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.

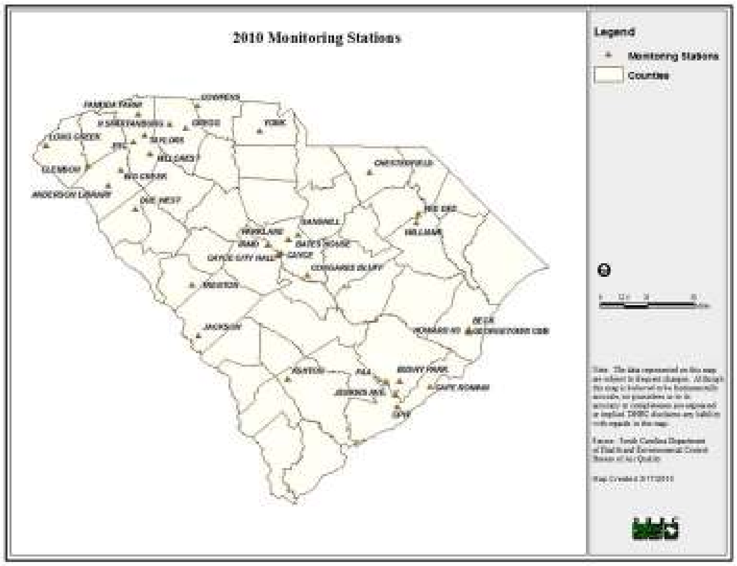
Scoring method

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.



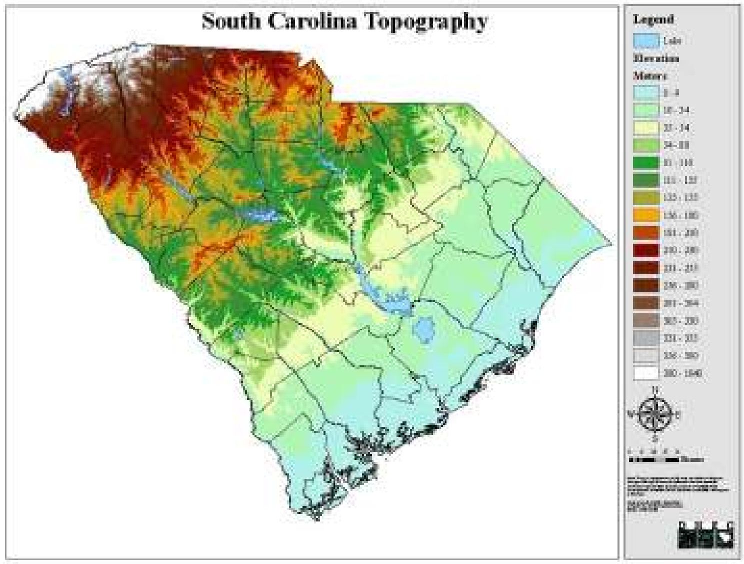
Technical analysis of South Carolina's ambient air monitoring network

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.

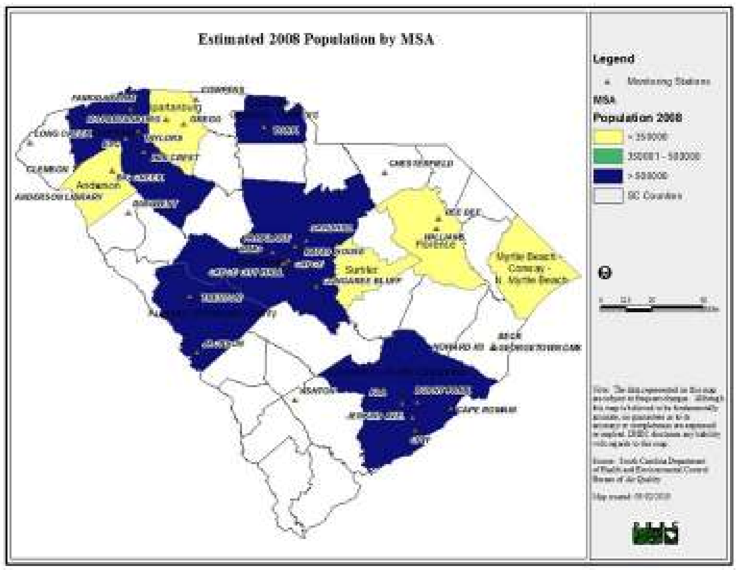
Monthly Normal High and Low Temperatures For Various South Carolina Cities												
City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Charleston	59/37	62/39	69/46	76/52	83/61	88/68	91/72	89/72	85/67	77/55	70/46	62/39
Columbia	55/34	60/36	67/44	76/51	83/60	89/68	92/72	90/71	85/65	76/52	67/43	58/36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

