Attachment B:
Duke Energy
Marshall Steam Station
Modeling Report
For 1-hour SO_2 National Ambient Air Quality Standard (NAAQS)

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1. Purpose

On June 2, 2010, USEPA issued a final rule that revised the SO_2 National Ambient Air Quality Standard.[1] The revised SO_2 standard is 75 ppb based on a three-year average of the 99th percentile of the daily maximum hourly concentration. On August 21, 2015, EPA issued the Data Requirements Rule [2] (DRR) to implement the new standard. The DRR requires all sources of SO_2 greater than 2,000 tons/year to characterize the SO_2 concentrations where the sources are located using either a modeling or monitoring approach. The North Carolina Division of Air Quality (NCDAQ) has followed the modeling approach to demonstrate attainment for the 1-hour SO_2 NAAQS for the Duke Energy Marshall Steam Station (Marshall). The modeling approach was based on the modeling protocol submitted to EPA on June 30, 2016 and comments received August 10, 2016 from EPA on the modeling protocol. The modeling analysis uses hourly actual emissions and hourly meteorology from the period 2013-2015. In general, the modeling procedures are consistent with applicable guidance, including the August 2016 SO_2 NAAQS Designations Modeling Technical Assistance Document[3] (TAD) issued by the EPA.

2. Plant Information

Duke Energy Carolina's Marshall Steam Station is a 2,090 MW coal fired power plant which consists of four coal/No. 2 fuel oil-fired electric utility boilers (ID Nos. ES-1, ES-2, ES-3, ES-4) and various supporting equipment. Units 1 & 2 are No. 2 fuel oil/coal-fired electric utility boilers (4,230 million Btu per hour heat input) equipped with low NOx concentric firing systems, separated overfire air/lowered fired low-NOx technologies (SOFA/LOFIR), and alkaline-based fuel additives. Units 3 & 4 are No. 2 fuel oil/coal-fired electric utility boilers (7,110 million Btu per hour heat input), also equipped with low NOx concentric firing systems, separated overfire air/lowered fired low-NOx technologies (SOFA/LOFIR), and alkaline-based fuel additives. All emission sources at the plant are covered by Title V Operating Permit (03676T52) issued on December 14, 2015.

The Marshall Steam Station is located on Lake Norman south of Sherrills Ford, Catawba County, NC. A map and aerial photograph of the facility and surrounding area are provided in Figures 1 and 2, respectively.

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[1] Primary National Ambient Air Quality Standard for Sulfur Dioxide75 FR 35520–35603, Jun 22, 2010

[2] *Data Requirements Rule for the 1-Hour Sulfur Dioxide (SO2) Primary National Ambient Air Quality Standards (NAAQS): Proposed Rule, Federal Register Vol. 79 No. 92, pages 27445-27472, May 13, 2014.*

[3] https://www.epa.gov/sites/production/files/2016-06/documents/so2modelingtad.pdf

Figure 1. Location of Duke-Marshall in Catawba County, NC

Figure 2. Aerial View of Duke-Marshall

3. Modeling Approach

Following the procedures in the modeling TAD, the dispersion modeling analysis evaluated the attainment status of the area in the vicinity of Marshall Steam Station for the 1 hour SO_2 NAAQS. The DRR allows the use of modeling rather than monitoring to make attainment designations. Air quality modeling provides a conservative estimate of the actual air quality within the vicinity of the plant. As per EPA guidance, the modeling analysis used the preferred model AERMOD. In addition, to allow for a more accurate representation of actual ambient SO_2 concentrations, the modeling analysis was conducted as follows:

- Using hourly varying actual emissions and stack release parameters as input for assessing current actual air quality;
- Using three years of modeling results to calculate a design value consistent with the 3-year monitoring period required to develop a design value for comparison to the NAAQS;
- Placing receptors for the modeling only in locations where a monitor could be placed; and
- Using actual stack heights rather than following the Good Engineering Practice (GEP) stack height policy when modeling actual emissions.

The following sections provide an overview of the modeling procedures to be used for Marshall.

4. Model Selection

The modeling analysis for the 1 hour SO_2 NAAQS was performed using AERMOD (version 15181), and pre-processing program, AERMAP (version 11130). The modeling analysis considered and included building downwash. The BPIPPRIME (version 04274) model was used to generate building downwash parameters for input to AERMOD. This modeling analysis was conducted using the AERMOD regulatory default run options. The pollutant identification was set to “SO_2” in AERMOD to allow AERMOD to properly calculate an SO_2 design value based on the 3-year average of the 99th percentile of the annual distribution of the daily maximum 1-hour concentrations for comparison with the 1-hour SO_2 NAAQS of 75 ppb (196 µg/m3).

