D H E C
PROMOTE PROTECT PROSPER
Catherine E. Heigel, Director
*Promoting and protecting the health of the public and the environment*

February 8, 2016

Beverly Banister, Director
Air, Pesticides & Toxics Management Division
U.S. EPA, Region 4
Sam Nunn Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-8960

Re: Addendum to the South Carolina 2016 Annual Air Network Monitoring Plan

Dear Ms. Banister:

On July 20, 2015, the South Carolina Department of Health and Environmental Control (Department) submitted the State of South Carolina Network Description and Ambient Air Network for Calendar Year 2016 (Monitoring Plan) in accordance with the requirements of 40 Code of Federal Regulations (CFR) 58.10. The Department received the Monitoring Plan approval from the United States Environmental Protection Agency (EPA), Region 4 on November 19, 2015. This letter is to inform you of modifications the Department wishes to make to the ozone monitoring network and to the Monitoring Plan. Specifically, the Department respectfully requests approval to terminate the Clemson CMS (45-077-0002) Site, Cowpens National Battlefield (45-021-0002) Site, Bushy Park Pump Station (45-015-0002) Site, the York CMS (45-091-0006) Site, the Famoda Farm (45-45-1003) Site, and the Bates House (45-079-0019) Site. Additionally, the Department requests approval to establish two new sites, which includes a new site to replace the York CMS Monitoring Site and the startup of the Coastal Carolina (45-051-0008) Site. An addendum to the Monitoring Plan reflecting the implementation of the recommended modifications can be found in Appendix A.

## Termination of the Clemson CMS (45-077-0002) Site

The Department is requesting permission to terminate the Clemson CMS (45-077-0002) Site. A technical justification for this request can be found in Appendix B.

## Termination of the Cowpens National Battlefield (45-019-0002) Site

The Department is providing notification that it intends to terminate all monitoring at Cowpens prior to the start of the 2016 ozone monitoring season. Ozone monitoring at this site is designated as a special purpose monitor and is not used to meet minimum monitoring requirements. Cowpens is not a critical monitoring site for our ozone forecasting program. In recent years trees have grown up around the monitoring site, and it no longer meets siting criteria found in 40 CFR 58, Appendix E. After discussions with National Park Service representatives, there are no other areas in the Battlefield that we can relocate to due to the presence of cultural and historical artifacts. Basic site information about the Cowpens National Battlefield site can be found in Table 1 along with a picture showing the extent of tree growth near the site in Figure 1.

| Table 1: General Information for the Cowpens Site | |
|---|---|
| **Item** | **Description** |
| AQS ID | 45-021-0002 |
| Street Address | McGinnis Road (Old SC Hwy 110) |
| Geographic coordinates | +35.13045, -81.81656 |
| Designation | SPM |
| Analysis method | FEM Ultraviolet Photometry |
| Sampling Frequency | Continuous |
| Monitoring objective | Upwind / Background |
| Monitoring scale | Urban |
| MSA represented | Greenville-Spartanburg-Anderson CSA/ None |

The picture in Figure 1 presents a panoramic view of the Site. A horizontal red line has been added to the picture to mark an angle of approximately 26 degrees, indicating the limit of the requirement in Appendix E, Section 4(a) concerning spacing from obstructions and height above the monitor probe. In other words, if the top of an object is above the top red line in the picture, then it does not meet the Appendix E, Section 4(a) requirements.

**Figure 1: Cowpens Panorama Taken from Ozone Monitor**

## Termination of the Bushy Park Pump Station (45-019-0002) Site

The Department requests approval for termination of the Bushy Park Pump Station Site in Berkeley County. Basic information on the Site is listed in Table 2, and an aerial picture is shown in Figure 2.

| Table 2: Bushy Park Pump Station Site Information | |
|---|---|
| **Item** | **Description** |
| AQS ID | 45-015-0002 |
| Street Address | River Oak Drive, Goose Creek, South Carolina, Berkeley County |
| Geographic coordinates | +32.98724, -79.93671 |
| Designation | SLAMS |
| Analysis method | FEM UV photometry method |
| Operating schedule | Continuous |
| Monitoring objective | Maximum ozone concentration |
| Monitoring scale | Urban |
| MSA represented | Charleston-North Charleston, South Carolina MSA |

**Figure 2: Bushy Park Site Location**

***Justification for request***

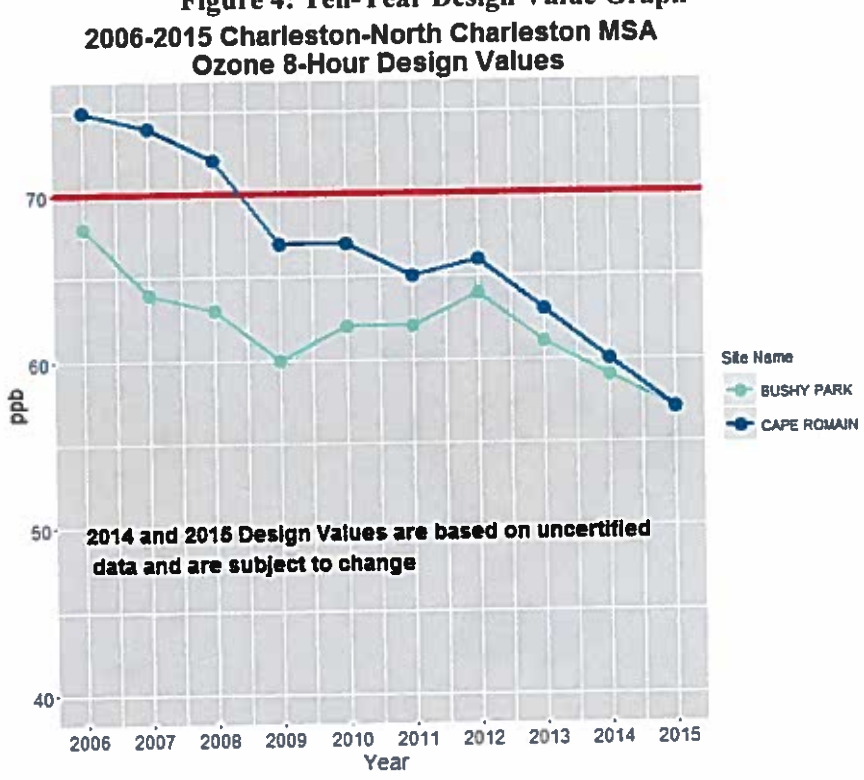
The Department has conducted an evaluation of siting criteria in accordance with 40 CFR Part 58, Appendix E. Two of the requirements were not met at this Site including: 1) Spacing from obstructions (Appendix E 4(a) and (b)); and 2) Spacing from trees (Appendix E 5(a)). After further evaluation, the Department has determined that the extent of the tree growth surrounding this Site would be too great to remedy by trimming or removing the trees and believes that the Site may not be providing ozone data consistent with the stated monitoring objective.

Appendix E, Section 4(a) requires that the distance from the obstacle (such as a tree) to the probe inlet must be at least twice the height that obstacle protrudes above the probe inlet. Figure 3 presents a panoramic view of the Site. A horizontal red line has been added to the picture to mark an angle of approximately 26 degrees, indicating the limit of the requirement in Section 4(a) concerning spacing from obstructions and height above the monitor probe. In other words, if the top of an object is above the top red line in the picture, then it does not meet the Section 4(a) requirements. As can be seen in Figure 3, numerous trees in almost all directions do not meet this requirement. The Department requests permission to terminate the Site. Termination of the Site will impact our 40 CFR 58, Appendix D requirements to maintain two ozone monitoring stations in the Charleston-North Charleston MSA. The Department is currently seeking a replacement site nearby within the same area of representativeness which will meet Appendix E requirements. Termination of the Bushy Park Site will occur once the replacement site is identified and approved by the EPA.

**Figure 3: Bushy Park Pump Station (45-015-0002) Site Panorama**

Figure 4 shows the ten-year design value trend graph for currently active monitors in the Charleston-North Charleston MSA. The Bushy Park Pump Station site has typically had lower design values than the other monitoring site in the MSA. As stated previously, the issues with meeting Appendix E siting criteria and review of available monitoring results has led the Department to conclude that a site location that meets exposure requirements and better serves the monitoring objectives for the MSA must be established, allowing termination of the Bushy Park site.

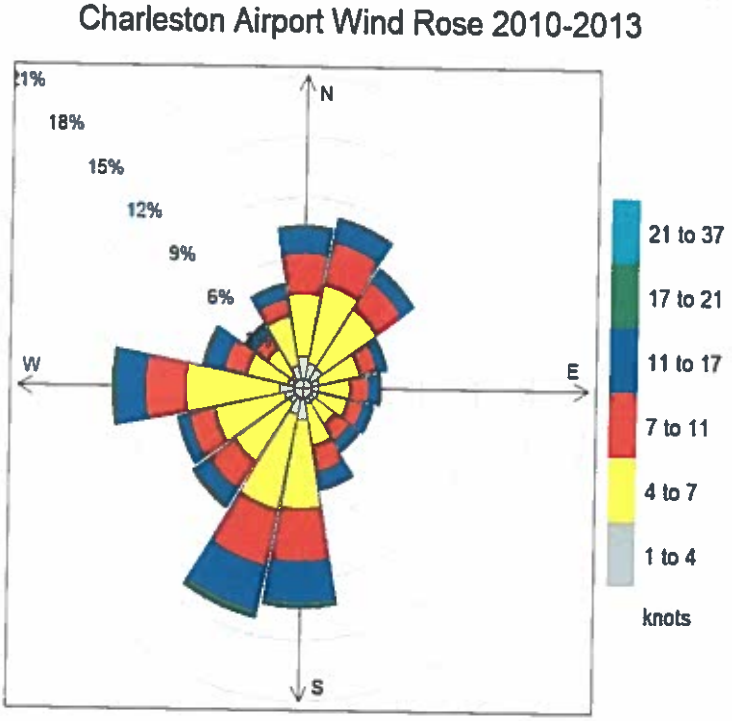
**Figure 4: Ten-Year Design Value Graph**




***Predominant and secondary wind patterns***

The wind data from the Charleston International Airport is representative of the wind pattern for the Bushy Park Site. The wind rose in Figure 5 was created using 2010-2013 wind data. It indicates that the predominant wind directions for this Site are from the south south-west, south, and west. Also, secondary dominant winds come from the north north-east.

**Figure 5: Wind Rose for the Bushy Park Site**




## Termination of the York CMS (45-091-0006) Site

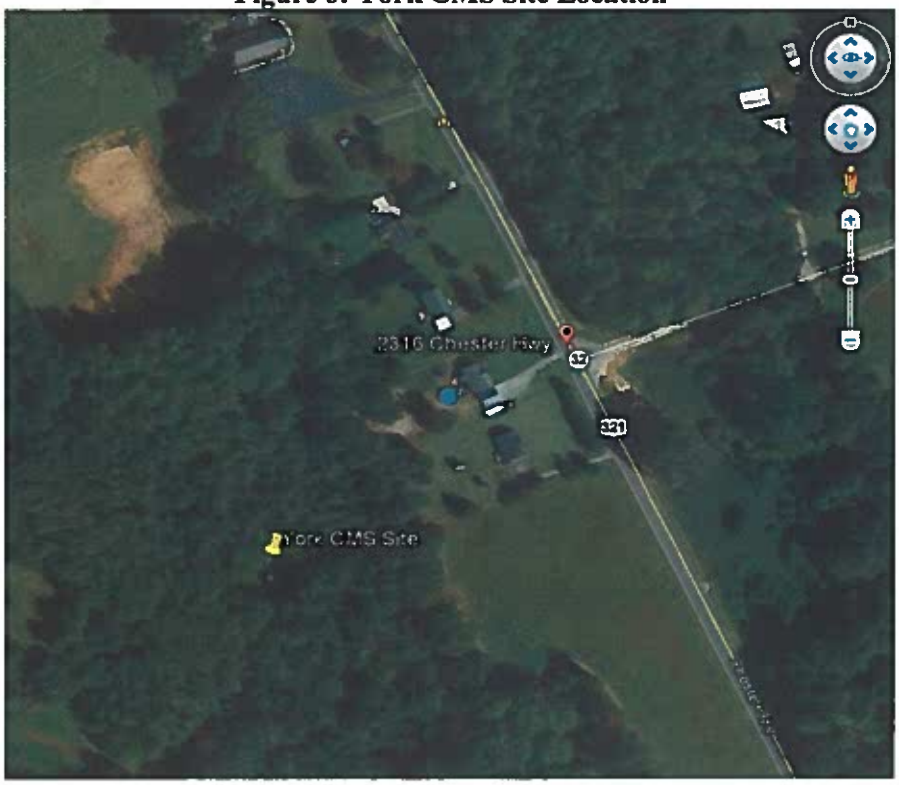
The Department requests approval for termination of all monitoring at the York CMS Site in York County, South Carolina. Basic information on the Site is listed in Table 3 below. An aerial view of the York CMS Site is shown in Figure 6.

**Table 3: York CMS Site Information**

| Item | Description |
|---|---|
| AQS ID | 45-091-0006 |
| Street Address | 2316 Chester Hwy (US 321) |
| Geographic coordinates | +34.93581, -81.22838 |
| ***OZONE*** | |
| Designation | SLAMS |
| Analysis method | FEM Ultraviolet Photometry |
| Operating schedule | Continuous |
| Monitoring objective | Upwind Background |
| Monitoring scale | Urban |
| ***SULFUR DIOXIDE*** | |
| Designation | SPM |
| Analysis method | FEM UV Fluorescence |
| Operating schedule | Continuous |

| Table 3: York CMS Site Information | |
|---|---|
| **Item** | **Description** |
| Monitoring objective | Upwind Background |
| Monitoring scale | Urban |
| ***WIND SPEED / WIND DIRECTION*** | |
| Designation | Non-regulatory |
| Analysis method | Instruments for wind speed, wind direction |
| Operating schedule | Continuous |
| Monitoring objective | Local Conditions |
| Monitoring scale | Neighborhood |
| MSA represented | Charlotte-Concord-Gastonia, NC-SC |

**Figure 6: York CMS Site Location**




***Justification for request***

The York CMS (45-091-0006) Site (Figure 7) is being discontinued because access to the location is no longer available. The land owner has asked the Department to terminate and remove the site by June 2016. The Department requests that the EPA approve termination of the York CMS (45-091-0006) Site. A new site is being established approximately 3.5 miles northeast of the York CMS Site. Information on the new site and concurrence for establishment can be found in the next section. The York CMS Site has provided upwind, background data for the Charlotte, North Carolina area and is not the design value site for the MSA as indicated in Figure 8. The York CMS Site has had the lowest design value for the MSA over the last ten years.

**Figure 7: York CMS (45-091-0006) Site**

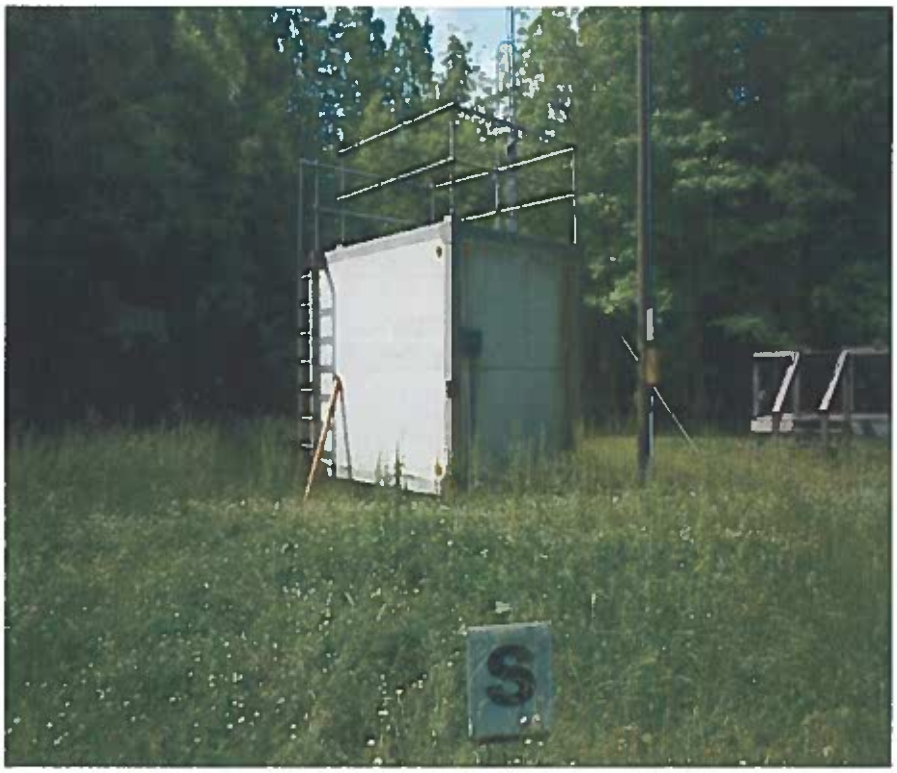
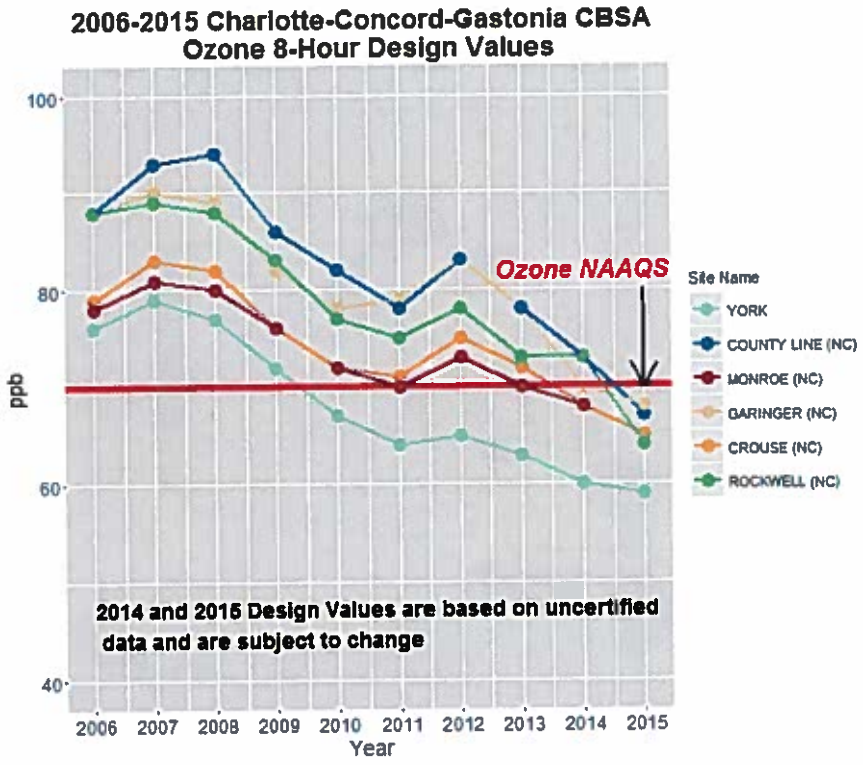


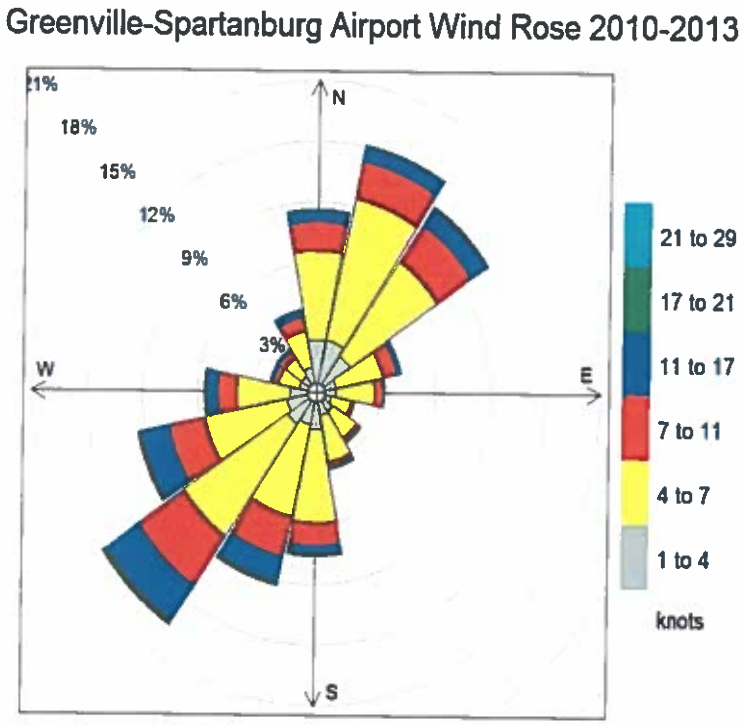
**Figure 8: Ten Year Design Value Graph**




***Predominant and secondary wind patterns***

The wind data from the Greenville-Spartanburg Airport is representative of the wind pattern for the York CMS Site. The wind rose in Figure 9 was created using 2010-2013 wind data. It indicates that the predominant wind directions for this Site are from the south-west and north north-east. Also, secondary dominant winds come from the north-east and west south-west.

**Figure 9: Wind Rose for the York CMS Site**




## Establishment of the York County Monitoring Site

Due to the impending loss of access at the York CMS Site, a replacement site is being established. The replacement site location is approximately 3.5 miles northeast of the current site in a rural area in central York County. This location is representative of the same area as the current location (Figure 10). The Department is in the process of obtaining the necessary permits for the new site construction. We anticipate startup of the new site during the 2016 ozone monitoring season, allowing several months of concurrent data collection at the current and replacement sites before the monitoring equipment at York CMS must be removed.

The location for the replacement York County site was visited by Science and Ecosystems Support Division and Air, Pesticides & Toxics Management Division staff in July 2015.

***Statement of Purpose***

The purpose of the new York County Monitoring site will be to provide upwind background ambient air concentrations of ozone and sulfur dioxide for the Charlotte-Concord-Gastonia MSA.

***Compliance with Appendices A, C, D and E***

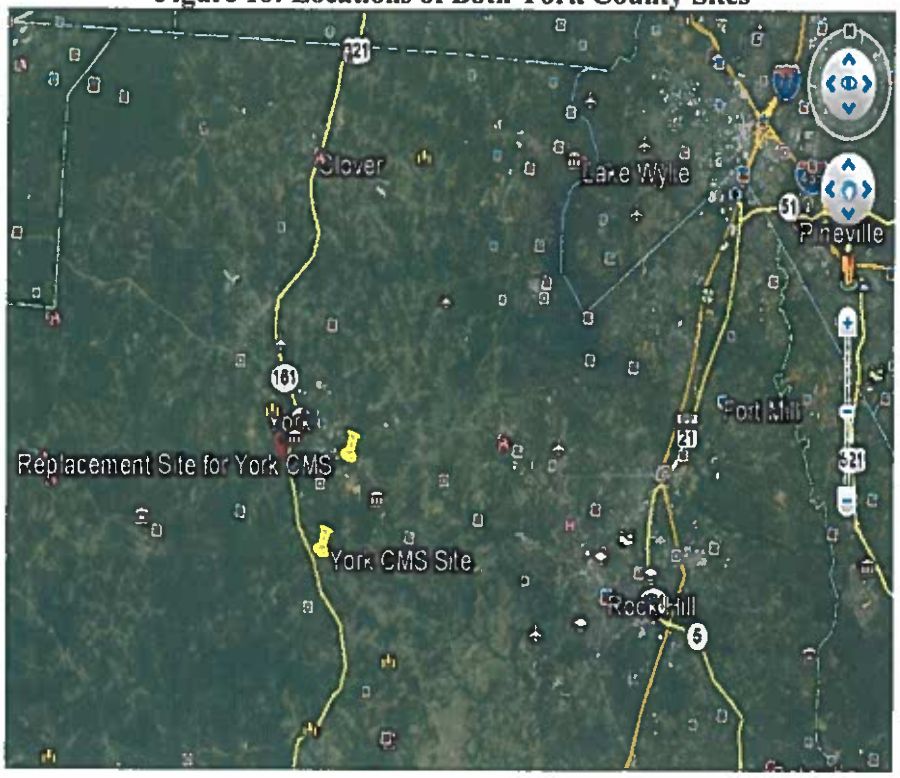
As required in 40 CFR Part 58 Appendix A, the Division of Air Quality Analysis (DAQA) in the Bureau of Environmental Health Services (Division) establishes, maintains, and operates the sites and instruments and performs the analysis of samples collected. Data generated by the network for

comparison to the NAAQS is verified to be accurate and reported by the Division to the national AQS database for storage and public access. Regular calibration and audits are performed to verify that the instruments are operating correctly and data being collected is accurate.
As required in 40 CFR Part 58 Appendix C, all criteria pollutant monitoring in the South Carolina Monitoring Network for the purpose of comparison to the NAAQS is performed using the EPA designated Federal Reference Methods (FRM) or Federal Equivalent Methods (FEM).
All criteria pollutant monitoring in the South Carolina Monitoring Network meets the monitoring objectives and spatial scales and design criteria as described in 40 CFR Part 58 Appendix D.
Basic site and monitor information is contained in Table 4 below. An aerial view of the York County Site and the York CMS Site is shown in Figure 10.

