0.158	11.57	4.43
	Yorkville	1322	0.288	12.21	7.38
n-Propylbenzene	S. DeKalb	1511	0.057	1.29	0.85
	Conyers	1851	0.020	0.70	0.68
	Yorkville	1322	0.020	4.55	1.13
Isopropylbenzene	S. DeKalb	1720	0.126	3.94	2.63
	Conyers	1851	0.010	1.84	1.03
	Yorkville	1322	0.036	3.51	0.91
o-Ethyltoluene	S. DeKalb	1511	0.117	1.84	1.32
	Conyers	1851	0.014	1.47	1.46
	Yorkville	1322	0.042	3.89	1.18
m-Ethyltoluene	S. DeKalb	N/A			
	Conyers	N/A			
	Yorkville	N/A			
m-Diethylbenzene	S. DeKalb	1511	0.031	1.83	1.45
	Conyers	1851	0.008	2.09	0.59
	Yorkville	1322	0.043	9.94	4.22
p-Diethylbenzene	S. DeKalb	1511	0.059	0.89	0.83
	Conyers	1850	0.031	1.67	1.32
	Yorkville	1322	0.021	2.76	2.54
Styrene	S. DeKalb	1720	0.161	2.06	1.76
	Conyers	1850	0.106	1.71	1.47
	Yorkville	1322	0.020	1.48	0.89
Beta Pinene and 1,2,3-Trimethylbenzene	S. DeKalb	1511	2.404	12.29	12.22
	Conyers	1851	1.932	24.15	22.68
	Yorkville	1322	1.390	9.55	9.26
Pinene and p-Ethyltoluene	S. DeKalb	N/A			
	Conyers	N/A			
	Yorkville	N/A			
m and p-Ethyltoluene	S. DeKalb	1511	1.790	8.31	7.73
	Conyers	1851	0.960	9.15	8.77
	Yorkville	1322	0.809	9.20	6.80
m/p-Ethyltoluene	S. DeKalb	N/A			
	Conyers	N/A			
	Yorkville	N/A			

N/A indicates not applicable

PAMS 2013 24-hour Canister Hydrocarbons

(concentrations in parts per billion Carbon (ppbC))

Name	Site	#Samples	#Detects^	Avg.*	1st Max	2nd Max
PAMSHC	S. DeKalb	59	59	56.37	190.0	180.0
	Conyers	58	58	41.81	210.0	180.0
	Yorkville	47	47	33.12	82.0	67.0
TNMOC	S. DeKalb	59	59	184.97	2900.0	430.0
	Conyers	58	58	128.97	360.0	340.0
	Yorkville	47	47	126.57	240.0	240.0
Ethane	S. DeKalb	59	44	4.93	14.0	12.0
	Conyers	58	45	4.21	11.0	11.0
	Yorkville	47	40	4.79	10.0	10.0
Ethylene	S. DeKalb	59	5	0.29	5.9	2.0
	Conyers	58	4	0.16	1.3	1.1
	Yorkville	47	6	0.20	1.3	1.3
Propane	S. DeKalb	59	50	4.68	13.0	12.0
	Conyers	58	49	3.51	8.6	8.5
	Yorkville	47	46	4.78	11.0	11.0
Propylene	S. DeKalb	59	45	0.68	5.0	2.3
	Conyers	58	37	0.30	1.0	0.8
	Yorkville	47	21	0.24	1.1	0.7
Acetylene	S. DeKalb	59	43	1.17	4.9	4.1
	Conyers	58	45	0.79	2.5	2.3
	Yorkville	47	38	0.74	3.3	1.6
n-Butane	S. DeKalb	59	56	3.98	12.0	12.0
	Conyers	58	56	2.15	6.7	6.5
	Yorkville	47	41	1.67	6.6	5.3
Isobutane	S. DeKalb	59	54	1.94	29.0	6.7
	Conyers	58	45	0.61	2.2	1.7
	Yorkville	47	34	1.5	3.3	1.6
trans-2-Butene	S. DeKalb	59	1	0.10	0.3	
	Conyers	58	ND			
	Yorkville	47	ND			
cis-2-Butene	S. DeKalb	59	ND			
	Conyers	58	ND			
	Yorkville	47	ND			
n-Pentane	S. DeKalb	59	58	2.71	8.4	6.0
	Conyers	58	54	2.51	47.0	33.0
	Yorkville	47	41	1.35	5.6	5.1
Isopentane	S. DeKalb	59	59	3.74	12.0	9.7
	Conyers	58	58	5.43	110.0	99.0
	Yorkville	47	44	1.07	3.1	2.8
1-Pentene	S. DeKalb	59	13	0.21	1.3	1.0
	Conyers	58	3	0.11	0.4	0.3
	Yorkville	47	3	0.12	0.5	0.4
trans-2-Pentene	S. DeKalb	59	12	0.52	5.4	4.5
	Conyers	58	10	0.69	5.8	5.4
	Yorkville	47	6	0.26	2.4	1.7

PAMS 2013 24-hour Canister Hydrocarbons (continued)

(concentrations in ppbC)