5. Rural or Urban Dispersion

Determination of rural or urban dispersion characterization was based on available satellite imagery showing that the majority of land use types within 3 km radius of the source are open water, forests, and agricultural. Figure 3 shows an aerial satellite image depicting land use within 3 km of the facility. The area can clearly be characterized as “rural”. Therefore, AERMOD default rural dispersion coefficients were applied to dispersion and pollutant concentration calculations.

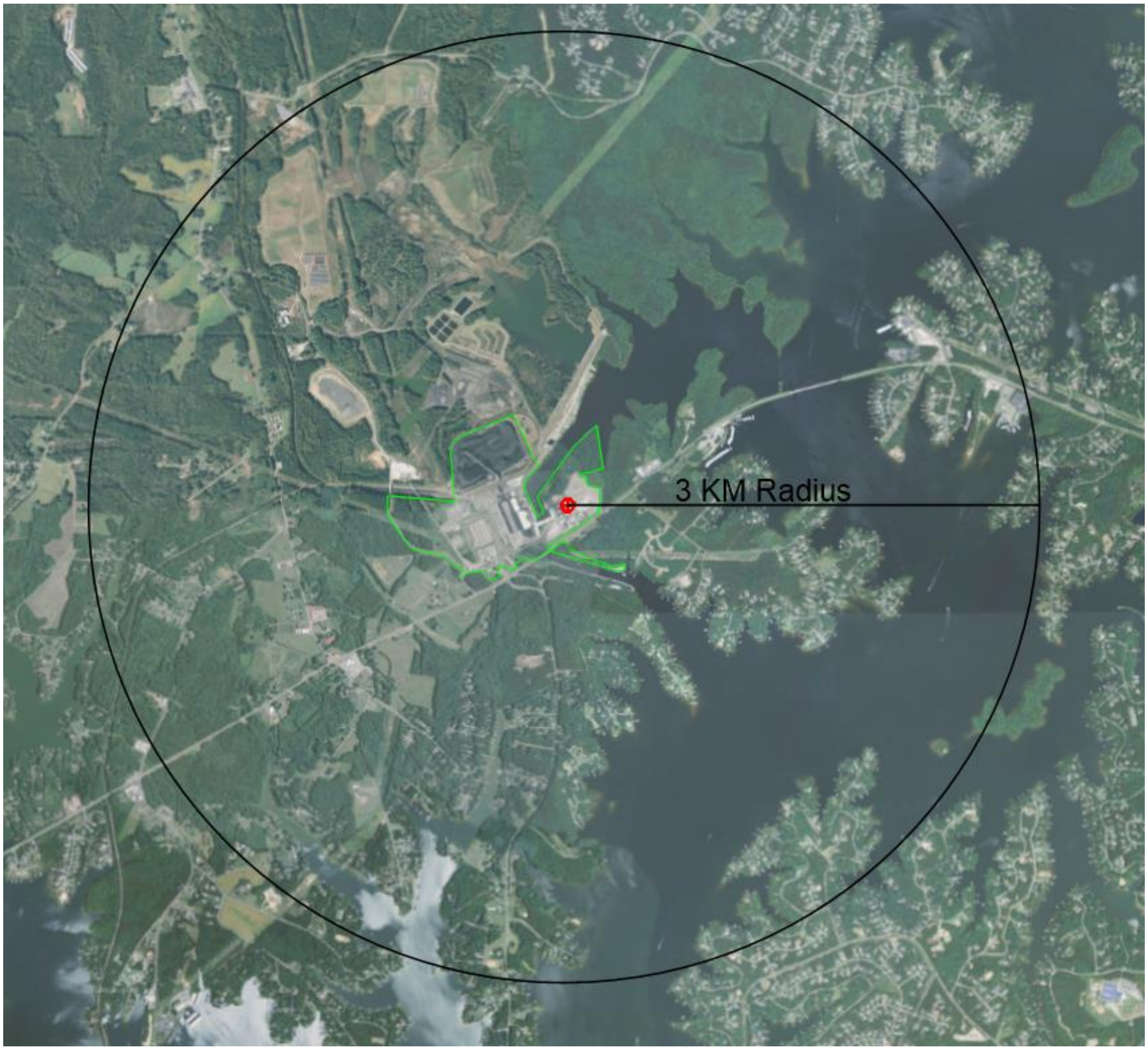

Figure 3. 3-KM Land Use Surrounding Marshall Steam Station

6. Building Downwash

EPA’s Building Profile Input Program (BPIP) with Plume Rise Model Enhancements (PRIME) (version 04274), was used to account for building downwash influences on the plume. Building downwash analysis is used to determine if the plume is affected by the turbulent wake from onsite buildings or other structures. The effects of downwash on the plume can result in elevated ground-level concentrations in the near wake of a building and is required for consideration in the modeling. Building downwash was also included for one nearby source (Duke Allen Steam Station) included in the modeling analysis.

7. Marshall Source Parameters

Marshall operates four coal fired boilers. Three flues vent through a single combined stack location with Units 1 and 2 venting to a single flue, while units 3 and 4 vent to their own flue. Figure 4 shows the facility's stack locations, buildings, and fence-line. Figure 5 shows a close-up view of relative building and source locations and model input identifications. Table 1 summarizes the source parameters that were used in the modeling.

As recommended in the SO_2 modeling TAD, the hourly varying emissions and stack release parameters were used in the modeling. The hourly varying emissions and release parameters coincided with the meteorological data for the period 1/1/2013 thru 12/31/2015. The hourly SO_2 emissions, flow rates, and flow temperatures measured by the continuous emissions monitoring system located on each of the boiler stacks was used in the modeling analysis. The hourly SO_2 pounds per hour emission rates were converted to units of grams per second for input to the model. The hourly varying emissions and release parameters were input into AERMOD using the HOUREMIS keyword in the source pathway of the AERMOD control file (AERMOD.INP).