**Table 4: York County Site Information**

| Item | Description |
|---|---|
| AQS ID | 45-091-0007 |
| Street Address | Langrum Branch Road |
| Geographic coordinates | +34.9776, -81.2074 |
| ***OZONE*** | |
| Designation | SLAMS |
| Analysis method | FEM Ultraviolet Photometry |
| Operating schedule | Continuous |
| Monitoring objective | Upwind Background |
| Monitoring scale | Urban |
| ***SULFUR DIOXIDE*** | |
| Designation | SPM |
| Analysis method | FEM UV Fluorescence |
| Operating schedule | Continuous |
| Monitoring objective | Upwind Background |
| Monitoring scale | Urban |
| ***WIND SPEED / WIND DIRECTION*** | |
| Designation | Non-regulatory |
| Analysis method | Instruments for wind speed, wind direction |
| Operating schedule | Continuous |
| Monitoring objective | Local Conditions |
| Monitoring scale | Neighborhood |
| MSA represented | Charlotte-Concord-Gastonia, NC-SC |

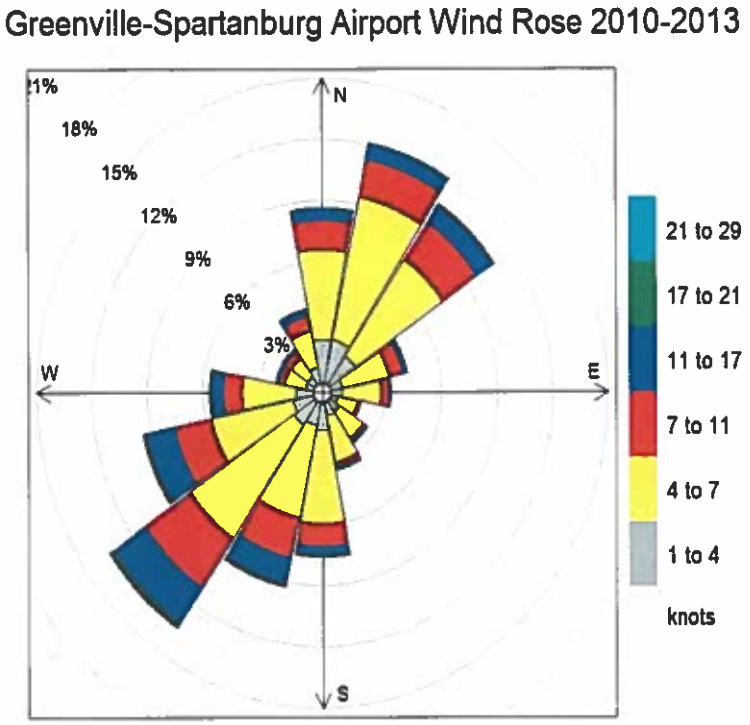
**Figure 10: Locations of Both York County Sites**




***Predominant and secondary wind patterns***

The wind data from the Greenville-Spartanburg Airport is representative of the wind pattern for the York County Site. The wind rose in Figure 11 was created using 2010-2013 wind data. It indicates that the predominant wind directions for this Site are from the south-west and north north-east. Also, secondary dominant winds come from the north-east and west south-west.

**Figure 11: Wind Rose for the York County Site**




## Termination of the Famoda Farm (45-045-1003) Site

The Department requests approval for termination of the Famoda Farm Site in Greenville County, South Carolina. Basic site and monitor information is contained in Table 5 below. An aerial view of the Famoda Farm Site is shown in Figure 12.

**Table 5: Famoda Farm Site Information**

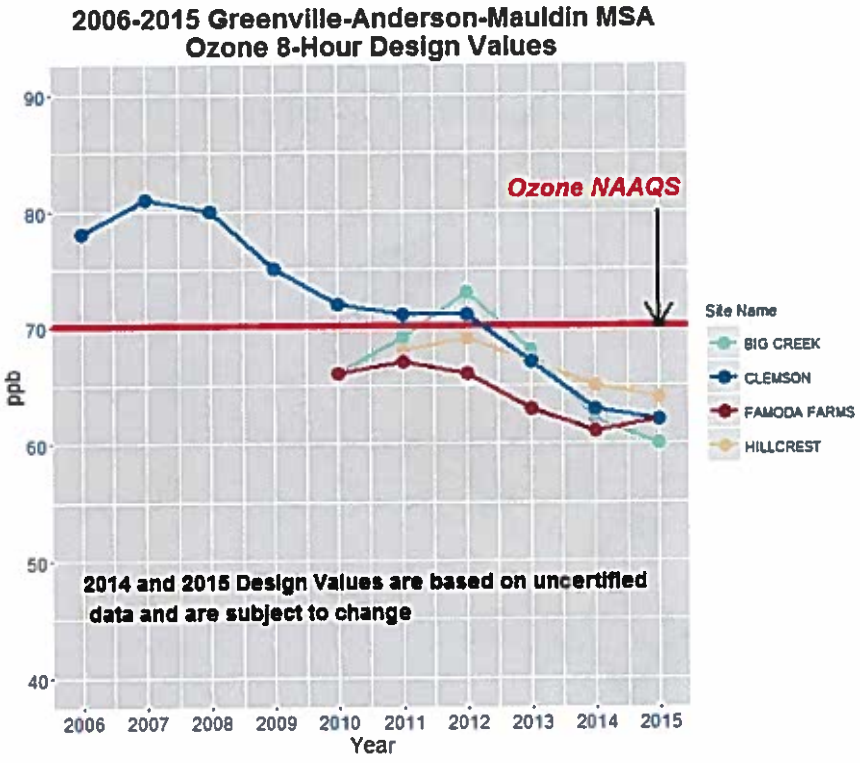
| Item | Description |
|---|---|
| AQS ID | 45-045-1003 |
| Street Address | 7401 Mountain View Road |
| Geographic coordinates | +35.05739, -82.37288 |
| Designation | SLAMS |
| Analysis method | FEM Ultraviolet Photometry |
| Operating schedule | Continuous |
| Monitoring objective | Max Ozone Concentration |
| Monitoring scale | Urban |
| MSA represented | Greenville-Anderson-Mauldin |

**Figure 12: Famoda Farm Site Location**


***Justification for request***

The current Greenville-Anderson-Mauldin MSA is required to have two ozone monitoring stations. The MSA currently has five ozone monitoring stations distributed along the I-85 corridor. The Department believes that loss of data due to the termination of the Famoda Farm Site will not compromise characterization of ozone in the Upstate of South Carolina. There will remain adequate coverage with the remaining network. Since data collection was reestablished in 2008 as a part of the Greenville MSA Ozone Study, the Famoda Farm site has had the lowest design value in the area and has not had a design value above the current level of the ozone standard (Figure 13).

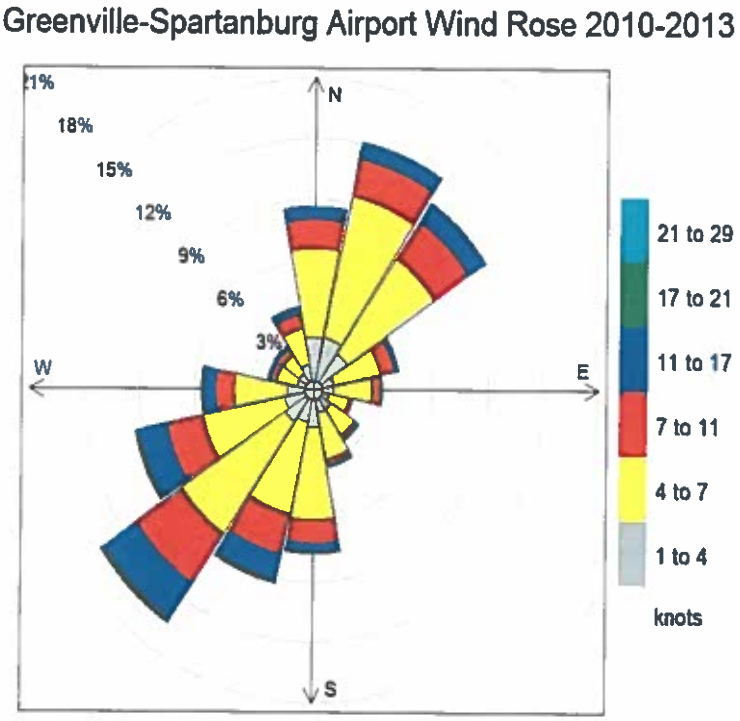
**Figure 13: Ten Year Design Value Graph**




***Predominant and secondary wind patterns***

The wind data from the Greenville-Spartanburg International Airport is representative of the wind pattern for the Famoda Farm Site. The wind rose in Figure 14 was created using 2010-2013 wind data. It indicates that the predominant wind directions for this Site are from the south-west and north north-east. Also, secondary dominant winds come from the north-east and west south-west.

**Figure 14: Wind Rose for the Famoda Farm Site**




## Termination of the Bates House (45-079-0019) Site

The Department requests approval for termination of the Bates House Site in Richland County, South Carolina. Basic site and monitor information is contained in Table 6 below. An aerial view of the Bates House Site is shown in Figure 15.

**Table 6: Bates House Site Information**

| Item | Description |
|---|---|
| AQS ID | 45-079-0019 |
| Street Address | 323 S. Bull Street |
| Geographic coordinates | +33.99150, -81.02413 |
| ***$PM_{2.5}$*** | |
| Designation | SLAMS |
| Analysis method | FRM Gravimetric |
| Operating schedule | 1:1 |
| Monitoring objective | Population Exposure |
| Monitoring scale | Neighborhood |
| ***$PM_{2.5}$ Collocated*** | |
| Designation | SLAMS (QA Collocated) |
| Analysis method | Gravimetric |
| Operating schedule | 1:6 |
| Monitoring objective | Quality Assurance |

| Table 6: Bates House Site Information | |
|---|---|
| **Item** | **Description** |
| Monitoring scale | Neighborhood |
| ***$PM_{10}$*** | |
| Designation | SLAMS |
| Analysis method | TEOM |
| Operating schedule | Continuous |
| Monitoring objective | Population Exposure |
| Monitoring scale | Neighborhood |
| MSA represented | Columbia |

**Figure 15: Bates House Site Location**


***Justification for request***

The Bates House (45-079-0019) Site is being discontinued because access to the location is anticipated to be lost during the summer of 2016. Demolition of a dormitory approximately 50 meters away is expected to commence at the conclusion of the current school semester. Based on this anticipated loss of access, the Department requests that the EPA approve the termination of the Bates House (45-079-0019) Site. There are a couple of trees to the south-west and west that do not meet Appendix E criteria for distance from the probe requirements (Figures 16 and 17). The Department will continue to flag data from these monitors in AQS to indicate issues with siting criteria until we have terminated sampling and monitoring activities at the site.

The current Columbia MSA is required to have one $PM_{2.5}$ sampler, one continuous $PM_{2.5}$ monitor and one to two $PM_{10}$ monitors. The MSA currently has four $PM_{2.5}$ samplers, two continuous $PM_{2.5}$ monitors, and three $PM_{10}$ monitors. If the Bates House Site is discontinued, the collocated $PM_{2.5}$ QA sampler would be

moved to the Parklane Site (45-079-0007), which is also located in Richland County. Elimination of this monitoring site would not impact the minimum number of monitors required for this MSA.
The $PM_{10}$ monitor at the Bates House site has had no expected exceedances of the NAAQS over the last ten years. As shown in Figure 18, the graph for the Daily $PM_{2.5}$ samplers in the Columbia MSA, including the Bates House sampler, have not had a design value above the current NAAQS of 35µg/m$^3$. As shown in Figure 19, the Annual $PM_{2.5}$ samplers for the Columbia MSA are well below the current annual NAAQS of 12.0µg/m$^3$. Furthermore, prior to 2012, the annual NAAQS was set at 15.0µg/m$^3$. Figure 19 shows that the Bates House sampler has not exceeded that level in 10 years.

**Figure 16: Bates House (45-079-0019) Site Panorama from the $PM_{10}$ Monitor**

**Figure 17: Bates House (45-079-0019) Site Panorama from the $PM_{2.5}$ Monitor**

**Figure 18: $PM_{2.5}$ Ten Year Design Value Graph**

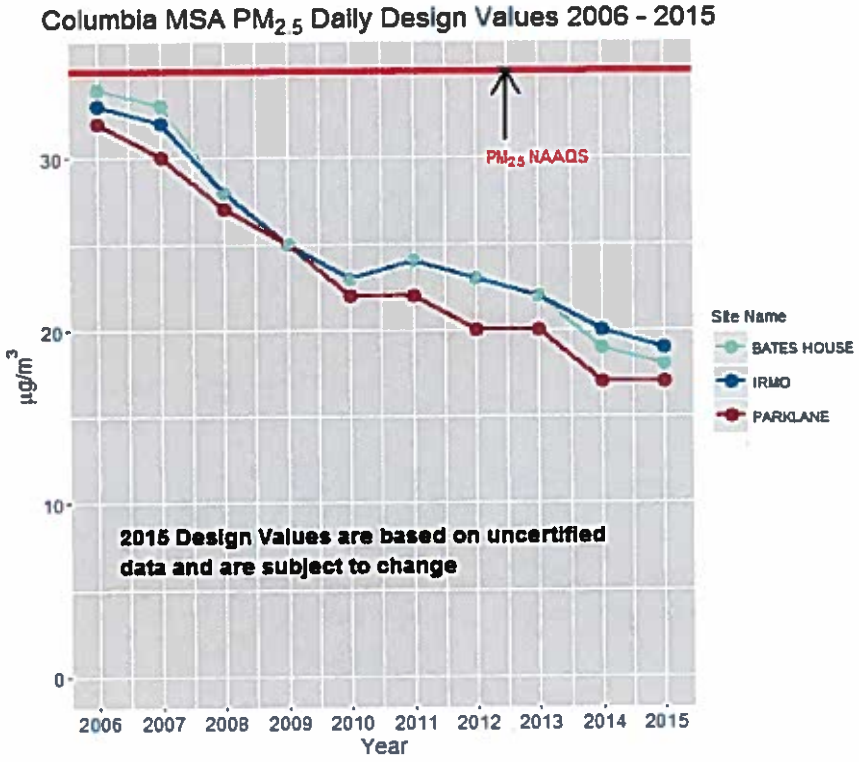
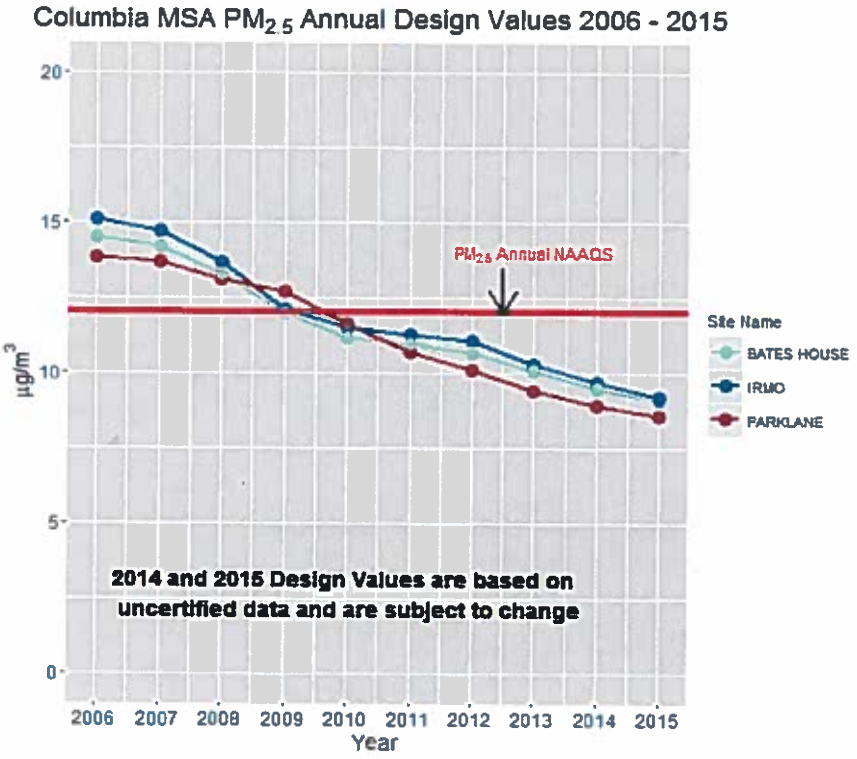


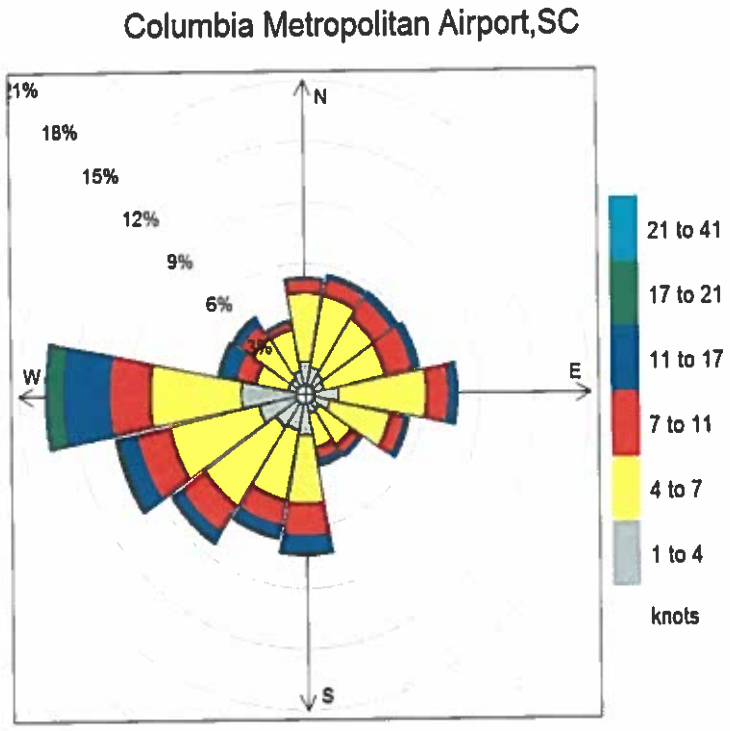
**Figure 19: Annual $PM_{2.5}$ Ten Year Design Value Graph**




***Predominant and secondary wind patterns***

The wind data from the Columbia Metropolitan Airport is representative of the wind pattern for the Bates House Site. Using 2010-2013 data, the wind rose in Figure 20 was created. It indicates that the predominant wind direction for this Site is from the west. Also, secondary dominant winds come from the west-southwest, southwest, and north.

**Figure 20: Wind Rose for the Bates House Site**




## Establishment of the Coastal Carolina Monitoring Site

The Coastal Carolina (45-051-0008) Site is being established in Horry County to represent the Myrtle Beach-Conway-North Myrtle Beach, SC-NC MSA. The replacement Site location is located on the grounds of the Coastal Carolina University. In February 2013, OMB combined Horry County with Brunswick County, NC to establish the Myrtle Beach-Conway-North Myrtle Beach, SC-NC MSA. In order to meet the minimum monitoring criteria in 40 CFR Part 58 Appendix D, at least one ozone monitor is required in the MSA. This Site will be representative of expected maximum ozone concentrations in northeast South Carolina.

The Department is in the process of obtaining the necessary permits for the new Site construction. We anticipate startup of the new Site prior to the beginning of the 2016 ozone monitoring season.

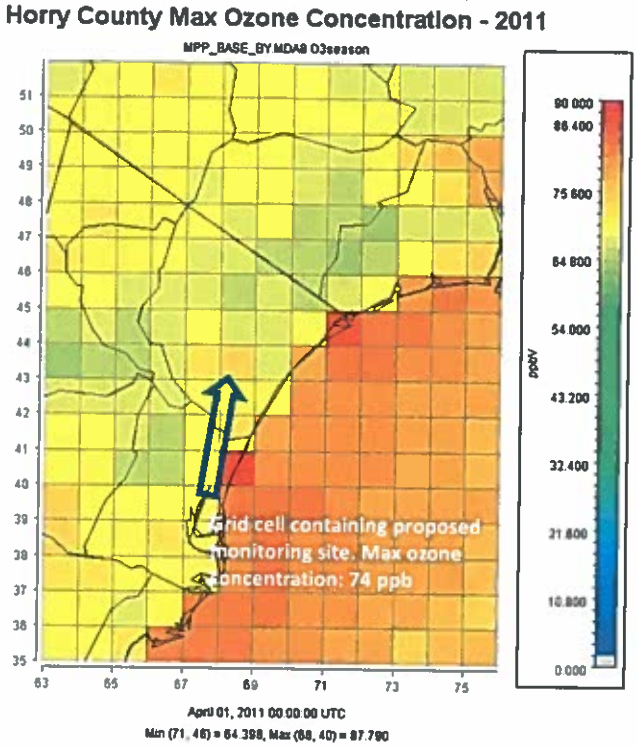
***Compliance with Appendices A, C, D and E***

As required in 40 CFR Part 58 Appendix A, the Division of Air Quality Analysis (DAQA) in the Bureau of Environmental Health Services (Division) establishes, maintains, and operates the sites and instruments and performs the analysis of samples collected. Data generated by the network for comparison to the NAAQS is verified to be accurate and reported by the Division to the national AQS database for storage and public access. Regular calibration and audits are performed to verify that the instruments are operating correctly and data being collected is accurate.

As required in 40 CFR Part 58 Appendix C, all criteria pollutant monitoring in the South Carolina Monitoring Network for the purpose of comparison to the NAAQS is performed using the EPA designated Federal Reference Methods (FRM) or Federal Equivalent Methods (FEM).

All criteria pollutant monitoring in the South Carolina Monitoring Network meet the monitoring objectives and spatial scales and design criteria as described in 40 CFR Part 58 Appendix D. In regards to the Coastal Carolina Site, Appendix D requires that the monitoring station be placed in an area of expected maximum ozone concentration. The most recent available Community Multiscale Air Quality (CMAQ)[1] modeling system outputs from 2011 were used to find the areas of maximum ozone concentration and are presented in Figure 21. The grid cell containing the proposed monitoring site (68, 43) is also the location containing the highest inland maximum daily 8-hour average ozone concentration for the 2011 modeling run.

**Figure 21: Ozone modeling for 2011 CMAQ baseline showing max ozone concentration location for Horry County**




Basic site and monitor information is contained in Table 7 below. An aerial view of the Coastal Carolina Site is shown in Figure 22. Based on the panorama in Figure 23, there appears to be no current obstructions to windflow.

[1] https://www.cmascenter.org/cmaq/

| Table 7: Coastal Carolina Site Information | |
|---|---|
| **Item** | **Description** |
| AQS ID | 45-051-0008 |
| Street Address | Century Circle |
| Geographic coordinates | +33.8007, -78.9939 |
| ***OZONE*** | |
| Designation | SLAMS |
| Analysis method | FEM Ultraviolet Photometry |
| Sampling Frequency | Continuous |
| Monitoring objective | Max Concentration |
| Monitoring scale | Urban |
| **WIND SPEED/DIRECTION** | |
| Designation | Non-regulatory |
| Analysis method | Instruments for wind speed and wind direction |
| Sampling Frequency | Continuous |
| Monitoring objective | Local Conditions |
| Monitoring scale | Neighborhood |

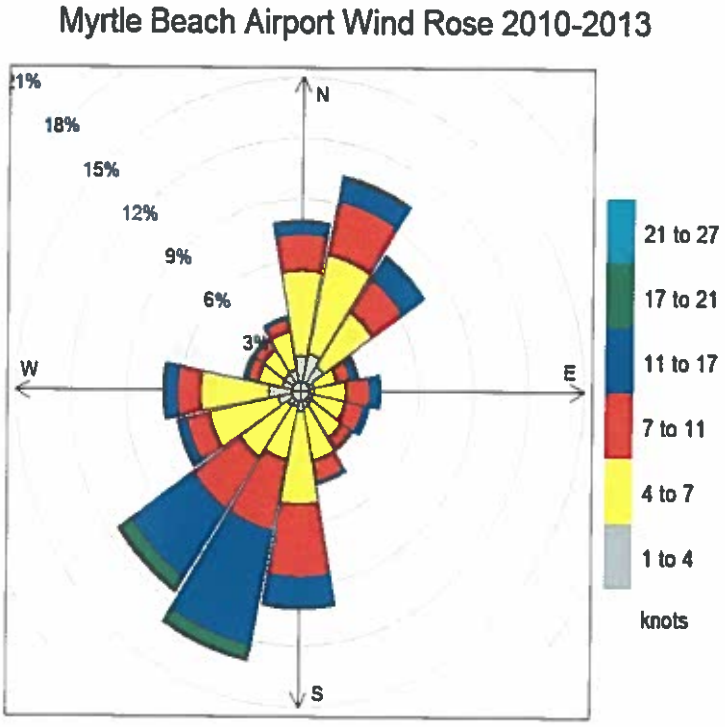
**Figure 22: Coastal Carolina Site Location**

**Figure 23: Coastal Carolina (45-051-0008) Site Panorama**

***Predominant and secondary wind patterns***

The wind data from the Myrtle Beach Airport is representative of the wind pattern for the Coastal Carolina Site. The wind rose in Figure 24 was created using 2010-2013 wind data. It indicates that the predominant wind directions for this Site are from the south south-west, north north-east, and south-west with secondary dominant winds out of the south.

**Figure 24: Wind Rose for the Coastal Carolina Site**



## Public comment period

The public comment period for these site monitoring plan modifications will be from February 8, 2016 through March 8, 2016. All comments received will be forwarded to the EPA Region 4 along with the Department's response.

The revisions to the plan are expected to assist in optimization of our monitoring network, allowing more efficient use of our limited resources. Should you have any questions or need additional information regarding these requests, please contact Robert Brown of my staff at (803) 898-4105.

Sincerely,

Rhonda Banks Thompson
Interim Bureau Chief
Bureau of Air Quality

cc: Todd Rinck, US EPA Region 4, Chief, Air Data & Analysis Section (w/o attachments)
Ryan Brown US EPA Region 4 (w/attachments)
Renee Shealy, BEHS (w/o attachments)
Sandra Flemming, BEHS (w/o attachments)
Robert Brown, BAQ (w/o attachments)
Scott Reynolds, BEHS (w/o attachments)

Attachments:
Appendix A: Addendum to the 2016 Monitoring Plan
Appendix B: Technical analysis for Clemson CMS termination

**Addendum**

**Plan Revisions**

The following pages contain revisions to the 2016 Network Description and Ambient Air Network Monitoring Plan. Changes to the 2016 plan are *italicized* with gray highlighting applied. Deletions to the 2016 plan are ~~*italicized*~~, struck-through and highlighted in gray. Page numbers from the original 2016 Ambient Air Network Monitoring Plan are provided at the bottom of each page as a reference.

## Introduction

The DHEC or its predecessors have operated an air quality monitoring network in South Carolina since 1959. During that time, the network has continually evolved to meet the requirements and needs of the DHEC's Air Program and to comply with federal requirements. In 2016 the network will be comprised of ~~104~~ *102* monitors and samplers at ~~34~~ *30* sites.