Name	Site	#Samples	#Detects^	Avg.*	1st Max	2nd Max
cis-2-Pentene	S. DeKalb	59	4	0.19	2.8	2.4
	Conyers	58	4	0.29	5.4	2.6
	Yorkville	47	1	0.17	3.2	
3-Methylpentane	S. DeKalb	59	45	0.62	2.3	2.2
	Conyers	59	34	0.59	2.7	2.1
	Yorkville	47	15	0.24	0.9	0.9
n-Hexane	S. DeKalb	59	49	1.63	6.4	6.1
	Conyers	58	38	0.67	3.3	2.6
	Yorkville	47	27	0.74	3.1	3.0
n-Heptane	S. DeKalb	59	27	0.27	0.9	0.9
	Conyers	58	9	0.13	0.5	0.4
	Yorkville	47	3	0.11	0.3	0.3
n-Octane	S. DeKalb	59	6	0.13	0.8	0.4
	Conyers	58	1	0.10	0.20	
	Yorkville	47	ND			
n-Nonane	S. DeKalb	59	2	0.11	0.3	0.3
	Conyers	58	ND			
	Yorkville	47	ND			
n-Decane	S. DeKalb	59	3	0.16	3.2	0.2
	Conyers	58	1	0.10	0.3	
	Yorkville	47	ND			
Cyclopentane	S. DeKalb	59	7	0.19	2.8	1.8
	Conyers	58	4	0.13	1.3	0.4
	Yorkville	47	5	0.19	1.7	1.4
Isoprene	S. DeKalb	59	24	2.84	15.0	11.0
	Conyers	58	33	3.47	20.0	17.0
	Yorkville	47	22	2.38	14.0	12.0
2,2-Dimethylbutane	S. DeKalb	59	14	0.15	0.7	0.4
	Conyers	58	24	0.38	3.9	1.3
	Yorkville	47	10	0.19	0.9	0.7
2,4-Dimethylpentane	S. DeKalb	59	15	0.17	1.0	0.6
	Conyers	58	7	0.15	0.9	0.9
	Yorkville	47	1	0.10	0.2	
Cyclohexane	S. DeKalb	59	17	0.18	1.1	0.6
	Conyers	58	11	1.18	11.0	9.2
	Yorkville	47	1	0.10	0.3	
3-Methylhexane	S. DeKalb	59	40	0.47	1.8	1.5
	Conyers	58	9	0.14	1.0	0.4
	Yorkville	47	7	0.15	1.4	0.6
2,2,4-Trimethylpentane	S. DeKalb	59	50	0.77	2.6	2.3
	Conyers	58	20	0.14	1.0	0.6
	Yorkville	47	9	0.12	2.8	0.5
2,3,4-Trimethylpentane	S. DeKalb	59	15	0.21	1.4	0.7
	Conyers	58	3	0.11	0.2	0.2
	Yorkville	47	1	0.12	0.9	

PAMS 2013 24-hour Canister Hydrocarbons (continued)

(concentrations in ppbC)

Name	Site	#Samples	#Detects^	Avg.*	1st Max	2nd Max
3-Methylheptane	S. DeKalb	59	7	0.12	0.4	0.3
	Conyers	58	1	0.12	1.2	
	Yorkville	47	ND			
Methylcyclohexane	S. DeKalb	59	8	0.13	0.5	0.4
	Conyers	58	ND			
	Yorkville	47	ND			
Methylcyclopentane	S. DeKalb	59	27	0.28	1.2	0.9
	Conyers	58	8	0.25	6.8	0.7
	Yorkville	47	ND			
2-Methylhexane	S. DeKalb	59	25	3.02	163.0	1.0
	Conyers	58	20	3.28	17.0	16.0
	Yorkville	47	2	0.11	0.5	0.3
1-Butene	S. DeKalb	59	11	0.15	0.5	0.5
	Conyers	58	5	0.12	0.4	0.3
	Yorkville	47	2	0.11	0.5	0.4
2,3-Dimenthylbutane	S. DeKalb	59	16	0.18	0.8	0.7
	Conyers	58	8	0.18	1.2	1.2
	Yorkville	47	1	0.10	0.3	
2-Methylpentane	S. DeKalb	59	50	0.83	3.1	2.5
	Conyers	58	33	0.33	1.2	1.0
	Yorkville	47	19	0.23	0.8	0.6
2,3-Dimethylpentane	S. DeKalb	59	21	0.24	0.8	0.7
	Conyers	58	20	2.19	13.0	12.0
	Yorkville	47	14	0.31	2.5	1.1
n-Undecane	S. DeKalb	59	22	0.93	39.0	2.9
	Conyers	58	8	0.18	1.8	1.0
	Yorkville	47	2	0.11	0.4	0.2
2-Methylheptane	S. DeKalb	59	4	0.13	1.6	0.3
	Conyers	58	1	0.10	0.3	
	Yorkville	47	1	0.10	0.3	
m & p Xylenes	S. DeKalb	59	57	1.05	3.3	3.0
	Conyers	58	38	0.34	1.9	1.0
	Yorkville	47	18	0.15	0.8	0.7
Benzene	S. DeKalb	59	57	1.04	2.3	2.3
	Conyers	58	56	0.77	1.4	1.4
	Yorkville	47	43	0.60	1.3	1.1
Toluene	S. DeKalb	59	58	2.58	6.5	6.1
	Conyers	58	56	1.28	3.0	2.9
	Yorkville	47	46	0.78	2.4	2.1
Ethylbenzene	S. DeKalb	59	25	0.18	0.8	0.8
	Conyers	58	7	0.04	0.5	0.4
	Yorkville	47	1	0.00	0.2	
o-Xylene	S. DeKalb	59	32	0.28	1.1	1.0
	Conyers	58	7	0.04	0.6	0.5
	Yorkville	47	1	0.00	0.2	

PAMS 2013 24-hour Canister Hydrocarbons (continued)

(concentrations in ppbC)

Name	Site	#Samples	#Detects^	Avg.*	1st Max	2nd Max
1,3,5-Trimethylbenzene	S. DeKalb	59	7	0.16	2.7	0.4
	Conyers	58	5	0.20	4.2	0.8
	Yorkville	47	ND			
1,2,4-Trimethylbenzene	S. DeKalb	59	51	7.55	30.0	30.0
	Conyers	58	41	2.96	9.3	7.3
	Yorkville	47	38	8.98	55.0	35.0
n-Propylbenzene	S. DeKalb	59	1	0.10	0.2	
	Conyers	58	ND			
	Yorkville	47	ND			
Isopropylbenzene	S. DeKalb	59	ND			
	Conyers	58	1	0.01	0.5	
	Yorkville	47	ND			
o-Ethyltoluene	S. DeKalb	59	16	0.17	0.7	0.6
	Conyers	58	10	0.16	1.2	0.7
	Yorkville	47	1	0.11	0.4	
m-Ethyltoluene	S. DeKalb	59	22	0.23	0.9	0.8
	Conyers	58	5	0.12	0.6	0.4
	Yorkville	47	ND			
p-Ethyltoluene	S. DeKalb	59	30	0.27	0.9	0.8
	Conyers	58	31	0.31	1.0	0.9
	Yorkville	47	9	0.13	0.4	0.3
m-Diethylbenzene	S. DeKalb	59	2	0.12	0.8	0.7
	Conyers	58	ND			
	Yorkville	47	ND			
p-Diethylbenzene	S. DeKalb	59	8	0.52	20.0	2.0
	Conyers	58	7	0.16	1.4	0.9
	Yorkville	47	1	0.11	0.4	
Styrene	S. DeKalb	59	31	0.29	2.7	1.1
	Conyers	58	29	0.35	3.0	1.9
	Yorkville	47	18	0.24	1.8	1.3
1,2,3-Trimethylbenzene	S. DeKalb	59	21	0.81	22.0	7.3
	Conyers	58	11	0.17	0.9	0.7
	Yorkville	47	2	0.11	0.6	0.3

ND indicates no detection

^Detect is counted as any value above half method detection limit.

