FINAL

Revision to the North Carolina State Implementation Plan

Demonstration that North Carolina Complies with the "Good Neighbor" Requirements of Clean Air Act Section 110(a)(2)(D)(i)(I) for the 2008 Ozone National Ambient Air Quality Standard

Prepared by

North Carolina Department of Environmental Quality

Division of Air Quality

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Preface: This revision to the North Carolina State Implementation Plan (SIP) for the 2008 Ozone standard provides information related to infrastructure requirements for interstate transport or the "good neighbor" provision of Clean Air Act Section 110(a)(2)(D)(i)(I).

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1.0 Good Neighbor Provision

Sections 110(a)(1) and (2) of the Clean Air Act (CAA) require all states to adopt and submit to the U. S. Environmental Protection Agency (EPA) any revisions to their infrastructure State Implementation Plans (SIP) which provide for the implementation, maintenance and enforcement of a new or revised national ambient air quality standard (NAAQS). The EPA revised the ozone NAAQS in March 2008 and completed the designation process to identify nonattainment areas in July 2012. The North Carolina Department of Environmental Quality, Division of Air Quality (DAQ) subsequently submitted North Carolina's infrastructure SIP certification on November 2, 2012.

CAA section 110(a)(2)(D)(i)(I) requires each state to prohibit emissions that will significantly contribute to nonattainment of a NAAQS, or interfere with maintenance of a NAAQS, in a downwind state. North Carolina's November 2, 2012, infrastructure certification relied on the nitrogen oxide (NOx) emissions reductions achieved from the state's Clean Smokestacks Act and EPA's Clean Air Interstate Rule (CAIR) and Cross State Air Pollution Rule (CSAPR) to show that emissions activities within North Carolina will not significantly contribute to nonattainment or interfere with maintenance of the 2008 ozone NAAQS in a neighboring state.

This document serves as a revision to the North Carolina SIP, and is based on a variety of actions and analysis conducted between November 2012 and October 2015, as explained below.

1.1 Background

The EPA promulgated CAIR to address regional interstate transport of soot (fine particulate matter) and smog (ozone). CAIR required 28 eastern states to make reductions in sulfur dioxide (SO_2) and NOx emissions that contribute to fine particle and ozone pollution in downwind states. CAIR was challenged in the Court of Appeals for the D.C. Circuit for relying too heavily on the trading of pollution credits, and failure to require controls to be installed expeditiously. On December 23, 2008, the Court remanded CAIR without vacatur. This ruling left CAIR in place until the EPA issued a new rule to replace CAIR in accordance with the Court's decision.

On July 6, 2011, the EPA promulgated CSAPR to address CAA requirements concerning interstate transport of air pollution and to replace CAIR in response to the D.C. Circuit decision. CSAPR required states to reduce power plant emissions that contribute to ozone and fine particle pollution in other states. Certain industry and state and local government petitioners challenged CSAPR in the D.C. Circuit and filed motions seeking a stay of the rule pending judicial review.

On December 30, 2011, the Court granted a stay of the rule, ordering the EPA to continue administering CAIR on an interim basis. In a subsequent decision on the merits, the Court vacated CSAPR on August 21, 2012.

On June 24, 2013, the U.S. Supreme Court agreed to hear the CSAPR case. On April 29, 2014, the U.S. Supreme Court reversed the D.C. Circuit, and held that (i) the plain text of the CAA allowed the states in the first instance to determine whether and to what extent their interstate emissions were unlawful and, where a state failed to do so, EPA could impose a Federal Implementation Plan, (ii) EPA's calculation of the states' interstate contributions to downwind nonattainment was a permissible construction of the CAA, and (iii) the CAA did not prohibit EPA from considering the cost of emission controls when determining the appropriate level of reductions. The Supreme Court further clarified CAA Section 110(a)(2)(D)(i)(I) and held that despite the lack of EPA guidance, states are required to meet their good neighbor requirements in a timely manner.[1]

Throughout the initial round of D.C. Circuit proceedings and the ensuing Supreme Court proceedings, the CSAPR stay remained in place and the EPA continued to implement CAIR. Following the Supreme Court decision, the EPA filed a motion asking the D.C. Circuit to lift the stay and to toll by three years all CSAPR compliance deadlines that had not passed as of the date of the stay order. On October 23, 2014, the Court granted the EPA's motion. Accordingly, CSAPR Phase I compliance requirements took effect on January 1, 2015, with Phase II beginning on January 1, 2017. However, on July 28, 2015, the D.C. Circuit Court of Appeals released a decision invalidating the EPA's 2014 ozone-season NOx budgets for North Carolina and 10 other states.[2] The Court remanded without vacatur to the EPA to reconsider the Phase II NOx budgets that may be too restrictive, but did not sustain other challenges to the rule. The EPA is addressing the Court remand to reconsider the ozone-season NOx emissions budgets for certain states including North Carolina in its *Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS*.[3]

North Carolina is on track to comply with the Phase I CSAPR requirements which are federally enforceable. Additionally, the Phase II CSAPR requirements for annual NOx and annual SO_2 budgets remain in effect and will be enforceable beginning on January 1, 2017. North Carolina

[1] EPA v. EME Homer City Generation, L.P. 134 S.Ct 1584, 1600-01 (2014).
[2] EPA v. EME Homer City Generation, L.P. U.S. Court of Appeals for the D.C. Circuit, No. 11-1302 (July 28, 2015), http://www.epa.gov/airtransport/CSAPR/index.html.
[3] See 80 FR 75706, December 3, 2015, for proposed rule.

will continue to comply with the Phase I CSAPR requirements, as well as the Phase II requirements when applicable.

1.2 Overview of North Carolina's Good Neighbor SIP

In August 2014, EPA informed the DAQ that it intended to disapprove North Carolina's November 2, 2012 submittal because it did not include a modeling demonstration. Therefore, at the EPA's request, on September 3, 2014, North Carolina requested withdrawal of the Section 110(a)(2)(D)(i)(I) portion of the submittal pending availability of EPA's transport modeling.

On January 22, 2015, the EPA released new, preliminary ozone modeling results for 2018 based on emission reductions anticipated from previously adopted air pollution control programs (see Attachment A). The EPA's preliminary modeling identified states that significantly contribute (i.e., at least 1 percent of the 75 parts per billion (ppb) NAAQS) to nonattainment/maintenance concerns in other states in 2018. North Carolina was one of those states whose air quality impacts to all downwind problem receptors were below this threshold, and was identified as a state not requiring further evaluation for actions to address transport. Section 2 of this SIP summarizes these findings. The EPA's conclusions are consistent with North Carolina's initial assessment that showed that the state does not significantly contribute to nonattainment or interfere with maintenance of the standard in a neighboring state. This conclusion is further supported by a 2018 Southeastern Modeling, Analysis and Planning (SEMAP) study and back-trajectory analysis that demonstrate that North Carolina does not significantly contribute to downwind state's nonattainment or maintenance issues for the 2008 ozone NAAQS.

On July 23, 2015, the EPA released its draft 2017 emissions data and modeling analysis that updates the previous 2018 emissions data and modeling analysis (dated January 22, 2015). The EPA's 2017 revised modeling analysis suggests that North Carolina may have a significant contribution to the Essex ozone monitor in Maryland that is a maintenance-only site now but projected by the modeling to exceed the 2008 ozone standard in 2017. The EPA's Notice of Data Availability (NODA) reports that the 2017 maximum design value for the Essex, Maryland monitor will be 76.2 ppb, and North Carolina contributes 0.93 ppb, or 1.2% of the 2008 ozone NAAQS (see Attachment B). In Section 3 of this SIP, the DAQ provides substantial evidence that the EPA's 2017 modeling analysis linking North Carolina to downwind contributions to ozone concentrations at the Essex ozone monitor is associated with inaccurate emissions inventories and deficiencies in the performance of the air quality modeling rather than a real contribution. A brief summary of the DAQ's findings is provided below.

The EPA's revised 2017 modeling incorporates some of the comments that the DAQ submitted to the EPA on the 2011 version 1 base year inventory and growth and control factors for the 2018 version 1 projection year inventory. However, the EPA did not incorporate all of the DAQ's comments particularly for the power supply sector and, consequently, are not reflected in the revised 2017 modeling analysis. On October 23, 2015, the DAQ submitted additional comments on the revised 2017 emissions data and modeling analysis. On December 3, 2015, the EPA published its proposed *Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS* that did not incorporate the DAQ's comments due to timing issues.[4] It is the DAQ's understanding that the EPA will address the DAQ's comments in its final *Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS.* The DAQ will also submit comments on the proposed rule.

Although the EPA's revised 2017 v2 modeling indicates that North Carolina has linkages to the Essex maintenance monitor in Maryland; the DAQ's review questions the EPA's findings due to the following factors:

1. The use of recently observed air quality trends and most recent design values show that the Essex, Maryland monitor currently is and is expected to continue to attain the 2008 ozone standard in 2017.

2. Trajectory analysis for the top 4 daily 8-hour ozone concentrations at the Essex monitor in 2010, 2011, and 2012 (ozone data that are used to compute the maximum design value) show that the trajectory for only 1 of the 12 days touched the northern portion of North Carolina, questioning whether North Carolina truly had a contribution to the observed readings. Further analysis was made for the 63 days with ozone ≥70 ppb at Essex from 2009 through 2014. Only 9 of the 63 days had trajectories that crossed into North Carolina. An analysis of the meteorological conditions on these 9 days suggest it is highly unlikely that significant amounts of ozone or ozone precursors were transported from North Carolina to the Essex monitor.

3. The model resolution of 12 kilometers (km) is unable to accurately simulate the effects of the Chesapeake Bay Breeze on modeled concentrations, which has large impacts on the modeled meteorology and air quality conditions at coastal monitors such as Essex. Poor model

[4] See 80 FR 75706, December 3, 2015, for proposed rule.

performance leads to greater uncertainty of future design value and contribution predictions at the Essex monitor.

4. The projected design value at the Essex monitor is inflated by water grid cells in the model. These water grid cells are shown to have much lower mixing heights compared to adjacent land cells which will inflate pollutant concentrations. Also, ozone within these water cells are at least partially the result of local emissions (i.e., shipping traffic) that cannot be controlled by North Carolina. The model is unable to accurately characterize the air quality in these water grid cells and over-predicts ozone concentrations. In addition, in its air quality modeling technical support document, the EPA acknowledges regional differences in model performance, where the model tends to over-predict ozone concentrations from the Southeast into the Northeast.[5]

5. The EPA's NODA reported model performance results based on statistics at the single monitor grid cell where the monitor is housed. While this method may be appropriate from solely a model performance evaluation standpoint, in this case there is a disconnect between the model performance evaluation and how the significant contribution assessment is conducted. Since the Relative Reduction Factors (RRFs) are calculated using the maximum grid cell in a 3x3 array surrounding the monitor location, and in the case of the Essex monitor, the 3x3 array contains water grid cells, the grid cell with the maximum concentration is rarely the cell containing the monitor. Instead, the maximum concentration actually occurs in a water cell. In situations where the 3x3 array spans a land-water interface, alternative model performance metrics may be appropriate, such as using the maximum value from the 3x3 array to compare to the observation. Alternatively, using the maximum value from the non-water cells in the array to compare to the observation may be appropriate. The model's ability to accurately predict maximum concentrations for use in the RRF calculation is not well characterized by solely looking at the performance at the grid cell containing the monitor. Nevertheless, the model performance of the single grid cell containing the Essex monitor was poor compared to other monitors throughout the domain, as reported in the NODA. The model bias was 6.79 ppb and the mean error was 10.48 ppb, among the highest for all monitors in the eastern US.

6. Due to the complexities associated with land-water interface and the over-predictions modeled for water grid cells, the EPA should determine future maximum design values using

[5] Updated Air Quality Modeling Technical Support Document for the 2008 Ozone NAAQS Transport Assessment, August 2015, page A-6. http://www3.epa.gov/airtransport/pdfs/Updated_2008_Ozone_NAAQS_Transport_AQModeling_TSD.pdf.

alternative approaches: (1) modified 3x3 grid cell array that eliminates grid cells over water and (2) a single cell array focused on the grid cell housing the monitor. Under both of these alternative approaches, the future design values are below the 76 ppb threshold and indicate that the Essex monitor will maintain compliance with the 2008 8-hour ozone NAAQS in 2017.

7. The 2017 ozone contribution from North Carolina to the Essex monitor is 0.45 ppb after removing three days with poor model performance as directed by the EPA's photochemical modeling guidance.[6] The contribution is much more statistically robust and defensible than the 0.93 ppb calculated by the EPA which includes days with poor model performance.

8. Of all the modeled ozone contributions to the Essex monitor, North Carolina had the 5th highest increase of any modeled contribution between 2018 v1 and 2017 v2, and the largest increase was due to boundary conditions. These spatial and inter-model version differences highlight volatility within the modeling platform at the Essex site.

9. The EPA has released three versions of its power sector forecast modeling within the last year. For the first forecast (IPM-NEEDS 5.13), the EPA estimated North Carolina's EGU NOx emissions at about 37,700 tons; this value was used in EPA's 2018 preliminary transport modeling that showed that North Carolina has no linkages to ozone problems in a downwind state. For the second forecast (IPM-NEEDS 5.14), the EPA estimated EGU NOx emissions at about 49,500 tons which was used in the EPA's transport modeling that showed that North Carolina had contributions to the Essex monitor (a maintenance-site) in Maryland. In August 2015, the EPA released a third forecast (IPM-NEEDS 5.15) for its Clean Power Plan rulemaking that estimated 2017 EGU NOx emissions to be 33,400 tons for North Carolina. The conflicting variations between the three EGU forecasts has the potential to significantly alter the EPA's determination of North Carolina linkages to ozone contributions for downwind states. The fact that the highest EGU forecast is causing transport related linkages brings into question the reliability of the EPA's EGU emissions estimates and ozone contributions. At a minimum, the DAQ estimates that North Carolina's EGU NOx emissions for 2017 are over predicted by 2,860 tons by the EPA, with more pronounced differences at the plant level.

[6] EPA, 2014: *Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*. Available from: http://www3.epa.gov/scram001/guidance/guide/Draft-O3-PM-RH-Modeling_Guidance-2014.pdf.

10. The EPA defines maintenance-only sites as those that have a projected 2017 average design value <76.0 ppb, but a projected 2017 maximum design value ≥76.0 ppb. Given all of the uncertainties associated with modeling the Essex ozone maintenance site and since the 2017 projected design value of the Essex monitor is 76.2 ppb (just 0.2 ppb above the threshold), the DAQ believes that the EPA should apply a more robust acceptance test that accounts for modeling uncertainties for determining a future design value for monitors with poor model performance. Alternatively, the EPA's bright-line test of 1 percent of the NAAQS should not be applied so rigidly for a poor performing monitor to determine significant contributions. The EPA's methodology overstates the 2017 future-year design value for the Essex maintenance site particularly since the Essex monitor has demonstrated attainment with the standard based on 2012-2014 EPA-certified monitoring data and preliminary monitoring data for 2013-2015. Given the uncertainties associated with the EPA's air quality modeling methodology for the Essex, Maryland monitor and its reliance on maximum concentrations for calculating future year design values, we believe that North Carolina's contribution of 1.2 percent (i.e., 0.2 percent above the threshold) should not be used solely to link North Carolina with the Essex ozone maintenance problem.

Considering all of the factors listed above, we are concluding through this extensive demonstration that North Carolina does not significantly contribute to ozone issues in downwind states. This in large part is due to the significant strides North Carolina has achieved in reducing its NOx emissions over the past several years. Based on EPA's guidance contained in the January 22, 2015 memorandum, states shown to not contribute significantly to downwind air quality problems have no further emission reduction obligation under the Good Neighbor Provision. The DAQ concludes that North Carolina has met its Good Neighbor Provision under the CAA with respect to the 2008 ozone standard.

1.3 Roadmap

The EPA's January 2015 guidance refers to a four-step process to address ozone transport: (1) identify downwind air quality problems, (2) identify upwind states that contribute to downwind ozone nonattainment and maintenance problems to warrant further review and analysis, (3) identify the emissions reductions necessary to prevent an identified upwind state from contributing significantly to those downwind air quality problems, and (4) adoption of permanent and enforceable measures needed to achieve the required emission reductions. The purpose of this SIP revision is to provide information supporting the state's compliance with the Good Neighbor provision using currently available data and modeling results. The demonstration discusses the results of three distinct modeling studies listed below:

1. 2018 EPA air quality modeling (January 22, 2015 preliminary results)
2. 2017 EPA air quality modeling (July 23, 2015 revised preliminary results)
3. 2018 SEMAP air quality modeling project

The SIP revision also includes a review of back trajectories using the Hybrid Single-Particle Lagrangian Integrated Theory (HYSPLIT) model on downwind monitoring sites. Trajectories ending at six distinct heights (10, 100, 500, 1000, 1500 and 2000 meters) were individually analyzed for all events with ozone exceedances in states downwind of North Carolina occurring between April 1, 2011 and June 15, 2015. The analysis identifies trajectories that crossed North Carolina's state boundary and based on the back trajectory paths and meteorological conditions, explains whether North Carolina could have contributed significantly to a deterioration of air quality to a downwind monitor.

In addition, the DAQ provides a review of current and projected air emissions levels from point, on-road, non-road and area source sectors. The purpose of this analysis is to quantify the emission reductions expected from the on-going transition within the electric utility sector and the on-road sector. The results provide an estimate of emissions expected in 2017, and a qualitative assessment of ozone contributions to downwind states.

2.0 2018 v1 EPA Modeling

The EPA has performed an initial round of air quality modeling to help states address the requirements of CAA Section 110(a)(2)(D)(i)(I) or "Good Neighbor SIPs" for the 2008 ozone NAAQS. The air quality modeling is used to project ozone concentrations at individual monitoring sites in 2018 and to estimate state-by-state contributions to those 2018 concentrations at sites that are projected to be nonattainment or have maintenance problems for the 2008 ozone NAAQS (i.e., 2018 nonattainment and maintenance receptors).

The EPA selected 2018 as the projection year because this would have been the attainment year for moderate ozone nonattainment areas based on the May 21, 2012 ozone classification rule. However, as previously discussed in Section 2, the U.S. Court of Appeals for the D.C. Circuit vacated EPA's use of 2018 as the states' deadlines for complying with the 2008 ozone NAAQS because EPA lacked authority to depart from the CAA-mandated deadlines. Despite this ruling, the large volume of work produced by the EPA to understand interstate contributions in 2018 is nonetheless valuable in developing Good Neighbor SIPs.

The EPA used a screening threshold (1 percent of the NAAQS) to identify contributing upwind states. States whose air quality impact to at least one downwind problem receptor was greater than or equal to the threshold were identified as needing further evaluation for actions to address transport. States whose air quality impacts to all downwind problem receptors were below this threshold were identified as states not requiring further evaluation for actions to address transport; and these states had no emissions reduction obligation under the "Good Neighbor" Provision.

The EPA model simulations used the Weather Research and Forecasting (WRF) meteorology model and the Comprehensive Air Quality Model with Extensions (CAMx) version 6.10 on a national 12-km domain.[7] Separate emission inventories were prepared for 2011 and 2018, and were processed through the Sparse Matrix Operator Kernel Emissions (SMOKE) model to generate air quality model inputs. The 2011 base year and 2018 version 1 projected emissions inventories are described in EPA's emissions inventory technical support document.[8] The 2018 version 1 emissions inventories do not incorporate more recent updates and feedback from states.

[7] Environ, 2014. http://www.camx.com/files/camxusersguide_v6-10.pdf.
[8] U.S. EPA, Preparation of Emissions Inventories for the Version 6.0, 2011 Emissions Modeling Platform, February 26, 2014, http://www.epa.gov/ttn/chief/emch/2011v6/outreach/2011v6_2018base_EmisMod_TSD_26feb2014.pdf.

The 2018 electricity generating unit (EGU) projections reflect CAIR and not CSAPR because at the time of the modeling CSAPR had been vacated by the D.C. Circuit Court. In addition, the EGU projections used for this analysis pre-date and do not reflect the expected impacts from the EPA's proposed Clean Power Plan proposed in June 2014.

The MOVES-based 2018 onroad and nonroad emissions account for changes in activity data and the impact of on-the-books national rules including the following:

Onroad

- Tier 3 Motor Vehicle Emission and Fuel Standards Program,
- Light-Duty Vehicle Tier 2 Rule,
- Heavy Duty Diesel Rule,
- Mobile Source Air Toxics Rule,
- Renewable Fuel Standard,
- Light-Duty Green House Gas/Corporate Average Fuel Efficiency Standards for 2012-2016,
- Heavy-Duty Vehicle Greenhouse Gas Rule, and
- 2017 and the Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards Rule.

Nonroad

- Clean Air Nonroad Diesel Final Rule - Tier 4
- Control of Emissions from Nonroad Large Spark-Ignition Engines, and Recreational Engines (Marine and Land-Based)
- Small Engine Spark Ignition ("Bond") Rule

To examine whether or not a state is projected to be in nonattainment or have maintenance problems in 2018, the EPA started with the average ambient 8-hour ozone design values for the period 2009 through 2013 (i.e., the average of design values for 2009-2011, 2010-2012 and 2011-2013). The 5-year weighted average ambient design value at each receptor site was projected to 2018 using model-predicted RRF.[9] The 2018 projected average ozone design values were evaluated to identify those sites with design values that exceed the 2008 ozone NAAQS. Those sites with 2018 average design values that exceed the NAAQS were projected to be nonattainment in 2018. To identify sites with projected maintenance problems, the maximum

[9] RRF for a receptor location is the ratio of the 2018 ozone model prediction to the 2011 ozone model prediction. EPA calculated RRFs using model outputs for the May through September ozone period.

ambient design value from the 2011-centered 5-year period (i.e., maximum of design values from 2009-2011, 2010-2012 and 2011-2013) was projected to 2018 using the site-specific RRFs. Monitoring sites with a 2018 maximum design value that exceeded the NAAQS were projected to have a maintenance problem in 2018.

To examine whether or not a state significantly contributed to ozone nonattainment or maintenance in a neighboring state, the EPA quantified interstate contributions using source apportionment modeling techniques based on CAMx Ozone Source Apportionment Technology/Anthropogenic Precursor Culpability Analysis (OSAT/APCA). This quantified the contribution of 2018 base case NOx and VOC emissions from all sources in each state to projected 2018 ozone concentrations at air quality monitoring sites. The results provided an indication of the states with "linkages" to downwind 2018 nonattainment receptors based on a 1 percent or more contribution of the 2008 ozone standard (i.e., greater than a 0.75 ppb contribution).

The following sections summarize EPA's preliminary findings related to North Carolina's future design values and interstate contributions.

