Bureau of Air Quality

South Carolina Department of Health and Environmental Control

State of South Carolina: 5-Year Ambient Air Monitoring Network Assessment

July 1, 2010

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South Carolina Department of Health and Environmental Control

List of Appendices

Introduction

On October 17, 2006, the EPA promulgated final ambient air monitoring regulations. As part of this final rule, the EPA required states to conduct periodic assessments of their ambient air monitoring networks.

> *"The State, or where applicable local, agency shall perform and submit to the EPA Regional Administrator an assessment of the air quality surveillance system every 5 years to determine, at a minimum, if the network meets the monitoring objectives defined in appendix D to this part, whether new sites are needed, whether existing sites are no longer needed and can be terminated, and whether new technologies are appropriate for incorporation into the ambient air monitoring network. The network assessment must consider the ability of existing and proposed sites to support air quality characterization for areas with relatively high populations of susceptible individuals (e.g., children with asthma), and, for any sites that are being proposed for discontinuance, the effect on data users other than the agency itself, such as nearby States and Tribes or health effects studies. For $PM_{2.5}$, the assessment also must identify needed changes to population-oriented sites. The State, or where applicable local, agency must submit a copy of this 5-year assessment, along with a revised annual network plan, to the Regional Administrator. The first assessment is due July 1, 2010."*

Additionally, EPA Region 4 required that states consider the following information when developing their network assessments:

1. Statewide and local level population statistics.
2. Statewide ambient air monitoring network pollutant concentration trends for the past 5 years.
3. Network suitability to measure the appropriate spatial scale of representativeness for selected pollutants.
4. Monitoring data spatial redundancy or gaps that need to be eliminated.
5. Programmatic trends or shifts in emphasis or funding that lead toward different data needs.

In February, 2007, the EPA provided guidance to the states detailing a series of analyses that could be used to conduct an ambient air monitoring network assessment[1]. According to this guidance document, a network assessment "includes (1) re-evaluation of the objectives and budget for air monitoring, (2) evaluation of a network's effectiveness and efficiency relative to its objectives and costs, (3) development of recommendations for network reconfigurations and improvements." As specified in this guidance, a network assessment consists of six steps detailed in the table below. This document will utilize these steps in the technical assessment of South Carolina's ambient air monitoring network.

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[1] Ambient Air Monitoring Network Assessment Guidance: Analytical Techniques for Technical Assessments of Ambient Air Monitoring Networks (http://www.epa.gov/ttn/amtic/files/ambient/pm25/datamang/network-assessment-guidance.pdf)

Steps to conduct an ambient air monitoring network assessment		
Step	**Description**	**Examples**
1	Prepare or update a regional description, discussing important features that should be considered for network design	Topography, climate, population, demographic trends, major emissions sources, and current air quality conditions
2	Prepare or update a network history that explains the development of the air monitoring network over time and the motivations for network alterations, such as shifting needs or resources.	Historical network specifications (e.g., number and locations of monitors by pollutant and by year in graphical or tabular format); history of individual monitoring sites.
3	Perform statistical analyses of available monitoring data. These analyses can be used to identify potential redundancies or to determine the adequacy of existing monitoring sites.	Site correlations, comparisons to the National Ambient Air Quality Standards (NAAQS), trend analysis, spatial analysis, and factor analysis.
4	Perform situational analyses, which may be objective or subjective. These analyses consider the network and individual sites in more detail, taking into account research, policy, and resource needs.	Risk of future NAAQS exceedances, demographic shifts, requirements of existing state implementation plans (SIP), or maintenance plans, density or sparseness of existing networks, scientific research or public health needs, and other circumstances (such as political factors)
5	Suggest changes to the monitoring network on the basis of statistical and situational analyses and specifically targeted to the prioritized objectives and budget of the air monitoring program.	Reduction of number of sites for a selected pollutant, enhanced leveraging with other networks, and addition of new measurements at sites to enhance usefulness of data
6	Acquire the input of state and local agencies or stakeholders and revise recommendations as appropriate.	

Document background

This document contains a technical description of the South Carolina Department of Health and Environmental Control (Department) ambient air monitoring network as of January 1, 2010, and analysis based on data for the years 2004 – 2008. At the time assessment was conducted, the 2009 data had not been certified. This assessment evaluates the networks for all criteria pollutants monitored by the Department. Non-criteria sampling was not required to be assessed as part of this review. Because the design of the technical tools provided by the EPA for assessing monitoring networks is applicable to higher density and spatially distributed networks, a more in-depth review of Ozone and Particulate Matter 2.5 ($PM_{2.5}$) Federal Reference Method (FRM) ambient monitoring has been conducted. The available statistical and spatial tools depend on large monitoring networks that are widely distributed over larger geographic areas. Therefore, only the monitoring networks with sufficient numbers of well distributed monitors, Ozone and $PM_{2.5}$ FRM, were assessed with the full array of tools. The remaining criteria pollutant networks do not have sufficient size and distribution for appropriate application of the tools provided by the EPA. The state networks for these monitors were evaluated based on the requirements specified by 40 CFR 58.10 (d) and associated guidance and were assessed on their perceived value to the Air Quality Program. Appendix B to this document provides the assessment rating and recommendations for optimizing the ambient air monitoring network.

Special project monitoring

In addition to conducting monitoring to meet minimum requirements (Appendix D to 40 CFR Part 58), the Department operates special project monitoring in various areas across the state to investigate and answer specific questions posed by the public. All special project monitoring is done in accordance with the Department's Quality Management Plan[2] (July 2008). Typically, these projects are defined by being short term monitoring focused on specific interests or concerns. This monitoring is typically driven by local issues and allows the Department to answer specific questions for the local area. For example, the Department recently conducted monitoring in an area where local citizens had concerns about the operation of asphalt plants near their neighborhood. In addition to evaluating the cumulative impacts of the operation of asphalt plants in the neighborhood, the project also gave insight into potential impacts of asphalt plants statewide.

South Carolina's commitment to additional ambient air monitoring is evident in its efforts with special project monitoring. Monitoring is often done in areas with sensitive subpopulations that may be identified as Environmental Justice (EJ) communities. Environmental justice has been defined as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

In the Charleston/North Charleston area, the Lowcountry Alliance for Model Communities (LAMC) is a nonprofit organization founded for the purpose of advocating environmental justice and promoting community development, education, employment, quality housing, and community involvement for neighborhoods in this area. The neighborhoods represented include the North Charleston neighborhoods of Accabee, Chicora/Cherokee, Union Heights, Howard Heights, Windsor Place, Five Mile and Liberty Hill. In 2009, this group was awarded EPA's Environmental Justice Achievement Award for their work in conjunction with the city of North Charleston and the South Carolina State Ports Authority to reduce $PM_{2.5}$ emissions. The Department conducted monitoring in this area in order to assess the spatial distribution of $PM_{2.5}$ ambient concentrations[3] and continues to partner with LAMC and other groups in

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[2] The Department's latest Quality Management Plan can be found at: http://www.scdhec.gov/environment/envserv/qa.htm
[3] More information on this special project can be found at: http://www.dhec.sc.gov/environment/baq/CharlestonNeckStudy.aspx

the area on these and other monitoring activities. In addition to the $PM_{2.5}$ monitoring, the Department successfully petitioned the EPA to select Chicora Elementary School to be included in their national study to monitor concentrations of toxic air pollutants near schools[4].

In Greenville, the Department partnered with community members, city and county officials, and local businesses/organizations to reach consensus on selection of a more representative location for a new ambient air monitoring site to represent the ambient air quality in the city of Greenville. Department staff held an "Air Fair" to inform and answer questions from local residents about the monitor and what it means for their community and worked with community leaders on environmental concerns in the area.

Minimum monitoring requirements

The EPA has established minimum ambient air monitoring requirements for each of the criteria pollutants (Ozone, $PM_{2.5}$, PM_{10}, Lead, SO_2, NO_2 and CO). The table below lists the minimum ambient air monitoring requirements for each Metropolitan Statistical Area (MSA) followed by the current number of sites where the indicated parameter is measured.

South Carolina currently meets or exceeds minimum ambient air monitoring requirements for all criteria pollutants. The EPA is currently proposing modifications to the Ozone monitoring network design which would require ambient air monitoring in several new MSAs across the country. Once the network design regulations are finalized, the Department will evaluate and seek out appropriate locations to site any new monitors required.

Minimum ambient air monitoring requirements by MSA for each criteria pollutant.

MSA	Ozone	$PM_{2.5}$	$PM_{2.5}$ Continuous	PM_{10}	Lead	SO_2	NO_2	CO
Columbia	2 (3)	2 (3)	1 (1)	1-2 (4)	1 (1)	1 (2)	1 (1)	
Greenville-Mauldin-Easley	2 (3)	2 (2)	1 (1)	1-2 (1)	1 (1)	0 (1)	1 (1)	0 (1)
Spartanburg	1 (1)	1 (1)	1 (1)	0-1 (0)				
Anderson	1 (1)							
Florence	1 (1)	0 (1)[5]						
Myrtle Beach-Conway-North Myrtle Beach				0-1 (3)				
Charleston-North Charleston	2 (2)	1 (2)	1 (1)	1-2 (1)	1 (1)	1 (2)	2 (2)	0 (1)
Sumter								
Charlotte-Gastonia-Concord (SC) ‡	3 (1)					2 (0)		
Augusta-Richmond County (SC) ‡	2 (2)	1 (1)				1 (0)		

Notes:
Numbers in parentheses indicate the number of current Department monitors for the given parameter.
Blank cells indicate parameters with no minimum ambient air monitoring requirements and no ambient air monitoring currently conducted.
‡ minimum ambient air monitoring requirements are met through cooperation with the State of Georgia and State of North Carolina. Only current ambient air monitoring/sampling contained within the South Carolina portion of the MSA is listed in this table.

[4]More information on the Chicora Elementary School toxic air pollutant study can be found at: http://www.dhec.sc.gov/environment/baq/NorthCharleston/schools.asp

[5] Recent declines in design values have eliminated minimum monitoring requirements for this MSA.

GIS Methodology for Conducting a Network Assessment

A series of parameters described in steps 2 and 3 of this document were scored to rank individual ambient air monitoring sites. As described earlier, this analysis will focus on the Ozone and $PM_{2.5}$ FRM networks. A limitation of the technique described in the next section is that it depends on large, spatially uniform monitoring networks. The Department has concerns about utilizing this methodology, but with the lack of other viable options, this was determined to be the best tool available.

Thiessen (Voronoi) polygons were created to divide the state into "areas of representation" and allocate each polygon to the nearest monitor. For this assessment, Thiessen polygons did not extend beyond the state boundary to capture ambient air monitoring sites in other states. Each polygon consists of the points closer to one particular site than any other site. The data for the emissions and population categories were aggregated by Thiessen polygons. Monitoring sites were scored based on these aggregated values. The Department chose this technique for scoring because it was the best available tool to objectively assign values to an individual ambient air monitoring site.

There are many limitations with using Thiessen polygons. These polygons are not a true indication of which site is most representative of the pollutant concentration in a given area. Meteorology (including pollutant transport), topography, and proximity to population or emission sources are not considered, so some areas assigned to a particular monitor may actually be better represented by a different monitor. Thiessen polygons tend to give more weight to rural sites and those sites on the edges of urban areas or other monitor clusters. The Department continues to search for additional techniques for assigning "areas of representation" and welcomes input from the EPA on improved methods for determining this metric to improve future assessments.

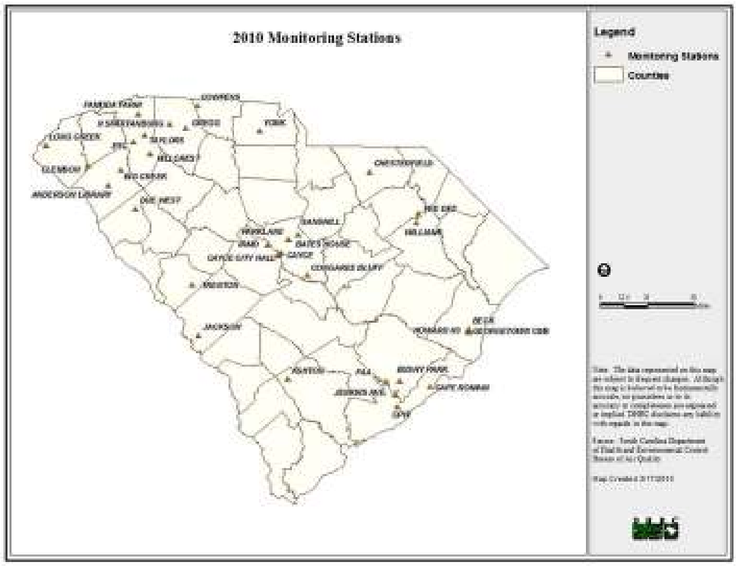
Scoring method

Each of the criteria listed in steps 2 and 3 produced a "ranked" score for each ambient air monitoring site. Appendix H lists the weights employed in this technique. The following steps were used in developing the "score."

1. The Thiessen polygon technique described above was used to divide the ambient air monitoring network into regions defined by polygons. Each polygon contains only one site and shows the land area centered on and nearest to the monitoring site.
2. The zonal statistics of each parameter are summarized for each Thiessen polygon and reported in a table.
3. The tabular data for the appropriate parameter are then related to each ambient air monitoring site.
4. Each ambient air monitoring site was scored proportionately utilizing the formula (Value-Min)/(Max-Min).
5. The above steps are repeated for each parameter.
6. Scores for each category were multiplied by their weights listed in Appendix H and weighted scores were summed for all the categories. Each site was ranked based on the total score using equal intervals between classifications and identified as "low," "medium" and "high" value. Final scores for Ozone and $PM_{2.5}$ monitors are represented in the "Results and Conclusions" section.

South Carolina’s current ambient air monitoring network

As of January 1, 2010, South Carolina’s ambient air monitoring network consisted of thirty-four sites measuring criteria pollutants. Ambient air monitoring sites are clustered in urbanized areas with several monitors located across the state in rural locations.



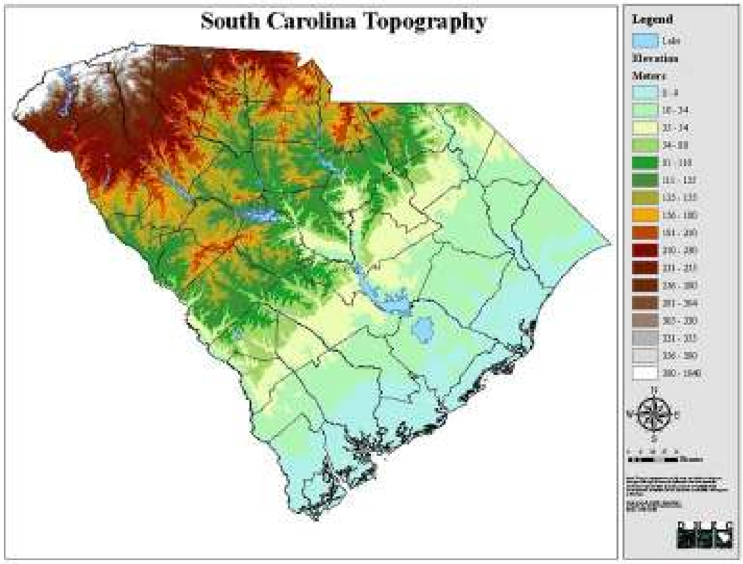
Technical analysis of South Carolina’s ambient air monitoring network

Step 1: General information

Topography

The topography of South Carolina is divided into two distinct areas, commonly known as the Piedmont and the Coastal Plain. The line of demarcation runs from the eastern boundary of Aiken County through central Chesterfield County to the North Carolina border. West of this line, elevations begin at about 300 feet and increasing to over 1,000 feet in the extreme northwestern counties, culminating in isolated peaks of 2,000 to over 3,500 feet above mean sea level. East of the line, there are evidences of outcroppings from the lower Appalachians in a ridge of low hills and rather broken country between the Congaree River and the north fork of the Edisto River, and also in a rather hilly and rolling region in the upper Lynches River drainage basin between the Catawba-Wateree and the Great Pee Dee Rivers. In about one-third of the coastal plain (or what is commonly known as the upper coastal plain), the elevations decrease rather abruptly from 300 to 100 feet and continue to decrease to the coast. The major part of the coastal area is not over 60 feet above mean sea level. In this region of lower levels, to the eastward and southward, the great swamp systems of the state predominate.

The slope of the land from the mountains seaward is toward the southeast, and all of South Carolina’s streams naturally follow that general direction to the Atlantic Ocean. The South Piedmont section of the state is on the eastern slope of the Appalachian Mountains with the main ridge of the mountains about 30 miles west. To some extent these mountains act as a barrier for weather systems and tend to protect the area from the full force of the cold air masses during the winter months. The relatively flat areas of the Central Plains and the coastal region allow free air movement and are conducive to effective dispersion of pollutants.



Climate

South Carolina has a humid, subtropical climate, although high elevation areas in the state's northwest Blue Ridge region have less subtropical characteristics than the middle Piedmont and the Atlantic Coastal Plain areas on the Atlantic coastline.

Summer is hot and humid with daytime temperatures averaging near 90° F (32° C) across most of the state with overnight lows near 70° F (21° C). Winter temperatures are not extrememly cold and vary from the mild coastal areas with high temperatures averaging near 60° F (16° C) and overnight lows near 38° F (3° C) to the Piedmont temperatures averaging between 55° F (13° C) during the day and 34° F (1° C) at night. On average, between 40-80 inches of precipitation falls annually across the state. Tropical cyclones contribute to the precipitation during the summer and fall months, while extratropical cyclones contribute to precipitation during the fall, winter, and spring months. Severe weather can be a concern across the state during the spring months.

Further information and analysis of meteorological patterns in areas of South Carolina where ambient air monitoring is conducted can be found in Appendix D.

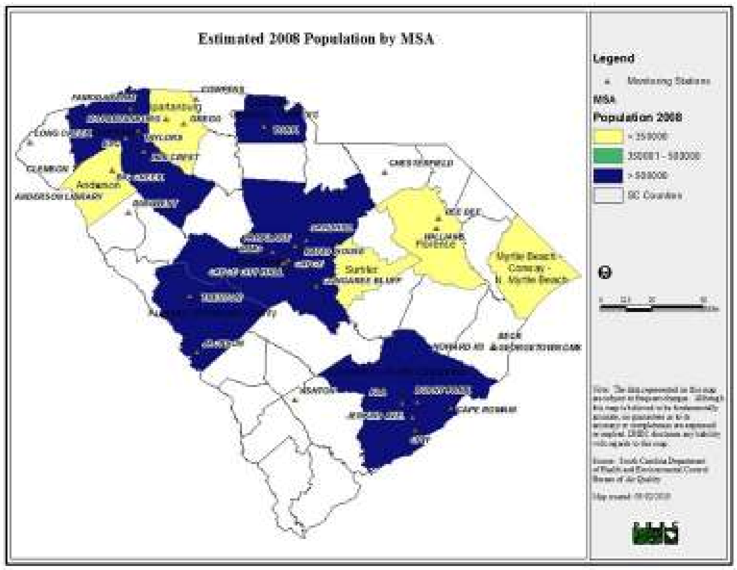
Monthly Normal High and Low Temperatures For Various South Carolina Cities												
City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Charleston	59/37	62/39	69/46	76/52	83/61	88/68	91/72	89/72	85/67	77/55	70/46	62/39
Columbia	55/34	60/36	67/44	76/51	83/60	89/68	92/72	90/71	85/65	76/52	67/43	58/36
Greenville	50/31	55/34	63/40	71/47	78/56	85/64	89/69	87/68	81/62	71/50	61/41	53/34

Population

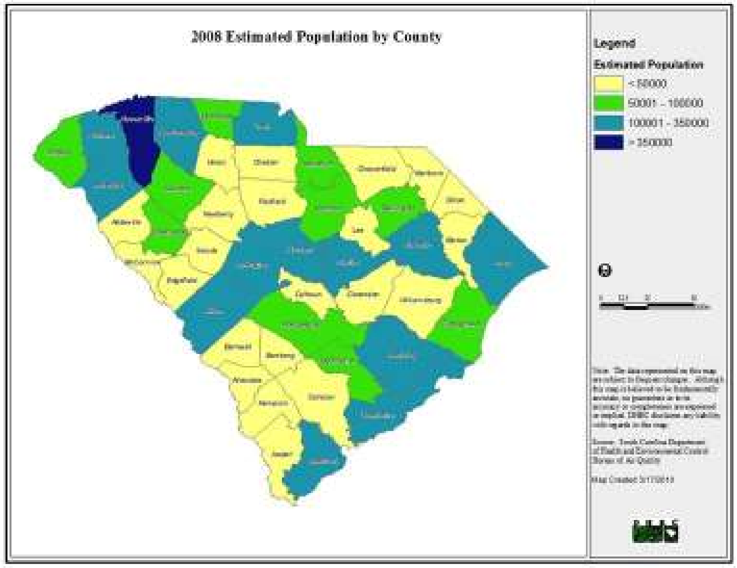
As of July 1, 2008, South Carolina ranks as the twenty-fourth most populated state and the sixth most populous EPA Region 4 state (out of eight states). There are ten MSAs in South Carolina with two of these being multi-state MSAs.

MSAs and micropolitan statistical areas (mSAs) are geographic entities defined by the U.S. Office of Management and Budget (OMB) for use by federal statistical agencies in collecting, tabulating, and publishing federal statistics. An MSA contains a core urban area of 50,000 or more population, and a mSA contains an urban core of at least 10,000 (but less than 50,000) population. Each MSA or mSA consists of one or more counties and includes the counties containing the core urban area, as well as any adjacent counties that have a high degree of social and economic integration (as measured by commuting to work) with the urban core.

The map below shows South Carolina's MSAs, the location of current ambient air monitoring sites and the population contained within them. South Carolina's largest MSAs contained wholly within the state are Charleston-North Charleston, Columbia and Greenville. York County is part of the larger Charlotte-Gastonia-Concord NC/SC MSA. Aiken and Edgefield counties are part of the Augusta-Richmond County GA/SC MSA.

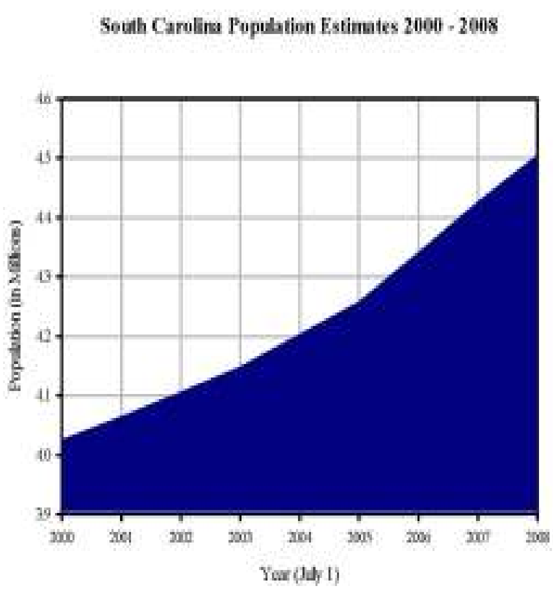


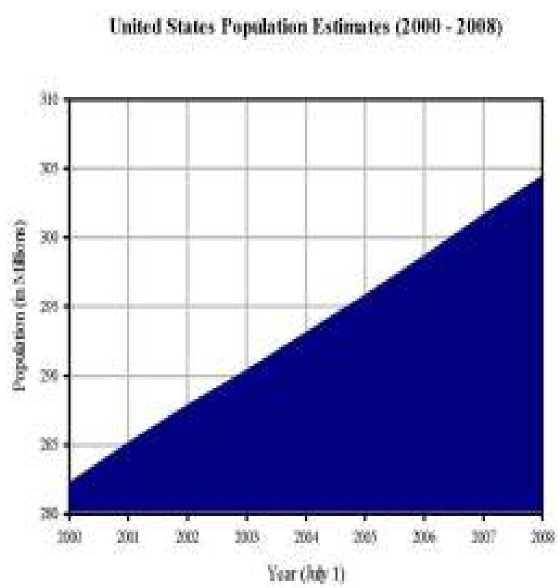
The most populated counties in South Carolina are Charleston, Richland, Greenville and Spartanburg. These counties form the core areas of each of their respective MSAs and are areas of the state where the most ambient air monitoring is conducted.



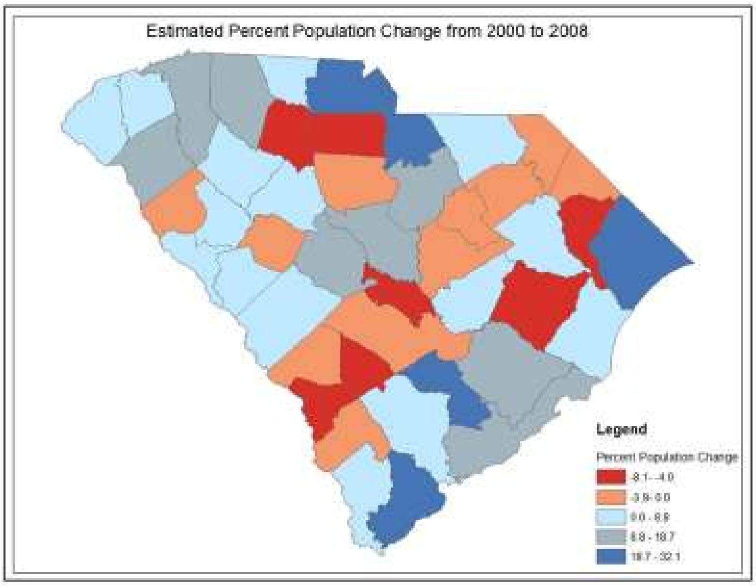
Demographics and trends

According to the U.S. Census Bureau, South Carolina had a 2008 estimated population of 4,503,280, which is an increase of 79,048 from the prior year and an increase of 491,268, or 10.9%, since the year 2000. This percent increase ranks as the tenth largest in the United States and fourth largest of the EPA Region 4 states.



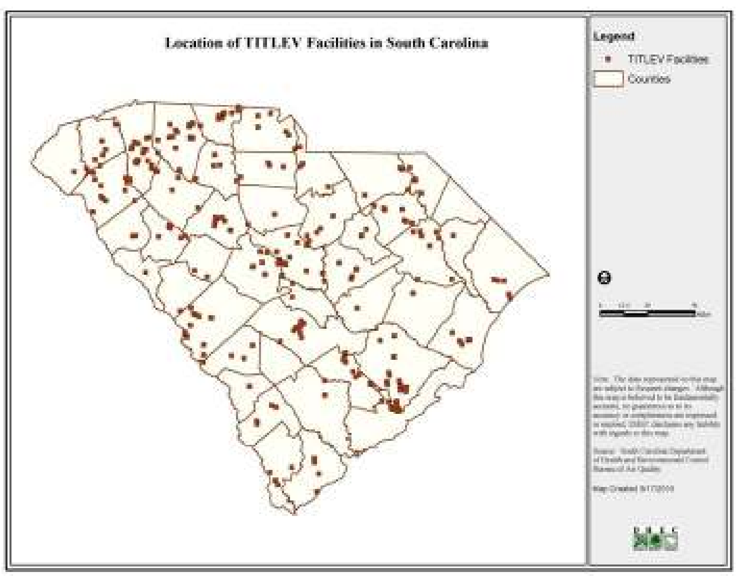


From 2000 to 2008, overall population growth occurred mainly along the coast of South Carolina and in the major urbanized areas of the state. Population decreases were mainly seen in more rural areas of the state.



Sources of emissions

Currently, there are 292 Title V sources in South Carolina emitting one or more of the criteria pollutants. These sources are scattered fairly uniformly across the state with some clustering near urbanized areas and along interstates.



South Carolina has three types of operating permits, issued dependent on potential emissions and limits: state minor, conditional major and Title V. Potential emissions are calculated on 8760 hours per year operation, maximum capacity, using worst case emitting material and no emission controls. A facility can add emission controls or other operating limits (such as hours of operation) if those limits are an enforceable limit in the permit.

The types of permits South Carolina issues to facilities include:

- **Title V** is a major source operating permit classification. Facilities with the potential to emit over 100 tons per year of any Title V pollutant (PM_{10}, SO_2, NO_x, CO, VOC) are subject to this type of permit. Facilities that can potentially emit 10 tons per year of a single hazardous air pollutant (HAP) or 25 tons per year of total HAPs are also subject. Facilities subject to Title V permitting program must also certify compliance with their permit each year.

- **Conditional major** is a permit type for facilities with potential emissions above 100 tons per year (or are above the 10/25 tons per year), but who have taken enforceable limits to stay below 100/10/25 tons per year. Facilities that have taken limits on their potential to emit also have reporting requirements related to their compliance.

- A **State** minor facility's potential emissions are below 100 tons per year for criteria pollutants and below 10 and 25 tons per year for HAPs.

Maps of countywide emissions, along with graphs containing contributions from the major source categories for all criteria pollutants can be found in Appendix E.

Air quality data 2004 - 2008

A summary of the current air quality, along with trends in the data over the last five years for South Carolina can be found in Appendix F.

Step 2: History of ambient air monitoring in South Carolina

The Department or its predecessors have operated an ambient air monitoring network in South Carolina since 1959. Since that time, the network has continually evolved to meet the requirements and needs of the Department's Air Program and to comply with federal requirements.

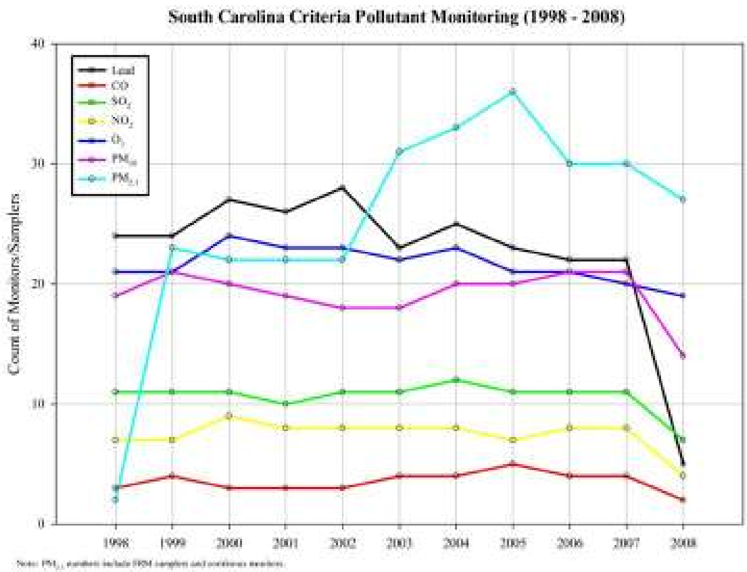
In October, 2006, the EPA published revisions to the ambient air monitoring regulations[6] changing requirements for quality assurance, monitor designations, minimum requirements for both number and distribution of monitors among MSAs, and probe siting. The regulation also included the requirement for an annual ambient air monitoring network plan and periodic network assessments.

In 2007, the Department along with a diverse stakeholder group representing regulated entities and local governments worked to review the existing ambient air monitoring network. As a result of this review, the Department realigned its network well before the mandated assessment required by the 2006 ambient air monitoring regulations. In this initial assessment, the Department sought to ensure that the minimum ambient air monitoring requirements in each MSA were met and that the ambient air monitoring sites met all applicable monitor siting requirements (Appendix E to 40 CFR Part 58).

Until 2008, the number of monitors for each criteria pollutant remained fairly stable with the exception of $PM_{2.5}$. The $PM_{2.5}$ network was established in response to the development of the $PM_{2.5}$ NAAQS in 1997 and this network was drastically increased in order to meet the requirements of the rule. In 2008, a number of lead sampling sites were terminated because data indicated ambient lead concentrations were well below the NAAQS. As a result of the 2006 ambient air monitoring regulations changes and the comprehensive review mentioned above, South Carolina discontinued much of the monitoring of

[6] Revisions to Ambient Air Monitoring Regulations; Final Rule 71 FR 61236 published in the *Federal Register* on October 17, 2006.

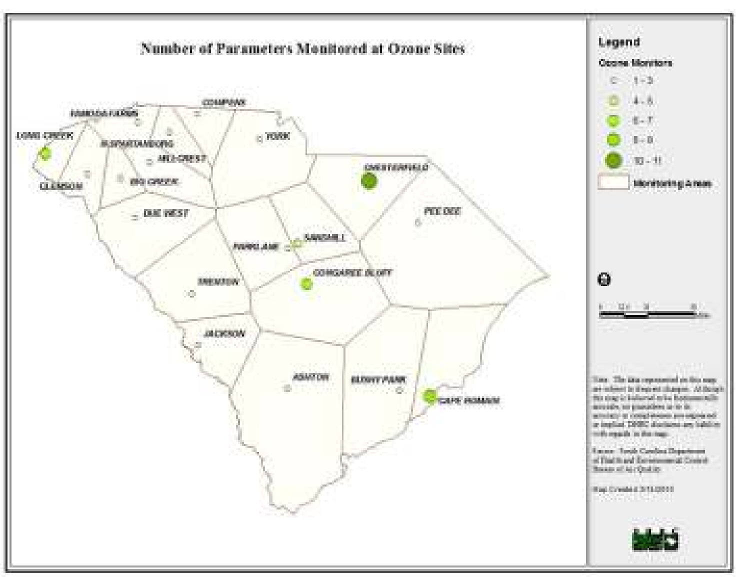
pollutants that did not have historical problems meeting the NAAQS, and instead focused on conserving resources to meet the challenges associated with tightening standards.



The following tests were adapted from the EPA's network assessment guidance document. An example graphic is provided after the description for each test. The graphics for both Ozone and $PM_{2.5}$ can be found in Appendix G.

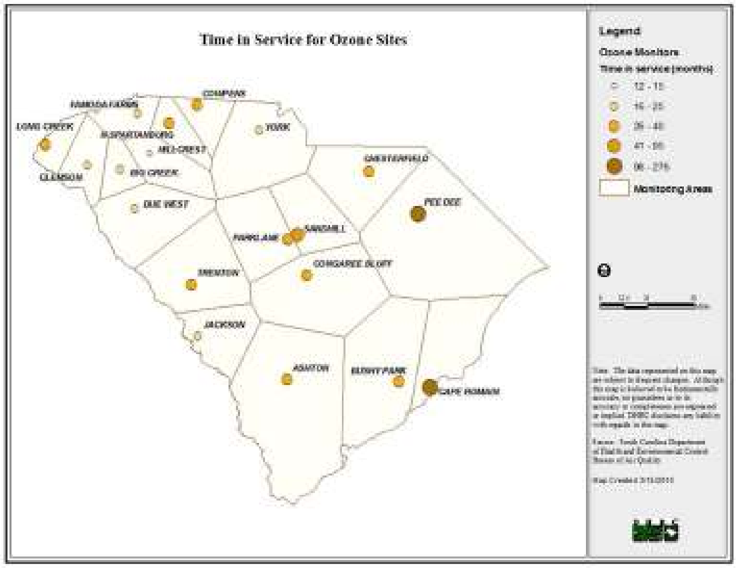
Number of other parameters monitored at the site

Sites were ranked by the number of parameters that are measured at a particular site. Air quality monitoring sites hosting monitors collocated with other measurement instruments are likely more valuable than sites at which fewer parameters are measured. In addition, the operating costs can be leveraged among several instruments at these sites. This analysis is performed by simply counting the number of other parameters that are measured at a site. Sites at which many parameters are measured are ranked highest.



Monitor time in service

Monitors that have a long historical record are valuable for tracking trends. In this analysis, monitors were ranked based on the duration of their continuous measurement records. The analysis can be as simple as ranking the available monitors based on the length of the continuous sampling record. For the purposes of this evaluation, the most important monitors are those with the longest continuous trend record.



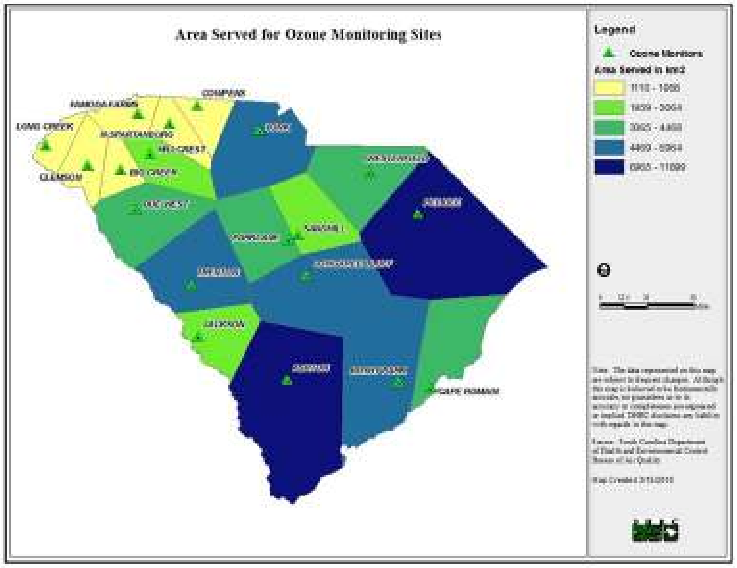
Step 3: Statistical analysis of the ambient air monitoring network

The technical tools provided by the EPA for assessing monitoring networks has made it possible to conduct a more in-depth review of Ozone and $PM_{2.5}$ FRM ambient monitoring. These tools are more appropriate for large monitoring networks that are widely distributed over larger geographic areas. Therefore, only the Ozone and $PM_{2.5}$ FRM networks were assessed with the full array of tools due to the size and spatial distribution of the monitors/samplers across the state. Because the remaining criteria pollutant networks are not of sufficient size to provide reasonable results using tools provided by the EPA, these networks were evaluated based on the requirements as specified by 40 CFR 58.10 (d), associated guidance, and their perceived value to the Air Program. Appendix B to this document provides the assessment rating and recommendations for optimizing the ambient air monitoring network.

Each of the tests used in the assessment is described in this section and an example graphic is provided after the description for each test. The following tests were adapted from the EPA's network assessment guidance document. All of the graphics for both Ozone and $PM_{2.5}$ can be found in Appendix G.

Area served

Sites were ranked based on their area of coverage. Sites that are used to represent a large area score highest in this analysis. Area of coverage (area served) for a monitor has been estimated using the Thiessen (Voronoi) polygons technique. Each polygon consists of the points closer to one particular site than any other site. The use of this technique gives the most weigh to rural sites and those sites on the edges of urban areas or other monitor clusters. Calculating Thiessen polygons is one of the simplest quantitative methods for estimating an area represented by a site, but it is not an accurate indication of which site is most representative of the pollutant concentration across a given area. Meteorology (including pollutant transport), topography, and proximity to population or emission sources are not considered, so some areas assigned to a particular monitor may actually be better represented by a different monitor.