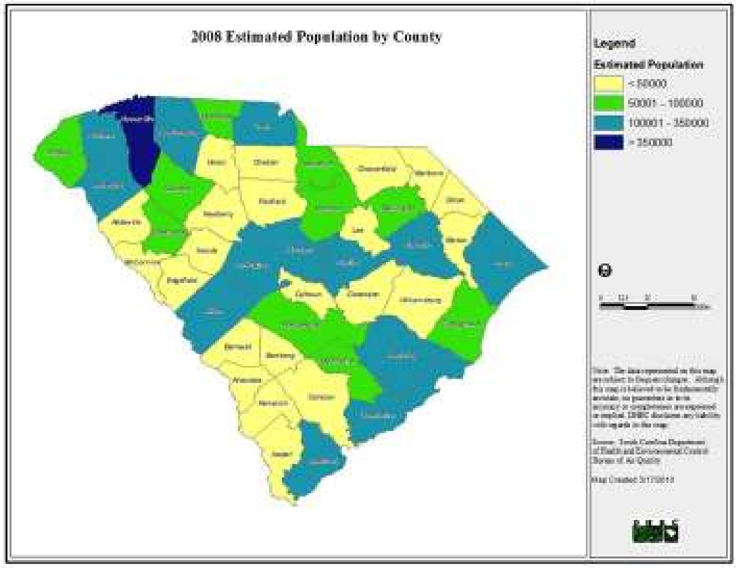
As of July 1, 2008, South Carolina ranks as the twenty-fourth most populated state and the sixth most populous EPA Region 4 state (out of eight states). There are ten MSAs in South Carolina with two of these being multi-state MSAs.

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.

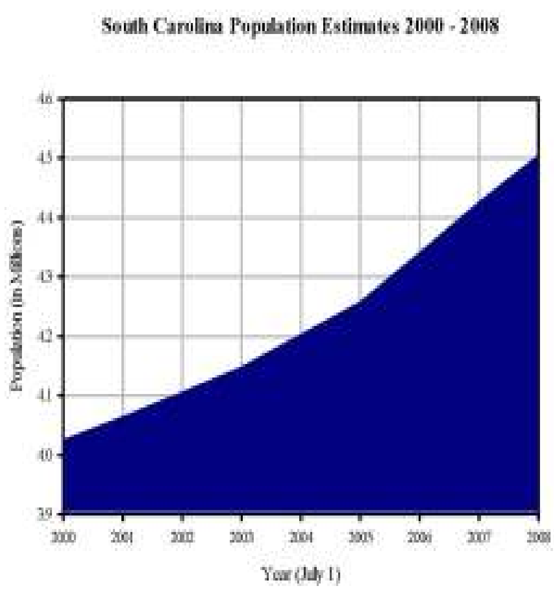


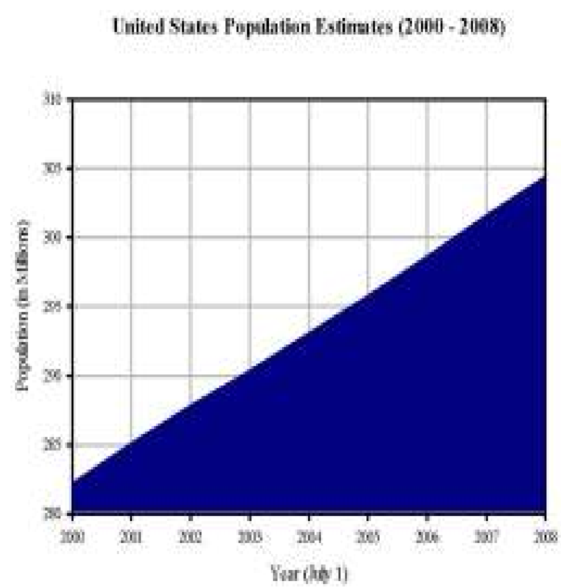
The most populated counties in South Carolina are Charleston, Richland, Greenville and Spartanburg. These counties form the core areas of each of their respective MSAs and are areas of the state where the most ambient air monitoring is conducted.