*When a detected concentration is below one half of the method detection limit, then one half of the method detection level is used to calculate the average.

Appendix D: Additional Toxics Data

2013 Metals

(concentrations in micrograms per cubic meter (µg/m^3))

Name	Site	#Samples	#Detects^	Avg.*	1st Max	2nd Max
Antimony	Macon	29	28	0.00104	0.00381	0.00283
	Savannah	29	24	0.00045	0.00135	0.00097
	General Coffee	27	18	0.00029	0.00080	0.00074
	Dawsonville	28	27	0.00067	0.00226	0.00221
	South DeKalb**	28	28	0.00152	0.00660	0.00510
	Yorkville	26	26	0.00072	0.00274	0.00163
Arsenic	Macon	29	19	0.00062	0.00176	0.00141
	Savannah	29	19	0.00073	0.00244	0.00158
	General Coffee	27	19	0.00084	0.00219	0.00213
	Dawsonville	28	20	0.00068	0.00153	0.00148
	South DeKalb**	27	20	0.00061	0.00154	0.00150
	Yorkville	26	13	0.00050	0.00169	0.00100
Beryllium	Macon	29	ND			
	Savannah	29	ND			
	General Coffee	27	1	0.00003	0.00006	
	Dawsonville	28	ND			
	South DeKalb**	50	2	0.00003	0.00006	0.00005
	Yorkville	26	ND			
Cadmium	Macon	29	12	0.00007	0.00019	0.00018
	Savannah	29	21	0.00030	0.00377	0.00047
	General Coffee	27	11	0.00010	0.00054	0.00042
	Dawsonville	28	11	0.00007	0.00022	0.00021
	South DeKalb**	28	10	0.00004	0.00016	0.00014
	Yorkville	26	4	0.00003	0.00033	0.00011
Chromium	Macon	29	29	0.00170	0.00297	0.00282
	Savannah	29	29	0.00200	0.00570	0.00280
	General Coffee	27	27	0.00143	0.00246	0.00223
	Dawsonville	28	27	0.00162	0.00227	0.00221
	South DeKalb**	28	27	0.00156	0.00314	0.00295
	Yorkville	26	25	0.00185	0.00821	0.00246
*Chromium+6****	South DeKalb	30	8	0.00001	0.00010	0.00006
Cobalt	Macon	29	17	0.00007	0.00015	0.00015
	Savannah	29	27	0.00010	0.00027	0.00022
	General Coffee	27	15	0.00006	0.00009	0.00009
	Dawsonville	28	17	0.00007	0.00013	0.00012
	South DeKalb**	28	12	0.00006	0.00018	0.00010
	Yorkville	26	7	0.00006	0.00031	0.00007

2013 Metals (continued)

(concentrations in µg/m^3)

Name	Site	#Samples	#Detects^	Avg.*	1st Max	2nd Max
Lead	Macon	29	29	0.00216	0.00671	0.00568
	Savannah	29	29	0.00224	0.00844	0.00371
	General Coffee	27	27	0.00128	0.00236	0.00216
	Dawsonville	28	28	0.00163	0.00338	0.00325
	South DeKalb**	28	28	0.00151	0.00372	0.00252
	Yorkville	26	26	0.00166	0.00930	0.00395
Manganese	Macon	29	29	0.00624	0.01441	0.01434
	Savannah	29	29	0.00575	0.04325	0.01269
	General Coffee	27	27	0.00323	0.00528	0.00502
	Dawsonville	28	28	0.00457	0.02366	0.01091
	South DeKalb**	28	28	0.00297	0.01068	0.00582
	Yorkville	26	26	0.00335	0.02080	0.01086
Nickel	Macon	29	29	0.00108	0.00175	0.00149
	Savannah	29	29	0.00208	0.00881	0.00311
	General Coffee	27	27	0.00170	0.00320	0.00278
	Dawsonville	28	28	0.00103	0.00221	0.00215
	South DeKalb**	28	28	0.00103	0.00214	0.00195
	Yorkville	26	26	0.00180	0.02244	0.00144
Selenium	Macon	29	22	0.00036	0.00133	0.00071
	Savannah	29	22	0.00038	0.00130	0.00090
	General Coffee	27	18	0.00031	0.00133	0.00060
	Dawsonville	28	24	0.00036	0.00121	0.00077
	South DeKalb**	28	25	0.00032	0.00100	0.00055
	Yorkville	26	10	0.00019	0.00115	0.00083
Zinc	Macon	29	29	0.02220	0.07711	0.06123
	Savannah	29	29	0.02058	0.05222	0.03299
	General Coffee	27	27	0.01859	0.02804	0.02784
	Dawsonville	28	28	0.01343	0.03149	0.02105
	South DeKalb**	28	28	0.01428	0.03908	0.02513
	Yorkville	26	26	0.01361	0.08758	0.01616

*When a detected concentration is below one half of the method detection limit, then one half of the method detection level is used to calculate the average.

** Selected PM_{10} Hi-Vol, sample collected every 6 days

*** Hexavalent Chromium, sample collected every 6 days, 2013 data only collected until 7/15/2013

ND indicates no detection

^Detect is counted as any value above half method detection limit.