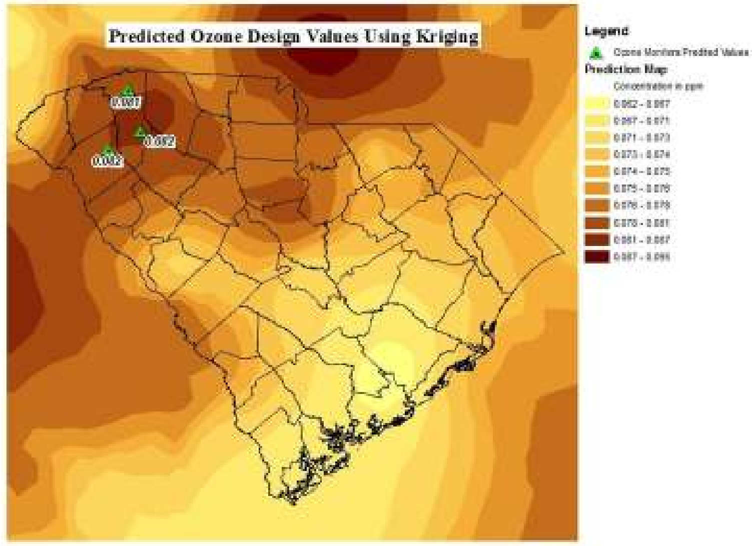


Measured concentrations

Individual monitors were ranked based on the concentration of pollutants they measure. Monitors that measure high concentrations or design values[7] are ranked higher than monitors that measure low concentrations. The analysis is relatively straightforward, requiring only the site design values. The greater the design value, the higher the site rank. If more than one standard exists for a pollutant (e.g., annual and 24-hr average), monitors can be scored for each standard. Appendix C contains the 2008 Design Values for each of the criteria pollutants.

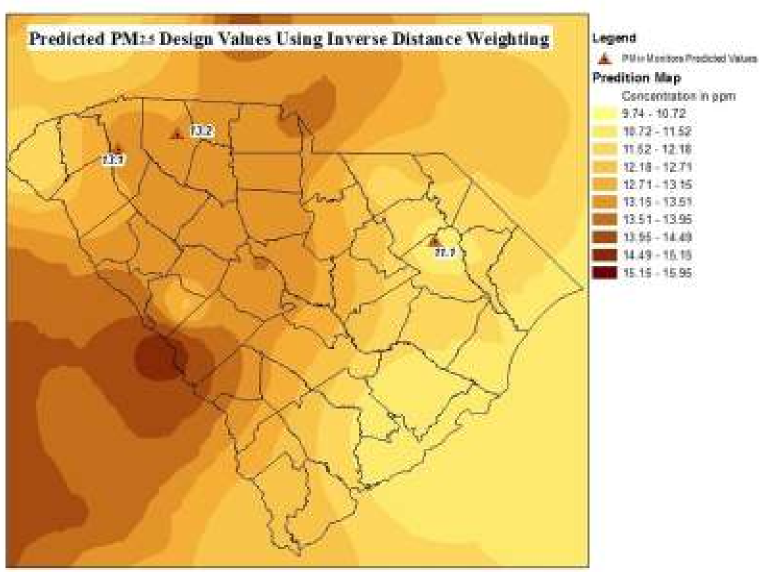
The Department used 2008 design values for Ozone and $PM_{2.5}$ sites to rank the ambient air monitoring sites. There was not enough data to calculate the design values for some of the newer sites recently placed in service. However, in order to score and evaluate all ambient air monitoring sites, the Department predicted the concentrations through geostatistical techniques. The concentration values for the new Ozone monitors were predicted using Kriging. Kriging is a geostatistical technique used to create surfaces incorporating the statistical properties of the measured data. To make a prediction for an unknown concentration value at the specific location, Kriging uses the fitted model from variography (spatial autocorrelation), the spatial data configuration, and the values of the measured sample points around the prediction location. The autocorrelation is a function of distance. Sites that are closer together are considered to be more alike than farther apart. The figure below shows a surface map of predicted Ozone values.

[7] A design value is a statistic that describes the air quality status of a given area relative to the level of the NAAQS.



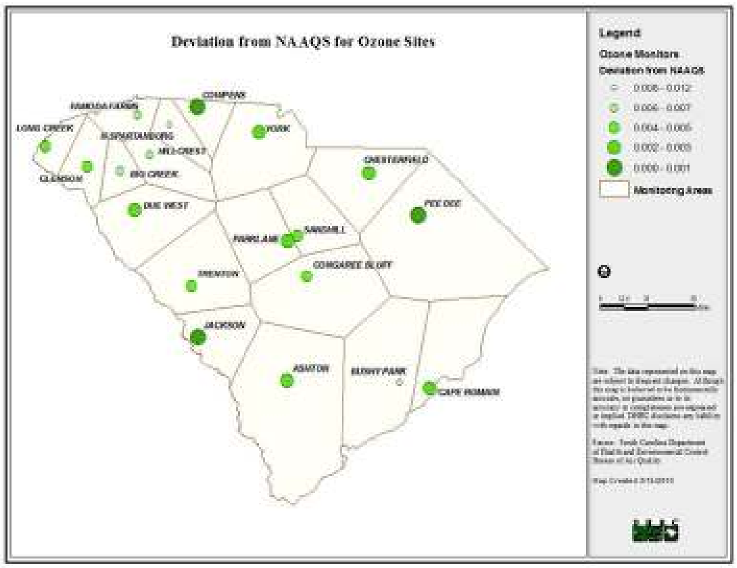
Due to the spatial distribution of $PM_{2.5}$ FRM monitors operating in South Carolina, Kriging did not produce results sufficient to predict values for the new ambient air monitoring sites. The Inverse Distance Weighted (IDW) method of interpolation was used to estimate $PM_{2.5}$ values at these locations. IDW is a deterministic method of interpolation and it creates a surface from the measured points based on the extent of similarity. It is based on the premise that the values at close proximity to each other influence the interpolation more that than the distant observations. In order to compare the IDW and Kriging methods the difference between the recorded $PM_{2.5}$ data and the interpolated $PM_{2.5}$ as the predicted data for the twelve $PM_{2.5}$ monitors were calculated. The IDW method was used because the difference between predicted and actual values for the existing monitors was smaller then the range in the Kriging method. The surface of predicted $PM_{2.5}$ values is shown below.

Monitors that measure high concentrations or design values and their estimated values are ranked higher than monitors that measure low concentrations.



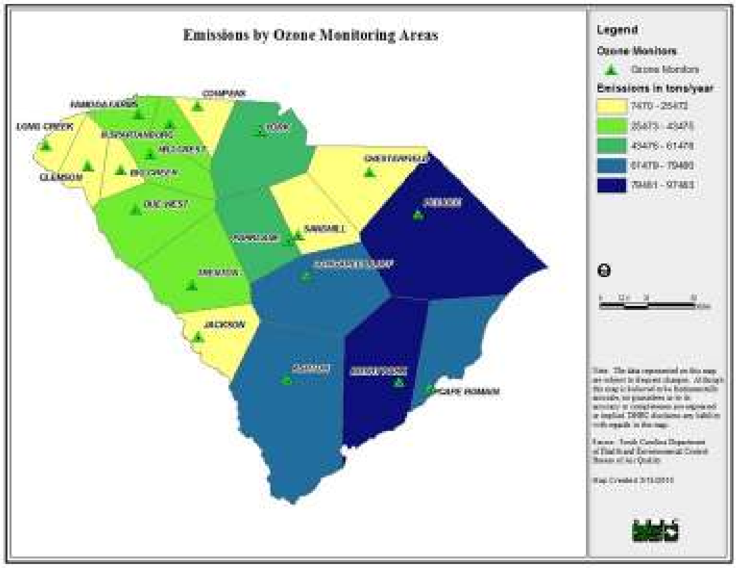
Deviation from NAAQS

Sites measuring concentrations or design values that are very close to the NAAQS exceedance threshold are ranked highest in this analysis. These sites may be considered more valuable for NAAQS compliance evaluation. Sites measuring concentrations well above or below the threshold do not provide as much information in terms of NAAQS compliance. This technique contrasts the difference between the standard and actual measurements or design values. It is a simple way to assess a site's potential value for evaluating compliance. If a pollutant (e.g., annual and 24-hr average) has more than one standard, sites can be scored for each standard.



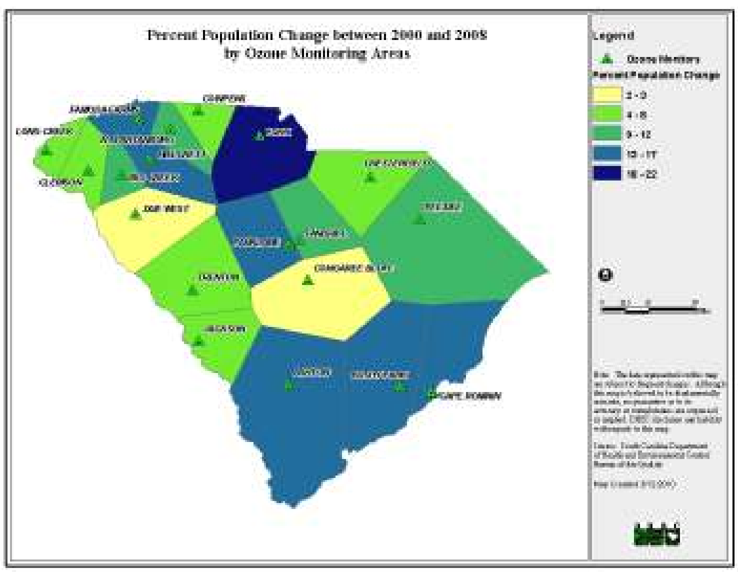
Emission inventory

Emission inventory data were used to find locations where emissions of pollutants of concern are concentrated. This analysis can be scaled to various levels of complexity, depending on available resources. At the simplest level, county-level emissions patterns, such as those in the National Emission Inventory, can be compared with monitor locations. For measuring maximum precursor or primary emissions, monitors should be placed in those counties with maximum emission density. More complex methods use gridded emissions and/or species-weighted emissions, depending on their importance producing secondary pollutants of concern.



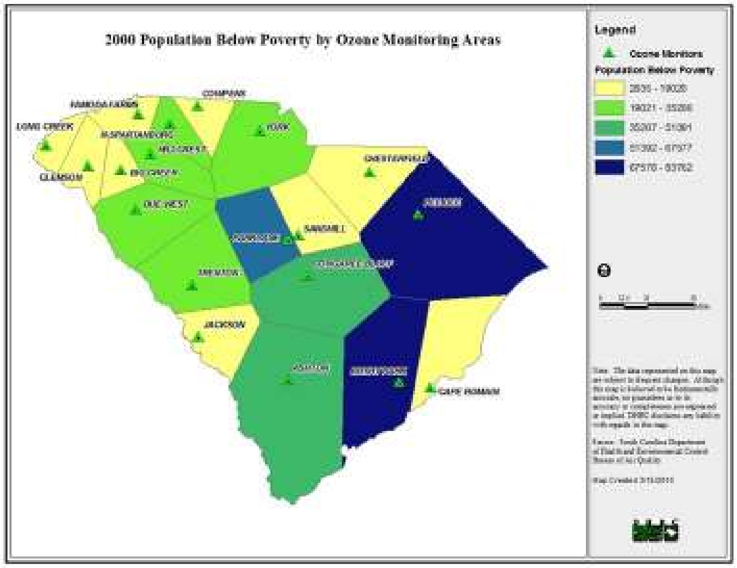
Population change

High rates of population increase are associated with potential increased emissions activity and exposure. Sites were ranked on population change in the area of representation. Area of representation was estimated using the Thiessen polygons technique. The total population change at the census tract or block group level that falls within the area of coverage of a monitor is assigned to that monitor. This technique gives most weight to sites in areas with high rates of population growth and large areas of representation.



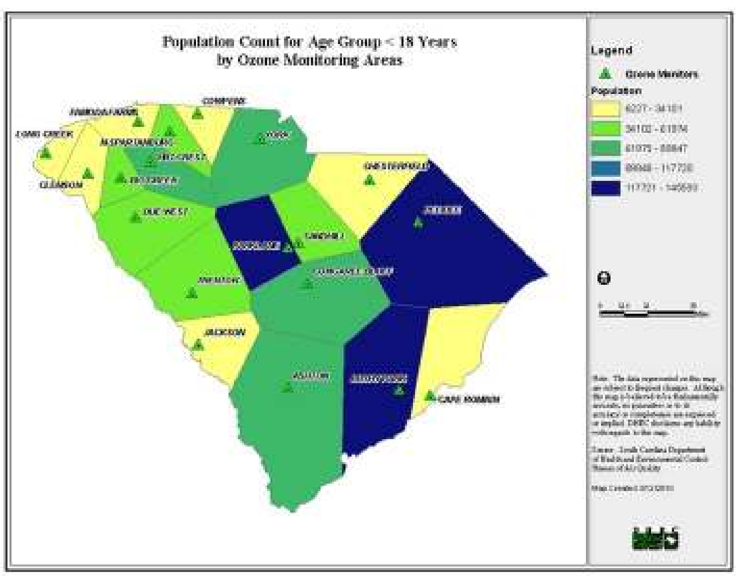
Population living below poverty level

This test is similar to the population change test except that it focuses on rates of poverty in the areas represented by each ambient air monitoring site. Area of representation was estimated using the Thiessen polygons technique. The total population living below the poverty level at the census tract or block group level that falls within the area of coverage of a monitor was assigned to that monitor. As stated earlier, the Thiessen polygons tend to be larger in more rural areas because ambient air monitoring networks tend to be concentrated in urbanized areas. Sites were ranked on the population living below the poverty level in the area of representation (as determined via the Thiessen polygon technique).



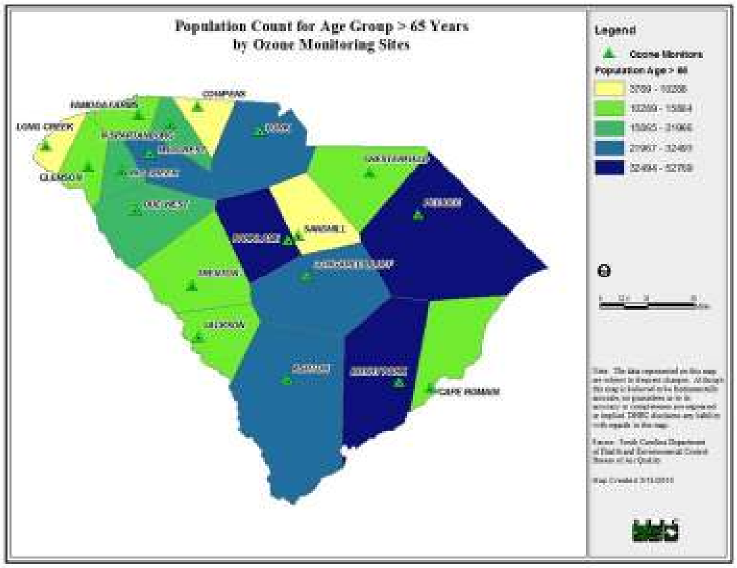
Population for age 18 and below

This test is similar to the population change test except that it focuses on the total population of younger individuals represented by each ambient air monitoring site. Areas with high populations of youth may be indicative of the effects of pollution on sensitive individuals. Sites were ranked on the population below age eighteen in the area of representation. Area of representation was estimated using the Thiessen polygons technique. The population of a county whose center falls within the area of coverage of a monitor is assigned to that monitor.



Population for age 65 and above

This test is similar to the population change test except that it focuses on the total population of older individuals in the area represented by each ambient air monitoring site. Areas with high populations of older individuals indicate the potential for the effects of pollution on sensitive individuals. Sites once again were ranked on the population of older individuals in the area of representation. Areas of representation were estimated using the Thiessen polygons technique. The population of a county whose center falls within the area of coverage of a monitor is assigned to that monitor.



Step 4: Situational analysis

Risk of future NAAQS exceedances

Appendix A contains calculations designed to predict the risk of a future NAAQS exceedance for each of the criteria pollutants. The purpose of this test is to see which sites are most likely to exceed the applicable NAAQS in the next three years based on previous data trends. In general, all Ozone, some $PM_{2.5}$ and some PM_{10} sites will exceed a 90 percent probability of exceeding 80 percent of the applicable NAAQS in the next three years.

Requirements of existing state implementation plans or maintenance plans

The only area in South Carolina with an ambient air monitoring requirement based on a 110 (a)(1) Maintenance Plan[8] is in Cherokee County. The Department will continue to use the Cowpens National Battlefield ambient air monitoring site (45-021-0002) to verify continued attainment of the Ozone NAAQS through the remainder of the maintenance plan period (currently set to expire in 2014).

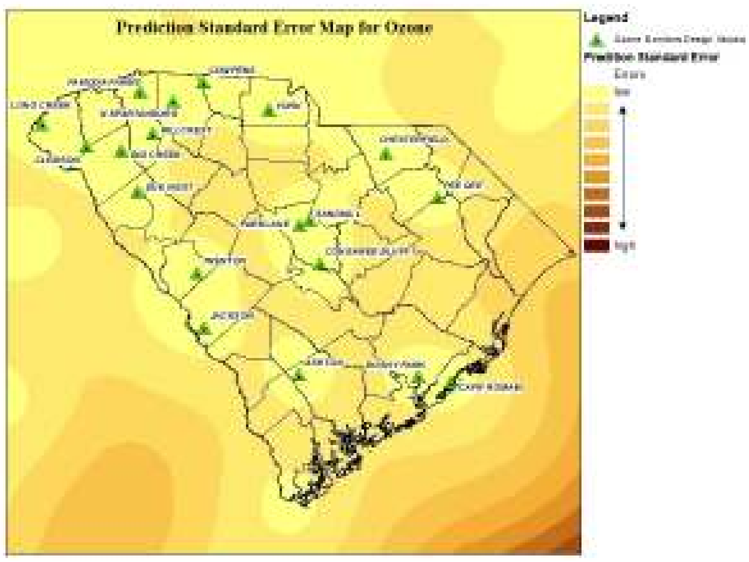
Density or sparseness of existing networks

As stated earlier, due to the spatial distribution of the South Carolina $PM_{2.5}$ FRM network required by the Network Design Criteria found in Appendix D to 40 CFR 58, Kriging did not produce results sufficient to predict concentrations throughout the state. The IDW method of interpolation to estimate $PM_{2.5}$ concentrations is a deterministic method that does not allow for the estimation of error in the prediction surface used to indicate potential gaps in the ambient air monitoring network. Due to this limitation in the

[8] A copy of the Department's 110(a)(1) Maintenance Plan for Cherokee, SC can be found at: http://www.dhec.sc.gov/environment/baq/docs/regs/other/20080206_Final%20Cherokee%20County%20Plan%20per%20EPA%20Comments.pdf

available tools, the Department was unable to evaluate the density or sparseness of the $PM_{2.5}$ FRM ambient air monitoring network to measure concentrations throughout the state, but does have high confidence, based on studies of $PM_{2.5}$ concentration variability in urban areas, that the primary monitoring objectives are being met by the existing network. South Carolina's $PM_{2.5}$ FRM ambient air monitoring network meets or exceeds the ambient air monitoring network design requirements in Appendix D to 40 CFR 58.

These analyses were conducted to determine where additional ambient air monitoring may be needed. The analyses included creating predicted Ozone surface described in the previous section and a map of standard errors associated with the Ozone predicted values. With the Kriging technique, an error or uncertainty surface was produced, indicating how well the values were interpolated. The map of standard errors is shown below. Areas in darker brown color have higher error associated with their interpolated concentrations.



Prediction standard error, distance to roads, population, NO_x emissions, and VOC emissions grids were input to the weighted overlay analysis. The rasters were reclassified to a common scale of 1 to 10 (1 being the least suitable, 10 being the most suitable for placing new monitors). Each raster was assigned the percentage weights. Since the prediction standard error provided the most information about the uncertainty of the network it was given the highest percentage weight. The rasters were overlain to produce the final suitability map for placing new monitors. The weighted overlay allows the user to look at the areas with the highest suitability and where the uncertainty of the network is the greatest and place new monitors if needed. The model was built and documented with the ModelBuilder[9] application within the Department's GIS program to ensure that the whole process could be easily repeated. The map below shows the suitability map and depicts the areas for possible new monitor selection. The color red indicates where new Ozone ambient air monitoring sites maybe placed. This analysis indicates that a gap in coverage may exist for Ozone ambient air monitoring in eastern South Carolina. The Department has monitored in the vicinity of this potential gap in Williamsburg County. The Indiantown site (45-089-0001) was operated through 2007 and indicated area concentrations were well below the 1997 Ozone

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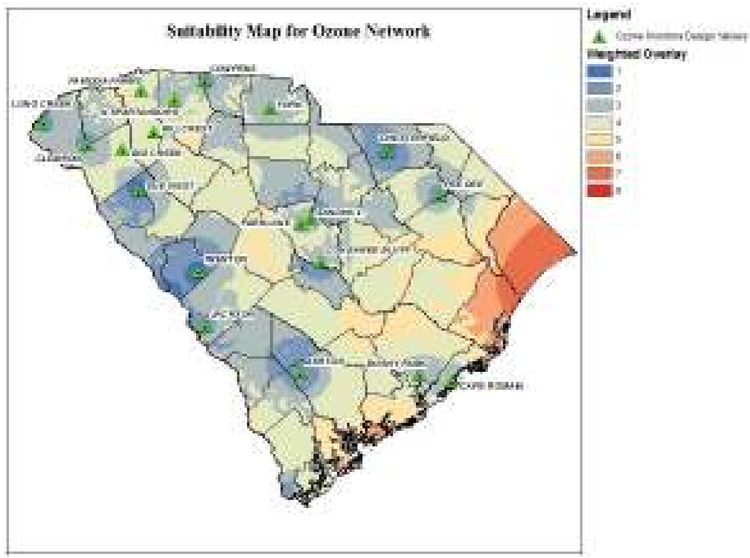
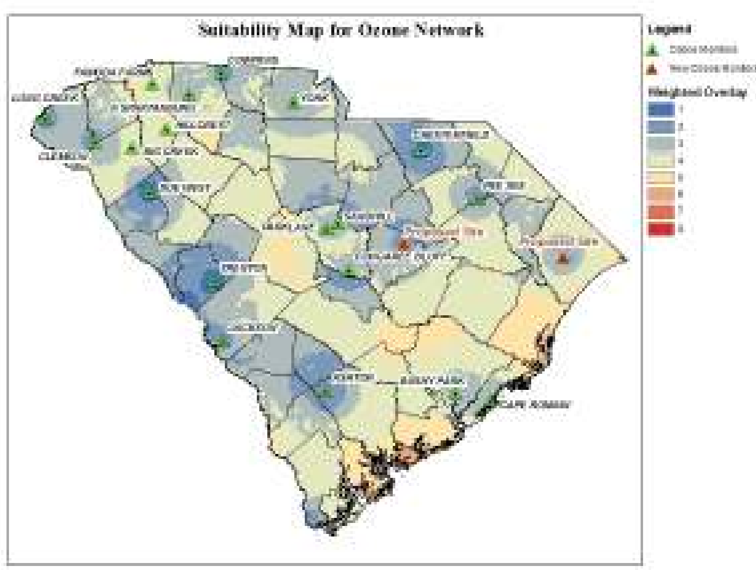
[9]An explanation of what ModelBuilder does can be found at:
http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=An_overview_of_ModelBuilder

NAAQS and correlated well with other monitors in the coastal plain of South Carolina. As a result of the 2007 review of the ambient air monitoring network mentioned elsewhere in this document, the Indiantown site was determined by the Department to be redundant and the EPA concurred with this assessment.



As noted earlier, the EPA has proposed revisions to the network design regulations for Ozone. The Department has determined that at least two areas in South Carolina could be affected by this proposed regulation. In order to test likely additions to the spatial coverage of the Ozone network in South Carolina, two "proposed" sites representing potential new sites were placed in the network and the model was rerun. As can be seen below, the area in red identified in eastern South Carolina would be addressed.



Scientific research or public health needs

As of this writing, the EPA has yet to provide details on any health studies or scientific research that utilizes South Carolina ambient air monitors. The Department currently knows of no local studies that depend on any site/monitor suggested for removal.

Step 5: Suggested changes based on assessment

Appendix B presents the results of the assessment and some potential realignment recommendations that are possible for the network. From a practicality standpoint, it is not feasible at this time to make many changes to the ambient air monitoring network. The EPA is currently reviewing many of the NAAQS and making changes not only to the level of the standards but to the associated ambient air monitoring requirements and network design. The Department evaluates each of the rulemakings as they are proposed in order to begin planning for revised networks, but we are unable to prepare for any new monitoring requirements of those pollutant standards that are still in the process of being developed and have not completed the formal rulemaking process.

Step 6: Availability of assessment

Due to the technical nature of this assessment, it is not intended to be a stand alone document. The Department will make this assessment available on the internet at www.dhec.sc.gov. The technical assessment, along with the Monitoring Plan will be submitted together as one package to the EPA on or before July 1, 2010.

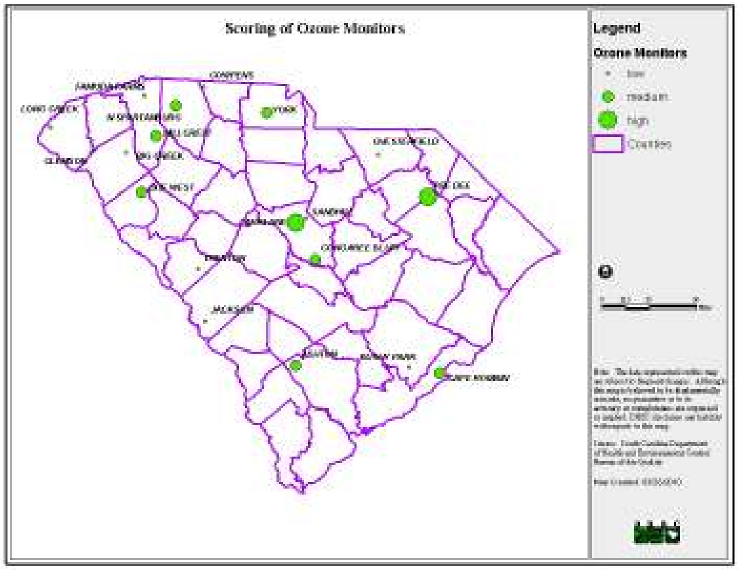
New Technologies

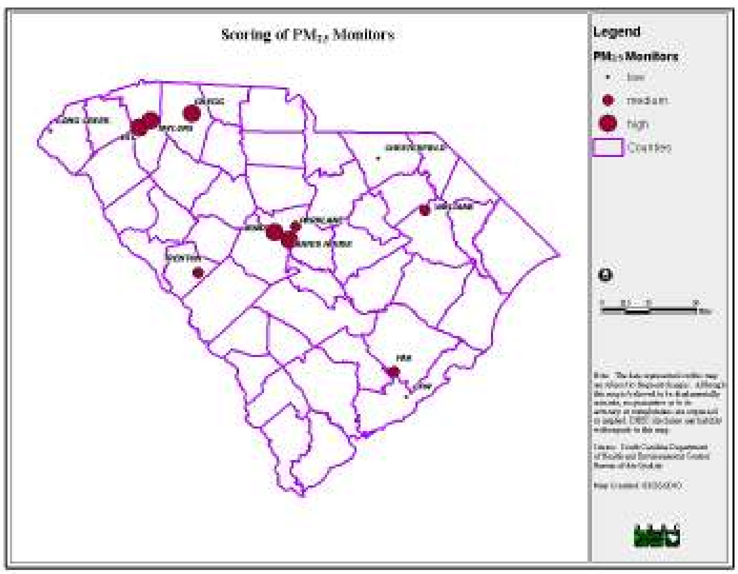
The Department knows of no new technologies that can be incorporated into its ambient air quality network at this time without significant cost. An example of a technology that would be useful but cost prohibitive at this time is an updated data acquisition system with the ability to analyze data and perform basic statistical calculations integrated with the ability to send ambient air monitoring data directly to the internet. Recent budget cuts have forced the Department to look at the efficiency of its ambient air monitoring network and the mandated ambient air monitoring requirements from the EPA. As long as the EPA continues to implement unfunded mandates upon the states in the form of new monitoring requirements without appropriate financial support for both capital and operating costs, the Department will remain at risk of being financially unable to incorporate new technologies into the ambient air monitoring network.

Results

The use of the EPA's technical tools resulted in a final ranking for the Ozone and $PM_{2.5}$ monitoring networks of the most and the least valuable sites. Three Ozone monitors that were scored highest included Pee Dee in Darlington County, Parklane in Richland County, and York in York County. The scoring technique gave the most influence to rural areas since the statistics were gathered and analyzed for Thiessen polygons. The Pee Dee monitor had the highest score because it represents the largest area. The Parklane and York monitors are located in highly populated counties in our state and their measured concentration values exceed the standard based on 2008 monitoring data. If 2009 monitoring data had been used for this analysis, it is likely that the value of the Parklane and York monitors would have changed slightly as ozone concentrations across the state decreased. Based on the design values for 2009, all but one monitor in South Carolina attains the 2008 ozone standard. Three Ozone monitors scoring the lowest were Long Creek in Oconee County, Trenton in Edgefield County and Bushy Park in Berkeley County. The Long Creek monitor was scored the lowest because of the small area it represents and measured concentrations are well below the standard.

The three most valuable $PM_{2.5}$ monitors based on their ranking are T.K. Gregg in Spartanburg County, Irmo in Lexington County, and Bates House in Richland County. All of these monitors represent highly populated areas. The two $PM_{2.5}$ monitors with the lowest scores are Long Creek in Oconee County and CPW in Charleston County. Long Creek and CPW represent small areas and have low measured concentrations.





Conclusions

This ambient air monitoring network assessment has been a combination of objective (Is it required?) and subjective (We need the data….), moderated by the capabilities and resources available (Can we do it?). The monitoring network has evolved from the simple exposure monitors of the 1960's to the sophisticated Federal Reference and Federal Equivalent methods and near real time data management systems in use today. The States were strongly encouraged in the 1990's to divest from the pollutants where significant progress had been made (SO_2, NO_x, Lead, and CO) to the point where there were no monitoring requirements at all for those pollutants. In 2007 South Carolina invested considerable effort in a site by site, parameter-by-parameter review of the ambient monitoring network, reflected in the significant changes proposed and implemented in the 2008 Network Description and Ambient Air Network Monitoring Plan.

The 2007 review and assessment was performed without the benefit of the applications described in the EPA Network Assessment Guidance or the tools made available in late 2009 and early 2010, but met the goals stated in the proposal to '… probe the current and expected relevancy of air monitoring networks through a combination of stakeholder participation and technical analyses.' Some portions of the network were reduced and some monitoring beyond the minimum required was maintained to meet the Air Program's objectives and data needs.

This 2010 review has required a significant investment of resources and time to develop tools, applications and models that mirrored many that EPA eventually provided. During this first assessment required by the monitoring rule changes, the limitations of the objective approaches used in the tools and suggested by guidance can generate results that conflict with more subjective examinations of the value of data that is being, or possibly should be, collected. The execution of this first mandated 5-year assessment and our previous experience leads us to several broad conclusions:

> **Regular periodic assessment of the network is necessary to ensure that requirements and objectives are being met.** A review of requirements and objectives is already part of the Annual Monitoring Network Plan, but a broader, more strategic review of the network described in the proposal and rule preambles is appropriate and necessary.
>
> **The tools available are inadequate for an objective assessment at the scales needed for our State.** The tools provided by EPA to assist the states for this scheduled assessment, or developed by South Carolina using national and regional guidance cannot provide actionable results with the limited resolution of the monitoring, emissions, population demographics, and health outcomes data that is readily available. Monitoring and supporting data does not (and typically will not) have the spatial resolution to allow adequate network assessment at the scale where most needed- the urban area or MSA. This is a particular concern at neighborhood and smaller scales associated with requirements for near road and source oriented monitoring.
>
> **Subjective evaluation of the value of monitoring data must be supported by, but not subordinate to objective (technical or statistical) evaluation.** The local knowledge of communities, industries, traffic patterns, weather, topography and data needs are more important in the design and evaluation of a monitoring effort than the generalizations provided in the available descriptive data.

The basis of network design in South Carolina has been the collection of data to document concentrations and exposure throughout the state, providing data that represents relatively remote areas, rural areas and smaller communities as well as the urban areas which are the focus of the EPA monitoring requirements. The value of monitoring for background, transport and context was indicated in early network design requirements. The state has maintained monitoring for all criteria pollutants in addition to the primarily urban-centric Ozone and $PM_{2.5}$ requirements to meet the full range of monitoring objectives. The value of context is being recognized again in the new and proposed requirements to monitor for background, transport and in smaller MSAs and non-urban areas – almost all of which can be met with our existing monitors.

The tools that have been developed are an improvement – the next generation – of methods used in EPA Regional ambient air monitoring network assessments completed in 2005. The tools are most useful and appropriate for regional and national scale assessment of the monitoring effort and data. EPA must take the experience gained by the states and local monitoring organizations in the development of these first assessment documents to immediately start development of new and refined tools and the data hinted at in the Monitoring Assessment Guidance to allow monitoring organizations to more closely approach the intent of the periodic assessment requirement and gain real value from the investment. Many monitoring organizations could greatly benefit from accessible tools that can be used to refine and improve MSA and state scale monitoring networks. For those pollutants that are more regional in scale, appropriate tools, data and support from the EPA Region with coordination, technical support and waivers when appropriate would encourage state and regional collaboration in the implementation of efficient and regionally appropriate networks that avoid duplication and minimize overall uncertainty. We could use improved tools now in the annual planning process and should not be waiting or duplicating effort when we are approaching the 2015 assessment.

The scores and ranking of the monitors obtained through the application of the tools and guidance can only provide an indicator of areas where a more subjective evaluation may be needed. The minimum monitoring requirements are currently being met throughout the state of South Carolina. Several areas were identified where there is greater uncertainty in the estimate of ozone concentrations. The uncertainty may be addressed by requirements proposed in rule changes expected to be finalized in August 2010. The appropriate design and implementation of the recently finalized NO_2 and SO_2 monitoring requirements are expected to require additional assessment of the existing monitoring to balance state objectives, monitoring requirements and available resources. Those assessments will be reflected in the implementation described in the associated Annual Monitoring Plans as will all monitoring network changes compelled by changes in requirements and available resources.

Appendix A: Risk of Future NAAQS Exceedances

This appendix contains calculations designed to predict the risk of a future NAAQS exceedance for each of the criteria pollutants. The purpose of this test is to see which sites are most likely to exceed the applicable NAAQS in the next three years based on previous data trends. In general, all ozone, some $PM_{2.5}$ and some PM_{10} sites will exceed a 90 percent probability of exceeding 80 percent of the applicable NAAQS in the next three years.

Appendix A: Risk of Future NAAQS Exceedances													
Pollutant	**Form**	**Site ID**	**Site Name**	**2004**	**2005**	**2006**	**2007**	**2008**	**Average**	**Standard Deviation**	**90% Upper Confidence Interval**	**0.8*NAAQS**	**Is 90% CI < 80% of NAAQS?**
Ozone	8-hour	45-001-0001	Due West	0.080	0.078	0.078	0.081	0.078	0.079	0.001	0.080	0.06	No
		45-003-0003	Jackson	0.080	0.075	0.076	0.077	0.076	0.077	0.002	0.079	0.06	No
		45-015-0002	Bushy Park	0.072	0.070	0.068	0.064	0.063	0.067	0.004	0.071	0.06	No
		45-019-0046	Cape Romain	0.073	0.073	0.075	0.074	0.072	0.073	0.001	0.074	0.06	No
		45-021-0002	Cowpens	0.080	0.075	0.074	0.073	0.074	0.075	0.003	0.078	0.06	No
		45-025-0001	Chesterfield	0.080	0.075	0.075	0.075	0.073	0.076	0.003	0.078	0.06	No
		45-029-0002	Ashton	0.075	0.070	0.073	0.074	0.073	0.073	0.002	0.075	0.06	No

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Pollutant	**Form**	**Site ID**	**Site Name**	**2004**	**2005**	**2006**	**2007**	**2008**	**Average**	**Standard Deviation**	**90% Upper Confidence Interval**	**0.8*NAAQS**	**Is 90% CI < 80% of NAAQS?**
		45-031-0003	Pee Dee	0.080	0.076	0.077	0.076	0.075	0.077	0.002	0.079	0.06	No
		45-037-0001	Trenton	0.077	0.070	0.070	0.070	0.070	0.071	0.003	0.074	0.06	No
		45-073-0001	Long Creek	0.082	0.076	0.071	0.072	0.071	0.074	0.005	0.079	0.06	No
		45-077-0002	Clemson	0.080	0.077	0.078	0.081	0.080	0.079	0.002	0.081	0.06	No
		45-079-0021	Congaree Bluff	0.074	0.073	0.072	0.073	0.071	0.073	0.001	0.074	0.06	No
		45-079-0007	Parklane	0.080	0.079	0.082	0.080	0.078	0.080	0.001	0.081	0.06	No
		45-079-1001	Sandhill	0.086	0.083	0.082	0.082	0.079	0.082	0.003	0.085	0.06	No
		45-083-0009	NSFS	0.084	0.081	0.083	0.083	0.084	0.083	0.001	0.084	0.06	No
		45-091-0006	York	0.081	0.075	0.076	0.079	0.077	0.078	0.002	0.080	0.06	No
$PM_{2.5}$	Annual												
		45-	Trenton	12.58	12.97	13.39	13.10	12.52	12.911	0.365	13.259	12	No

Appendix A: Risk of Future NAAQS Exceedances

Pollutant	Form	Site ID	Site Name	2004	2005	2006	2007	2008	Average	Standard Deviation	90% Upper Confidence Interval	0.8*NAAQS	Is 90% CI < 80% of NAAQS?
		037-0001											
		45-073-0001	Long Creek	10.30	10.59	11.04	11.25	10.46	10.727	0.398	11.106	12	Yes
		45-045-0009	Taylors	14.30	14.55	14.85	14.68	13.76	14.428	0.425	14.833	12	No
		45-063-0008	Irmo	13.67	14.23	15.07	14.66	13.65	14.257	0.619	14.847	12	No
		45-079-0019	Bates House	13.68	14.13	14.48	14.20	13.28	13.953	0.473	14.404	12	No
		45-025-0001	Chesterfield	12.34	12.42	12.75	12.45	11.97	12.386	0.282	12.654	12	No
		45-019-0048	Charleston FAA Beacon	11.65	12.15	12.49	12.06	11.00	11.870	0.569	12.412	12	No
		45-019-0049	Charleston Public Works	11.23	11.69	11.82	11.29	10.34	11.274	0.578	11.825	12	Yes
	24-Hour	45-037-0001	Trenton	32.00	33.73	32.80	30.17	23.80	30.500	3.968	34.280	28	No
		45-073-	Long Creek	26.10	28.23	27.73	29.33	20.77	26.433	3.375	29.648	28	No

Appendix A: Risk of Future NAAQS Exceedances													
Pollutant	**Form**	**Site ID**	**Site Name**	**2004**	**2005**	**2006**	**2007**	**2008**	**Average**	**Standard Deviation**	**90% Upper Confidence Interval**	**0.8*NAAQS**	**Is 90% CI < 80% of NAAQS?**
		0001											
		45-045-0009	Taylors	30.93	33.53	32.78	31.72	27.82	31.357	2.214	33.466	28	No
		45-063-0008	Irmo	31.80	33.30	33.43	31.90	27.93	31.673	2.225	33.793	28	No
		45-079-0019	Bates House	31.40	33.50	33.83	32.47	27.97	31.833	2.362	34.083	28	No
		45-025-0001	Chesterfield	28.63	28.43	29.90	28.03	25.13	28.027	1.762	29.705	28	No
		45-019-0048	Charleston FAA Beacon	25.97	27.80	28.00	27.87	24.30	26.787	1.622	28.332	28	No
		45-019-0049	Charleston Public Works	25.23	27.90	27.97	26.50	23.17	26.153	2.014	28.072	28	No
PM_{10}	24-hr (2nd Max)	45-079-0019	Bates House	47	47	92	103	46	67.0	28.1	93.8	120	Yes
		45-063-0009	Cayce CMS	106	128	114	100	80	105.6	17.7	122.5	120	No
		45-025-0001	Chesterfield	62	66	63	68	59	63.6	3.5	66.9	120	Yes

Appendix A: Risk of Future NAAQS Exceedances													
Pollutant	**Form**	**Site ID**	**Site Name**	**2004**	**2005**	**2006**	**2007**	**2008**	**Average**	**Standard Deviation**	**90% Upper Confidence Interval**	**0.8*NAAQS**	**Is 90% CI < 80% of NAAQS?**
		45-043-0006	Georgetown	131	157	87	73	81	105.8	36.4	140.5	120	No
		45-019-0003	Jenkins Ave.	45	48	37	57	34	44.2	9.1	52.9	120	Yes
CO	1-hour (2nd Max)	45-019-0046	Cape Romain	2.2	1.5	0.6	0.9	0.8	1.2	0.7	1.8	28	Yes
	8-hour (2nd Max)	45-019-0046	Cape Romain	1.3	0.5	0.3	0.4	0.5	0.6	0.4	1.0	7.2	Yes
SO_2	Annual	45-019-0046	Cape Romain	0.002	0.002	0.002	0.002	0.001	0.002	0.0	0.0	0.02	Yes
		45-079-0021	Congaree Bluff	0.002	0.002	0.002	0.001	0.001	0.002	0.0	0.0	0.02	Yes
		45-063-0008	Irmo	0.003	0.003	0.003	0.003	0.003	0.003	0.0	0.0	0.02	Yes
		45-019-0003	Jenkins Ave.	0.003	0.003	0.002	0.002	0.002	0.002	0.0	0.0	0.02	Yes
		45-073-0001	Long Creek	0.002	0.002	0.002	0.001	0.001	0.002	0.0	0.0	0.02	Yes
	24 hour												
		45-019-	Cape Romain	0.007	0.007	0.007	0.006	0.006	0.007	0.0	0.0	0.11	Yes

Appendix A: Risk of Future NAAQS Exceedances													
Pollutant	**Form**	**Site ID**	**Site Name**	**2004**	**2005**	**2006**	**2007**	**2008**	**Average**	**Standard Deviation**	**90% Upper Confidence Interval**	**0.8*NAAQS**	**Is 90% CI < 80% of NAAQS?**
	(2nd Max)	0046											
		45-079-0021	Congaree Bluff	0.009	0.011	0.009	0.008	0.009	0.009	0.0	0.0	0.11	Yes
		45-063-0008	Irmo	0.018	0.017	0.017	0.017	0.016	0.017	0.0	0.0	0.11	Yes
		45-019-0003	Jenkins Ave.	0.012	0.012	0.009	0.011	0.011	0.011	0.0	0.0	0.11	Yes
		45-073-0001	Long Creek	0.009	0.009	0.008	0.006	0.005	0.007	0.0	0.0	0.11	Yes
NO_2	Annual	45-019-0003	Jenkins Ave.	0.0098	0.0101	0.0091	0.0082	0.0091	0.009	0.001	0.010	0.05	Yes

Appendix B: Recommendations for Network Optimization

Site Name	Site ID	Site Established	Monitor Type	Monitoring Objective	Pollutant/Method	Assigned Value from Assessment	Recommendations for Optimization
Anderson Library	45-007-0004	March 25, 2008	SPM	Population Exposure	$PM_{2.5}$ Continuous	N/A	The sampling at this location will be discontinued at the end of 2010. The SPM data was intended to assess a previously unevaluated area of the Greenville Spartanburg-Anderson CSA.
Big Creek	45-007-0005	June 6, 2008	SLAMS	Max Ozone Concentration / Upwind Background	Ozone	Low	Even though this site is ranked low, it will be retained to fulfill the ozone monitoring requirement for the Anderson MSA.
Cowpens	45-021-0002	March 25, 1988	SPM	Upwind / Background	Ozone	Low	This site will be retained through at least 2014 to fulfill the Cherokee County Ozone Maintenance Plan requirements.
Taylors	45-045-0009	May 1, 1999	SLAMS	Population Exposure	$PM_{2.5}$	Medium	This monitor is expected to be relocated within the MSA to better meet the monitoring objective and partially fulfill the monitoring requirements for the MSA. Changes in the use of this site by the property owner have made the site less suitable.
			QA Collocated	Population Exposure	$PM_{2.5}$ Collocated	N/A	The precision sampler is expected to be accommodated at the new site.
Greenville ESC	45-045-0015	April 11, 2008	SLAMS	Population Exposure / Welfare Related Impacts	$PM_{2.5}$	Medium	No changes. This monitor partially fulfills the requirements for the MSA.
			SPM	Population Exposure	$PM_{2.5}$ Continuous	N/A	No changes. This monitor fulfills the continuous monitoring requirement for the MSA.
			SPM	Population Exposure	$PM_{2.5}$ Speciation	N/A	No changes anticipated at this time.