2.1 North Carolina Design Value Discussion

The EPA modeling predicts that all ozone monitors in North Carolina will attain the 75 ppb ozone NAAQS in 2018 (see Table 2-1). Additionally, current 2012-2014 design values for all North Carolina monitors are below the 75 ppb standard.

Table 2-1. North Carolina 2009-2013 Ambient and Projected 2018 Ozone Design Values (DV) from the EPA modeling, units in ppb

Site ID	County	2009 - 2013 Average DV	2009 - 2013 Maximum DV	Projected 2018 Average DV	Projected 2018 Maximum DV	Current 2012-2014 DV
371190041	Mecklenburg	80.0	83.0	67.3	69.8	70
371191009	Mecklenburg	79.7	83.0	65.2	67.9	73
371590021	Rowan	75.3	78.0	62.2	64.4	68
370670022	Forsyth	75.3	78.0	64.4	66.7	70
371191005	Mecklenburg	75.0	77.0	62.4	64.1	66
371590022	Rowan	75.0	77.0	61.5	63.1	-
370810013	Guilford	74.0	76.0	63.0	64.7	68
370670030	Forsyth	72.7	76.0	61.7	64.5	68
371090004	Lincoln	72.7	75.0	61.3	63.3	68
370671008	Forsyth	72.3	75.0	61.7	64.0	68
371830016	Wake	73.0	75.0	62.2	63.9	65
371010002	Johnston	71.7	74.0	59.7	61.6	66
371450003	Person	71.0	74.0	63.4	66.1	66
370330001	Caswell	70.7	73.0	60.2	62.2	68
371570099	Rockingham	71.0	73.0	61.1	62.8	67
371790003	Union	71.0	73.0	59.0	60.6	68
370590003	Davie	71.0	73.0	59.7	61.4	-
371830014	Wake	70.3	72.0	58.8	60.2	65
370630015	Durham	70.0	72.0	58.3	60.0	66
370670028	Forsyth	69.7	72.0	59.7	61.7	65
370511003	Cumberland	70.7	72.0	59.7	60.8	65
370770001	Granville	70.7	72.0	59.8	60.9	66
370750001	Graham	70.3	72.0	60.8	62.2	64
370690001	Franklin	69.3	71.0	57.8	59.2	64
370650099	Edgecombe	70.0	71.0	60.1	60.9	-
371470006	Pitt	69.7	71.0	59.9	61.1	65
371990004	Yancey	69.7	71.0	60.4	61.5	66
370510008	Cumberland	68.7	70.0	58.3	59.4	63
371070004	Lenoir	67.7	69.0	57.9	59.1	65
370870036	Haywood	67.7	69.0	61.0	62.1	66
370210030	Buncombe	66.7	68.0	58.0	59.1	62
370030004	Alexander	66.7	68.0	56.8	57.9	-
370270003	Caldwell	66.0	67.0	56.7	57.6	62
371170001	Martin	66.3	67.0	57.2	57.8	64
370990005	Jackson	67.0	67.0	59.4	59.4	-
371239991	Montgomery	66.0	66.0	53.4	53.4	63
370370004	Chatham	64.0	66.0	54.1	55.7	59
370110002	Avery	63.3	65.0	55.3	56.8	61
371290002	New Hanover	63.0	64.0	53.3	54.1	63
370119991	Avery	63.0	63.0	55.1	55.1	63
371730002	Swain	60.7	62.0	53.3	54.5	58
370870008	Haywood	61.0	61.0	54.5	54.5	60

2.2 North Carolina Contributions

The ambient and 2018 projected average and maximum ozone design values, and contributions from North Carolina, at each of the 2018 nonattainment and maintenance-only receptors in the Eastern U.S. are provided in Tables 2-2 and 2-3, respectively[10]. The maximum contribution by North Carolina to nonattainment in 2018 is 0.57 ppb, which is below the 1 percent significant contribution threshold. The maximum contribution by North Carolina to maintenance in 2018 is 0.55 ppb, which is also below the 1 percent significant contribution threshold.

Table 2-2. Ambient and 2018 Design Values (DVs) and North Carolina Contributions to Nonattainment Areas in the Eastern U.S.

Site ID	State	County	2009 - 2013 Average DV (ppb)	Projected 2018 Average DV (ppb)	North Carolina Contribution (ppb)*
480391004	Texas	Brazoria	88.0	80.5	0.09
484392003	Texas	Tarrant	87.3	79.7	0.09
240251001	Maryland	Harford	90.0	79.4	0.50
484393009	Texas	Tarrant	86.0	78.3	0.05
361030002	New York	Suffolk	83.3	78.2	0.41
482011039	Texas	Harris	82.0	77.7	0.07
90019003	Connecticut	Fairfield	83.7	77.5	0.43
481210034	Texas	Denton	84.3	77.0	0.17
90013007	Connecticut	Fairfield	84.3	76.7	0.57
482010024	Texas	Harris	80.3	76.4	0.34
				Maximum Contribution	0.57

* North Carolina Contributions obtained from: http://www.epa.gov/airtransport/OzoneTransportDataFile.xlsx.

Table 2-3. Ambient and 2018 Design Values (DVs), and North Carolina Contributions, to Maintenance Areas in the Eastern U.S.

Site ID	State	County	2009 - 2013 Maximum DV (ppb)	Projected 2018 Maximum DV (ppb)	2018 North Carolina Contribution (ppb)*
90099002	Connecticut	New Haven	89.0	78.8	0.46
421010024	Pennsylvania	Philadelphia	87.0	78.0	0.50
551170006	Wisconsin	Sheboygan	87.0	77.8	0.07
481130069	Texas	Dallas	84.0	77.7	0.16
260050003	Michigan	Allegan	86.0	77.5	0.06
291831002	Missouri	Saint Charles	86.0	77.4	0.11
90010017	Connecticut	Fairfield	83.0	76.6	0.35
482010055	Texas	Harris	83.0	76.6	0.17

[10] Nonattainment receptors have a 2018 average design value of ≥76.0 ppb. Maintenance receptors have a 2018 average design values <76.0 ppb, but 2018 maximum design value of ≥76.0 ppb.

Site ID	State	County	2009 - 2013 Maximum DV (ppb)	Projected 2018 Maximum DV (ppb)	2018 North Carolina Contribution (ppb)*
484390075	Texas	Tarrant	83.0	76.4	0.05
211110067	Kentucky	Jefferson	85.0	76.4	0.01
482010029	Texas	Harris	84.0	76.3	0.36
340150002	New Jersey	Gloucester	87.0	76.3	0.33
481211032	Texas	Denton	84.0	76.3	0.12
484393011	Texas	Tarrant	83.0	76.3	0.03
360850067	New York	Richmond	83.0	76.2	0.55
480850005	Texas	Collin	84.0	76.2	0.15
481130075	Texas	Dallas	83.0	76.1	0.16
340071001	New Jersey	Camden	87.0	76.0	0.08
				Maximum Contribution	0.55

* North Carolina Contributions obtained from: http://www.epa.gov/airtransport/OzoneTransportDataFile.xlsx.

2.3 Conclusions from 2018 EPA Modeling

All sites within North Carolina are predicted to be well below the 2008 ozone standard by 2018. North Carolina is not predicted to be a significant contributor to downwind ozone nonattainment and maintenance in 2018.

3.0 2017 v2 EPA Modeling

The EPA promulgated the 2008 ozone NAAQS Classifications Rule on May 21, 2012, which extended the ozone attainment dates to the end of calendar year (77 FR 30160). This means that moderate nonattainment areas would have until December 20, 2018 to come into attainment. The EPA used its action under the Classifications Rule to conduct ozone transport analysis by developing emission inventories and performing air quality modeling relative to a 2018 future year.

The EPA's decision to extend the attainment dates was challenged in NRDC v. EPA in the U.S. Court of Appeals for the D.C. Circuit (D.C. Cir. No. 12–1321). On December 23, 2014, the Court issued an opinion holding that the EPA's decision to run the attainment periods from the end of the calendar year in which areas were designated was unreasonable. The Court concluded that nothing in the CAA or congressional intent authorized the EPA to establish the attainment dates for designated ozone nonattainment areas as December 31st of the relevant calendar years, but rather that such deadlines are more appropriately calculated as annual periods running from the date of designation and classification as the EPA had done in past ozone implementation rules.

To provide clarity to states after the D.C. Circuit decision, the EPA promulgated the 2008 ozone NAAQS SIP Requirements Rule on March 6, 2015 (80 CFR 12264). In this rulemaking, the EPA modified 40 CFR 51.1103 consistent with the Court's decision and established attainment dates that run from the effective date of designation (i.e., July 20, 2012). The maximum attainment dates for nonattainment areas in each classification under the 2008 NAAQS based on the July 20, 2012, effective date are as follows: Marginal—3 years from effective date of designation; Moderate—6 years; Serious—9 years; Severe—15 years (or 17 years); and Extreme—20 years. The rule effectively shortened by one ozone season the maximum allowable attainment date for all classifications. Moderate and above area attainment demonstrations must ensure emissions controls are implemented no later than the beginning of the ozone season that is prior to the attainment date (e.g., beginning of the 2017 ozone season for Moderate areas).

With 2017 being the current attainment year for moderate ozone nonattainment areas, the EPA revised its future year transport modeling analysis from 2018 to 2017. On July 23, 2015, the EPA issued a NODA and request for public comment on its 2017 emissions and air quality data files for ozone transport modeling (see Attachment B).[11] The EPA posted its 2017 emissions and

[11] Notice of Availability of the Environmental Protection Agency's Updated Ozone Transport Modeling Data for the 2008 Ozone National Ambient Air Quality Standard (NAAQS), 80 FR 46271.

air quality modeling files for public review on July 23, 2015, and posted the technical support documentation on August 18, 2015.[12] On October 23, 2015, the DAQ submitted to the EPA detailed comments on the emissions inventory data and air quality modeling analysis (see Attachment B). This information updates the previous 2018 emissions and modeling data that the EPA released on January 22, 2015, and was used to inform the EPA's proposed *Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS*.[13]

The following highlights the major differences between the emissions inventories used for the 2017 versus the previously discussed 2018 projection year modeling. The effects of certain inaccuracies in the 2017 emissions inventories in producing unreliable emissions / air quality modeling results are described in more detail in Section 5.

- The revised 2017 modeling used the EPA's 2011 version 2 (v6.2) base year inventory that incorporates comments that states provided on the 2011 version 1 (v6.1) base year inventory used for the 2018 modeling.
- For EGU emissions projections, the EPA replaced the NOx and SO_2 CAIR budgets with the final CSAPR budgets. However, as with the 2018 emissions forecast, the 2017 forecast does not reflect the expected emission levels from North Carolina's power plants.
- For onroad and nonroad model sources, the EPA did not explicitly model 2017 county-level emissions by running MOVES2014 using 2017 activity data. Instead, the EPA first generated 2018 county-level emissions by running MOVES2014 with 2018 input and activity data. They then ran MOVES2014 at the national level for 2017 and 2018 and developed factors by source classification code and pollutant that were applied to the modeled 2018 emissions to estimate 2017 emissions. For onroad sources, the EPA did generate the 2018 county-level emissions using the 2018 county database input files that the DAQ prepared and submitted to the EPA as a part of the DAQ's comments on the EPA's version 1 of the 2018 Emissions Modeling Platform (EMP) in June 2014.
- For non-EGU stationary point and area (nonpoint) sources, for the 2017 modeling, the DAQ has identified issues with the control factors used by the EPA in modeling the boiler Maximum Achievable Control Technology (MACT) standards for industrial,

[12] 2011v6.2 Emissions Modeling Platform Technical Support Document for 2011, 2017, and 2025 (8/18/15), located at: http://www.epa.gov/ttn/chief/emch/index.html#2011.
[13] See 80 FR 75706, December 3, 2015, for proposed rule.

commercial, and institutional boilers in North Carolina. In addition, the DAQ is reviewing the EPA's methods for forecasting emissions for these sectors.

To examine whether or not a state is projected to be in nonattainment or have maintenance problems in 2017, the EPA started with the average ambient 8-hour ozone design values for the period 2009 through 2013 (i.e., the average of design values for 2009-2011, 2010-2012 and 2011-2013). The 5-year weighted average ambient design value at each receptor site was projected to 2017 using model-predicted RRF.[14] The 2017 projected average ozone design values were evaluated to identify those sites with design values that exceed the 2008 ozone NAAQS. Those sites with 2017 average design values that exceed the NAAQS were projected to be nonattainment in 2017. To identify sites with projected maintenance problems, the maximum ambient design value from the 2011-centered 5-year period (i.e., maximum of design values from 2009-2011, 2010-2012 and 2011-2013) was projected to 2017 using the site-specific RRFs. Monitoring sites with a 2017 maximum design value that exceeded the NAAQS were projected to have a potential maintenance problem in 2017.

To examine whether or not a state significantly contributed to ozone nonattainment or maintenance in a neighboring state, the EPA quantified interstate contributions using source apportionment modeling techniques based on CAMx OSAT/APCA. This quantified the contribution of 2017 base case NOx and VOC emissions from all sources in each state to projected 2017 ozone concentrations at air quality monitoring sites. The results provide an indication of the states with potential "linkages" to downwind 2017 nonattainment receptors based on a 1 percent or more contribution of the 2008 ozone standard (i.e., greater than a 0.75 ppb contribution).

The following sections present EPA's findings related to North Carolina's future design values and interstate contributions, and summarize the DAQ's concerns with the performance of the air quality model and 2017 emissions inventory data for EGU sources.

3.1 Review of North Carolina Design Value Discussion

The EPA modeling predicts that all ozone monitors in North Carolina will attain the 75 ppb ozone NAAQS in 2017 (Table 3-1). Additionally, current 2012-2014 design values for all North Carolina monitors are below the 75 ppb standard.[15]

[14] RRF for a receptor location is the ratio of the 2017 ozone model prediction to the 2011 ozone model prediction. EPA calculated RRFs using model outputs for the May through September ozone period.
[15] The lone remaining ozone nonattainment area (i.e., the Charlotte-Gastonia-Salisbury area) was re-designated as attainment on August 27, 2015, based on 2012-2014 ozone design value data for that area (see 80 FR 44873).

Table 3-1. North Carolina 2009-2013 Ambient and Projected 2017 Ozone Design Values (DV) from the EPA modeling, units in ppb

Site ID	County	2009 - 2013 Average DV	2009 - 2013 Maximum DV	Projected 2017 Average DV	Projected 2017 Maximum DV	Current 2012-2014 DV
371190041	Mecklenburg	80	83	70.0	72.6	70
371191009	Mecklenburg	79.7	83	67.1	69.9	73
371590021	Rowan	75.3	78	62.1	64.4	68
370670022	Forsyth	75.3	78	64.1	66.4	70
371191005	Mecklenburg	75	77	65.1	66.8	66
371590022	Rowan	75	77	62.5	64.2	-
370810013	Guilford	74	76	63.0	64.7	68
370670030	Forsyth	72.7	76	61.5	64.3	68
371090004	Lincoln	72.7	75	61.2	63.2	68
370671008	Forsyth	72.3	75	61.2	63.5	68
371830016	Wake	73	75	62.9	64.6	65
371010002	Johnston	71.7	74	60.7	62.6	66
371450003	Person	71	74	67.5	70.3	66
370330001	Caswell	70.7	73	59.9	61.8	68
371570099	Rockingham	71	73	62.0	63.7	67
371790003	Union	71	73	59.7	61.4	68
370590003	Davie	71	73	59.4	61.1	-
371830014	Wake	70.3	72	59.5	60.9	65
370630015	Durham	70	72	58.0	59.7	66
370670028	Forsyth	69.7	72	59.5	61.4	65
370511003	Cumberland	70.7	72	60.2	61.3	65
370770001	Granville	70.7	72	61.1	62.2	66
370750001	Graham	70.3	72	61.2	62.7	64
370690001	Franklin	69.3	71	57.9	59.3	64
370650099	Edgecombe	70	71	61.2	62.1	-
371470006	Pitt	69.7	71	60.3	61.4	65
371990004	Yancey	69.7	71	59.7	60.8	66
370510008	Cumberland	68.7	70	59.3	60.4	63
371070004	Lenoir	67.7	69	58.4	59.5	65
370870036	Haywood	67.7	69	59.5	60.7	66
370210030	Buncombe	66.7	68	56.8	57.9	62
370030004	Alexander	66.7	68	56.3	57.4	-
370270003	Caldwell	66	67	55.7	56.6	62
371170001	Martin	66.3	67	55.5	56.1	64
370990005	Jackson	67	67	58.9	58.9	-
371239991	Montgomery	66	66	55.0	55.0	63
370370004	Chatham	64	66	53.9	55.6	59
370110002	Avery	63.3	65	54.1	55.5	61
371290002	New Hanover	63	64	53.9	54.7	63
370119991	Avery	63	63	54.2	54.2	63
371730002	Swain	60.7	62	53.3	54.4	58
370870008	Haywood	61	61	53.6	53.6	60

3.2 North Carolina Contributions

Actual observed ambient and 2017 projected average and maximum ozone design values, and contributions from North Carolina, at each of the 2017 nonattainment and maintenance-only receptors in the Eastern U.S. are provided in Tables 3-2 and 3-3, respectively.[16] The maximum contribution by North Carolina to a nonattainment area in 2017 is 0.55 ppb, which is below the 1 percent significant contribution threshold.

The maximum contribution by North Carolina to maintenance in 2017 is 0.93 ppb to the Essex monitor in Baltimore County, Maryland, which is 1.2 percent of the standard. Given that the 2017 modeling shows a contribution slightly over the 1 percent threshold for the Essex monitor and that the EPA's 2018 modeling did not, the DAQ conducted further analyses, which are summarized in the following sections, to understand the factors that appear to be overestimating North Carolina's contribution to the Essex monitor.

Table 3-2. Ambient and 2017 Design Values (DVs) and North Carolina Contributions to Nonattainment Areas in the Eastern U.S.

Site ID	State	County	2009-2013 Average Design Value (ppb)	Projected 2017 Average Design Value (ppb)	2017 North Carolina Contribution (ppb)*
90013007	Connecticut	Fairfield	84.3	77.1	0.55
90019003	Connecticut	Fairfield	83.7	78.0	0.47
90099002	Connecticut	New Haven	85.7	77.2	0.38
240251001	Maryland	Harford	90.0	81.3	0.46
360850067	New York	Richmond	81.3	76.3	0.55
361030002	New York	Suffolk	83.3	79.2	0.38
390610006	Ohio	Hamilton	82.0	76.3	0.13
480391004	Texas	Brazoria	88.0	81.4	0.08
481210034	Texas	Denton	84.3	76.9	0.08
482011034	Texas	Harris	81.0	76.8	0.16
482011039	Texas	Harris	82.0	78.2	0.06
484392003	Texas	Tarrant	87.3	79.6	0.09
484393009	Texas	Tarrant	86.0	78.6	0.13
551170006	Wisconsin	Sheboygan	84.3	77.0	0.06
				Maximum Contribution	0.55

* North Carolina Contributions obtained from: http://www.epa.gov/airtransport/pdfs/2017 Ozone Contributions_Transport NODA.xlsx.

[16] Nonattainment receptors have a 2017 average design value of ≥76.0 ppb. Maintenance receptors have a 2017 average design values <76.0 ppb, but 2017 maximum design value of ≥76.0 ppb.

Table 3-3. Ambient and 2017 Design Values (DVs), and North Carolina Contributions, to Maintenance Areas in the Eastern U.S.

Site ID	State	County	2009 - 2013 Maximum Design Value (ppb)	Projected 2017 Maximum Design Value (ppb)	2017 North Carolina Contribution (ppb)*
90010017	Connecticut	Fairfield	83.0	78.4	0.33
211110067	Kentucky	Jefferson	85.0	78.6	0.01
211850004	Kentucky	Oldham	86.0	77.3	0.02
240053001	Maryland	Baltimore	84.0	76.2	0.93
260050003	Michigan	Allegan	86.0	78.5	0.05
261630019	Michigan	Wayne	81.0	76.2	0.32
340071001	New Jersey	Camden	87.0	78.1	0.07
340150002	New Jersey	Gloucester	87.0	77.5	0.33
340230011	New Jersey	Middlesex	85.0	76.3	0.50
340290006	New Jersey	Ocean	85.0	76.6	0.33
360810124	New York	Queens	80.0	77.6	0.39
420031005	Pennsylvania	Allegheny	82.0	76.5	0.07
421010024	Pennsylvania	Philadelphia	87.0	78.4	0.72
480850005	Texas	Collin	84.0	76.0	0.14
481130069	Texas	Dallas	84.0	78.0	0.22
481130075	Texas	Dallas	83.0	76.7	0.16
481211032	Texas	Denton	84.0	76.3	0.11
482010024	Texas	Harris	83.0	78.5	0.14
482010026	Texas	Harris	80.0	76.1	0.00
482010055	Texas	Harris	83.0	77.0	0.16
482011050	Texas	Harris	80.0	76.2	0.05
484390075	Texas	Tarrant	83.0	76.4	0.05
484393011	Texas	Tarrant	83.0	76.6	0.10
				Maximum Contribution	0.93

* North Carolina Contributions obtained from: http://www.epa.gov/airtransport/pdfs/2017 Ozone Contributions_Transport NODA.xlsx.

3.2.1 Sensitivity of Future Design Value Calculations

The DAQ analyzed the future design values that the EPA estimated for the Essex monitor for a variety of different scenarios for computing the base design value (see Table 3-4). The RRF from the projected 2017 modeling was used for all calculations. This sensitivity analysis shows that the use of the maximum design value within the 2009-2013 base period (i.e., 84 ppb observed in 2010-2012) is the only scenario in which the Essex monitor would exceed the 2008 ozone standard in 2017. This is the same scenario used by the EPA in the 2017 modeling to link North Carolina with Maryland. However, when more recent observed design values are used, the Essex monitor is expected to maintain compliance with the 2008 8-hour ozone NAAQS in 2017 under all scenarios (see Table 3-4). In fact, ozone values have decreased dramatically at the Essex monitor since 2012 and the monitor reached attainment with the standard in 2014. Based on current monitoring data, it is likely that Essex will continue to attain the 2008 ozone

NAAQS in 2015 (see Table 3-5). In conclusion, we believe that the use of more recent design values does not show that the Essex maintenance monitor could exceed the ozone NAAQS in the future and thus, does not link North Carolina as contributing significantly to ozone maintenance problems in Maryland.