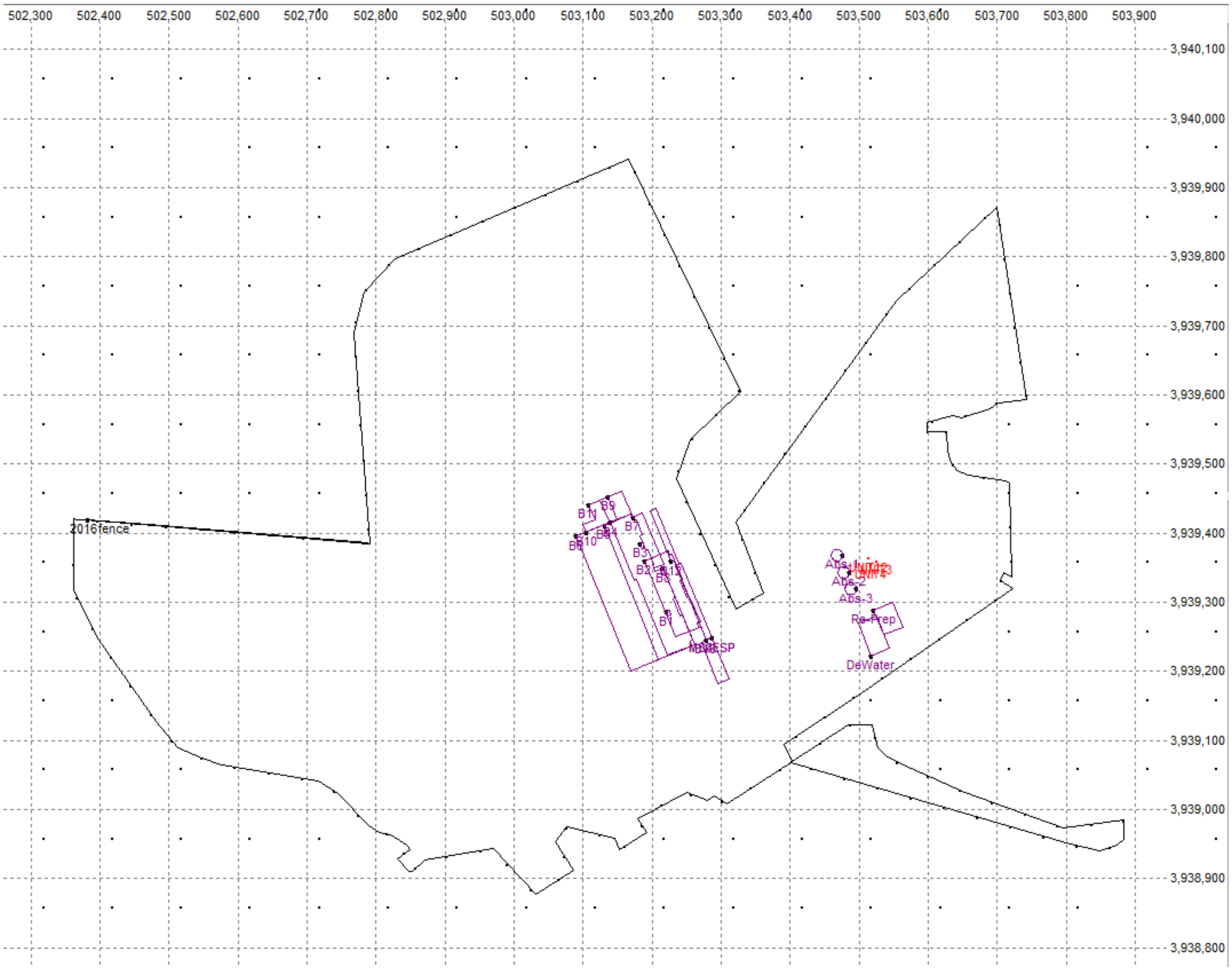

Figure 4. Layout of the Fenceline, Source and Building Locations for Duke-Marshall