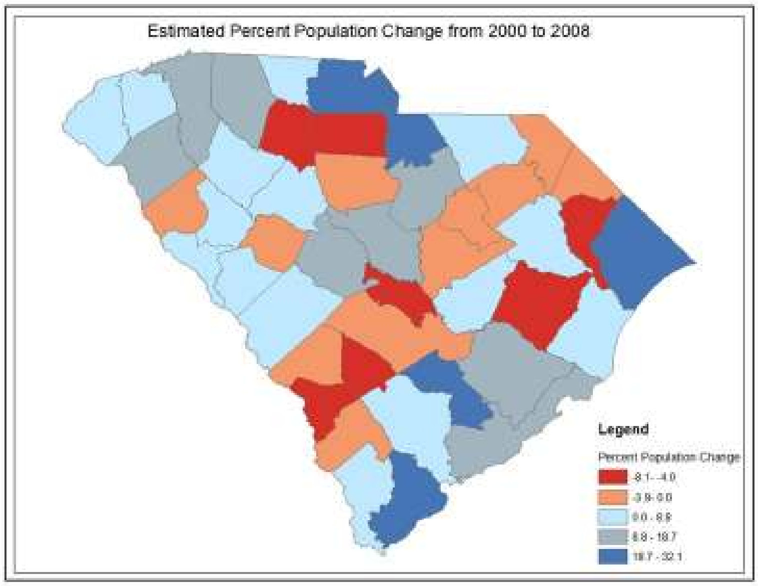
Demographics and trends

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.



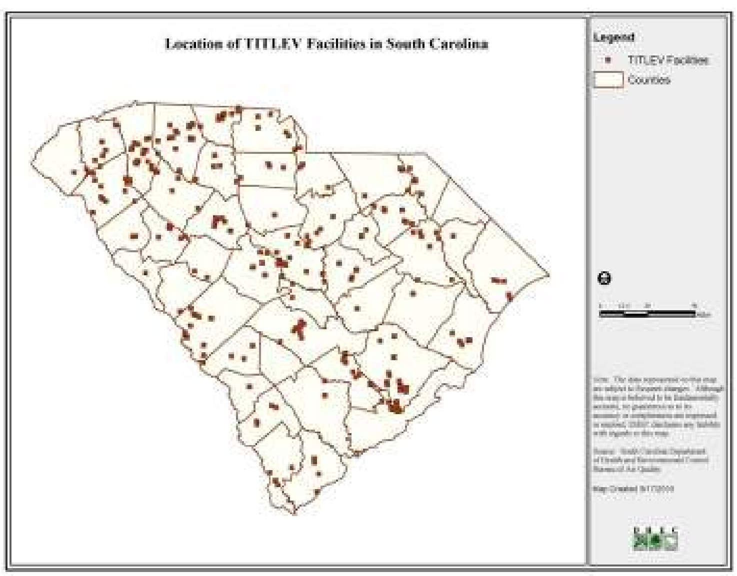


From 2000 to 2008, overall population growth occurred mainly along the coast of South Carolina and in the major urbanized areas of the state. Population decreases were mainly seen in more rural areas of the state.



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.

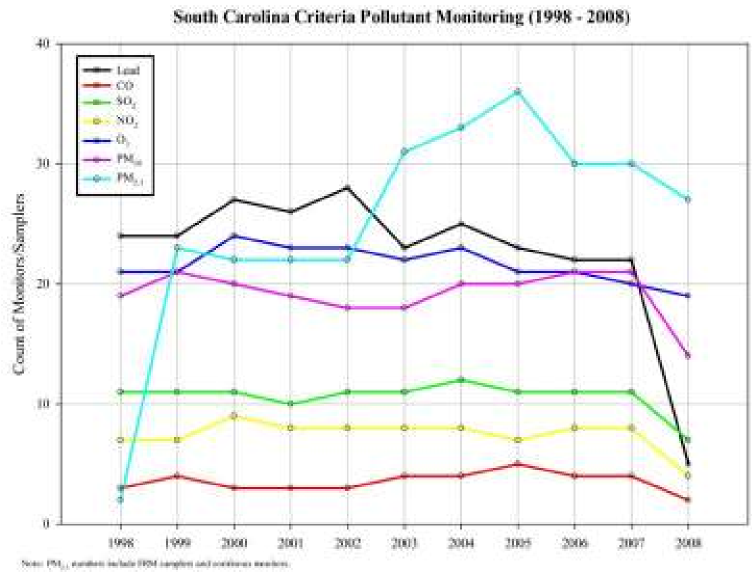
In October, 2006, the EPA published revisions to the ambient air monitoring regulations[6] changing requirements for quality assurance, monitor designations, minimum requirements for both number and distribution of monitors among MSAs, and probe siting. The regulation also included the requirement for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