2013 Semi-Volatile Compounds

(concentrations in µg/m^3)

Name	Site	#Samples	#Detects^	Avg.**	1st Max	2nd Max
Acenaphthene	Macon	29	15	0.00167	0.01125	0.00699
	Savannah	26	21	0.00168	0.00576	0.00451
	General Coffee	27	13	0.00083	0.00354	0.00338
	Dawsonville	30	5	0.00022	0.00077	0.00074
	South DeKalb*	51	22	0.00084	0.00448	0.00433
	Yorkville	27	9	0.00039	0.00173	0.00148
Acenaphthylene	Macon	29	3	0.00037	0.00273	0.00214
	Savannah	26	1	0.00016	0.00051	
	General Coffee	27	ND			
	Dawsonville	30	ND			
	South DeKalb*	51	1	0.00025	0.00529	
	Yorkville	27	1	0.00016	0.00037	
Anthracene	Macon	29	ND			
	Savannah	26	ND	.		
	General Coffee	27	ND			
	Dawsonville	30	ND			
	South DeKalb*	51	2	0.00022	0.00379	0.00023
	Yorkville	27	ND			
Benzo(a)anthracene	Macon	29	ND			
	Savannah	26	ND			
	General Coffee	27	ND			
	Dawsonville	30	ND			
	South DeKalb*	51	ND			
	Yorkville	27	ND			
Benzo(b)fluoranthene	Macon	29	ND			
	Savannah	26	ND			
	General Coffee	27	ND			
	Dawsonville	30	1	0.00016	0.00046	
	South DeKalb*	51	ND			
	Yorkville	27	ND			
Benzo(k)fluoranthene	Macon	29	ND	.		
	Savannah	26	ND			
	General Coffee	27	ND			
	Dawsonville	30	1	0.00016	0.00034	
	South DeKalb*	51	ND			
	Yorkville	27	ND			
Benzo(a)pyrene	Macon	29	ND			
	Savannah	26	ND			
	General Coffee	27	ND			
	Dawsonville	30	ND			
	South DeKalb*	51	ND			
	Yorkville	27	ND			

2013 Semi-Volatile Compounds (continued)

(concentrations in µg/m^3)

Name	Site	#Samples	#Detects^	Avg.**	1st Max	2nd Max
Benzo(e)pyrene	Macon	29	ND			
	Savannah	26	ND			
	General Coffee	27	ND			
	Dawsonville	30	ND			
	South DeKalb*	51	ND			
	Yorkville	27	ND			
Benzo(g,h,i)perylene	Macon	29	ND			
	Savannah	26	ND			
	General Coffee	27	ND			
	Dawsonville	30	ND			
	South DeKalb*	51	ND			
	Yorkville	27	ND			
Chrysene	Macon	29	ND			
	Savannah	26	ND			
	General Coffee	27	ND			
	Dawsonville	30	ND			
	South DeKalb*	51	ND			.
	Yorkville	27	1	0.00015	0.00023	
Dibenzo(a,h)anthracene	Macon	29	ND			
	Savannah	27	ND			
	General Coffee	28	ND			
	Dawsonville	30	ND			
	South DeKalb*	51	ND			
	Yorkville	28	ND			
Fluoranthene	Macon	29	25	0.00094	0.00290	0.00271
	Savannah	26	19	0.00067	0.00271	0.00139
	General Coffee	27	1	0.00016	0.00036	
	Dawsonville	30	7	0.00021	0.00055	0.00043
	South DeKalb*	51	23	0.00042	0.00131	0.00112
	Yorkville	27	15	0.00033	0.00079	0.00074
Fluorene	Macon	29	13	0.00125	0.00760	0.00516
	Savannah	26	15	0.00132	0.00440	0.00417
	General Coffee	27	10	0.00066	0.00415	0.00188
	Dawsonville	30	13	0.00057	0.00218	0.00183
	South DeKalb*	51	25	0.00141	0.00571	0.00474
	Yorkville	27	14	0.00085	0.00262	0.00239
Indeno(1,2,3-cd)pyrene	Macon	29	ND			
	Savannah	26	ND			
	General Coffee	27	ND			
	Dawsonville	30	ND			
	South DeKalb*	51	ND			
	Yorkville	27	ND			
Naphthalene	Macon	29	27	0.01535	0.04562	0.03760
	Savannah	26	26	0.01288	0.09136	0.03779
	General Coffee	27	26	0.00723	0.01836	0.01801
	Dawsonville	30	30	0.01101	0.02845	0.02315

2013 Semi-Volatile Compounds (continued)

(concentrations in µg/m³)

Name	Site	#Samples	#Detects^	Avg.**	1st Max	2nd Max
Naphthalene (continued)	South DeKalb*	51	50	0.05080	0.17621	0.13778
	Yorkville	27	27	0.01506	0.04819	0.03811
Phenanthrene	Macon	29	29	0.00460	0.01673	0.01184
	Savannah	26	26	0.00327	0.00745	0.00680
	General Coffee	27	24	0.00169	0.00629	0.00319
	Dawsonville	30	23	0.00119	0.00367	0.00245
	South DeKalb*	51	49	0.00334	0.00762	0.00667
	Yorkville	27	26	0.00178	0.00340	0.00306
Pyrene	Macon	29	3	0.00018	0.00062	0.00040
	Savannah	26	4	0.00019	0.00088	0.00027
	General Coffee	27	ND			
	Dawsonville	30	3	0.00016	0.00034	0.00032
	South DeKalb*	51	10	0.00021	0.00069	0.00061
	Yorkville	27	4	0.00017	0.00035	0.00032
Perylene	South DeKalb*	48	ND			

ND indicates no detection
^Detect is counted as any value above half method detection limit.
*Sample collected every 6 days and analyzed at ERG laboratory with gas chromatography.
**When a detected concentration is below one half of the method detection limit, then one half of the method detection level is used to calculate the average.