Table 3-4. Ozone Base and Future Design Value Calculations for a Variety of Base Design Value Scenarios at the Essex Ozone Monitor Site

Base Scenario*	Base Design Value (ppb)	2011-2017 Relative Reduction Factor (RRF)	Future Design Value (ppb)
5-year unweighted average, 2009-2013	78.2	0.907	70.9
5-year weighted average, 2009-2013**	80.7	0.907	73.2
5-year unweighted average, 2010-2014	77.4	0.907	70.2
5-year weighted average, 2010-2014	78.4	0.907	71.1
2010-2012 design value***	84.0	0.907	**76.2**
2011-2013 design value	78.6	0.907	71.2
2012-2014 design value	72.6	0.907	65.8
2013-2015 design value	66.3	0.907	60.1

* A weighted average is the average of the three design values within the 5-year period of study. An unweighted average gives equal weight to each year's 4th-highest ozone value within the 5-year period of study.
** This value is given as the "average 2009-2013 design value" for the Essex ozone monitor in the USEPA's 2017 modeling NODA.
*** This value is given as the "maximum 2009-2013 design value" for the Essex ozone monitor in the USEPA's 2017 modeling NODA.

Table 3-5. Fourth-Highest Ozone Values at the Essex Ozone Monitoring Site

4th-Highest Ozone Value		Design Value	
Year	PPB	Year	PPB
2009	71		
2010	84		
2011	85	2009-2011	80.0
2012	83	2010-2012	84.0
2013	68	2011-2013	78.6
2014	67	2012-2014	72.6
2015	70	2013-2015*	68.3

***** Represents 4th-highest value at Essex monitor as of October 10, 2015.

3.2.2 Trajectory Analysis

The DAQ reviewed the meteorology for four days with the highest ozone concentrations recorded by the Essex monitor in 2010, 2011 and 2012 (total of 12 days), and performed trajectory analyses on these days to determine if any air parcels moved across North Carolina (see Figure 3-1). We utilized the same methodology for this exercise as we did for other trajectory analysis work which is described in greater detail in Section 4. The results showed

that the trajectory for only one of the 12 days touched the northern portion of North Carolina, while the trajectories for the other 11 days were oriented to the north and west of the Essex monitor moving over the Ohio Valley and interior Northeast. This finding (as well as others generated by other trajectory analyses discussed below) calls into question whether North Carolina truly had a contribution to these readings.

In addition to analyzing trajectories for the top-4 ozone days from the Essex ozone monitoring site, the DAQ performed an analysis of all days where there was an 8-hour reading of 70 ppb or greater at the Essex monitor for the years 2009 through 2014 (see Figure 3-2). Each trajectory ended at the Essex monitor at 4 PM Eastern; typically the hour during which the highest ozone concentrations occur. Six different trajectories were run for each day, each of these ending at different heights: 10 m, 100 m, 500 m, 1000 m, 1500 m, and 2000 m. All trajectories went back 60 hours, and used the 12 km North American Mesoscale (NAM) model for meteorology. There were 63 days where a 70+ ppb reading was observed at Essex and all of these were reviewed to see if the trajectory moved across any part of North Carolina, and nine of these days met this criterion. We reviewed meteorology for these nine days and conclude that it would have been extremely unlikely that air mass flows on these days could have transported ozone or related precursors from North Carolina to impact the Essex monitor. The specific analysis of each day and determination whether North Carolina appeared to contribute to Essex's ozone values on each day can be found in Attachment C (see slides 3 through 11). The remaining 54 days had no trajectories that passed through any part of North Carolina. The findings from this trajectory analysis also raises questions about how North Carolina could significantly contribute to nonattainment at the Essex monitor, as is projected in the 2017 CAMx modeling.

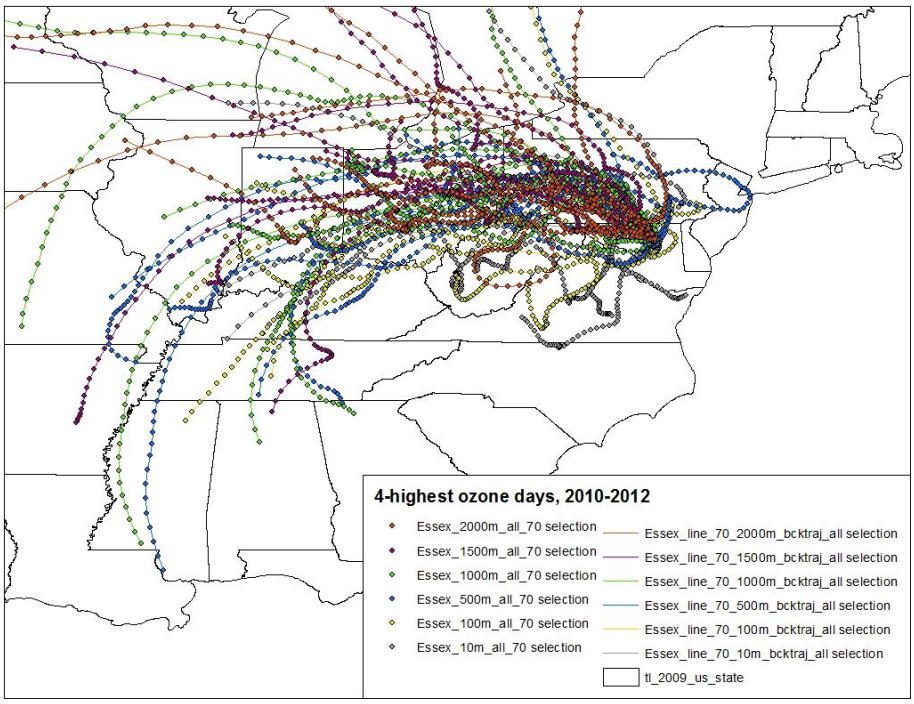


Figure 3-1. 60-hour Back Trajectory Analysis for the Top 4 Ozone Days, 2010-2012.

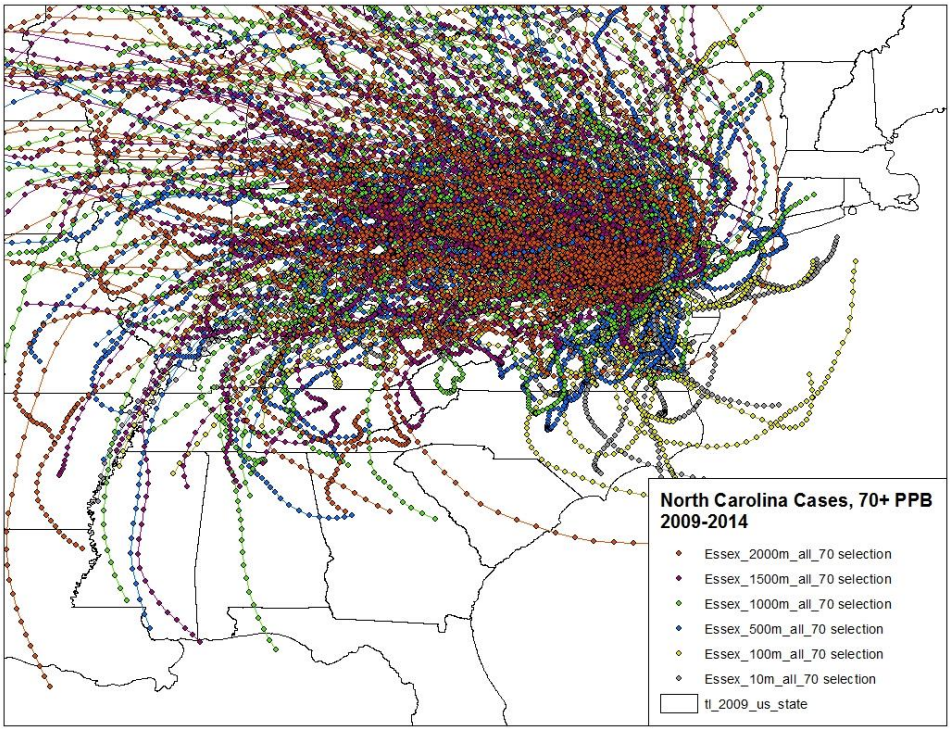


Figure 3-2. 60-Hour Back Trajectory Analysis for all 70+ ppb Ozone Days, 2009-2014.

3.2.3 CAMx Model Performance Analysis

To demonstrate the model performance, the EPA provided the statistics for all monitors with mean observed ozone greater than 70 ppb and more than 10 days with observed ozone at or above 60 ppb in the NODA (see Table 3-6). This cutoff was applied to evaluate the model for a statistically significant number of days with elevated ozone which are more policy relevant (i.e., ozone sufficiently high to be used as days to compute the RRF). Note that in reporting model performance related to those monitors that were ultimately linked to nonattainment or maintenance, the EPA shows only the statistics for the single cell in the 3x3 array where the monitor is housed. The single cell model performance of the Essex monitor, while within the statistical parameters that the EPA deems acceptable, was poor compared to other monitors throughout the domain, having the third greatest bias of these monitors.

The true model performance for the Essex monitor should be based on the grid cell with the highest value in the base model run (i.e., water cell with elevated ozone values). As discussed later, this method shows a significantly higher mean bias and absolute error, and is the true representation of the EPA's method used to link North Carolina with the Essex monitor.

Table 3-6. May to September 2011 v2 Ozone Model Performance Statistics within the Single Monitor Grid Cell for Monitors with Mean Observed Ozone >70 ppb and >10 Days with Observed Ozone ≥60 ppb

Site_ID	State	County	Number of Obs ≥60 ppb	Obs Mean (ppb)	Model Mean (ppb)	Obs Median (ppb)	Model Median (ppb)	Mean Bias (ppb)	Mean Error (ppb)	Normalized Mean Bias (%)	Normalized Mean Error (%)
90110124	Connecticut	New London	25	70.92	80.15	68.38	78.30	9.23	14.80	13.02	20.86
371191005	North Carolina	Mecklenburg	40	70.08	78.81	69.31	77.48	8.73	13.32	12.45	19.00
240053001	Maryland	Baltimore	44	70.33	77.12	67.00	78.44	6.79	10.48	9.65	14.90
340290006	New Jersey	Ocean	27	73.32	79.64	73.00	82.02	6.33	8.84	8.63	12.05
420170012	Pennsylvania	Bucks	26	70.29	76.59	69.06	76.91	6.30	9.52	8.96	13.54
515100009	Virginia	Alexandria City	41	70.46	76.52	66.83	75.31	6.06	11.92	8.60	16.92
510360002	Virginia	Charles City	26	70.57	76.34	68.08	75.59	5.78	9.70	8.18	13.75
90090027	Connecticut	New Haven	16	73.58	78.80	71.38	72.37	5.22	11.16	7.09	15.17
132470001	Georgia	Rockdale	70	70.58	75.74	69.31	75.13	5.16	8.24	7.31	11.68
240030014	Maryland	Anne Arundel	41	71.26	76.15	68.63	72.45	4.89	10.05	6.87	14.10
340250005	New Jersey	Monmouth	27	70.79	74.92	66.88	74.96	4.13	8.51	5.83	12.03
240330030	Maryland	Prince Georges	31	70.56	74.31	67.38	72.19	3.75	8.43	5.31	11.95
291890014	Missouri	St Louis	36	70.27	73.93	69.04	71.77	3.66	8.48	5.20	12.07
371190041	North Carolina	Mecklenburg	57	70.90	74.54	69.75	73.38	3.63	9.29	5.12	13.10
90093002	Connecticut	New Haven	25	74.28	77.87	69.38	75.09	3.60	9.20	4.84	12.39
220770001	Louisiana	Pointe Coupee	21	70.21	73.58	69.63	73.14	3.37	4.30	4.80	6.12
250070001	Massachusetts	Dukes	17	72.73	75.96	69.57	78.39	3.22	9.04	4.43	12.42
550890009	Wisconsin	Ozaukee	13	70.44	73.65	69.75	75.95	3.21	11.73	4.55	16.65
482010047	Texas	Harris	30	70.00	73.10	67.69	72.12	3.10	8.90	4.43	12.71

Site_ID	State	County	Number of Obs ≥60 ppb	Obs Mean (ppb)	Model Mean (ppb)	Obs Median (ppb)	Model Median (ppb)	Mean Bias (ppb)	Mean Error (ppb)	Normalized Mean Bias (%)	Normalized Mean Error (%)
90019003	Connecticut	Fairfield	29	71.95	75.00	69.63	71.39	3.05	8.82	4.23	12.25
240338003	Maryland	Prince Georges	38	73.68	76.71	72.06	73.13	3.03	9.48	4.11	12.87
131210055	Georgia	Fulton	69	70.05	72.89	68.63	71.66	2.84	10.73	4.05	15.32
240290002	Maryland	Kent	42	70.91	73.62	68.38	71.87	2.70	6.87	3.81	9.69
100031013	Delaware	New Castle	34	70.79	73.45	66.37	72.18	2.66	7.57	3.76	10.70
510590030	Virginia	Fairfax	46	70.30	72.16	66.13	72.02	1.86	10.11	2.65	14.38
482010416	Texas	Harris	24	71.11	72.66	68.96	73.53	1.54	7.99	2.17	11.23
90013007	Connecticut	Fairfield	26	72.95	74.31	71.38	69.93	1.35	9.47	1.86	12.98
60659001	California	Riverside	80	73.92	75.13	71.38	74.78	1.21	8.61	1.64	11.65
90070007	Connecticut	Middlesex	20	70.60	71.72	67.06	70.82	1.11	7.43	1.58	10.52
360050133	New York	Bronx	19	70.48	71.41	69.63	71.64	0.93	7.02	1.32	9.96
482011050	Texas	Harris	26	71.28	72.18	69.88	73.26	0.89	8.25	1.25	11.58
290470005	Missouri	Clay	35	70.09	70.89	67.38	69.42	0.80	9.13	1.14	13.03
510130020	Virginia	Arlington	54	70.35	71.02	68.75	70.87	0.68	9.79	0.96	13.92
260210014	Michigan	Berrien	36	70.20	70.79	66.38	66.94	0.59	8.69	0.84	12.38
295100085	Missouri	St Louis City	41	70.06	70.63	69.63	71.12	0.56	9.02	0.80	12.87
340190001	New Jersey	Hunterdon	34	70.43	70.77	69.38	70.99	0.33	5.09	0.47	7.23
240150003	Maryland	Cecil	38	71.30	71.58	68.44	70.05	0.28	7.16	0.39	10.04
60370002	California	Los Angeles	36	72.04	72.17	70.44	70.67	0.13	8.08	0.18	11.22
240251001	Maryland	Harford	54	73.66	73.78	69.25	73.35	0.11	8.84	0.15	12.00
291831002	Missouri	St Charles	55	70.71	70.81	68.63	70.89	0.10	7.10	0.14	10.04
60610003	California	Placer	56	70.59	70.57	68.38	71.17	-0.02	7.53	-0.03	10.67
340230011	New Jersey	Middlesex	41	70.43	70.35	67.25	68.89	-0.07	5.77	-0.11	8.19
391650007	Ohio	Warren	39	71.46	71.04	69.75	73.29	-0.42	10.63	-0.59	14.87
90011123	Connecticut	Fairfield	26	70.04	69.61	66.75	68.93	-0.43	8.34	-0.61	11.90
550590019	Wisconsin	Kenosha	28	70.47	69.94	67.81	67.85	-0.53	7.61	-0.75	10.80
482010055	Texas	Harris	25	74.92	74.14	71.38	74.37	-0.78	6.61	-1.05	8.82
390271002	Ohio	Clinton	49	70.15	69.35	70.00	69.63	-0.79	7.01	-1.13	9.99
340130003	New Jersey	Essex	28	70.87	70.00	69.63	67.07	-0.86	5.74	-1.22	8.10
551010017	Wisconsin	Racine	20	70.74	69.79	68.19	66.46	-0.95	7.81	-1.34	11.04
482010046	Texas	Harris	26	73.17	72.16	73.63	73.82	-1.00	8.88	-1.37	12.14
421011002	Pennsylvania	Philadelphia	34	71.83	70.75	68.81	70.69	-1.07	6.49	-1.49	9.04
211850004	Kentucky	Oldham	53	71.00	69.91	68.88	68.52	-1.09	7.66	-1.53	10.78
220470012	Louisiana	Iberville	34	70.02	68.92	68.77	70.95	-1.10	8.52	-1.58	12.16
340150002	New Jersey	Gloucester	36	73.19	71.94	68.19	72.66	-1.25	7.91	-1.71	10.80
240259001	Maryland	Harford	45	72.24	70.92	69.75	69.73	-1.32	8.46	-1.83	11.71
482010024	Texas	Harris	40	70.83	69.49	69.81	70.95	-1.34	8.52	-1.90	12.03
220150008	Louisiana	Bossier	60	70.04	68.58	67.50	68.45	-1.46	7.38	-2.09	10.54
482010029	Texas	Harris	44	72.87	71.15	70.75	71.20	-1.72	7.50	-2.37	10.30
482011035	Texas	Harris	24	71.89	70.13	69.58	70.90	-1.76	9.52	-2.45	13.24
361030002	New York	Suffolk	34	73.00	71.04	68.48	68.11	-1.95	7.23	-2.67	9.90
261050007	Michigan	Mason	11	71.55	69.52	68.00	69.75	-2.02	8.40	-2.83	11.75
482010075	Texas	Harris	24	70.93	68.50	68.88	69.66	-2.43	7.54	-3.43	10.62
360850067	New York	Richmond	39	71.30	68.81	68.75	67.11	-2.49	7.98	-3.49	11.19
401430137	Oklahoma	Tulsa	64	70.99	68.31	69.00	68.61	-2.68	7.61	-3.78	10.71
482011039	Texas	Harris	29	73.17	70.40	72.63	69.80	-2.78	8.46	-3.79	11.56
482010051	Texas	Harris	26	75.40	72.51	73.56	72.08	-2.90	7.96	-3.84	10.55
401431127	Oklahoma	Tulsa	59	70.53	67.59	68.88	68.76	-2.94	8.58	-4.18	12.17
170317002	Illinois	Cook	19	70.25	67.21	67.25	73.11	-3.04	10.27	-4.33	14.62
481671034	Texas	Galveston	27	71.76	68.59	70.13	67.96	-3.17	8.32	-4.41	11.59
550710007	Wisconsin	Manitowoc	14	73.04	69.85	70.63	69.51	-3.18	8.83	-4.36	12.09

Site_ID	State	County	Number of Obs ≥60 ppb	Obs Mean (ppb)	Model Mean (ppb)	Obs Median (ppb)	Model Median (ppb)	Mean Bias (ppb)	Mean Error (ppb)	Normalized Mean Bias (%)	Normalized Mean Error (%)
180910005	Indiana	La Porte	36	71.08	67.87	69.81	66.79	-3.21	8.40	-4.51	11.82
390610006	Ohio	Hamilton	58	71.78	68.17	69.44	68.39	-3.60	10.31	-5.02	14.36
60170020	California	El Dorado	85	71.34	67.68	70.00	67.65	-3.66	7.42	-5.13	10.41
390610040	Ohio	Hamilton	61	70.08	66.28	67.75	66.81	-3.81	9.70	-5.43	13.84
421010024	Pennsylvania	Philadelphia	47	71.96	68.04	69.13	66.27	-3.92	6.78	-5.45	9.42
60656001	California	Riverside	100	77.15	73.14	76.56	73.49	-4.01	7.48	-5.20	9.69
260270003	Michigan	Cass	31	70.31	66.10	69.38	65.42	-4.21	7.31	-5.99	10.40
60371701	California	Los Angeles	44	72.86	68.54	71.31	69.48	-4.31	8.87	-5.92	12.17
360610135	New York	New York	19	71.72	67.37	71.88	66.19	-4.35	9.18	-6.06	12.79
261470005	Michigan	St Clair	22	70.26	65.49	68.25	65.17	-4.77	9.33	-6.79	13.28
482010026	Texas	Harris	28	71.62	66.81	69.06	68.09	-4.81	8.42	-6.71	11.75
60650012	California	Riverside	88	76.78	71.49	75.19	70.79	-5.29	9.85	-6.89	12.82
484393009	Texas	Tarrant	59	71.38	65.96	68.38	65.58	-5.42	9.22	-7.59	12.92
60610002	California	Placer	10	72.91	67.42	70.13	67.66	-5.49	6.62	-7.53	9.08
550790085	Wisconsin	Milwaukee	12	71.15	65.53	68.50	62.81	-5.62	10.72	-7.90	15.07
60371201	California	Los Angeles	84	70.99	65.20	67.27	65.25	-5.79	8.07	-8.16	11.37
360810124	New York	Queens	25	72.13	66.31	70.25	64.97	-5.82	8.88	-8.07	12.31
482011034	Texas	Harris	35	74.23	68.16	74.25	70.74	-6.07	9.40	-8.18	12.66
482450022	Texas	Jefferson	23	70.15	64.04	70.86	65.87	-6.11	7.16	-8.71	10.21
482450101	Texas	Jefferson	29	73.09	66.67	70.63	64.33	-6.42	8.40	-8.78	11.49
60610006	California	Placer	61	70.54	63.97	69.00	62.82	-6.57	9.40	-9.31	13.33
483550026	Texas	Nueces	16	71.29	64.65	69.56	64.28	-6.64	7.32	-9.32	10.27
60290232	California	Kern	105	71.88	65.09	71.25	64.05	-6.78	7.70	-9.44	10.71
484391002	Texas	Tarrant	34	71.34	64.43	69.44	64.96	-6.91	10.50	-9.68	14.72
60675003	California	Sacramento	67	71.06	64.00	69.25	61.38	-7.07	8.15	-9.94	11.48
551170006	Wisconsin	Sheboygan	26	72.94	65.79	67.19	63.45	-7.15	11.11	-9.80	15.23
482010070	Texas	Harris	26	75.14	67.72	73.94	68.52	-7.42	9.47	-9.87	12.60
60295002	California	Kern	83	74.34	66.83	73.00	66.19	-7.50	7.78	-10.09	10.47
480850005	Texas	Collin	66	72.91	65.38	70.19	65.95	-7.53	10.81	-10.33	14.83
60719004	California	San Bernardino	96	76.81	69.25	74.06	69.80	-7.56	10.14	-9.85	13.20
481211032	Texas	Denton	79	72.70	64.91	69.13	64.11	-7.80	9.42	-10.72	12.96
60670012	California	Sacramento	70	74.81	66.61	74.63	65.82	-8.20	10.86	-10.96	14.51
481210034	Texas	Denton	78	72.71	64.49	69.32	63.18	-8.22	9.65	-11.30	13.27
60990006	California	Stanislaus	76	70.88	62.56	69.38	62.52	-8.32	8.74	-11.73	12.34
60194001	California	Fresno	105	74.09	65.76	73.13	64.92	-8.33	9.00	-11.25	12.14
60290007	California	Kern	113	74.71	66.14	73.38	64.95	-8.58	9.14	-11.48	12.24
60290014	California	Kern	97	71.20	62.49	70.50	62.24	-8.71	9.07	-12.24	12.74
61072010	California	Tulare	115	74.82	65.67	73.88	65.52	-9.15	9.54	-12.23	12.75
60652002	California	Riverside	94	70.23	61.06	68.19	61.10	-9.18	10.18	-13.07	14.49
60710012	California	San Bernardino	117	73.66	64.33	72.38	64.01	-9.33	10.17	-12.66	13.81
480391004	Texas	Brazoria	32	78.43	69.07	77.56	67.74	-9.36	10.62	-11.93	13.54
481130069	Texas	Dallas	49	70.29	60.92	68.25	61.58	-9.38	11.40	-13.34	16.22
60655001	California	Riverside	121	73.17	63.73	71.43	63.85	-9.44	10.01	-12.90	13.68
400190297	Oklahoma	Carter	74	70.09	60.61	67.69	59.72	-9.48	10.40	-13.53	14.84
60658005	California	Riverside	107	73.84	64.23	71.63	64.32	-9.61	11.65	-13.02	15.78
60376012	California	Los Angeles	81	75.14	65.04	71.88	65.00	-10.11	11.56	-13.45	15.39
60190008	California	Fresno	92	73.11	62.88	71.75	61.72	-10.23	10.77	-13.99	14.72
60296001	California	Kern	88	70.44	60.10	70.06	59.60	-10.34	10.45	-14.67	14.84
61070006	California	Tulare	94	72.13	61.59	72.25	62.28	-10.54	10.80	-14.61	14.97
60470003	California	Merced	87	70.10	59.40	70.00	58.85	-10.71	11.11	-15.27	15.85