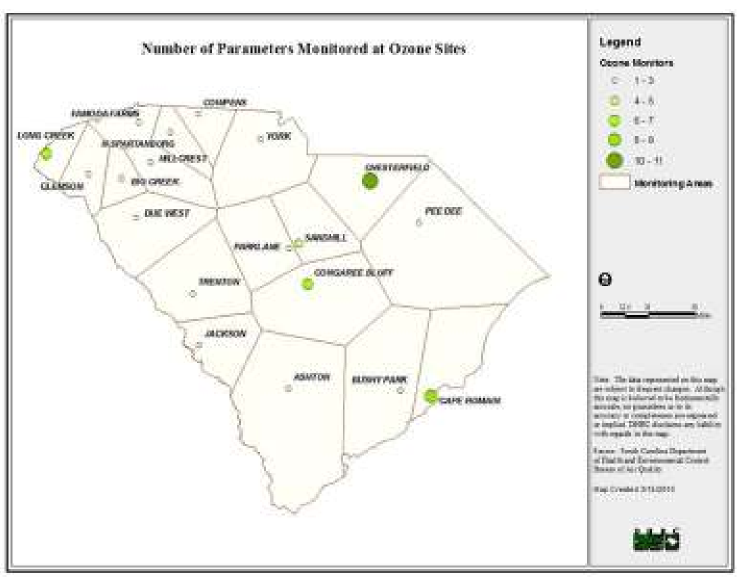
pollutants that did not have historical problems meeting the NAAQS, and instead focused on conserving resources to meet the challenges associated with tightening standards.



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.

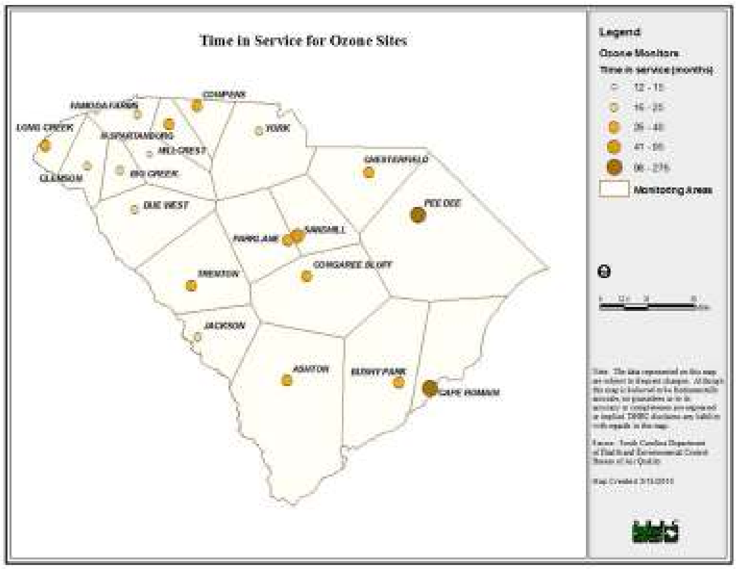
Number of other parameters monitored at the site

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.



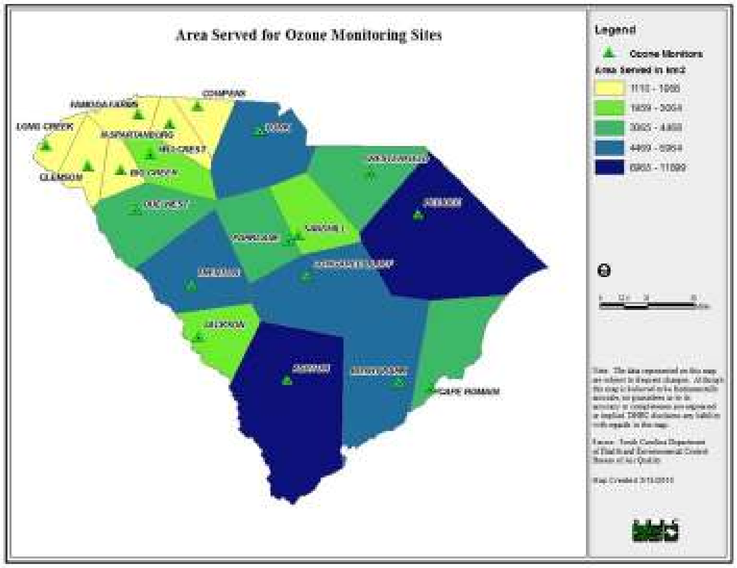
Step 3: Statistical analysis of the ambient air monitoring network

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.

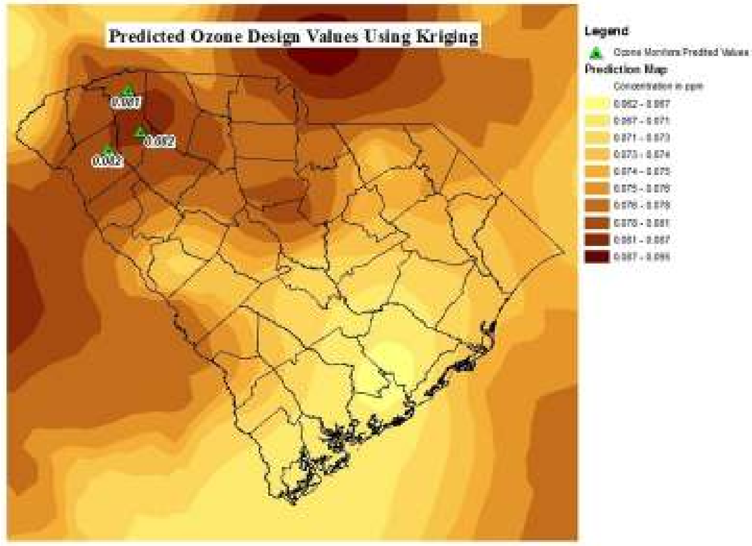


Measured concentrations

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.