Appendix B: Recommendations for Network Optimization							
Site Name	**Site ID**	**Site Established**	**Monitor Type**	**Monitoring Objective**	**Pollutant/Method**	**Assigned Value from Assessment**	**Recommendations for Optimization**
			SLAMS	Population Exposure	PM_{10}	N/A	No changes. This monitor fulfills the PM_{10} monitoring requirements for the MSA.
			SPM	Population Exposure	Lead	N/A	No changes anticipated at this time.
			SPM	Population Exposure	SO_2	N/A	No changes anticipated at this time.
			SPM	Population Exposure / General Background	NO_2	N/A	No changes anticipated at this time.
			SPM	Max Precursor Impact	CO	N/A	No changes anticipated at this time.
Hillcrest Middle School	45-045-0016	February 17, 2009	SLAMS	Population Exposure	Ozone	Medium	The Department will continue to monitor ozone at this location as part of an evaluation of the most appropriate monitor configuration to represent the MSA.
Famoda Farm	45-045-1003	August 7, 2008	SLAMS	Max Ozone Concentration	Ozone	Medium	The Department will continue to monitor ozone at this location as part of an evaluation of the most appropriate monitor configuration to represent the MSA.
Clemson CMS	45-077-0002	July 14, 1979	SLAMS	General Background	Ozone	Low	The Department intends to establish a replacement site in Pickens County that better represents the area.
Long Creek	45-073-0001	August 1, 1983	SLAMS	General / Background	$PM_{2.5}$	Low	This monitor is a candidate for removal. The site does provide unique information about transport of $PM_{2.5}$ across the southeast, but may not provide the most relevant data about transport and impact of $PM_{2.5}$ into South Carolina.
			SPM	General / Background	$PM_{2.5}$ Continuous	N/A	This monitor is a possible candidate for removal. Retention of continuous $PM_{2.5}$ monitoring at Longcreek could continue to provide information on $PM_{2.5}$ transport across the south east if the FRM is removed.

Appendix B: Recommendations for Network Optimization							
Site Name	**Site ID**	**Site Established**	**Monitor Type**	**Monitoring Objective**	**Pollutant/Method**	**Assigned Value from Assessment**	**Recommendations for Optimization**
			SPM	General / Background	Ozone	Low	This monitor is a candidate for removal. The Department will evaluate the new ozone network in the context of the final revisions to design criteria and make a decision about the future status of this site.
			SPM	Regional Transport	SO_2	N/A	No changes anticipated at this time.
North Spartanburg Fire Station #2	45-083-0009	April 4, 1990	SLAMS	Max Ozone Concentration	Ozone	Medium	The Department will make no changes to this site. This site fulfills the monitoring requirements for the MSA and is currently violating the ozone NAAQS.
T.K. Gregg Recreation Center	45-083-0011	December 29, 2008	SLAMS	Highest Concentration	$PM_{2.5}$	High	This site is the required $PM_{2.5}$ SLAMS site for the MSA.
			SPM	Highest Concentration	$PM_{2.5}$ Continuous	N/A	This monitor fulfills the continuous $PM_{2.5}$ monitoring requirement for the MSA.
Irmo	45-063-0008	April 7, 1989	SLAMS	Population Exposure	$PM_{2.5}$	High	No changes. This monitor partially fulfills the monitoring requirements for the MSA.
			SPM	Population Exposure	$PM_{2.5}$ Continuous	N/A	No changes. This monitor fulfills the continuous monitoring requirement for the MSA.
			SPM	Source-Oriented	SO_2	N/A	No changes anticipated at this time.
Cayce CMS	45-063-0009	October 26, 1991	SPM	Source Oriented	PM_{10}	N/A	No changes anticipated at this time.
Cayce City Hall	45-063-0010	December 6, 2007	SLAMS	Population Exposure	PM_{10}	N/A	No changes anticipated at this time.
Parklane	45-079-0007	April 3, 1980	Proposed NCore	Population Exposure	$PM_{2.5}$	Medium	Parklane is expected to be the NCore site for South Carolina and all is required monitoring. Will be operational by January 1, 2011.
				TBD	$PM_{2.5}$ Continuous	N/A	

Appendix B: Recommendations for Network Optimization							
Site Name	**Site ID**	**Site Established**	**Monitor Type**	**Monitoring Objective**	**Pollutant/Method**	**Assigned Value from Assessment**	**Recommendations for Optimization**
				TBD	$PM_{2.5}$ Speciation	N/A	
				TBD	$PM_{10-2.5}$	N/A	
				TBD	$PM_{10-2.5}$ Speciation	N/A	
				Max Ozone Concentration	Ozone	High	
				TBD	SO_2	N/A	
				TBD	CO	N/A	
				TBD	NO	N/A	
				TBD	NO_y	N/A	
				TBD	Lead	N/A	
Bates House	45-079-0019	November 24, 1998	SLAMS	Population Exposure	$PM_{2.5}$	High	No changes. This monitor partially fulfills the monitoring requirements for the MSA.
			QA Collocated	Quality Assurance	Collocated $PM_{2.5}$	N/A	No changes anticipated at this time.
			SLAMS	Population Exposure	PM_{10}	N/A	This monitor currently fulfills the PM_{10} monitoring requirements for the MSA but may be supplanted by the required NCore PM_{10} monitoring at Parklane.
			SLAMS	Population Exposure	Lead	N/A	No changes anticipated at this time but monitoring may be supplanted by the required NCore Lead monitoring at Parklane.
Congaree Bluff	45-079-0021	December 27, 1999	SPM	General / Background	Ozone	Medium	No changes anticipated at this time.
			SPM	General / Background	SO_2	N/A	No changes planned at this time.
Sandhill Experimental Station	45-079-1001	January 1, 1959	SLAMS	Max Ozone Concentration	Ozone	Medium	No changes. This site fulfills the monitoring requirements for the MSA.
			SPM	General / Background	NO_2	N/A	No changes are anticipated at this time. The Department may have to discontinue monitoring at this location to

Appendix B: Recommendations for Network Optimization							
Site Name	**Site ID**	**Site Established**	**Monitor Type**	**Monitoring Objective**	**Pollutant/Method**	**Assigned Value from Assessment**	**Recommendations for Optimization**
				Max Precursor Emissions Impact			redirect resources to meet the requirements of the new NO_2 near-road monitoring network mandated by EPA.
York CMS	45-091-0006	March 30, 1993	SLAMS	Upwind Background	Ozone	High	No changes are anticipated at this time. Siting criteria may become an issue in the future as several trees are approaching heights that may impact probe exposure.
Georgetown CMS	45-043-0006	October 25, 1972	SPM	Source Oriented Highest Concentration	PM_{10}	N/A	This monitor is a candidate for removal. The original purpose of this monitor was to measure emissions from area industry. Reduced activity at surrounding industries and availability of data from local population exposure sites may allow discontinuation of the monitoring at this site.
Howard High School #3	45-043-0011	July, 15 2008	SPM	Population Exposure Highest Concentration	PM_{10}	N/A	This monitor will be maintained to provide an indicator of population exposure to emissions from industries near Georgetown.
Beck Administration Center	45-043-0012	July, 23, 2008	SPM	Population Exposure	PM_{10}	N/A	This site is a candidate for removal. The Beck Administration site is located far away from where the majority of the citizens in Georgetown live. Howard High #3 provides a better indicator of maximum population exposure.
Jackson Middle School	45-003-0003	October 24, 1985	SLAMS	Upwind Background	Ozone	Low	Based on this assessment, this site is a candidate for removal. This monitor provides upwind, background data supporting ozone forecasting for the CSA.
Trenton	45-037-0001	March 28, 1980	SPM	Extreme Downwind	$PM_{2.5}$	Medium	No changes are anticipated for this sampler.
			SPM	Extreme Downwind	$PM_{2.5}$ Continuous	N/A	No changes are anticipated.
			SLAMS	Highest	Ozone	Low	This monitor is a candidate for removal. This monitor does

Appendix B: Recommendations for Network Optimization							
Site Name	**Site ID**	**Site Established**	**Monitor Type**	**Monitoring Objective**	**Pollutant/Method**	**Assigned Value from Assessment**	**Recommendations for Optimization**
				Concentration/ Extreme Downwind			provide downwind and transport data supporting ozone forecasting for the CSA.
Bushy Park	45-015-0002	June 20, 1978	SLAMS	Max Ozone Concentration	Ozone	Low-site is heavily vegetated and may not meet Appendix E to Part 58 requirements	The monitor is being considered for relocation to better meet required monitoring and monitoring objectives for the Charleston – North Charleston MSA.
Jenkins Avenue Fire Station	45-019-0003	February 14, 1969	SLAMS	Highest Concentration	PM_{10}	N/A	No changes are anticipated at this time. This monitor currently fulfills the PM_{10} monitoring requirements for the MSA
			SLAMS	Population Exposure	Lead	N/A	The Department may discontinue lead monitoring at this site depending on requirements in the final lead network design criteria.
			SPM	Population Exposure	SO_2	N/A	No changes planned at this time.
			SPM	Highest Concentration, Source Oriented	NO_2	N/A	No changes are anticipated at this time. The Department may have to discontinue monitoring at this location to redirect resources to meet the requirements of the new NO_2 near-road monitoring network mandated by EPA.
Cape Romain	45-019-0046	July 11, 1983	SLAMS	General Background	Ozone	Medium	No changes are anticipated at this time. Cape Romain is South Carolina's sole Class I area.
			IMPROVE	IMPROVE protocol	$PM_{2.5}$ Speciation	N/A	No changes are anticipated at this time.
			SPM	General Background	$PM_{2.5}$ Continuous	N/A	No changes are anticipated at this time.

Appendix B: Recommendations for Network Optimization							
Site Name	**Site ID**	**Site Established**	**Monitor Type**	**Monitoring Objective**	**Pollutant/Method**	**Assigned Value from Assessment**	**Recommendations for Optimization**
			SPM	Source Oriented	SO_2	N/A	No changes planned at this time.
			SPM	General Background	NO_2	N/A	No changes are anticipated at this time. The Department may have to discontinue monitoring at this location to redirect resources to meet the requirements of the new NO_2 near-road monitoring network mandated by EPA.
			SPM	General Background	CO	N/A	No changes are anticipated at this time. Future regulatory actions related to CO may necessitate relocation of this monitor. The Department will reevaluate once the rule has been proposed and finalized.
FAA	45-019-0048	April 9, 1999	SPM	Population Exposure	$PM_{2.5}$	Medium	No changes. This monitor partially fulfills the minimum monitoring requirements for the MSA.
			QA Collocated	Population Exposure	$PM_{2.5}$ Collocated	N/A	No changes. This monitor fulfills the continuous monitoring requirement for the MSA.
Charleston Public Works	45-019-0049	November 20, 1998	SLAMS	Population Exposure	$PM_{2.5}$	Low	Recent study results indicate maximum population exposure may be better represented by monitoring in North Charleston. The Department expects to relocate $PM_{2.5}$ and $PM_{2.5}$ continuous to a new site in North Charleston. The STN $PM_{2.5}$ sampler will be moved to the NCore site in Columbia, SC starting January 1, 2011.
			SLAMS	Population Exposure	$PM_{2.5}$ Continuous	N/A	
			STN	Population Exposure	$PM_{2.5}$ Speciation	N/A	
Pee Dee Experimental Station	45-031-0003	February 25, 1993	SLAMS	Max Ozone Concentration	Ozone	High	No changes. This monitor fulfills the monitoring requirements for the MSA.
Williams Middle School	45-041-0003	August 4, 2008	SLAMS	Population Exposure Highest Concentration	$PM_{2.5}$	Medium	No changes. This site fulfills the monitoring requirements for the MSA.
			SPM	Population Exposure	$PM_{2.5}$ Continuous	N/A	No changes. This site fulfills the continuous $PM_{2.5}$ monitoring requirements for the MSA.

Appendix B: Recommendations for Network Optimization							
Site Name	**Site ID**	**Site Established**	**Monitor Type**	**Monitoring Objective**	**Pollutant/Method**	**Assigned Value from Assessment**	**Recommendations for Optimization**
				Highest Concentration			
Due West	45-001-0001	April 2, 1991	SLAMS	General / Background	Ozone	Medium	No changes anticipated at this time.
Chesterfield	45-025-0001	January 6, 2000	SLAMS	Regional Transport	$PM_{2.5}$	Medium	No changes anticipated at this time.
			SPM	Regional Transport	Continuous $PM_{2.5}$	N/A	No changes anticipated at this time.
			CSN	Regional Transport	Speciated $PM_{2.5}$	N/A	No changes anticipated at this time.
			SPM	General / Background	PM_{10}	N/A	No changes anticipated at this time.
			QA Collocated	General / Background	Collocated PM_{10}	N/A	No changes anticipated at this time.
			SPM	General / Background	Ozone	Medium	No changes anticipated at this time.
Ashton	45-029-0002	March 7, 1990	SPM	General / Background	$PM_{2.5}$ Continuous	N/A	This monitor is a candidate for removal.
			SPM	General / Background	Ozone	Medium	This monitor is a candidate for removal. This monitor is not required by the network design criteria, but data is useful for coastal plain characterization and forecasting.

Appendix C: South Carolina 2008 Ambient Air Design Values			
Parameter	Standard	Site Name	2008 Design Value
$PM_{2.5}$ Daily	35 µg/m^3	Bates House	28
		Chesterfield	25
		CPW	23
		FAA	24
		Irmo	28
		Long Creek	25
		Parklane	27
		Taylors	28
		Trenton	26
		West View	29
$PM_{2.5}$ Annual	15.0 µg/m^3	Bates House	13.2
		Chesterfield	12.0
		CPW	10.3
		FAA	11.0
		Irmo	13.7
		Long Creek	10.5
		Parklane	13.1
		Taylors	13.7
		Trenton	12.5
		West View	13.3
PM_{10}	1.0 Expected Exceedance	Bates House	0
		Cayce CMS	0
		Chesterfield	0
		Georgetown	0
		Jenkins Ave.	0
O_3	0.075 ppm	Bushy Park	0.063
		Cape Romain	0.072
		Clemson CMS	0.08
		Congaree Bluff	0.071
		Cowpens	0.074
		Due West	0.078
		Long Creek	0.071
		NSFS #2	0.084
		Parklane	0.078
		Pee Dee	0.075
		Sandhill	0.079
		Trenton	0.07
		York	0.077
		Ashton	0.073
		Jackson Middle School	0.076

Appendix C: South Carolina 2008 Ambient Air Design Values			
Parameter	Standard	Site Name	2008 Design Value
		Chesterfield	0.073
NO_2	0.053 ppm	Jenkins Ave.	0.0091
SO_2 Annual	0.03 ppm	Cape Romain	0.0014
		Congaree Bluff	0.001
		Irmo	0.0028
		Jenkins Ave.	0.002
		Long Creek	0.001
SO_2 24-Hour	0.14 ppm	Cape Romain	0.006
		Congaree Bluff	0.009
		Irmo	0.016
		Jenkins Ave.	0.011
		Long Creek	0.005
SO_2 3-Hour	0.5 ppm	Cape Romain	0.017
		Congaree Bluff	0.042
		Irmo	0.059
		Jenkins Ave.	0.038
		Long Creek	0.014
CO 1-Hour	35 ppb	Cape Romain	0.8
CO 8-Hour	9 ppb	Cape Romain	0.5
Lead	0.15 $\mu g/m^3$	Jenkins Ave.	0.01

Appendix D: Climate and Meteorological Analysis

The following pages describe meteorology and climate for all areas of South Carolina where ambient air monitoring exists as of January 1, 2010. Each area of the state that has monitoring is paired with a National Weather Service station and a description of the climate for each area is given followed by an analysis of windroses generated for the year, ozone monitoring season (currently, April – October) and quarterly.

Abbeville County Meteorology and Climate

Abbeville County is located in the lower Piedmont of South Carolina, adjacent to the Georgia state line. The Abbeville County area is represented by the National Weather Service office station located in Greenwood, South Carolina. Greenwood is located in Greenwood County, which is just east of Abbeville County. Abbeville County lies in between the more temperate climate to the north and west and the more subtropical climate to the south and east. Winters are generally mild with sporadic cold outbreaks which are modified by the Appalachian Mountains. Chilly, wedge scenrios are common during the cooler months when high pressure, to the north, ridges down just east of the Appalachain Mountains. This pattern results in cloudy, chilly weather with drizzle and sometimes heavier precipitation is possible when weather systems approach from the west or southwest. During the summer months, when the Bermuda high is centered close to climatology, very warm to hot weather is common across the Abbeville County area with afternoon thunderstorms possible from time to time. When the Bermuda high is displaced to the south and west of its normal position, hot and dry conditions often develop across the Abbeville County with little chances for afternoon thunderstorm activity. During these summers, drought can develop across the South Carolina. Elevated ozone concentrations are generally more common during these hot and dry summers.

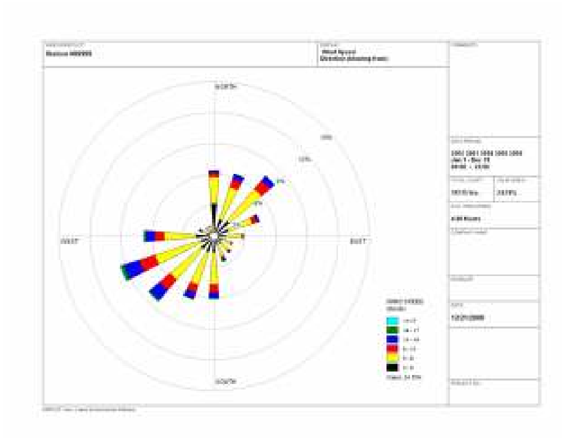
Using the Greenwood weather station, a series of windroses was developed for the lower Piedmont of South Carolina. The annual windrose represents wind patterns across the lower Piedmont throughout the entire year. On an annual basis, the dominant wind directions are from the southwest, west, west-southwest and from the northeast. Wind directions that are least common include south-southeast winds, southeast, east-southeast, easterly, northwesterly, and north-northwesterly winds. The average wind speed for an entire year is 4.98 knots with calm winds occurring 25 percent of the time.

The second windrose represents the wind patterns during ozone season. Ozone season runs from April through October across Abbeville County. Wind patterns during the ozone season look very similar to the annual wind rose. Average wind speeds for the ozone season windrose are 4.63 knots with calm winds occurring 26 percent of the time.

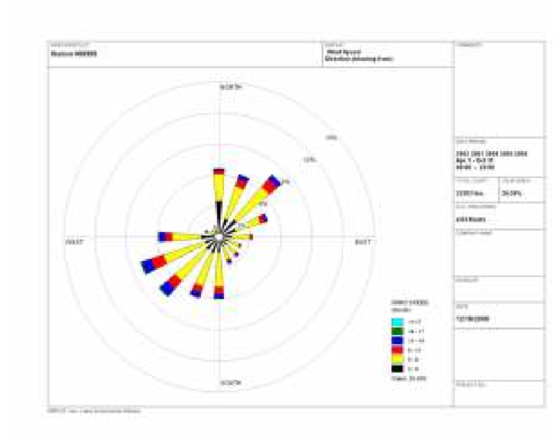
The next four wind roses are broken up into the four quarters that make up one year. January through March represents the first quarter, April through June represents the second quarter, the third quarter includes July through September, and the fourth quarter runs from October thruogh December. The first quarter windroses indicates that a southwesterly, west-southwesterly, and westerly wind directions are most common. Average wind speeds during the first quarter are 5.94 knots with calm winds occurring 18 percent of the time. The third quarter windrose shows that a variety of different wind directions occur across Abbeville County. The least frequent wind directions are from the southeast, south-southeast, east-southeast, east, west, west-northwest, and northwest. Average wind speeds during the third quarter are 4.20 knots with calm winds occurring 30 percent of the time. Finally, the fourth quarter windrose shows winds from the southwest, west-southwest, west, north, north-northeast, and northeast are the more common wind directions. Average wind speeds during the fourth quarter are 4.60 knots with calm wnids occurring 29 percent of the time.

Greenwood-Abbeville County Annual Windrose (2002-2006)

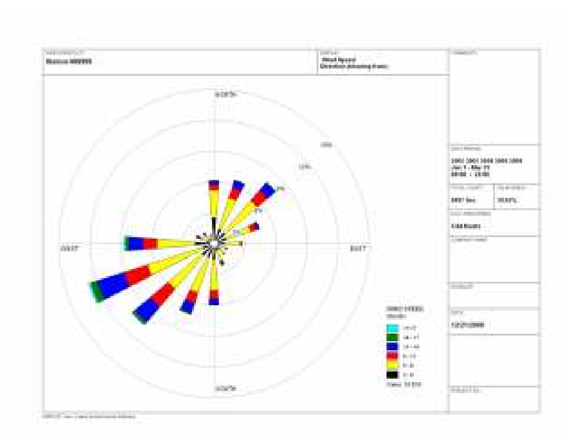
Greenwood-Abbeville County Ozone Season Windrose (2002-2006)



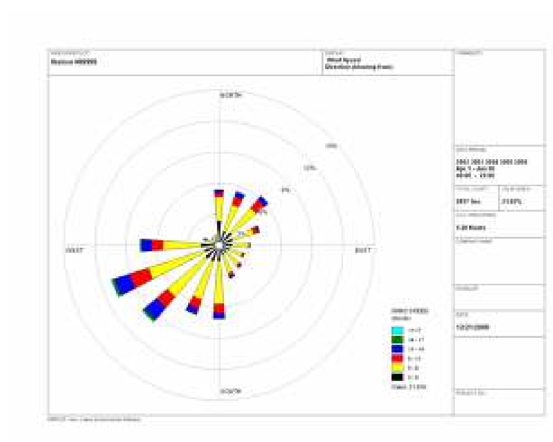
Greenwood-Abbeville County 1st Quarter Windrose (2002-2006)



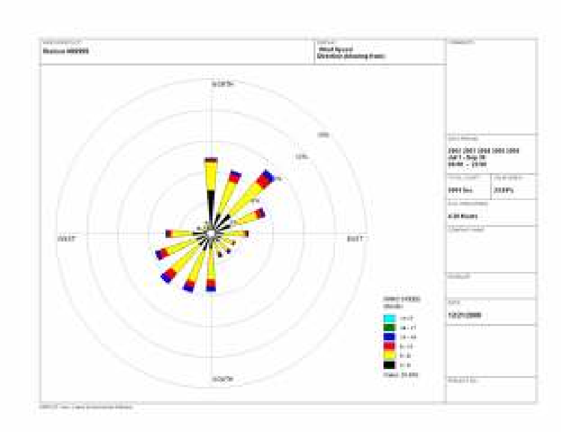
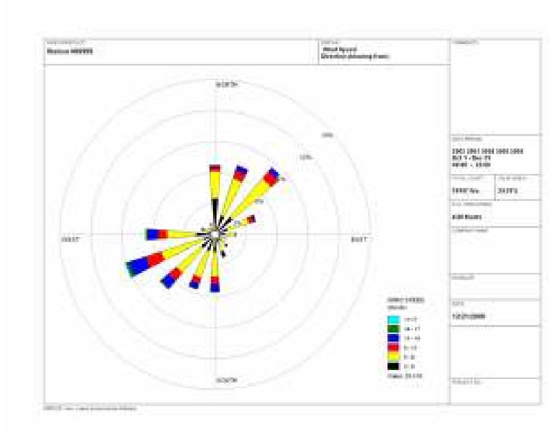
Greenwood-Abbeville County 2nd Quarter Windrose (2002-2006)



Greenwood-Abbeville County 3rd Quarter Windrose (2002-2006)



Greenwood-Abbeville County 4th Quarter Windrose (2002-2006)

Anderson MSA Meteorology and Climate

The Anderson area is located just south and east of the Appalachian Mountains, near the Georgia border. This area is frequently referred to as the Upstate of South Carolina. Anderson County area's elevation above sea level is significantly higher than is the midlands of South Carolina. The Anderson County area is represented by the National Weather Service office station known as Greer. Greer is located almost half way between the cities of Greenville and Spartanburg. Meteorological conditions are a bit more temperate here than the more subtropical conditions across the midlands and inland, coastal plains. Occasional cold spells can affect the area during the winter months; however, these cold spells are modified by the Appalachian Mountains located just north and west of the Anderson area. Chilly, wedge scenarios are common during the cooler months when high pressure, to the north, ridges down just east of the Appalachian Mountains. This pattern results in cloudy, chilly weather with drizzle and sometimes heavier precipitation possible when weather systems approach from the west or southwest. Summers in the Anderson area are noticeably milder than the summers across the Midlands of South Carolina. During the summer months, when the Bermuda high is centered close to the climatology, very warm weather is common across the Upstate with afternoon thunderstorms possible from time to time. When the Bermuda high is displaced to the south and west of its normal position, hot and dry conditions often develop across the Upstate with little chances for afternoon thunderstorm activity. During these summers, drought can develop across the Upstate of South Carolina. Elevated ozone concentrations are generally more common during these hot and dry summers.

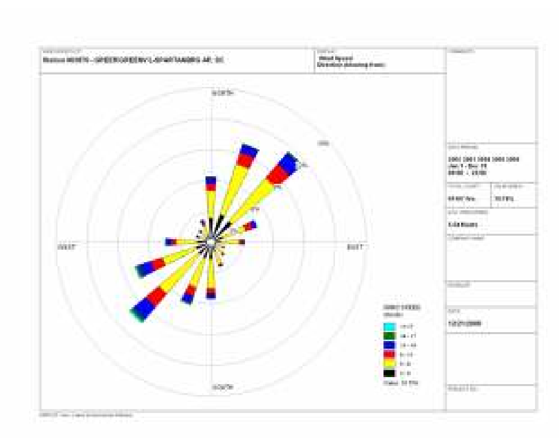
Using the Greer weather station, a series of windroses was developed for the Upstate of South Carolina. The annual windrose represents wind patterns across the Upstate throughout the entire year. Dominant wind directions are from the southwest and from the northeast across the Upstate on an annual basis. These dominant southwesterly and northeasterly wind directions are partially due to the Appalachian Mountains that run from the northeast to the southwest, located just north and west of the Anderson area. It is easy to see how the wind patterns are parallel to the mountain range located just to the north and west. This mountain range helps to funnel the air flow from the southwest to northeast and from the northeast to southwest, depending on other meteorological conditions. The average annual wind speed across the Anderson area is 5.54 knots with calm winds occurring nineteen percent of the time.

The next windrose represents the wind patterns during ozone season across the Upstate. Ozone season runs from April through October across the Upstate. Once again, the pattern that occurred during the annual time period shows up again for the ozone season. Southwesterly and northeasterly wind directions are dominant during ozone season. This results in ozone precursor transport from the Charlotte and

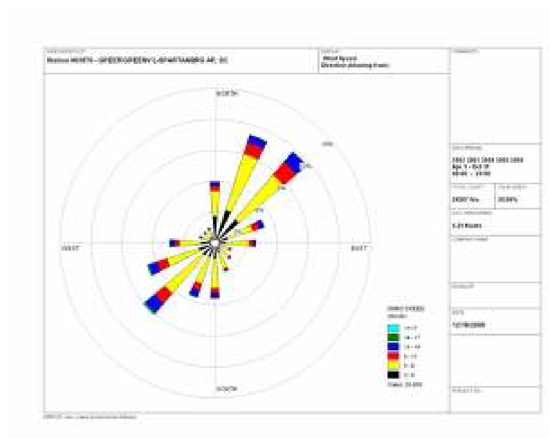
Atlanta areas into the Upstate of South Carolina throughout ozone season. The average wind speed from April through October is 5.21 knots with calm winds representing twenty percent of the wind speeds.

The next four windroses represents each quarter during the year. The first quarter runs from January through March, the second quarter runs from April through June, the third quarter runs from July through September, and the fourth quarter runs from October through December. The first quarter windrose indicates no suprises. Just as with the annual and ozone windroses, the first quarter windrose shows an even more extreme southwest to northeast or northeast to southwest flow across the Upstate. The average wind speed during the first quarter is 6.42 knots with calm winds occurring only fifteen percent of the time. During the second quarter, the dominant wind directions are once again skewed by the Appalachian Mountains. Dominant wind directions from the southwest to northeast or northeast to southwest again prevail across the Upstate. The average wind speed during the second quarter is 5.83 knots with calm winds occurring seventeen percent of the time. The third quarter windrose shows a somewhat different wind pattern than the first four windroses. Dominant wind directions are from the north-northeast and northeast with the southwesterly wind direction being quite a bit less dominant. This is due to the northeasterly bias that occurs throughout much of South Carolina during the latter half of the third quarter, especially during the month of September. This north-northeasterly and northeasterly wind is even more common in the Upstate due to the southwest to northeasterly running Appalachian Mountains. The average wind speed during the third quarter is the lowest wind speed for any quarter, at 4.65 knots. Calm winds make up 23 percent of the wind speeds during the third quarter. This is the largest amounts of calms of any quarter. The fourth quarter also shows the most dominant wind direction is from the north-northeast and from the northeast with a secondary, smaller maximum, occurring from the southwest. The average wind speed for the fourth quarter is 5.29 knots with calms occurring 21 percent of the time.

Greer- Anderson MSA Annual Windroses (2002-2006)

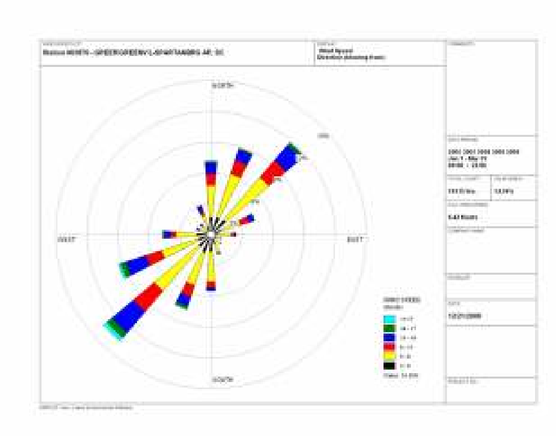


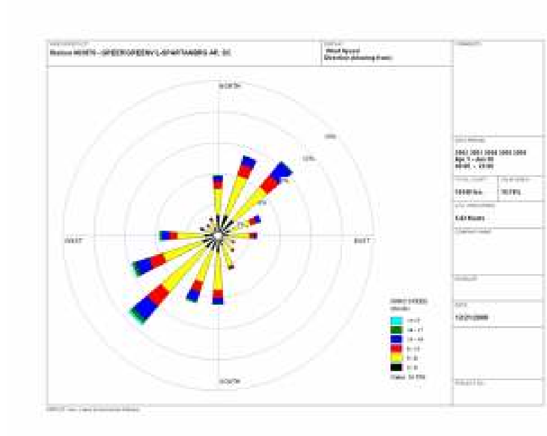
Greer- Anderson MSA Ozone Season Windroses (2002-2006)



Greer- Anderson MSA 1st Quarter Windroses (2002-2006)

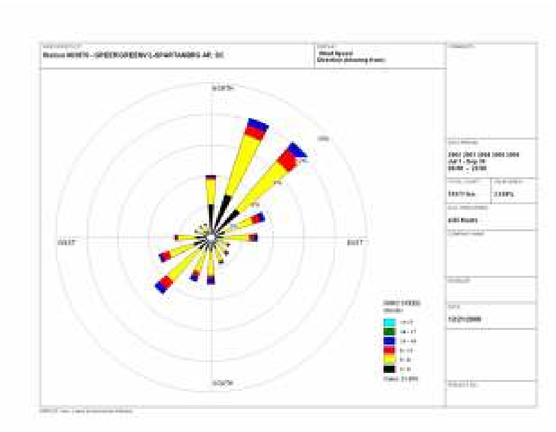
Greer- Anderson MSA 2nd Quarter Windroses (2002-2006)

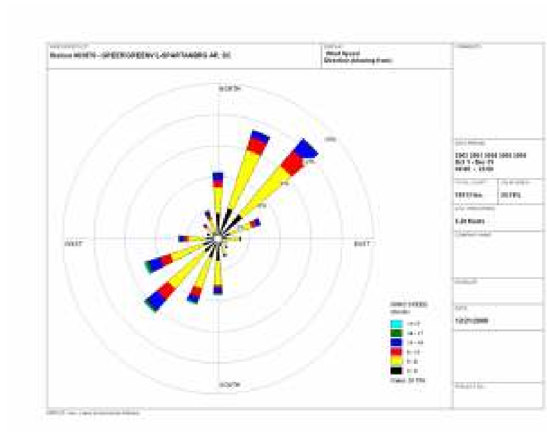




Greer- Anderson MSA 3rd Quarter Windroses (2002-2006)

Greer- Anderson MSA 4th Quarter Windroses (2002-2006)





Augusta-Richmond County MSA Meteorology and Climate

The eastern portion of the Augusta-Richmond MSA extends into the west–central part of South Carolina.This area is often referred to at the Central Savannah River area. The most representative meteorological data for the central Savannah River of South Carolina is just over the border in Georgia at the Augusta National Weather Service Office. The Central Savannah River area of South Carolina has sporadic cold outbreaks during the winter months; however, the Appalachian Mountains to the west and north block the coldest of air masses from invading the west-central portion of the state. For this reason, the Central Savannah River area stays relatively mild during most of the winter months when compared to other sections of the Southeast. The terrain and the location away from the ocean results in little relief from the summer heat that is common during the summer months. Hot weather along with scattered afternoon and evening thunderstorms are the norm across the Central Savannah River area for three to four months out of the year. Rainfall can be quite variable during the summer months, and this variability is associated with the strength and position of the Bermuda high. During a normal summer, the Bermuda high is centered well out into the Atlantic with its western flank extending into the Southeastern United States. This normal position of the Bermuda high keeps a moist and unstable, southwesterly flow across South Carolina during the summer. With day time heating, scattered afternoon and evening thunderstorms occur. In some years, the Bermuda high is centered south and west of its normal position, which cuts off the Gulf of Mexico and results in subsidence across the Southeast. This pattern results in fair weather with very hot temperatures. The normal scattered afternoon and evening thunderstorm activity is suppressed, and this pattern is very favorable for droughts across much of the Southeast, including South Carolina. During these very hot and dry summers, ozone levels can rise to above normal levels, resulting in some exceedances across the region.