Site_ID	State	County	Number of Obs ≥60 ppb	Obs Mean (ppb)	Model Mean (ppb)	Obs Median (ppb)	Model Median (ppb)	Mean Bias (ppb)	Mean Error (ppb)	Normalized Mean Bias (%)	Normalized Mean Error (%)
483670081	Texas	Parker	58	71.28	60.34	68.88	59.30	-10.93	11.11	-15.34	15.58
60370016	California	Los Angeles	69	75.89	64.95	73.88	65.86	-10.94	12.67	-14.42	16.69
550790026	Wisconsin	Milwaukee	13	70.19	59.24	68.63	57.76	-10.95	11.79	-15.60	16.80
481130075	Texas	Dallas	58	72.64	61.64	69.94	62.00	-11.00	12.83	-15.14	17.67
60651016	California	Riverside	115	77.92	66.79	76.50	66.65	-11.14	12.31	-14.29	15.80
60379033	California	Los Angeles	120	74.75	63.16	74.50	62.99	-11.59	12.02	-15.51	16.08
484392003	Texas	Tarrant	76	74.37	62.48	70.44	61.99	-11.89	12.43	-15.99	16.72
60712002	California	San Bernardino	92	75.79	63.78	72.44	62.74	-12.02	13.39	-15.85	17.67
60195001	California	Fresno	101	75.78	63.75	74.33	62.55	-12.03	12.43	-15.87	16.41
60714001	California	San Bernardino	135	76.35	64.19	75.13	64.72	-12.16	13.06	-15.93	17.10
60290008	California	Kern	95	74.43	61.67	73.38	60.88	-12.76	12.76	-17.14	17.14
60719002	California	San Bernardino	122	75.09	62.06	74.25	61.89	-13.03	13.51	-17.35	17.99
60711004	California	San Bernardino	83	75.72	62.46	71.63	61.94	-13.26	14.56	-17.52	19.22
60311004	California	Kings	89	72.19	58.29	70.88	57.82	-13.90	13.95	-19.25	19.32
60390500	California	Madera	41	76.61	61.95	75.63	62.03	-14.66	14.69	-19.14	19.17
60710005	California	San Bernardino	125	81.70	66.31	82.00	65.63	-15.39	15.93	-18.84	19.50
60714003	California	San Bernardino	112	82.60	66.93	81.88	67.69	-15.67	16.29	-18.97	19.72
60658001	California	Riverside	120	79.04	63.29	76.25	63.29	-15.75	16.50	-19.92	20.87
60190242	California	Fresno	104	74.68	58.52	73.69	57.49	-16.15	16.15	-21.63	21.63
60190007	California	Fresno	106	76.21	59.75	74.63	59.09	-16.46	16.57	-21.60	21.74
61070009	California	Tulare	121	81.47	64.29	83.00	64.96	-17.18	17.18	-21.09	21.09

Source: http://www.epa.gov/airtransport/pdfs/Updated_2011_CAMx_Performance_Stats.xlsx). (Table is sorted on mean bias, highest to lowest).

3.2.4 Insufficient Model Resolution

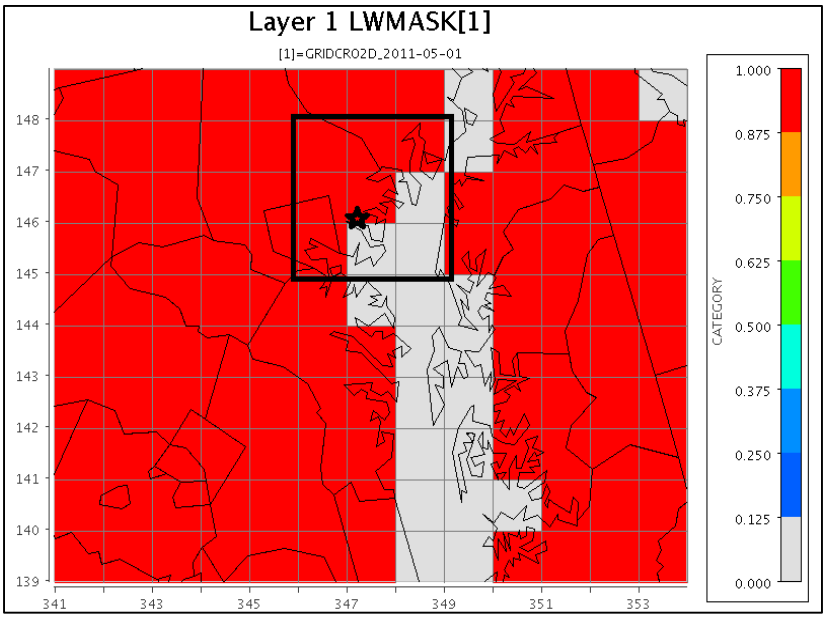
A model resolution of 12 km is unable to accurately resolve the Chesapeake Bay Breeze, which has large impacts on the modeled meteorological and air quality conditions at coastal monitors such as Essex. An examination of the Chesapeake Bay Breeze's effect on surface ozone for the Baltimore metropolitan area by He et al. determined that: "high-resolution (4 km or better) is necessary to predict accurately surface ozone for the Baltimore metropolitan area, and probably for other urban coastal areas where a bay breeze or sea breeze plays an important role in circulation and local air quality."[17] Based on C.P. Loughner et al., simulations at 4.5, 1.5, and 0.5 km resolutions produce more accurate 8 hour maximum ozone concentrations at locations near the Bay Breeze convergence zone compared to the 13.5 km resolution.[18] Studies from C.P. Loughner et al. found differences of 10 ppb between the 13.5 km and 0.5 km simulations over

[17] He et al., Atmospheric Environment 85 (2014) 18-30.
[18] C.P. Loughner et al., Atmospheric Environment 45 (2011) 4060-4072.

the Chesapeake Bay, which is supported by the fact that the mean error at the Essex monitor in the EPA's 2011 Ozone Model Performance statistics was 10.48 ppb.

3.2.5 Coastal Sites and the 3x3 Grid Cell Array

The EPA's methodology to calculate RRFs, future design values, and contributions uses ozone data for a 3x3 grid cell array around a monitor.[19] For coastal sites like Essex, a portion of the 3x3 cell array will capture grid cells that are over water. As seen in Figure 3-3, two of the nine grid cells within the array are almost entirely water cells, while another is predominantly a water cell. However, meteorological and air quality conditions over the water are not consistent with those over land, including at the Essex monitor.



Note: The star denotes the location of the monitor. Red cells are land, gray cells are water.

Figure 3-3. Land-Water Mask for Grid Cells Near the Essex, Maryland Monitor.

Oftentimes, photochemical air quality models such as CAMx and the Community Multiscale Air Quality (CMAQ) model produce higher concentrations of ozone over interior bodies of water including the Chesapeake Bay than over adjacent land. In July 2011, Goldberg et al. did an analysis of surface ozone concentrations over the Chesapeake Bay and compared them to model

[19] USEPA 2007, Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze, page 26. Available from http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf.

predictions.[20] They found that surface ozone concentrations were 10 to 20 percent higher over the bay than the closest upwind surface ozone monitors (such as Essex). The marine environment over the Chesapeake Bay is characterized by lower boundary layer heights and less cloud cover compared to adjacent land locations, which will tend to concentrate ozone precursors and promote more rapid ozone formation. Additionally, Goldberg et al. concluded that one of the primary reasons for the higher ozone concentrations measured over the Chesapeake Bay was due to "shallower boundary layers trapping shipping emissions near the surface" (p. 18). They concluded that the CMAQ model was able to accurately depict this local maximum in ozone concentrations; however, the concern is that this marine maximum is part of the 3x3 grid cell array for the Essex monitor and is not representative of the local land characteristics near the monitor. Much of the ozone within these water cells is formed locally and neighboring states have no ability to control the precursor emissions that result in the ozone formation in this area.

The inclusion of these water cells in the design value calculation, in tandem with the insufficient model resolution of 12 km used, helps explain the 10.48 ppb mean error in ozone prediction by the CAMx model for the Essex monitor. The DAQ reviewed the EPA's modeling files and determined that the water cells are indeed inflating ozone design value projections at the Essex monitor and should not be considered for ozone transport-related decisions. The following section discusses the DAQ's alternative approach to characterizing this performance issue.

3.2.6 CAMx Model Performance Analysis & Evaluation of Design Values for Different Array Approaches

Following its guidance, the EPA computed RRFs and future design values for a 3x3 grid cell array from modeling with a 12 km horizontal resolution.[21] The 3x3 grid cell array consists of the grid cell containing the monitor and the 8 grid cells immediately surrounding the monitor. The highest value within any of these grid cells on a given day in the base model run, and that same grid cell for the same day in the future model run, are used to calculate the RRF and associated design values. In the modeling technical support document for the NODA, the EPA reports model performance statistics for the single grid cell containing the monitor rather than the statistics associated with the maximum modeled concentration within the 3x3 grid cell array that

[20] Daniel L. Goldberg et al. / Atmospheric Environment 84 (2014) 9-19.
[21] EPA, 2014: *Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM2s, and Regional Haze*. Available from: http://www3.epa.gov/scram001/guidance/guide/Draft-O3-PM-RH-Modeling_Guidance-2014.pdf

the EPA used to calculate the RRF and associated design values.[22] The purpose of this discussion is to compare the model performance statistics for the 3x3 grid cell array and two alternative approaches that show much improved model performance for the Essex ozone monitor site. The approaches evaluated include the following:

- EPA's 3x3 grid cell array that includes grid cells over water (which are known to have elevated values of ozone, see Section 3.2.5)
- Modified 3x3 grid cell array that eliminates grid cells over water
- Single cell array focused on the grid cell housing the monitor

Figure 3-4 shows a time series comparing the daily maximum 8 hour ozone from the three approaches to observed ozone. Of the three approaches, the single cell approach tracked observations the best, followed closely by the modified 3x3 cell array. The EPA's 3x3 array clearly results in the poorest of the three approaches for predicting actual ozone concentrations for the Essex monitor.

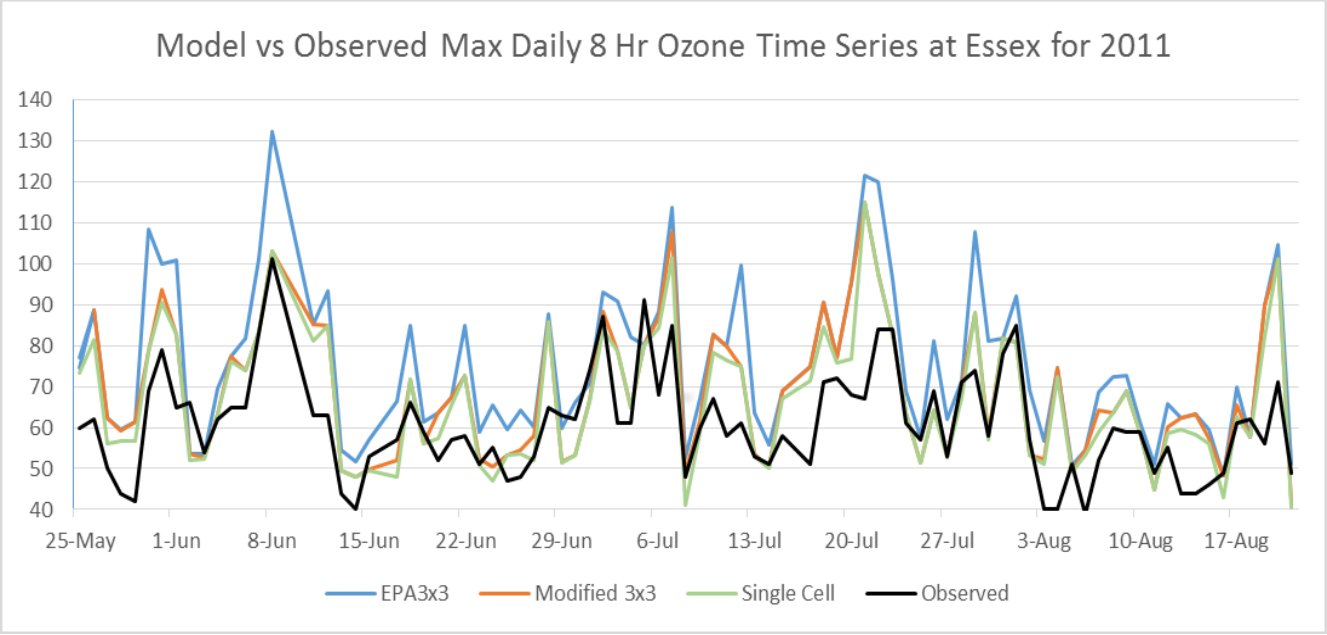


Figure 3-4. Time Series of Maximum Daily 8 Hour Ozone at the Essex Monitor for 2011

[22] Updated 8-Hour Ozone Model Performance Statistics by Monitoring Site for the 2011 Base Year CAMx Model Simulation, United States Environmental Protection Agency, July 2015, http://www3.epa.gov/airtransport/pdfs/Updated_2011_CAMx_Performance_Stats.xlsx

Table 3-7 presents the model performance statistics for the three approaches using the same criteria as the EPA for selecting the sample size to review (i.e., days at or above 60 ppb). The results of this analysis show that the mean bias and absolute error are much higher for the EPA's prescribed 3x3 array than for the modified 3x3 grid cell array that excludes the water cells or the single cell that contains the monitor. The single cell and the Modified 3x3 approaches have much lower bias and error compared to the recommended EPA 3x3 grid cell approach, and will provide more trustworthy RRF and future design values. Note that the statistical measures that the DAQ computed for the single cell containing the monitor (see Table 3-7) are slightly different than what the EPA computed (see Table 3-6). The DAQ used the truncated integer observed ozone value at the Essex monitor posted on EPA's website to calculate the mean bias and absolute error. It appears that the EPA used a non-truncated integer value to calculate mean bias and absolute error because the EPA-calculated observed value is about 0.5 ppb higher than the value the DAQ calculated using the truncated value. This difference in the observed values carries over into the DAQ's calculation of the mean bias and absolute error making it difficult for the DAQ to duplicate the EPA's calculations.

Table 3-7. Comparison of Model Statistical Performance at the Essex Monitor for Alternative Approaches

	EPA 3x3	Modified 3x3	Single Cell
Mean Bias (ppb)	16.98	8.87	7.26
Mean Absolute Error (ppb)	18.51	11.85	10.67
Normalized Mean Bias	24.3%	12.7%	10.4%
Normalized Mean Absolute Error	26.5%	17.0%	15.3%

Table 3-8 compares the design values at the Essex monitor using the EPA 3x3 methodology, the monitor grid cell (1x1) approach, and the modified 3x3 grid cell array which omits water grid cells. The future average and maximum design values using the two alternative approaches are statistically superior methods and show that the modeled contributions in 2017 to the Essex monitor are below the 76 ppb threshold.

Table 3-8. Comparison of Design Values at the Essex Monitor for Alternative Approaches

	Average 2009-2013 DV	**Max 2009-2013 DV**	**Base 2011**	**Future 2017**	**RRF**	**Future Average DV**	**Future Maximum DV**
EPA 3x3	80.7	84.0	111.0	100.8	0.908	73.3	76.3*
Modified 3x3	80.7	84.0	96.7	85.5	0.884	71.3	74.2
Single Cell	80.7	84.0	95.2	85.2	0.895	72.2	75.2

* The DAQ independently computed design values using the EPA's methodology. There is a discrepancy of 0.1 ppb between the DAQ calculated design value and the EPA design value.

3.2.7 Impact of Model Performance on Ozone Contributions

The EPA performed nationwide, state-level ozone source apportionment modeling using the CAMx OSAT/APCA technique (ENVIRON, 2014)[23] to quantify the contribution of 2017 base case NOx and VOC emissions from all sources in each state to projected 2017 ozone concentrations at ozone monitoring sites. CAMx OSAT/APCA model runs were performed for the period May 1 through September 30 using the projected 2017 base case emissions and 2011 meteorology for this time period. The hourly contributions from each state, contributions from Canada and Mexico, as well as initial and boundary contributions were tagged and processed to calculate an 8-hour average contribution metric (each entity is henceforth referred to as a "tag" in this document). The process for calculating the contribution metric uses the contribution modeling outputs in a "relative sense" to apportion the projected 2017 average design value at each monitoring location into contributions from each individual tag. This process is similar in concept to the approach for using model predictions to calculate 2017 ozone design values. The approach used to calculate the contribution metric is outlined in the EPA's technical support document[24] and described by the following steps:

Step 1. Modeled hourly ozone concentrations are used to calculate the 8-hour daily maximum ozone (MDA8) concentration in the 3x3 grid cell array over and surrounding a given monitor on each day.

Step 2. The gridded hourly ozone contributions from each tag are subtracted from the corresponding gridded hourly total ozone concentrations to create a "pseudo" hourly ozone value for each tag for each hour in each grid cell.

Step 3. The hourly "pseudo" concentrations from Step 2 are used to calculate 8-hour average "pseudo" concentrations for each tag for the time period that corresponds to the MDA8 concentration from Step 1. Step 2 results in spatial fields of 8-hour average "pseudo" concentrations for each grid cell for each tag on each day.

Step 4. The 8-hour average "pseudo" concentrations for each tag and the MDA8 concentrations are extracted for those 3x3 grid cell arrays over ozone monitoring sites. The EPA used the data for all days with 2017 MDA8 concentrations ≥76 ppb (i.e., projected 2017 exceedance days) in

[23] ENVIRON, 2014. User's Guide Comprehensive Air Quality Model with Extensions version 6.11, www.camx.com. ENVIRON International Corporation, Novato, CA

[24] Updated Air Quality Modeling Technical Support Document for the 2008 Ozone NAAQS Transport Assessment, August 2015. http://www3.epa.gov/airtransport/pdfs/Updated_2008_Ozone_NAAQS_Transport_AQModeling_TSD.pdf.

the downstream calculations. If there were fewer than five 2017 exceedance days at a particular monitoring site, then the data from the top five 2017 MDA8 concentration days are extracted and used in the calculations.

Step 5. For each monitoring site and each tag, the 8-hour "pseudo" concentrations are then averaged across the days selected in Step 4 to create a multi-day average "pseudo" concentration for tag at each site. Similarly, the MDA8 concentrations were average across the days selected in Step 4.

Step 6. The multi-day average "pseudo" concentration and the corresponding multi-day average MDA8 concentration are used to create a Relative Contribution Factor (RCF) for each tag at each monitoring site. The RCF is the difference between the MDA8 concentration and the corresponding "pseudo" concentration, normalized by the MDA8 concentration.

Step 7. The RCF for each tag is multiplied by the 2017 average ozone design value to create the ozone contribution metrics for each tag at each site. Note that the sum of the contributions from each tag equals the 2017 average design value for that site.

Table 3-9 shows the calculation of contributions from North Carolina to the Essex monitor, starting with step 4, above. The table includes the daily "pseudo" concentrations for North Carolina and the corresponding MDA8 ozone concentrations on those days with 2017 model-predicted exceedances at this site. The MDA8 ozone concentrations on these days are rank-ordered in the table. The 2017 average design value for the Essex monitor is 73.2 ppb. Using the data in Table 3-9, the RCF for North Carolina is calculated as:

$$(83.0261 - 81.9671) / 83.0261 = 0.01275 \text{ ppb}$$

The contributions from North Carolina to the 2017 average design value at the Essex monitor are calculated as:

$73.2 \times 0.01275 = 0.9336$ ppb, which is truncated to 0.93 ppb

Table 3-9. Calculation of 2017 Ozone Contributions from North Carolina to the Essex Monitor

Date	Predicted MDA8 Ozone for 2017 Modeled Exceedance Days	"Pseudo" 2017 8-Hr Ozone for North Carolina	Predicted 2011 MDA8 Ozone for 2017 Modeled Exceedance Days	2011 Observed (ppb)	Bias (ppb)	Normalized Bias (%)
7/21/2011	99.214	98.569	114.745	67	47.7	**71.3**
8/20/2011	94.810	92.603	101.266	71	30.3	**42.6**
6/8/2011	93.927	93.842	102.855	101	1.9	1.8
7/7/2011	89.274	89.087	101.532	85	16.5	19.4
7/22/2011	86.223	86.187	97.816	84	13.8	16.4
5/31/2011	80.742	80.735	90.549	79	11.5	14.6
7/29/2011	79.927	79.561	87.957	74	14.0	18.9
7/6/2011	79.285	79.209	84.329	68	16.3	24.0
6/9/2011	79.154	78.788	86.145	N/A*		
6/28/2011	77.981	77.246	85.916	65	20.9	32.2
6/1/2011	77.901	77.627	82.796	65	17.8	27.4
9/14/2011	77.215	76.682	75.322	58	17.3	29.9
6/7/2011	76.726	76.553	83.180	83	0.2	0.2
8/19/2011	76.696	69.700	82.057	56	26.1	**46.5**
7/18/2011	76.317	73.118	84.667	71	13.7	19.2
Multi-Day Average =>	83.0261	81.9671			15.3	23.7
2017 Average Design Value is 73.2 ppb (using EPA Guidance 3x3)	Relative Contribution Factor =>	0.01275				
	Contributions =>	0.9336				
	Truncated Contributions (ppb) =>	0.93				

* Observed ozone is unavailable for June 9.