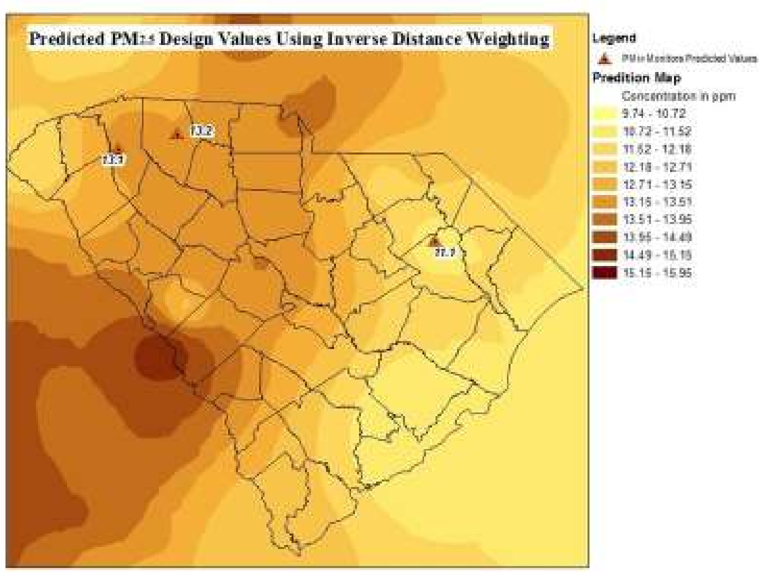
The Department used 2008 design values for Ozone and $PM_{2.5}$ sites to rank the ambient air monitoring sites. There was not enough data to calculate the design values for some of the newer sites recently placed in service. However, in order to score and evaluate all ambient air monitoring sites, the 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.



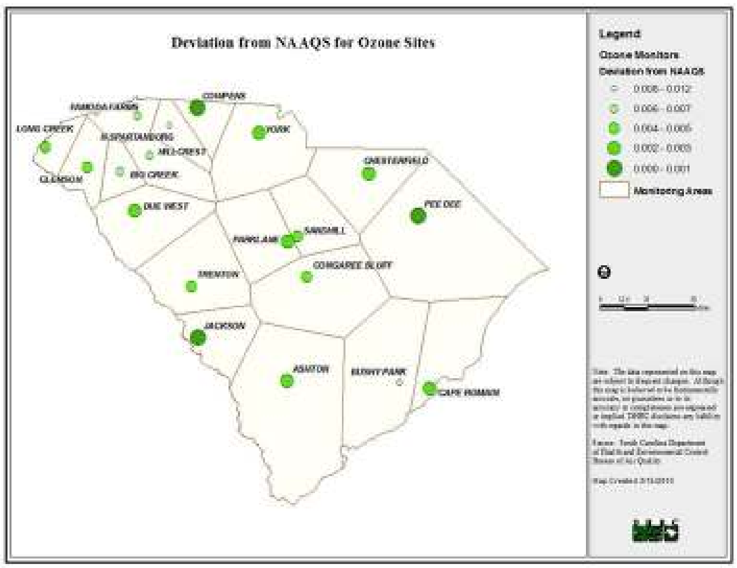
Due to the spatial distribution of $PM_{2.5}$ FRM monitors operating in South Carolina, Kriging did not produce results sufficient to predict values for the new ambient air monitoring sites. The Inverse Distance Weighted (IDW) method of interpolation was used to estimate $PM_{2.5}$ values at these locations. 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.



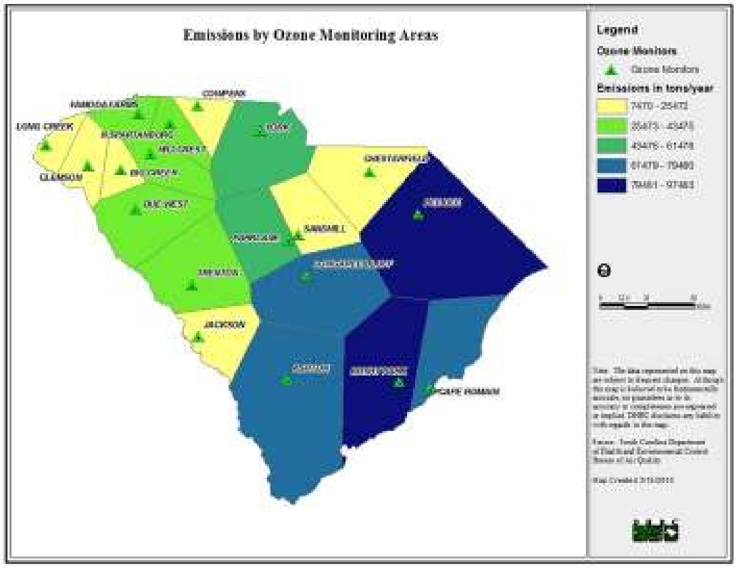
Deviation from NAAQS

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.