In October, 2006, the EPA published revisions to the ambient monitoring regulations (71 FR 61236, October 17, 2006) requiring quality assurance (QA), monitor designations, minimum requirements for both number and distribution of monitors among metropolitan statistical areas (MSAs), and probe siting changes. The regulation also included the requirement for an annual monitoring network plan and periodic network assessments.

This plan covers the eighteen month period from July 1, 2015 through December 31, 2016. This period includes a 6 month implementation period during which sites indicated as 'New' will be identified, secured, and prepared for the installation of monitoring equipment. It is expected that any monitoring indicated as 'New' or 'To be established' will be installed, calibrated, and operating in 2016 with the exception of some Ozone monitors which may begin operation at the start of the South Carolina Ozone Monitoring Season (April-October). The annual Network Description and Ambient Air Monitoring Plan, as required and described in 40 CFR Part 58.10, and Periodic Network Assessment, must contain the following information for each monitoring station in the network:

- The Air Quality System (AQS) site identification number (ID) for existing stations
- The location, including street address and geographical coordinates, for each monitoring station
- The sampling and analysis method used for each measured parameter
- The operating schedule for each monitor
- Any proposal to remove or relocate a monitoring station within a period of eighteen months following the plan submittal
- The monitoring objective and spatial scale of representativeness for each monitor
- The identification of any sites that are suitable for comparison against the Particulate Matter < 2.5 microns ($PM_{2.5}$) National Ambient Air Quality Standard (NAAQS), and
- The MSA, Core-Based Statistical Area (CBSA), Combined Statistical Area (CSA) or other area represented by the monitor

This document constitutes the 2016 South Carolina Air Monitoring Network Plan and is organized into two main parts:

- Air Monitoring Station Descriptions: An outline of the designations, parameters, monitoring methods, and the purpose for each monitor at the site and
- Network Summaries: A table which presents the total number of sites and monitors for the State, including a list of all proposed changes to the current network.

The Monitoring Network is reviewed annually. Planned changes are described in this 2016 Monitoring Plan and provided for public review and comment prior to submission to the EPA Region 4 Administrator.

### Public Participation Opportunities

In response to public interest and the potential impact of the monitoring regulation changes, the DHEC's Air Program solicits involvement from both internal (to the DHEC) and external workgroups. 1

*Network Summary*

| Network Summary: Calendar Year 2016 Air Monitoring Stations | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Region | Sites | $PM_{2.5}$ | $PM_{2.5}$ Cont. | Speciation | $PM_{10}$ | TSP/Lead | Ozone | $SO_2$ | $NO_2$/NO/N $O_y$ | CO | Sulfate | BC | Carbonyls | SVOC | VOC | Mercury | Precip Chem. | Precip. | *MET |
| Augusta-Richmond County, GA-SC MSA | 2 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Charleston-N. Charleston MSA | 5 | 3 | 2 | 0 | 1 | 0 | 2 | 2 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Charlotte-Concord-Gastonia, NC-SC MSA | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Columbia MSA | 7 | 4 | 2 | 1 | 3 | 1 | 3 | 3 | 3 | 1 | 0 | 1 | 2 | 3 | 0 | 2 | 2 | 2 | 2 |
| Florence MSA | 5 | 1 | 1 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Greenville-Anderson-Mauldin MSA | ~~7~~ ~~6~~ 7 | 3 | 1 | 0 | 1 | 0 | ~~4~~ 3 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Myrtle Beach-Conway-North Myrtle Beach, SC-NC MSA | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Spartanburg MSA | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rest of State | ~~7~~ ~~6~~ 5 | 1 | 3 | 1 | 3 | 0 | ~~5~~ 4 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | ~~2~~ 1 | ~~1~~ 0 | 1 |
| TOTALS | ~~35~~ 32 | 14 | 11 | 2 | 8 | 5 | ~~20~~ 18 | 8 | 6 | 1 | 1 | 4 | 3 | 4 | 1 | 2 | ~~4~~ 3 | ~~3~~ 2 | 7 |

This summary table presents the elements of the 2016 Monitoring Plan after implementation of changes described in this plan.

*MET data includes wind speed and wind direction

*Summary of 2016 Network Changes*

**Augusta-Richmond County, GA-SC MSA (South Carolina portion includes Aiken and Edgefield Counties)**

No changes planned for 2016.

**Charleston-North Charleston MSA**

~~*No changes planned for 2016.*~~

*Bushy Park (45-015-0002) - Site will be terminated before the beginning of the 2016 Ozone season.*

*Replacement Site for Bushy Park (45-015-XXXX) - A Replacement Site for Bushy Park will be sought. The Department will provide site details in the 2017 Plan.*

**Charlotte-Concord-Gastonia, NC-SC MSA**

~~*No changes planned for 2016.*~~

*York CMS (45-091-0006) - Site will be terminated before the beginning of the 2016 Ozone season.*

*York County Monitoring Site (45-091-0007) - A Replacement Site for York CMS will be established.*

**Columbia MSA**

No changes planned for 2016.

**Florence MSA**

No changes planned for 2016.

**Greenville-Anderson-Mauldin MSA**

Greenville ESC (45-045-0015) - $PM_{2.5}$ Speciation sampling at this site was terminated due to a loss in federal funding.

*Famoda Farm (45-045-1003) - Site will be terminated before the beginning of the 2016 Ozone season.*

*Clemson CMS (45-077-0002) - Site will be terminated before the beginning of the 2016 Ozone season.*

**Hilton Head Island-Bluffton-Beaufort MSA**

No changes planned for 2016.

**Myrtle Beach-Conway-North Myrtle Beach SC-NC MSA**

*Coastal Carolina (45-051-0008) – An ozone monitor will be established before the beginning of the 2016 Ozone season.*

**Spartanburg MSA**

No changes planned for 2016.

**Sumter MSA**

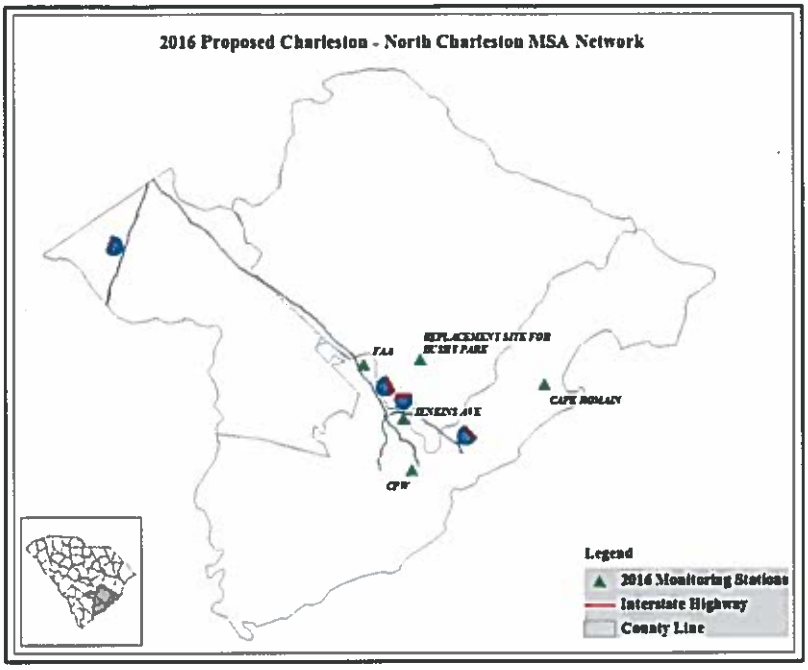
No changes planned for 2016.

**Remainder of State**

~~*No changes planned for 2016.*~~

*Cowpens (45-021-0002) - Site will terminated before the beginning of the 2016 Ozone season.*

*Charleston-North Charleston MSA*




Classification of Monitoring Type by Site

| Site ID | Site Name | $PM_{2.5}$ | $PM_{2.5}$ Cont. | Speciation | $PM_{10}$ | Lead / TSP | Ozone | $SO_2$ | $NO_2$ | CO | Sulfate | BC | Carbonyls | SVOC | VOCs | Mercury | Precip Chem. | Precip. MET | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ~~45-015-0002~~ 45-015-XXXX | ~~Bushy Park Pump Station~~ Replacement Site for Bushy Park Pump Station | | | | | | ● | | | | | | | | | | | | |
| 45-019-0003 | Jenkins Ave. Fire Station | | | | ● | | | ● | O | | | | | | | | | | |
| 45-019-0046 | Cape Romain | | O | | | | ● | O | O | | O | O | | | | | | | O |
| 45-019-0048 | FAA | OO | | | | | | | | | | | | | | | | | |
| 45-019-0049 | CPW | ● | O | | | | | | | | | | | | | | | | |
| | TOTAL | 3 | 2 | 0 | 1 | 0 | 2 | 2 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

O SPM / Other
● SLAMS
●●/OO indicates duplicate / QA monitors

***Bushy Park Pump Station (This site is to be discontinued)***
**CSA/MSA: none/*Charleston-North Charleston MSA***
**AQS Site ID:** 45-015-0002
**Location:** River Oak Drive (Goose Creek)
**County:** Berkeley
**Coordinates:** +32.98724, -79.93671
**Date Established:** June 20, 1978
**Site Evaluation:** The most recent site evaluation was conducted on March 17, 2003 (QA Check: May 19, 2011).

The Bushy Park Pump Station site is located in southeastern Berkeley County downwind from the Charleston urban area. This site monitors for Ozone and the monitoring objective is maximum Ozone concentration. The sample inlets are 11 meters from the nearest road.

**Changes for 2016:**

There are no changes planned for 2016, but encroaching vegetation may require changes to the site or relocation.

*The Bushy Park Pump Station site is being discontinued because access to the location is no longer available. A replacement site will be established when a suitable location has been identified.*

**Monitors:**

| Parameter | Scale | Objective | Designation | Probe Height (m) | Analysis Method | Sampling Frequency |
|---|---|---|---|---|---|---|
| Ozone | Urban | Max Ozone Concentration | SLAMS | 3-12 | FEM Ultraviolet Photometry | Continuous |

***Replacement Site for Bushy Park Pump Station***
***CSA/MSA: none/Charleston-North Charleston MSA***
***AQS Site ID: 45-015-XXXX***
***Location:***
***County: Berkeley***
***Coordinates:***
***Date Established: 2016***
***Site Evaluation: This is a new site. It has not had a site evaluation or QA check performed.***

*The Replacement Site for the Bushy Park Pump Station site is located in southeastern Berkeley County downwind from the Charleston urban area. This site monitors for Ozone and the monitoring objective is maximum concentration. The sample inlet is XXX meters from the nearest road.*

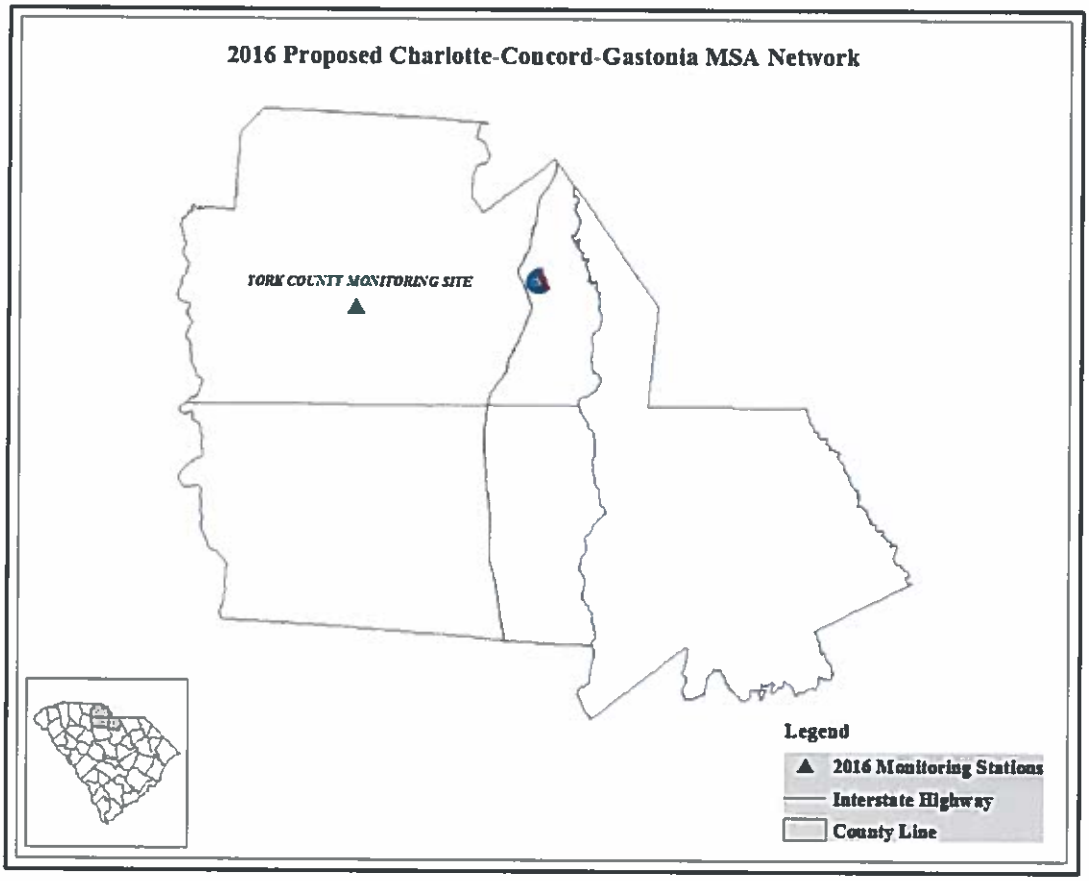
*Changes for 2016:*

*The Replacement Site for the Bushy Park Pump Station site was established as a replacement for the Bushy Park Pump Station (45-015-0002).*

*Monitors:*

| Parameter | Scale | Objective | Designation | Probe Height (m) | Analysis Method | Sampling Frequency |
|---|---|---|---|---|---|---|
| Ozone | Urban | Max Ozone Concentration | SLAMS | 3.12 | FEM Ultraviolet Photometry | Continuous |

*Charlotte-Concord-Gastonia MSA*




Classification of Monitoring Type by Site

| Site ID | Site Name | $PM_{2.5}$ | $PM_{2.5}$ Cont. | Speciation | $PM_{10}$ | Lead / TSP | Ozone | $SO_2$ | $NO_2$ | CO | Sulfate | BC | Carbonyls | SVOC | VOCs | Mercury | Precip Chem. | Precip. | MET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ~~45-091-0006~~ 45-091-0007 | ~~York CMS~~ York County Monitoring Site | | | | | | ● | ○ | | | | | | | | | | | ○ |
| | TOTAL | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

○ SPM / Other ● SLAMS
●●/○○ indicates duplicate / QA monitors

***York Continuous Monitoring Site (CMS) (This site will be terminated)***

***CSA/MSA: Charlotte-Concord CSA / Charlotte-Concord-Gastonia MSA***

***AQS Site ID: 45-091-0006***

***Location: 2316 Chester Hwy (US 321)***

***County: York***

***Coordinates: +34.93581, -81.22838***

***Date Established: March 30, 1993***

***Site Evaluation: The most recent site evaluation was conducted on June 13, 2006 (QA Check: May 21, 2013).***

***The York CMS site is located in south central York County in a rural setting. The site was established to represent background levels near the Charlotte urban area. York CMS has monitors for Ozone and $SO_x$ as well as a wind tower. The long historical record and location of the site make the data useful to both North and South Carolina Air Programs. The sample inlets are 171 meters from the nearest road.***

***Changes for 2016:***

***This site is not expected to be available in 2016 and will be replaced by a monitoring station established nearby and representative of the same area. The York CMS ambient air monitoring station is being discontinued because access to the location is no longer available. A replacement site location has been selected approximately 3 1/2 miles northeast of the current site and is representative of the same area.***

***Monitors:***

| Parameter | Scale | Objective | Designation | Probe Height (m) | Analysis Method | Sampling Frequency |
|---|---|---|---|---|---|---|
| Ozone | Urban | Upwind Background | SLAMS | 4.72 | FEM Ultraviolet Photometry | Continuous |
| Sulfur Dioxide | Urban | Upwind Background | SPM | 4.72 | FEM UV fluoreseence | Continuous |
| Wind Speed / Direction | Neighbor-hood | Local Conditions | Non-regulatory | 10.0 | Instruments for wind speed, wind direction | Continuous |

***York County Monitoring Site***
***CSA/MSA:*** *Charlotte-Concord CSA / Charlotte-Concord-Gastonia MSA*
***AQS Site ID:*** *45-091-0007*
***Location:*** *Langrum Branch Rd.*
***County:*** *York*
***Coordinates:*** +34.977, -81.207
***Date Established:*** *2016*
***Site Evaluation:*** *This is a new site. It has not had a site evaluation or QA check performed.*

*The York County Monitoring Site is located in central York County in a rural setting. The site was established to represent background levels near the Charlotte urban area. This site has monitors for Ozone and $SO_2$, as well as a wind tower. The data from this site is useful to both North and South Carolina Air Programs. The sample inlets are XXX meters from the nearest road.*

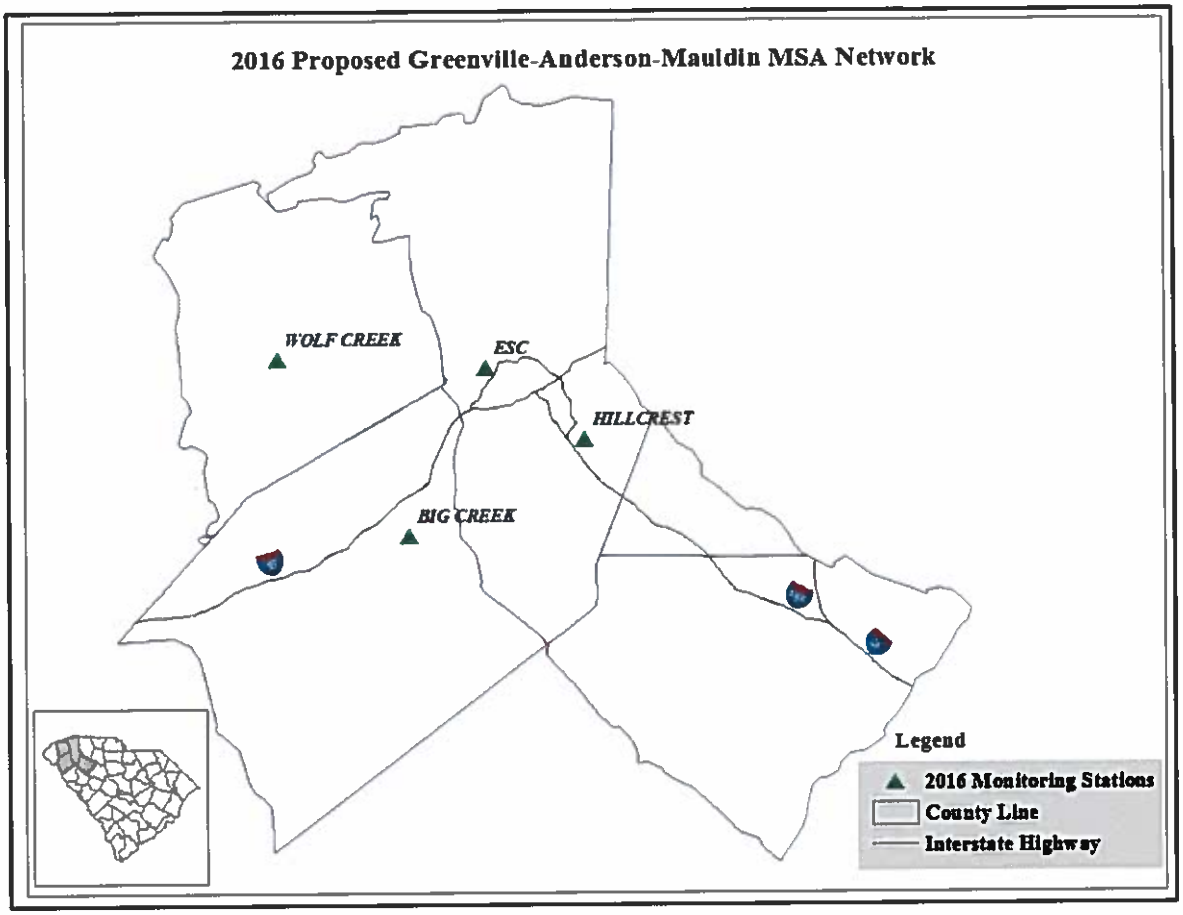
*Changes for 2016:*

*Site assess was lost to the York CMS site. This is the replacement ambient air monitoring station. It is representative of the same area and monitors the same parameters.*

*Monitors:*

| Parameter | Scale | Objective | Designation | Probe Height (m) | Analysis Method | Sampling Frequency |
|---|---|---|---|---|---|---|
| Ozone | Urban | Upwind Background | SLAMS | 4.72 | FEM Ultraviolet Photometry | Continuous |
| Sulfur Dioxide | Urban | Upwind Background | SPM | 4.72 | FEM UV fluorescence | Continuous |
| Wind Speed / Direction | Neighbor-hood | Local Conditions | Non-regulatory | 10.0 | Instruments for wind speed, wind direction | Continuous |

*Greenville-Anderson-Mauldin MSA*



Classification of Monitoring Type by Site

| Site ID | Site Name | $PM_{2.5}$ | $PM_{2.5}$ Cont. | Speciation | $PM_{10}$ | Lead / TSP | Ozone | $SO_2$ | $NO_2$ | CO | Sulfate | BC | Carbonyls | SVOC | VOCs | Mercury | Precip Chem. | Precip. | MET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45-007-0005 | Big Creek | | | | | | ● | | | | | | | | | | | | |
| 45-045-0015 | Greenville ESC | ● | ○ | | ● | | | ● | ● | | | ○ | | | | | | | ○ |
| 45-045-0016 | Hillcrest | ●<br>● | | | | | ● | | | | | | | | | | | | |
| ~~45-045-1003~~ | ~~Famoda Farm~~ | | | | | | ● | | | | | | | | | | | | |
| 45-077-0003 | Wolf Creek | | | | | | ○ | | | | | | | | | | | | |
| | TOTAL | 3 | 1 | 0 | 1 | 0 | ~~4~~ 3 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

○ SPM / Other
● SLAMS
●●/○○ indicates duplicate / QA samplers

## ~~Famoda Farm (This site will be terminated.)~~

~~**CSA/MSA:** Greenville-Spartanburg-Anderson CSA / Greenville-Anderson-Mauldin MSA~~
~~**AQS Site ID:** 45-045-1003~~
~~**Location:** 7401 Mountain View Road~~
~~**County:** Greenville~~
~~**Coordinates:** +35.05739, -82.37288~~
~~**Date Established:** October 24, 1969~~
~~**Site Evaluation:** PENDING (QA Check: April 30, 2013).~~

~~The Famoda Farm site is located in a rural area of northern Greenville County. It was originally established in 1969 and operated until 1982. In 2008, this site was reactivated as part of the Greenville MSA Ozone study, which was designed to investigate Ozone concentration variability across the Upstate by providing information to help refine the monitoring network to better meet monitoring objectives. The site has been retained to represent rural Ozone impacts downwind of the Anderson and Greenville urbanized areas. This site supports an Ozone monitor. The sample inlet is 24 meters from the nearest road.~~

~~**Changes for 2016:**~~

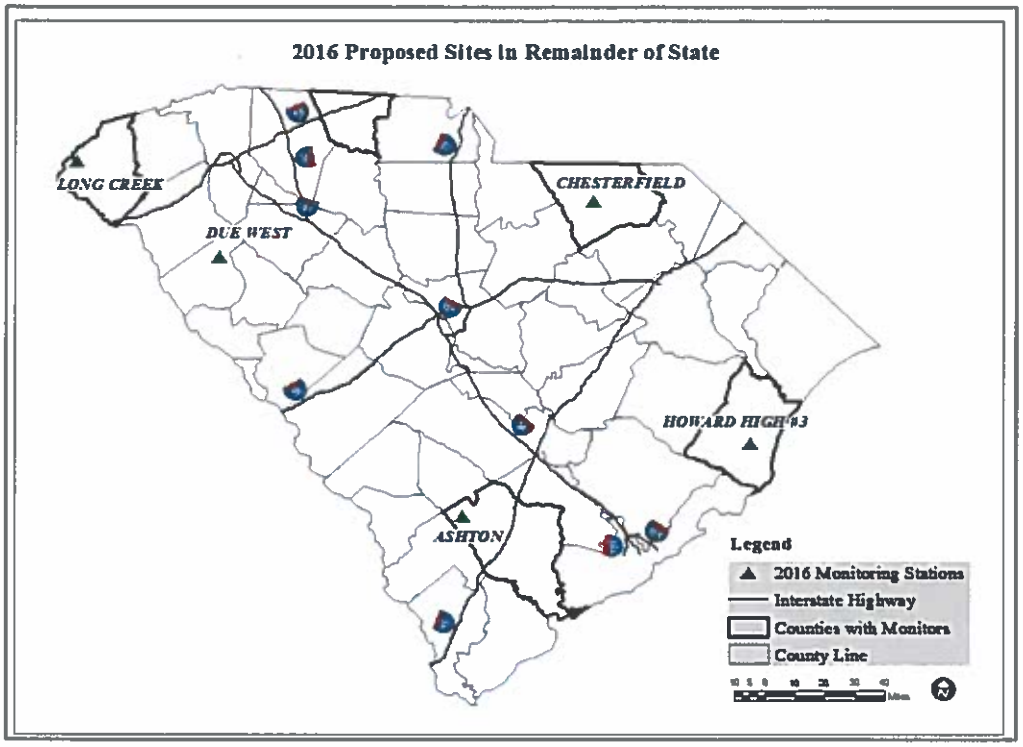
~~**There are no changes planned for 2016.**~~

~~**This site has been found to be duplicative and will be terminated in 2016.**~~

~~**Monitors:**~~

| ~~Parameter~~ | ~~Scale~~ | ~~Objective~~ | ~~Designation~~ | ~~Probe Height (m)~~ | ~~Analysis Method~~ | ~~Sampling Frequency~~ |
|---|---|---|---|---|---|---|
| ~~Ozone~~ | ~~Urban~~ | ~~Max Ozone Concentration~~ | ~~SLAMS~~ | ~~3.47~~ | ~~FEM Ultraviolet Photometry~~ | ~~Continuous~~ |

*Remainder of State*




Classification of Monitoring Type by Site

| Site ID | Site Name | $PM_{2.5}$ | Cont. | Speciation | $PM_{10}$ | Lead | Ozone | $SO_2$ | $NO_2$ | CO | Sulfate | BC | Carbonyls | SVOC | VOCs | Mercury | Precip Chem. | Precip. | MET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45-001-0001 | Due West | | | | | | ● | | | | | | | | | | ○ | ○ | |
| ~~45-021-0002~~ | ~~Cowpens~~ | | | | | | | | | | | | | | | | | | |
| 45-025-0001 | Chesterfield | ● | ○ | ○ | ○<br>○ | | ○ | | | | | ○ | ○ | ○ | ○ | | | | ○ |
| 45-029-0002 | Ashton | | ● | | | | ○ | | | | | | | | | | | | |
| 45-043-0011 | Howard High School #3 | | | | ○ | | | | | | | | | | | | | | |
| 45-073-0001 | Long Creek | | ○ | | | | ○ | ○ | | | | | | | | | | | |
| | TOTAL | 1 | 3 | 1 | 3 | 0 | 5 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 2 | 1 | 1 |

○ SPM / Other
● SLAMS
●●/○○ indicates duplicate QA monitors

~~**Cowpens**~~
~~**CSA/MSA: Greenville-Spartanburg-Anderson CSA/ None**~~
~~**AQS Site ID: 45-021-0002**~~
~~**Location: McGinnis Road (Old SC Hwy 110)**~~
~~**County: Cherokee**~~
~~**Coordinates: +35.13048, -81.81656**~~
~~**Date Established: March 29, 1988**~~
~~**Site Evaluation: The most recent site evaluation was conducted on June 26, 2006 (QA Check: May 14, 2013).**~~

~~*The Cowpens site is located in northwestern Cherokee County at the Cowpens National Battlefield. Cowpens is sited to represent Ozone concentrations between the Greenville-Spartanburg-Anderson CSA and the Charlotte-Concord CSA. The operation of the Ozone monitor fulfills the ambient monitoring commitment in the Cherokee County Maintenance Plan.[1] In addition to Ozone, the Cowpens site also supports a precipitation chemistry sampler. The sample inlets are 25 meters from the nearest road.*~~

~~*The monitor will be operated through the 2016 Ozone season to fulfill the Cherokee County Maintenance Plan commitments.*~~

~~**Changes for 2016:**~~

~~**There are no changes planned for 2016.**~~

~~**Monitors:**~~

| ~~Parameter~~ | ~~Scale~~ | ~~Objective~~ | ~~Designation~~ | ~~Probe Height (m)~~ | ~~Analysis Method~~ | ~~Sampling Frequency~~ |
|---|---|---|---|---|---|---|
| ~~Ozone~~ | ~~Urban~~ | ~~Upwind / Background~~ | ~~SPM~~ | ~~3.05~~ | ~~FEM Ultraviolet Photometry~~ | ~~Continuous~~ |
| ~~Precipitation Chemistry~~ | ~~Regional~~ | ~~Regional Transport~~ | ~~Non-regulatory~~ | ~~1.50~~ | ~~IC~~ | ~~Weekly-Tue-Tue~~ |



[1] 110(a)(1) Maintenance Plan: 8-hour Ozone National Ambient Air Quality Standard, Cherokee County, South Carolina, December, 2007.