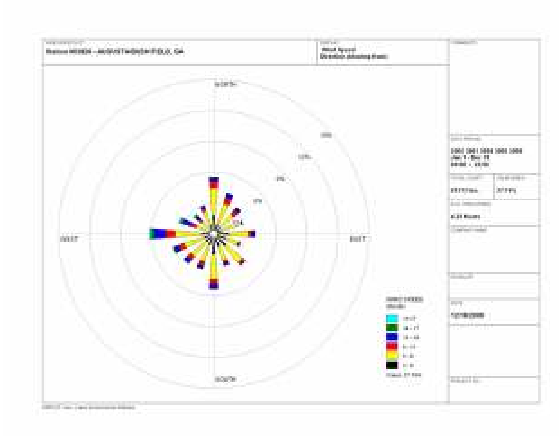
Since the Augusta area and much of the central Savannah River area is in a river valley, the wind directions are frequently skewed resulting in a more northerly or southerly component than otherwise would be. Wind speeds are generally less near the Augusta area, and many more calms are likely than some of the other weather stations due to the adjacent river valley. The first windrose created for the central Savannah River area shows the annual wind pattern and speeds that occur on a yearly basis. On an annual basis, the dominant wind directions are from the west, north, and from the south. The westerly component is seen through the central portions of South Carolina during the winter months. The northerly and southerly components are mostly likely due to the adjacent Savannah River which stretches northwest to southeast, creating a natural barrier between South Carolina and Georgia. The average annual wind speed at the Augusta site is 4.23 knots with calm winds occurring about 37 percent of the time.

The ozone season windrose looks a great deal like the annual windrose, except for the fact the three wind directions listed above are not quite as dominant during this period. The most dominant wind directions during ozone season are westerly, northerly, easterly, southeasterly, and southerly. Westerly wind directions can frequently transport ozone pre-cursors into the Central Savannah River area from the Atlanta metro area. Average wind speeds during ozone season are 3.91 knots with calm winds occurring 39 percent of the time.

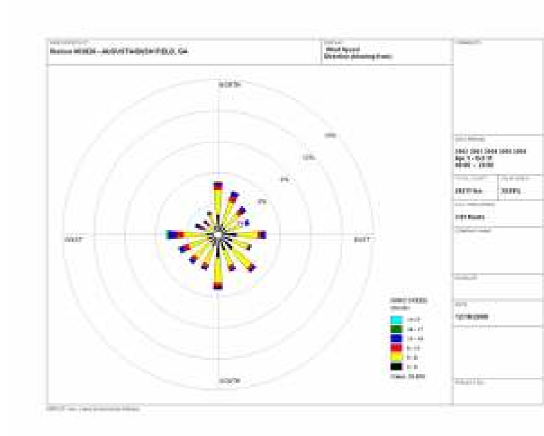
The next four windroses are broken up in quarters. The first quarterly windrose runs from January through March, the second quarterly windrose runs from April through June, the third quarterly wind rose runs from July through September, and the fourth quarterly windrose runs from October through December. The first quarter windrose for the Central Savannah River area shows that the most dominant wind direction is from the west with a southerly and northerly wind direction coming in at a close second. Average wind speeds during the first quarter are 5.23 knots with calm winds occurring 30 percent of the time. The second quarter windrose indicates that the most dominant wind direction are from the west, south, southeast, north, and west-southwest. The average wind speed during the second quarter is 4.38 knots with calm winds occurring 35 percent of the time. During the third quarter, the dominant wind directions in the Central Savannah River area are from the north, the north-northeast, the east, the southeast, and the south. Average wind speeds during the third quarter are only 3.74 knots with calm winds occurring 39 percent of the time. The fourth quarter windrose indicates that the most dominant winds originate from west. Winds from the south and the north also occur quite often during the fourth quarter. The average wind speed during the fourth quarter is 3.68 knots with calm winds occurring 46 percent of the time.

Augusta-Richmond County MSA Annual Windroses (2002-2006)

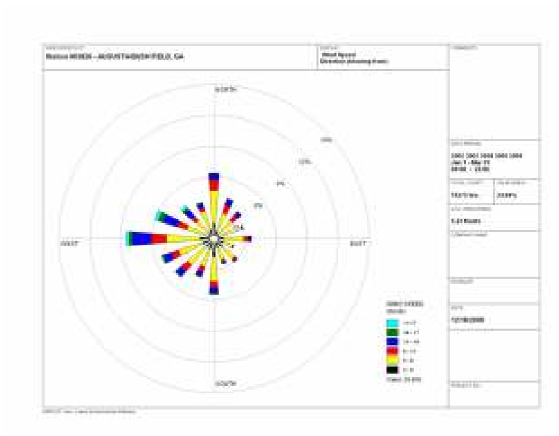
Augusta-Richmond County MSA Ozone Season Windroses (2002-2006)



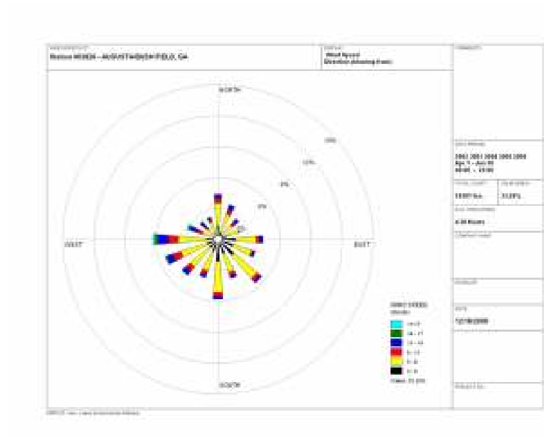
Augusta-Richmond County MSA 1st Quarter Windroses (2002-2006)



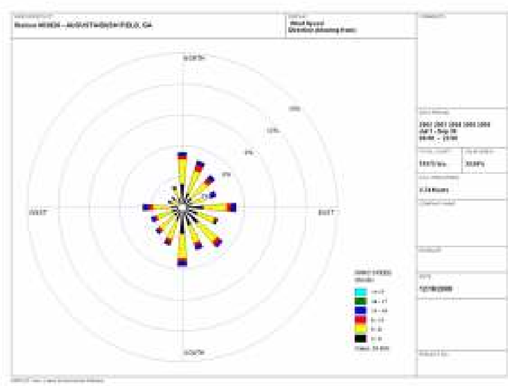
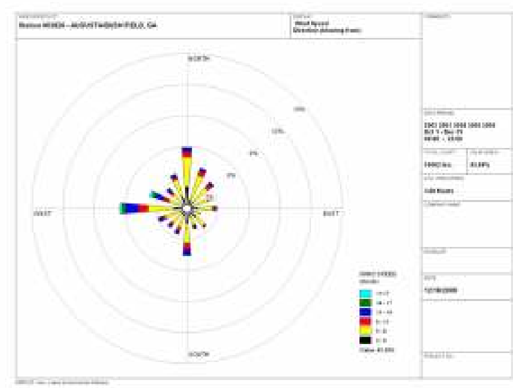
Augusta-Richmond County MSA 2nd Quarter Windroses (2002-2006)



Augusta-Richmond County MSA 3rd Quarter Windroses (2002-2006)



Augusta-Richmond County MSA 4th Quarter Windroses (2002-2006)

Charleston-North Charleston MSA Meteorology and Climate

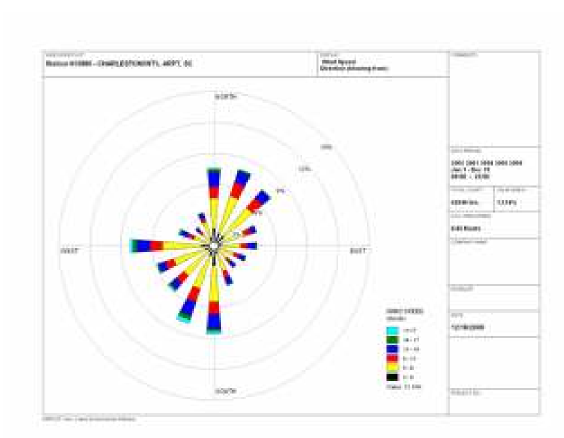
It should be noted that most pollutant concentrations are generally lower in the Charleston County area than in other parts of South Carolina. This is primarily due to the sea breeze which pushes inland during the warmer months. In many instances, this meteorological phenomenon cleans out the air in coastal counties of South Carolina. As a result, the air quality is good across Charleston County much of the time. Charleston's climate is marine, subtropical with mild winters and very warm and humid summers. During the winter months, cold air masses are modified significantly, having a hard time passing across the Appalachian Mountains. In addition, the close proximity of the Gulf Stream helps to modify cold air masses. Hard freezes are rare in the city of Charleston and along the immediate coast. During a normal summer, the Bermuda high pressure's western flank covers the Southeastern United States. This pumps in a very warm, moist, and unstable air mass across the Southeast, resulting in scattered afternoon and evening thunderstorms across coastal South Carolina. During the warmer months, a pressure gradient develops between the ocean and the land. The colder water temperatures and warmer land temperatures result in lower pressure across the land with higher pressure just above the ocean. This sets up a pressure gradient which causes winds to blow from the ocean to the land. As a result, the sea breeze develops during the warmer months. As a result, winds blow from the oceans (from the south) northward across the land. This ocean to land breeze (the sea breeze) results in cleaner air across the coastal counties of South Carolina. During some summers, the Bermuda high is centered south and west of its normal position, cutting off Gulf moisture and resulting in hot and dry summers across the coastal counties. When this occurs, the normal scattered afternoon and evening thunderstorm activity is suppressed, and much of the area may experience drought. Ozone concentrations tend to be higher during these hot and dry summers.

The windroses depict the five year wind direction and speeds at the Charleston airport. The 2002-2006 annual windrose for Charleston shows three dominant transport regimes. Winds most often come from a north and northeasterly directions, from a south, south-southwest, or westerly directions. Winds rarely come from an easterly, southeasterly, or northwesterly direction. The average annual wind speed for the Charleston area is 6.35 knots with 13 percent of the hours having calm winds.

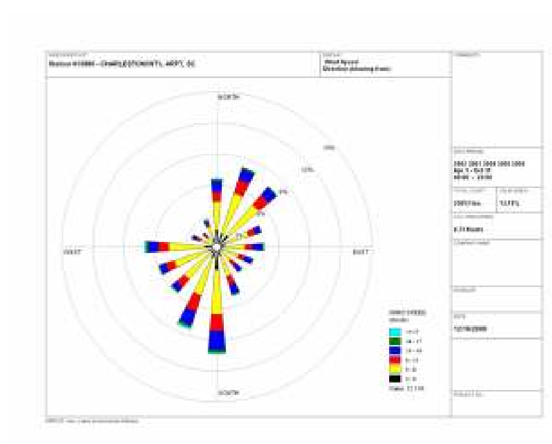
A windrose was also created for ozone season which runs from April through October. During the ozone season, the windrose shows that the most dominant wind direction is from the south. This southerly wind direction is the result of the sea breeze that develops during the warm months across the coastal areas of South Carolina. As the sea breeze pushes inland, a southerly flow off the ocean develops, and this generally keeps ozone levels lower in the Charleston area. During ozone season, the wind rose also depicts common wind directions occurring from the south-southwest, westerly, and northeasterly directions. The average wind speed during the ozone season is 6.73 knots with 12 percent of the hours having calm winds.

The remaining windroses were created for each quarter of the year. The first quarter runs from January through March, with the second quarter running from April through June. July through September represents the third quarter, with the fourth quarter running from October through December. The first quarter wind rose shows two dominant wind directions. Wind directions from the north and from the west occur more often than other wind directions. Winds also frequently come from the southwest during the first quarter. Average wind speeds during the first quarter are 7.46 knots with 11 percent of the hours having calm winds. The second quarter runs from spring into early summer. As expected, the dominant wind directions during this quarter are from the south and south-southwest. The more dominant southerly direction is caused by the sea breeze which frequently develops during the spring and early summer. The average wind speed during the second quarter is 7.21 knots. Winds are calm 10 percent of the time which is the least amount of calm hours during any quarter. This low amount of calm hours is likely due to the contrast in sea and land temperatures. The third quarter wind rose shows two dominant wind directions. Winds from the south and from the northeast occur most often during the third quarter. The southerly wind direction is most likely to occur during July and August when the sea breeze is still a common phenomenon. During the latter half of the period, wind directions switch off to the northeast, which is a common wind direction across much of South Carolina, especially during September. The average wind speed during the third quarter is 6.60 knots with 12 percent of the hours having calm winds. During the colder fourth quarter, the windrose shows the dominant wind directions originating from the north, northeast, and west. In contrast with the warmer second and third quarters, the fourth quarter wind rose shows minimal wind directions from the south. This is due to the absence of a sea breeze during the colder, winter months. Average wind speeds for the fourth quarter are 6.14 knots with calms occurring 19 percent of the time.

Charleston-North Charleston MSA Annual Windroses (2002-2006)



Charleston-North Charleston MSA Ozone Season Windroses (2002-2006)

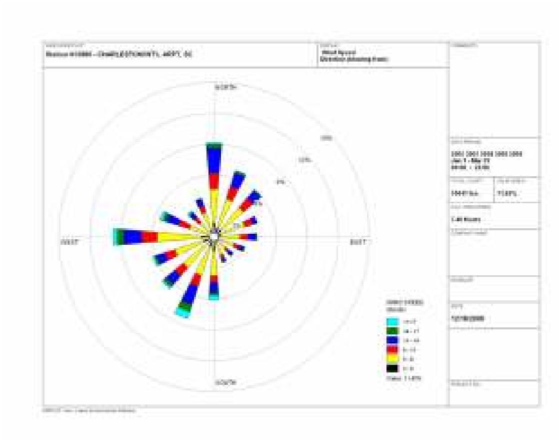


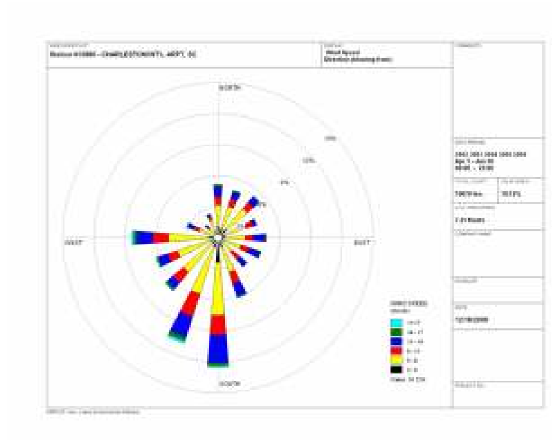
Charleston-North Charleston MSA 1st Quarter

Charleston-North Charleston MSA 2nd

Windroses (2002-2006)

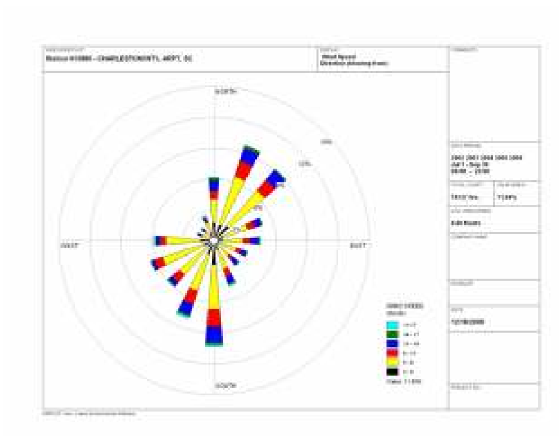
Quarter Windroses (2002-2006)

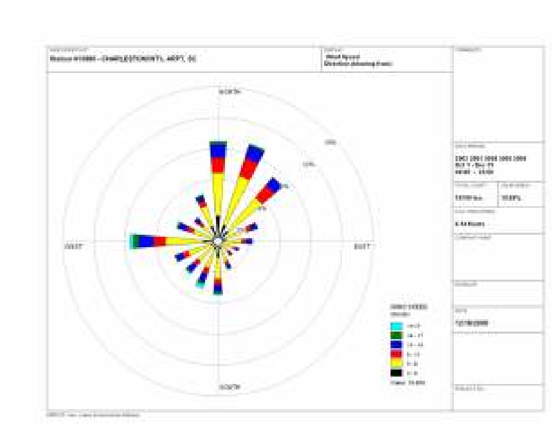




Charleston-North Charleston MSA 3rd Quarter Windroses (2002-2006)

Charleston-North Charleston MSA 4th Quarter Windroses (2002-2006)





Charlotte-Gastonia-Concord MSA Meteorology and Climate

The York area is located in the north-central portion of South Carolina, an area known as the upper Piedmont. The York county area's elevation above sea level is significantly higher than is the Midlands of South Carolina. The York County area meteorological conditions are represented by the Charlotte National Weather Service office station. Charlotte is located just north of York, across south-central North Carolina. Meteorological conditions are a bit more temperate here than the more subtropical conditions across the Midlands and inland, coastal plains. Occational cold spells can affect the area during the winter months; however, these cold spells a modified by the Appalachian Mountains located north and west of the York area. Chilly, wedge scenrios are common during the cooler months when high pressure, to the north, ridges down just east of the Appalachain Mountains. This pattern results in cloudy, chilly weather with drizzle and sometimes heavier precipitation is possible when weather systems approach from the west or southwest. Summers in the Charlotte area are noticably milder than the summers across the Midlands of South Carolina. During the summer months, when the Bermuda high is centered close to climatology, very warm weather is common across the upper Piedmont with afternoon thunderstorms possible from time to time. When the Bermuda high is displace to the south and west of its normal position, hot and dry conditions often develop across the upper Piedmont with little chances for afternoon thunderstorm activity. During these summers, drought can develop across the Piedmont of South Carolina. Ozone exceedances are generally more common during the hot and dry summers.

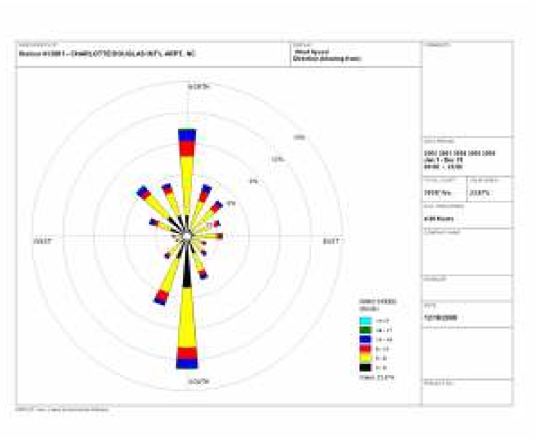
The National Weather Service station at Charlotte was used to create windroes for the north-central portions of South Carolina. The Charlotte station is located in an indention that runs from north to south across the area. This indention in topography skews the wind directions to a more northerly and southerly direction. An annual windrose was created for the Charlotte area using 2002 through 2006 wind data. On an annual basis, the windrose shows that the dominant wind directions are from the north and south. This more northerly and southerly component to the wind direction is related to the topography in the Charlotte area. The avarage wind direction on an annual basis is 4.98 knots with calm winds occurring 22 percent of the time.

The second windrose was created during the ozone season for the Charlotte area. Ozone season runs from April through October in the York County area. The Ozone season windrose looks very similar to the annual windrose at Charlotte. Once again, the northerly and southerly wind directions are the most dominant during the ozone season. The average wind speed during the ozone season is 4.76 knots with calm winds occurring 24 percent of the time.

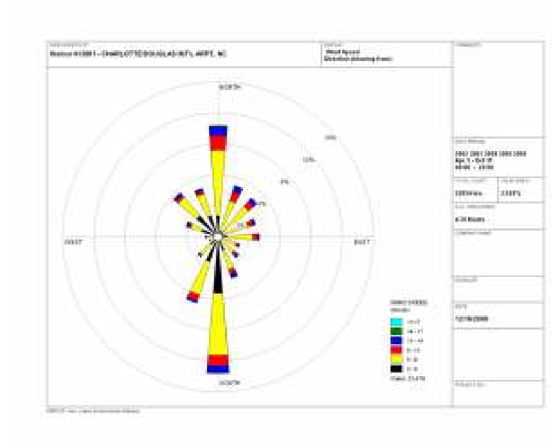
The next four windroses are broken up by quarters. January through March represents the first quarter, April through June represents the second quarter, July through September represents the third quarter, and the fourth quarter runs from October through December. The first quarter wind rose is similar to the annual and ozone season windroses. Again, the most dominant wind directions are from the south and the north. The average wind speed during the first quarter is 5.69 knots with calms winds occurring 17 percent of the time. A southerly wind direction is by far the most dominant wind direction during the second quarter with the norherly direction also occurring quite often. The avearage wind speed during the second quarter is 5.15 knots with calm winds occurring 21 percent of the time. A northerly wind direction is by far the most common wind direction during the third quarter. This is most likely due to the second half of the third quarter when wind directions across most areas turn a bit more to the northeast. A northeast wind is likely being skewed to a more northerly direction in the Charlotte area due to the terrain influences. The average wind direction during the third quarter is 4.49 knots with calm winds occurring 25 percnet of the time. There are three dominant wind directions during the fourth quarter across the Charlotte area. Northerly, northwesterly, and southerly wind directions are dominant during the fourth quarter with an average wind speed of 4.62 knots. Calm winds occur 27 percent of the time during the fourth quarter.

Charlotte-Gastonia-Concord MSA Annual Windroses (2002-2006)

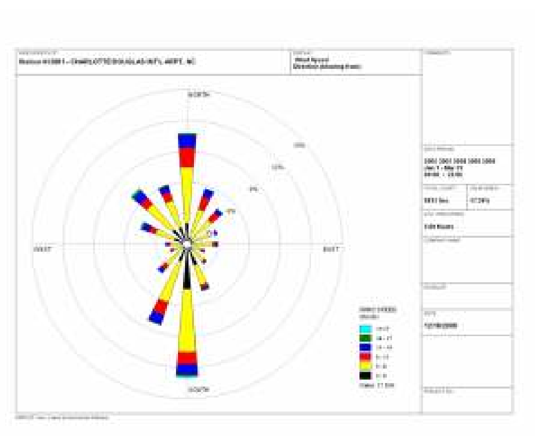
Charlotte-Gastonia-Concord MSA Ozone Season Windroses (2002-2006)



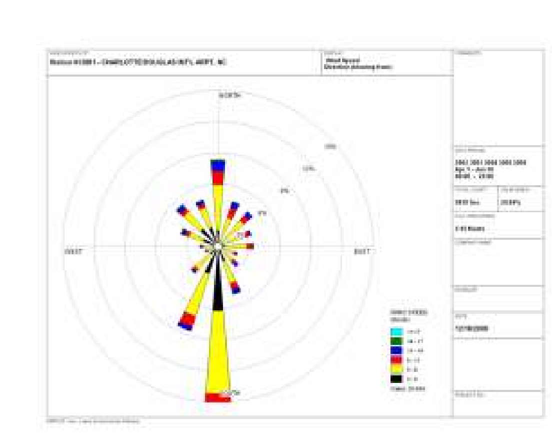
Charlotte-Gastonia-Concord MSA 1st Quarter Windroses (2002-2006)



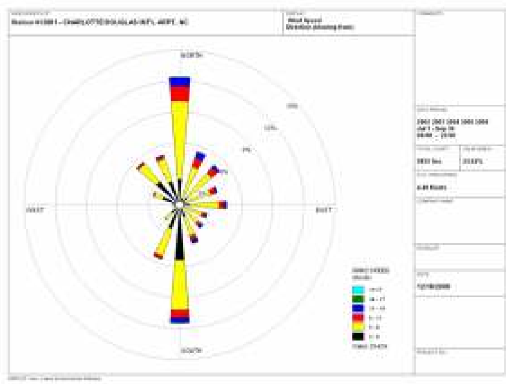
Charlotte-Gastonia-Concord MSA 2nd Quarter Windroses (2002-2006)

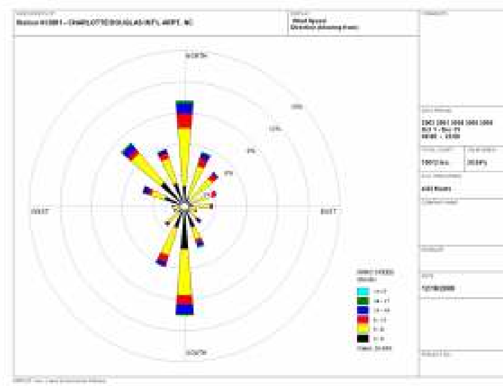


Charlotte-Gastonia-Concord MSA 3rd Quarter Windroses (2002-2006)



Charlotte-Gastonia-Concord MSA 4th Quarter Windroses (2002-2006)





Gaffney mSA Meteorology and Climate

Gaffney is located in the upper Piedmont of South Carolina, in Cherokee County. This area is frequently referred to as the Upstate of South Carolina. The Cherokee county area's elevation above sea level is significantly higher than is the Midlands of South Carolina. The Cherokee County area is represented by the National Weather Service office station known as Greer. Greer is located almost half way between the city of Greenville and Spartanburg. Meteorological conditions are a bit more temperate here than the more subtropical conditions across the Midlands and inland, coastal plains. Occasional cold spells can affect the area during the winter months; however, these cold spells are modified by the Appalachian Mountains located just north and west of the Gaffney area. Chilly, wedge scenarios are common during the cooler months when high pressure, to the north, ridges down just east of the Appalachian Mountains. This pattern results in cloudy, chilly weather with drizzle and sometimes heavier precipitation is possible when weather systems approach from the west or southwest. Summers in the Gaffney area are noticeably milder than the summers across the Midlands of South Carolina. During the summer months when the Bermuda high is centered close to climatology, very warm weather is common across the Upstate with afternoon thunderstorms possible from time to time. When the Bermuda high is displaced to the south and west of its normal position, hot and dry conditions often develop across the Upstate with little chances for afternoon thunderstorm activity. During these summers, drought can develop across the Upstate of South Carolina. Elevated ozone concentrations are generally more common during these hot and dry summers.

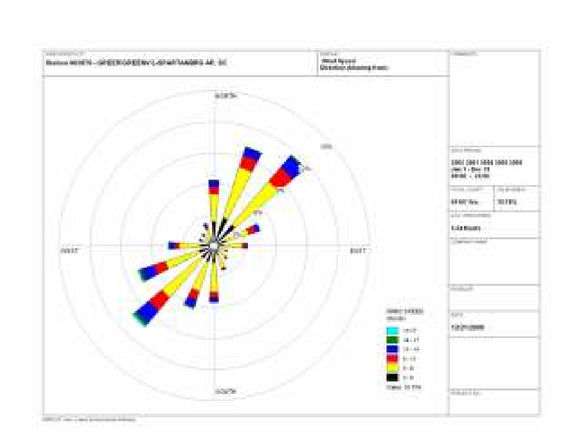
Using the Greer weather station, a series of windroses was developed for the Upstate of South Carolina. The annual windrose represents wind patterns across the Upstate throughout the entire year. Dominant wind directions are from the southwest and from the northeast across the Upstate on an annual basis. These dominant southwesterly and northeasterly wind directions are partially due to the Appalachian Mountains that run from the northeast to the southwest, located just north and west of the Gaffney area. It is easy to see how the wind patterns are parallel to the mountain range located just to the north and west. This mountain range helps to funnel the air flow from the southwest to northeast and from the northeast to southwest, depending on other meteorological conditions. The average annual wind speed across the Gaffney area is 5.54 knots with calm winds occurring nineteen percent of the time.

The next windrose represents the wind patterns during ozone season across the Upstate. Ozone season runs from April through October across the Upstate. Once again, the pattern that occurred during the annual time period shows up again for the ozone season. Southwesterly and northeasterly wind directions are dominant during ozone season. This results in ozone precursor transport from the Charlotte and

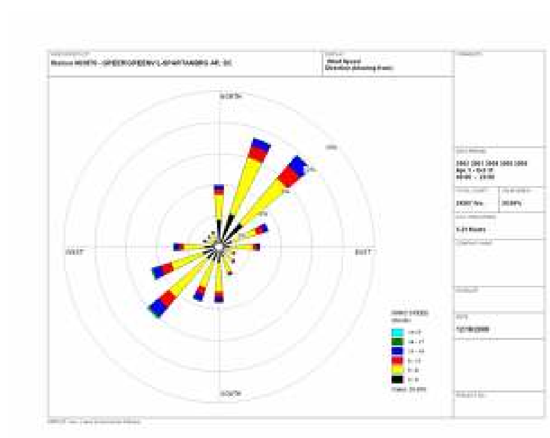
Atlanta areas into the Upstate of South Carolina throughout ozone season. The average wind speed from April through October is 5.21 knots with calm winds representing twenty percent of the wind speeds.

The next four windroses represents each quarter during the year. The first quarter runs from January through March, the second quarter runs from April through June, the third quarter runs from July through September, and the fourth quarter runs from October through December. The first quarter windrose indicates no surprises. Just as with the annual and ozone windroses, the first quarter windrose shows a southwest to northeast or northeast to southwest flow across the Upstate. The average wind speed during the first quarter is 6.42 knots with calm winds occurring only 15 percent of the time. During the second quarter, the dominant wind directions are once again skewed by the Appalachian Mountains. Dominant wind directions from the southwest to northeast or northeast to southwest once again prevail across the Upstate. The average windspeed during the second quarter is 5.83 knots with calm winds occurring seventeen percent of the time. The third quarter windrose shows a somewhat different wind pattern than the first four windroses. Dominant wind directions are from the north-northeast and northeast with the southwesterly wind direction being quite a bit less dominant. This is due to the northeasterly bias that occurs throughout much of South Carolina during the latter half of the third quarter, especially during the month of September. This north-northeasterly and northeasterly wind is even more common in the Upstate due to the southwest to northeasterly running Appalachian Mountains. The average wind speed during the third quarter is the lowest wind speed for any quarter, at 4.65 knots. Calm winds make up 23 percent of the wind speeds during the third quarter. This is the largest amounts of calms of any quarter. The fourth quarter also shows the most dominant wind direction being from the north-northeast and from the northeast with a secondary, smaller maximum occurring from the southwest. The average wind speed for the fourth quarter is 5.29 knots with calms occurring 21 percent of the time.

Gaffney mSA Annual Windroses (2002-2006)

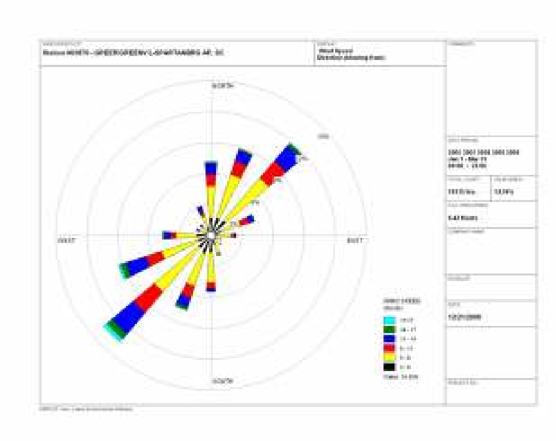


Gaffney mSA Ozone Season Windroses (2002-2006)

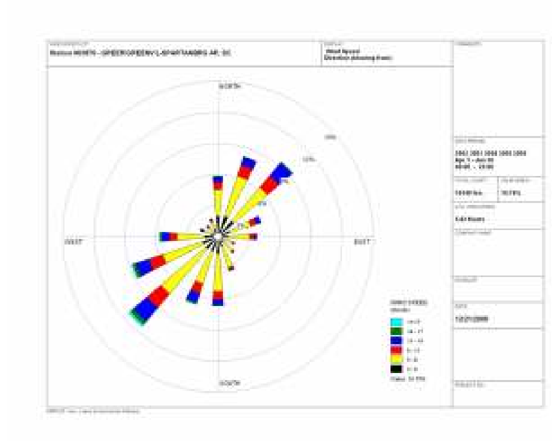


Greer-Gaffney MSA 1st Quarter Windroses (2002-2006)

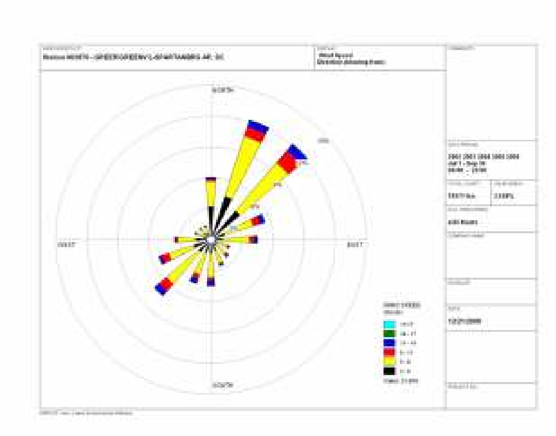
Greer-Gaffney MSA 2nd Quarter Windroses (2002-2006)

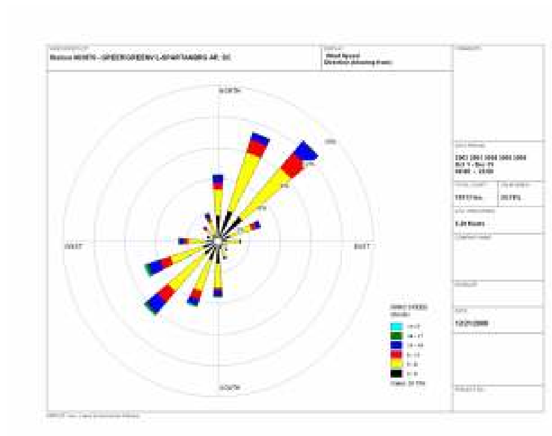


Greer-Gaffney MSA 3rd Quarter Windroses (2002-2006)



Greer-Gaffney MSA 4th Quarter Windroses (2002-2006)





** Greenville windroses were used instead of Charlotte windroses. The reason for this is that the wind directions in the Charlotte area are skewed from north to south or south to north due to an indention in the topography.

Chesterfield County Meteorology and Climate

Chesterfield County, South Carolina is located in the northeastern portion of South Carolina, just south of the North Carolina border. The most representative meteorological site for Chesterfield is located in North Carolina, and is known as the Lauringburg-Maxton station. Chesterfield County lies in between the more temperate climate to the north and west and the more subtropical climate to the south and east. Winters are generally mild with sporadic cold outbreaks which are modified by the Appalachian Mountains. Chilly, wedge scenrios are common during the cooler months when high pressure, to the north, ridges down just east of the Appalachain mountains. This pattern results in cloudy, chilly weather with drizzle and sometimes heavier precipitation is possible when weather systems approach from the west or southwest. During the summer months, when the Bermuda high is centered close to climatology, very warm to hot weather is common across the Chesterfield County area with afternoon thunderstorms possible from time to time. When the Bermuda high is displaced to the south and west of its normal position, hot and dry conditions often develop across the Chesterfield County with little chances for afternoon thunderstorm activity. During these summers, drought can develop across the South Carolina. Elevated Ozone concentrations are generally more common during these hot and dry summers.

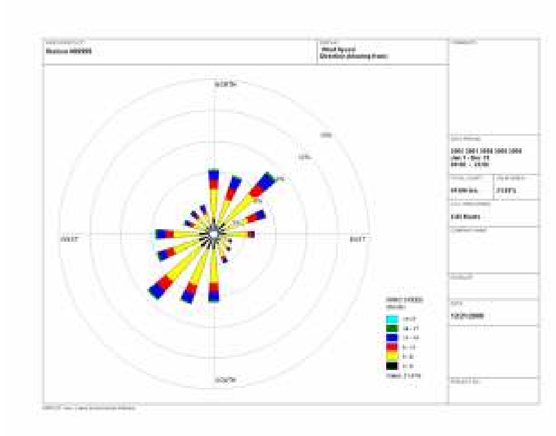
Six windroses were created for the Chesterfield County area using the wind data from the Lauringburg-Maxton, NC station. The annual windrose cover the entire years from 2002 through 2006. During the annual time period, a verity of wind directions was common, especially from the northeast and from the southwest. The least common wind directions were from the east, east-southeast, southeast, south-southeast, west-northwest, northwest, and north-northwest. The average annual wind speed is 5.65 knots with calm winds occurring 21.01 % of the time.

The second wind rose was created for the ozone season. Ozone season starts in April and ends in October across Chesterfield County. The overall wind pattern for the ozone season is fairly similar to the wind pattern found during the annual period. The average wind speed during ozone season is 5.49 knots with calm winds occurring 20.26% of the time.

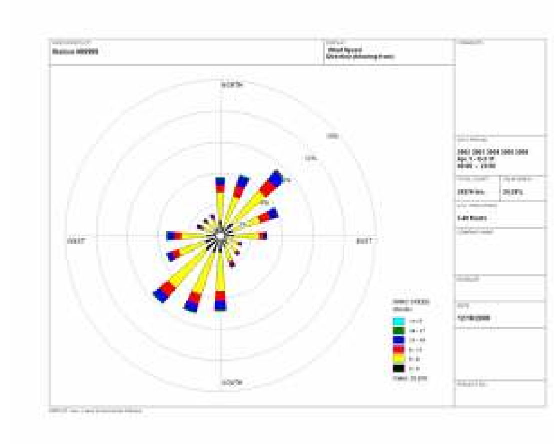
Quarterly windroses for the Chesterfield County area were created next. The first quarter begins in January and ends in March, the second quarter runs from April through June, the third quarter lasts from July through September, and the fourth quarter runs from October through December. During the first quarter, dominant wind directions were from the north, northeast, and southwest. The average wind speed during the first quarter is 6.52 knots with calm winds occurring 16.17% of the time. The second quarter windrose indicates a completely different wind pattern from the previous windroses. Southerly, south-southwesterly, and southwesterly winds occurred most often during the second quarter. The average wind speed during this quarter is 6.26 knots with calm winds occurring 16.17% of the time. Wind directions from the northeast and from the southwest were most common during the third quarter, but there were variety of different wind directions that occurred. Average wind speeds during the third quarter are 4.97 knots with calm winds occurring 23.35% of the time. The fourth quarter windrose shows a wind pattern that is completely different from all of the other windroses. Northerly, north-northeasterly, and, northeasterly winds occurred most often during the fourth quarter. Northerly and northeasterly winds are more common across the area during the colder, fourth quarter. The average wind speeds for the fourth quarter is 4.97 knots with calm winds occurring 29.08% of the time.