Note that there are three days (July 21, August 19 and August 20, 2011) used in the contribution calculations that have particularly poor model performance (defined as a normalized bias of greater than 40 percent). The EPA notes in its photochemical modeling guidance[25] (page 102) that days with normalized bias greater than 20 percent should be examined for appropriateness, and also that days with bias greater than +/- 20 ppb may have a detrimental effect on design value calculations. Likewise, use of the days for which model performance is poor will

[25] Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 and Regional Haze - http://www3.epa.gov/scram001/guidance/guide/Draft-O3-PM-RH-Modeling_Guidance-2014.pdf.

significantly increase the uncertainty in the calculation of ozone contributions. For example, the observed ozone on August 19, 2011 was 56 ppb, while the 2011 model prediction was 82 ppb, an over-prediction of 26.1 percent. Incorporating these poor performing model days leads to the calculation of unrepresentative and unrealistic contributions. Table 3-10 shows the contributions to Essex if these three days are removed from the calculation of the RCF. The ozone contribution from North Carolina using the better performing model days is 0.45 ppb, which is less than the threshold established by the EPA as a significant contribution.

Table 3-10. Calculation of 2017 Ozone Contributions from North Carolina to the Essex Monitor Omitting Days with Normalized Bias >40 Percent

Date	Predicted MDA8 Ozone for 2017 Modeled Exceedance Days	"Pseudo" 2017 8-Hr Ozone for North Carolina	Predicted 2011 MDA8 Ozone for 2017 Modeled Exceedance Days	2011 Observed (ppb)	Bias (ppb)	Normalized Bias (%)
6/8/2011	93.927	93.842	102.855	101	1.9	1.8
7/7/2011	89.274	89.087	101.532	85	16.5	19.4
7/22/2011	86.223	86.187	97.816	84	13.8	16.4
5/31/2011	80.742	80.735	90.549	79	11.5	14.6
7/29/2011	79.927	79.561	87.957	74	14.0	18.9
7/6/2011	79.285	79.209	84.329	68	16.3	24.0
6/9/2011	79.154	78.788	86.145	N/A*		
6/28/2011	77.981	77.246	85.916	65	20.9	32.2
6/1/2011	77.901	77.627	82.796	65	17.8	27.4
9/14/2011	77.215	76.682	75.322	58	17.3	29.9
6/7/2011	76.726	76.553	83.180	83	0.2	0.2
7/18/2011	76.317	73.118	84.667	71	13.7	19.2
Multi-Day Average =>	81.223	80.720			14.0	20.8
2017 Average Design Value is 73.2 ppb (using EPA Guidance 3x3)	Relative Contribution Factor =>	0.00619				
	Contributions =>	0.4533				
	Truncated Contributions (ppb) =>	0.45				

* Observed ozone is unavailable for June 9.

The DAQ also calculated 2017 contributions for days with observed ozone ≥76 ppb in 2011 (see Table 3-11). The model performance for these days is well within the EPA's acceptable range of model performance. Using these days with actual ozone exceedances in 2011, North Carolina is estimated to contribute 0.04 ppb of ozone to the Essex monitor.

Table 3-11. Calculation of 2017 Ozone Contributions from North Carolina to the Essex Monitor Using Days with Observed Ozone ≥76 ppb in 2011

Date	Predicted 2017 MDA8 Ozone for 2011 Observed Exceedance Days	"Pseudo" 2017 8-Hr Ozone for North Carolina	Predicted 2011 MDA8 Ozone for 2011 Observed Exceedance Days	2011 Observed (ppb)	Bias (ppb)	Normalized Bias (%)
6/8/2011	93.927	93.842	102.855	101	1.9	1.8
7/5/2011	74.622	74.621	80.217	91	-10.8	-11.8
7/2/2011	75.353	75.353	83.802	87	-3.2	-3.7
7/7/2011	89.274	89.087	101.532	85	16.5	19.4
8/1/2011	73.200	73.193	80.687	85	-4.3	-5.1
7/22/2011	86.223	86.187	97.816	84	13.8	16.4
7/23/2011	73.189	73.153	82.766	84	-1.2	-1.5
6/7/2011	76.726	76.553	83.180	83	0.2	0.2
5/31/2011	80.742	80.735	90.549	79	11.5	14.6
7/31/2011	72.994	72.990	81.876	78	3.9	5.0
Multi-Day Average =>	79.625	79.571			5.8	7.0
2017 Average Design Value is 73.2 ppb (using EPA Guidance 3x3)	Relative Contribution Factor =>	0.00067				
	Contributions =>	0.0493				
	Truncated Contributions (ppb) =>	0.04				

In summary, the 2017 ozone contribution from North Carolina to the Essex monitor is 0.45 ppb after removing three days with poor model performance as directed by the EPA's photochemical modeling guidance. The contribution is much more statistically robust and defensible than the 0.93 ppb calculated by the EPA which includes days with poor model performance. For the set of days in 2011 for which the Essex monitor recorded actual ozone concentrations above 76 ppb, the projected ozone contribution from North Carolina to the Essex monitor is 0.04 ppb in 2017.

3.2.8 High Inter-Version Variability and Differences

The DAQ analyzed all modeled ozone contributors (i.e., states, biogenic, boundary, and tribal) to the Essex monitor, and found that North Carolina had the fifth highest increase of any modeled contributor from the 2018 v1 modeling to the 2017 v2 modeling results, going from 0.48 ppb to 0.93 ppb (see Table 3-12). The largest increase in contribution; however, was due to boundary conditions; this contribution increased by 2.38 ppb from the 2018 v1 modeling to the 2017 v2 modeling results. Additionally, the model boundary contribution at the nearby Padonia ozone monitoring site (located in the same county and 13.4 miles away from Essex) *decreased* by 1.73 ppb from the 2018 modeling to the 2017 modeling results. The DAQ believes these spatial and inter-version differences highlight the volatility within the modeling platform at the Essex monitoring site. Additionally, the modeled mean ozone for the 2011 base year increased from 76.16 ppb to 78.44 ppb from 2011 v1 to 2011 v2, respectively. Likewise the mean error – although significantly high in both runs – increased further from 9.66 ppb in the 2011 v1 modeling results to 10.48 ppb in the 2011 v2 modeling results (see Table 3-13).

The DAQ also reviewed the difference in contributions from North Carolina to all Maryland ozone monitors between the 2018 v1 modeling to the 2017 v2 modeling results (see Table 3-14). The 0.45 ppb increase at the Essex site was the largest increase in North Carolina's contribution to any Maryland ozone monitoring site from the 2018 v1 modeling to the 2017 v2 modeling results. By comparison, the contribution to the Padonia site only increased by 0.07 ppb, and the contribution to the nearby Edgewood ozone monitoring site decreased by 0.04 ppb.

Table 3-12. All CAMx-Modeled Source Contributions to Essex Monitor for 2017 v2 and 2018 v1

Contribution Source	2018 v1 Modeling	2017 v2 Modeling	Difference (2017 v2 – 2018 v1)*
Boundary	13.29	15.67	2.38
VA	3.31	4.70	1.39
KY	1.01	1.77	0.76
WV	1.99	2.65	0.66
NC	0.48	0.93	0.45
TN	0.37	0.67	0.30
MD	22.90	23.15	0.25
GA	0.10	0.27	0.17
DC	0.51	0.64	0.13
Biogenic	4.96	5.04	0.08

Note: The data, all in PPB, has been sorted by difference in contributions from 2018 version 1 to 2017 version 2.

Table 3-13. CAMx Model Performance Statistics for 2011 v2 and 2011 v1 modeling at the Essex monitor

CAMx Statistics	2011 v1 Modeling	2011 v2 Modeling	Difference (2011 v2 – 2011 v1)
Number of Observations ≥60 ppb	44	44	0
Observation Mean (ppb)	70.33	70.33	0
Model Mean (ppb)	75.15	77.12	1.967
Observation Median (ppb)	67.00	67.00	0
Model Median (ppb)	76.16	78.44	2.2795
Mean Bias (ppb)	**4.82**	**6.79**	**1.9675**
Mean Error (ppb)	**9.66**	**10.48**	**0.8215**

Table 3-14. EPA CAMx Modeling of North Carolina's Contribution to all Maryland Ozone Monitoring Sites for 2017 v2 and 2018 v1

Site ID	County	2018 v1 Modeling (ppb)	2017 v2 Modeling (ppb)	Difference (ppb, 2017 v2 – 2018 v1)
240053001	Baltimore	0.48	0.93	0.45
240290002	Kent	0.17	0.51	0.34
240030014	Anne Arundel	0.07	0.15	0.08
240051007	Baltimore	0.73	0.80	0.07
240430009	Washington	0.01	0.05	0.04
240330030	Prince George's	1.00	1.02	0.02
240130001	Carroll	0.29	0.30	0.01
240210037	Frederick	0.03	0.04	0.01
240259001	Harford	0.51	0.51	0.00
240170010	Charles	0.22	0.21	-0.01
240230002	Garrett	0.10	0.08	-0.02
240251001	Harford	0.50	0.46	-0.04
240338003	Prince George's	0.16	0.12	-0.04
240090011	Calvert	0.32	0.27	-0.05
240150003	Cecil	0.31	0.26	-0.05
240339991	Prince George's	0.98	0.81	-0.17
245100054	Baltimore (City)	1.60	1.21	-0.39
240313001	Montgomery	1.22	0.82	-0.40
240199991	Dorchester	3.06	2.06	-1.00

Note: The column at the right is the difference in contribution from version 1 to version 2, and the data is sorted by this column from largest increase to largest decrease.

3.2.9 Influence of Boundary Contributions on Design Value Uncertainty

As shown in Table 3-15, North Carolina's contribution represents only 1.2% of the total contribution to the 2017 projected design value for the Essex ozone monitor; thus, based on EPA's 1 percent threshold criterion, North Carolina's contribution would be considered significant. As previously discussed, the DAQ has identified several issues with the EPA's 2017 modeling analysis that suggest that North Carolina's actual contribution to the Essex monitor is likely below the 1 percent threshold. In addition, North Carolina's contribution is dwarfed by the contribution from initial and boundary contributions that attempt to account for emissions from international sources and stratospheric ozone intrusion not included in the modeling domain. As shown in Table 3-15, initial and boundary contributions account for nearly 21 percent of the 2017 projected design value for the Essex ozone monitor. Unlike US emissions sources, the EPA held 2011 base year emissions constant for 2017 for international sources. This is contrary to the widely recognized expectation that emissions from international sources will continue to increase in future years. The EPA's approach introduces further uncertainty into the modeling analysis and understates future year emissions and contributions to ozone from international sources.

Table 3-15. Contribution of Emissions Sources to 2017 Projected Maximum Design Value (DV) for the Essex Ozone Monitor[26]

Essex Monitor 2017 Projected Maximum DV (ppb)	NC's Largest Contribution to Essex Monitor (ppb)	Initial and Boundary Contribution (ppb)*	All Other Contributions Inside Modeling Domain (ppb)**	NC Contribution (% of Max. DV)	Initial and Boundary Contribution (%of Max. DV)*	All Other Contributions (%of Max. DV)**
76.2	0.93	15.76	59.51	1.2%	20.7%	78.1%

* Contribution to design value from sources outside of the modeling domain (i.e., international sources and stratospheric intrusion of ozone).

** Contribution to design value from all sources within the modeling domain except for North Carolina's contribution (i.e., individual state and tribal, Canadian and Mexican, offshore, wild and prescribed fire, and biogenic emissions sources).

[26] Reference: Data File with 2017 Ozone Contributions (Excel format) posted on the EPA's website for Transport for the 2008 Ozone NAAQS, July 2015-Notice of Data Availability, http://www3.epa.gov/airtransport/ozonetransportNAAQS.html.

3.3 Conclusions from 2017 EPA Modeling

All sites within North Carolina are predicted to be well below the 2008 ozone standard by 2017. North Carolina is not predicted to be a significant contributor to downwind ozone nonattainment in 2017. The EPA's modeling predicts North Carolina to be a significant contributor to downwind ozone maintenance in 2017 at a single site, specifically the Essex ozone monitoring site in Baltimore County, Maryland. For the reasons explained above and summarized below, the EPA's modeling analysis and its conclusions are flawed in linking North Carolina to a maintenance receptor.

Backward wind trajectories indicate little impact from North Carolina and are unsupportive of the modeled contributions. Additionally, the Essex site's recent design values indicate that it is currently in attainment of the 2008 ozone standard, but yet is modeled to be in nonattainment in 2017 while emissions are projected to further decrease by 2017. The use of more recent design value data does not support maintenance contributions from North Carolina. The accuracy of the model design value calculation at the Essex, Maryland monitor appears compromised by a combination of poor model performance, model volatility at the model boundary, and ozone-inflated water grid cells that were contained within the array used in the calculation. The key reason for the poor model performance is due to the model's inability to handle the complex land-sea boundary interactions that take place around the monitor; this is due to the 12 km model resolution being too large to resolve the microscale phenomena that characterize the Chesapeake Bay Breeze and resultant allocation of surface ozone at and around the Essex monitor. Additionally, modeled domain boundary ozone contributions varied greatly over short distances which the DAQ believes is an indicator of significant model volatility. Most importantly, the DAQ believes the projected design value at the Essex monitor was inflated by over-predictions in the water grid cell concentrations.

4.0 Trajectory Analysis

As part of our review of North Carolina's contributions to ozone levels measured at downwind states' ozone monitoring sites, the DAQ conducted a review of back trajectories using the HYSPLIT model on sites identified by the EPA's version 2 CAMx modeling as being having significant contributions from North Carolina. In this case, only one ozone monitor site was linked to North Carolina: Essex, Maryland.

4.1 Methodology

An additional analysis was conducted specifically for the Essex, Maryland ozone monitor site based on a linkage given by the EPA's projected year-2017 v2 modeling. These trajectories ended at six distinct heights above the ozone monitor at which the exceedances occurred: 10, 100, 500, 1000, 1500 and 2000 meters. The trajectory heights selected ensure that any impacts from the Mid-Atlantic coastal Low Level Jet (LLJ) were captured in our analyses, particularly when the LLJ was oriented from southwest to northeast. This LLJ can play an important role in air pollution transport in the Eastern U.S.[27]

The 2000 UTC hour, or 4 PM EST, was chosen as the end hour in the trajectory analyses because 2000 UTC generally represented the time of peak hourly ozone concentrations and it was near the middle of the 8-hour period that comprised each ozone exceedance. The next step in the analysis was to select any trajectories that crossed North Carolina's state boundary on any exceedance day based on the aforementioned criteria. The trajectory points each represented a temporal resolution of one hour. For the Essex monitor analysis, 34 exceedance days and trajectories for each height were analyzed between the years 2010-2014 (see Attachment C). No exceedances were observed in the years 2013 and 2014, thus the exceedances were limited specifically to 2010-2012. Of these 34 days, four were selected for further study.

4.2 Trajectory Analysis for Essex Monitor in Maryland

For each day that was analyzed in this study, the extent of each trajectory's fetch across North Carolina was scrutinized. Daily ozone values for monitoring sites upwind, within, and downwind of North Carolina were identified and utilized if possible to describe the state of the

[27] Ryan, William, 2004: The Low Level Jet in Maryland: Profiler Observations and Preliminary Climatology. Maryland DEP, 29 September 2004. Available from URL: http://www.mde.state.md.us/assets/document/AirQuality/BALT_OZONE_SIP/Appendix_G5.pdf.

air quality of the air parcel as it approached the Essex, Maryland ozone monitor site (see Attachment D, slides 13-66).

For the Essex monitor, the percentage of back trajectories analyzed relative to the total number of exceedances studied, in combination with the analysis of the trajectories that crossed North Carolina and the corresponding analyses of ozone monitoring data near the back trajectory paths, collectively showed strong evidence that North Carolina did not contribute significantly to a deterioration of air quality downwind at the Essex, Maryland monitor.

4.3 Ozone Transport Commission (OTC) Region Trajectory Analysis

As part of our review of North Carolina's contributions to ozone levels measured at downwind states' ozone monitoring sites, the DAQ also conducted a broader review of back trajectories using the HYSPLIT model on a number of downwind sites in the mid-Atlantic and northeast. This trajectory review was performed to provide additional evidence in support of North Carolina's Good Neighbor SIP. The ozone monitors considered in this analysis were selected based on the following criteria: (1) located in a projected 2018 nonattainment or maintenance area within a state participating in the OTC region (see Attachment A, Table 1 and 2), (2) located in a current nonattainment area, or (3) otherwise of geographical interest.

A total of 103 days were identified where one or more ozone exceedances occurred at one or more monitors between April 1, 2011 and June 15, 2015 (see Attachment D-1). In total, 552 trajectories were produced for each trajectory height level, each ending at 2000 Coordinated Universal Time (UTC) on the day of the given exceedance and extending 60 hours backward in time (see Attachment D-2, slide 4). Using the methodology for analyzing trajectories further as described in Section 4.1, there were 11 trajectories selected for further study at the 2000-meter level, 14 at the 1500-meter level, 17 at the 1000-meter level, 24 at the 500-meter level, 61 at the 100-meter level, and 65 at the 10-meter level (see Attachment D-2, slide 5). All 10, 100, 500, 1000, 1500 and 2000-meter back trajectories to exceeding monitors were mapped on the given day.

As was the case with the review of Essex, Maryland back trajectories, the extent of each trajectory's fetch across North Carolina was scrutinized for each day that was analyzed in this study. Daily ozone values for monitoring sites upwind, within, and downwind of North Carolina were identified and utilized if possible to describe the state of the air quality of the air parcel as it approached the studied monitor(s) in the OTC region (see Attachment D-2, slides 12-65).

The percentage of back trajectories analyzed relative to the total number of exceedances studied, in combination with the analysis of the trajectories that crossed North Carolina and the corresponding analyses of ozone monitoring data near the back trajectory paths, collectively showed strong evidence that North Carolina did not contribute significantly to a deterioration of air quality downwind in the Mid-Atlantic and Northeastern states.

Table 4-1 lists the number of exceedance days studied between April 1, 2011 and June 15, 2015 for each monitor site, the number of days in which any trajectory crossed a portion of North Carolina, and the number of days within the total days in which any trajectory crossed North Carolina where some contribution from North Carolina might have been possible.

Table 4-1. Exceedances and North Carolina (NC) Impacts

Monitoring Site	Total Exceedance Days	Days with Trajectories Crossing a Portion of NC	Days with Contribution from NC Possible
Ancona NJ	21	2	0
Babylon NY	21	2	0
Bristol PA	24	4	1
Clarksboro NJ	28	2	1
Danbury CT	18	4	1
E Hartford CT	16	3	2
E Providence RI	17	3	1
Edgewood MD	29	2	1
Essex MD	19	1	0
Fair Hill MD	27	6	1
Greenwich CT	36	6	2
Groton CT	24	6	1
Harrison Township PA	2	0	0
Lebanon PA	15	2	1
Madison CT	10	5	1
Middletown CT	31	5	2
New Haven CT	19	2	1
Newgarden PA	22	3	1
PG Eq. Ctr., MD	28	2	1
Philadelphia (BAX) PA	1	1	1
Philadelphia (NEA) PA	34	4	1
Stafford CT	20	6	2
Stratford CT	38	6	1
W Greenwich RI	8	2	1
Wagner NY	20	4	2
Westport CT	43	10	2

Moreover, the majority of the transport-level winds (e.g., 1-2 km) during days in which exceedances were observed in this region came from areas to the west of the OTC region; a density count of trajectory points from the studied heights indicated a corridor of elevated trajectory density values across states west of this region (see Attachment D-2, slides 6-11). At least one day within the studied period (e.g., 26 May 2011) appeared to feature a Mid-Atlantic coastal LLJ blowing northeastward across the Carolinas into Maryland and the Mid-Atlantic states. However, only one marginal exceedance was observed in southern Pennsylvania, downwind from both the Washington D.C. and Baltimore metro areas (see Attachment D-2, slides 12-19). In conclusion, the analysis shows that on days in which exceedances were observed over the OTC region in the Mid-Atlantic and Northeast, North Carolina did not significantly contribute to ozone levels that exceeded the 75 ppb Ozone NAAQS for monitors in the region.

5.0 Emissions Trends

Ozone formation is promoted by strong sunlight, warm temperatures, and light winds. High concentrations tend to be a problem in the eastern United States during the hot summer months when these conditions frequently occur. Therefore, the EPA requires seasonal monitoring of ambient ozone concentrations in North Carolina from April 1 through October 31 (40 CFR 58 App. D, 2.5).[28]

The DAQ has examined both the man-made and natural sources of VOC emissions and their contribution to ozone formation in North Carolina. Because of the generally warm and moist climate of North Carolina, vegetation abounds in many forms, and forested lands naturally cover much of the state. As a result, the biogenic sector is the most abundant source of VOCs in North Carolina and accounts for approximately 90 percent of the total VOC emissions statewide. The overwhelming abundance of biogenic VOCs makes the majority of North Carolina a NOx-limited environment for the formation of ozone. This is supported by a study published in the Journal of Environmental Management that concludes that the sensitivity of ozone to anthropogenic VOC emissions in the Southeastern United States is 2-3 orders of magnitude smaller than the sensitivity of ozone to NOx emissions, primarily due to the abundance of biogenic VOC emissions in this region.[29] As a result, controlling anthropogenic VOC emissions in the Southeast is far less effective than controlling NOx emissions for purposes of reducing ozone levels.

Figures 5-1 and 5-2 illustrate the annual NOx and VOC emissions inventory for 2002 and 2011. Emissions from all sectors have declined dramatically, particularly in the EGU and onroad sectors.

[28] 40 CFR 58 App. D, 2.5.

[29] Odman, M Talat et al., *Quantifying the sources of ozone, fine particulate matter, and regional haze in the Southeastern United States,* 90 Journal of Environmental Management 3155-3168 (2009).