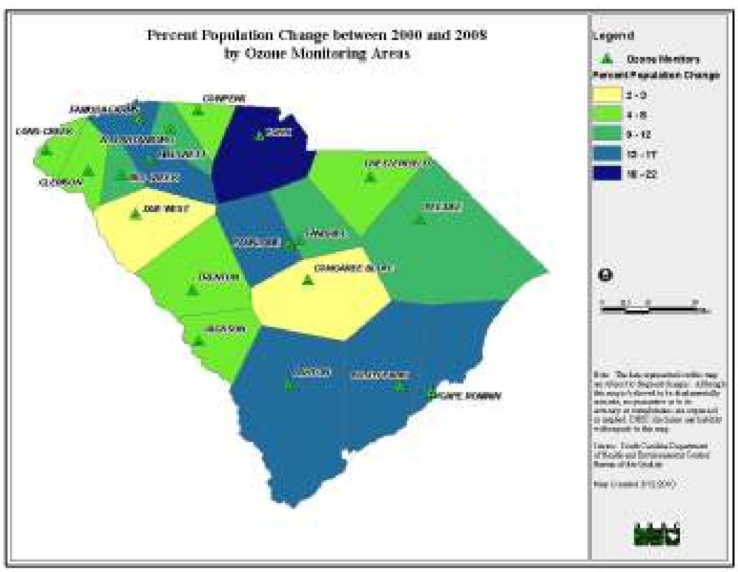
Emission inventory

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.



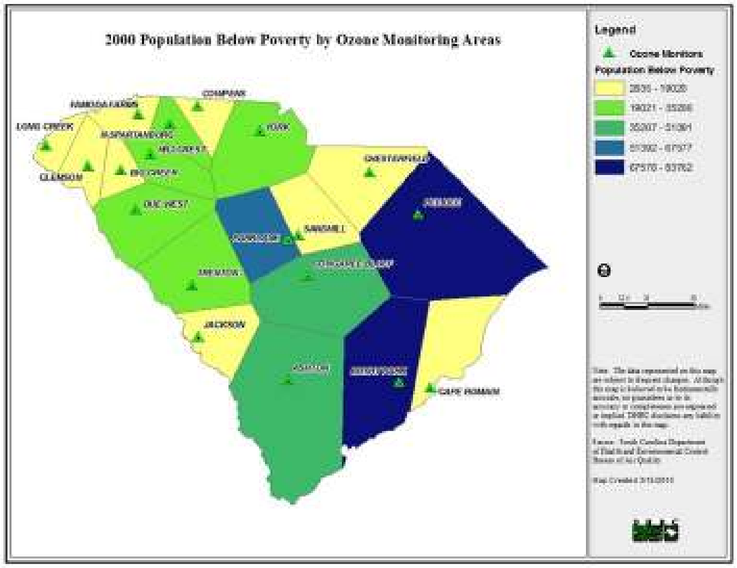
Population change

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.



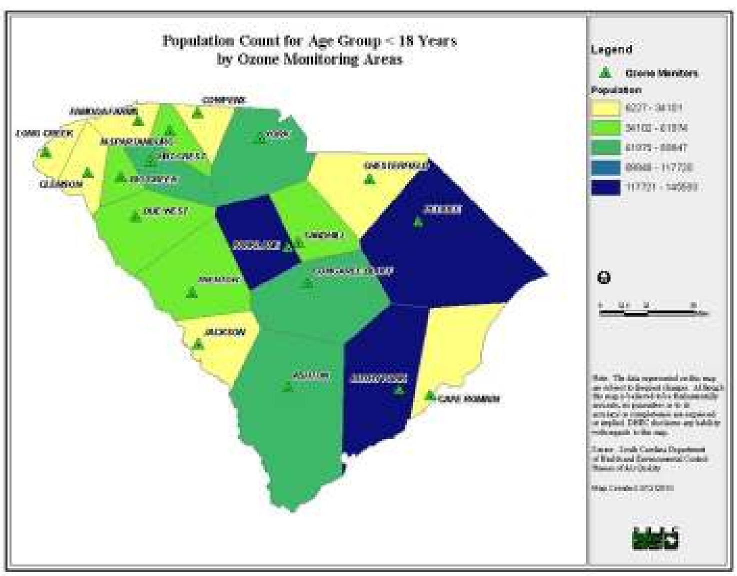
Population living below poverty level

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).