Lauringburg-Maxton, NC- Chesterfield MSA Annual Windroses (2002-2006)

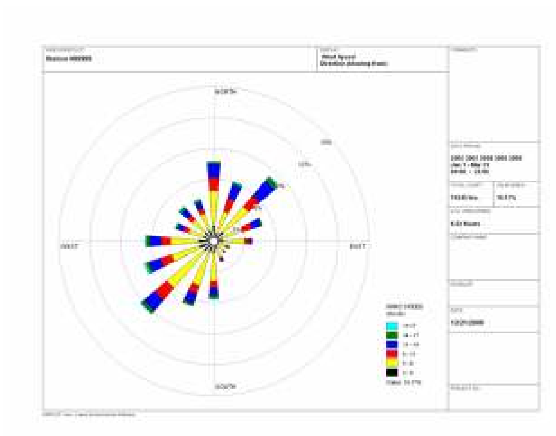
Lauringburg- Maxton, NC- Chesterfield MSA Ozone Season Windroses (2002-2006)



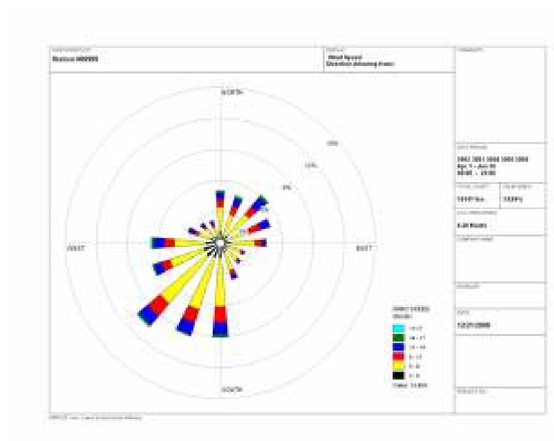
Lauringbourg-Maxton, NC- Chesterfield MSA 1st Quarter Windroses (2002-2006)



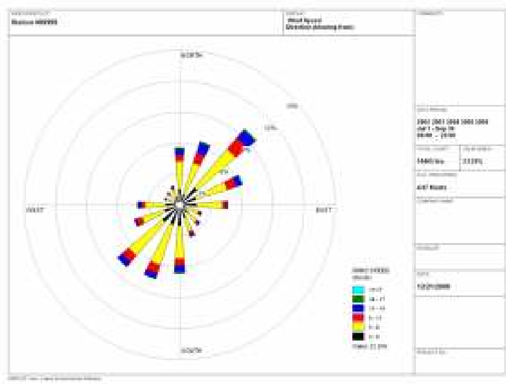
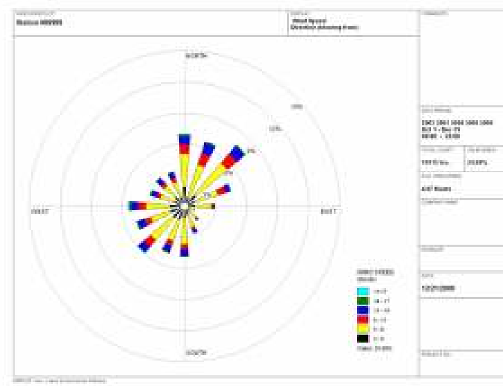
Lauringbourg-Maxton, NC- Florence MSA 2nd Quarter Windroses (2002-2006)



Lauringburg-Maxton, NC- Chesterfield MSA 3rd Quarter Windroses (2002-2006)



Lauringburg-Maxton, NC- Chesterfield MSA 4th Quarter Windroses (2002-2006)

Colleton County Meteorology and Climate

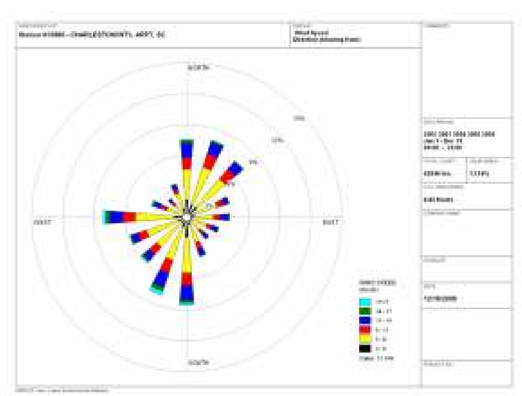
Most pollutant concentrations are generally lower in the Colleton County area than in other parts of South Carolina. This is primarily due to the sea breeze which pushes inland during the warmer months. In many instances, this meteorological phenomenon cleans out the air in coastal counties of South Carolina. As a result, the air quality is good across Colleton County much of the time. Colleton County's climate is subtropical with mild winters. During the winter months, cold air masses are modified significantly, having a hard time passing across the Appalachian Mountains. Summers are hot and humid across the lower coastal plains. During a normal summer, the Bermuda high pressure's western flank covers the Southeastern United States. This pumps in a very warm, moist, and unstable air mass across the Southeast, resulting in scattered afternoon and evening thunderstorms across coastal South Carolina. During the warmer months, a pressure gradient develops between the ocean and the land. The colder water temperatures and warmer land temperatures result in lower pressure across the land with higher pressure just above the ocean. This sets up a pressure gradient which causes winds to blow from the ocean to the land. As a result, the sea breeze develops during the warmer months. Winds blow from the oceans (from the south) northward across the land. This ocean to land breeze (the sea breeze) results in cleaner air across the coastal counties of South Carolina. Since the Ashton monitoring site is located inland across the lower coastal plains, the sea breeze generally pushes into the Ashton monitoring area during the late afternoon hours. This is generally during the maximum heating of the day. The arrival of the sea breeze front in addition to maximum heating that occurs late in the day, results in a good coverage of afternoon and evening thunderstorms across inland Colleton County. During some summers, the Bermuda high is centered south and west of its normal position, cutting off Gulf moisture and resulting in very hot and dry summers across the coastal counties. In addition, this pattern also suppresses the sea breeze front. When this occurs, the normal scattered afternoon and evening thunderstorm activity is suppressed, and much of the area may experience drought. Ozone concentrations tend to be higher during these hot and dry summers.

The most representative meteorological station for Colleton County is the Charleston meteorological station. It should be noted that the wind patterns across inland Colleton County may not be exactly like the wind patterns in Charleston due to Charleston being closer to the coast. However, the wind patterns should be fairly similar at the Ashton monitoring site and Charleston. The windroses depict the five year wind direction and speeds at the Charleston airport. The 2002-2006 annual windrose for Charleston shows three dominant transport regimes. Winds most often come from a north and northeasterly directions, from a south, south-southwest, or westerly directions. Winds rarely come from an easterly, southeasterly, or northwesterly direction. The average annual wind speed for the Charleston area is 6.35 knots with 13 percent of the hours having calm winds.

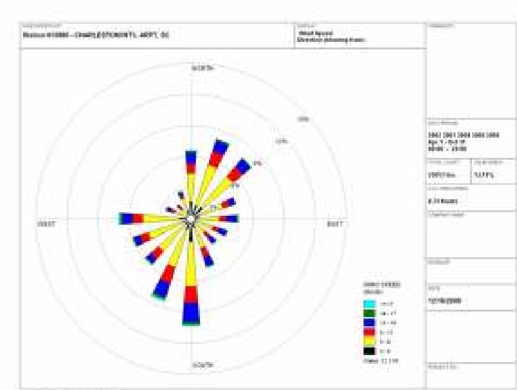
A windrose was also created for ozone season which runs from April through October. During the ozone season, the windrose shows that the most dominant wind direction is from the south. This southerly wind direction is the result of the sea breeze that develops during the warm months across the coastal areas of South Carolina. As the sea breeze pushes inland, a southerly flow off the ocean develops, and this generally keeps ozone levels lower in the Colleton County area. During ozone season, the wind rose also depicts common wind directions occurring from the south-southwest, westerly, and northeasterly directions. The average wind speed during the ozone season is 6.73 knots with twelve percent of the hours having calm winds.

The remaining windroses were created for each quarter of the year. The first quarter runs from January through March, with the second quarter running from April through June. July through September represents the third quarter, with the fourth quarter running from October through December. The first quarter wind rose shows two dominant wind directions. Wind directions from the north and from the west occur more often than other wind directions. In addition, winds frequently come from the southwest during the first quarter. Average wind speeds during the first quarter are 7.46 knots with eleven percent of the hours having calm winds. The second quarter runs from spring into early summer. As expected, the dominant wind directions during this quarter are from the south and south-southwest. The more dominant southerly direction is caused by the sea breeze which frequently develops during the spring and early summer. The average wind speed during the second quarter is 7.21 knots. Winds are calm ten percent of the time which is the least amount of calm hours during any quarter. This low amount of calm hours is likely due to the contrast in sea and land temperatures. The third quarter wind rose shows two dominant wind directions. Winds from the south and from the northeast occur most often during the third quarter. The southerly wind direction is most likely to occur during July and August when the sea breeze is still a common phenomenon. During the latter half of the period, wind directions switch off to the northeast, which is a common wind direction across much of South Carolina, especially during September. The average wind speed during the third quarter is 6.60 knots with twelve percent of the hours having calm winds. During the colder fourth quarter, the wind rose shows the dominant wind directions originating from the north, northeast, and west. In contrast with the warmer second and third quarters, the fourth quarter wind rose shows minimal wind directions from the south. This is due to the absence of a sea breeze during the colder, winter months. Average wind speeds for the fourth quarter are 6.14 knots with calms occurring nineteen percent of the time.

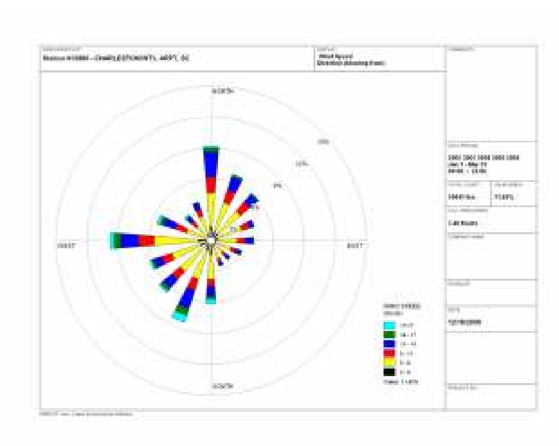
Charleston- Colleton MSA Annual Windroses (2002-2006)



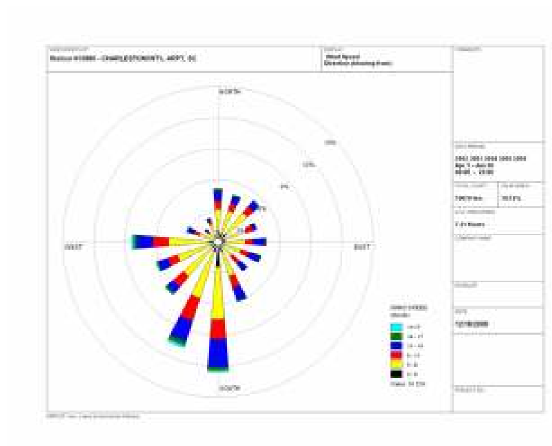
Charleston- Colleton MSA Ozone Season Windroses (2002-2006)



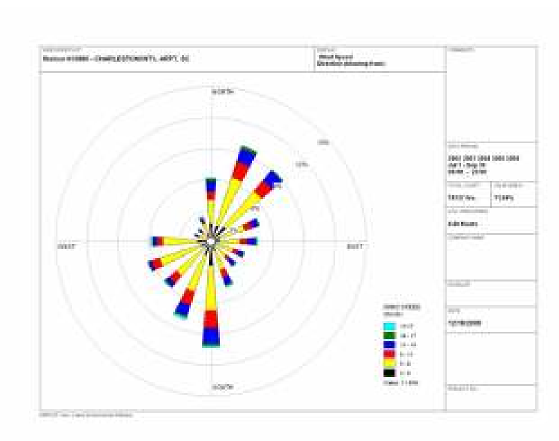
Charleston - Colleton MSA 1st Quarter Windroses (2002-2006)



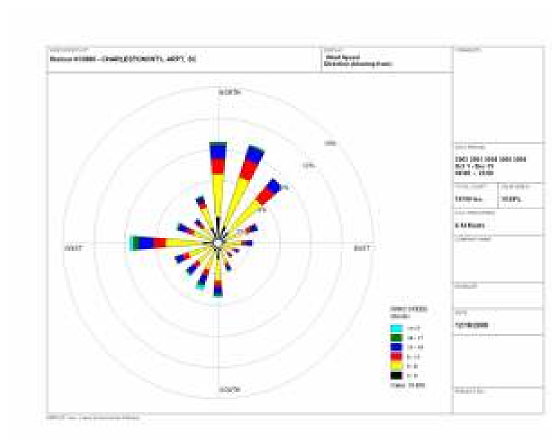
Charleston - Colleton MSA 2nd Quarter Windroses (2002-2006)



Charleston- Colleton MSA 3rd Quarter Windroses (2002-2006)



Charleston- Colleton MSA 4th Quarter Windroses (2002-2006)



Columbia MSA Meteorology and Climate

The Columbia MSA is located in the central portion of South Carolina which is commonly referred to as the Midlands. The weather service office station that represents the Columbia area is located at the Columbia metropolitan airport in the town of Cayce, which is just southwest of the city of Columbia. The Midlands of South Carolina have sporadic cold outbreaks during the winter months; however, the Appalachian Mountains to the west and north block the coldest of air masses from invading the central portions of the state. For this reason, the Midlands of South Carolina stays relatively mild during most of the winter months when compared to other sections of the Southeast. The terrain and the location away from the ocean results in little relief from the summer heat that is common during the summer months. Hot weather along with scattered afternoon and evening thunderstorms are the norm across the Midlands for three to four months out of the year. Rainfall can be quite variable during the summer months, and this variability is associated with the strength and position of the Bermuda high. During a normal summer, the Bermuda high is centered well out into the Atlantic with its western flank extending into the Southeastern United States. This normal position of the Bermuda high keeps a moist and unstable, southwesterly flow across South Carolina during the summer. With day time heating, scattered afternoon and evening, thunderstorms occur. In some years, the Bermuda high is centered south and west of its normal position, which cuts off the Gulf of Mexico and results in subsidence across the Southeast. This pattern results in fair weather with very hot temperatures. The normal scattered afternoon and evening thunderstorm activity is suppressed, and this pattern is very favorable for droughts across much of the Southeast, including South Carolina. During these very hot and dry summers, ozone levels can rise to above normal levels, resulting in some exceedances across the region.

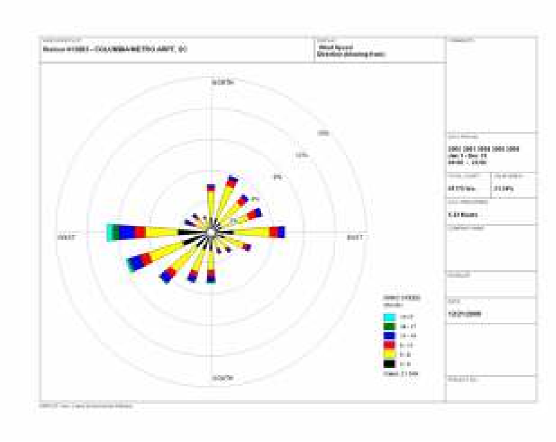
Windroses were created for the Columbia area (Midlands), using the meteorological wind data from the Columbia metropolitan airport. The first windrose covers the annual period from 2002 through 2006. During an entire year, the wind pattern across the midlands shows a dominant wind direction from the west, west-southwest, and from the east. The average wind speed for the year is 5.33 knots with winds being calm about 21 percent of the time.

The second windrose represents the ozone season only, which runs from April through October. The ozone season windrose for the Columbia area shows the dominant wind directions areas are from the west, west-southwest, the north-northeast, and from the east. Ozone precursors are frequently transported into the Midlands from the Charlotte and Atlanta areas, as noted by the ozone season windrose. The average wind speed during ozone season is 5.21 knots with calm winds occurring 20 percent of the time.

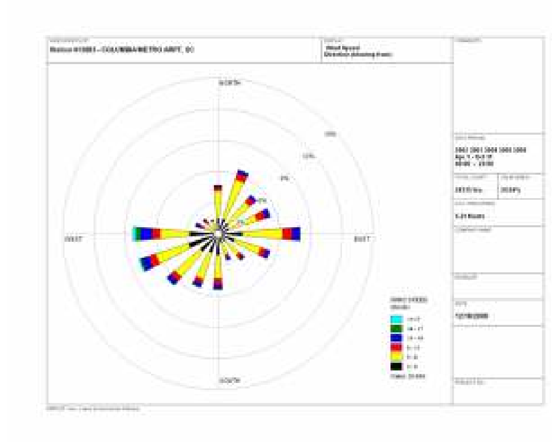
The next four wind roses are broken up by quarters. There are four quarters for each year. The first quarter runs from January through March, the second quarter runs from April through June, the third quarter runs from July through September, and the fourth quarter runs from October through December. The first quarter windrose clearly shows that the westerly, west-southwesterly, and to some extent the southwesterly wind directions are most common from January through March. An easterly component also shows up during the first quarter across the Midlands. The average wind speed during the first quarter is 5.93 knots with calm winds occurring 20 percent of the time. During the second quarter, the dominant wind directions are from the west, west-southwest, southwest, and east. The most dominant wind direction during this period is from the west. The average wind speed for the second quarter is 5.77 knots with calm winds occurring 17 percent of the time. The third quarter wind rose shows that the most dominant wind directions are from the north-northeast and east. Fairly dominant wind directions are also from the west and southwest. West and southwesterly winds are more likely to occur through the first half of the third quarter with north-northeast and easterly winds occurring more often during the second half of the quarter, especially in September. It should be noted that north-northeasterly winds also occur during the first half of the third quarter, especially after a frontal passage. The average wind speed during the third quarter is 4.91 knots with calm winds occurring 21 percent of the time. Finally, the fourth quarter indicates that by far the most dominant wind directions are from the west and west-southwest. Northeasterly winds are a far second from the most dominant wind directions across the midlands. The average wind speed during the fourth quarter is 4.71 knots with calm winds occurring 28 percent of the time.

Columbia- Columbia MSA Annual Windroses (2002-2006)

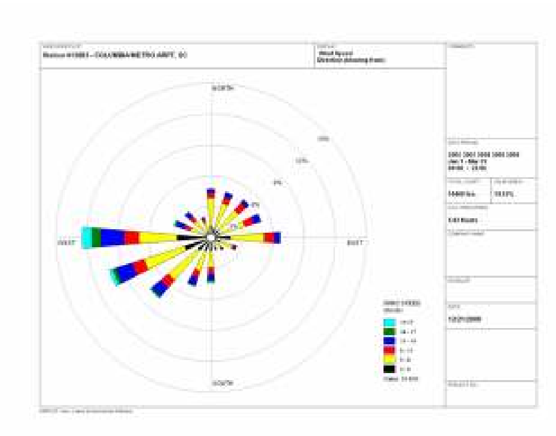
Columbia- Columbia MSA Ozone Season Windroses (2002-2006)



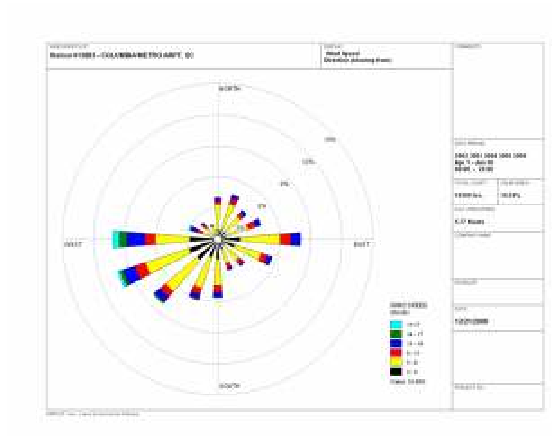
Columbia- Columbia MSA 1st Quarter Windroses (2002-2006)



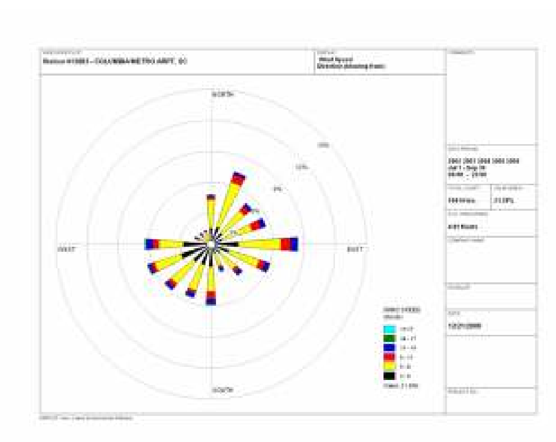
Columbia- Columbia MSA 2nd Quarter Windroses (2002-2006)

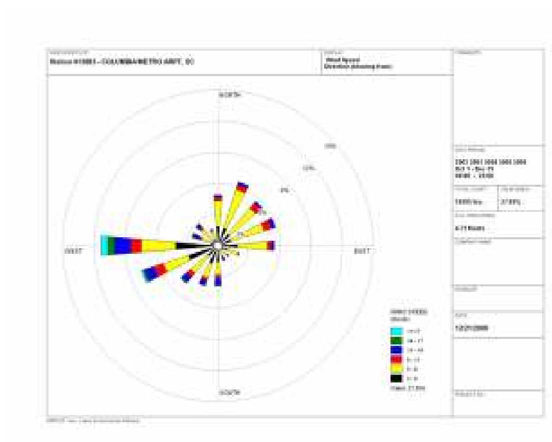


Columbia- Columbia MSA 3rd Quarter Windroses (2002-2006)



Columbia- Columbia MSA 4th Quarter Windroses (2002-2006)





Florence MSA Meteorology and Climate

The Florence MSA is located in the inland, northeastern portion of South Carolina which is commonly referred to as the Pee Dee. The weather service office station that represents the Pee Dee area is located in the city of Florence. The Pee Dee of South Carolina has sporadic cold outbreaks during the winter months; however, the Appalachian Mountains to the west and north block the coldest of air masses from invading the Pee Dee area of the state. For this reason, the Pee Dee area of South Carolina stays relatively mild during most of the winter months when compared to other sections of the Southeast. The terrain is almost flat, and the area is located in the northeastern coastal plain of South Carolina. Hot weather along with scattered afternoon and evening thunderstorms are the norm across the Pee Dee for three to four months out of the year. The Pee Dee area is just far enough inland so that it is usually not affected by the sea breeze front. Rainfall can be quite variable during the summer months, and this variability is associated with the strength and position of the Bermuda high. During a normal summer, the Bermuda high is centered well out into the Atlantic with its western flank extending into the Southeastern United States. This normal position of the Bermuda high keeps a moist and unstable, southwesterly flow across South Carolina during the summer. With day time heating, scattered afternoon and evening thunderstorms occur. In some years, the Bermuda high is centered south and west of its normal position, which cuts off the Gulf of Mexico and results in subsidence across the Southeast. This pattern results in fair weather with very hot temperatures. The normal scattered afternoon and evening thunderstorm activity is suppressed, and this pattern is very favorable for droughts across much of the Southeast, including South Carolina. During these very hot and dry summers, ozone levels can rise to above normal levels, resulting in some exceedances across the region.

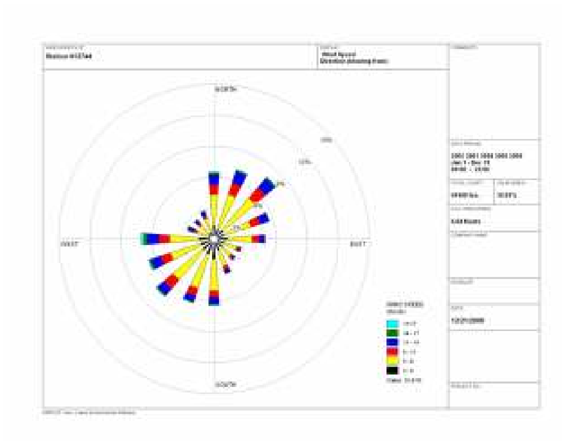
Six windroses were created for the Pee Dee area using the wind data from the Florence site. The annual windrose cover the entire years from 2002 through 2006. During the annual time period, there is no real dominant wind direction; rather the wind comes from a variety of directions. It is easier to identify where the wind directions occur less frequently during an entire year. The least common wind directions during the annual period are from the northwest, north-northwest, west-northwest, south-southeast, southeast, and from the east-southeast. The average wind speed during the annual period is 6.04 knots with calm winds occurring seventeen percent of the time.

The wind pattern during the ozone season, which runs from April through October, is very similar to the annual wind pattern. Once again, the least common wind directions are from the northwest, north-northwest, west-northwest, south-southeast, southeast, and from the east-southeast. The average wind speed during the ozone season is 5.84 knots with calm winds occurring seventeen percent of the time.

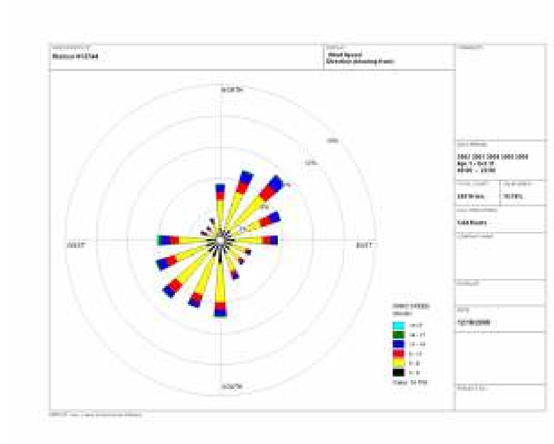
Quarterly windroses make up the next four windroses for the Pee Dee area. The first quarter runs from January through March, the second quarter runs from April through June, the third quarter runs from July through September, and the fourth quarter begins in October and ends in December. During the first quarter, the windrose shows a variety of wind directions with the more dominant directions being from the north, northeast, west, and southwest. The average wind speed during the first quarter is 6.84 knots with calm winds occurring thirteen percent of the time. The second quarter windrose shows a different wind pattern than the previous windroses for the Florence area. Westerly, west-southwest, southwest, and south-southwesterly wind direction occur more often than the other wind directions during the second quarter. The average wind speed for the second quarter is 6.42 knots with calm winds occurring thirteen percent of the time. During the third quarter, the windrose shows a variety of different wind directions are common. Northwesterly, north-northwesterly, west-northwesterly, easterly, east-southeasterly, southeasterly, south-southeasterly, and southerly wind directions are the least common during the third quarter. The average wind speed during the third quarter is 5.49 knots with calm winds occurring nineteen percent of the time. The fourth quarter wind rose looks different than any of the other windroses for the Florence area. By far the most dominant wind directions for the fourth quarter are from the north,

north-northeast, and northeast. A northerly and northeasterly wind direction becomes more common across much of South Carolina during the cooler months. Average wind speeds during the fourth quarter are 5.49 knots with calm winds occurring 22 percent of the time.

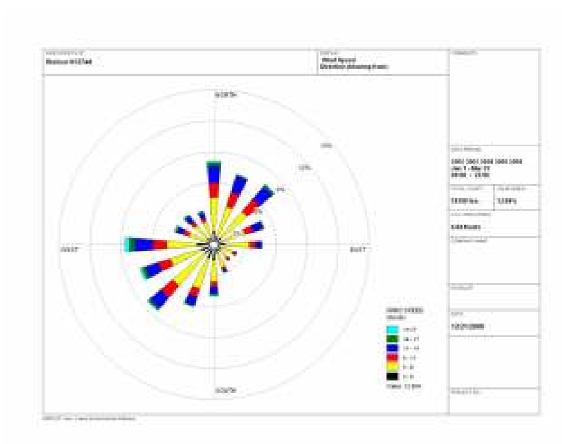
Florence- Florence MSA Annual Windroses (2002-2006)



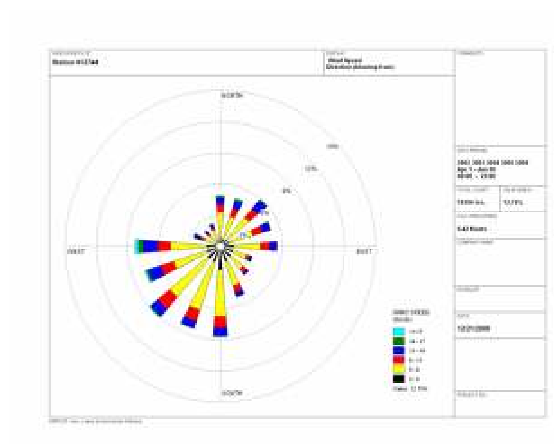
Florence- Florence MSA Ozone Season Windroses (2002-2006)



Florence- Florence MSA 1st Quarter Windroses (2002-2006)

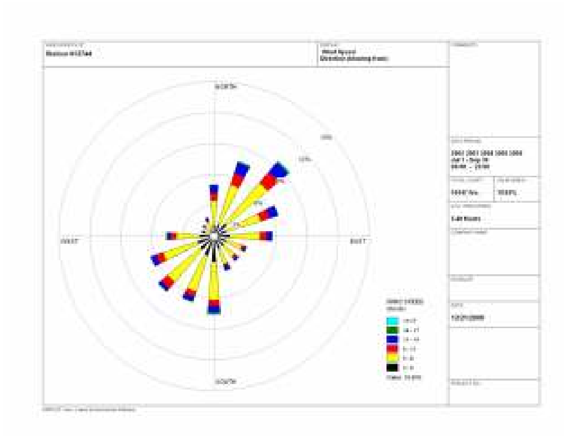


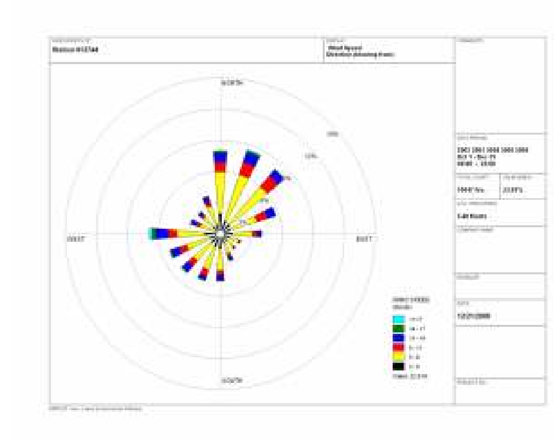
Florence- Florence MSA 2nd Quarter Windroses (2002-2006)



Florence- Florence MSA 3rd Quarter Windroses (2002-2006)

Florence- Florence MSA 4th Quarter Windroses (2002-2006)





Georgetown mSA Meteorology and Climate

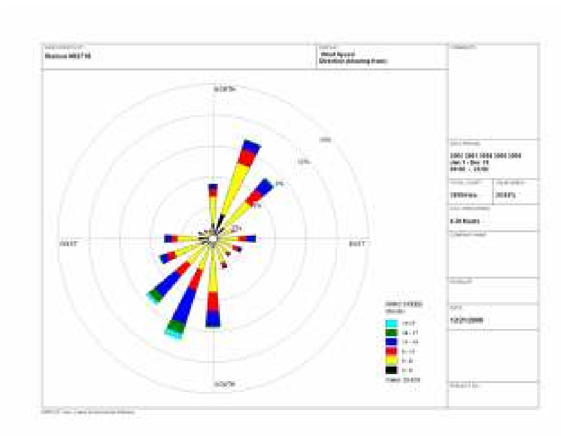
Most pollutant concentrations are generally lower in the Georgetown County area than in other parts of South Carolina. This is primarily due to the sea breeze which pushes inland during the warmer months. In many instances, this meteorological phenomenon cleans out the air in coastal counties of South Carolina. As a result, the air quality is good across Georgetown County much of the time. Georgetown's climate is marine, subtropical with mild winters and very warm and humid summers. During the winter months, cold air masses are modified significantly, having a difficult time passing across the Appalachian Mountains. In addition, the close proximity of the Gulf Stream helps to modify cold air masses. During a normal summer, the Bermuda high pressure's western flank covers the Southeastern United States. This pumps in a very warm, moist, and unstable air mass across the Southeast, resulting in scattered afternoon and evening thunderstorms across coastal South Carolina. During the warmer months, a pressure gradient develops between the ocean and the land. The colder water temperatures and warmer land temperatures result in lower pressure across the land with higher pressure just above the ocean. This sets up a pressure gradient which causes winds to blow from the ocean to the land. As a result, the sea breeze develops during the warmer months. As a result, winds blow from the oceans (from the south) northward across the land. This ocean to land breeze (the sea breeze) results in cleaner air across the coastal counties of South Carolina. During some summers, the Bermuda high is centered south and west of its normal position, cutting off Gulf moisture and resulting in hot and dry summers across the coastal counties. When this occurs, the normal scattered afternoon and evening thunderstorm activity is suppressed, and much of the area may experience drought. Ozone concentrations tend to be higher during these hot and dry summers.

A series of windroses were created for the Georgetown mSA using the most representative meteorological station. Wind data from the Myrtle Beach area was used to represent the Georgetown mSA. The wind roses depict the five year wind direction and speeds for the northern coastal counties. The 2002-2006 annual wind rose for Georgetown shows that wind directions from the southwest and northeast are the most common. On an annual basis, the average wind speed is 6.30 knots with calm winds occurring 21 percent of the time.

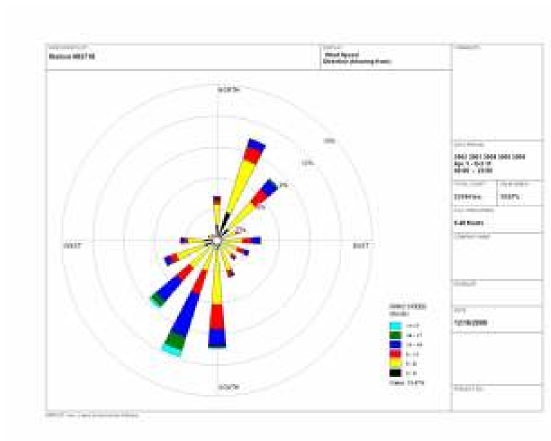
The second wind rose represents wind patterns during the ozone season. Ozone season runs from April through October in the coastal counties of South Carolina. During this time, the dominant wind directions are from the northeast, south, and south-southwest. A southerly wind direction occurs more frequently during the ozone season due to the sea breeze front that develops during the warmer months. The average wind speed during ozone season is 6.48 knots with calm winds occurring nineteen percent of the time.

The next four wind roses represent the wind patterns during the four quarters that make up a year. January through March represents the first quarter, April through June represents the second quarter, the third quarter runs from July through September, and the fourth quarter runs begins in October and ends in December. During the first quarter, the wind pattern mirrors the annual wind pattern. Wind directions from the southwest and from the northeast are the most dominant directions from January through March. The average wind speed during the first quarter is 6.56 knots with calm winds occurring eighteen percent of the time. The second quarter windrose shows a much stronger southerly and south-southwesterly component to the wind than the other windroses. This southerly wind direction is the result of the sea breeze that develops during the warm months across the coastal areas of South Carolina. As the sea breeze pushes inland, a southerly flow off the ocean develops, and this generally keeps air quality cleaner the Georgetown area. The average wind speed during the second quarter is 7.01 knots with calm winds occurring only sixteen percent of the time. The third quarter wind rose shows dominant wind directions from the south, south-southwest, north-northeast, and from the northeast are common. Average wind speeds for the third quarter are 6.43 knots with calm winds occurring nineteen percent of the time. Wind patterns during the fourth quarter are quite a bit different than the wind patterns during the other quarters. A north-northeasterly and northeasterly wind direction is most common from October through December. A more northerly and northeasterly wind direction shows up more often across much of South Carolina during the colder quarters. The average wind speed during the fourth quarter is 5.26 knots with calm winds occurring 28 percent of the time.

Myrtle Beach- Georgetown mSA Annual Windroses (2002-2006)

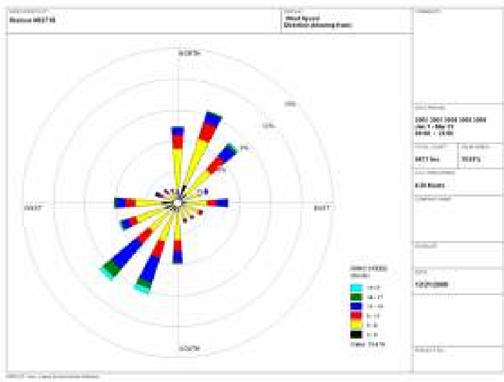


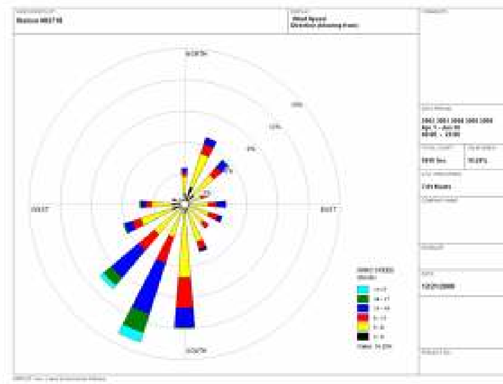
Myrtle Beach- Georgetown mSA Ozone Season Windroses (2002-2006)



Myrtle Beach- Georgetown mSA 1st Quarter Windroses (2002-2006)

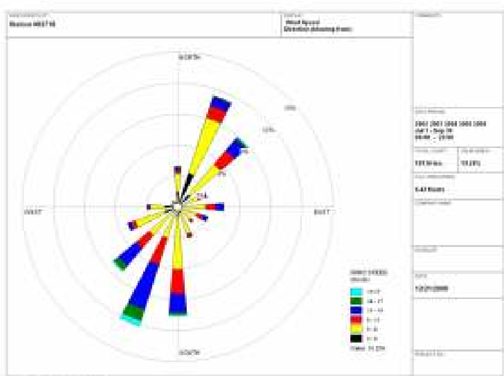
Myrtle Beach- Georgetown mSA 2nd Quarter Windroses (2002-2006)

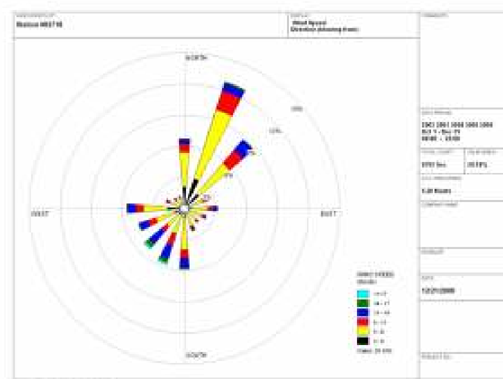




Myrtle Beach- Georgetown mSA 3rd Quarter Windroses (2002-2006)

Myrtle Beach- Georgetown mSA 4th Quarter Windroses (2002-2006)





Greenville MSA Meteorology and Climate

The Greenville area is located just south and east of the Appalachian Mountains. This area is frequently referred to as the Upstate of South Carolina. The Greenville County area's elevation above sea level is significantly higher than is the Midlands of South Carolina. The Greenville County area is represented by the National Weather Service office station known as Greer. Greer is located almost half way between the city of Greenville and Spartanburg. Meteorological conditions are a bit more temperate here than the more subtropical conditions across the Midlands and inland, coastal plains. Occasional cold spells can affect the area during the winter months; however, these cold spells a modified by the Appalachian Mountains located just north and west of the Greenville area. Chilly, wedge scenarios are common during the cooler months when high pressure, to the north, ridges down just east of the Appalachian Mountains. This pattern results in cloudy, chilly weather with drizzle and sometimes heavier precipitation is possible when weather systems approach from the west or southwest. Summers in the Greenville area are noticeably milder than the summers across the midlands of South Carolina. During the summer months when the Bermuda high is centered close to climatology, very warm weather is common across the Upstate with afternoon thunderstorms possible from time to time. When the Bermuda high is displace to the south and west of its normal position, hot and dry conditions often develop across the Upstate with little chances for afternoon thunderstorm activity. During these summers, drought can develop across the Upstate of South Carolina.

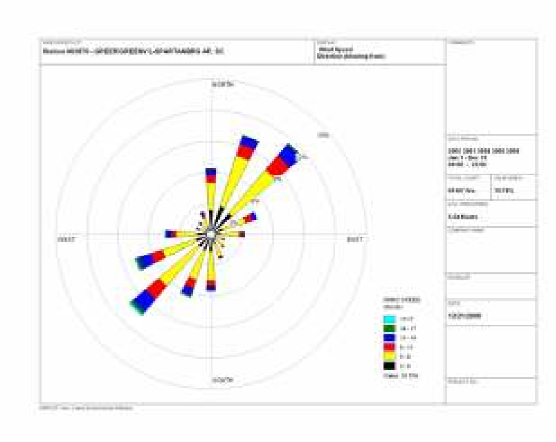
Using the Greer weather station, a series of windroses was developed for the Upstate of South Carolina. The annual windrose represents wind patterns across the Upstate throughout the entire year. Dominant wind directions are from the southwest and from the northeast across the Upstate on an annual basis. These dominant southwesterly and northeasterly wind directions are partially due to the Appalachian Mountains that run from the northeast to the southwest, located just north and west of the Greenville area. It is easy to see how the wind patterns are parallel to the mountain range located just to the north and west. This mountain range helps to funnel the air flow from the southwest to northeast and from the northeast to southwest, depending on other meteorological conditions. The average annual wind speed across the Greenville area is 5.54 knots with calm winds occurring 19 percent of the time.