## *New and Discontinued Sites*

The Table below contains information on the monitoring *sites* the DHEC has scheduled for discontinuance *and new sites scheduled to begin operation.*

| Site | ID | Date Established | Notes |
|---|---|---|---|
| Clemson CMS | 45-077-0002 | 07/14/1979 | The DHEC has determined that the Ozone monitoring at this site is duplicative and will be discontinued at the conclusion of the 2015 Ozone season. |
| *Bushy Park Pump Station* | *45-015-0002* | *06/20/78* | *The Bushy Park Pump Station site is being discontinued because access to the location is no longer available. A replacement site will be established when a suitable location has been identified.* |
| *Replacement Site for Bushy Park Pump Station* | *45-015-XXXX* | | *A Replacement Site is being established to replace the Bushy Park Pump Station (45-015-0002) site.* |
| *York Continuous Monitoring Site (CMS)* | *45-091-0006* | *03/30/93* | *The York CMS site is being discontinued because access to the location is no longer available. A replacement site location has been selected approximately 3 1/2 miles northeast of the current site and is representative of the same area.* |
| *York County Monitioring Site* | *45-091-0007* | | *The York County Monitoring site is being established to replace the York CMS (45-091-0006) site. It is located approximately 3 1/2 miles northeast of the current site in a rural area in central York County. This location is representative of the same area. The Department is in the process of obtaining the necessary permits for the new site construction.* |
| *Famoda Farm* | *45-045-1003* | *10/24/69* | *This site has been found to be duplicative and will be terminated in 2016.* |
| *Cowpens* | *45-021-0002* | *03/25/88* | *This site is not required for the minimum monitoring requirements and will be terminated in 2016.* |

# Appendix B: Technical analysis for Clemson CMS termination

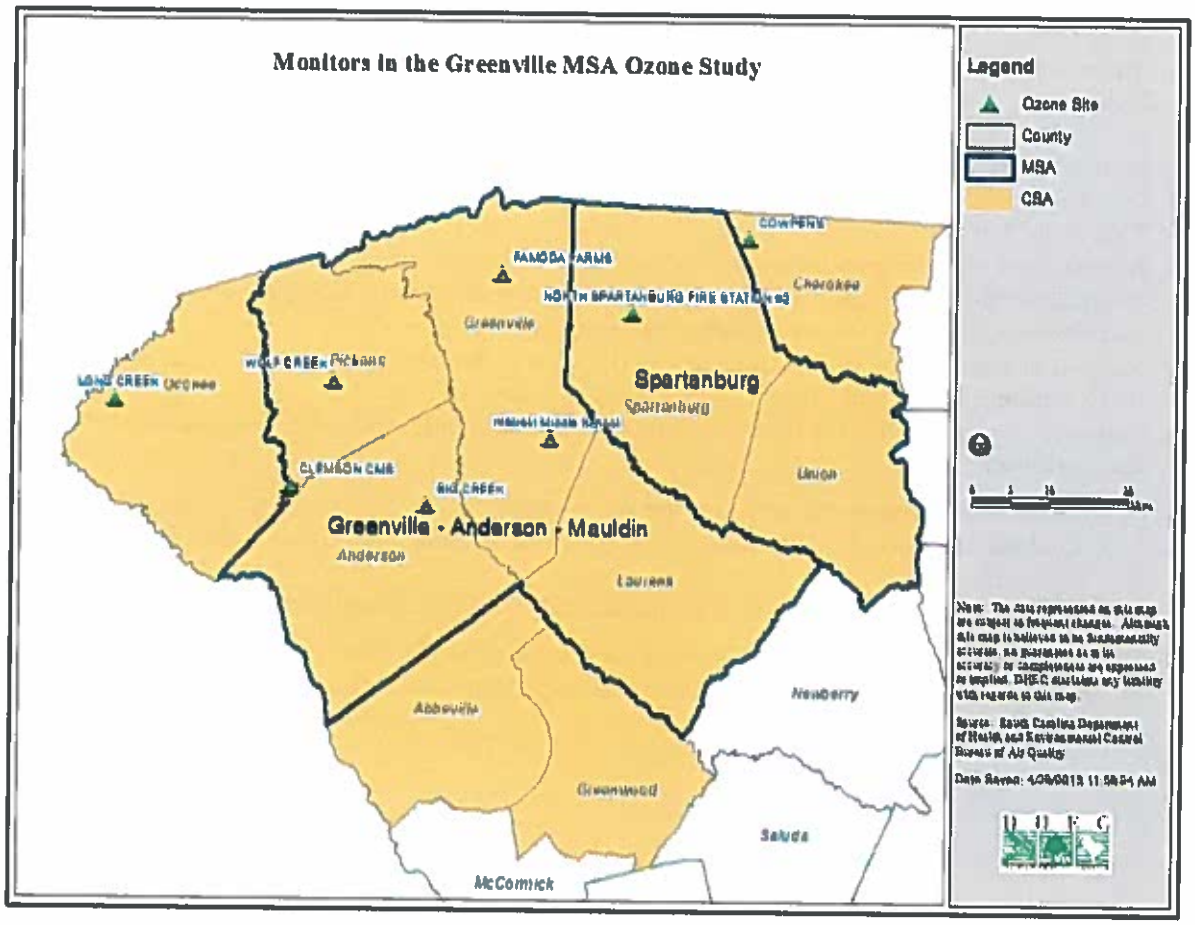
**Major Points**

- EPA Technical Systems Audit of SCDHEC ambient air monitoring network has indicated that there are too many monitoring sites being operated and it has been suggested that excess monitoring be terminated so that a focus on core sites will bring about an improvement in data quality.
- SCDHEC has determined that Clemson CMS should be terminated in order to improve data quality at other sites in the Upstate.
- There are two trees near Clemson CMS that may be impacting ambient ozone concentrations. We believe that this site does not meet 40 CFR Part 58, Appendix E siting requirements. Furthermore, we believe that due to the historic nature of the land adjacent to this site we will be unable to secure permission to trim or otherwise remove the trees which violate Appendix E requirements.
- Ozone design values at Big Creek and Clemson are within 1 ppb of each other.
- This is the first year since 2011 when Clemson had a higher design value.
- Hourly ozone concentrations between the two sites are similar once the mixing heights break down.
- Overnight, Wolf Creek measures extremely low ozone concentrations. Supplementary analysis shows that Famoda Farm sees low overnight ozone concentrations as well.
- Analysis of regression slopes shows significant differences between Clemson and Big Creek and suggests that Clemson reads slightly higher ozone concentrations.
- Trajectory analysis indicates that "high" ozone concentrations occur when winds are out of the north and northeast.
  - These trajectories are centered on the I-85 corridor.
  - Analysis suggests that Clemson and Big Creek are now "downwind" sites for Charlotte and Greenville.
  - Less evidence that Upstate is being impacted by "Atlanta plume" on high ozone days.
- Evidence from this analysis does not conclusively point to Big Creek being the "design value" site. Some suggestion that Big Creek may adequately represent Clemson.

## Introduction

In order to support the refinement of the ozone monitoring network in the Upstate of South Carolina (encompassing the current Greenville-Anderson-Mauldin and Spartanburg Metropolitan Statistical Areas) the Department of Health and Environmental Control (DHEC) added additional monitors to improve the spatial coverage and has conducted an analysis of all ozone monitoring data collected from the existing and additional monitors (Map 1). Table 1 lists the site name, site ID, county, page in the 2016 Monitoring Plan that contains the purpose of the site and date ozone monitor was established for those monitors in the Greenville MSA Ozone Study identified in the 2016 Plan.

*Map 1: Location of monitoring stations used in this analysis*




Recognizing that maintenance of large monitoring networks in the face of ever increasing budget cuts is no longer possible or practical, the SC Air Program conducted a significant review of the Ambient Monitoring network in 2007. The DHEC has made it a priority to eliminate redundant or low value monitors, even at the cost of ending long-term monitoring records, in order to have sufficient resources to meet the mandatory monitoring requirements and data collection needed to adequately operate the program. While the DHEC understands the importance of maintaining a long term monitoring record, ensuring that an area is appropriately monitored in the most efficient manner is the priority for our monitoring program.

**The DHEC is signaling our intention to terminate monitoring at Clemson CMS (45-077-0002) at the conclusion of the 2015 Ozone Monitoring Season. The Clemson CMS (45-077-0002) monitoring site for several years in a row has not had the highest ozone design value site in the MSA.** The DHEC may propose further modifications to the ozone network in the Upstate in subsequent Plans to best use resources and ensure that an efficient, adequate monitoring network is maintained.

The DHEC recognizes that the explicit requirements of 40 CFR 58.14, paragraph c (System Modification) for discontinuation of a State/Local Air Monitoring Station (SLAMS) are not met for the Clemson CMS monitor. However, the System Modification requirement states "Other requests for discontinuation may be approved on a case-by-case basis if discontinuance does not compromise data collection needed for implementation of a NAAQS and if the requirements of Appendix D to this part, if any, continue to be met." The DHEC provides evidence below that the continued operation of existing monitors in the Greenville-Anderson-Mauldin MSA provide the appropriate data collection needed for implementation of the Ozone NAAQS. The minimum monitoring requirements specified in Appendix D to 40 CFR Part 58 will continue to be met or exceeded for the MSAs.

### Background on Monitoring Configuration in the Upstate and Top-down Assessment

The monitoring configuration of the 'legacy' monitoring sites operating in 2007 in the Upstate of South Carolina (west to east: Long Creek Clemson, North Spartanburg and Cowpens) predates the Greenville MSA Ozone study referenced below. Prior to the study, the Greenville - Spartanburg - Anderson MSA consisted of Greenville, Spartanburg, Anderson, Pickens and Cherokee Counties [1]. The configuration of monitors at that time included Clemson (45-077-0002: Pickens County), Long Creek (45-073-0001: Oconee County) and Powdersville (45-007-0003: Anderson County discontinued Nov 2006) sites as monitors representing upwind concentrations for the MSA. North Spartanburg (45-083-0009: Spartanburg County) and to some extent Cowpens (45-021-0002: Cherokee County) represented expected maximum downwind concentrations for the then current MSA configuration.

Table 1 lists how the area monitors, as proposed, meet or exceed the minimum monitoring requirements found in Appendix D to 40 CFR Part 58. The Monitoring rule repeatedly reinforces that the Regional Administrator and the responsible monitoring agency must work together to design and maintain the most appropriate network to meet the data needs of the area. The ozone design values for 2014 are based on uncertified data at the time of this writing and are subject to change.

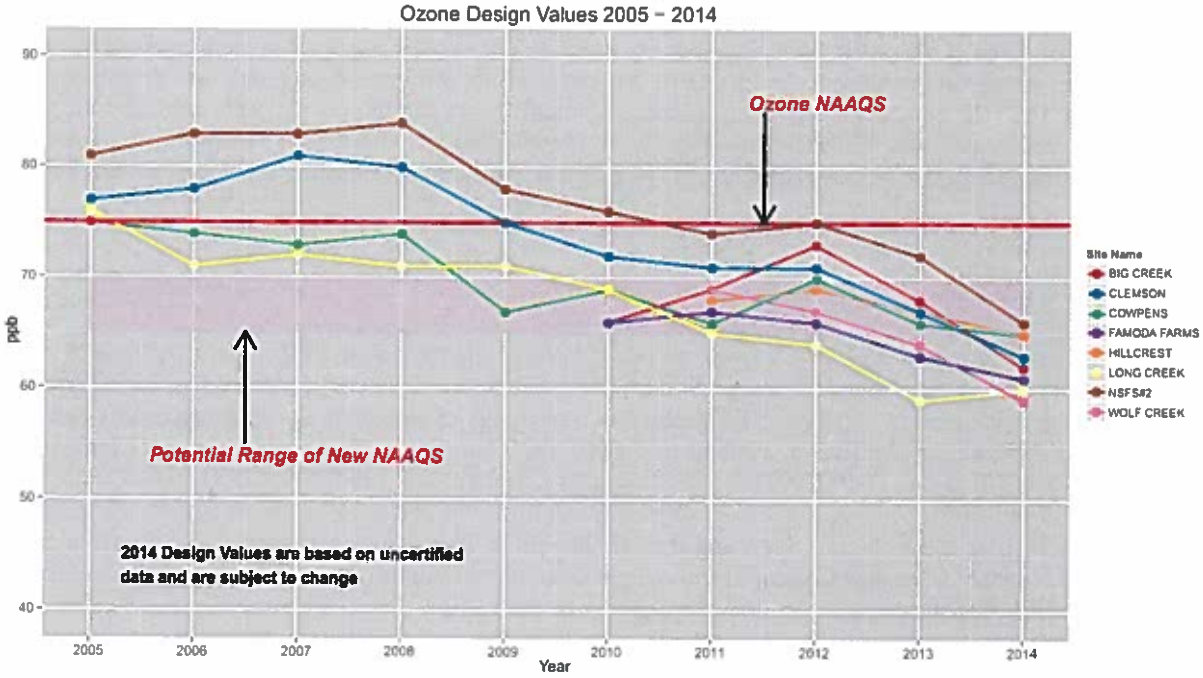
Table 1: Table 1: Listing of monitors used in this analysis

| Site Name | Site ID | County | 2014 Ozone DV (ppb) | Appendix D? | Start Date | Page in Plan |
|---|---|---|---|---|---|---|
| Long Creek | 450730001 | Oconee | 60 | Exceeds | 5/4/1989 | 69 |
| Wolf Creek | 450770003 | Pickens | 59 | Exceeds | 8/10/2010 | 56 |
| Clemson CMS | 450770002 | Pickens | 63 | NA | 7/20/1979 | 72 |
| Famoda Farms | 450451003 | Greenville | 61 | Meets | 8/7/2008 | 55 |
| Hillcrest | 450450016 | Greenville | 65 | Meets | 3/4/2009 | 54 |
| Big Creek | 450070005 | Anderson | 62 | Exceeds | 6/6/2008 | 51 |
| North Spartanburg | 450830009 | Spartanburg | 66 | Meets | 4/10/1990 | 60 |
| Cowpens | 450210002 | Cherokee | 65 | Meets | 4/21/1988 | 64 |

Figure 1 contains the 10-year ozone design value trends for the monitors in the Upstate of South Carolina. Ozone concentrations have been steadily declining across the region since 2008 and have accelerated this decline between 2012 and 2014.

[1] http://www.census.gov/population/metro/files/lists/historical/99mfips.txt

*Figure 1: Ozone Design Value trends 2005 - 2014*




In October, 2006, the United States Environmental Protection Agency (EPA) published ambient air monitoring regulations[2] containing revisions to quality assurance (QA), 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 monitoring network plan and periodic network assessments.

In June 2003[3] , the Office of Management and Budget (OMB) redefined the MSA definitions for the Upstate of South Carolina, separating the former single Greenville-Spartanburg-Anderson MSA into three distinct MSAs. The breakup of the original MSA into three distinct areas and the 2006 revision to the regulations triggered new minimum monitoring requirements for each independent MSA based on the Chapter 40, Appendix D to Part 58 of the Code of Federal Regulations. This change in the monitoring requirements was not driven by air quality planning needs, but by dynamic boundaries delineated by the Office of Management and Budget (OMB) for use by Federal statistical agencies in collecting, tabulating, and publishing Federal statistics. The DHEC believes that a monitoring network based on the air flow within and through the airshed is more appropriate to capture the evolution and transport of ozone in the area and indicate potential population exposure across the upstate during typical elevated ozone episodes. The generally east to west configuration of the network mirrors the airflow along the foot of the Appalachians, the successive inputs of precursor emissions from the urbanized areas, and provides data useful for the public notification for the citizens in the Upstate and the development of appropriate air management policy.

Monitoring was added in Anderson County (Big Creek) to address the regulatory requirement for the newly designated Anderson MSA, but it was done in the context of the concern about the Clemson site location being very close to the MSA boundary, the historical knowledge of the development and movement of ozone in the Upstate and the constellation of monitors being installed to support development of the most appropriate monitoring configuration for the region.

In February 2013, the Office of Management and Budget released new Metropolitan Statistical Area (MSA) definitions[4] . The new definitions recombined the Anderson MSA with the Greenville-Mauldin-Easley MSA

[2] 71 FR 61236, October 17, 2006

[3] Office of Management and Budget Bulletin No. 03-01, announcing metropolitan and micropolitan statistical areas as of June 6, 2003, based on application of the 2000 OMB standards to Census 2000 data, http://www.whitehouse.gov/omb/bulletins_b03-04.

[4] http://www.census.gov/population/metro/

forming the Greenville-Anderson-Mauldin MSA. Based on the Network Design Criteria provided in Part 58 Appendix D and the rich ozone data set available for the Upstate, this area has significantly more than the minimum or needed number of monitors necessary to characterize ozone concentrations in the area. The Clemson CMS (45-007-0002) site no longer has the highest ozone design value in the MSA. The DHEC believes that the Greenville-Anderson-Mauldin MSA is adequately represented by the other existing monitoring sites in Greenville and Anderson counties.

OMB cautions users that "OMB establishes and maintains the definitions of Metropolitan and Micropolitan Statistical Areas ... solely for statistical purposes. This classification is intended to provide nationally consistent definitions for collecting, tabulating, and publishing Federal statistics for a set of geographic areas."[5] Nowhere in the OMB bulletin does it suggest that the MSA definitions are appropriate for, or are based on important data elements applicable to the definition of an ambient air monitoring network. While the DHEC understands the need for establishing minimum monitoring requirements, the EPA appropriately has mechanisms included in the monitoring plan approval and network assessment process to allow states the flexibility to implement a monitoring network that meets the three basic monitoring objectives and addresses National and State needs. The recent changes in the MSA definitions is an example of the reason for the incorporation of flexibility in the regulations and illustrates the necessity that the EPA use the discretion available in the monitoring regulations to afford states flexibility to implement appropriate monitoring design that meets or exceeds the requirements and the needs of the state air programs.

### Clemson CMS Termination Request Background

In July 2007, the DHEC submitted their first annually required[6] Network Description and Ambient Air Monitoring Plan (2008 Plan)[7]. In the 2008 Plan, the DHEC stated that monitoring at the Clemson CMS site (45-077-0002) would be maintained through the 2008 ozone season as part of the Greenville MSA Ozone Study[8] . On October 24, 2007, the EPA conditionally approved the establishment of two ozone monitoring sites as part of the Greenville MSA Ozone Study.

In 2008, the DHEC designed and initiated the Greenville MSA Ozone study to investigate ozone concentration variability across the Upstate and provide information to help refine the monitoring network to better meet monitoring objectives. The study sites proposed to improve the spatial distribution of available data were not established as quickly as desired but monitoring has been maintained at the additional sites for several years beyond the expected duration of the study. The DHEC has evaluated data from all of the previously existing and the supplementary monitors to arrive at a configuration of monitors and locations that best represents air quality and meets area monitoring objectives.

In July 2008, based on ozone data collected from 2005 – 2007, the DHEC determined that it would terminate all monitoring at the Clemson CMS site (45-077-0002)[9] , establish the Famoda Farm site (45-045-1003)[10] and establish a site in Southeastern Greenville County[11] in execution of the 2008 Plan. In their October 27, 2008 response, the EPA denied the request to discontinue ozone monitoring at the Clemson site because "The sites above that are currently violating the NAAQS[12] , cannot be terminated at this time. The monitor types for these sites must be changed back to SLAMS in AQS and they must operate for at least one additional calendar year to compare with new sites that SC DHEC is proposing to establish." On March 25, 2009 the EPA submitted a follow-up letter as a confirmation of discussions between the DHEC and the EPA staff

[5] Office of Management and Budget Bulletin No. 03-04, announcing metropolitan and micropolitan statistical areas as of June 6, 2003, based on application of the 2000 OMB standards to Census 2000 data, http://www.whitehouse.gov/omb/bulletins_b03-04,.paragraph 4.

[6] 40 CFR 58.10(a)(1)

[7] State of South Carolina: Network Description and Ambient Air Network Monitoring Plan for Calendar Year 2008 (2008 Plan) at page 21

[8] *Id.*, at page 32

[9] State of South Carolina: Network Description and Ambient Air Network Monitoring Plan for Calendar Year 2009 (2009 Plan) at page 65

[10] *Id.*, at page 23

[11] *Id.*, at page 24

[12] On March 27, 2008, the EPA finalized a revised Ozone NAAQS set at 0.075 ppm, 73 FR 16435.

that listed the Clemson CMS ozone monitor as a site that is "eligible to be shutdown dependent on the establishment of new sites and the data comparisons."

On February 1, 2011, the DHEC submitted an amendment to the 2011 Monitoring Plan establishing the Wolf Creek monitoring site. In the cover letter to the amendment, the DHEC stated "We wish to add the Wolf Creek monitoring site (45-077-0003), near the town of Pickens, in central Pickens County, to the 2011 Annual Air Network Monitoring Plan. Stakeholders in Pickens County have voiced concerns that the data being collected at the Clemson CMS monitoring site (45-077-0002 SLAMS) is not representative of ozone concentrations in Pickens County. The Wolf Creek site is expected to be better representative of both Pickens County and the Greenville-Mauldin-Easley MSA ambient ozone concentrations. Ozone data from the Wolf Creek monitoring site will be collected concurrently with, and compared to data collected at the Clemson CMS site to allow an evaluation to determine if revision of the local ozone monitoring network is appropriate. The network revisions may include redesignation of Wolf Creek as one of the two required [Greenville-Mauldin-Easley] MSA SLAMS Ozone monitors and discontinuation of the Clemson site." The EPA subsequently approved this amendment to the 2011 Monitoring Plan in a letter dated March 14, 2011.

On June 4, 2012, the DHEC submitted an amendment to the 2012 Monitoring Plan requesting approval to terminate the Clemson CMS (45-077-0002) monitoring site in Pickens County. Appendix D to 40 CFR Part 58 requires only two ozone monitors for the MSA based on current population and design values. At that time, the Greenville-Mauldin-Easley Metropolitan Statistical Area (MSA) had four ozone monitoring stations in operation. Additional monitoring in the MSA established in 2008 and 2009 at Hillcrest (45-045-0016) and Famoda Farm (45-045-1003) provided what the DHEC contends is representative data and ozone design values for the MSA. Termination of monitoring at Clemson CMS would have allowed the DHEC to redirect limited resources to more pressing and informative program monitoring priorities. The EPA disapproved this request until there was enough data collected at each of the four Greenville-Mauldin-Easley MSA sites to calculate a design value.