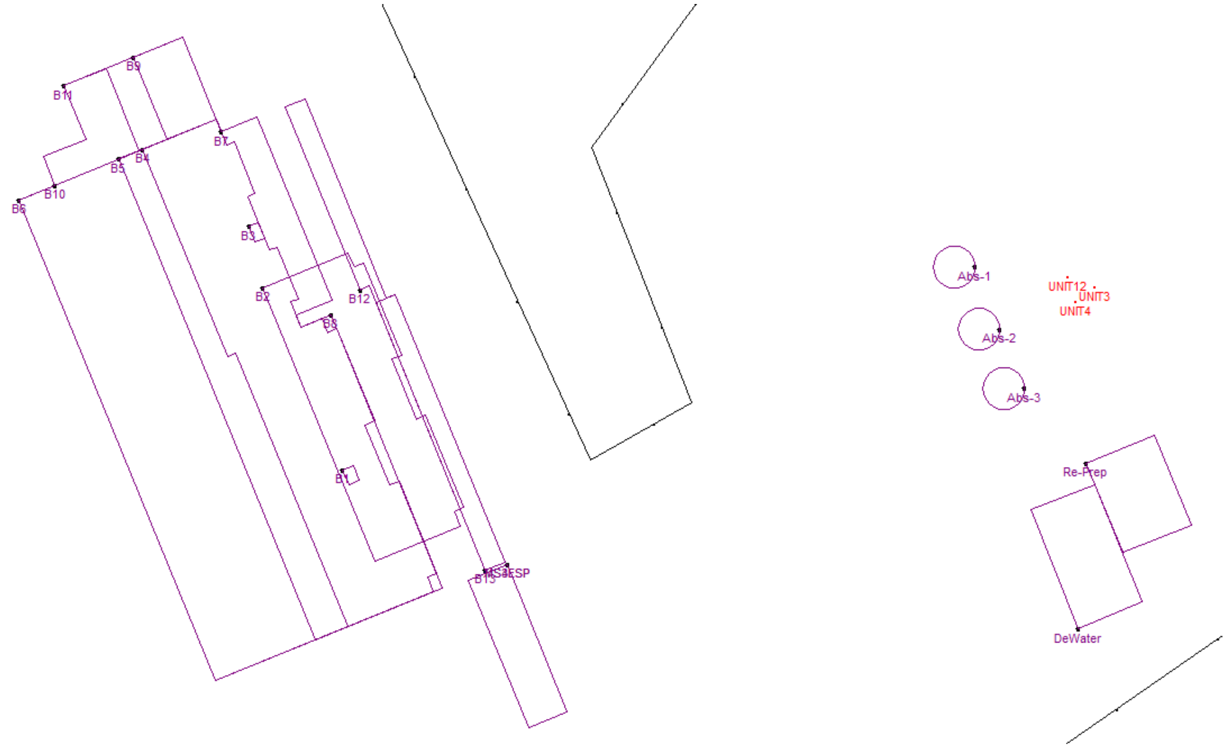

Figure 5. Close Up of Layout of Source and Building Locations for Duke-Marshall

Table 1. Duke-Marshall Stack Parameters

Source ID / Description	Easting (X)	Northing (Y)	Elevation	Stack Height	Exit Temp	Exit Velocity	Stack Diameter
	(m)	(m)	(m)	(m)	(K)	(m/s)	(m)
UNIT12 – Boiler Units 1 & 2	503,514	3,939,364	253.9	96.0	Varying	Varying	9.0
UNIT3 – Boiler Unit 3	503,525	3,939,360	253.9	96.0	Varying	Varying	9.0
UNIT4 – Boiler Unit 4	503,517	3,939,354	253.9	96.0	Varying	Varying	9.0

8. Intermittent Sources

Most other emitting sources at Duke-Marshall are associated with coal and ash handling, conveying, and transport and do not emit SO_2. Duke-Marshall also operates two emergency generators, an emergency water pump, and an emergency air compressor which operate infrequently, combust ultra-low sulfur diesel (ULSD), and emit small quantities of SO_2. According to Section 5.4 of the modeling TAD, EPA states that it is most appropriate to include sources of emissions which operate continuously or frequent enough to contribute to the annual distribution of the daily maximum concentrations. Table 2 summarizes the emissions and operation of the intermittent sources. As shown in the table, max annual emissions of SO_2 from each of these sources during the period 2013-2015 is eight pounds per year, with max hourly emission rates well below the hundreds of pounds per hour continuously emitted from the coal-fired boilers. Thus, these intermittent sources operate at neither a frequency or magnitude great enough to contribute to the annual distribution of the daily maximum concentrations, and therefore, were not included in the analysis.

Table 2. Intermittent Sources of SO2 at Duke-Marshall

Source ID	**Emissions Source**	**Capacity**	**Max. Hourly Emission Rate* (lbs/hr)**	**Max Annual Emissions 2013-2015 (lbs)**	**Max Annual Fuel Use 2013-2015 (gal)**
ES-26 (EQWP)	Emergency water pump	1000 hp	0.012	2.0	165
ES-35 (EmGen)	Emergency Blackout protection generator	2681 hp	0.037	2.2	1550
ES-36 (AC)	Emergency Air Compressor	525 hp	0.006	4.0	105