The next windrose represents the wind patterns during ozone season across the Upstate. Ozone season runs from April through October across the Upstate. Once again, the pattern that occurred during the annual time period shows up again for the ozone season. Southwesterly and northeasterly wind directions are dominant during ozone season. This results in ozone precursor transport from the Charlotte and Atlanta areas into the Upstate of South Carolina throughout ozone season. The average wind speed from April through October is 5.21 knots with calm winds representing twenty percent of the wind speeds.

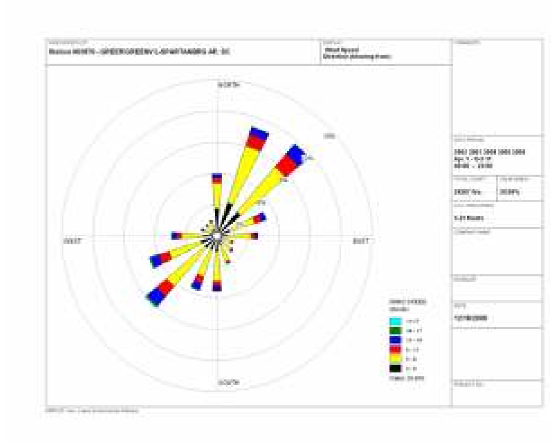
The next four windroses represents each quarter during the year. The first quarter runs from January through March, the second quarter runs from April through June, the third quarter runs from July through September, and the fourth quarter runs from October through December. The first quarter windrose indicates no surprises. Just as with the annual and ozone windroses, the first quarter windrose shows an even more extreme southwest to northeast or northeast to southwest flow across the Upstate. The average wind speed during the first quarter is 6.42 knots with calm winds occurring only fifteen percent of the time. During the second quarter, the dominant wind directions are once again skewed by the Appalachian Mountains. Dominant wind directions from the southwest to northeast or northeast to southwest again prevail across the Upstate. The average wind speed during the second quarter is 5.83 knots with calm winds occurring seventeen percent of the time. The third quarter windrose shows a somewhat different wind pattern than the first four windroses. Dominant wind directions are from the north-northeast and northeast with the southwesterly wind direction being quite a bit less dominant. This is due to the northeasterly bias that occurs throughout much of South Carolina during the latter half of the third quarter, especially during the month of September. This north-northeasterly and northeasterly wind is even more common in the Upstate due to the southwest to northeasterly running Appalachian Mountains. The average wind speed during the third quarter is the lowest wind speed for any quarter, at 4.65 knots. Calm winds make up 23 percent of the wind speeds during the third quarter. This is the largest amounts of calms of any quarter. The fourth quarter also shows the most dominant wind direction being from the north-northeast and from the northeast with a secondary, smaller maximum occurring from the southwest. The average wind speed for the fourth quarter is 5.29 knots with calms occurring 21 percent of the time.

Greenville- Greenville MSA Annual Windroses (2002-2006)

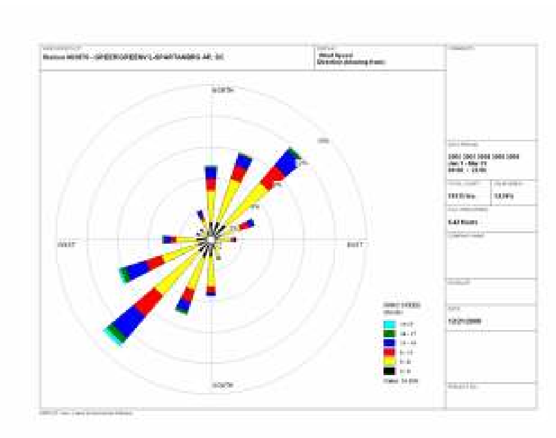
Greenville- Greenville MSA Ozone Season Windroses (2002-2006)



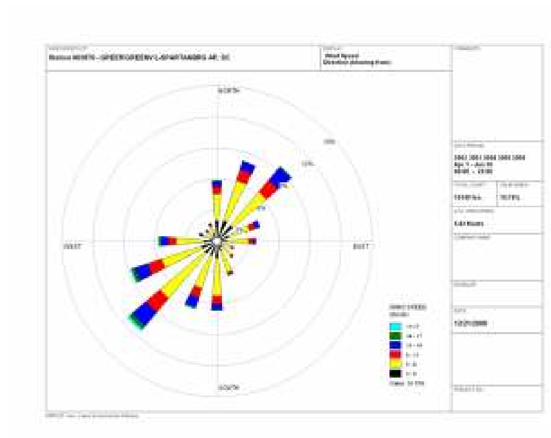
Greenville- Greenville MSA 1st Quarter Windroses (2002-2006)



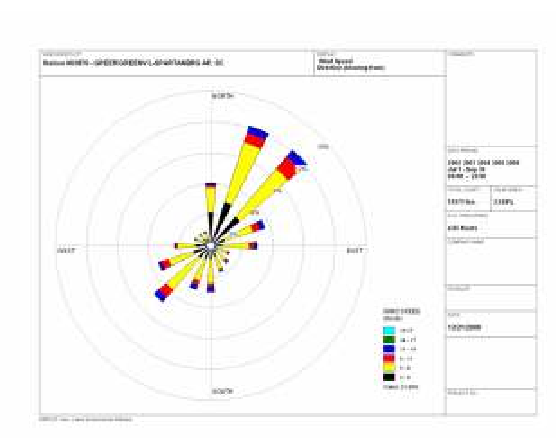
Greenville- Greenville MSA 2nd Quarter Windroses (2002-2006)

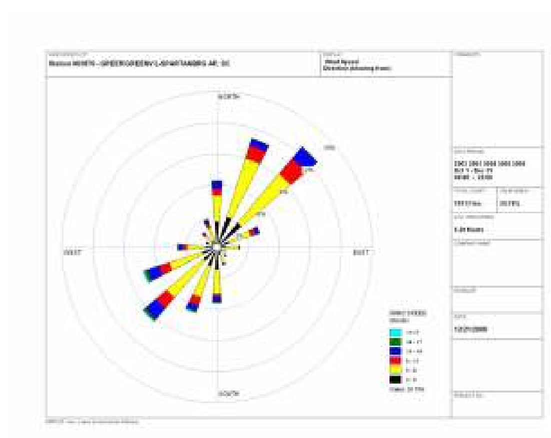


Greenville- Greenville MSA 3rd Quarter Windroses (2002-2006)



Greenville- Greenville MSA 4th Quarter Windroses (2002-2006)





Seneca mSA Meteorology and Climate

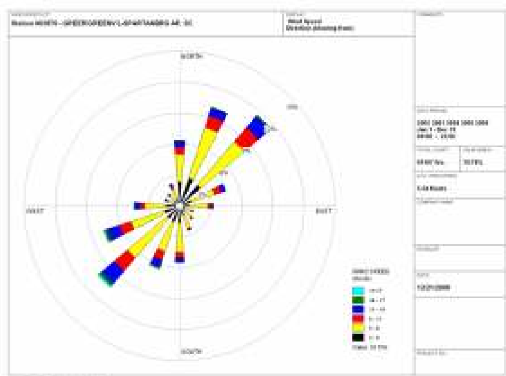
The Seneca area is located just south and east of the Appalachian Mountains. This area is frequently referred to as the Upstate of South Carolina. Seneca area's elevation above sea level is significantly higher than is the Midlands of South Carolina. The Seneca area is represented by the National Weather Service office station known as Greer. Greer is located almost half way between the city of Greenville and Spartanburg. Meteorological conditions are a bit more temperate here than the more subtropical conditions across the Midlands and inland, coastal plains. Occasional cold spells can affect the area during the winter months; however, these cold spells are modified by the Appalachian Mountains located just north and west of the Greenville area. Chilly, wedge scenarios are common during the cooler months when high pressure, to the north, ridges down just east of the Appalachian Mountains. This pattern results in cloudy, chilly weather with drizzle and sometimes heavier precipitation possible when weather systems approach from the west or southwest. Summers in the Seneca area are noticeably milder than the summers across the Midlands of South Carolina. During the summer months, when the Bermuda high is centered close to climatology, very warm weather is common across the Upstate with afternoon thunderstorms possible from time to time. When the Bermuda high is displaced to the south and west of its normal position, hot and dry conditions often develop across the Upstate with little chances for afternoon thunderstorm activity. During these summers, drought can develop across the Upstate of South Carolina. Elevated ozone concentrations are generally more common during these hot and dry summers.

Using the Greer weather station, a series of windroses was developed for the Upstate of South Carolina. The annual windrose represents wind patterns across the Upstate throughout the entire year. Dominant wind directions are from the southwest and from the northeast across the Upstate on an annual basis. These dominant southwesterly and northeasterly wind directions are partially due to the Appalachian Mountains that run from the northeast to the southwest, located just north and west of the Greenville area. It is easy to see how the wind patterns are parallel to the mountain range located just to the north and west. This mountain range helps to funnel the air flow from the southwest to northeast and from the northeast to southwest, depending on other meteorological conditions. The average annual wind speed across the Seneca area is 5.54 knots with calm winds occurring 19 percent of the time.

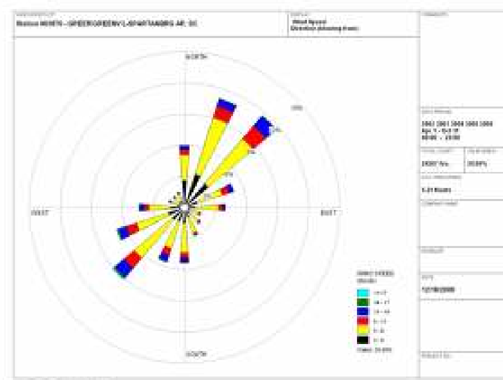
The next windrose represents the wind patterns during ozone season across the Upstate. Ozone season runs from April through October across the Upstate. Once again, the pattern that occurred during the annual time period shows up again for the ozone season. Southwesterly and northeasterly wind directions are dominant during ozone season. This results in ozone precursor transport from the Charlotte and Atlanta areas into the Upstate of South Carolina throughout ozone season. The average wind speed from April through October is 5.21 knots with calm winds representing twenty percent of the wind speeds.

The next four windroses represents each quarter during the year. The first quarter runs from January through March, the second quarter runs from April through June, the third quarter runs from July through September, and the fourth quarter runs from October through December. The first quarter windrose indicates no surprises. Just as with the annual and ozone windroses, the first quarter windrose shows an even more extreme southwest to northeast or northeast to southwest flow across the Upstate. The average wind speed during the first quarter is 6.42 knots with calm winds occurring only fifteen percent of the time. During the second quarter, the dominant wind directions are again skewed by the Appalachian Mountains. Dominant wind directions from the southwest to northeast or northeast to southwest again prevail across the Upstate. The average wind speed during the second quarter is 5.83 knots with calm winds occurring seventeen percent of the time. The third quarter windrose shows a somewhat different wind pattern than the first four windroses. Dominant wind directions are from the north-northeast and northeast with the southwesterly wind direction being quite a bit less common. This is due to the northeasterly bias that occurs throughout much of South Carolina during the latter half of the third quarter, especially during the month of September. This north-northeasterly and northeasterly wind is even more common in the Upstate due to the southwest to northeasterly running Appalachian Mountains. The average wind speed during the third quarter is the lowest wind speed for any quarter, at 4.65 knots. Calm winds make up 23 percent of the wind speeds during the third quarter. This is the largest amounts of calms of any quarter. The fourth quarter also shows the most dominant wind direction being from the north-northeast and from the northeast with a secondary, smaller maximum occurring from the southwest. The average wind speed for the fourth quarter is 5.29 knots with calms occurring 21 percent of the time.

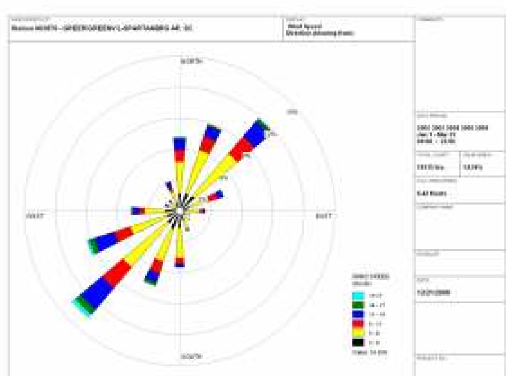
Greer- Greenville MSA Annual Windroses (2002-2006)



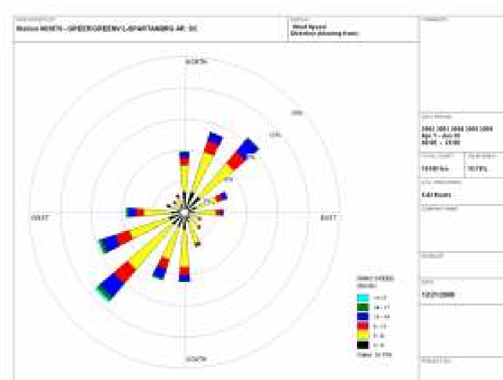
Greer- Greenville MSA Ozone Season Windroses (2002-2006)



Greer- Greenville MSA 1st Quarter Windroses (2002-2006)

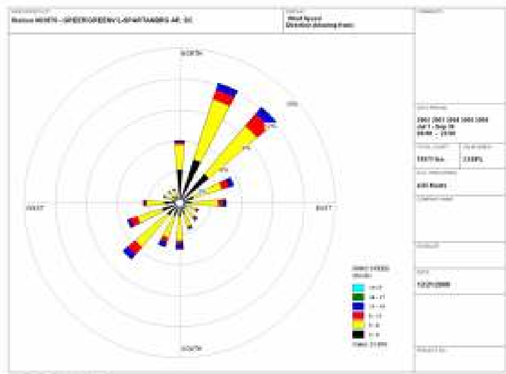


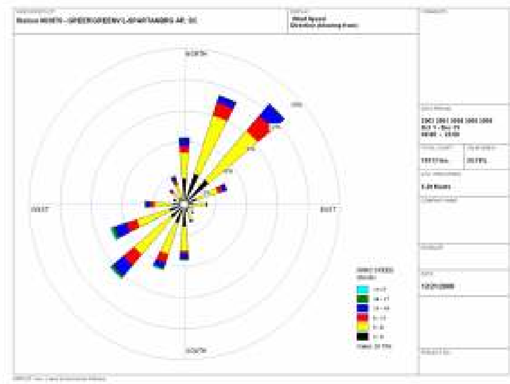
Greer- Greenville MSA 2nd Quarter Windroses (2002-2006)



Greer- Greenville MSA 3rd Quarter Windroses (2002-2006)

Greer- Greenville MSA 4th Quarter Windroses (2002-2006)





Spartanburg MSA Meteorology and Climate

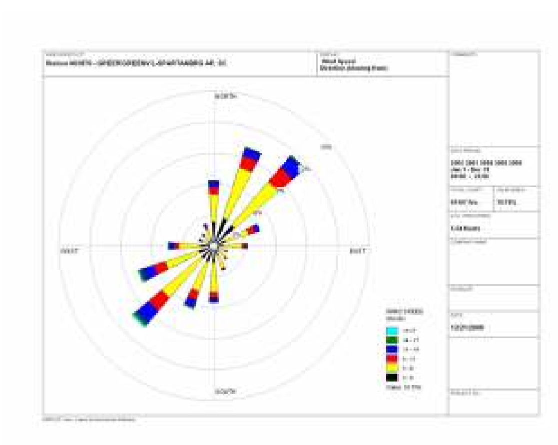
The Spartanburg area is located just south and east of the Appalachian Mountains. This area is frequently referred to as the Upstate of South Carolina. The Spartanburg County area's elevation above sea level is significantly higher than is the Midlands of South Carolina. The Spartanburg County area is represented by the National Weather Service office station known as Greer. Greer is located almost half way between the cities of Greenville and Spartanburg. Meteorological conditions are a bit more temperate here than the more subtropical conditions across the Midlands and inland, coastal plains. Occational cold spells can affect the area during the winter months; however, these cold spells are modified by the Appalachian Mountains located just north and west of the Spartanburg area. Chilly, wedge scenrios are common during the cooler months when high pressure to the north ridges down just east of the Appalachain Mountains. This pattern results in cloudy, chilly weather with drizzle and sometimes heavier precipitation possible when weather systems approach from the west or southwest. Summers in the Spartanburg area are noticably milder than the summers across the Midlands of South Carolina. During the summer months when the Bermuda high is centered close to climatology, very warm weather is common across the Upstate with afternoon thunderstorms possible from time to time. When the Bermuda high is displace to the south and west of its normal position, hot and dry conditions often develop across the Upstate with little chances for afternoon thunderstorm activity. During these summers, drought can develop across the Upstate of South Carolina.

Using the Greer weather station, a series of windroses was developed for the Upstate of South Carolina. The annual windrose represents wind patterns across the Upstate throughout the entire year. Dominant wind directions are from the southwest and from the northeast across the Upstate on an annual basis. These dominant southwesterly and northeasterly wind directions are partially due to the Appalachian Mountains that run from the northeast to the southwest, located just north and west of the Spartanburg area. It is easy to see how the wind patterns are parallel to the mountain range located just to the north and west. This mountain range helps to funnel the air flow from the southwest to northeast and from the northeast to southwest, depending on other meteorological conditions. The average annual wind speed across the Spartanburg area is 5.54 knots with calm winds occurring nineteen percent of the time.

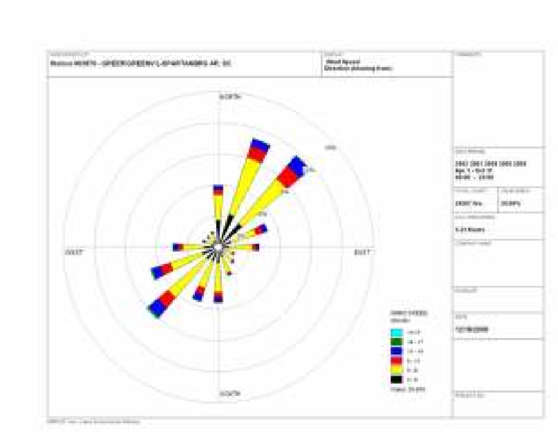
The next windrose represents the wind patterns during ozone season across the Upstate. Ozone season runs from April through October across the Upstate. Once again, the pattern that occurred during the annual time period shows up again for the ozone season. Southwesterly and northeasterly wind directions are dominant during Ozone season. This results in Ozone precursor transport from the Charlotte and Atlanta areas into the Upstate of South Carolina throughout Ozone season. The average wind speed from April through October is 5.21 knots with calm winds representing twenty percent of the wind speeds.

The next four windroses represents each quarter during the year. The first quarter runs from January through March, the second quarter runs from April through June, the third quarter runs from July through September, and the fourth quarter runs from October through December. The first quarter windrose indicates no suprises. Just as with the annual and ozone windroses, the first quarter windrose shows an even more extreme southwest to northeast or northeast to southwest flow across the Upstate. The average wind speed during the first quarter is 6.42 knots with calm winds occurring only fifteen percent of the time. During the second quarter, the dominant wind directions are once again skewed by the Appalachian Mountains. Dominant wind directions from the southwest to northeast or northeast to southwest again prevail across the Upstate. The average wind speed during the second quarter is 5.83 knots with calm winds occurring seventeen percent of the time. The third quarter windrose shows a somewhat different wind pattern than the first four windroses. Dominant wind directions are from the north-northeast and northeast with the southwesterly wind direction being quite a bit less dominant. This is due to the northeasterly bias that occurs throughout much of South Carolina during the latter half of the thrid quarter, especially during the month of September. This north-northeasterly and northeasterly wind is even more common in the Upstate due to the southwest to northeasterly running Appalachian Mountains. The average wind speed during the third quarter is the lowest wind speed for any quarter, at 4.65 knots. Calm winds make up 23.08 percent of the wind speeds during the third quarter. This is the largest amounts of calms of any quarter. The fourth quarter also shows the most dominant wind direction being from the north-northeast and from the northeast with a secondary, smaller maximum occurring from the southwest. The average wind speed for the fourth quarter is 5.29 knots with calms occurring 21 percent of the time.

Greenville- Spartanburg MSA Annual Windroses (2002-2006)

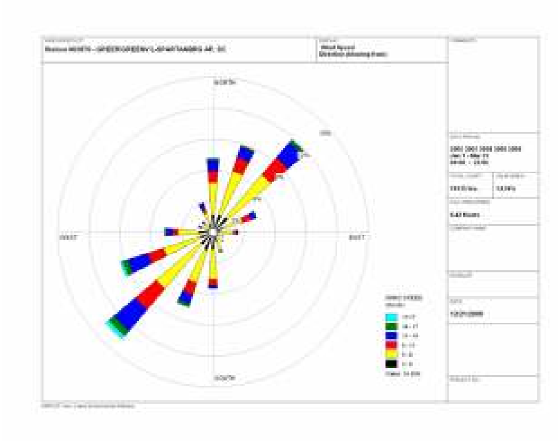


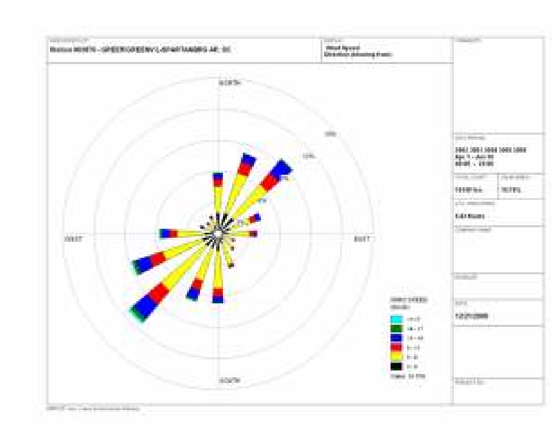
Greenville- Spartanburg MSA Ozone Season Windroses (2002-2006)



Greenville- Spartanburg MSA 1st Quarter Windroses (2002-2006)

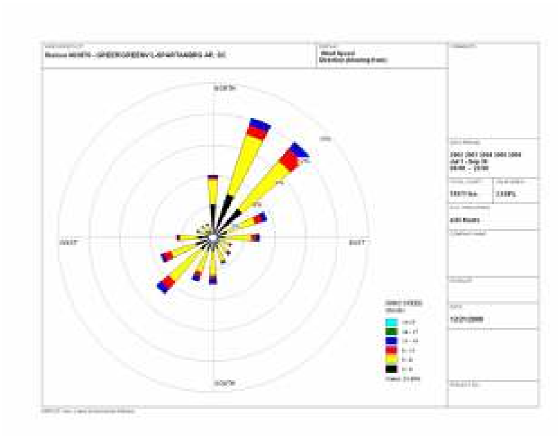
Greenville- Spartanburg MSA 2nd Quarter Windroses (2002-2006)

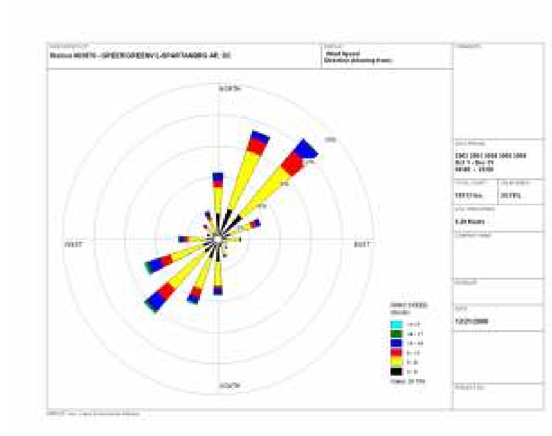




Greenville- Spartanburg MSA 3rd Quarter Windroses (2002-2006)

Greenville- Spartanburg MSA 4th Quarter Windroses (2002-2006)

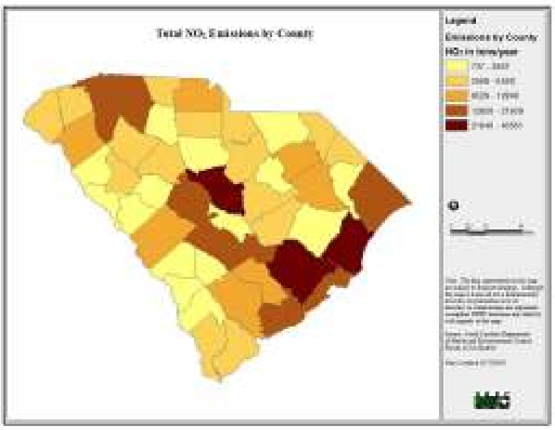


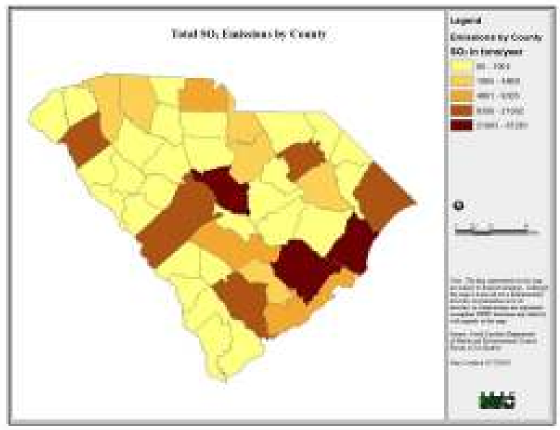


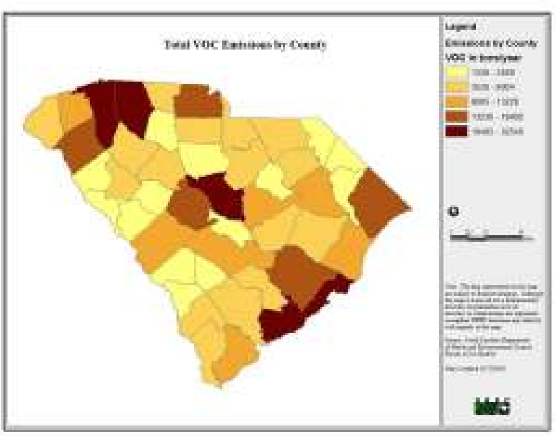
Appendix E: Detailed emissions data

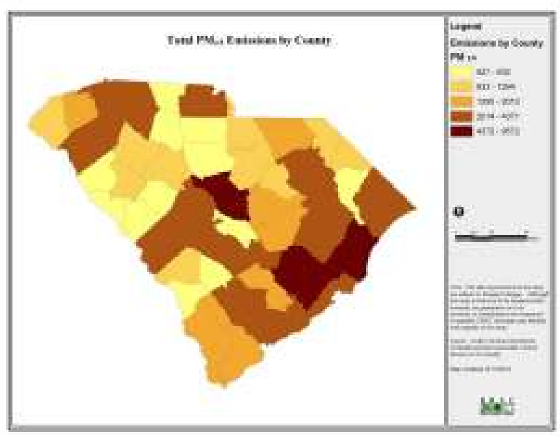
The maps below show the total emissions for VOC, SO_2, NO_2, CO, Lead, PM_{10} and $PM_{2.5}$ on a county-wide basis. These maps include emissions from point, area, mobile, biogenic and non-road sources. On-road mobile sources of pollution include most forms of transportation such as automobiles, trucks, and buses. Non-road mobile sources include a wide variety of internal combustion engines not associated with highway vehicles. Examples of non-road mobile sources would be construction equipment, lawn mowers, and boats. A point source of pollution refers to a source at a fixed point, such as an industrial boiler or storage tank, that emits air pollutants. An area source refers to a series of small sources that together can affect air quality in a region. Examples of area sources include gas stations and residential heaters. Biogenic emissions are emissions that originate from natural sources such as vegetation.

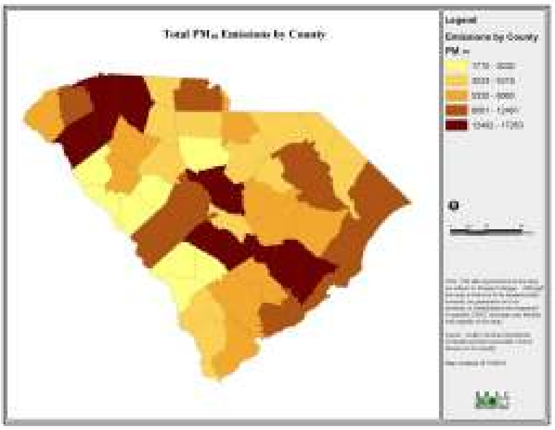
Total emissions tend to be highest in those counties with higher populations where a large number of motor vehicles and facilities are located than in more rural counties.

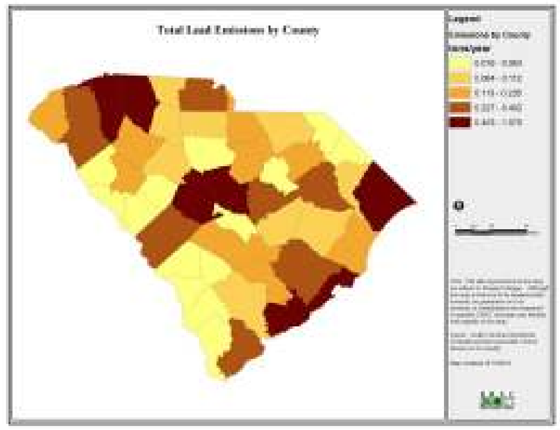






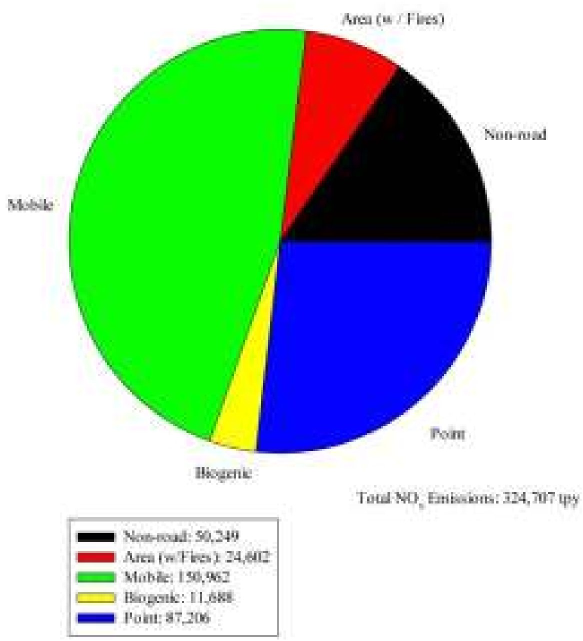




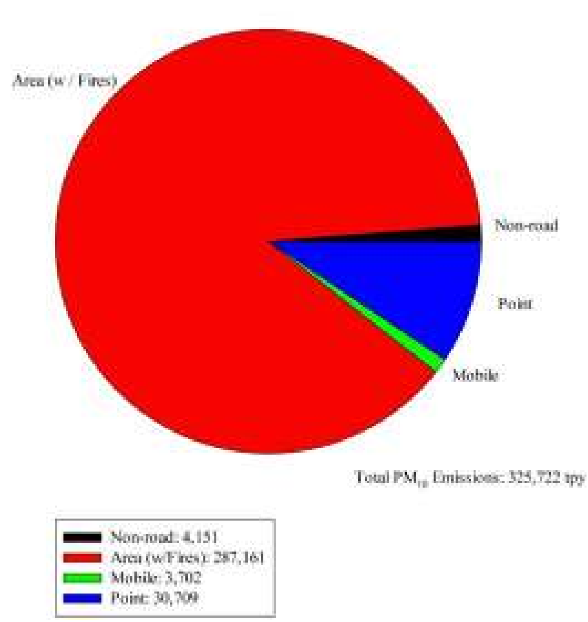


The total NO_x emissions were 324,707 tons per year. Mobile sources made up almost 50 percent of statewide NO_x emissions. There are 325,722 tons per year of PM_{10} emissions, of which area sources make up in excess of 85 percent of the total emissions. The total amount of $PM_{2.5}$ emissions in South Carolina is 91,286 tons per year. Area sources account for almost 70 percent of the total emissions. There are 243,465 total SO_2 emissions in South Carolina with point sources accounting for over 89 percent of total emissions. There are approximately 1,333,964 tons per year of VOCs emissions in South Carolina. By far, biogenic sources make up the majority of VOCs. In fact, biogenic sources make up over 70 percent of the total amount of VOCs in South Carolina. In 2002, there was a total of 926,739 tons per year of CO emissions reported in the South Carolina. Area and non-road sources combined to account for more than 80 percent of the total CO emissions. The total Lead emissions across South Carolina were 14.08 tons per year. Area sources account for more than 50 percent of statewide lead emissions.

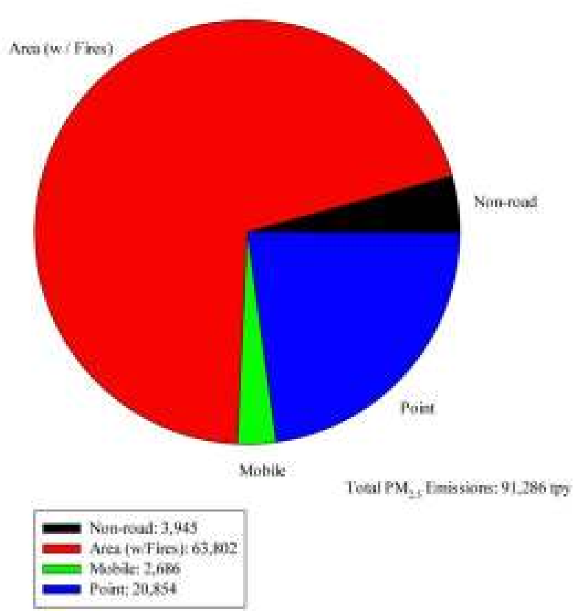
South Carolina NO_x Emissions (Tons per year)



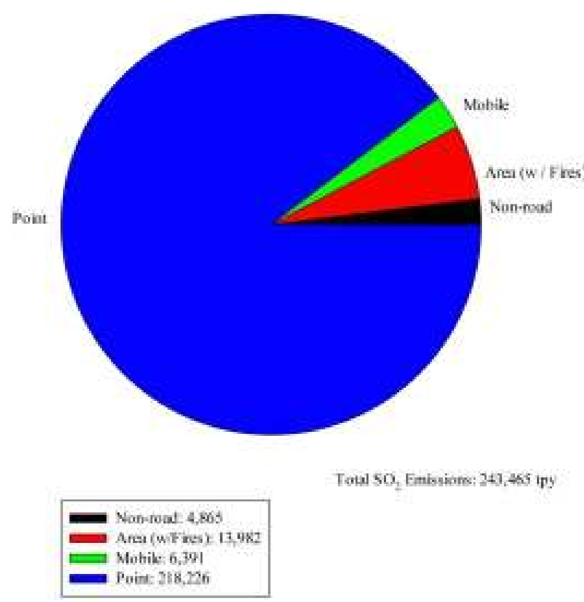
South Carolina PM_{10} Emissions (Tons per year)

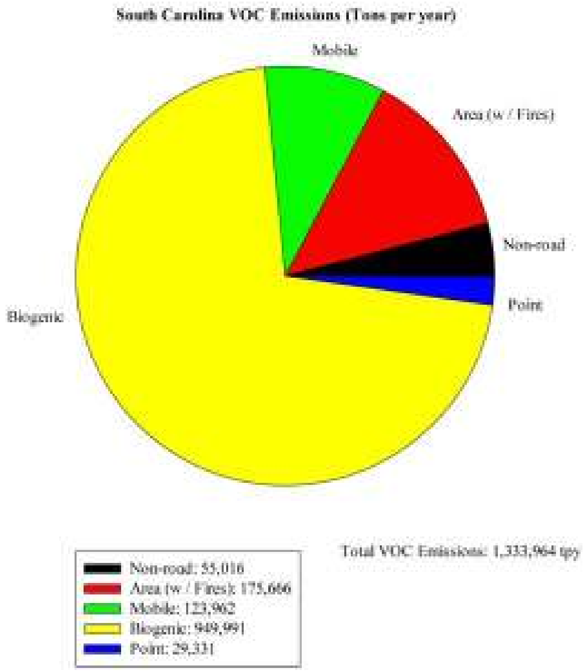


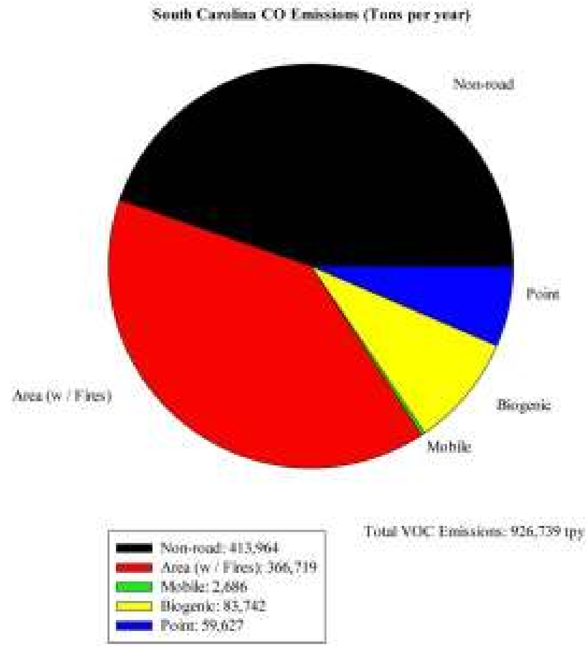
South Carolina $PM_{2.5}$ Emissions (Tons per year)

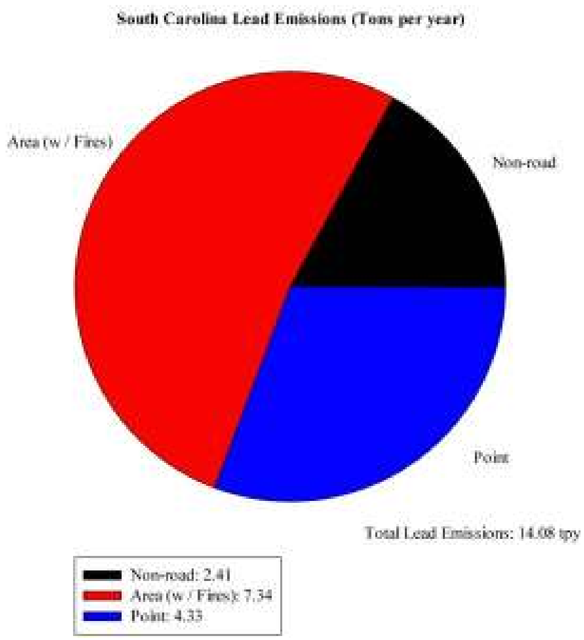


South Carolina SO_2 Emissions (Tons per year)




South Carolina VOC Emissions (Tons per year)
Mobile
Area (w / Fires)
Non-road
Point
Biogenic
Total VOC Emissions: 1,333,964 tpy
Non-road: 55,016
Area (w / Fires): 175,666
Mobile: 123,962
Biogenic: 949,991
Point: 29,331

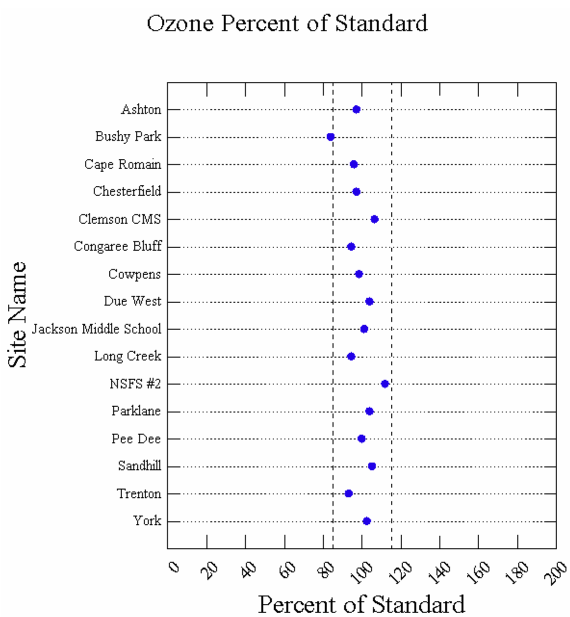

South Carolina CO Emissions (Tons per year)
Non-road
Point
Area (w / Fires)
Biogenic
Mobile
Total VOC Emissions: 926,739 tpy
Non-road: 413,964
Area (w / Fires): 366,719
Mobile: 2,686
Biogenic: 83,742
Point: 59,627


South Carolina Lead Emissions (Tons per year)
Area (w / Fires)
Non-road
Point
Total Lead Emissions: 14.08 tpy
Non-road: 2.41
Area (w / Fires): 7.34
Point: 4.33

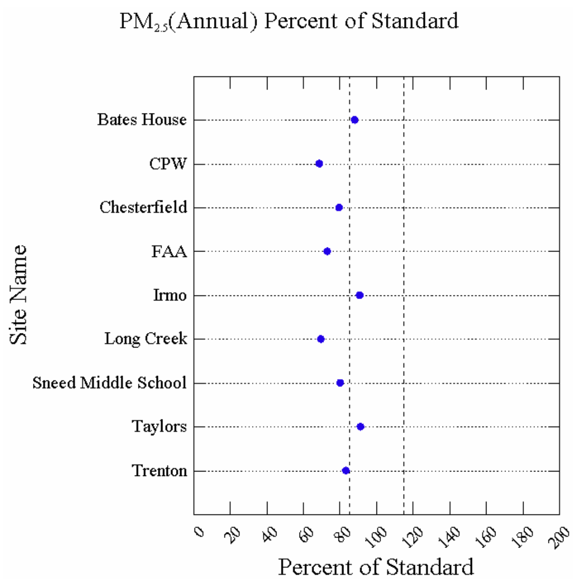
Appendix F: Current air quality and ambient air data trends

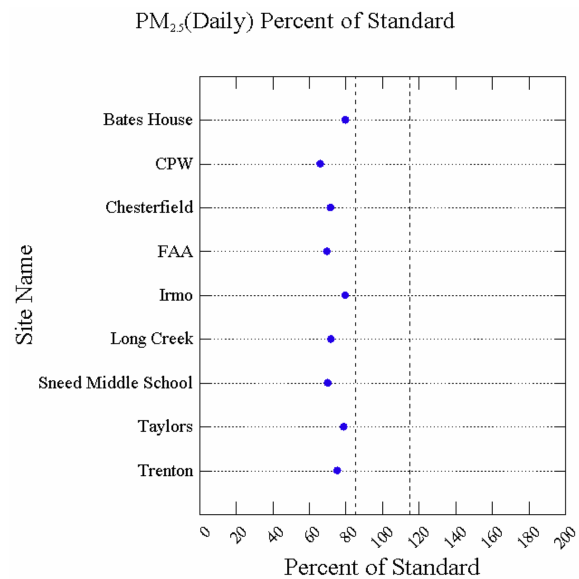
South Carolina currently attains six of the seven National Ambient Air Quality Standards. There is one ozone nonattainment area located in York County as part of the Charlotte-Gastonia-Rock Hill NC-SC Nonattainment Area. The graphs below depict the 2008 design values as the percentage of the standard for each criteria pollutant. The dashed vertical lines on each graph depict ±15 percent of the standard. For the purposes of this assessment, a monitor that had a design value ±15 percent of the standard was deemed to be of high importance in providing information concerning NAAQS compliance.