We are not aware of any regulatory language that requires calculation of a Design Value at a replacement site prior to termination of an existing monitor. The regulations allow termination "...if discontinuance does not compromise data collection needed for implementation of the NAAQS and if requirements of Appendix D of this part, if any, continue to be met." [13]

Finally, in July 2013, the DHEC provided a technical analysis of ambient ozone concentrations and trajectory analysis illustrating our position that the Big Creek monitoring site was comparible to the Clemson CMS. On November 6, 2013, the EPA rejected our analysis and offered to consider shutdown another site in the MSA that was of lower value to the EPA than the Clemson CMS site.

Before and after the recent MSA definition changes, the Greenville-Anderson-Mauldin MSA has had more monitoring than is necessary to meet National and State Monitoring objectives. The DHEC still believes that it is appropriate to discontinue ozone monitoring at the Clemson CMS (45-077-0002) site. As stated elsewhere, due to the definition changes, the highest MSA design value site is now located at the Big Creek (45-007-0005) site and the EPA's original concern that the DHEC is requesting termination of the MSA's design value site is now moot. As demonstrated below, the DHEC believes that the Big Creek (45-007-0005) site is a more appropriate site than Clemson to represent ozone concentrations in this part of the Greenville-Anderson-Mauldin MSA.

### Conclusions

A technical analysis of ambient ozone monitoring concentrations and meteorological analysis can be found in the appendix below. An analysis of daily maximum ozone concentrations, 1-hour ozone concentrations (Appendix Section 1.0) and 36-hour back trajectories (Appendix Section 2.0) on days with daily maximum concentrations greater than 60 ppb all show that Big Creek and Clemson exibit similar ozone concentrations and are certainly exposed to the same air mass (especially on peak ozone days). While it appears that there are certain times when the Clemson monitor is slightly higher than Big Creek, the DHEC believes that this

[13] 40CFR §58.14 (c)

is well within the error of the instrument. The DHEC believes that discontinuation of the Clemson CMS site will not result in a loss of a design value site for the Greenville MSA. The Big Creek site has similar design values to Clemson and has been regularly within 3-5 ppb of the Clemson design value. As to the EPA's concerns about data longevity, the DHEC believes that the number of design values measured at both Clemson and Big Creek concurrently allows us to confidently measure the long term changes in air quality for the Upstate of at Big Creek instead of Clemson.

In light of this evidence and the current minimum monitoring requirements, the DHEC signaling its intention to terminate ozone monitoring at the Clemson CMS (45-077-0002) site after the conclusion of the 2015 Ozone Monitoring Season. Based on the data collected and data needs for the air program and area, the DHEC may propose further refinements to the Upstate ozone monitoring network in future monitoring plans and or amendments to approved plans to better meet the monitoring objectives.

# Appendix

## 1.0 Data Evaluation and Bottom-up Assessment

For this evaluation, the DHEC focused the bottom-up assessment of the three ozone monitoring sites, including the Clemson CMS monitoring site, that represent air quality generally upwind of the South Carolina Upstate urban areas. After establishing relationships with Clemson, Wolf Creek and Big Creek, we further refinied our analysis to focus only on the Clemson and Big Creek monitoring sites.

In order to conduct this analysis, the R Statistics Package along with several community developed packages were utilized to import, prepare and analyze ambient ozone monitoring data obtained from the EPA's Air Quality System database. The most extensively used community developed package was `openair`. This package was developed with specific functions aimed at the analysis of ambient air monitoring data. Please see the References & Citations section for a full listing of the packages and versions that were used.

**1.1 Boxplots** Boxplots give a general overview of the way the data is distributed without having to plot every single point in the data set. The thick line in the middle of the "box" is the median, which means that half of the data lies below the thick line, and half lies above. The lines below and above the median (which form part of the box) are the 25th and 75th percentiles of the data, respectively. The middle 50% of the data falls between these two lines, so the tighter the box is, the less variability the middle 50% of the data has. Any dots below or above the lines extending from the box are potential outliers.

Boxplots of hourly concentrations (Figure 2) for the Clemson area monitors shows that Big Creek and Clemson median concentrations are very similar with some higher concentrations occurring at Big Creek, mainly in 2012 (Figure 3).

*Figure 2: Boxplots of hourly ozone concentrations*

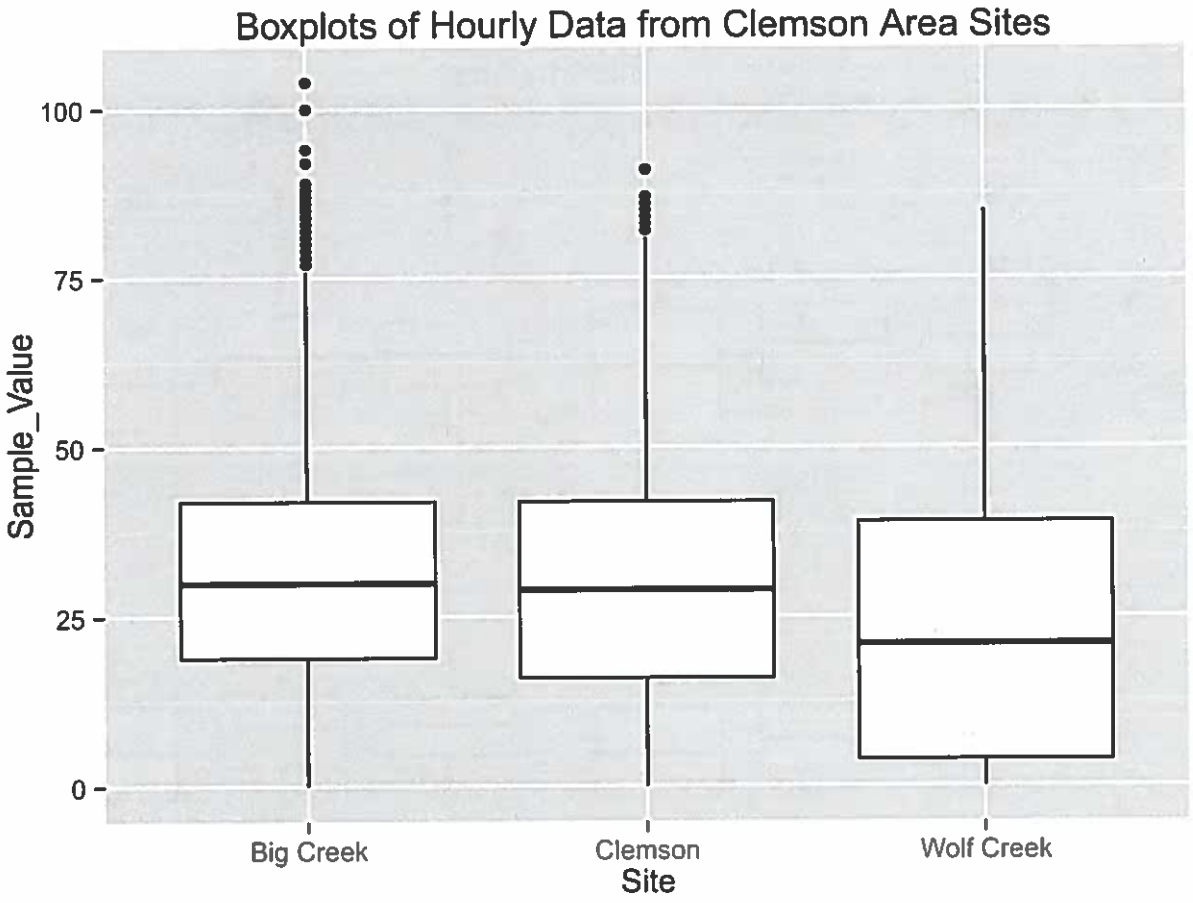
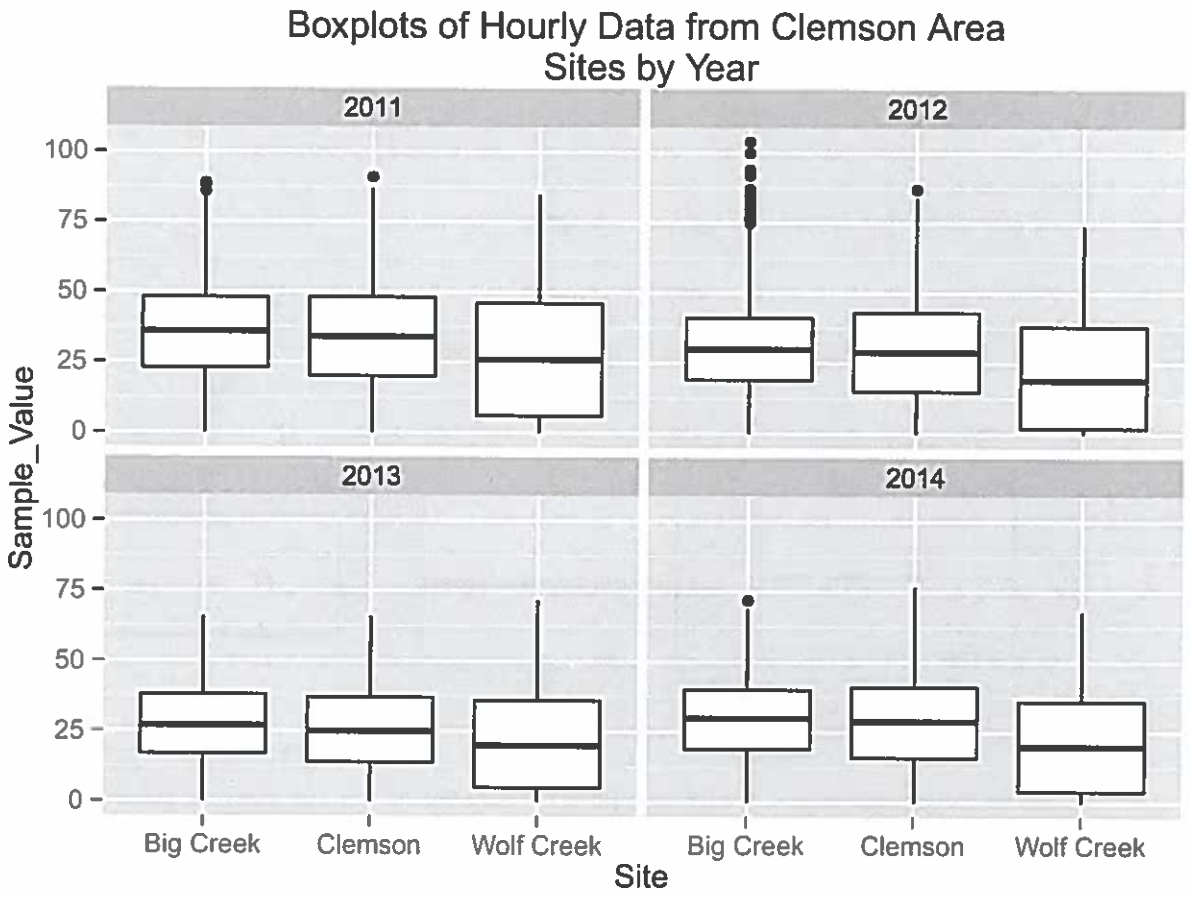


*Figure 3: Boxplots of hourly ozone concentrations by year*




**1.2 Density Plots** Density plots are similar to histograms, but instead of bars that show a count for each "bin" of numbers, the estimates are shown as a smooth curve representing the distribution of the data. Like most estimations in statistics, the accuracy of these estimations depends a good deal on the sample size: the more observations you have, the more accurate of a picture you will get. A count of vaild samples by four year study period, year and month are provied in Tables 2-4.

An examination of Table 2 shows that Clemson and Big Creek have similar numbers of valid samples. Wolf Creek has approximately 2000 less samples, which could impact the shape of the density graphs.

Table 2: Table 2: Valid Samples by Site 2011 - 2014

| Site Name | Valid Samples |
|---|---|
| Big Creek | 20309 |
| Clemson | 20377 |
| Wolf Creek | 18253 |

On a year-by-year basis (Table 3), Clemson and Big Creek have similar number of valid samples. Wolf Creek had fewer samples than the other two monitoring sites. Wolf Creek had signficantly fewer samples than the other sites in 2013.

Table 3: Table 3: Valid Samples by Site and Year

| Site Name | Year | Valid Samples |
|---|---|---|
| Big Creek | 2011 | 5073 |
| Big Creek | 2012 | 5038 |
| Big Creek | 2013 | 5102 |
| Big Creek | 2014 | 5096 |
| Clemson | 2011 | 5079 |
| Clemson | 2012 | 5102 |
| Clemson | 2013 | 5100 |
| Clemson | 2014 | 5096 |
| Wolf Creek | 2011 | 4702 |
| Wolf Creek | 2012 | 4627 |
| Wolf Creek | 2013 | 3940 |
| Wolf Creek | 2014 | 4984 |

On a month-by-month basis (Table 4), Clemson and Big Creek have similar number of vaild samples. Wolf Creek has a lower number of valid samples except for the months of July and October.

Table 4: Table 4: Valid Samples by Site and Month

| Site Name | Month | Valid Samples |
|---|---|---|
| Big Creek | 4 | 2838 |
| Big Creek | 5 | 2950 |
| Big Creek | 6 | 2857 |
| Big Creek | 7 | 2922 |
| Big Creek | 8 | 2958 |
| Big Creek | 9 | 2828 |
| Big Creek | 10 | 2956 |
| Clemson | 4 | 2859 |
| Clemson | 5 | 2961 |
| Clemson | 6 | 2830 |
| Clemson | 7 | 2953 |
| Clemson | 8 | 2956 |
| Clemson | 9 | 2856 |
| Clemson | 10 | 2962 |
| Wolf Creek | 4 | 2661 |
| Wolf Creek | 5 | 2666 |
| Wolf Creek | 6 | 2019 |
| Wolf Creek | 7 | 2954 |
| Wolf Creek | 8 | 2372 |
| Wolf Creek | 9 | 2631 |
| Wolf Creek | 10 | 2950 |

An examination of the density plots (Figure 4) shows that Big Creek has a higher frequency of hourly concentrations in the mid-range of concentrations. However, Clemson has a slightly higher frequency of higher concentrations. The DHEC believes that this is well within the error of the instruments and does not indicate a systemic bias in concentrations at Big Creek. This pattern is is repeated in Figures 5-7.

One note of interest in these graphs is the high frequency of low concentrations of ozone at Wolf Creek indicated in Figures 4-7. This pattern is only seen at two ozone sites in South Carolina, Wolf Creek and Famoda Farm in Pickens and neighboring Greenville County respectively, both located in rural areas, near the

foothills north of I-85. An examination of audit data indicates both monitoring sites are operating correctly. The DHEC believes that this pattern is indicative of current very low night and early morning concentrations in the relatively clean areas along the Appalachian foothills north of the I-85 corridor.

*Figure 4: Density plot for study period (2011 - 2014)*

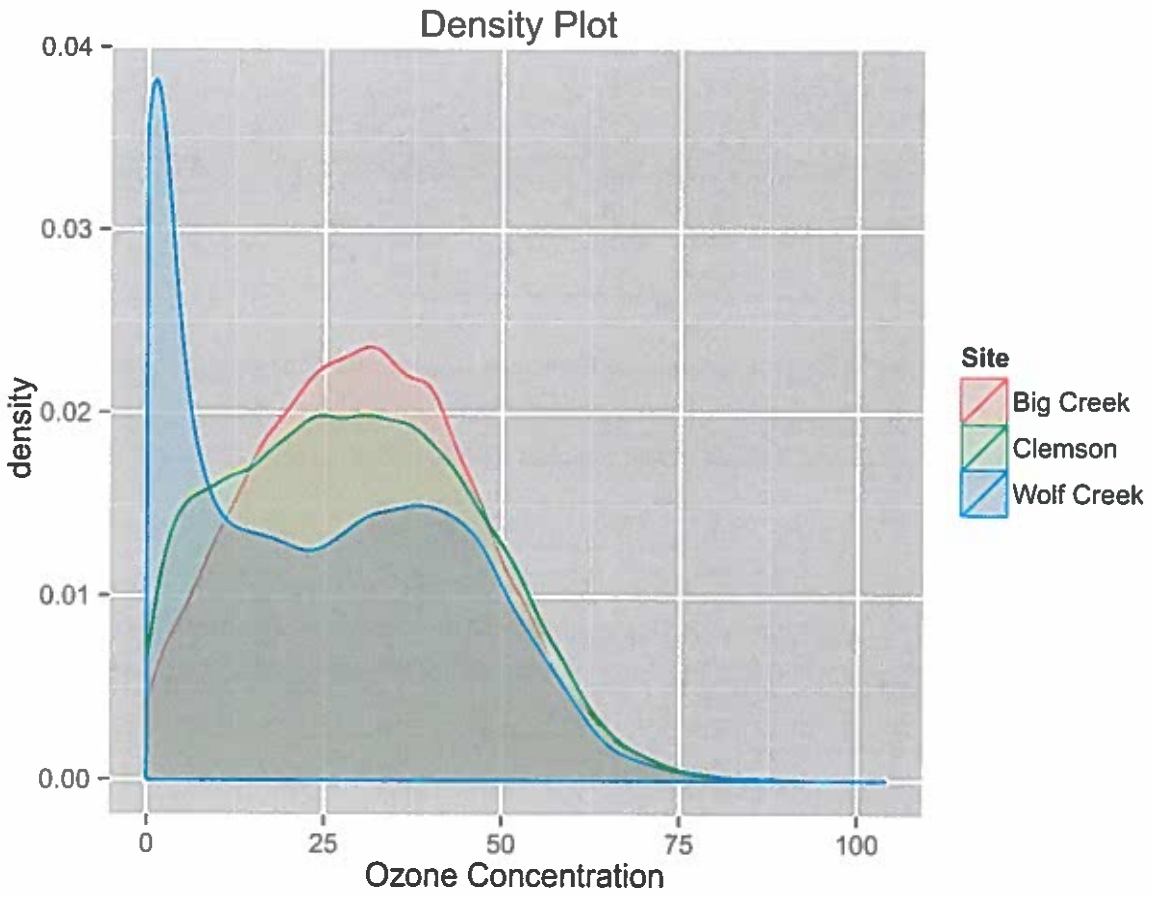


*Figure 5: Density plot by year*

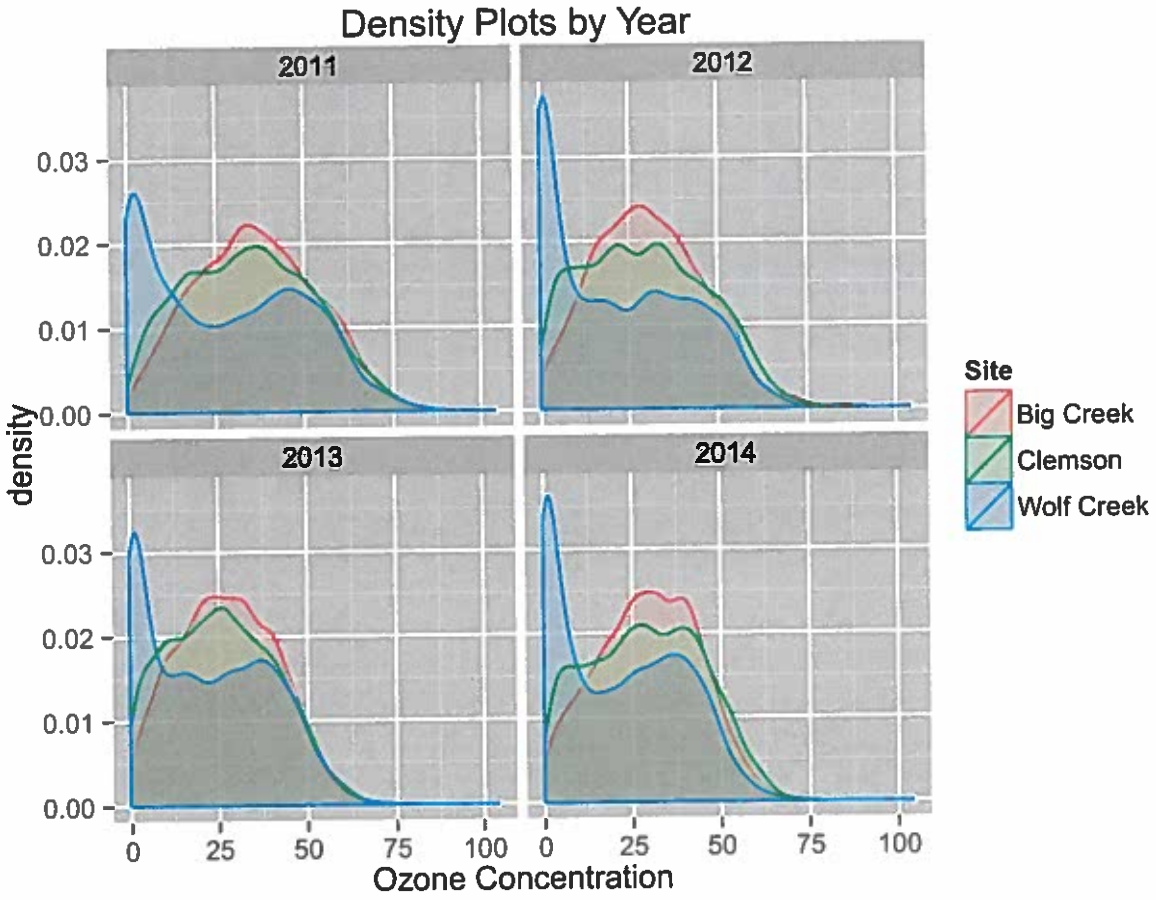


*Figure 6: Density Plot by month*

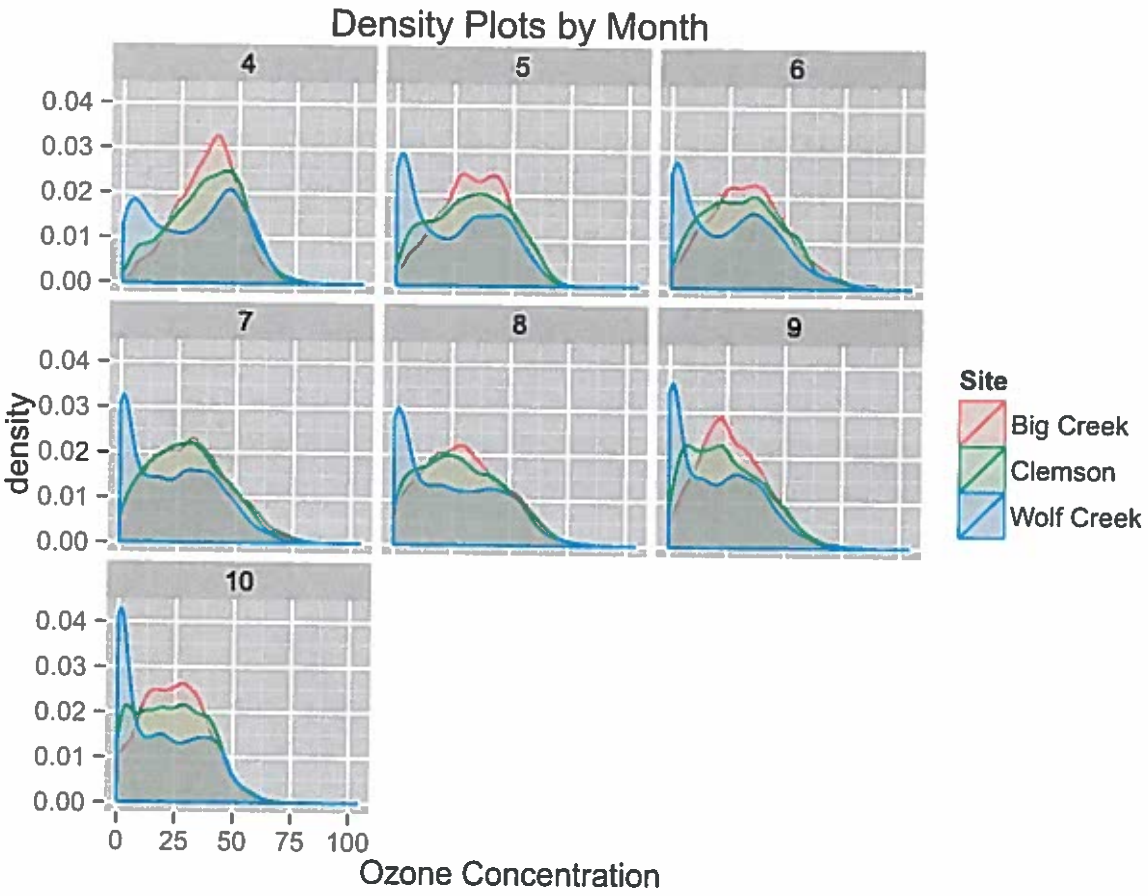
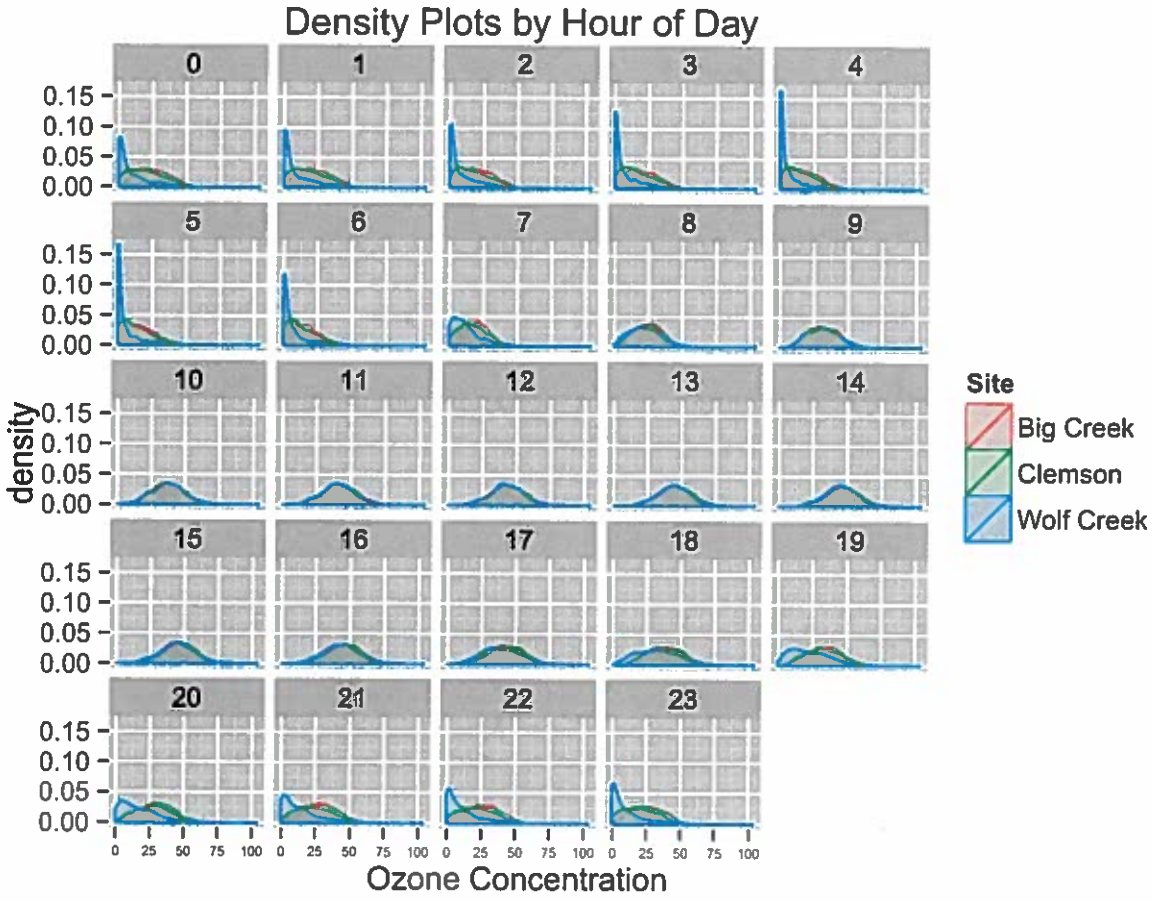