2013 Volatile Organic Compounds

(concentrations in $\mu g/m^3$)

Name	Site	#Samples	#Detects^	Avg.**	1st Max	2nd Max
Freon 113	Macon	26	ND			
	Savannah	28	1	0.9594	0.9964	
	General Coffee	26	ND			
	Dawsonville	30	1	0.9619	1.0730	
	South DeKalb*	59	1	0.9587	0.9964	
	Yorkville	25	ND			
Freon 114	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
1,3-Butadiene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Cyclohexane	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	1	0.4850	2.0663	
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Chloromethane	Macon	26	26	1.2798	1.7763	1.6110
	Savannah	28	28	1.4340	1.7969	1.7350
	General Coffee	26	26	1.3919	2.2720	1.7556
	Dawsonville	30	30	1.3060	1.6317	1.6317
	South DeKalb*	59	59	1.2687	2.0035	1.6524
	Yorkville	25	25	1.2112	1.4665	1.4665
Dichloromethane	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Chloroform	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Carbon tetrachloride	Macon	26	ND			
	Savannah	25	ND			
	General Coffee	28	ND			
	Dawsonville	30	1	0.7873	0.8178	

2013 Volatile Organic Compounds (continued)

(concentrations in $\mu g/m^3$)

Name	Site	#Samples	#Detects^	Avg.**	1st Max	2nd Max
Carbon tetrachloride (continued)	South DeKalb*	59	2	0.7895	0.9436	0.8176
	Yorkville	25	ND			
Trichlorofluoromethane	Macon	26	26	1.3357	1.6859	1.5735
	Savannah	28	28	1.3728	1.6859	1.6297
	General Coffee	26	26	1.3574	1.6859	1.5735
	Dawsonville	30	30	1.3618	1.7421	1.6859
	South DeKalb*	59	59	1.4211	1.9107	1.9107
	Yorkville	25	25	1.3083	1.5735	1.5173
Chloroethane	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
1,1-Dichloroethane	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Methyl chloroform	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Ethylene dichloride	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Tetrachloroethylene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
1,1,2,2-Tetrachloroethane	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			

2013 Volatile Organic Compounds (continued)

(concentrations in µg/m^3)

Name	Site	#Samples	#Detects^	Avg.**	1st Max	2nd Max
Bromomethane	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
1,1,2-Trichloroethane	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Dichlorodifluoromethane	Macon	26	26	2.4191	3.2141	2.8680
	Savannah	28	28	2.4689	3.0163	2.8680
	General Coffee	26	26	2.5275	3.4119	3.1647
	Dawsonville	30	30	2.4411	3.4119	3.3625
	South DeKalb*	59	59	2.5001	3.6097	3.5108
	Yorkville	25	25	2.3399	2.9669	2.7691
Trichloroethylene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
1,1-Dichloroethylene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
1,2-Dichloropropane	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
trans-1,3-Dichloropropylene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
cis-1,3-Dichloropropylene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			

2013 Volatile Organic Compounds (continued)

(concentrations in µg/m^3)

Name	Site	#Samples	#Detects^	Avg.**	1st Max	2nd Max
cis-1,3-Dichloropropylene (continued)	South DeKalb*	59	ND			
	Yorkville	25	ND			
cis-1,2-Dichloroethene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Ethylene dibromide	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Hexachlorobutadiene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Vinyl chloride	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
m/p Xylene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	2	0.5466	0.6950	0.6081
	Yorkville	25	ND			
Benzene	Macon	26	18	3.4658	30.9845	10.5411
	Savannah	28	13	0.4608	1.1499	0.7347
	General Coffee	26	8	0.4236	0.6069	0.5750
	Dawsonville	30	30	0.8039	1.9485	1.3097
	South DeKalb*	59	37	0.5582	1.1499	1.0861
	Yorkville	25	7	0.4257	0.5750	0.5430
Toluene	Macon	26	3	0.4977	1.0924	0.5274
	Savannah	28	7	0.5334	1.0547	0.9794
	General Coffee	26	ND			
	Dawsonville	30	1	0.4740	0.5650	
	South DeKalb*	59	33	0.7796	2.8252	2.1848
	Yorkville	25	ND			
Ethylbenzene	Macon	26	ND			
	Savannah	28	ND			

2013 Volatile Organic Compounds (continued)

(concentrations in µg/m^3)

Name	Site	#Samples	#Detects^	Avg.**	1st Max	2nd Max
Ethylbenzene (continuted)	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
o- Xylene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
1,3,5-Trimethylbenzene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
1,2,4-Trimethylbenzene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Styrene	Macon	26	1	0.5368	0.6393	
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Benzene,1-ethenyl-4-methyl	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	24	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Chlorobenzene	Macon	26	10	0.7386	2.1184	1.1513
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
1,2-Dichlorobenzene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			

2013 Volatile Organic Compounds (continued)

(concentrations in µg/m^3)

Name	Site	#Samples	#Detects^	Avg.**	1st Max	2nd Max
1,3-Dichlorobenzene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
1,4-Dichlorobenzene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
Benzyl chloride	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			
1,2,4-Trichlorobenzene	Macon	26	ND			
	Savannah	28	ND			
	General Coffee	26	ND			
	Dawsonville	30	ND			
	South DeKalb*	59	ND			
	Yorkville	25	ND			

ND indicates no detection
^Detect is counted as any value above half method detection limit.
*Sample collected every 6 days
**When a detected concentration is below one half of the method detection limit, then one half of the method detection level is used to calculate the average.

2013 Black Carbon (NATTS)

(concentrations in micrograms per cubic meter)

Site ID	City	County	Site Name	Hours Measured	Annual Mean	1st Max	2nd Max
130890002	Decatur	DeKalb	South DeKalb	8667	1.097	9.05	8.52

2013 Carbonyl Compounds, 3-hour (June-August)

(concentrations in micrograms per cubic meter)

Name	Site	Time	#Samples	#Detects^	Avg.*	1st Max	2nd Max
Formaldehyde	S. DeKalb	0600	30	30	2.5194	5.2436	3.5144
		0900	30	30	4.7146	8.6399	7.6837
		1200	30	30	5.6387	11.0122	8.5651
		1500	30	29	5.0907	13.4337	7.4610
Acetaldehyde	S. DeKalb	0600	30	ND			
		0900	30	21	1.6351	3.4114	2.9956
		1200	30	25	2.2973	4.4772	4.4105
		1500	30	23	1.9021	5.0223	4.9249
Propionaldehyde	S. DeKalb	0600	30	ND			
		0900	30	ND			
		1200	30	ND			
		1500	30	ND			
Butyraldehyde	S. DeKalb	0600	30	ND			
		0900	30	ND			
		1200	30	ND			
		1500	30	ND			
Acetone	S. DeKalb	0600	30	30	4.0837	6.5374	5.9346
		0900	30	30	5.6952	10.5351	9.4098
		1200	30	30	6.6308	13.0701	12.4861
		1500	30	29	6.0032	14.3255	10.6347
Benzaldehyde	S. DeKalb	0600	30	ND			
		0900	30	ND			
		1200	30	ND			
		1500	30	ND			

ND indicates no detection

^Detect is counted as any value above half method detection limit.