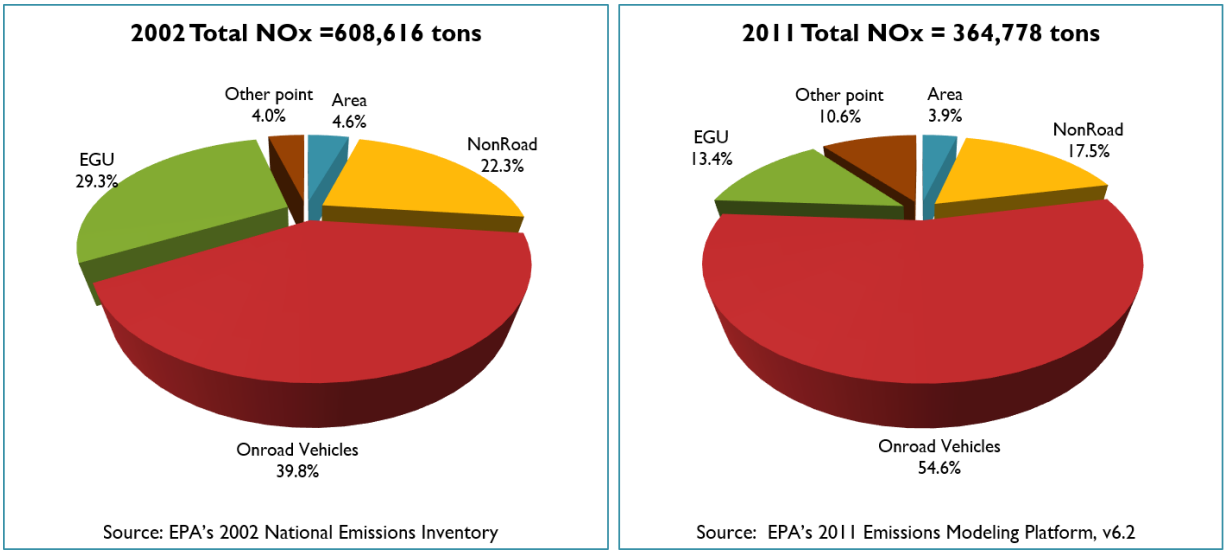


Figure 5-1. North Carolina NOx Emissions in 2002 and 2011.

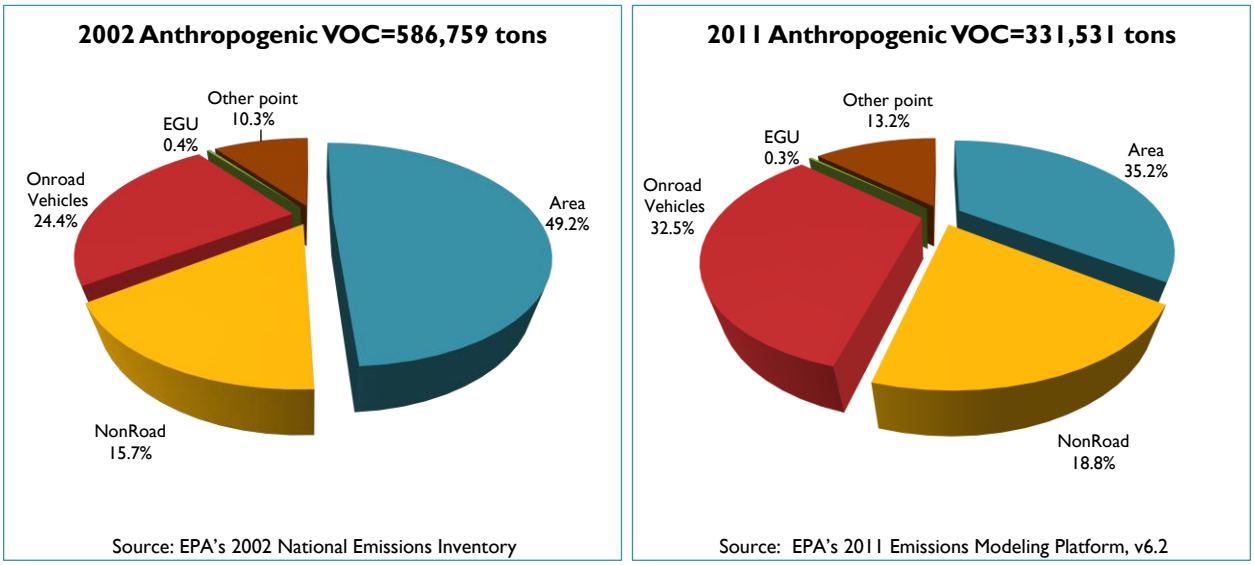


Figure 5-2. North Carolina Anthropogenic VOC Emissions in 2002 and 2011.

5.1 Future Statewide Emissions Trends

The DAQ relied on currently available EPA datasets and the state's best understanding of emissions levels for available forecast years to examine emission trends and their impact to ozone transport. Table 5-1 provides a summary of North Carolina's annual NOx emissions by sector for the base year 2011 and two forecast years: 2017 and 2018. Table 5-2 provides a comparison of the 2011 base year inventory to each of the forecast year inventories to show the percent change in annual NOx emissions by sector. The Table 5-1 values display the following:

- EPA's latest 2011 and 2017 NOx emission estimates from their latest EMP, which was released in August 2015 and used in 2017 air quality modeling analysis (discussed in Section 3 of this SIP); and
- EPA's 2018 NOx emission estimates as reported in their previous EMP, which was released in November 2014 and used in 2018 air quality modeling analysis (discussed in Section 2 of this SIP).

The 2011 base year and 2017 forecast year emissions are from the EPA's 2011 NEI v2-based EMP, which the EPA abbreviates as "2011 v6.2."[30,31] The EPA's 2018 preliminary modeling, which is discussed in Section 2 of this SIP, is based on the previous version of its EMP (Ozone NAAQS EMP, which is abbreviated as "2011 v6.1") for which the EPA provided an emissions forecast for 2018.[32]

Overall, the EPA projects NOx emissions to decline by about 36 percent from 2011 levels by 2017. Relative to the previous 2018 forecast, the current EPA forecast estimates 2017 NOx emissions to be lower by about 8 percent statewide. However, there are much more significant differences at the sector level which could form different conclusions regarding transport related contributions. The DAQ is especially concerned with the 41 percent higher EGU NOx emissions in 2017; the DAQ's concerns with the 2017 estimates for the EGU sector are discussed in more detail in the following section.

[30] EPA's 2011 NEI v6.2-based Platform (2011v6.2) is located at ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform/reports/2011eh_state_fullSCC_summary.xlsx.
[31] EPA's 2017 v6.2 modeling platform emissions summary is located at: ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform/reports/2017eh_cb6v2_v6_11g_state_sector_totals.xlsx.
[32] EPA's Ozone NAAQS Emissions Modeling Platform (2011 v6.1). Used in the EPA's 2018 preliminary modeling analysis (see Section 2).

Table 5-1. North Carolina Annual NOx Emissions Trends by Sector (tons/year)

Sector	EPA 2011 v6.2	EPA 2017 v6.2	EPA 2018 v6.1
Point EGU	48,813	49,538[33]	34,946
Point Non-EGU[34]	38,604	40,882	52,115
Area[35]	14,193	13,628	25,482
Onroad	199,289	84,693	102,023
Nonroad	63,879	45,938	40,356
Totals	**364,778**	**234,679**	**254,922**
Reduction from EPA 2011 v6.2		**36%**	**30%**

Table 5-2. Comparison of Changes in Annual NOx Emissions by Sector*

Sector	2011 v6.2 vs. 2017 v6.2	2017 v6.2 vs. 2018 v6.1
Point EGU	1.5%	41.8%
Point Non-EGU	5.9%	-21.6%
Area	-4.0%	-46.5%
Onroad	-57.5%	-17.0%
Nonroad	-28.1%	13.8%
Totals	-35.7%	-7.9%

* For ozone transport modeling purposes, the EPA's 2017 v6.2 emissions forecast replaces its 2018 v6.1 forecast.

5.1.1 EPA Electricity Generating Unit (EGU) Emission Forecasts

For EGU's, the EPA prepared the 2018 v6.1 emissions forecast using the Integrated Planning Model-National Electric Energy Data System version 5.13 (IPM-NEEDS v5.13).[36] The DAQ conducted an extensive review of the NEEDS v5.13 data base and submitted its revised data base for North Carolina's EGU fleet to the EPA. The EPA released the NEEDS v5.14 data base and documentation on March 25, 2015 for public review and comment.[37] The EPA incorporated many of the DAQ's comments into its revised data base (NEEDS v5.14) but missed some key

[33] Note that the DAQ's estimate of 2017 EGU emissions for Duke Energy and 2017 EGU emissions from non-Duke Energy EGUs is even lower than the EPA's total 2017 EGU estimate (48,132 tons versus 49,538 tons). At a plant level, Duke Energy's projections show substantially different plant-level emissions versus EPA's projections (e.g., Roxboro: EPA = 10,458 tons; Duke = 7,767 tons).
[34] For the point non-EGU sector, the large discrepancy between v6.1 and v6.2 emission estimates is generally caused by the EPA incorporating the DAQ's 2011 emission estimates for the prescribed burning and wildfire categories in v6.2 (the v6.1 total non-EGU point source emission estimate for 2011 was 49,582 tons/year).
[35] For the area (nonpoint) sector, the large discrepancy between v6.1 and v6.2 emission estimates is primarily a result of the EPA incorporating the DAQ's 2011 emission estimates for the industrial, commercial, institutional fuel combustion categories in v6.2 (unlike the EPA's v6.1 estimates, the v6.2 estimates incorporated the effect of point source subtractions).
[36] EPA's Power Sector Modeling Platform v.5.13, http://www.epa.gov/airmarkets/programs/ipm/psmodel.html.
[37] EPA's Power Sector Modeling Platform v.5.14, http://www.epa.gov/powersectormodeling/psmodel514.html.

revisions and changed some assumptions that resulted in a generation forecast that does not align with recent past and expected future trends in North Carolina's generation mix. The DAQ prepared and submitted additional comments to the EPA on June 9, 2015 for North Carolina's EGUs (provided in Attachment E to this SIP); however, the EPA did not incorporate the requested changes before releasing the 2017 transport modeling results (discussed in Section 3 of this SIP). Consequently, the EPA's 2017 transport modeling is based on an EGU forecast that overstates NOx emissions for North Carolina.

Subsequently, on August 3, 2015 the EPA released IPM-NEEDS v5.15 that it used to support modeling for the Clean Power Plan.[38] This new forecast yields EGU NOx emissions estimates for 2016 and 2018 that are closer to what the DAQ expects based on forecast data provided by Duke Energy. As shown in the following discussion, the EPA has produced three conflicting EGU forecasts; two of which EPA used in its draft 2017 and 2018 transport modeling. The fact that the highest EGU forecast is causing transport related linkages brings into question the reliability of the EPA's EGU emissions estimates and ozone contributions.

Concerns with IPM-NEEDS v5.14 EGU Forecast used in 2017 Transport Modeling

Comparison of IPM-NEEDS Forecasts: Table 5-3 compares NOx emissions for North Carolina's EGU fleet for the EPA's three separate IPM-NEEDS forecasts. Based on this comparison, it is clear that the IPM-NEEDS 5.14 forecast that the EPA used in its 2017 transport modeling significantly overestimates NOx emissions as compared to the IPM-NEEDS 5.13 that the EPA used in its initial transport modeling that demonstrated that North Carolina did not have any significant contributions to ozone problems in other states. In addition, the EPA most recent IPM-NEEDS 5.15 forecast for the Clean Power Plan forecasts emissions to be even lower than its IPM-NEEDS 5.13. The DAQ believes that the previous IPM-NEEDS 5.13 and most recent IPM-NEEDS 5.15 forecasts more accurately reflect future year NOx emissions for North Carolina's EGU fleet. At this time it is clear that for the IPM-NEEDS 5.15 forecast the EPA did not incorporate the DAQ's requested revisions to the NEEDS 5.14 database. The DAQ will review the IPM-NEEDS 5.15 forecast when the EPA provides the detailed data files for public review.

[38] EPA's Power Sector Modeling Platform v.5.15, http://www.epa.gov/airmarkets/programs/ipm/psmodel515.html.

Table 5-3. Comparison of Three Recent IPM Forecasts of Annual NOx Emissions for North Carolina EGUs (thousand tons)

IPM-NEEDS Version	2016	2017	2018	2020	2025	2030	2040	2050
v5.13[a]	34.4	**36.1***	37.7	41.4	43.4	44.8	41.4	49.3
v5.14[b]	50.1	**49.5**	49.5	46.3	49.3	47.7	45.6	51.2
v5.15[c]	31.3	**33.4***	35.5	29.4	26.7	27.7	16.4	17.6
%Changes (v5.14 vs. 5.13)	31%	**27%**	24%	11%	12%	6%	9%	4%
%Changes (v5.14 vs. 5.15)	38%	**33%**	28%	37%	46%	42%	64%	66%

* Interpolated value using 2016 and 2018 modeled values because the EPA did not provide 2017 emissions in its data summary file.

a. Used in the EPA's draft 2018 transport modeling analysis, January 22, 2015 (see Attachment A).

b. Used in the EPA's revised draft 2017 transport modeling analysis, July 23, 2015 (see Attachment A).

c. Used in the EPA's Clean Power Plan modeling, August 3, 2015 see http://www.epa.gov/airmarkets/programs/ipm/cleanpowerplan.html.

Generation Mix: The IPM-NEEDS v5.14 forecast does not accurately reflect current and future trends in the generation mix for North Carolina. This incorrect modeling of some of Duke Energy's coal and natural gas plants results in significant increases in NOx emissions relative to the previous modeling forecast. The IPM-NEEDS v5.14 forecasts that coal will provide 84 percent of the fossil fuel base load electricity generation in 2017 or 2018, which is a significant shift from current day operations where coal only provides 64 percent of the fossil fuel base load generation (as of December 2014). Since 2011, Duke Energy has built 2,782 megawatts (MW) of new natural gas combined cycle units and these units are all operating at 60 to 70 percent of their annual capacity. In addition, in November 2014 Duke Energy provided the DAQ with its latest forecast to 2030 and it does not indicate an increase in coal use, but rather a steady decline in coal generation. This trend is also reported in Duke Energy's latest Integrated Resource Plan to the North Carolina Utilities Commission.[39]

Coal-Plant-Specific Errors: The DAQ has identified errors in the EPA's assumptions and the NEEDS v5.14 input data for three coal-fired plants (GG Allen, Marshall, and Roxboro) which are summarized here.

a. Roxboro Units 1, 2, 3A, 3B, 4A, and 4b: The EPA accidentally revised the heat rates at these coal-fired units to 14,900 British thermal units per kilowatt hour (Btu/kWh) based

[39] Duke Energy Progress Integrated Resource Plan (Annual Report), September 1, 2014, http://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=badec175-5e4f-4bea-a267-80e113db8c16. Duke Energy Carolinas Integrated Resource Plan (Annual Report), September 1, 2014, http://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=c3c5cbb5-51f2-423a-9dfc-a43ec559d307.

on comments pertaining to a wood fired unit located in Roxboro, North Carolina. Actual heat rates for the Roxboro units range from 10,051 Btu/kWh and 10,352 Btu/kWh.

b. GG Allen Units 1, 2, 3, 4 and 5: Currently, all five coal units are operating 3% to 4% of the time during the ozone season and are equipped with selective non-catalytic reduction (SNCR) NOx controls. The EPA's IPM-NEEDS v5.14 modeling for 2017 shut down Units 1, 2, and 5. For Units 3 and 4, the EPA's IPM-NEEDS v5.14 modeling replaced SNCR with selective catalytic reduction (SCR), significantly increased coal generation for these two units, and applied an uncontrolled NOx rate of 0.36 pound per million British thermal unit (lb/MMBtu) to model post-SCR controlled NOx emissions. As a result, the IPM modeling caused many issues that significantly increased emissions for this plant. Duke Energy has not indicated that it plans to discontinue operation of any of the units by 2017. Under a recent consent decree agreement between the EPA and Duke Energy Corporation, by 2016 Duke must operate the existing SNCR controls for Units 1 and 2 continuously and comply with a 365-day rolling average NOx emission rate of 0.250 lb/MMBtu and a NOx tonnage cap of 600 tons per year. Duke Energy's forecast for all of Allen's units is 2,133 tons of NOx for 2017. The EPA's 2017 v2 estimates Allen's emissions for all units at 6,120 tons of NOx, which is much greater than the amount projected by the utility. The consent decree also requires Duke Energy to permanently shut down Units 1, 2, and 3 by December 31, 2024.[40]

c. Marshall Units 1 and 2: The IPM forecast retires these units as a result of the SCR retrofit at GG Allen. According to Duke Energy's May 19, 2015 forecast, these coal units will not be retired.

Table 5-4 shows North Carolina coal-fired plant 2017 NOx emissions based on Duke Energy's May 18, 2015 forecast, EPA's 2017 projection based on v5.14, and their difference. The EPA's 2017 NOx emissions forecast for all of North Carolina's coal-fired EGUs is 2,860 tons more than the forecast that Duke Energy submitted to the DAQ. At the plant level, the EPA projected much higher NOx emissions for Allen (3,987 tons) and Roxboro (2,691 tons) and much lower NOx emissions for Marshall (-5,104 tons) and Belews Creek (-1,817 tons) than the Duke Energy forecast. It is not clear how this shift will impact the modeling results for interstate transport contributions.

[40] Consent decree between the United States of America on behalf of the US EPA and Duke Energy Corporation, Civil Action No.: 1:00 cv 1262, September 10, 2015, see http://www2.epa.gov/enforcement/duke-energy-corporation-clean-air-act-caa-settlement.

Table 5-4. North Carolina Coal-Fired Plants 2017 NOx Emissions Comparison (tons/year)

Plant	EPA EMP v2 2011	Duke Forecast 2017	2017 IPM-NEEDS v5.14	2017 Difference (EPA-Duke)
Allen	4,401	2,133	6,120	3,987
Roxboro	6,788	7,767	10,458	2,691
Mayo	1,510	2,285	4,088	1,803
Cliffside	710	1,800	2,908	1,108
Asheville	1,037	999	1,190	191
Belews Creek	4,002	7,357	5,540	-1,817
Marshall	9,086	12,850	7,746	-5,104
Retired since 2011	**11,751**			
Total	**39,285**	**35,191**	**38,051**	**2,860**

5.1.2 EGU Emission Trends

As noted earlier, NOx emissions from the EGU sector have declined dramatically in North Carolina. These reductions are primarily due to North Carolina's landmark legislation called the CSA which set entity-wide caps on the total annual emissions of NOx and SO_2 from investor-owned coal-fired EGUs.[41] The CSA emissions limits were set at 56,000 tons/year for NOx by 2009 and thereafter and 250,000 tons/year for SO_2 by 2013 and thereafter. This means that, relative to 1999 levels, coal-fired EGUs must achieve a 77 percent reduction in NOx emissions and a 73 percent reduction in SO_2 emissions by 2013. These limits have been adopted into the North Carolina SIP and are federally enforceable. An important feature of the CSA is that North Carolina's two largest utility companies, Duke Energy and Progress Energy (recently merged to form Duke Energy Progress), must achieve these cuts through actual reductions at their 14 EGU facilities in the state.

By 2014, seven remained as coal plants while four plants were converted to natural gas and three smaller plants were retired. The seven remaining coal plants were retrofitted with selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) technologies for NOx control. SCR is the most efficient technology available to control NOx emissions and is in place at all but seven units. Table 5-5 summarizes the current emission controls at each of the seven operating coal plants.

As of calendar year 2014, statewide NOx emissions from the affected units continue to be below the CSA limit. In 2014, annual NOx emissions level was 34,847 tons, which is well below the

[41] Clean Smokestacks Act, 2002 N.C. Session Law 72 (codified as amended at N.C. General Statutes §§62-133.6 and in other sections of ch. 143, article 21B (2011).

56,000 tons annual limit. Furthermore, EGU-related NOx emissions levels during the ozone season have been below the 2012 CSAPR emissions limit which was put on hold during the extended litigation period. North Carolina is well positioned to comply with the Phase I CSAPR limit which took effect on January 1, 2015.

In addition to the early installation of emission control technologies, North Carolina's power plants are ahead of the nation in transitioning from coal to natural gas and renewable resources. Between the period of 2002 and 2012, electricity generation from coal plants declined from 62 percent to 45 percent; while the generation from natural gas increased from 2 percent to 15 percent. Figure 5-3 illustrates the resulting change in NOx emission levels from the electric utility sector. This trend is expected to continue into the future, with further reduction in coal capacity utilization. Figure 5-4 illustrates the current projected NOx emission levels for the major electric power plants in the state.

Table 5-5. Current Air Pollution Controls at North Carolina's Coal Plants

Facility	Units	NOx Controls	SO2 Controls	PM2.5 Controls	Mercury Controls
GG Allen	1, 2, 3, 4, 5	SNCR	FGD	ESP/ Wet Scrubber	SCR/ESP/ Wet Scrubber
Asheville	1, 2	SCR			
Belews Creek	1, 2	SCR			
Cliffside	5	SCR			
	6			Fabric filter/ Wet scrubber	SCR/Spray dryer/ Fabric filter/Wet Scrubber
Marshall	1, 2, 3, 4	SCR/SNCR		ESP/ Wet Scrubber	SCR/ESP/ Wet Scrubber
Mayo	1A, 1B	SCR			
Roxboro	1, 2, 3, 4				
Total	21				

SCR: selective catalytic reduction
SNCR: selective non-catalytic reduction
FGD: flue gas desulfurization
ESP: electrostatic precipitation

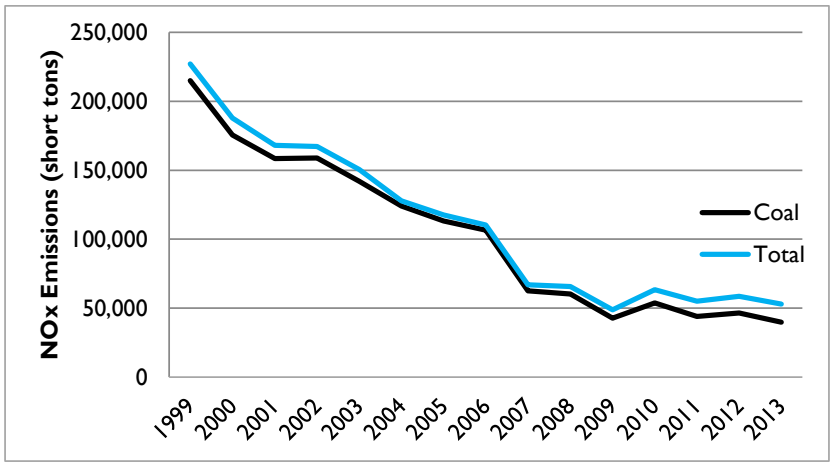


Figure 5-3. Power Plant Related Emission Trends (1999-2013).