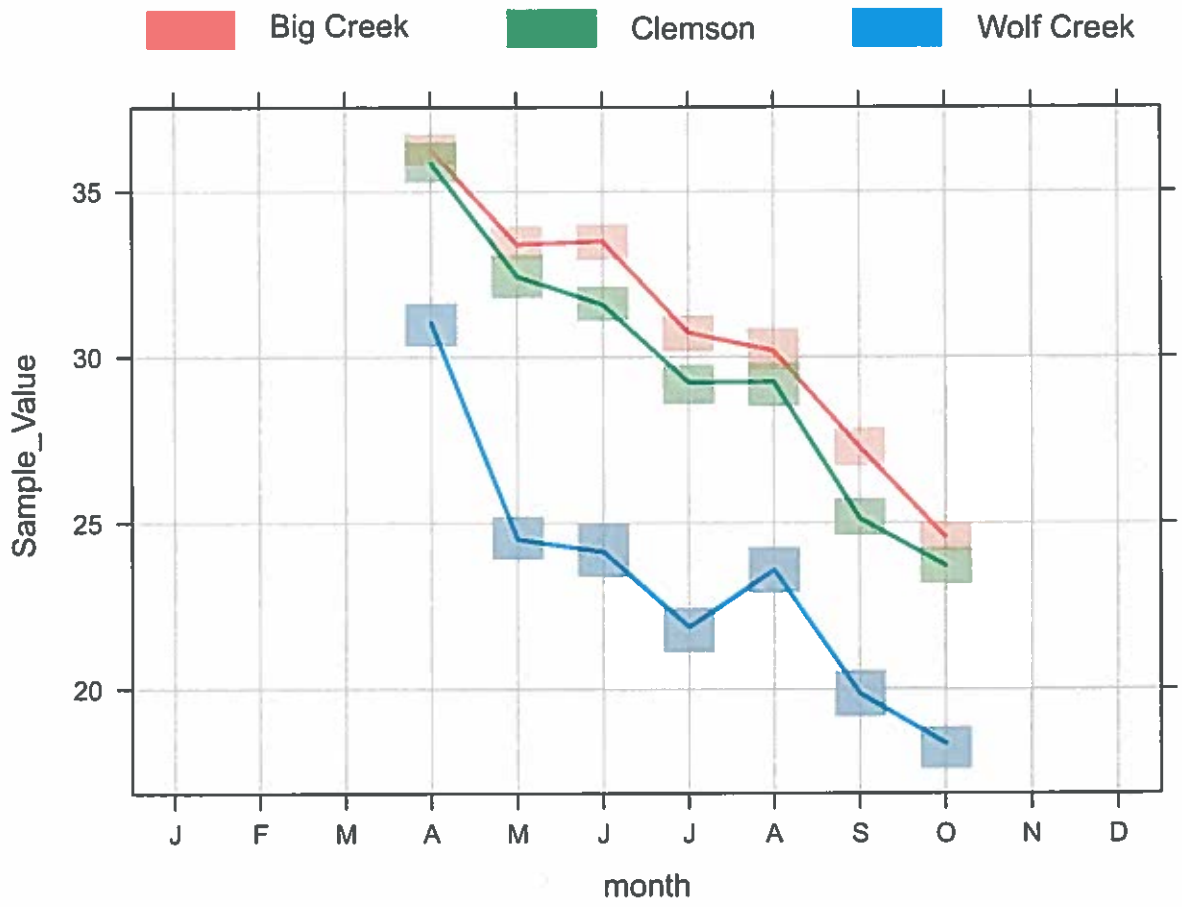
*Figure 7: Density plot by hour of day*




**1.3 Diel/Time Variation Plots** Diel plots (produced by the timeVariation function in openair) provide and indication of how pollutant concentrations vary by the month or hour of day. The thin, dark line on the graph connects the mean monthly or hourly concentrations for each site, and the lighter bands around the mean show the 95% confidence interval for the mean concentrations.

The highest daily maximum 8-hour ozone average concentrations during 2011 – 2014 were examined in order to ensure that the monitors exhibited similar behaviors in the highest values measured (Figure 8). The DHEC selected these years because they cover the time period in which all monitoring stations shown in Map 1 were operating for full ozone monitoring season. The Big Creek, Clemson and Wolf Creek sites exhibited similar hourly average monthly concentrations throughout the study period providing evidence that they are measuring similar peak concentrations.

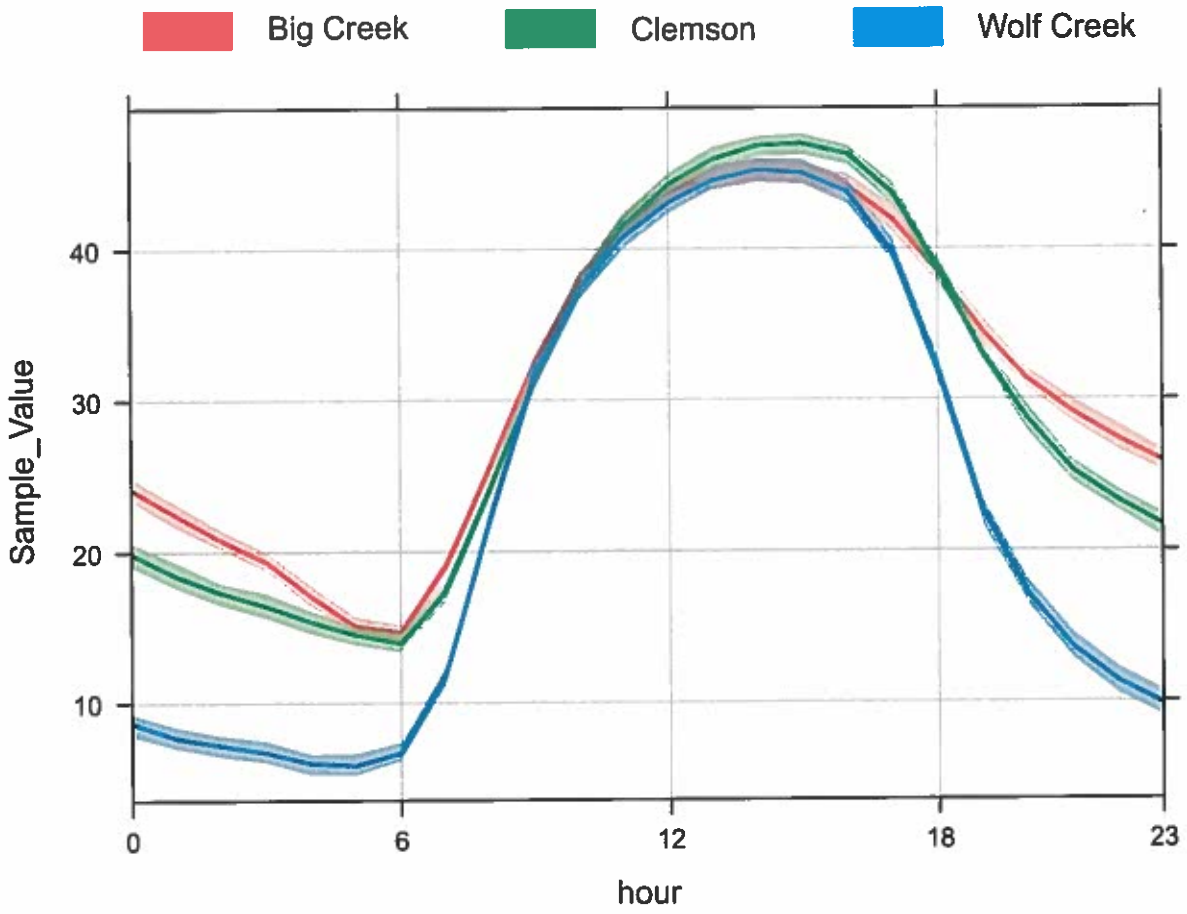
*Figure 8: Average Upstate Ozone Concentrations by Month*




The DHEC examined diel patterns in the three monitoring sites to determine if there was a time of day in which the monitors were dissimilar. As can be seen in Figure 9, diel patterns are very similar for Big Creek and Clemson. There is a distinct difference between the three monitors during the overnight hours, but once the mixing heights start to break down in the mornings, all three sites increase at a similar rate. Clemson does appear to be slightly higher during the peak of the curve, but the DHEC believes that this is well within the uncertainty of the measurement systems and not due to a significant difference in the air quality between Big Creek and Clemson. During the peak in the curve in Figure 9 (approximately hours 10 -19), it is evident that Big Creek and Clemson CMS are reading almost identical average concentrations suggesting that the Clemson CMS site does not provide unique data or information impacting implementation or actions to maintain attainment of the NAAQS in the MSA.

At this point in the analysis, the DHEC focused on the relationship between Clemson and Big Creek since it had become obvious that Wolf Creek is representing a different regime within the MSA having much lower overnight ozone concentrations than seen in the areas nearer to the I-85 corridor and the more urbanized portions of the MSA.

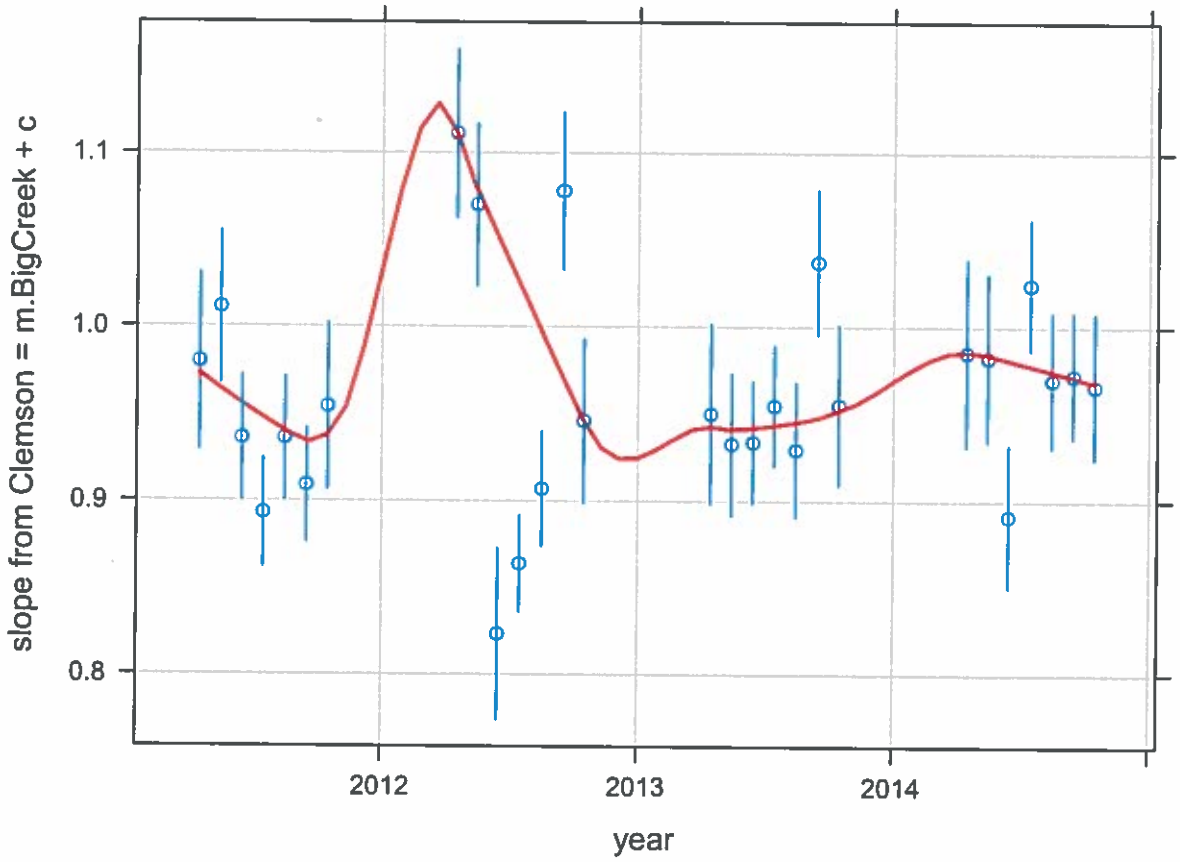
*Figure 9: Average Upstate Ozone Concentrations by Hour*




**1.4 Quantile Tests** The quantile test is used to test whether or not the specified quantile is equal to a pre-specified number. In our case, we wanted to perform a test on the median, so our quantile is 0.5.

The initial goal was to test whether or not the median of the slopes from the simple linear regression lines between Clemson and Big Creek for each month was equal to 1 (Figure 10). A value of 1 would mean a perfect linear relationship between the two monitors; however this is almost never achievable in real data. Therefore, the test was used to determine whether there is a significant deviation from 1. A monthly slope term greater than 1.0 means that Big Creek tended to be higher than Clemson. Conversely, a monthly slope term less than 1.0 means that Clemson tended to be higher than Big Creek.

*Figure 10: Timeseries graph of Big Creek vs. Clemson regression slopes by month*




First, though, we needed to establish whether we could use a parametric test or not. If the data are non-normal a nonparametric test gives the best results. Two graphical ways to look at the distribution of the test were used: a histogram (Figure 11) and a q-q (quantile-quantile) plot (Figure 12). The histograms for the two data sets we analyzed were both skewed, and the q-q plots did not fit their theoretical lines.

*Figure 11: Histogram All Hours*

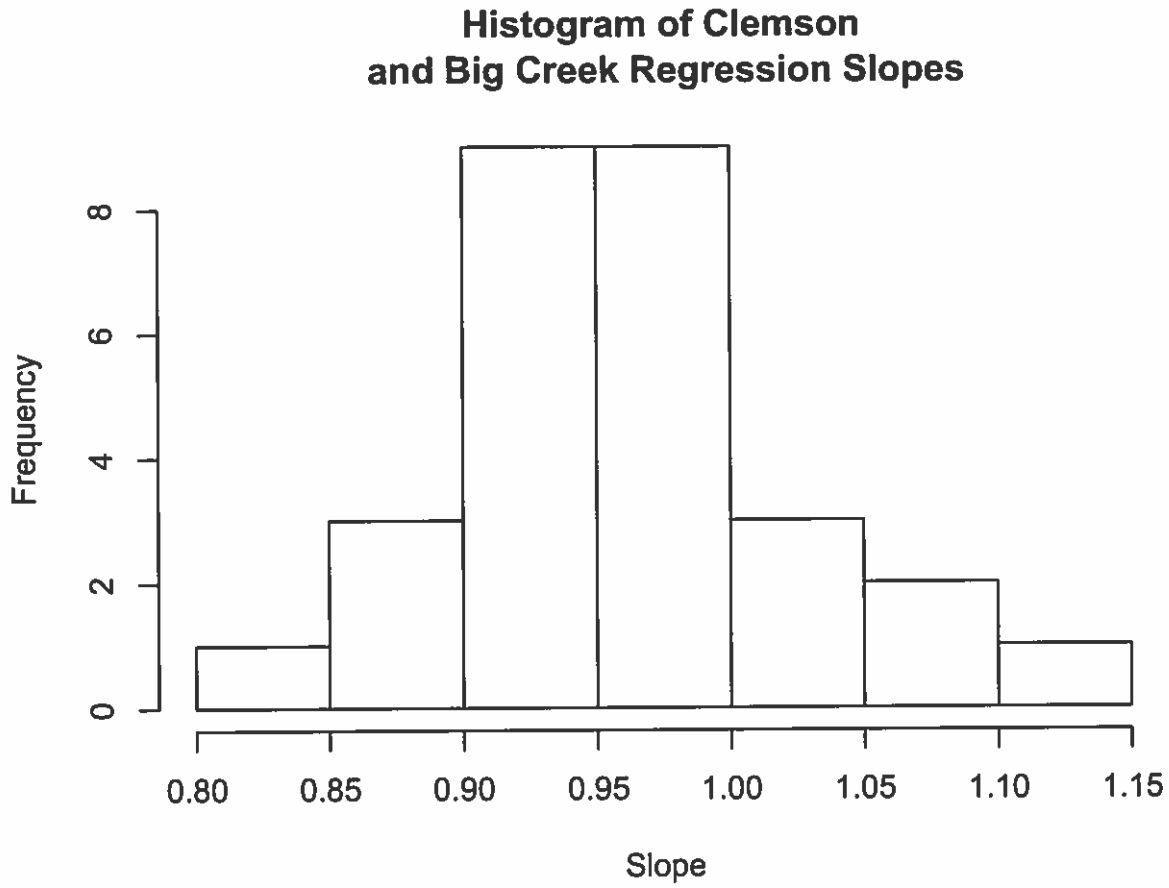
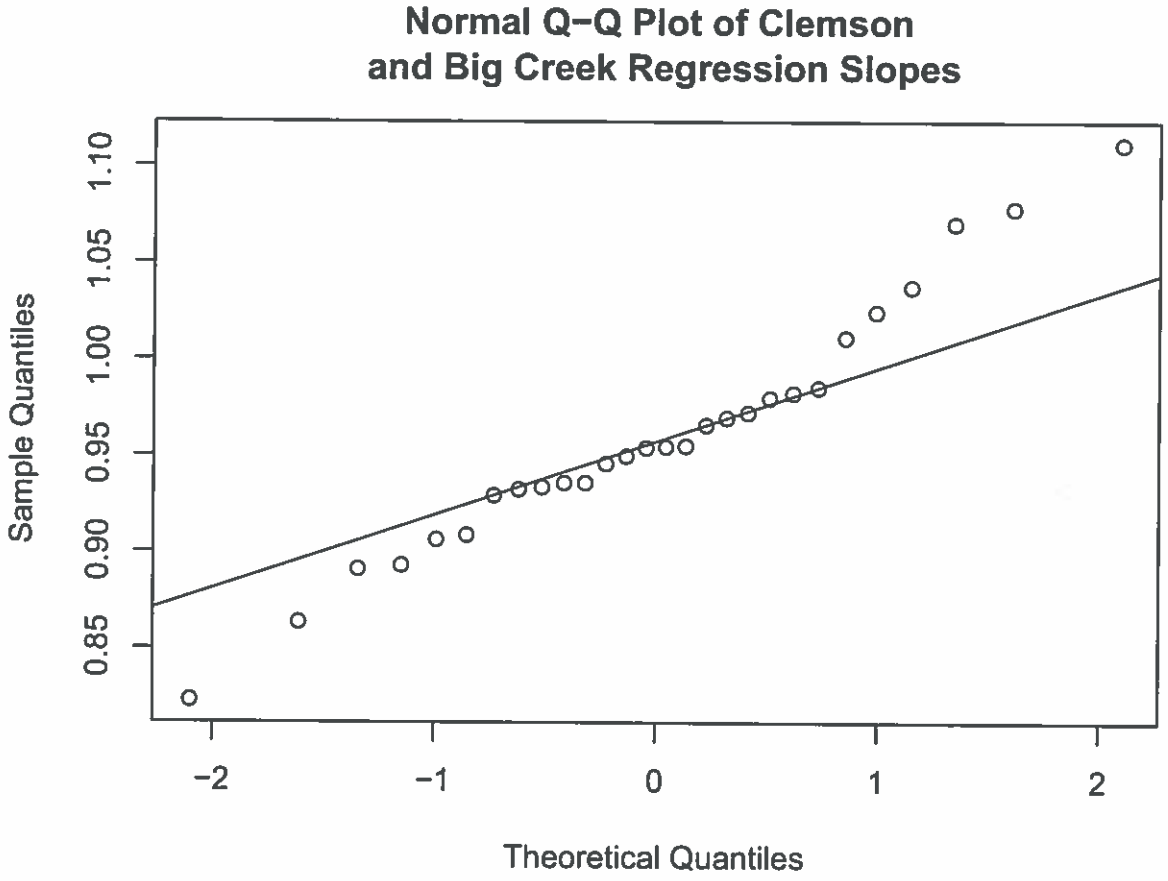


*Figure 12: Normal Q-Q Plot All Hours*




Thus, instead of performing a normal t-test, we used the quantile test. For both the entire Clemson-Big Creek data set and the Clemson-Big Creek data set to only "peak" hours (8 AM-7PM, as shown by a histogram of the times in which 8-hour daily maxes occurred) (Figure 13). A histogram (Figure 14) and q-q plot (Figure 15) confirmed that the distributions were not normally distributed and that the quantile test would be appropriate to use. The test showed that the median slope was significantly different than 1 (Table 5), meaning that Clemson's hourly data and Big Creek's hourly data do not necessarily correspond during those time periods.