* When a detected concentration is below one half of the method detection limit, then one half of the method detection level is used to calculate the average.

2013 Carbonyl Compounds, 24-hour

(concentrations in micrograms per cubic meter)

Name	Site	#Samples	#Detects^	Avg.**	1st Max	2nd Max
Formaldehyde	Savannah	29	26	2.0259	4.9806	3.5944
	Dawsonville	30	23	1.6179	4.0389	3.9944
	S. DeKalb*	56	53	7.3469	41.8824	35.6471
Acetaldehyde	Savannah	29	5	0.7274	1.7833	1.6889
	Dawsonville	30	4	0.6608	1.3500	1.3167
	S. DeKalb*	56	37	1.8551	6.5882	5.9412
Propionaldehyde	Savannah	29	ND			
	Dawsonville	30	ND			
	S. DeKalb*	56	ND			
Butyraldehyde	Savannah	29	ND			
	Dawsonville	30	ND			
	S. DeKalb*	56	ND			
Acetone	Savannah	29	17	2.4848	7.3889	7.1468
	Dawsonville	30	23	2.6832	9.8691	5.5616
	S. DeKalb*	56	42	4.1995	11.9590	9.7436
Benzaldehyde	Savannah	29	ND			
	Dawsonville	30	ND			
	S. DeKalb*	56	ND			
Acrolein (with canister method)	Macon	26	22	0.5842	1.0096	0.9637
	Savannah	28	20	0.8317	5.0479	2.7538
	General Coffee	26	13	0.4611	0.8490	0.7801
	Dawsonville	30	30	0.8008	1.4226	1.2620
	South DeKalb*	59	45	0.6281	2.9828	2.7534
	Yorkville	25	17	0.5387	1.1931	1.1243

ND indicates no detection
^Detect is counted as any value above half method detection limit.
* When a detected concentration is below one half of the method detection limit, then one half of the method detection level is used to calculate the average.

Appendix E: Monitoring Network Survey

(40 CFR 58, Appendix D)

Georgia Gaseous Criteria Pollutant Monitoring as of January 2013

Parameter Measured	**Ozone**	**Nitrogen Dioxide**	**Carbon Monoxide**	**Sulfur Dioxide**
Sampling Schedule	Continuous hourly average			
Number of GASN Sites	20	3	3	7
Method Used	Ultraviolet photometry	Ultraviolet photometry	Non-dispersive Infrared photometry	Ultraviolet fluorescence detector
EPA Reference Method	Ultraviolet photometry	Ultraviolet photometry	Non-dispersive Infrared photometry	Spectrophotometry (pararosaniline method)
Data Availability	U.S. EPA Air Quality System (AQS) (http://www.epa.gov/ttn/airs/airsaqs/) and GA DNR/EPD Ambient Air Monitoring Program (http://www.air.dnr.state.ga.us/amp)			

Georgia Ambient Air Particulate Matter Monitoring as of January 2013

Parameter Measured	**PM_{10}**		**$PM_{2.5}$**		
	Mass (integrated)	Mass (semi-continuous)	Mass (integrated)	Mass (semi-continuous)	Speciated
Sampling Schedule	Every 6 days	Continuous hourly averages	Varies; daily, every day, every third day, or every sixth day	Continuous hourly averages	1 in 6 days; 1 in 3 days for South DeKalb
Collection Method	Mass sequential, single channel	BAM	FRM sampler	TEOM; BAM	Speciation air sampling system (SASS)
Sampling Media	Teflon filter – 46.2mm,	Proprietary filter; filter tape	Teflon filter – 46.2mm	Proprietary filter; filter tape	Teflon, nylon & quartz filter – 46.2mm
Number of Sites Analyzed	2	1	23	17	8
Number of Collocated Sites	1	0	3	0	0
Analysis Method	Method 016 Electronic analytical balance	Method 122 Beta Attenuation Monitor	Method 055 Electronic analytical balance	Method 703 R&P TEOM with SCC at 30 degrees C; Beta Attenuation Monitor	Method 055 Electronic analytical balance Method 014 x-ray fluorescence Method 062 filter preparation Method 064 Ion chromatography Method 065 Thermal/optical carbon
Data Availability	U.S. EPA Air Quality System (AQS) (http://www.epa.gov/ttn/airs/airsaqs/) and GA DNR/EPD Ambient Air Monitoring Program (http://www.air.dnr.state.ga.us/amp)				

Georgia Organic Air Toxic Contaminant Monitoring as of January 2013

Parameter Measured	Volatile Organic Compounds (VOCs)	Carbonyls	Semi - VOCs	Metals
Method	TO-15	TO-11A	TO – 13A	10-2.I
Sampling Schedule	Every 12 days, 24-hour; 1 in 6 day schedule for South DeKalb	Every 12 days, 24-hour; 1 in 6 day schedule for South DeKalb	Every 12 days, 24-hour; 1 in 6 day schedule for South DeKalb	Every 12 days, 24-hour; 1 in 6 day schedule for South DeKalb*
Collection Equipment	AVOCS or ATEC2200	ATEC100 and or ATEC2200	PUF sampler	High volume TSP
Sampling Media	Polished stainless steel canister	DNPH-coated silica cartridges and Polished stainless steel canister	Polyurethane Foam filter	Quartz micro-fiber filter 8 x 10 inch
Number of Sites Analyzed	6[**]	3	6[**]	6[**]
Number of Collocated Sites	1	1	1	1
Data Availability	U.S. EPA Air Quality System (AQS) (http://www.epa.gov/ttn/airs/airsaqs/) and GA DNR/EPD Ambient Air Monitoring Program (http://www.air.dnr.state.ga.us/amp)			

* Sampler at this site is a PM_{10} Hi-Vol

[**] 5 GA ATN sites, 1 NATTS (South DeKalb)