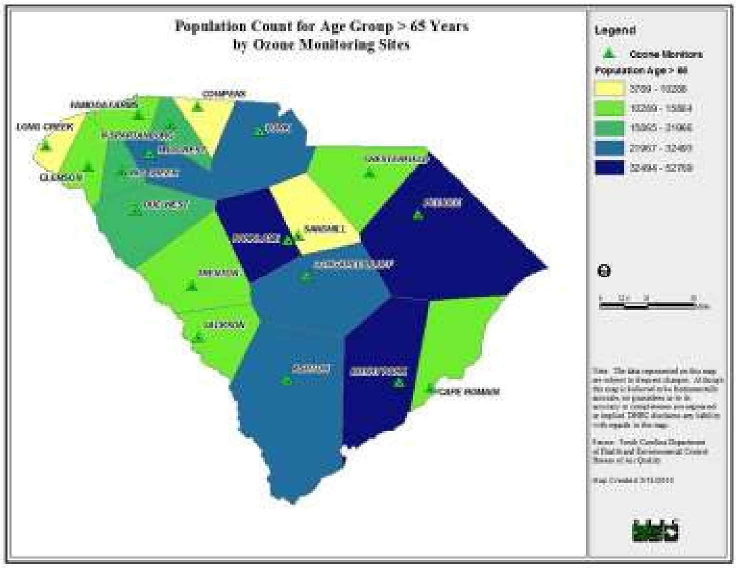
Population for age 18 and below

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).

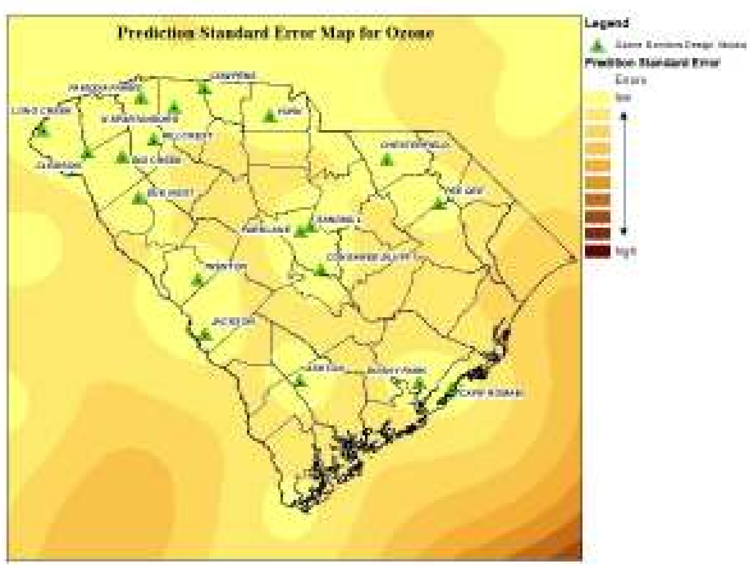
Density or sparseness of existing networks

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.

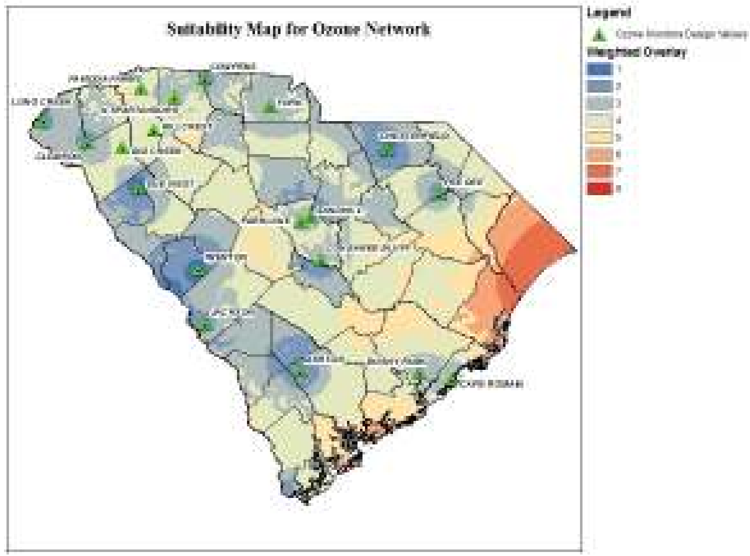
These analyses were conducted to determine where additional ambient air monitoring may be needed. The analyses included creating predicted Ozone surface described in the previous section and a map of standard errors associated with the Ozone predicted values. With the Kriging technique, an error or uncertainty 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.