*Figure 13: Histogram of Hour when daily maximum ozone concentration occured*

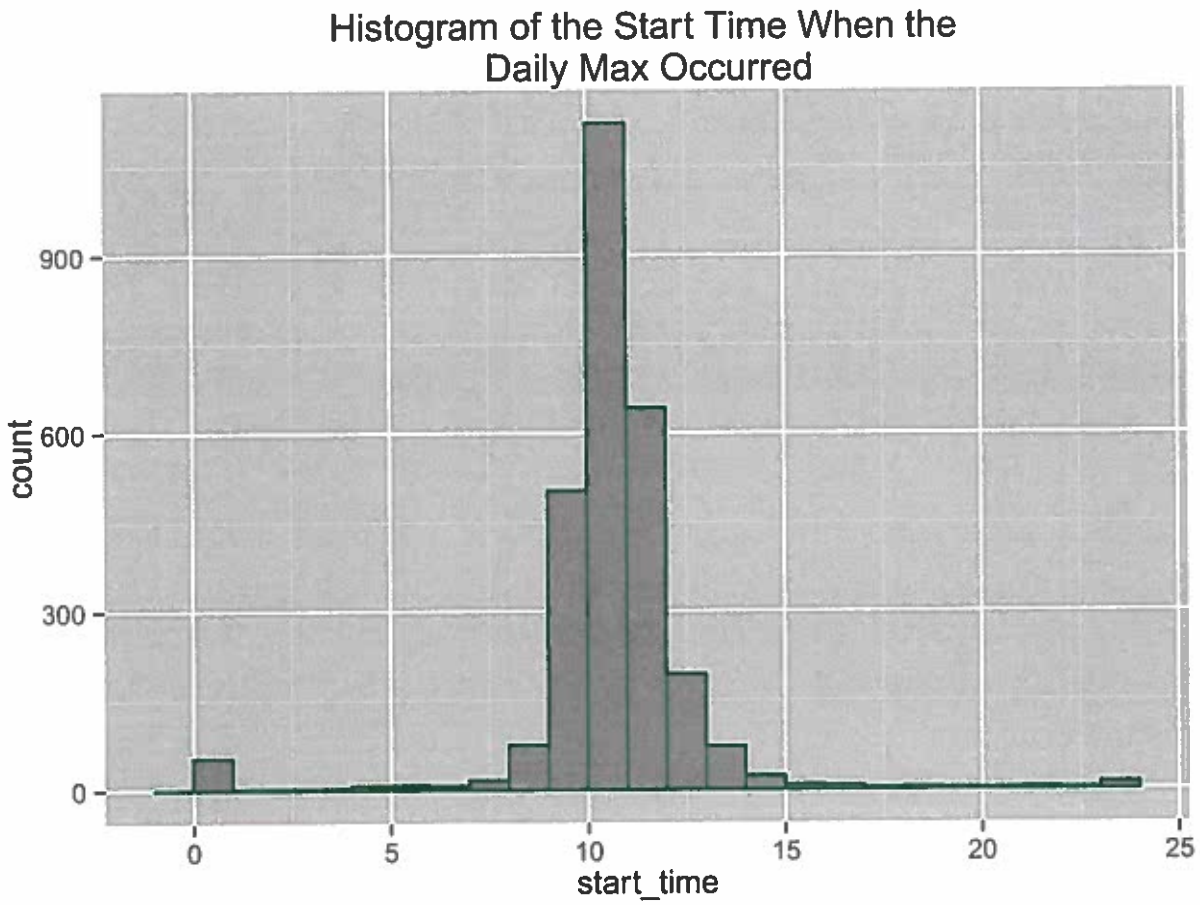


*Figure 14: Histogram 0800 - 1900 EST*

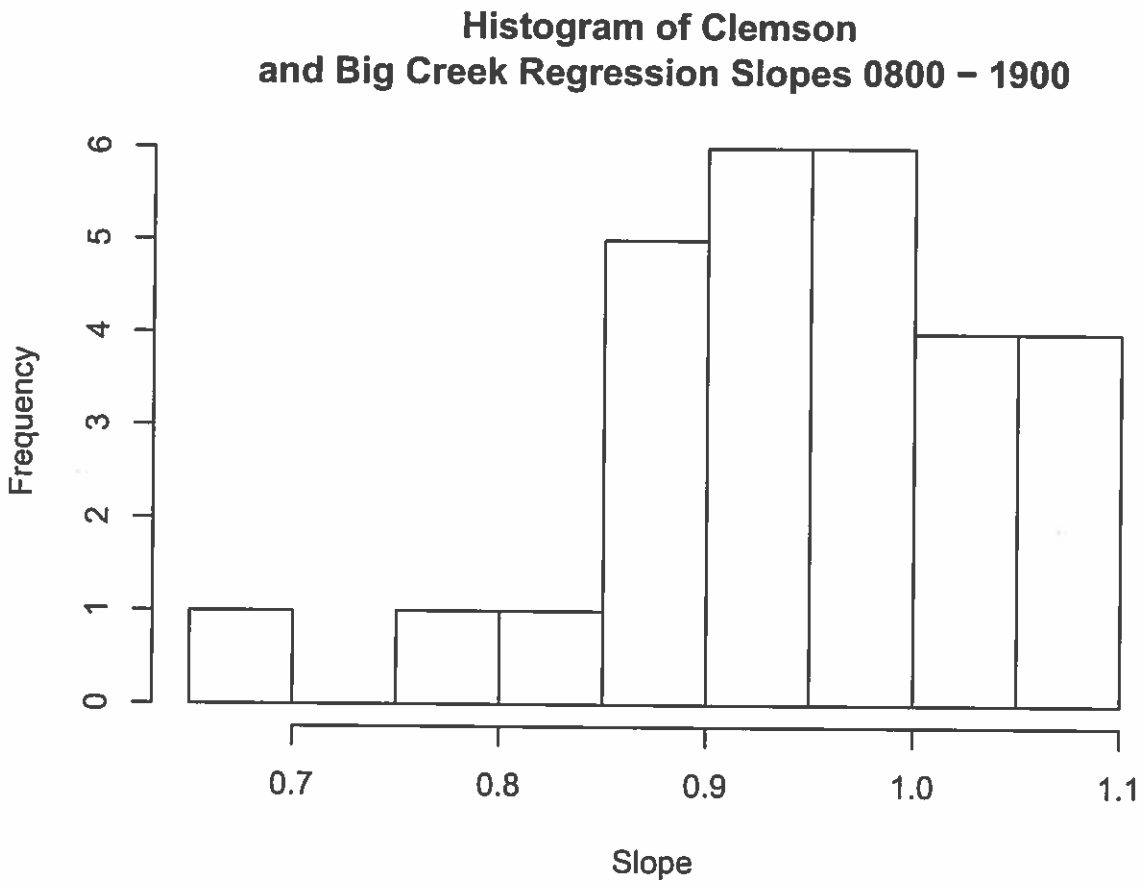
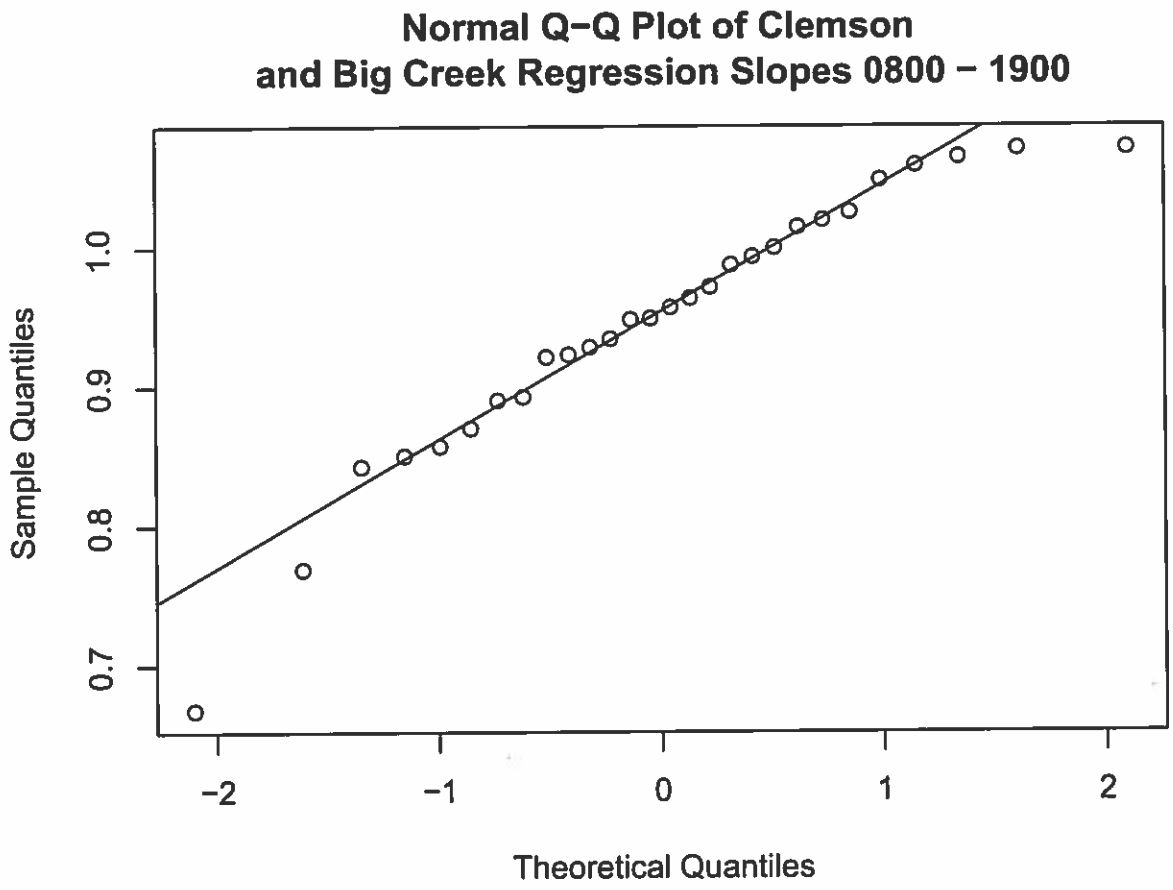


*Figure 15: Normal Q-Q Plot 0800 - 1900 EST*




The r user function used to perform the quantile test:

```
quantile.test<-function(x,eta=0,quantile=.5,alternative="two.sided"){
  n<-length(x); p<-quantile; T1<-sum(x<=eta); T2<-sum(x< eta)
  if (alternative=="less") {
    p.value<-1-pbinom(T2-1,n,p)}
  if (alternative=="greater"){
    p.value<-pbinom(T1,n,p)}
  if (alternative=="two.sided"){
    p.value<-2*min(1-pbinom(T2-1,n,p),pbinom(T1,n,p))}
  list(eta=eta,alternative=alternative,T1=T1,T2=T2,p.value=p.value)}
```

Table 5: Table 5: Quantile Test

| eta | alternative | T1 | T2 | p.value | test.name |
|---|---|---|---|---|---|
| 1 | two.sided | 22 | 22 | 0.0037 | hrs: all |
| 1 | two.sided | 20 | 20 | 0.0357 | hrs: 0800-1900 |

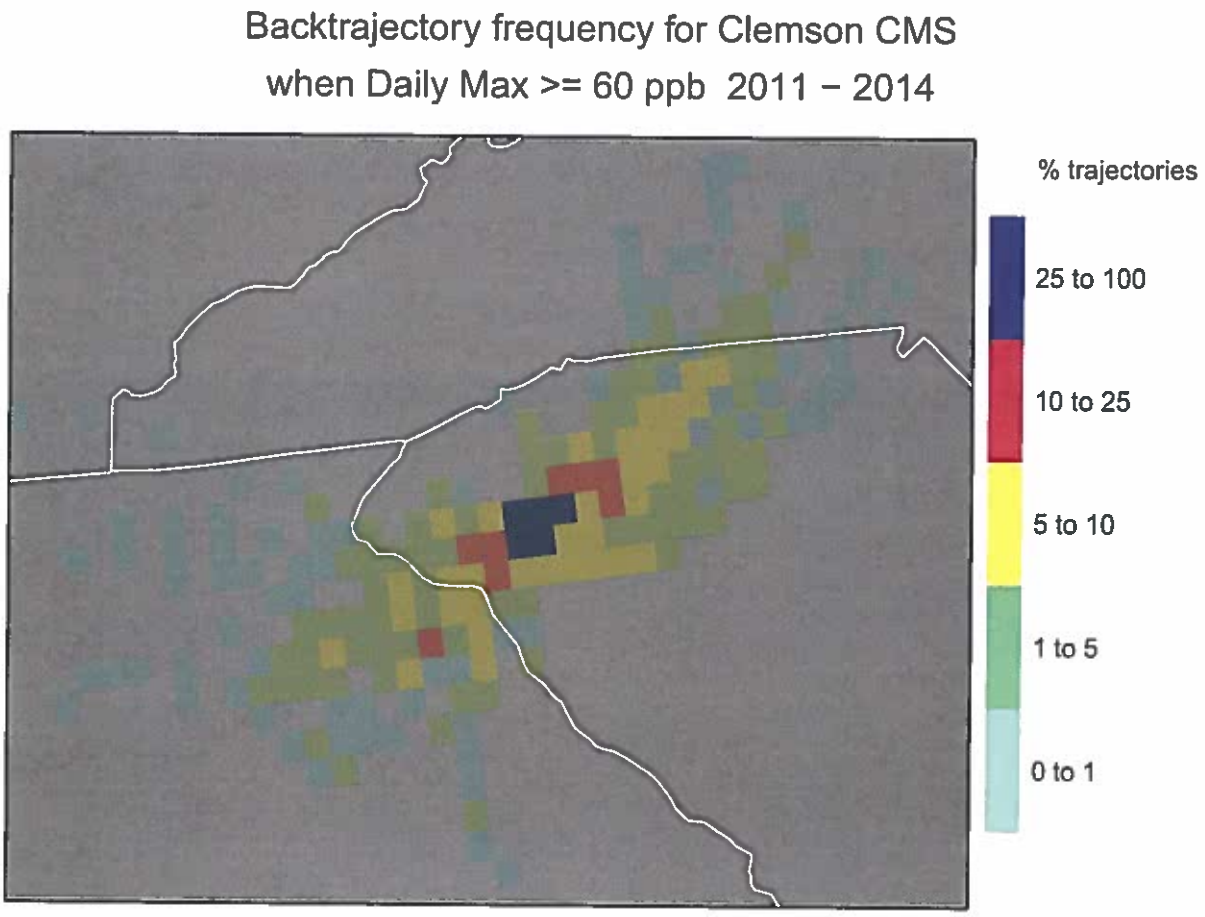
## 2.0 Meteorological and Trajectory Analysis

A trajectory analysis was conducted for all ozone monitoring season days from 2011 to 2014 with daily maximum 8-hour ozone averages greater than or equal to 60 ppb. The trajectories help visualize the areas the air masses originated and where they traveled before ending up at the impact location. Thirty-six hour back trajectories were run using the HYSPLIT (Hybrid Lagrangian Integrated Trajectory) model[14] for Big Creek and Clemson CMS. The backtrajectories were run using the North American Mesoscale Model (NAM) Data Assimilation System (EDAS) 40 kilometer grid at 300 meters beginning at 20 Coordinated Universal Time (UTC) and reset every three hours per day.

**2.1 Gridded trajectories** Due to the grid resolution with the NAM EDAS model (40 km X 40 km grid resolution), a single representative point in the middle of the three sites (Clemson and Big Creek centered latitude: 34.6874, longitude: -82.6667) was selected to originate the back trajectories. Ozone data from each site was then merged with the trajectories to produce the graphics. Due to the large grid cell size, the DHEC believes that this is the most straight forward way to analyze the trajectories.

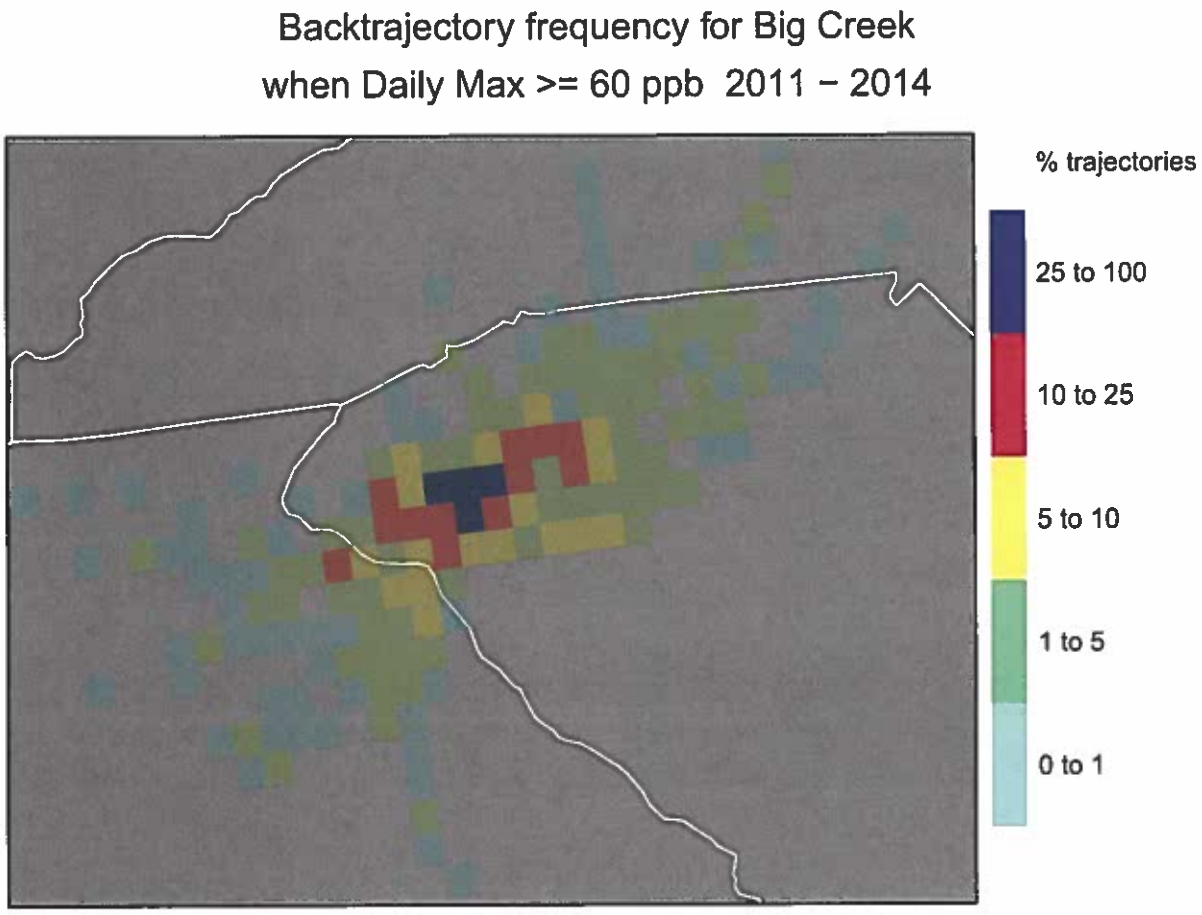
Figures 16 and 17 show the frequency of backtrajectories on days with daily maximum ozone concentrations greater than or equal to 60 ppb for Clemson, Wolf Creek and Big Creek, respectively. All three figures reveal that days greater than or equal to 60 ppb have trajectories which roughly follow the I-85 corridor with most originating from the north-east.

*Figure 16: Clemson CMS backtrajectory frequency*




[14] http://www.arl.noaa.gov/HYSPLIT_info.php

*Figure 17: Big Creek backtrajectory frequency*




One analysis type taken from the `openair` package is looking at the origin of high concentrations for ozone. The difference argument in the `trajLevel` function allows us to look at the percent difference between ozone monitoring season and the $90^{th}$ percentile ozone concentration. Figures 18 and 19 show the percent difference for the two monitoring stations. Figures 18 and 19 shows that compared to the monitoring season, high ozone concentrations are more prevalent when the backtrajectories originate from the north (red grid cells in the figures). This is consistent with the trajectory frequency maps found in Figures 16 and 17 suggesting that the majority of trajectories are originating from the Charlotte area. The proximity of the the "high" cells in Figures 18 and 19 also suggest that high levels of ozone are also associated with relatively low wind speeds.

*Figure 18: Trajectory frequencies showing percent difference in occurance for high $O_3$ concentrations at Clemson CMS*

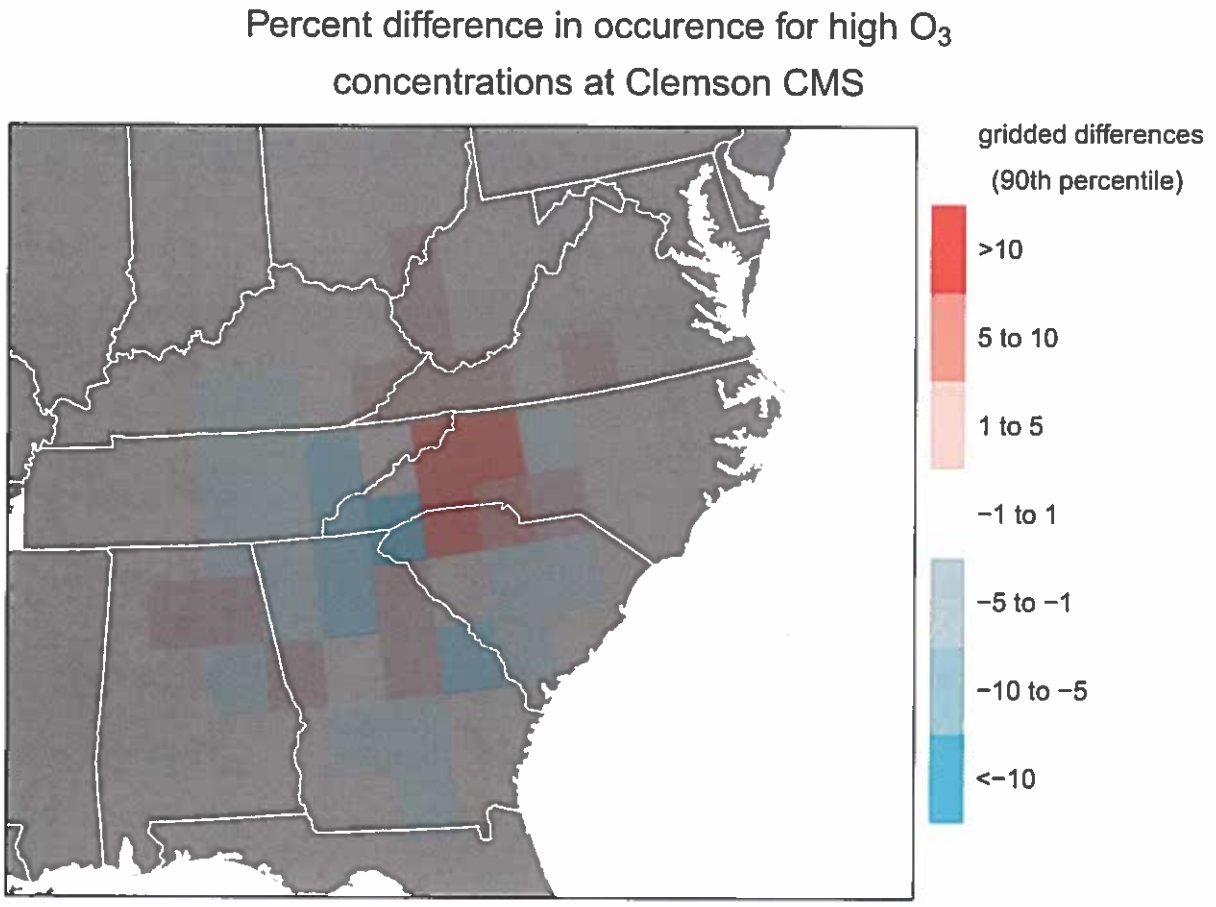
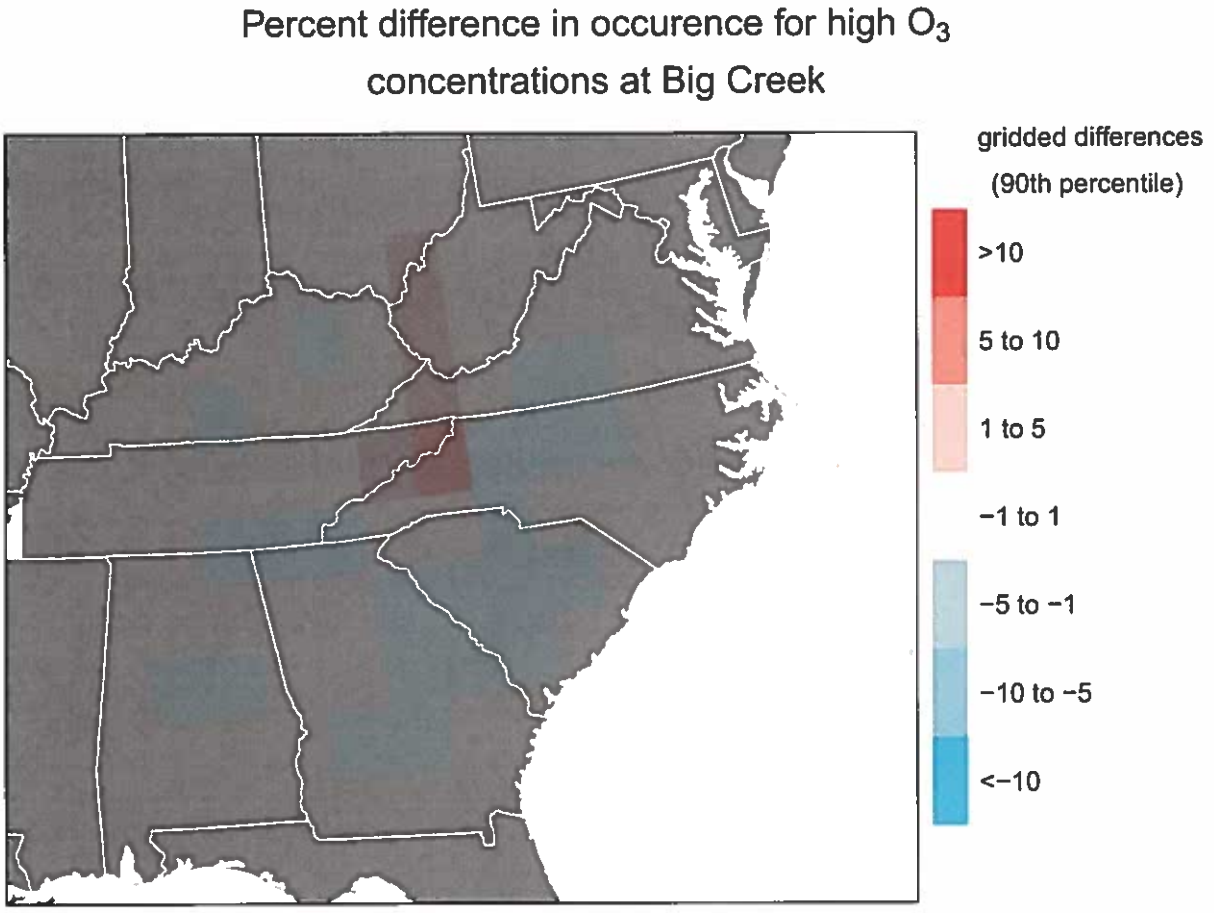


*Figure 19: Trajectory frequencies showing percent difference in occurance for high $O_3$ concentrations at Big Creek*




**2.2 Trajectory cluster analysis** Finally, the DHEC undertook a cluster analysis on the backtrajectory data. Cluster analysis is used to group similar air masses together. The `openair` clustering algorithim is based on the same methodology as HYSPLIT. Backtrajectory data for the Clemson area was imported along with the hourly average ozone concentration. Before we can conduct the cluster analysis, we need to determine an appropriate number of clusters to calculate. One method of determining the appropriate number of clusters is to compare the sum of squared error (SSE) for a number of cluster solutions. A plot of the SSE against the number of clusters can then be plotted to determine the appropriate number of clusters[15] (Figure 20). To interpret, the appropriate number of clusters is defined where the rate of change in SSE between clusters starts to level out.