PAMS Monitoring as of January 2013

Parameter	56 PAMS-Speciated VOCs & Total NMHC	Continuous 56-PAMS Speciated VOCs & Total NMHC	Carbonyl Compounds
Sampling Schedule	24-hour 1 in 6 day schedule (all year)	Continuous hourly average (June-August)	3-hour sample (June-August); 24-hour, 1 in 6 day (all year)
Collection Equipment	ATEC 2200	Perkin-Elmer HC GC	ATEC 8000
Sampling Media	Polished stainless steel canister	Direct injection	DNPH – coated silica gel Cartridge
Number of Sites	3	3	1
Analysis Method	PAMS GC/FID	GC/FID	High performance liquid chromatograph/ultraviolet detector
Data Availability	U.S. EPA Air Quality System (AQS) (http://www.epa.gov/ttn/airs/airsaqs/) and GA DNR/EPD Ambient Air Monitoring Program (http://www.air.dnr.state.ga.us/amp)		

Georgia Meteorological Monitoring as of January 2013

Parameter Measured	Wind Speed (m/s)	Wind Direction (degrees)	Ambient Temperature (ºC)	Relative Humidity (%)	Atmosphere Pressure (mb)	Solar Radiation (w/m^2)	Precip (in)	Sig. Theta (deg)	Total Ultraviolet Radiation
Sampling Schedule	Continuous hourly average								
Number of Sites	16	16	8	8	6	3	6	1	3
Method Used	Propeller or cup anemometer	Wind vane potentiometer	Aspirated Thermocouple or thermistor	Thin film capacitor	Pressure transducer	Thermopile or pyranometer	Tipping bucket	Wind direction	UV radiometer
Data Availability	U.S. EPA Air Quality System (AQS) (http://www.epa.gov/ttn/airs/airsaqs/) and GA DNR/EPD Ambient Air Monitoring Program (http://www.air.dnr.state.ga.us/amp)								

Appendix F: Siting Criteria

(40 CFR 58, Appendix E)

Instrument	Height Above Ground		Space Between Samplers	Height Above Obstructions	Distance From Obstacles	Distance From Tree Dripline	Distance from Walls, Parapets, etc.	Airflow Arc
	Micro	Other						
PM$_{10}$, AISI Nephelometer	2-7m	2-15m	2m		2 times height or obstacle above inlet	Should be 20m, must be 10m if considered an obstruction	2m	270
Dichot, TEOM, PM$_{2.5}$	2-7m	2-15m	1m		2 times height or obstacles above inlet	Should be 20m, must be 10m if considered an obstruction	2m	270
Lead, TSP	207m	2-15m	2m		2 times height of obstacles above inlet	Micro and middle: no trees between sampler and source Neighborhood: should be 20m, must be 10m if considered an obstruction	2m	270
O$_3$	3-15m	3-15m		1m	2 times height of obstacles above inlet	Should be 20m, must be 10m if considered an obstruction	1m	270, or on side of building 180
CO	2.5–3.5m	3-5m	1m	2 times height of obstacle above inlet	Micro: must be no trees between sampler and road Others: must be 10m if trees, 5m above sampler	Micro: must be no trees between sampler and road Others: must be 10m if trees, 5m above sampler	1m	270, or on side of building 180
NO$_2$	3-15m	3-15m		1m	2 times height of obstacle above inlet	Should be 20m, if individual tree 5m above probe, must be 10m from dripline	1m	270, or on side of building 180

Instrument	**Height Above Ground**		**Space Between Samplers**	**Height Above Obstructions**	**Distance From Obstacles**	**Distance From Tree Dripline**	**Distance from Walls, Parapets, etc.**	**Airflow Arc**
	Micro	**Other**						
SO_2	3-15m	3-15m		1m	2 times height of obstacle above inlet	Should be 20m, must be 10m if considered an obstruction	1m	270, or on side of building 180
H_2S	3-15m	3-15m		1m	2 times height of obstacle above inlet	Should be 20m, must be 10m if considered an obstruction	1m	270, or on side of building 180
CH_4, THC, NMHC, PAMS	3-15m	3-15m		1m	2 times height of obstacle above inlet	Should be 20m, must be 10m in direction of urban core	1m	270, or on side of building 180
Toxics: Gaseous 910, 910A, 929, 920	3-15m	3-15m		2m	2 times height of obstacle above inlet			
Temperature and Relative Humidity	1.25-2m	2.25-2m			4 times height of obstacle above sensor	1 tower width from tower side	4.5m	
Wind Speed and Direction	10m	10m			1.5 times height of obstacle above sensor	2 tower widths from tower side, 1 tower width from tower top		
Solar Radiation	1.5m	1.5m						

Appendix G: Instrument and Sensor Control Limits

(from manuals)

ARB'S CONTROL AND WARNING LIMITS		
LIMITS		INSTRUMENT
Control	Warning	
±15%	±10%	All gaseous criteria and non-criteria analyzers
±15%	±10%	Total suspended particulate (TSP) samplers
±10%	±7%	PM$_{10}$ Dichotomous (Dichot), Lead (Pb), Tapered Element Oscillating Microbalalance (TEOM), Toxic Air Contaminant (XonTech920) Samplers, Beta Attenuation Monitors (BAM), and Carbonyl (XonTech9250) Samplers
±4% (Flow)	None	PM$_{2.5}$
±5% (Design)	None	
±20%	None	Laboratory audits (Toxics, PAMS, Motor Vehicle Exhaust and Total Metals)

ACCEPTANCE CRITERIA FOR METEOROLOGICAL (MET) SENSORS	
LIMITS	SENSOR
±1.0° Celsius (±0.5°C PAMS only)	Ambient Temperature
±1mb~ _ 0.75mm Mercury (Hg)	Barometric Pressure
±5% RH for <10% or >90% RH	Relative Humidity
±5% Watts/m^2	Solar Radiation and Total UV Radiation
Less than or equal to 5° combined accuracy and orientation error	Wind Direction
Between 0.5 and 5m/s and less 0.2m/s ±5% difference above 5 m/s	Horizontal Wind Speed
Less than or equal to 0.5m/s	Horizontal Wind Speed Starting Threshold
±0.25 m/s between 0.5 and 5 m/s and less than 5% difference above 5 m/s	Vertical Wind Speed
Less than or equal to 0.5 m/s	Vertical wind Speed Starting Threshold