Ozone concentrations in 2008 hovered near 85 – 115 percent of the Ozone NAAQS (set at 0.075 ppm as of this writing). More than half of the ozone monitoring sites in South Carolina have design values in excess of the standard.

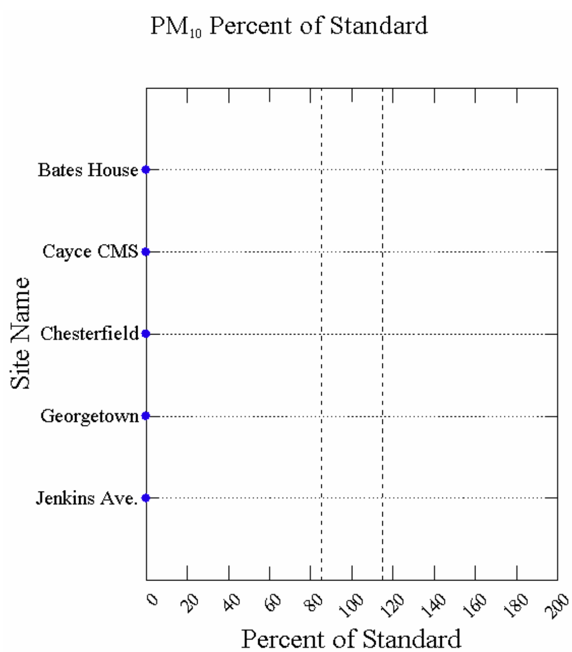


$PM_{2.5}$ concentrations across the state for the most part are less than 85 percent of the NAAQS with a few exceptions. The sites that are greater than 85 percent of the NAAQS are located in urbanized areas where $PM_{2.5}$ emissions tend to be higher.

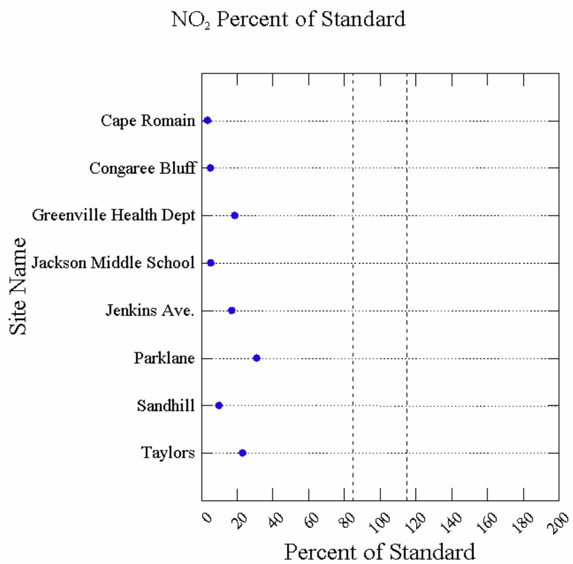




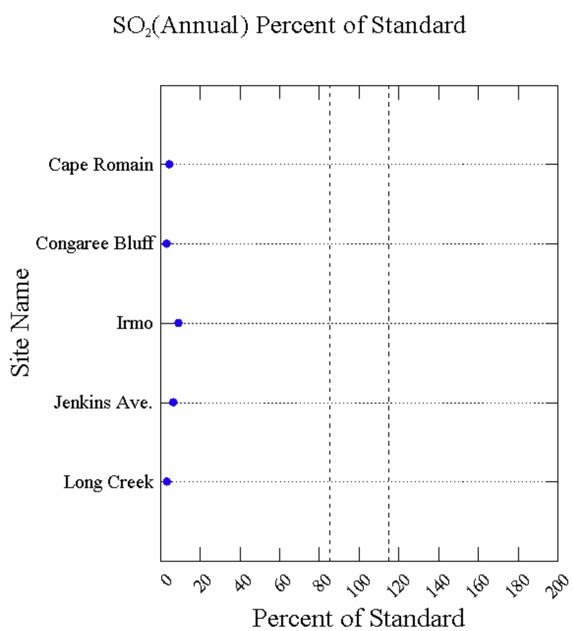
All monitoring for PM_{10} is well below the level of the NAAQS.

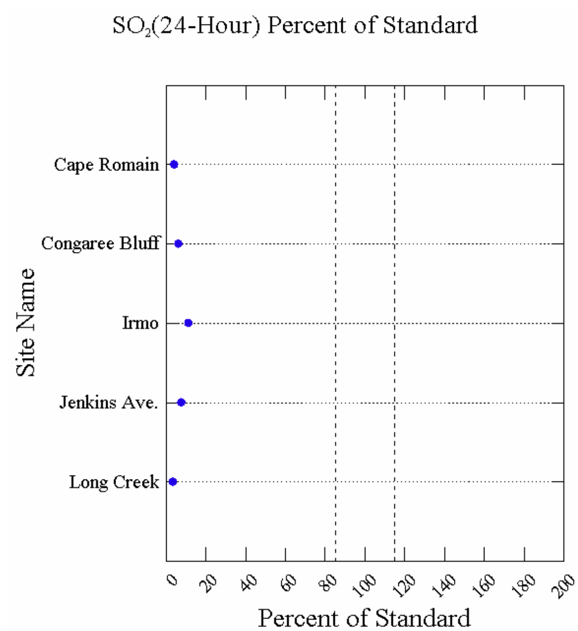


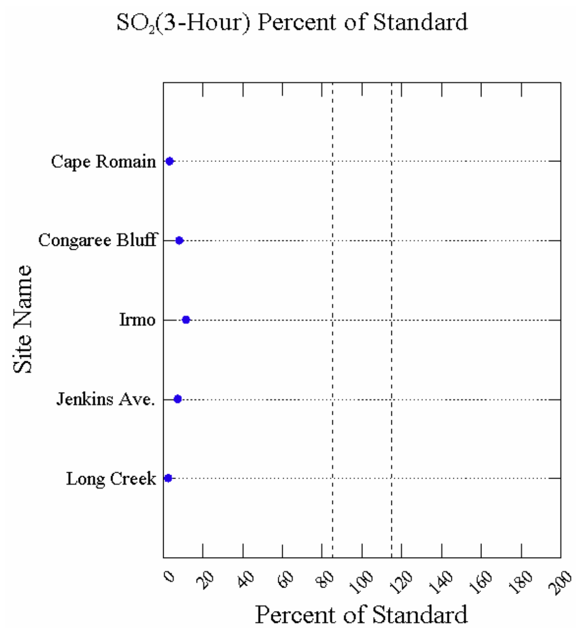
All monitoring for NO_2 is well below the level of the NAAQS.



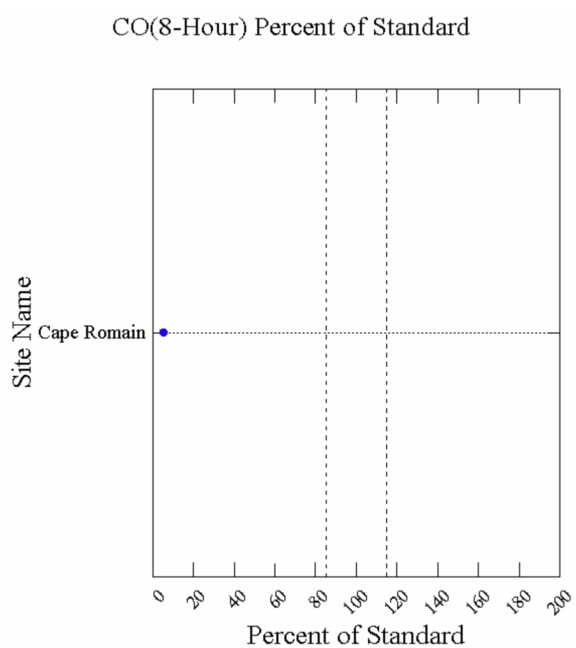
All monitoring for SO_2 is well below the level of the NAAQS.

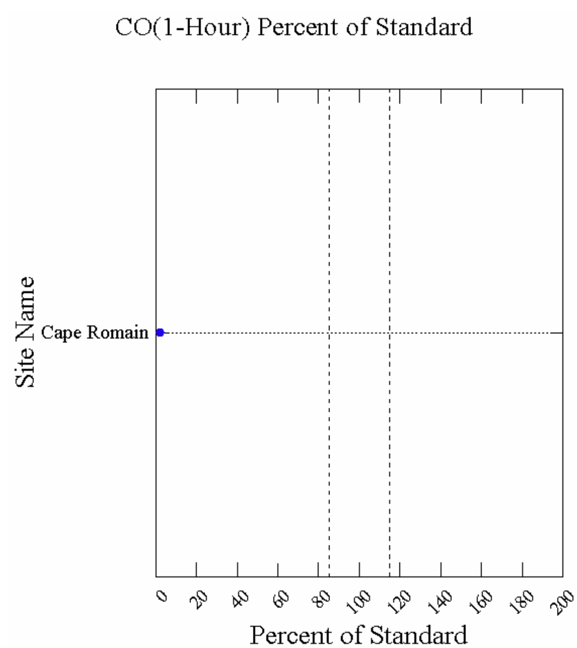




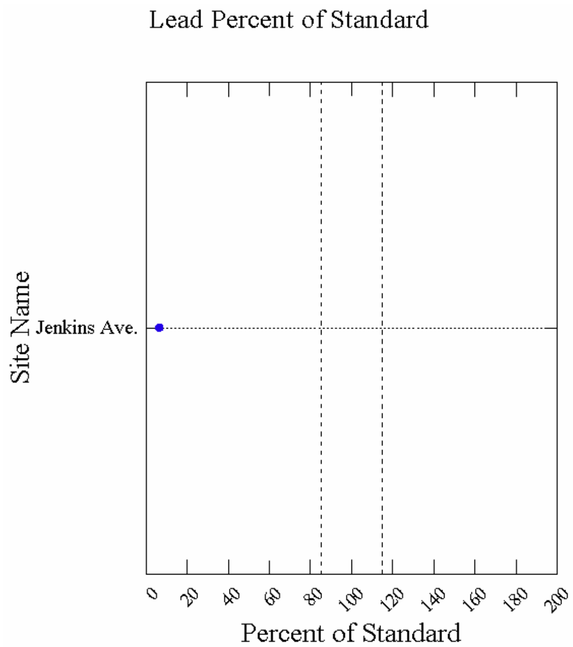


All monitoring for CO is well below the level of the NAAQS.

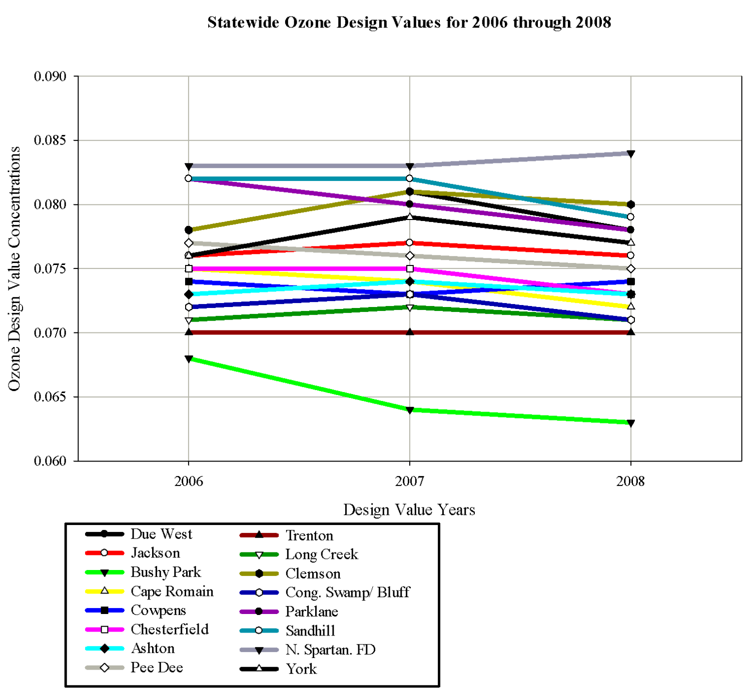




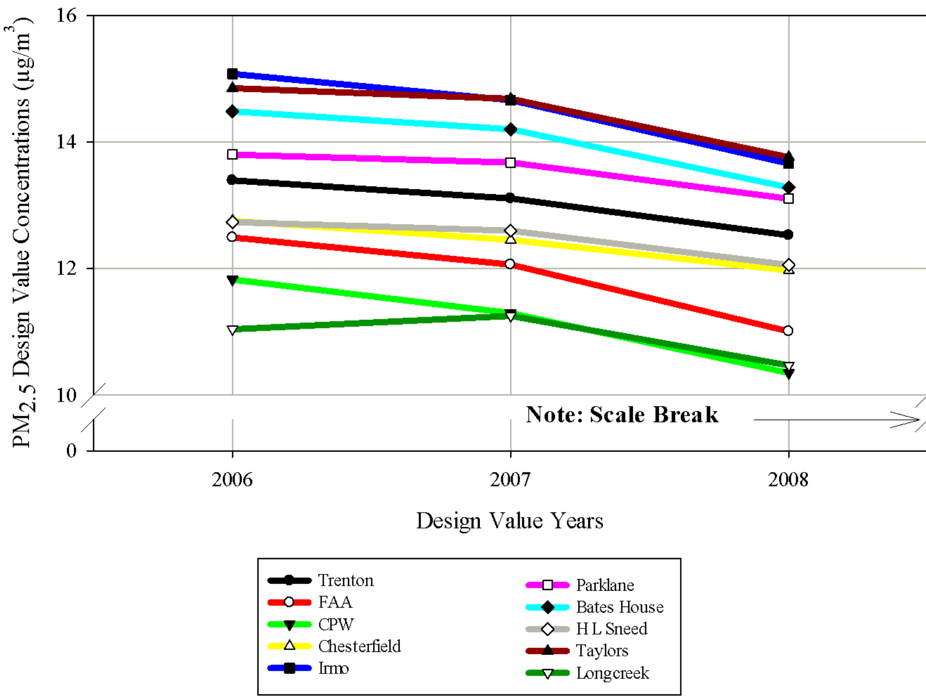
All sampling for Lead is well below the level of the NAAQS.



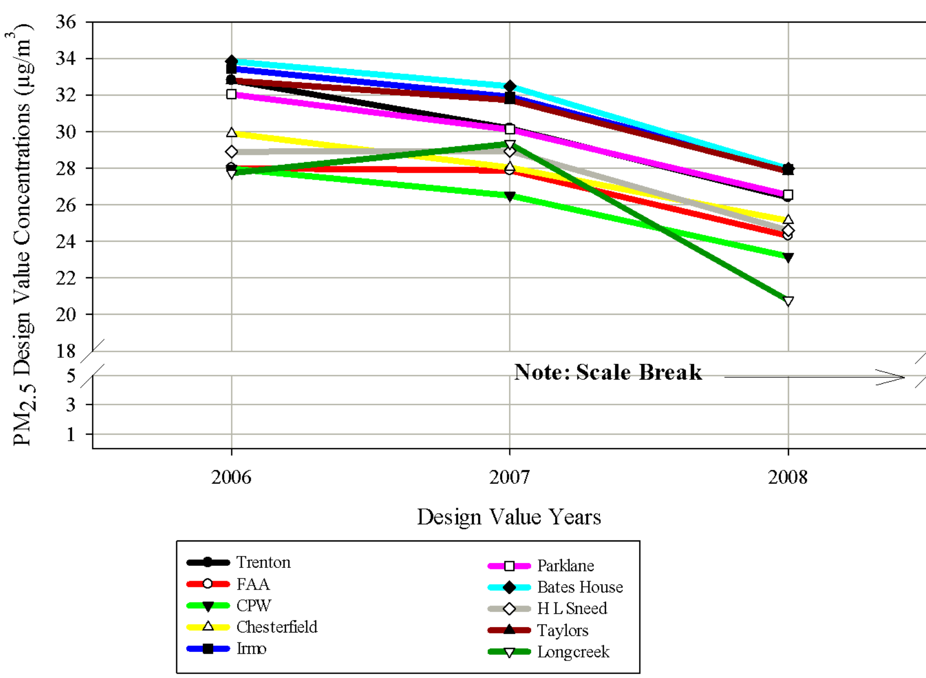
The following graphs provide trends in the design values for each of the pollutants for data collected from 2004 to 2008.



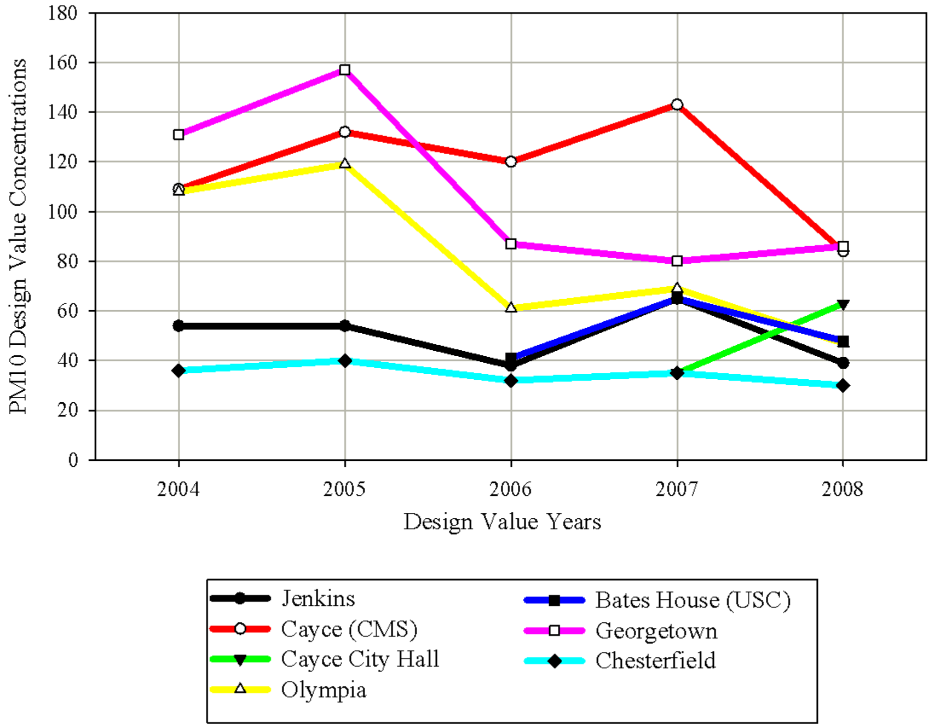
Statewide $PM_{2.5}$ Annual Design Values for 2006 through 2008



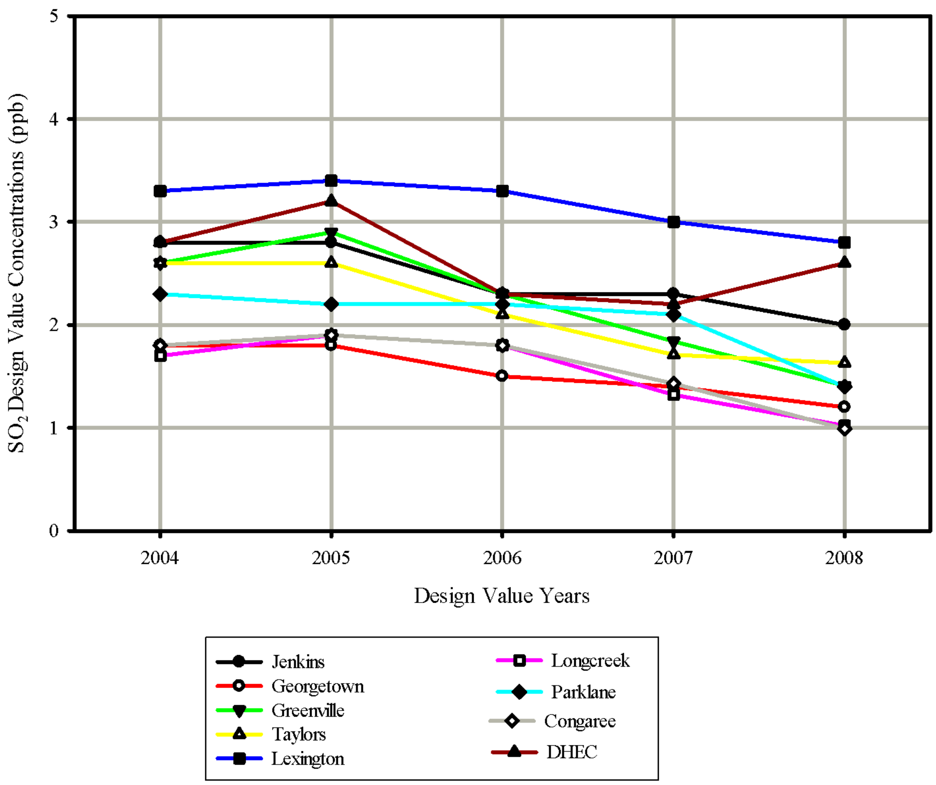
Statewide $PM_{2.5}$ 24 Hour Design Values for 2006 through 2008



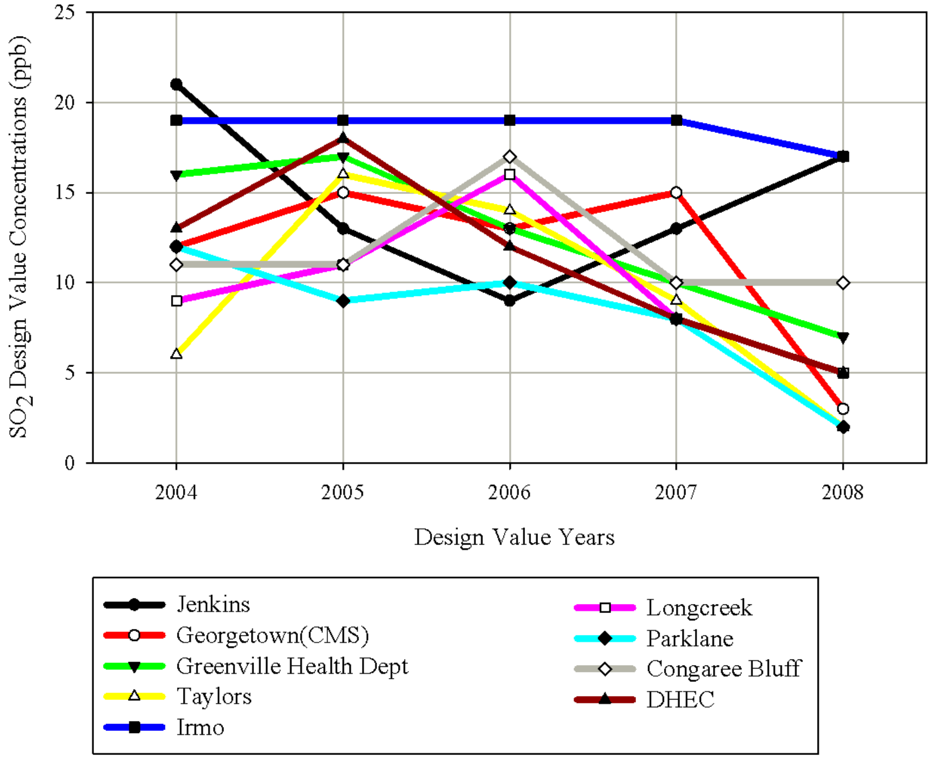
Statewide PM_{10} Design Values for 2004 through 2008

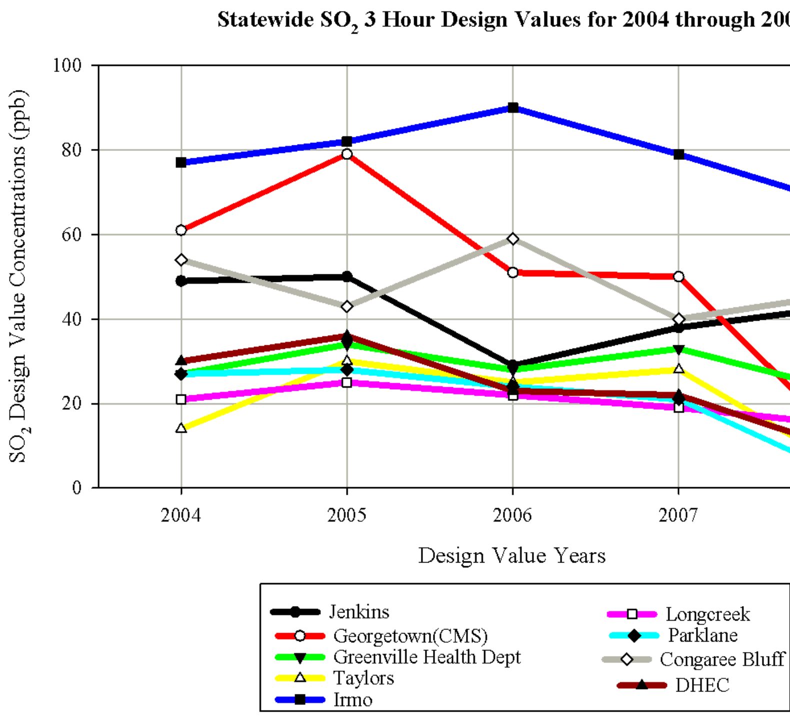


Statewide SO_2 Annual Design Values for 2004-2008

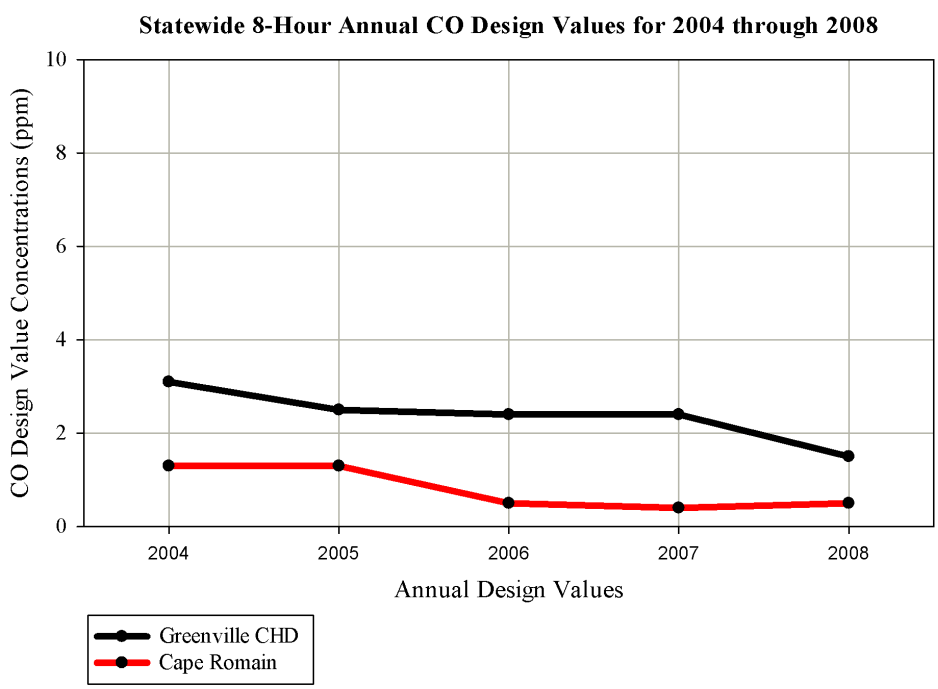


Statewide SO_2 24 Hour Design Values for 2004 through 2008

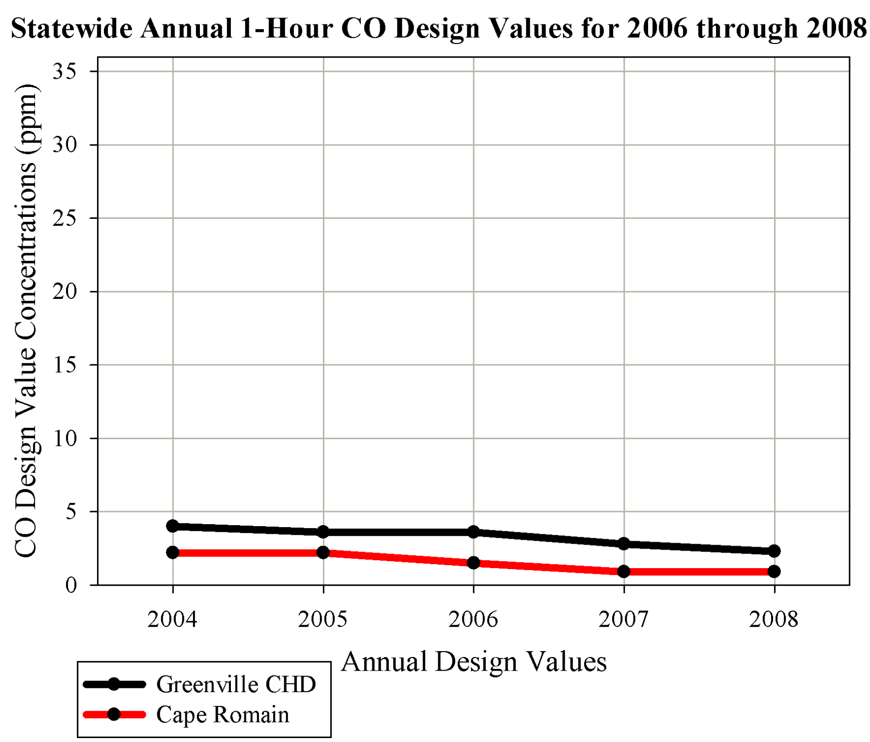


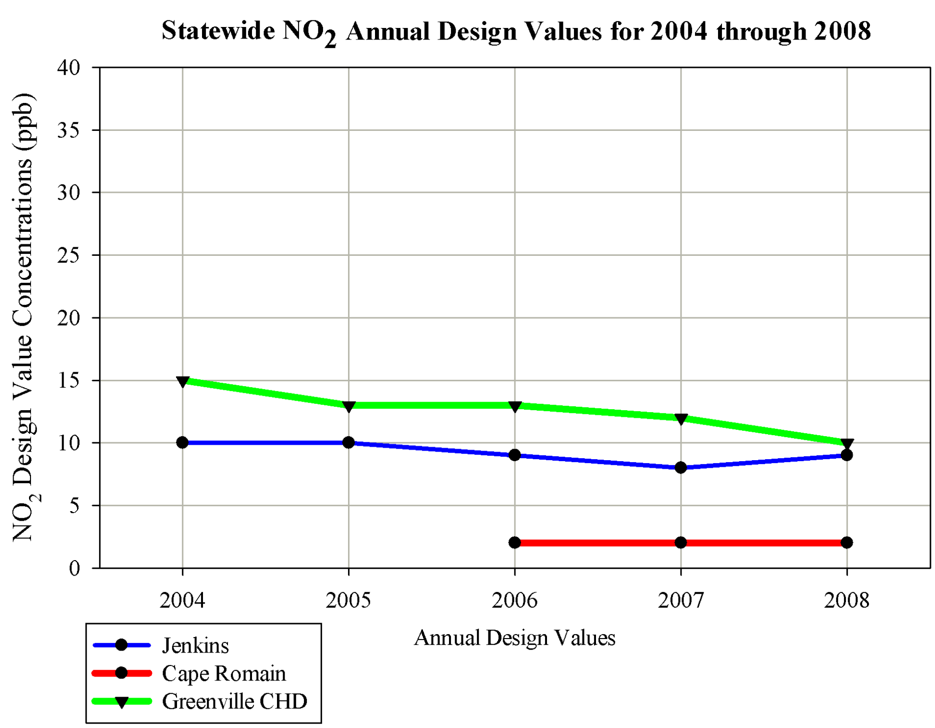


Statewide SO_2 3 Hour Design Values for 2004 through 2008
SO_2 Design Value Concentrations (ppb)
0
20
40
60
80
100
2004
2005
2006
2007
2008
Design Value Years
Jenkins
Georgetown(CMS)
Greenville Health Dept
Taylors
Irmo
Longcreek
Parklane
Congaree Bluff
DHEC

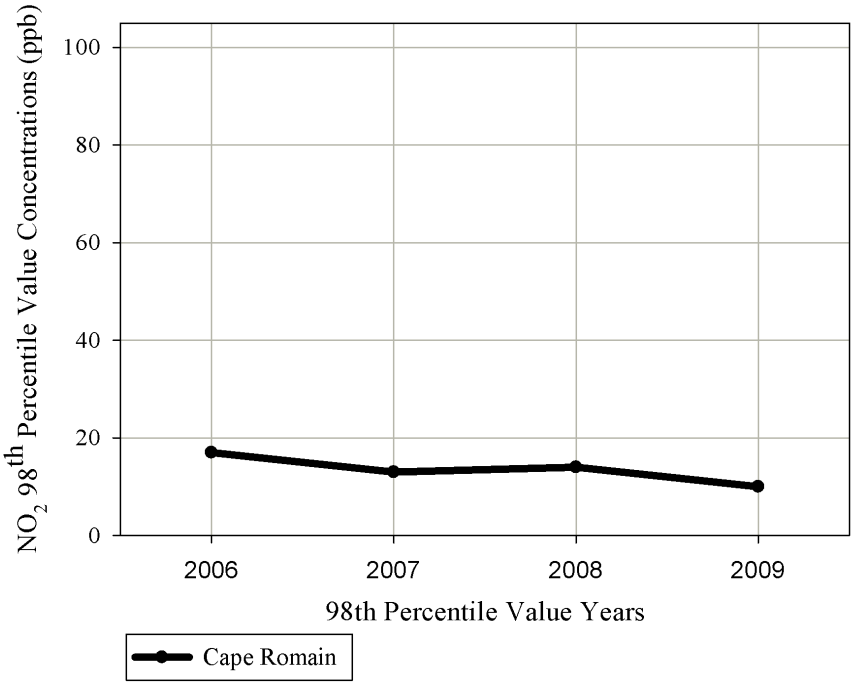


Statewide 8-Hour Annual CO Design Values for 2004 through 2008
CO Design Value Concentrations (ppm)
0
2
4
6
8
10
2004
2005
2006
2007
2008
Annual Design Values
Greenville CHD
Cape Romain


Statewide Annual 1-Hour CO Design Values for 2006 through 2008
CO Design Value Concentrations (ppm)
35
30
25
20
15
10
5
0
2004
2005
2006
2007
2008
Annual Design Values
Greenville CHD
Cape Romain

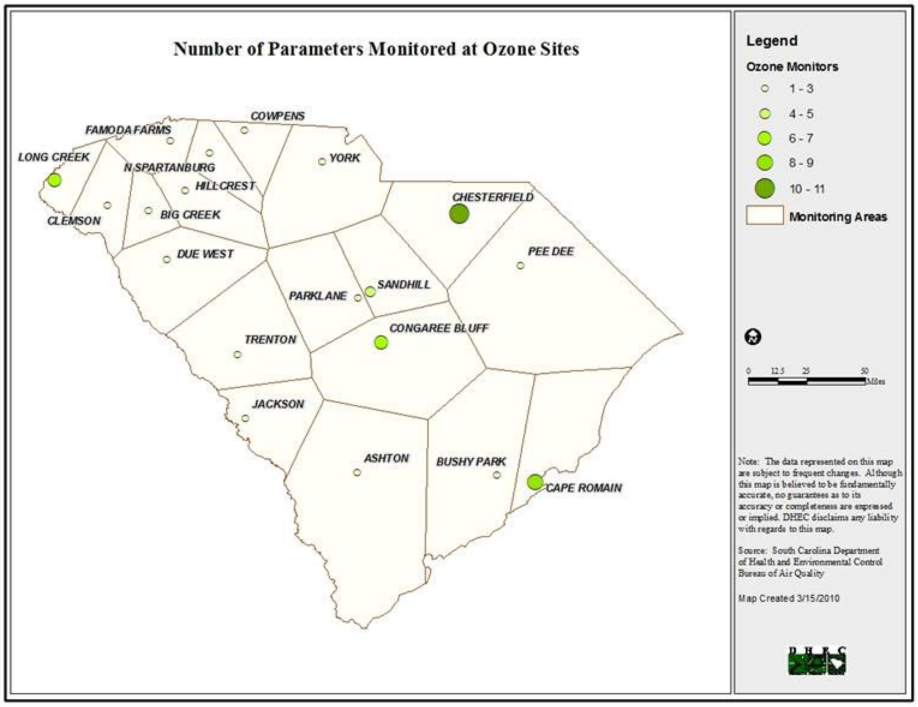

Statewide NO_2 Annual Design Values for 2004 through 2008
NO_2 Design Value Concentrations (ppb)
40
35
30
25
20
15
10
5
0
2004
2005
2006
2007
2008
Annual Design Values
Jenkins
Cape Romain
Greenville CHD

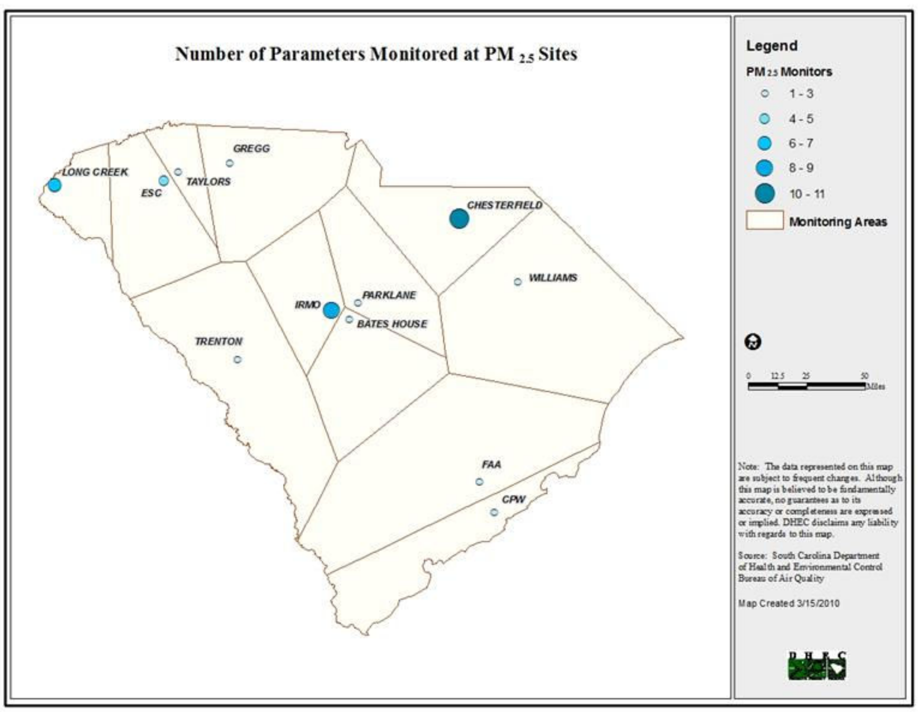
Statewide Annual NO_2 98th Percentile Values for 2006 through 2009



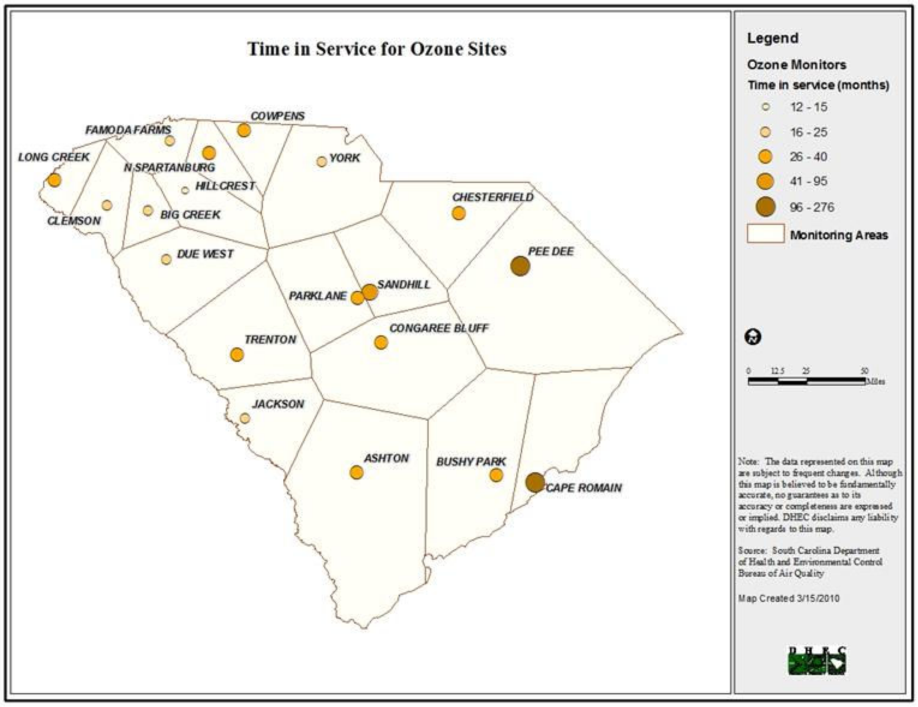
Appendix G: Maps depicting steps of the technical assessment of the ozone and $PM_{2.5}$ ambient air monitoring networks.