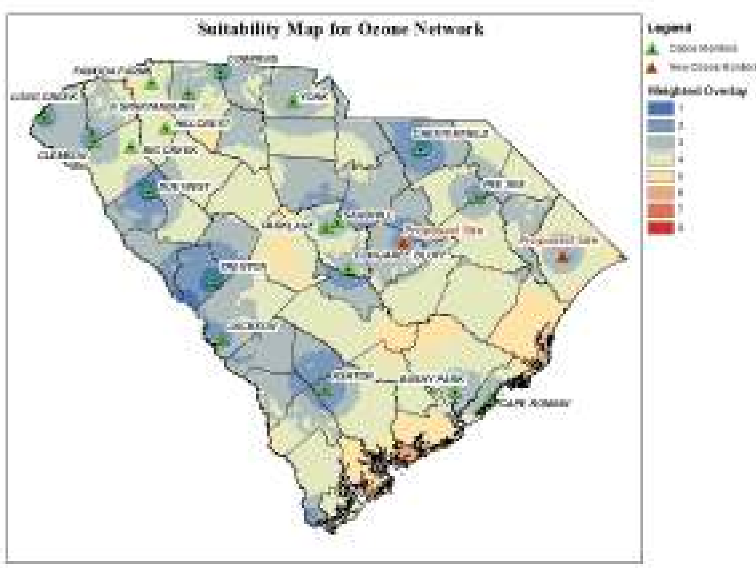
Prediction standard error, distance to roads, population, NO_x emissions, and VOC emissions grids were input to the weighted overlay analysis. The rasters were reclassified to a common scale of 1 to 10 (1 being the least suitable, 10 being the most suitable for placing new monitors). Each raster was 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

[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.

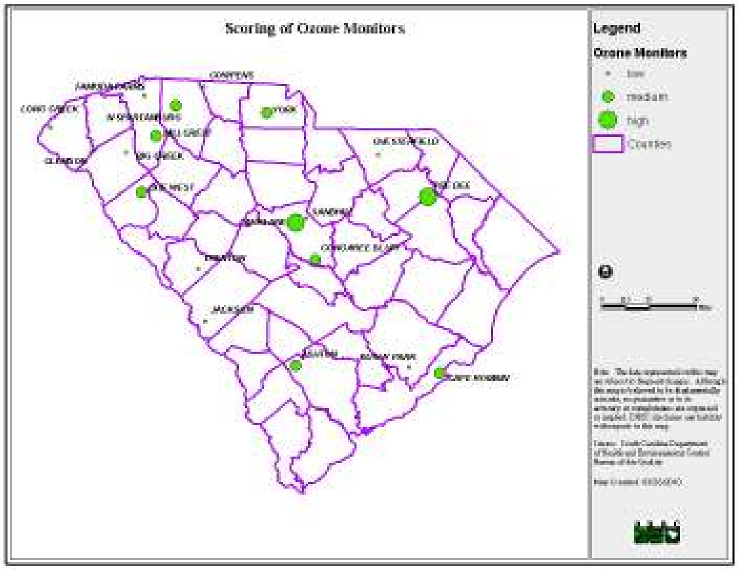
New Technologies

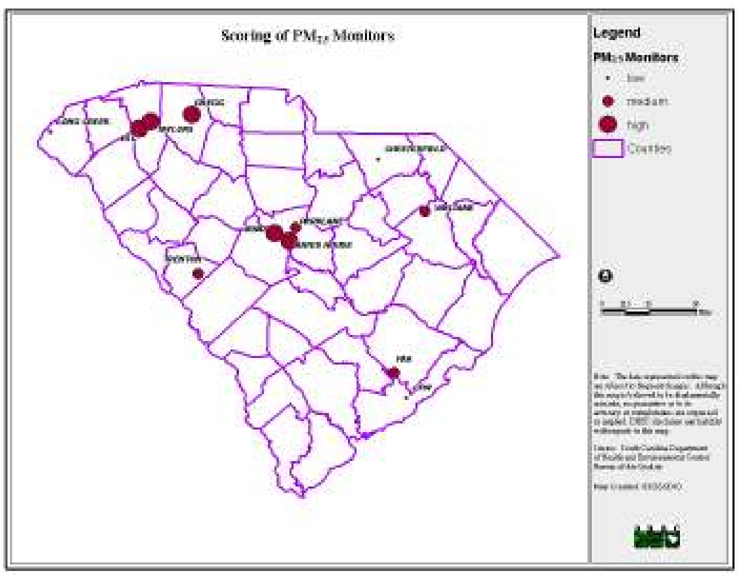
The Department knows of no new technologies that can be incorporated into its ambient air quality network at this time without significant cost. An example of a technology that would be useful but cost prohibitive at this time is an updated data acquisition system with the ability to analyze data and 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.