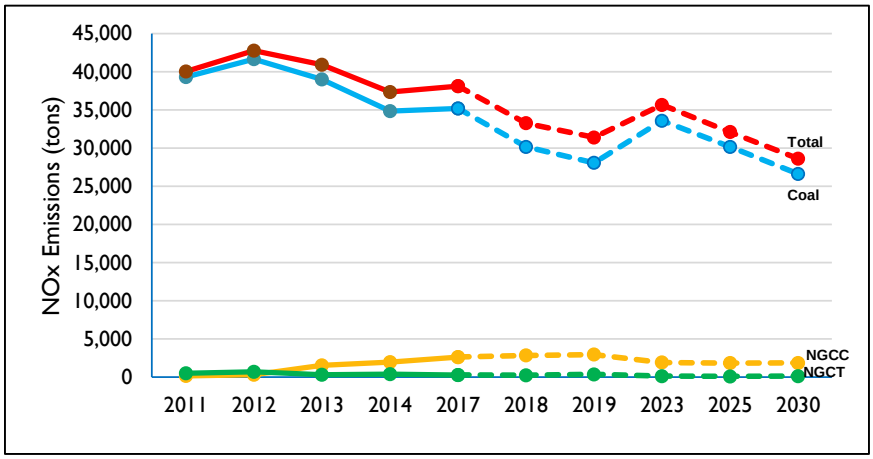


Figure 5-4. Projected Power Plant Related Emissions (2017-2030).

EGU Related NOx Emission Rate

Several Mid-Atlantic and Northeast states have expressed strong concerns about their inability to attain the 2008 ozone NAAQS due to ozone transport and due to the delayed implementation of a federal transport rule. On December 9, 2013, the Ozone Transport Commission (OTC) filed Section 176A petition under the CAA to add nine states to the Ozone Transport Region (OTR), which included North Carolina. [42] The primary argument cited in the petition is that states outside and upwind of the OTR "are not required to install and generally do not impose controls

[42] Petition to the U.S. Environmental Protection Agency for the Addition of Illinois, Indiana, Kentucky, Michigan, North Carolina, Ohio, Tennessee, Virginia, and West Virginia to the Ozone Transport Region Established Pursuant to Section 184 of the Federal Clean Air Act As Permitted by Section 176A of the Federal Clean Air Act, See http://www.ct.gov/deep/lib/deep/air/176a/Petition_2013Dec9.pdf, (accessed February 2015).

as stringent as those required of OTR-state sources". The EPA has 18 months to approve or disapprove the petition.

A key argument made by the OTC states is that power plants equipped with SCR controls had higher NO_x emission rates from 2011-2013 ozone seasons. In a June 13, 2013 statement from the OTC, it was noted that "OTC's evaluation of recent continuous emissions monitoring data shows that some EGUs equipped with NO_x controls are either not operating or are limiting the operation of their existing air pollution control devices."[43] Our review of the Clean Air Markets Division data showed that NO_x emissions rates are increasing for most EGUs in North Carolina. However, we do not agree on 1) the reasons for the increases or 2) the impact of NOx rate increases on downwind states as discussed below.

Figure 5-5 illustrates the trends in ozone season NO_x emission rates (tons emitted per million Btu heat input) for the seven coal-fired facilities currently operating in North Carolina. The state-wide average NO_x rate during the 2002 ozone season was 0.37 lb/MMBtu (pound per million Btu), and reached the lowest level in 2009 at 0.09 lb/MMBtu after NO_x controls were added under the CSA. After 2010, the statewide average NOx rate increased each of the following years to the current level of 0.16 lb/MMBtu. Since 2009, NO_x rates have increased specifically at the following facilities; Allen, Marshall, Mayo and Roxboro (see Table 5-6).

[43] Statement from the Ozone Transport Commission Requesting the Use and Operation of Existing Control Devices Installed at Electric Generating Units, See http://www.otcair.org/upload/Documents/Formal%20Actions/Statement_EGUs.pdf, (accessed February 2015).

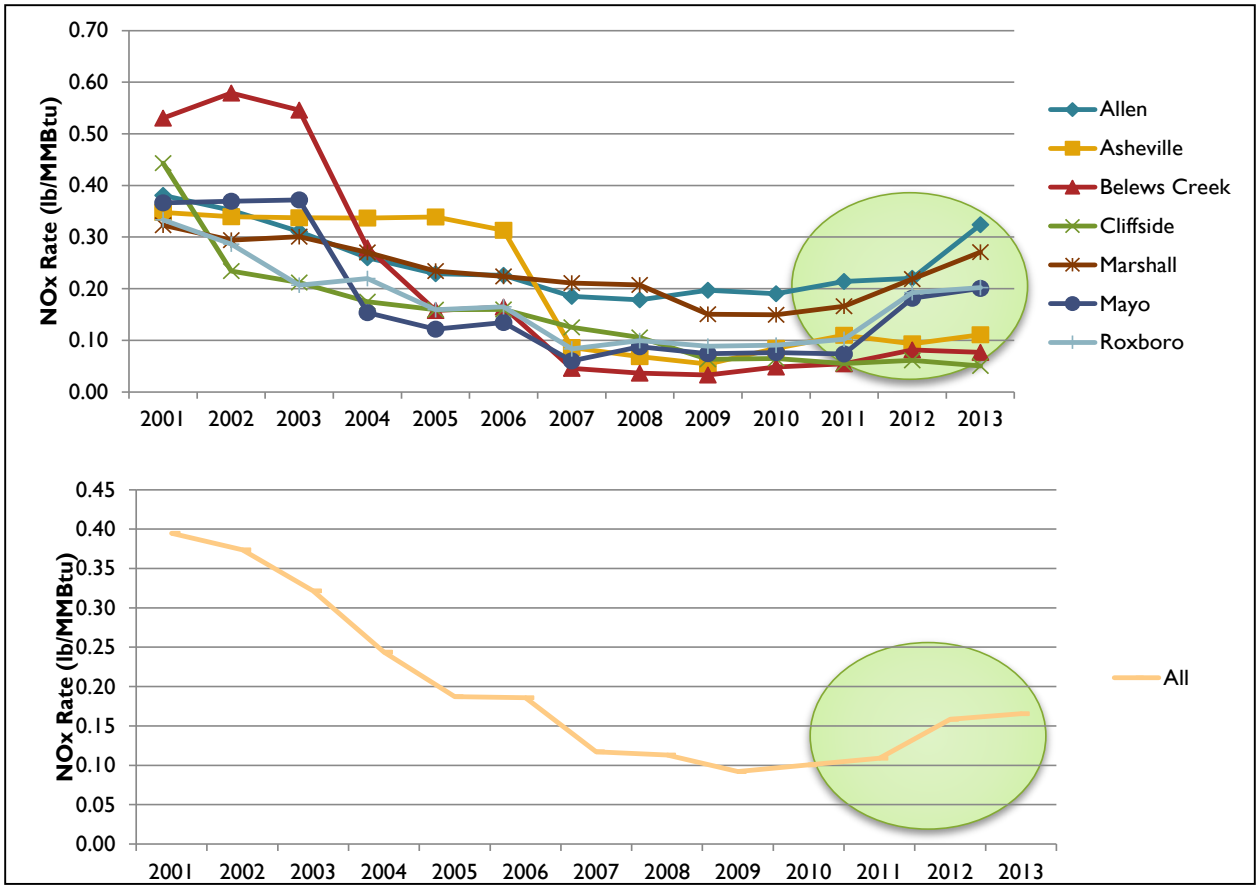


Figure 5-5. Ozone Season NO_x Rate (lb/MMBtu).

Table 5-6. Reductions in NOx Rate, NO_x Emissions and Heat Input from 2002 to 2012

Facility Name	2002			2012			Percent Reduction		
	Average NO_x Rate (lb/MMBtu)	NO_x (tons)	Heat Input (MMBtu)	Average NO_x Rate (lb/MMBtu)	NO_x (tons)	Heat Input (MMBtu)	Average NO_x	NO_x Emissions	Heat Input
G G Allen	0.38	9,018	47,932,588	0.23	2,297	20,199,556	40%	75%	58%
Marshall	0.31	19,170	124,783,020	0.23	11,027	96,126,862	25%	42%	23%
Mayo	0.37	9,710	52,674,734	0.16	2,968	37,234,175	57%	69%	29%
Roxboro	0.32	23,656	145,590,652	0.18	13,068	141,877,409	43%	45%	3%

Based on the observed increases in NOx rates, Maryland has stated that "many EGUs appear to not be running their controls during the ozone season because of recent changes in the energy market, reduced coal capacity and inexpensive allowances."[44] In reference to North Carolina EGU NO_x emission rates, it was stated that specific units are not running controls in later years.

Despite an increase in the NO_x emissions rate from 2009 to 2013, North Carolina has still reduced its state-wide emission rate by 57 percent from the 2002 uncontrolled rate to the 2013 rate. Secondly, the tons of NO_x emitted annually has dropped by 75 percent since 2002, as discussed earlier. The significant reductions in both NO_x emissions and NO_x emissions rates are due to the installation and operation of SCR and SNCR on North Carolina's coal-fired power plants.

To further address concerns regarding NO_x controls, the DAQ conducted an extensive review of hourly emissions and operating data for each of North Carolina's coal-fired power plants. Our review confirmed that North Carolina coal-fired EGUs are consistently operating NO_x controls year round. For one plant, we discovered that the ozone season SCR NOx removal efficiency had dropped from 70 percent to 50 percent between 2011 and 2013. In its most recent release of the Integrated Planning Model – NEEDS v5.14, the EPA evaluated the operational status of EGU controls throughout the ozone transport region. For North Carolina, the EPA concluded that all EGUs are indeed operating their SCRs and SNCRs, with the exception of the GG Allen plant. The DAQ requested a correction to be made regarding the Allen plant because our review revealed that an error was made by EPA in its use of an SCR based NOx emission rate. The Allen plant is equipped with SNCRs and an emission rate appropriate for this technology should have been used to conduct EPA's analysis.

[44] Review of EGU Data, North Carolina, Tad Aburn, April 21, 2014.

One contributing factor in the increases in NO_x rates from 2011 to 2013 is the recent changes in the capacity factor of the coal-fired power plants. Capacity factor is defined as the actual annual heat input divided by the maximum heat input potential. Coal-fired plants traditionally operate as "base load" units, operating at high capacity factors most days of the year. In North Carolina, many of the coal-fired plants are now operating as "intermediate load" units, with annual capacity factors below 50 percent. As shown in Figure 5-6, five of the seven coal-fired plants, including Allen, Marshall and Mayo, have reduced annual capacity factors to well below 50 percent in recent years. The change is most dramatic at the Allen plant, where each of its five units operated less than 5 percent of the hours during the 2014 ozone season. The shift to intermediate load is due in part to the availability of cheaper, more efficient, natural gas combined cycle units.

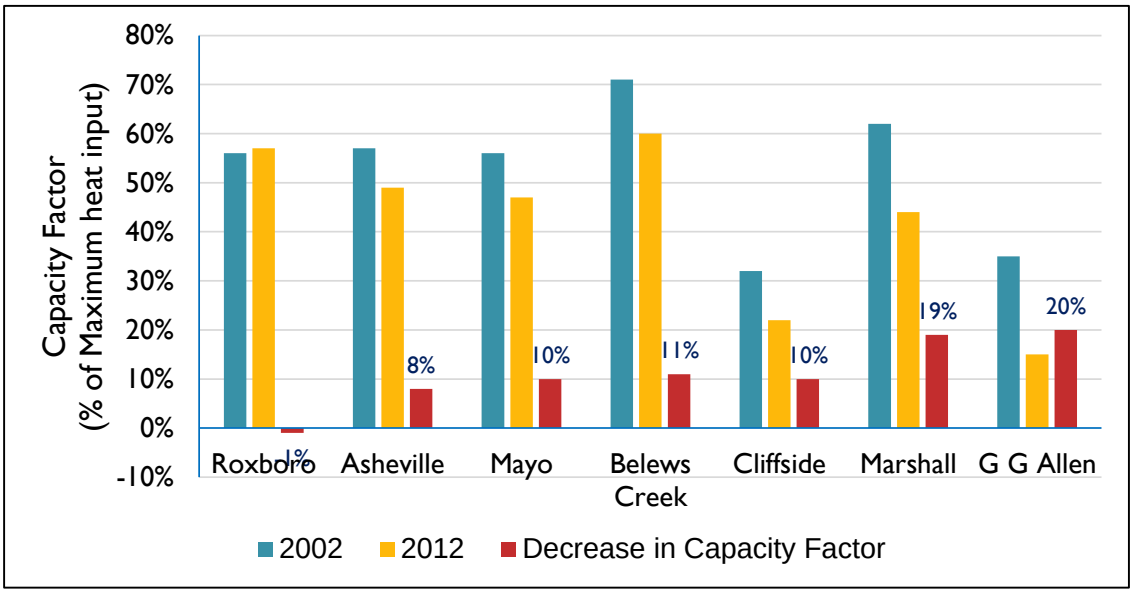


Figure 5-6. Decline in North Carolina's Coal Plant Capacity Factors.

At lower capacity factors, the emission per MMBtu increases simply because the denominator, the boiler heat input, decreases. In addition, SCR and SNCR controls generally operate less efficiently at loads less than 50 percent, potentially increasing NO_x emissions. Despite recent increases in the NO_x rate and the control equipment potentially operating less effectively, the facilities have continued to reduce NO_x emissions significantly due to the use of emissions controls (see Table 5-6). Coal power plant related emission reductions have helped to reduce ozone exceedances in North Carolina as well as ozone and ozone precursor transport to neighbor states. The EPA's latest 2018 preliminary modeling confirms that North Carolina's EGUs do not significantly contribute to ozone transport issues.

5.1.3 Onroad Mobile Source Emissions

The DAQ's initial review of the 2017 v6.2 onroad NOx emission and activity data, comparing the updated data to the 2018 v6.1 data. Overall, 2017 v6.2 data show a statewide reduction in onroad NOx emissions of about 17 percent relative to the 2018 v6.1 data, as shown in Table 5-7. Onroad mobile source NOx emissions are categorized by the types of vehicle operation processes that produce NOx, namely rate per distance (RPD) emissions (related to vehicle miles traveled, VMT), rate per vehicle (RPV) emissions (related to the number of vehicles – includes emissions from vehicle starts), and rate per hour (RPH) emissions (related to the hours of "hoteling" or extended idling - specific to long-haul combination trucks). Table 5-7 also shows the statewide changes in NOx emissions in each of these three categories.

Table 5-7. Statewide Onroad NOx Emissions Differences from 2018 v6.1 to 2017 v6.2 Modeling Platform Inventories

NOx Emissions Category	2018 v6.1 (tons per year)	2017 v6.2 (tons per year)	Change in NOx Emissions (tons per year)	Percent Change in NOx Emissions
RPD NOx	80,243	63,182	-17,061	-21%
RPV NOx	18,642	15,618	-3,024	-16%
RPH NOx	3,138	5,894	2,756	88%
Total NOx	**102,023**	**84,693**	**-17,330**	**-17%**

Note: RPD = rate per distance, RPV = rate per vehicle, RPH = rate per hour.

In 2017 v6.2, county-level onroad NOx emissions increased in only 8 of 100 counties in North Carolina. However, for two of these eight counties, Macon and McDowell, the increases are largely due to corrections to 2018 v6.1 input data errors. These errors caused a mismatch between activity data and emissions and their associated county, and affected the four counties shown below in Table 5-8. Table 5-9 shows the other counties for which NOx emissions increased.

Table 5-8. Changes in Onroad NOx Emissions for Counties with Data Corrections 2018 v6.1 and 2017 v6.2 Modeling Platform Inventories

FIPS	County	Difference (tons per year)	Difference (percent)
37111	McDowell	227	50.0%
37113	Macon	9	3.1%
37115	Madison	-96	-28.0%
37117	Martin	-530	-68.8%

Table 5-9. Counties with Increased Onroad NOx Emissions from 2018 v6.1 to 2017 v6.2

FIPS	County	Difference (tons per year)	Difference (percent)
37183	Wake	281	4.2%
37119	Mecklenburg	117	1.4%
37101	Johnston	103	4.9%
37093	Hoke	30	10.5%
37149	Polk	9	2.2%
37029	Camden	4	4.8%

Figure 5-7 shows the geographic distribution of the changes in onroad NOx emissions at the county level. In general, larger changes occurred in counties with higher population or along interstate highway corridors.

These 2017 v6.2 NOx emissions decreases relative to 2018 v6.1 emissions can be due to several factors, including changes to the emissions model version and modeling procedures as well as changes and corrections to the model input data used. For the 2018 v6.1 modeling, the EPA used a version of MOVES referred to as "MOVESTier3NPRM", while the EPA used its most current model, MOVES2014, for the 2017 v6.2 modeling. Along with the to the MOVES2014 model, the EPA made changes in procedures for estimating idling hours for long-haul trucks, which generally led to increases in RPH NOx emissions. Another significant change between 2018 v6.1 and 2017 v6.2 was in the MOVES input datasets used to model 2018 emissions. For the 2018 v6.1 modeling, the EPA used 2018 input data that was derived by projecting the data provided for the 2011 NEI. However, for the 2017 v6.2 modeling, the EPA used 2018 MOVES input databases provided by the DAQ. These databases were created based on the latest available county-level VMT, vehicle population, and vehicle age distribution, and the DAQ believes that these input data are more accurate than the 2018 v6.1 input data. Also, use of the DAQ-supplied input data corrected the errors related to the counties shown in Table 5-8. The net effects of these changes are shown in Table 5-7, with the increases in RPH NOx emissions more than compensated for by reductions in RPD and RPV emissions.

For the 2017 v6.2 platform, the EPA estimated 2017 emissions from onroad sources by first modeling emissions for the year 2018 and then adjusting the results to represent 2017 using factors derived from national scale runs of MOVES2014. The agency anticipates that for the final rule to address interstate transport for the 2008 ozone standard, the mobile source emissions for 2017 that will be used in the air quality modeling will be generated by explicitly modeling emissions for the year 2017 with MOVES2014. The DAQ believes that the changes made by EPA to generate the 2017 v6.2 modeling platform have resulted in a more accurate representation of onroad mobile source NOx emissions for North Carolina, and that the plan for

the next round of modeling will further improve the NOx emissions estimates. The DAQ completed a thorough evaluation of the 2017 v6.2 data and provided recommendations for improving the 2017 onroad emissions inventory in response to the EPA's NODA for its 2017 emissions and air quality modeling for ozone transport. As part of these recommendations, MOVES2014 inputs for 2017 were developed based on the latest available data and provided for the final air quality modeling.

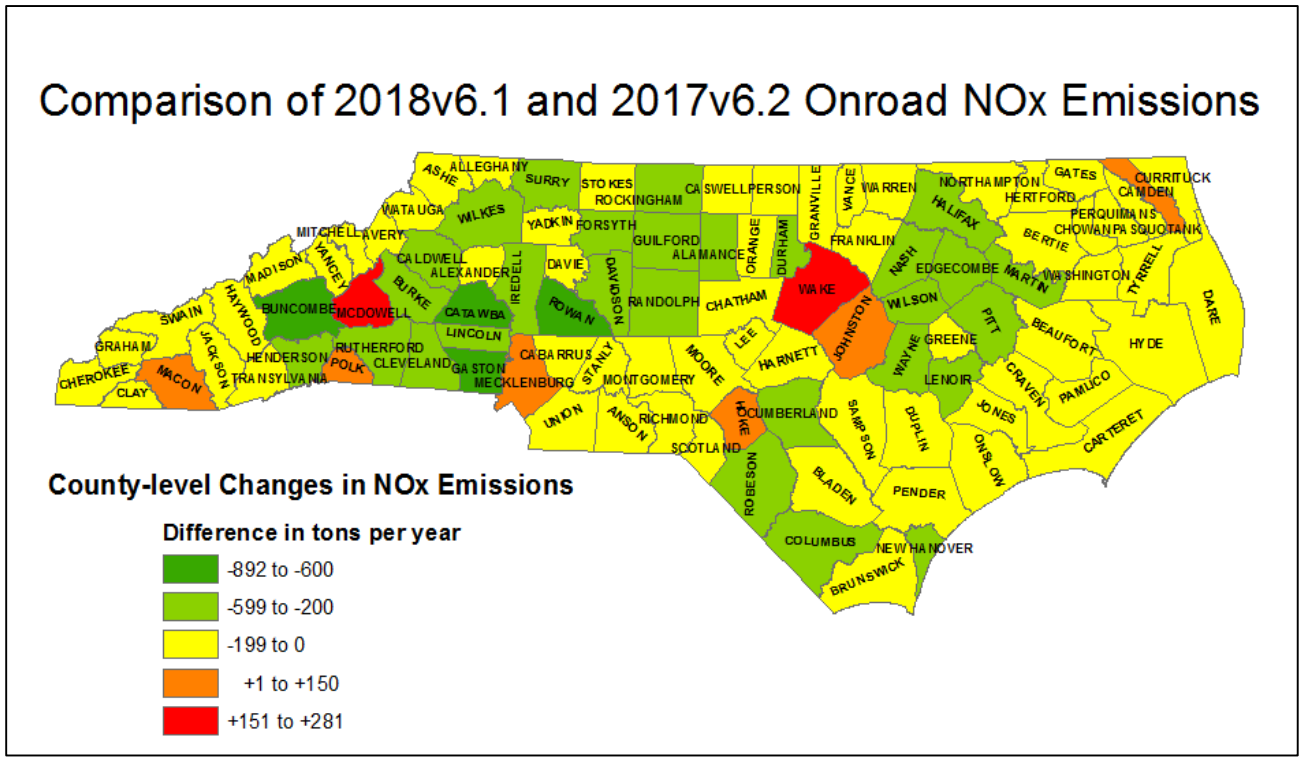


Figure 5-7. County-level Changes in Onroad NOx Emissions between 2018 v6.1 and 2017 v6.2.

5.1.4 Non-EGU Stationary Point and Area (Nonpoint) Sources

The DAQ has identified issues with the control factors used by the EPA in modeling the boiler Maximum Achievable Control Technology (MACT) standards for industrial, commercial, and institutional boilers in North Carolina. In addition, the DAQ will be requesting that the EPA remove from the 2017 inventory emissions projected for a new plant, Titan Cement located in New Hanover County, because the plant will not be built and placed into operation until after 2018. This revision will remove 1,533 tons of NOx emissions from the non-EGU point source inventory.