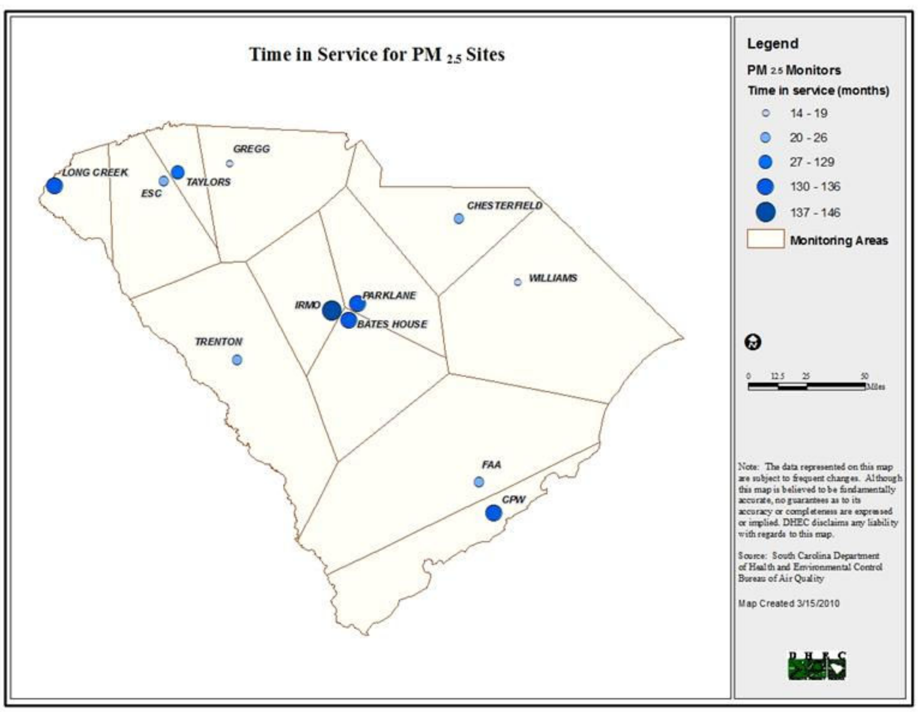
Number of other parameters monitored at the site



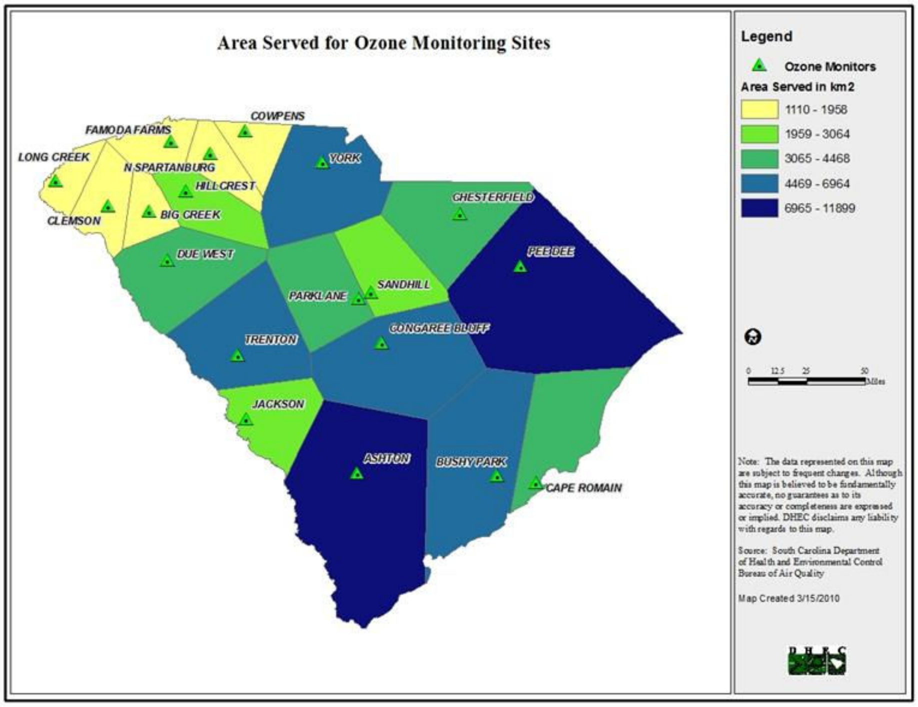


Trends impact

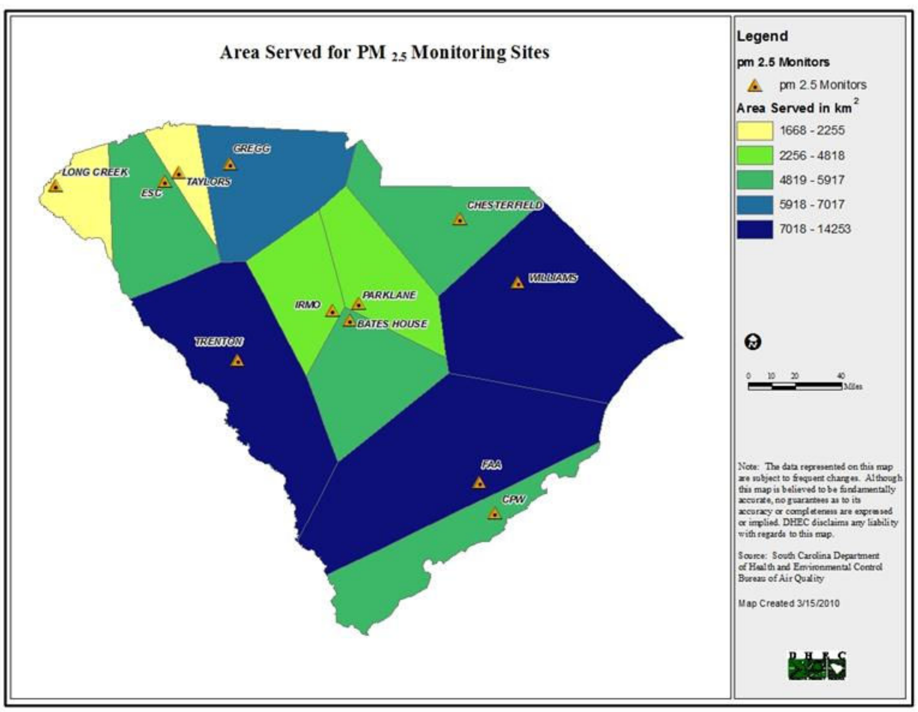




Area served

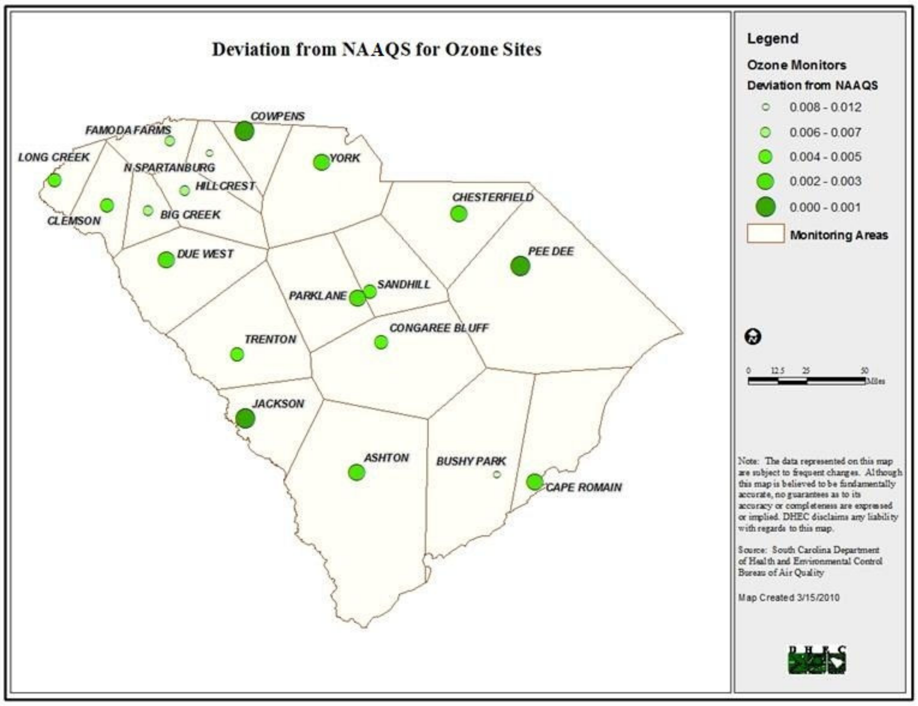


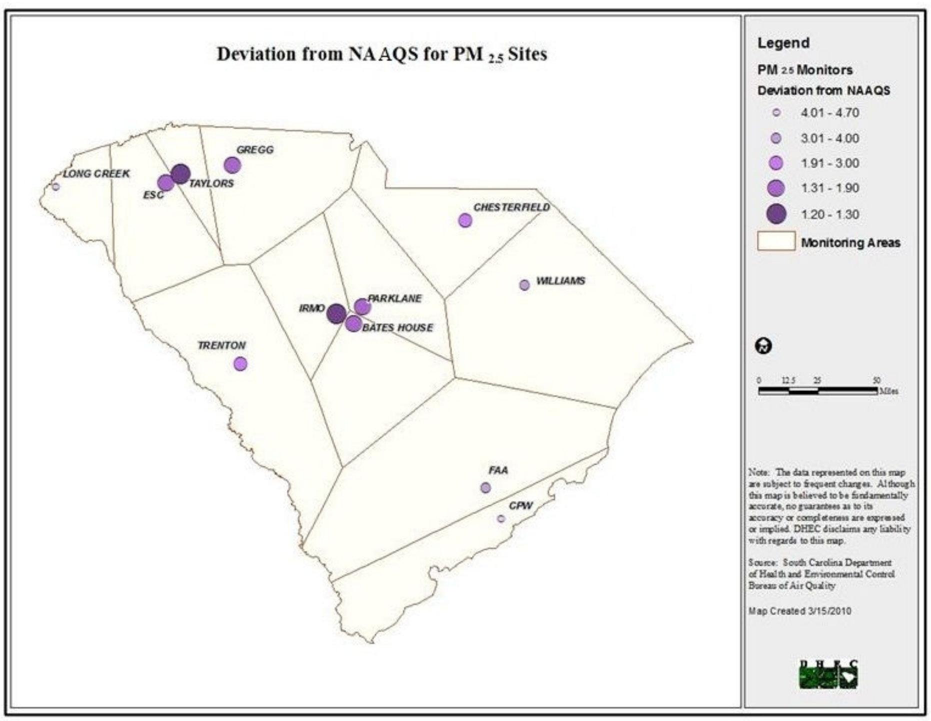
Area Served for Ozone Monitoring Sites
Legend
Ozone Monitors
Area Served in km2
1110 - 1958
1959 - 3064
3065 - 4468
4469 - 6964
6965 - 11899
COWPENS
FAMODA FARMS
LONG CREEK
N SPARTANBURG
HILL CREST
YORK
CLEMSON
BIG CREEK
CHESTERFIELD
DUE WEST
PEE DEE
SANDHILL
PARKLANE
CONGAREE BLUFF
TRENTON
JACKSON
ASHTON
BUSHY PARK
CAPE ROMAIN
0 12.5 25 50 Miles
Note: The data represented on this map are subject to frequent changes. Although this map is believed to be fundamentally accurate, no guarantees as to its accuracy or completeness are expressed or implied. DHEC disclaims any liability with regards to this map.
Source: South Carolina Department of Health and Environmental Control Bureau of Air Quality
Map Created 3/15/2010



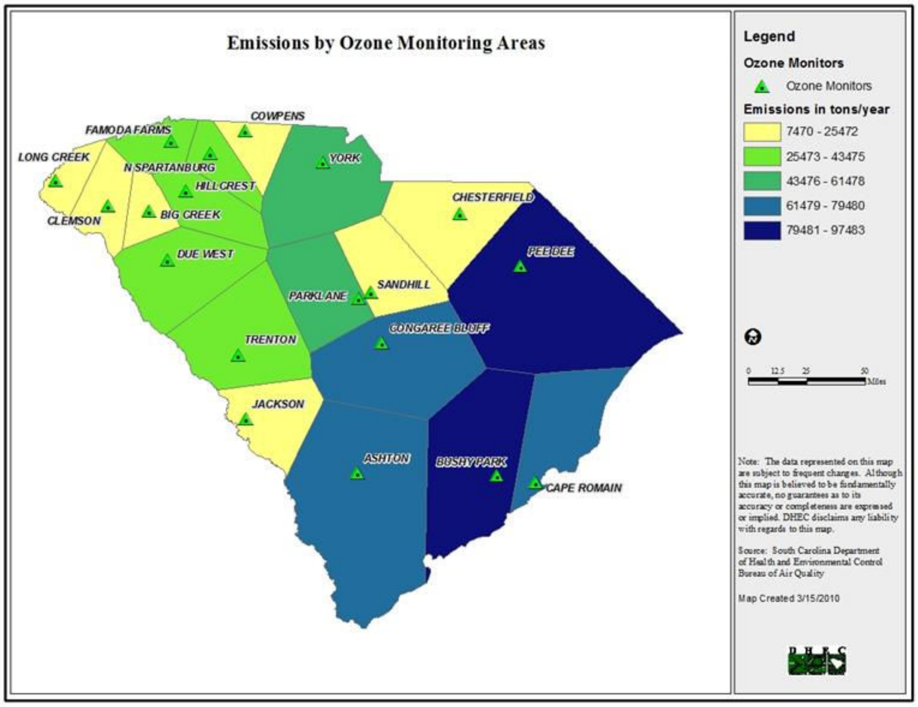
Area Served for PM 2.5 Monitoring Sites
Legend
pm 2.5 Monitors
pm 2.5 Monitors
Area Served in km2
1668 - 2255
2256 - 4818
4819 - 5917
5918 - 7017
7018 - 14253
GREGG
LONG CREEK
ESC
TAYLORS
CHESTERFIELD
WILLIAMS
IRMO
PARKLANE
BATES HOUSE
TRENTON
FAA
CPW
0 10 20 40 Miles
Note: The data represented on this map are subject to frequent changes. Although this map is believed to be fundamentally accurate, no guarantees as to its accuracy or completeness are expressed or implied. DHEC disclaims any liability with regards to this map.
Source: South Carolina Department of Health and Environmental Control Bureau of Air Quality
Map Created 3/15/2010

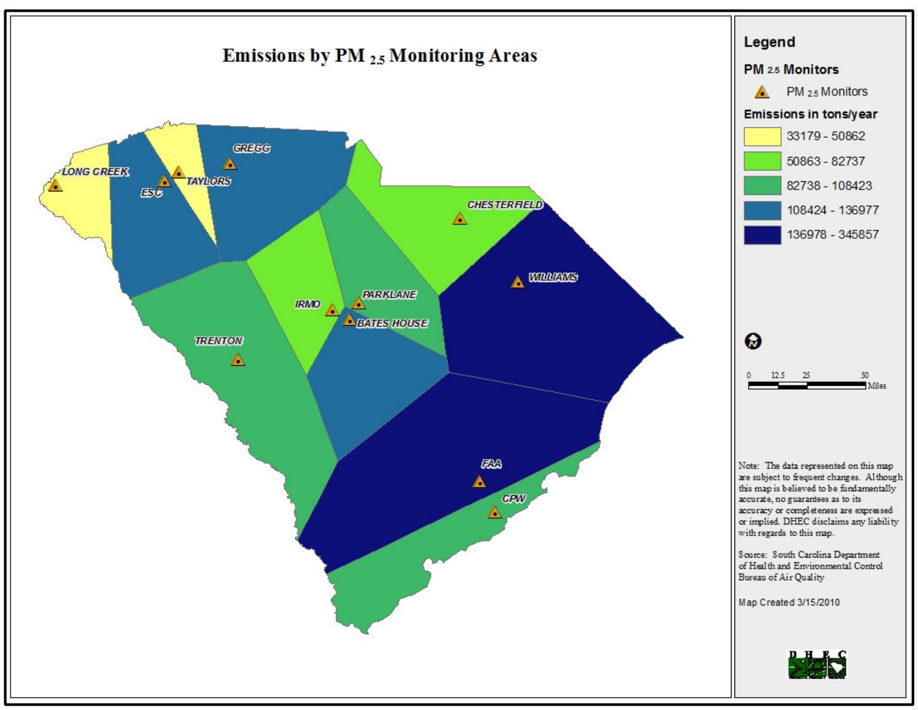
Deviation from NAAQS



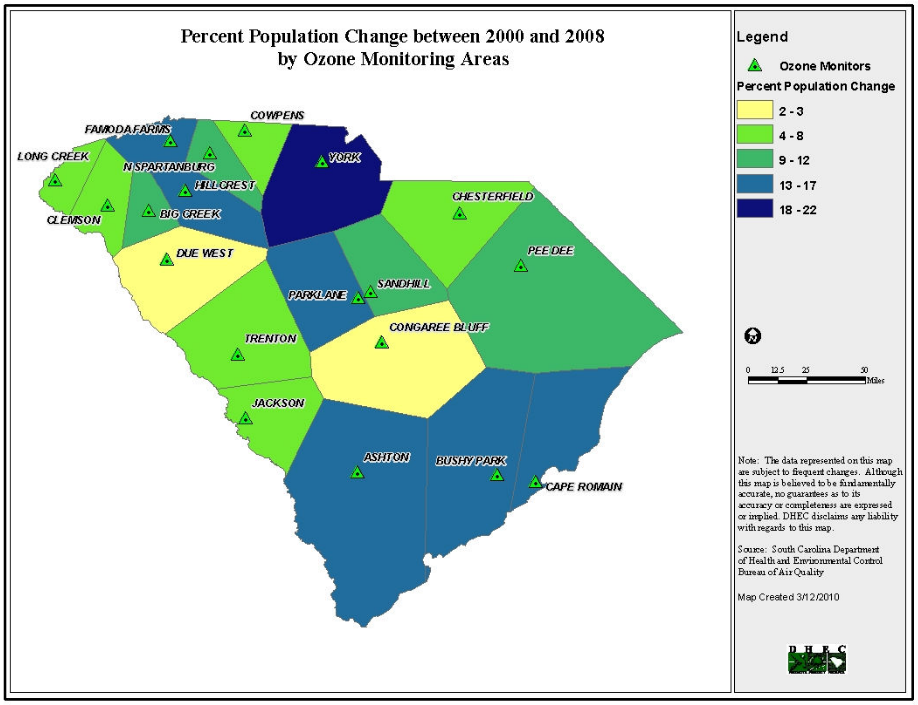


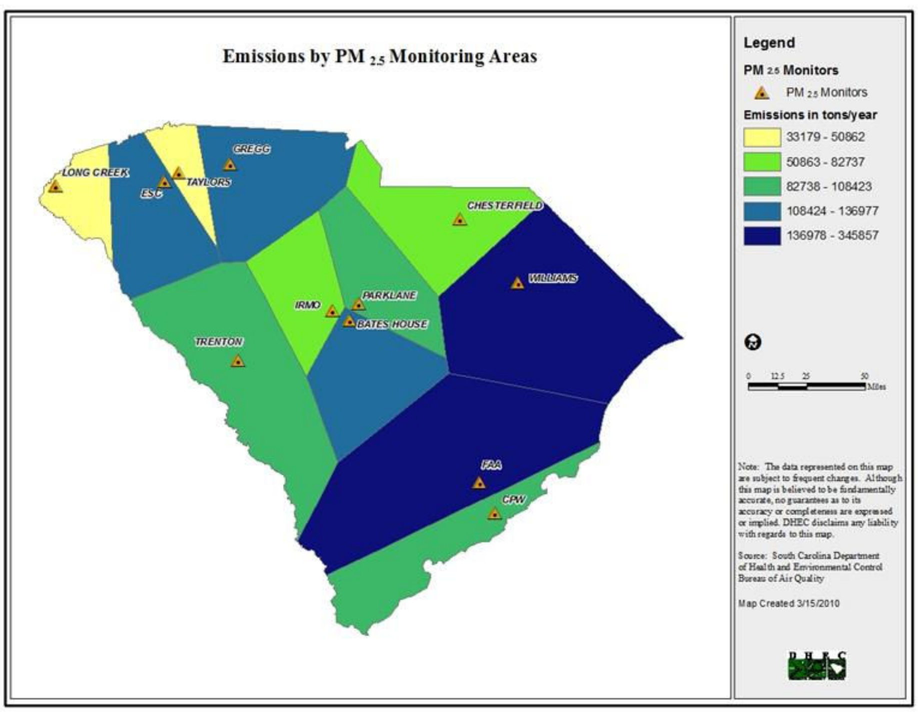
Emission inventory



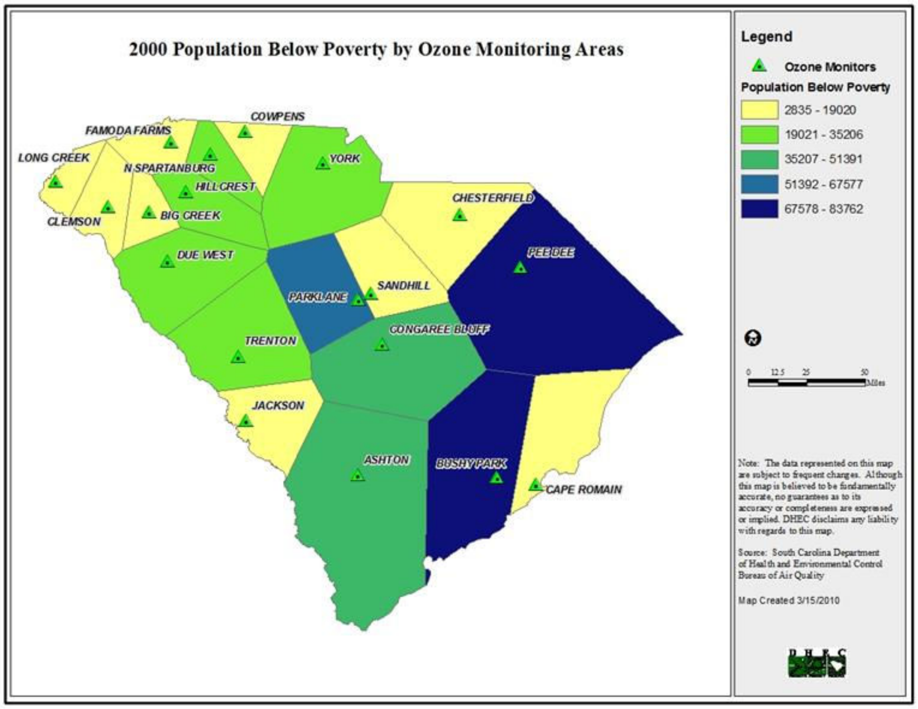


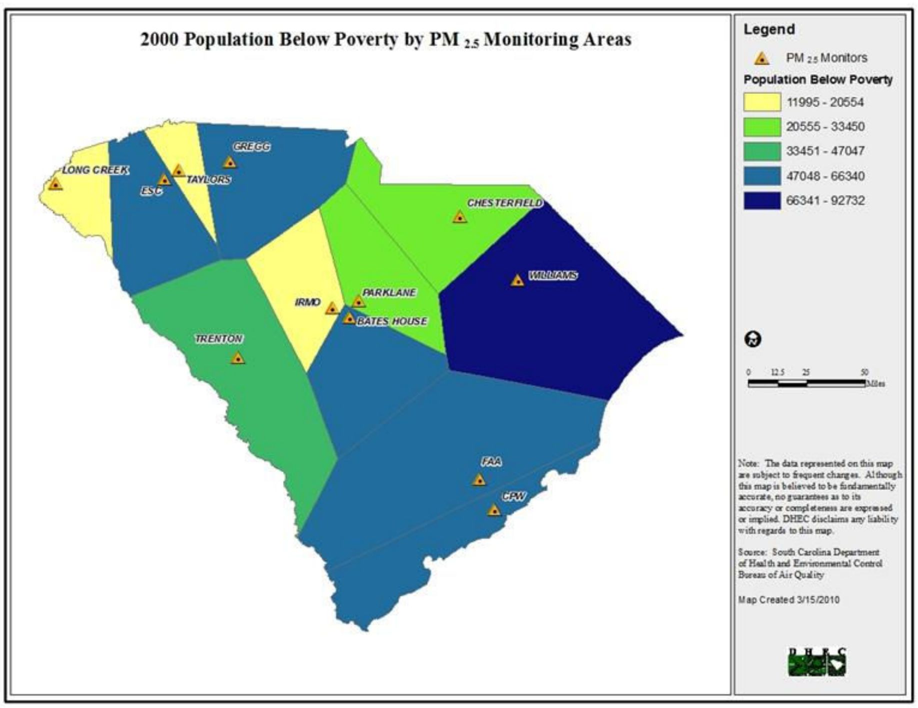
Population change



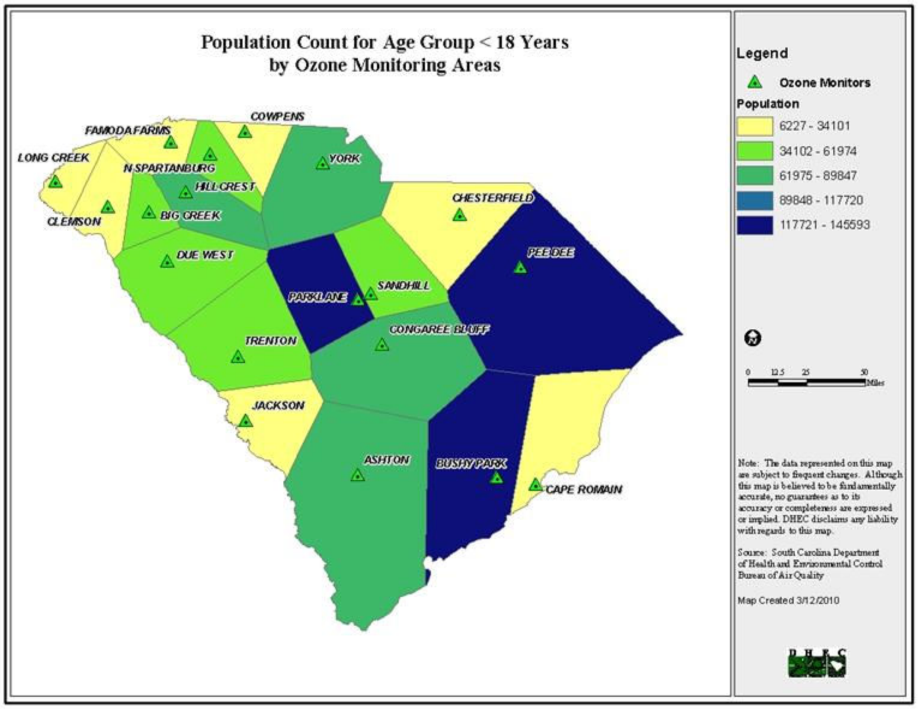


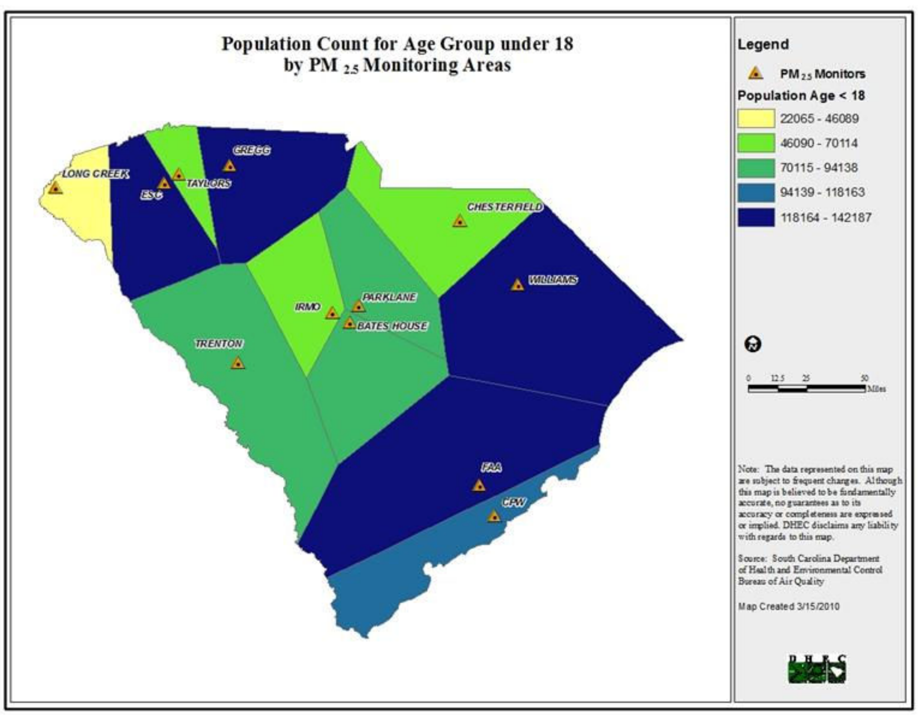
Poverty Rate



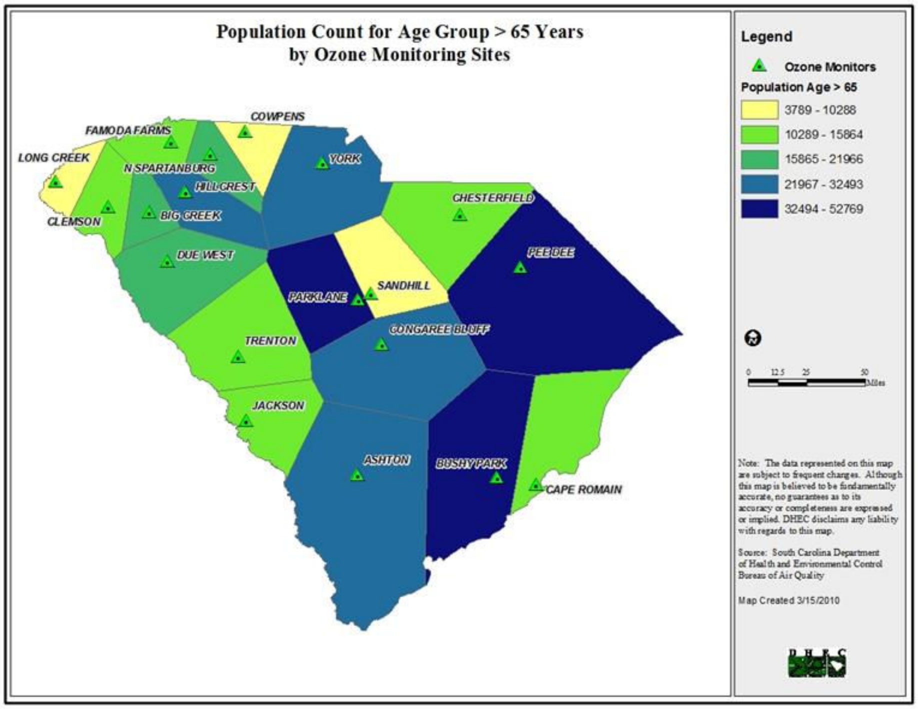


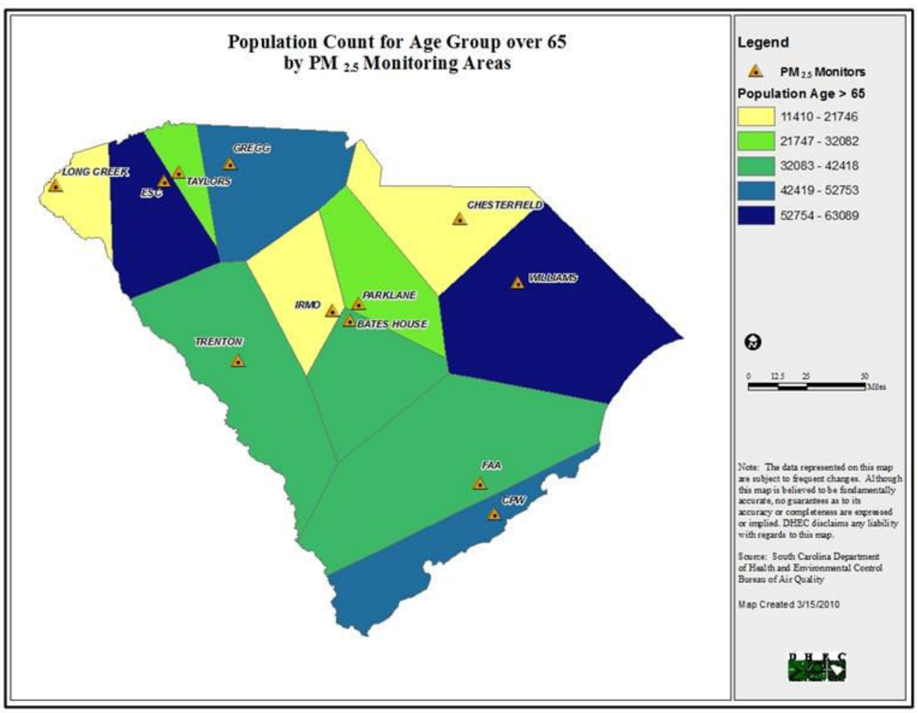
Population for Age 18 and Below





Population for Age 65 and Above





Appendix H – Weighting scheme used in network assessment technical tools

Weighting technique showing the importance of each category.	
Criteria	Weight
Area served	2%
Measured Concentrations	26%
Deviation from NAAQS	20%
Emissions	10%
Population:	
Population Change	2%
Population Living Below Poverty Level	2%
Population for Age 18 and Below	14%
Population for Age 65 and Above	14%
Time in Service	5%
Number of Parameters	5%