References

http://www.airnow.gov/index.cfm?action=static.aqi. "Air Quality Index (AQI) - A Guide to Air Quality and Your Health."

http://www.airnowtech.org/2011pollingsummary.htm AIRNOW Data Management Center. 2011 Data Polling Summary. Sonoma Technology, Petaluma, California.

http://www.epa.gov/region4/waste/ots/ U.S. EPA Region 4: Superfund. Technical Services-Risk Assessment and Hydrology.

http://www.epa.gov/air/emissions/ U.S. EPA. Air Emission Sources.

http://www.epa.gov/cleanschoolbus/retrofit.htm U.S. EPA. Clean School Bus U.S.A.

http://www.georgiaair.org/retrofit/index.htm Georgia Retrofit Program. Georgia Environmental Protection Division.

http://www.gfc.state.ga.us/GFCNews/CFI.cfm Georgia Forestry Commission.

ATSDR, 1992. Toxicological Profile for 1,3-Butadiene. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 1996. ToxFAQS for Polycyclic Aromatic Hydrocarbons (PAHs). U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 1997a. Toxicological Profile for Benzene. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 1997b. ToxFAQs for Tetrachloroethylene (PERC). U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 1999. Toxicological Profile for Formaldehyde. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2000a. Toxicological Profile for Manganese. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2000b. Toxicological Profile for Chromium. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2001a. Toxicological Profile for 1,2-Dichloroethane. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2001b. ToxFAQS for Methylene Chloride. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2003. ToxFAQS for Trichloroetheylene (TCE). U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2005a. Toxicological Profile for Carbon Tetrachloride. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2005b. Toxicological Profile for Arsenic, Draft For Public Comment. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2005d. ToxFAQS for Nickel. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2005e. Toxicological Profile for Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2006a. ToxFAQS for 1,1,1-Trichloroethane. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2006b. Toxicological Profile for Dichlorobenzenes. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2006c. ToxFAQS for Vinyl Chloride. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2007a. Case Studies in Environmental Medicine (CSEM) Nitrite/Nitrate Toxicity. What Are Nitrate and Nitrite? U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2007b. ToxFAQs for Xylene. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2009. ToxFAQS for 1,3-Butadiene. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

ATSDR, 2010. ToxFAQS for Ethylbenzene. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registery, Atlanta, Georgia.

ATSDR, 2011. ToxFAQs for Acrolein. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

Code of Federal Regulations, Title 40, Protection of the Environment, Parts 50, 51, 53, and 58.

Georgia Department of Natural Resources. Georgia Ambient Monitoring Network Plan.

Georgia Department of Natural Resources. Georgia Ambient Air Monitoring Quality Assurance Manual, Quality Assurance Plan.

GADNR, 1993. Toxic Release Inventory Report, 1991. Georgia Department of Natural Resources, Environmental Protection Division. Atlanta, Georgia.

GADNR, 1996a. The 1994 Chatham County Air Toxics Study, Georgia Department of Natural Resources, Environmental Protection Division. Atlanta, Georgia.

GADNR, 1996b. 1996 Glynn county Initiative: Air Toxics Dataset Ground Level Measurements, Georgia Department of Natural Resources, Environmental Protection Division. Atlanta, Georgia.

GADNR, 2006. 2005 Ambient Air Surveillance Report. Georgia Department of Natural Resources, Environmental Protection Division. Atlanta, Georgia.

McCarthy, M. C., Hafner, H. R., & Montzka, S. A. (2006). Background Concentrations of 18 Air Toxics for North America. Journal of the Air & Waste Management Association, 56, 3-11.

U.S. EPA, 1987. Health Assessment Document for Acetaldehyde. U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA, 1991a. Integrated Risk Information System, Carbon Tetrachloride. U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA, 1991b. Integrated Risk Information System, Acetaldehyde. U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA, 1994a. OPPT Chemical Fact Sheet, Chemicals in the environment: 1,2,4-trimethylbenzene (CAS No. 95-63-6). U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA, 1994b. Quality Assurance Handbook for Air Pollution Measurement System. Volume 1: Principles. EPA-600/R-94/038A, January 1994.

U.S. EPA, 1998. Quality Assurance Handbook for Air Pollution Measurement System. Volume 1: Principles. EPA-600/R-94/038B, April 1998.

U.S. EPA, 2000. Integrated Risk Information System, Benzene. U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA, 2002. Integrated Risk Information System, 1,3-Butadiene. U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA, 2003. Integrated Risk Information System, Acrolein. U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA, 2004a. Air Quality Criteria for Particulate Matter. U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA, 2004b. Provisional Peer Reviewed Toxicity Value Database. U.S. Environmental Protection Agency, Region IV, Atlanta, Georgia.

U.S. EPA, 2006. A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Data Sets. U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA, 2007. Latest Findings on National Air Quality: Status and Trends through 2006, No. EPA-454/R-07-007. Office of Air Quality Planning and Standards EPA Publication Air Quality Assessment Division Research Triangle Park, NC.

U.S. EPA, 2008. National Air Quality-Status and Trends through 2007, No. EPA-454/R-08-006. Office of Air Quality Planning and Standards EPA Publication Air Quality Assessment Division Research Triangle Park, NC.

U.S. EPA, 2008b. Toxicologial Review of Propionaldehyde (CAS No. 123-38-6), In Support of Summary Information on the Integrated Risk Information System (IRIS). U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA, 2009. Air Toxics Data Analysis Workbook, STI:908304.03-3224. U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Research Triangle Park, NC.

U.S. EPA, 2010. Our Nation's Air Quality-Status and Trends through 2008, No. EPA-454/R-09-002. Office of Air Quality Planning and Standards EPA Publication Air Quality Assessment Division Research Triangle Park, NC.

U.S. EPA, 2014. "Table 1. Prioritized Chronic Dose-Response Values for Screening Risk Assessments (5/09/2014)". http://www2.epa.gov/fera/dose-response-assessment-assessing-health-risks-associated-exposure-hazardous-air-pollutants Office of Air Quality Planning and Standards EPA Publication Air Quality Assessment Division Research Triangle Park, NC.