6.0 Southeastern Modeling, Analysis, and Planning 2018 Modeling

The Southeast States Air Resources Managers (SESARM) initiated the Southeastern Modeling, Analysis, and Planning (SEMAP) air quality modeling project in 2009 to support the 10 southeastern states in developing SIPs for ozone, fine particulates, and regional haze. The Community Multiscale Air Quality (CMAQ) model version 5.0.1 was used to simulate air pollutants over a national 36 km domain and a regional 12-km domain covering the southeast U.S. (Figure 6-1). Major model configuration options are shown in Table 6-1. The WRF model was used to generate meteorological inputs. For the modeling platform, the base year is 2007 and the future/projection year is 2018. The base year model performance met or exceeded the EPA's guidelines.[45]

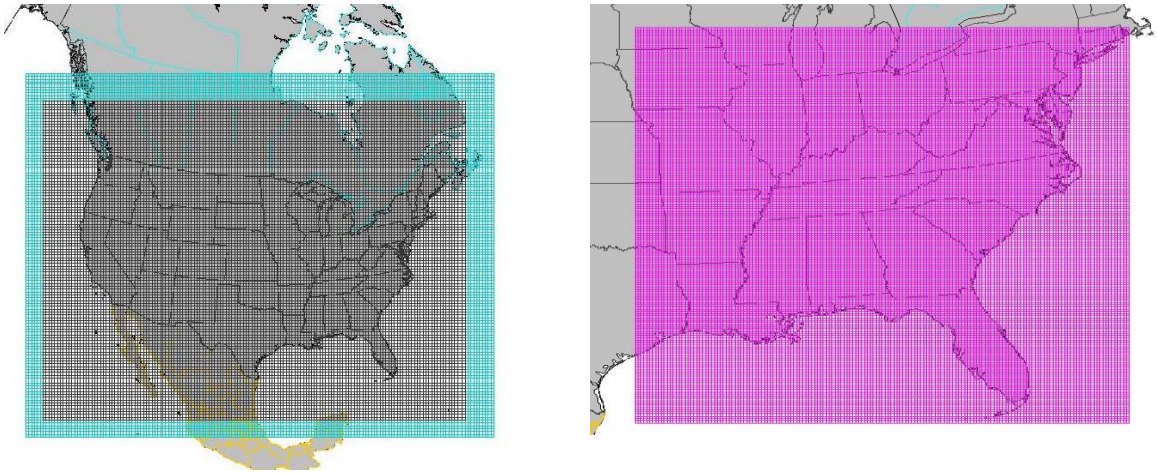


Figure 6-1. 36 km (left) and 12 km (right) SEMAP air quality modeling grids.

[45] US EPA - Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze, http://www.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf.

Table 6-1. CMAQ Configuration Options

Model Parameter	CMAQ_v5.0
Horizontal Advection	Yamartino (hyamo)
Vertical Advection	WRF (vwrf[46])
Horizontal Diffusion	Multiscale
Vertical Diffusion	Advanced Convective Method (ACM2)
Gas Chemistry Mechanism	CB05 with Chlorine (cb05tucl_ae6_aq[47])
Gas Chemistry Solver	Euler Backward Iterative (ebi_cb05tucl)
Aerosol Mechanism	CMAQ 6th Generation (aero6[48])
Clouds/Aqueous Chemistry	ACM clouds with aero6 (cloud_acm_ae6)
Plume in Grid	none

The 2018 SEMAP emissions estimates reflect most federal and state rules that are or will be scheduled to become effective by January 1, 2018. However, the 2018 SEMAP emissions do not include more recent rules and regulations such as Tier 3 motor vehicle emission and fuel standards. Additional details can be found at Odman, Adelman et al., 2014.[49]

To quantify the sensitivities of ozone to NO_x and VOC emissions, a series of five-month ozone season simulations were made with the CMAQ model on the 12 km SEMAP grid for 28 different emission reduction scenarios to quantify the sensitivities of ozone to NO_x and VOC emissions. The 2018 future year emissions were reduced by 30 percent for either anthropogenic NO_x or anthropogenic VOCs, in each of the ten SESARM states, each of the three RPO portions in the 12 km SEMAP domain, and the State of Maryland. Stacked bar charts of the ozone sensitivities were prepared and posted on the project website at http://semap.ce.gatech.edu/node/1861. A detailed discussion of this sensitivity analysis can be found in Odman, Adelman et al., 2014.

[46] First the change in column mass is computed and then the vertical velocity is computed layer-by-layer using the horizontal mass divergence.
[47] Updated toluene chemistry and reactions of toluene and xylene with chlorine
[48] PM-other speciation includes non-carbon organic matter and metals. Primary organic carbon is aged. ISORROPIA v1.7 is replaced with ISORROPIA v.2.1 which treats the thermodynamics of crustal material.
[49] SEMAP final report: http://semap.ce.gatech.edu/sites/default/files/files/SEMAP-Revised-Final-Report_Final.pdf.

6.1 North Carolina Design Value Discussion

The SEMAP modeling predicts that all ozone monitors will be below the 75 ppb standard in 2018 (Table 6-2). Design values were computed using the monitor grid cell, and the 3x3 array of grid cells around the monitor. Note that including Tier 3 standards will reduce ozone another 1-2 ppb[50].

Table 6-2. North Carolina 2005-2009 Ambient and Projected 2018 Design Values (DV) from the EPA modeling, units in ppb

Site ID	County	2005-2009 Average DV	2005-2009 Maximum DV	Projected Average 2018 DV 3x3 cell	Projected Average 2018 DV single cell	Projected Maximum DV 2018 3x3 cell	Projected Maximum DV 2018 single cell
370030004	Alexander	76.3	79	61.6	60.6	63.8	62.8
370110002	Avery	67	69	55.2	56.1	56.8	57.7
370210030	Buncombe	71.3	74	56.8	58.8	59	61
370270003	Caldwell	74	76	57.3	57.7	58.8	59.3
370330001	Caswell	77.3	77	60.9	60.8	60.6	60.6
370370004	Chatham	71.7	74	55	57.5	56.7	59.4
370510008	Cumberland	75.3	78	59.1	59.6	61.3	61.7
370511003	Cumberland	77.7	82	61.7	61.9	65.1	65.3
370590002	Davie	81	83	64.1	64.2	65.7	65.8
370630015	Durham	76.7	78	60.3	61.3	61.4	62.3
370650099	Edgecombe	75.3	77	60.5	61	61.9	62.4
370670022	Forsyth	79	79	63.4	64	63.4	64
370670028	Forsyth	73	73	58.6	57.7	58.6	57.7
370670030	Forsyth	75	76	60.3	59.8	61.1	60.6
370671008	Forsyth	79	81	63.4	62.9	65	64.5
370690001	Franklin	76.3	78	58	57.6	59.3	58.9
370750001	Graham	77	78	61.5	63.8	62.3	64.7
370770001	Granville	79.3	81	60.9	60.4	62.3	61.7
370810013	Guilford	81	82	64.7	64.3	65.5	65.1
370870004	Haywood	70.3	72	60.3	61.6	61.8	63.1
370870035	Haywood	77	79	63.1	65.5	64.8	67.2
370870036	Haywood	76.3	78	64.1	64.7	65.6	66.2
370990005	Jackson	76	76	63.1	63.6	63.1	63.6
371010002	Johnston	75	77	58.9	58.3	60.5	59.9
371070004	Lenoir	73.7	76	61.4	61.9	63.3	63.8

[50] See the EPA Tier 3 Modeling Technical Support Document, EPA-454/R-14-002, February 2014, http://www.epa.gov/otaq/tier3.htm.

Site ID	County	2005-2009 Average DV	2005-2009 Maximum DV	Projected Average 2018 DV 3x3 cell	Projected Average 2018 DV single cell	Projected Maximum DV 2018 3x3 cell	Projected Maximum DV 2018 single cell
371090004	Lincoln	80.3	83	64	65.3	66.2	67.5
371170001	Martin	72.7	74	62.1	63	63.2	64.1
371190041	Mecklenburg	87	90	70.8	72.2	73.3	74.7
371191005	Mecklenburg	79.3	83	65.2	63.9	68.2	66.9
371191009	Mecklenburg	91	93	72.1	72	73.7	73.6
371290002	New Hanover	68	72	55.8	55.4	59	58.6
371450003	Person	76	77	60.5	60.7	61.3	61.5
371470099	Pitt	75.7	77	60.1	62.7	61.2	63.7
371570099	Rockingham	78.7	78	63.4	63.1	62.9	62.5
371590021	Rowan	86.7	89	67.7	68.8	69.5	70.6
371590022	Rowan	87	90	68.6	69.1	70.9	71.5
371730002	Swain	65	66	53.6	54.1	54.4	54.9
371790003	Union	79	81	62.1	61.7	63.7	63.3
371830014	Wake	79	81	62.7	64.1	64.3	65.7
371830016	Wake	77	79	62.3	61.3	64	62.8
371990004	Yancey	76.3	78	63.6	64.5	65	66

6.2 North Carolina Contributions with the SEMAP Modeling

The ambient and 2018 projected average and maximum ozone design values, and contributions from North Carolina, at each of the 2018 nonattainment and maintenance-only receptors in the Eastern U.S. are provided in Tables 6-3 and 6-4, respectively[51]. The maximum contribution by North Carolina to nonattainment in 2018 is 0.738 ppb, which is below the 1 percent significant contribution threshold. There are two monitors where North Carolina has a greater than 1 percent contribution to maintenance in 2018: 0.953 ppb at site 240053001 in Maryland and 0.843 ppb at site 110010043 in Washington DC. Both of these sites are currently in attainment of the 2008 ozone standard. Both sites have predicted maximum design values just above 76 ppb and are expected to drop below 76 ppb with the additional 1-2 ppb ozone reductions from the Tier 3 motor vehicle emission and fuel standards.

[51] Nonattainment receptors have a 2018 average design value of ≥76.0 ppb. Maintenance receptors have a 2018 average design values <76.0 ppb, but 2018 maximum design value of ≥76.0 ppb.

Table 6-3. Ambient and 2018 Design Values (DVs) and North Carolina Contributions to Nonattainment Areas in the Eastern U.S. using the SEMAP modeling, units in ppb

STATE	Site	DV-2007	DV-2018	3x3	NC
CT	90010017	86.3	79.1	78.8	0.369
CT	90011123	88.7	75.8	76.9	0.328
CT	90013007	87	79.1	77.9	0.554
CT	90019003	85.3	76.3	77.1	0.483
CT	90093002	87.3	76.8	77.3	0.179
CT	90110008	88	76.9	77.6	0.231
GA	130890002	90.7	74.4	77.2	0.347
GA	131210055	90.3	76.3	77.3	0.738
GA	131510002	92	74.7	76.2	0.349
LA	220050004	81.7	76.4	75.4	0.102
LA	220330003	83	76.3	76.2	0.076
LA	220511001	79.3	80	73	0.160
LA	220770001	82	75	77.6	0.050
LA	220930002	74	76.6	68.9	0.077
MD	240251001	90.7	76.2	77.1	0.330
MI	260991003	81.3	75.9	76.9	0.051
MI	261630019	81.7	80	75.6	0.053
MO	290990012	86	78.6	77.3	0.026
MO	291890004	82	75.7	76.1	0.000
MO	291890014	82.3	76	75.6	0.025
MO	295100086	83.5	77.6	76.9	-0.026
NJ	340070003	87.5	79.2	77.6	-0.370
NJ	340150002	85.7	75.2	76.1	0.276
NJ	340170006	85	77.7	77.5	0.673
NJ	340210005	86.3	74.6	76.1	0.721
NY	361030002	85.3	79	80.2	0.421
NY	361030004	86	74.9	76.7	0.225
NY	361030009	88	80.5	79.9	0.268
NY	361192004	86.3	78.3	79	0.444
PA	420170012	90.7	80.4	80.1	0.402
PA	421010024	88	78.1	79.5	0.312
TX	480391004	86.7	78.8	81.3	0.158
TX	482010024	83.3	74.2	78.9	0.074
TX	482010026	80.3	79.2	80.1	0.053
TX	482010029	86.7	76.1	75.6	0.076
TX	482010055	90.3	84.6	84.3	0.141
TX	482010062	81	82.1	78.2	0.192
TX	482010066	86.7	82.6	81.5	0.248
TX	482010070	75.7	77.5	73	0.413
TX	482010075	76.3	78.2	73.6	0.417
TX	482010416	83.5	85.6	80.2	0.171
TX	482011015	82	80.9	81.8	0.054
TX	482011039	87	83.2	84.7	0.194
TX	482011050	81.3	77.8	79.2	0.104
TX	482450101	79	72.2	76.1	0.024
WI	551170006	83.3	76.5	72.2	0.025

Table 6-4. Ambient and 2018 Design Values (DVs) and North Carolina Contributions to Maintenance Areas in the Eastern U.S. using the SEMAP Modeling, units in ppb

STATE	Site	DV-2007	DV-2018	MAX	NC
AL	10730023	83.3	73.8	76.2	0.123
AL	10736002	84.7	72.5	76.2	0.145
AR	50350005	82.3	71	76.8	0.237
CT	90031003	86	73.3	76.7	0.562
CT	90070007	87	74.2	79.7	0.297
DC	110010043	84.7	74.4	76.4	0.843
GA	132470001	91.7	73.4	77.9	0.220
LA	220190002	76.7	65.6	76.4	0.022
LA	220331001	78.7	72.7	78.6	0.073
LA	220470007	80.3	73.7	79.7	0.098
LA	220470012	81.3	72.9	78.8	0.049
LA	221210001	78	72.5	77.1	0.000
MD	240053001	83.3	73.3	76.5	0.953
MD	240150003	89	73.7	77.9	0.197
MD	240259001	87.3	73.9	77	0.714
MD	240338003	85.3	70.5	76.5	0.047
MI	260050003	86.7	75.6	81.1	0.025
MI	260990009	82	73	77.1	0.024
MI	261470005	79.3	71.4	76.5	0.048
MO	290470005	80.7	69.2	76.5	0.023
MO	291831002	84	74.9	79.4	0.025
MO	291831004	82.3	71.8	78.8	0.024
MO	295100085	79	73.4	78.1	0.024
NJ	340071001	85.3	71.4	76.6	0.048
NJ	340230011	86.3	73.4	78.3	0.661
NJ	340250005	85	72.2	77.3	0.481
NJ	340290006	86.3	71.2	78.3	0.166
NY	360130006	83	73.2	76.5	0.024
NY	360290002	81	72.4	76.9	0.000
NY	360810124	76.7	74	76.3	0.666
NY	360850067	80.7	73.6	81.2	0.466
OH	390071001	84.7	67	76.9	0.022
OH	390490029	84	72.3	76	0.072
OH	390610006	84.3	74.9	76.4	0.125
PA	420030010	78	72.5	77.2	0.387
PA	420450002	81.7	73.7	76.7	0.491
PA	420910013	83	72.5	76.4	0.362
TX	481830001	79	70.8	76.4	0.283
TX	482010051	81	75.9	81.5	0.126
TX	482450009	78.3	75.9	79.5	0.051
VA	510590018	85.3	71.8	76.2	0.144

6.3 Conclusions from 2018 SEMAP Modeling

All sites within North Carolina are predicted to be below the 2008 ozone standard by 2018. North Carolina is not predicted to be a significant contributor to downwind ozone nonattainment monitors in 2018. North Carolina is predicted to contribute just above 1 percent to 2 downwind maintenance monitors in 2018. The maximum design values at these monitors are predicted by the SEMAP modeling to be 76.4-76.5 ppb in 2018. The Tier 3 standards, which were not included in the SEMAP modeling, will provide another 1-2 ppb reduction in ozone, which will bring maximum design values below 76 ppb and thus avoid ozone maintenance problems at these monitors.

7.0 Concluding Remarks

As previously discussed, the EPA's preliminary 2018 and the SEMAP modeling, and back-trajectory analysis demonstrate that North Carolina does not significantly contribute to downwind state's nonattainment or maintenance issues for the 2008 ozone NAAQS. Although the EPA's revised 2017 v2 modeling indicates that North Carolina has linkages to one maintenance monitor in Maryland; the DAQ's review questions the EPA's findings due to the following factors:

1. The use of recently observed air quality trends and most recent design values show that the Essex, Maryland monitor currently is and is expected to continue to attain the 2008 ozone standard in 2017.

2. Trajectory analysis for the top 4 daily 8-hour ozone concentrations at the Essex monitor in 2010, 2011, and 2012 (ozone data that are used to compute the maximum design value) show that the trajectory for only 1 of the 12 days touched the northern portion of North Carolina, questioning whether North Carolina truly had a contribution to the observed readings. Further analysis was made for the 63 days with ozone ≥70 ppb at Essex from 2009 through 2014. Only 9 of the 63 days had trajectories that crossed into North Carolina. An analysis of the meteorological conditions on these 9 days suggest it is highly unlikely that significant amounts of ozone or ozone precursors were transported from North Carolina to the Essex monitor.

3. The model resolution of 12 kilometers (km) is unable to accurately simulate the effects of the Chesapeake Bay Breeze on modeled concentrations, which has large impacts on the modeled meteorology and air quality conditions at coastal monitors such as Essex. Poor model performance leads to greater uncertainty of future design value and contribution predictions at the Essex monitor.

4. The projected design value at the Essex monitor is inflated by water grid cells in the model. These water grid cells are shown to have much lower mixing heights compared to adjacent land cells which will inflate pollutant concentrations. Also, ozone within these water cells are at least partially the result of local emissions (i.e., shipping traffic) that cannot be controlled by North Carolina. The model is unable to accurately characterize the air quality in these water grid cells and over-predicts ozone concentrations. In addition, in its air quality modeling technical support document, the EPA acknowledges

regional differences in model performance, where the model tends to over-predict ozone concentrations from the Southeast into the Northeast.[52]

5. The EPA's NODA reported model performance results based on statistics at the single monitor grid cell where the monitor is housed. While this method may be appropriate from solely a model performance evaluation standpoint, in this case there is a disconnect between the model performance evaluation and how the significant contribution assessment is conducted. Since the RRFs are calculated using the maximum grid cell in a 3x3 array surrounding the monitor location, and in the case of the Essex monitor, the 3x3 array contains water grid cells, the grid cell with the maximum concentration is rarely the cell containing the monitor. Instead, the maximum concentration actually occurs in a water cell. In situations where the 3x3 array spans a land-water interface, alternative model performance metrics may be appropriate, such as using the maximum value from the 3x3 array to compare to the observation. Alternatively, using the maximum value from the non-water cells in the array to compare to the observation may be appropriate. The model's ability to accurately predict maximum concentrations for use in the RRF calculation is not well characterized by solely looking at the performance at the grid cell containing the monitor. Nevertheless, the model performance of the single grid cell containing the Essex monitor was poor compared to other monitors throughout the domain, as reported in the NODA. The model bias was 6.79 ppb and the mean error was 10.48 ppb, among the highest for all monitors in the eastern US.

6. Due to the complexities associated with land-water interface and the over-predictions modeled for water grid cells, the EPA should determine future maximum design values using alternative approaches: (1) modified 3x3 grid cell array that eliminates grid cells over water and (2) a single cell array focused on the grid cell housing the monitor. Under both of these alternative approaches, the future design values are below the 76 ppb threshold and indicate that the Essex monitor will maintain compliance with the 2008 8-hour ozone NAAQS in 2017.

[52] Updated Air Quality Modeling Technical Support Document for the 2008 Ozone NAAQS Transport Assessment, August 2015, page A-6. http://www3.epa.gov/airtransport/pdfs/Updated_2008_Ozone_NAAQS_Transport_AQModeling_TSD.pdf.

7. The 2017 ozone contribution from North Carolina to the Essex monitor is 0.45 ppb after removing three days with poor model performance as directed by the EPA's photochemical modeling guidance.[53] The contribution is much more statistically robust and defensible than the 0.93 ppb calculated by the EPA which includes days with poor model performance.

8. Of all the modeled ozone contributions to the Essex monitor, North Carolina had the 5th highest increase of any modeled contribution between 2018 v1 and 2017 v2, and the largest increase was due to boundary conditions. These spatial and inter-model version differences highlight volatility within the modeling platform at the Essex site.

9. The EPA has released three versions of its power sector forecast modeling within the last year. For the first forecast (IPM-NEEDS 5.13), the EPA estimated North Carolina's EGU NOx emissions at about 37,700 tons; this value was used in EPA's 2018 preliminary transport modeling that showed that North Carolina has no linkages to ozone problems in a downwind state. For the second forecast (IPM-NEEDS 5.14), the EPA estimated EGU NOx emissions at about 49,500 tons which was used in the EPA's transport modeling that showed that North Carolina had contributions to the Essex monitor (a maintenance-site) in Maryland. In August 2015, the EPA released a third forecast (IPM-NEEDS 5.15) for its Clean Power Plan rulemaking that estimated 2017 EGU NOx emissions to be 33,400 tons for North Carolina. The conflicting variations between the three EGU forecasts has the potential to significantly alter the EPA's determination of North Carolina linkages to ozone contributions for downwind states. The fact that the highest EGU forecast is causing transport related linkages brings into question the reliability of the EPA's EGU emissions estimates and ozone contributions. At a minimum, the DAQ estimates that North Carolina's EGU NOx emissions for 2017 are over predicted by 2,860 tons by the EPA, with more pronounced differences at the plant level.

10. The EPA defines maintenance-only sites as those that have a projected 2017 average design value <76.0 ppb, but a projected 2017 maximum design value ≥76.0 ppb. Given all of the uncertainties associated with modeling the Essex ozone maintenance site and since the 2017 projected design value of the Essex monitor is 76.2 ppb (just 0.2 ppb above the threshold), the DAQ believes that the EPA should apply a more robust

[53] EPA, 2014: *Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*. Available from: http://www3.epa.gov/scram001/guidance/guide/Draft-O3-PM-RH-Modeling_Guidance-2014.pdf.

acceptance test that accounts for modeling uncertainties for determining a future design value for monitors with poor model performance. Alternatively, the EPA's bright-line test of 1 percent of the NAAQS should not be applied so rigidly for a poor performing monitor to determine significant contributions. The EPA's methodology overstates the 2017 future-year design value for the Essex maintenance site particularly since the Essex monitor has demonstrated attainment with the standard based on 2012-2014 EPA-certified monitoring data and preliminary monitoring data for 2013-2015. Given the uncertainties associated with the EPA's air quality modeling methodology for the Essex, Maryland monitor and its reliance on maximum concentrations for calculating future year design values, we believe that North Carolina's contribution of 1.2 percent (i.e., 0.2 percent above the threshold) should not be used solely to link North Carolina with the Essex ozone maintenance problem.

Considering all of the factors listed above, we are concluding through this extensive demonstration that North Carolina does not significantly contribute to ozone issues in downwind states. This in large part is due to the significant strides North Carolina has achieved in reducing its NOx emissions over the past several years. Based on EPA's guidance contained in the January 22, 2015 memorandum, states shown to not contribute significantly to downwind air quality problems have no emission reduction obligation under the Good Neighbor Provision. The DAQ concludes that North Carolina has met its Good Neighbor Provision under the CAA with respect to the 2008 ozone standard.