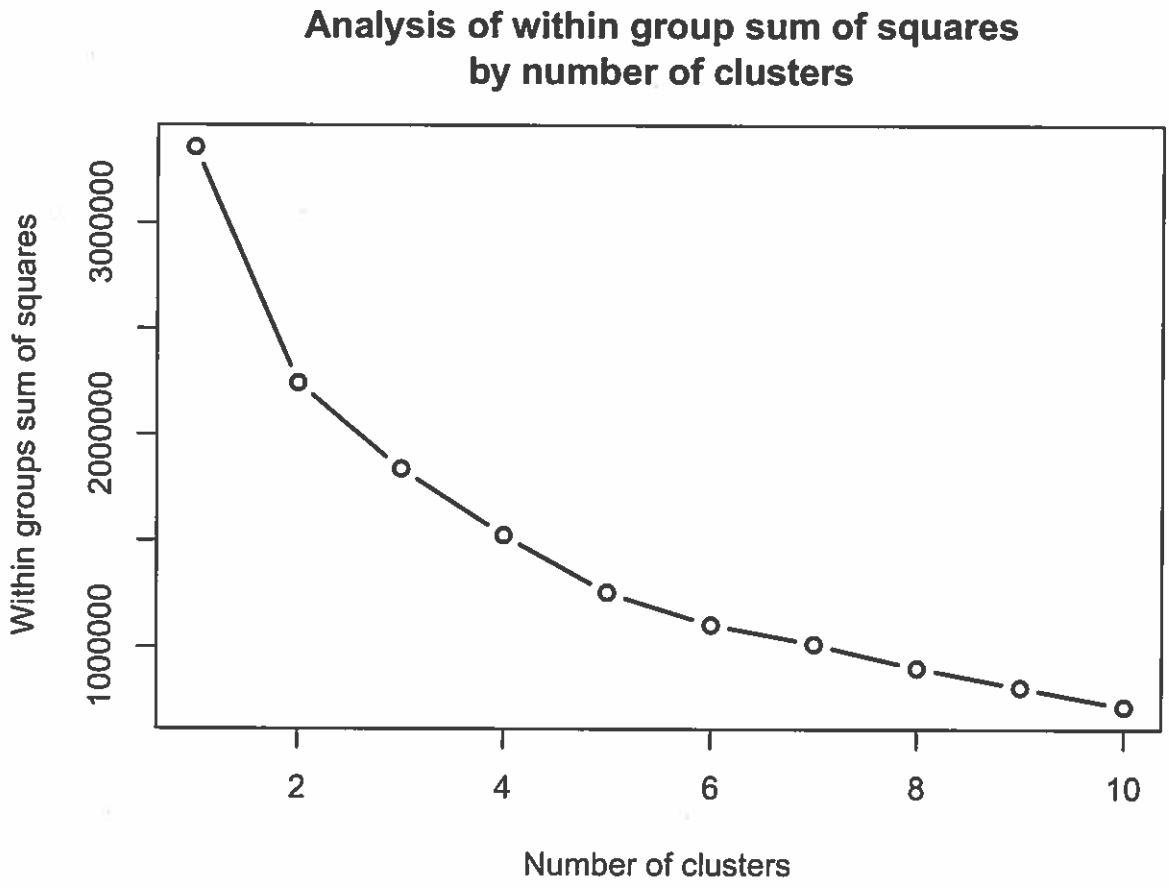
The script used to calculate the SSE and generate the "scree" plot is:

```
#Determine the appropriate number of clusters
clemsclust<-clemsonstudy
clemsclust<-clemsclust[,-c(1,2,3,4,5,6,9,10,11,12,13),drop=FALSE]

n<-nrow(clemsclust)
#find within group ss for all the data
wss1<-(n-1)*sum(apply(clemsclust,2,var))
```

[15] http://www.mattpeeples.net/kmeans.html

```
wss<-numeric(0)
#calculate within group ss for 2 to 6 group partitions given by k-means clustering
for(i in 2:10){
  W<-sum(kmeans(clemsclust,i)$withinss)
  wss<-c(wss,W)
}
wss<-c(wssl,wss)

plot(1:10,wss,type="b",xlab="Number of clusters",
     ylab="Within groups sum of squares",
     main="Analysis of within group sum of squares\nby number of clusters",
     lwd=2)
```

*Figure 20: Scree plot to determine appropriate number of clusters for analysis*



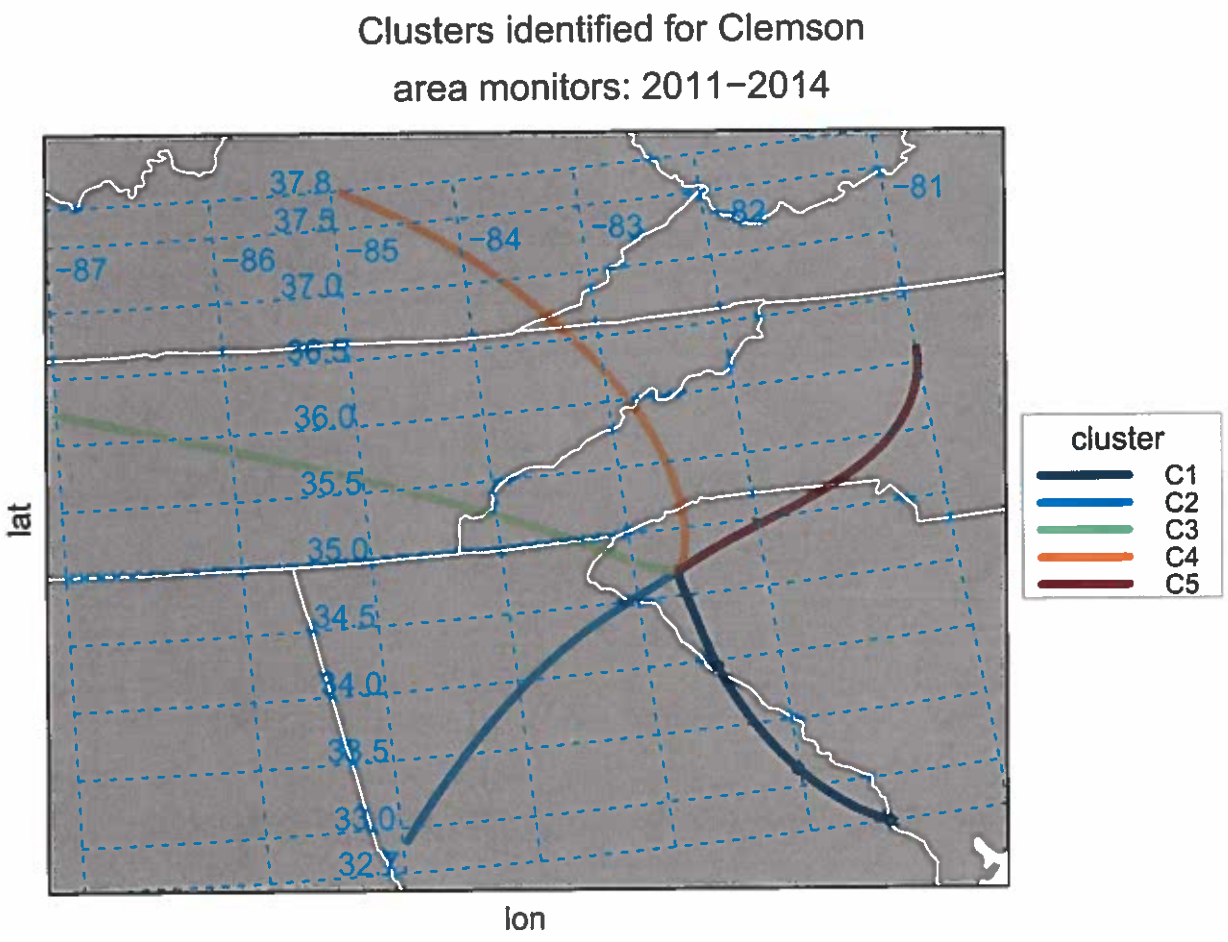

The percent difference between number of clusters added indicates that five clusters minimize the within groups sum of squares.

Table 6: Table 6: Percent Change in Within Sum of Squares Per Cluster Added

| perchglags | clustnumber | wss |
|---|---|---|
| NA | 1 | 3359787.5 |
| -33.2 | 2 | 2244170.1 |
| -18.1 | 3 | 1838483.4 |
| -17.0 | 4 | 1526701.3 |
| -17.7 | 5 | 1257219.2 |
| -12.0 | 6 | 1106387.8 |
| -8.1 | 7 | 1016818.3 |
| -11.1 | 8 | 904257.4 |
| -10.1 | 9 | 813146.8 |
| -11.0 | 10 | 723471.1 |

Based on this analysis, the DHEC estimates that five clusters adequately minimizes the SSE and are the most appropriate division of the data available for the analysis. Figure 21 shows the areas represented by the five clusters.

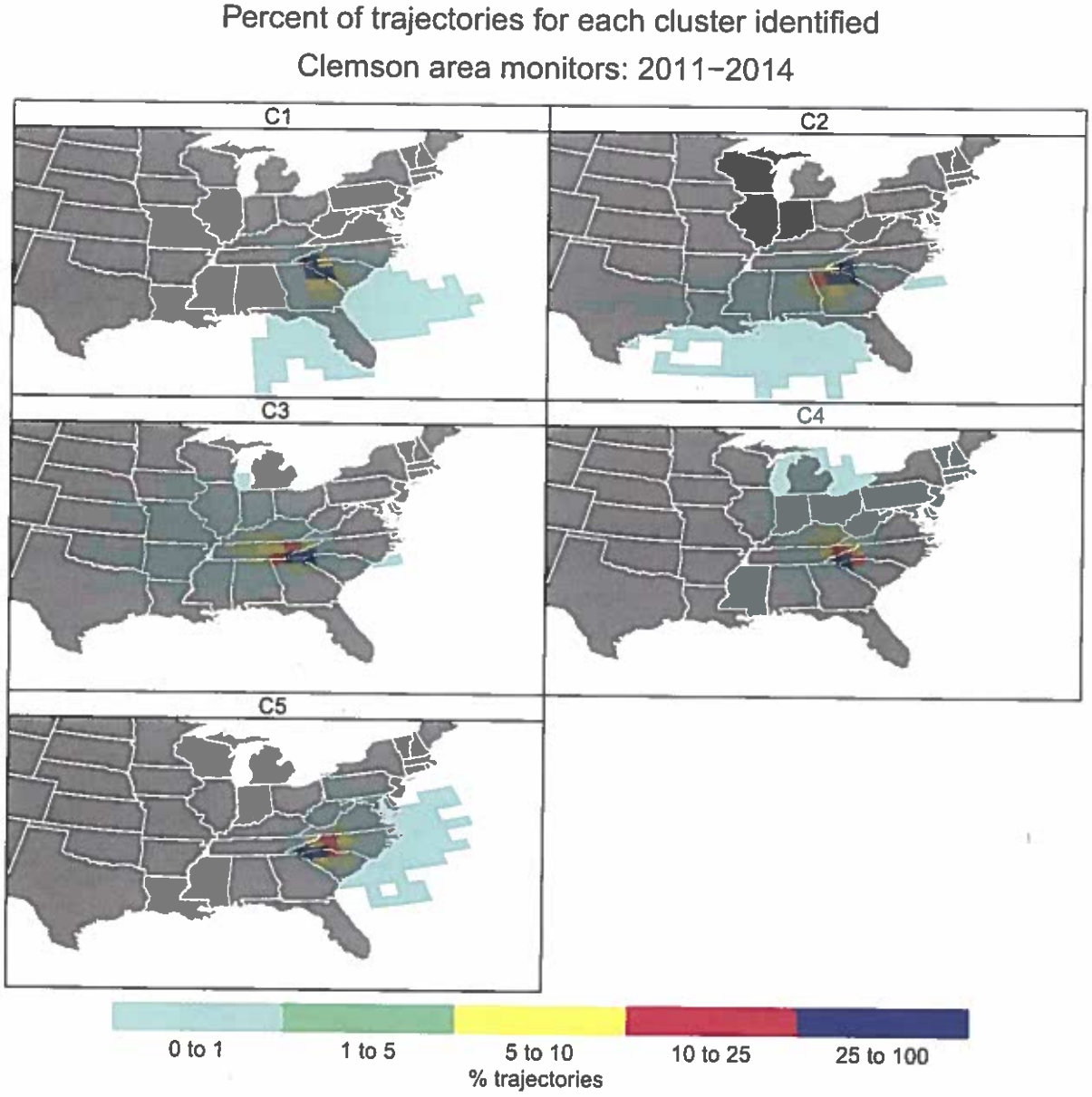
*Figure 21: Cluster Analysis for Clemson Area Monitors*




Next, we gridded the trajectories by cluster (Figure 22) to determine the percent of trajectories that passed through each grid square. Cluster 1 contains trajectories approaching along the Savannah River valley and

is normally associated with cleaner air masses. Cluster 2 is from the southwest, centered between Atlanta and Macon, Georgia. Cluster 3 contains trajectories that generally approach the Clemson area from the west through the southern Appalachians. Cluster 4 contains trajectories that approach the Clemson area from the northwest from what appears to be the Midwest and Ohio River valley. Finally, Cluster 5 includes trajectories primarily from the Northeast passing through the Charlotte area and along the I-85 corridor.

*Figure 22: Percent of trajectories for five identified clusters*




Figures 23 - 24 presents the average ozone concentration by cluster, month and hour for this study. Based on the DHEC's analysis, it appears that Clusters 3, 4 and 5 have the highest ozone averages for the study period at Clemson and Big Creek. Examination of these graphs indicates that the highest average ozone concentrations thoughout the monitoring season is most likely on days in which the wind is approaching the area from the northeast. Combine this with Figure 25 which shows that the highest peak one hour ozone concentrations occurrs during the summer months (June - August). These graphics along with the fact that both Clemson and Big Creek lie on the western edge of the monitoring area, suggests that both monitors are

generally seeing the same air mass, especially on high ozone days.

*Figure 23: Clemson CMS average ozone concentrations by cluster*

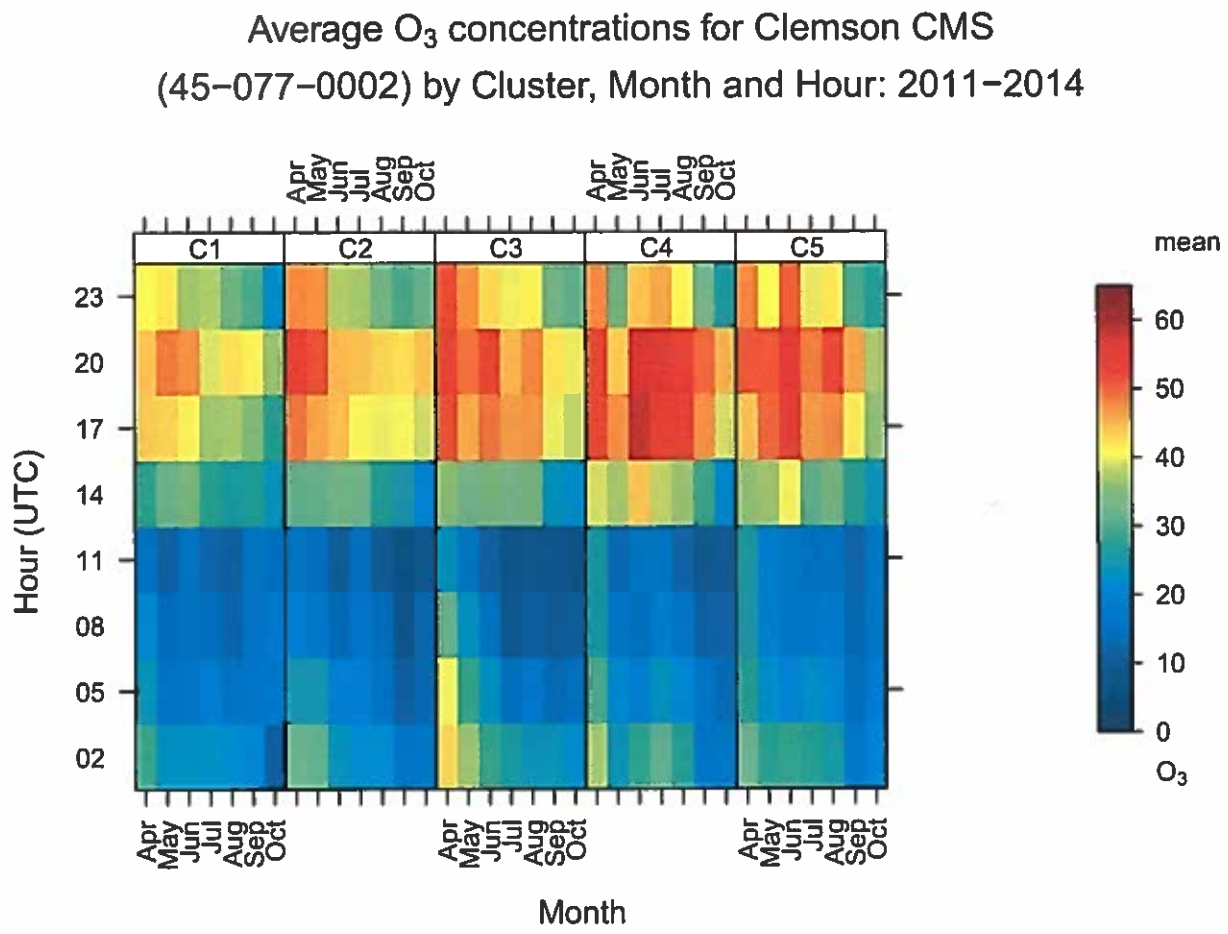


*Figure 24: Big Creek average ozone concentrations by cluster*

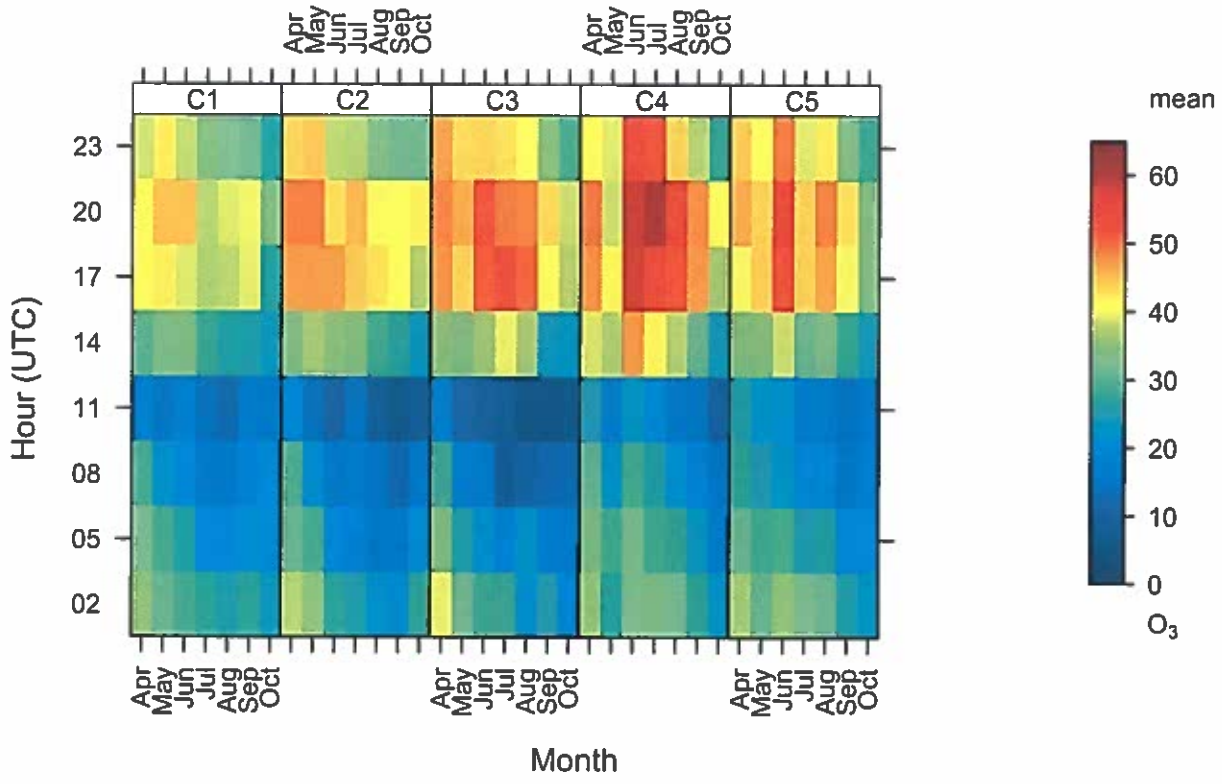
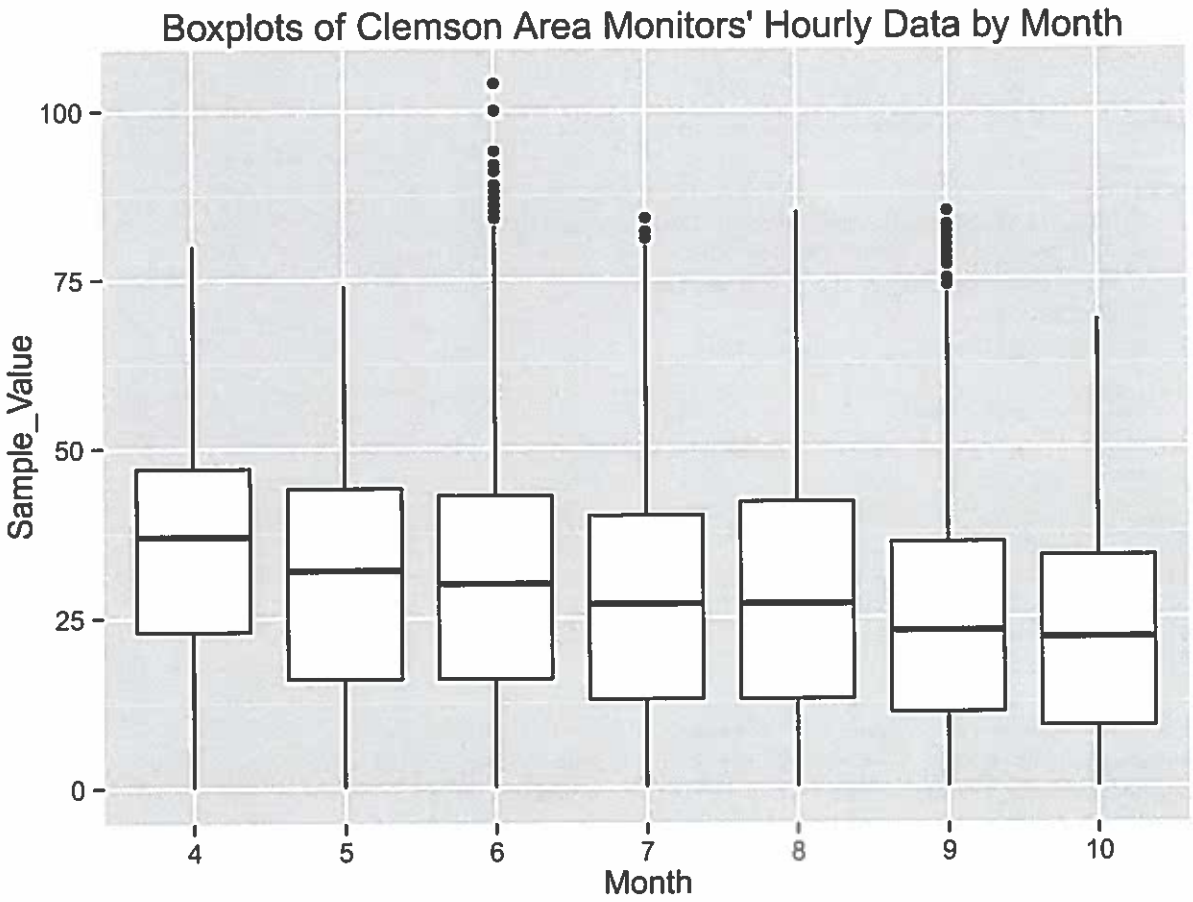


*Figure 25: Boxplots of Clemson Area Monitors' Hourly Data by Month*




After merging the trajectory and ozone data together, each trajectory was allocated to one of eight wind sectors (ie, NE,E,SE,S,SW,W,NW,N). Average ozone concentrations and proportion of the winds for each monitoring site were then calculated. The results are depicted in Table 7.

Table 7: Table 7: $98^{th}$ Percentile Ozone Concentration (ppb) by Wind Sector

| | Big Creek | Clemson |
|---|---|---|
| NE | 75 | 71 |
| E | 68 | 71 |
| SE | 64 | 66 |
| S | 66 | 66 |
| SW | 65 | 65 |
| W | 66 | 63 |
| NW | 66 | 62 |
| N | 70 | 69 |

### References and Citations

R version 3.1.2 along with RStudio Version 0.98.1102 was used to analyze the ambient monitoring and meteorological data. Session information containing the R packages used and the versions are given below.

```
R version 3.1.2 (2014-10-31)
Platform: x86_64-w64-mingw32/x64 (64-bit)

locale:
[1] LC_COLLATE=English_United States.1252
[2] LC_CTYPE=English_United States.1252
[3] LC_MONETARY=English_United States.1252
[4] LC_NUMERIC=C
[5] LC_TIME=English_United States.1252

attached base packages:
[1] grid      stats     graphics  grDevices utils     datasets  methods
[8] base

other attached packages:
 [1] mapproj_1.2-2   knitr_1.10.5    png_0.1-7       mapdata_2.2-3
 [5] plyr_1.8.2      RODBC_1.3-11    reshape2_1.4.1  openair_1.5-2
 [9] maps_2.3-9      dplyr_0.4.1     lazyeval_0.1.10 lubridate_1.3.3
[13] ggplot2_1.0.1

loaded via a namespace (and not attached):
 [1] assertthat_0.1      cluster_2.0.1       codetools_0.2-11
 [4] colorspace_1.2-6    DBI_0.3.1           digest_0.6.8
 [7] evaluate_0.7        formatR_1.2         gtable_0.1.2
[10] hexbin_1.27.0       highr_0.5           htmltools_0.2.6
[13] labeling_0.3        lattice_0.20-31     latticeExtra_0.6-26
[16] magrittr_1.5        MASS_7.3-40         Matrix_1.2-1
[19] memoise_0.2.1       mgcv_1.8-6          munsell_0.4.2
[22] nlme_3.1-120        parallel_3.1.2      proto_0.3-10
[25] RColorBrewer_1.1-2  Rcpp_0.11.6         RgoogleMaps_1.2.0.7
[28] RJSONIO_1.3-0       rmarkdown_0.6.1     scales_0.2.4
[31] stringi_0.4-1       stringr_1.0.0       tools_3.1.2
[34] yaml_2.1.13


To cite R in publications use:

  R Core Team (2014). R: A language and environment for
  statistical computing. R Foundation for Statistical Computing,
  Vienna, Austria. URL http://www.R-project.org/.

A BibTeX entry for LaTeX users is

  @Manual{,
    title = {R: A Language and Environment for Statistical Computing},
    author = {{R Core Team}},
    organization = {R Foundation for Statistical Computing},
    address = {Vienna, Austria},
    year = {2014},
```

```
    url = {http://www.R-project.org/},
  }

We have invested a lot of time and effort in creating R, please
cite it when using it for data analysis. See also
'citation("pkgname")' for citing R packages.


To cite package 'openair' in publications use:

  Carslaw, D. C. and K. Ropkins, (2012) openair --- an R package
  for air quality data analysis.  Environmental Modelling &
  Software. Volume 27-28, 52-61.

Carslaw D and Ropkins K (2015). _openair: Open-source tools for
the analysis of air pollution data_. R package version 1.5-2,
<URL: http://CRAN.R-project.org/package=openair>.
```