ES-37EMGENLF	Emergency Generator at Landfill	134 hp	0.002	0.04	165

* Based on NC DAQ IC Engine Spreadsheets using 0.0015% ULSD

9. Nearby Emissions Sources

An evaluation was conducted to determine if other sources of SO_2 emissions in the area surrounding Duke-Marshall should be included in the modeling to fully characterize the air quality in the area. According to the EPA March 1, 2011 Memorandum[4] and the analysis presented at the 2011 EPA modeling workshop,[5] selection of regional background sources should be focused on sources located within 10 kilometers from Marshall. According to the NCDAQ's Emissions Inventory for 2013-2015, there were no other sources of SO_2 located within 10 km of the Marshall plant; however, based on EPA comments, large sources that were more than 10 km from Marshall were evaluated to determine if they should be included in the analysis. As shown in Table 3, three additional sources were identified within the 50 km AERMOD modeling range. However, only the Duke-Allen facility, located approximately 45 km south of the Marshall facility, was determined to have significant SO_2 emissions. As such, Duke-Allen hourly varying emissions and hourly varying stack release parameters were added to the modeling for Duke-Marshall under the DRR.

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[4] http://www.epa.gov/scram001/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf

[5] http://www.cleanairinfo.com/regionalstatelocalmodelingworkshop/archive/2011/Presentations/6-Thursday_AM/6-3_AB-3_Presentation_at_EPA_Modeling_Workshop.pdf,

Table 3. Sources of SO2 Near Duke-Marshall Within the 50 km AERMOD Modeling Range

Facility Name	Emissions TPY (Q)	Year	Distance km (D)	Q/D
Cardinal Fg Flat Glass Plant	160	2015	16	10
Tyson Farms, Inc. - Harmony	286	2015	44	7
Duke Allen Steam Station	1,128	2015	45	25

10. Receptor Grid

The size, spacing, and location of the receptor grid is unique to the modeling analysis. The receptor grid takes into account the location of the sources to be modeled, terrain features, and areas where the public generally has access. In accordance with the modeling TAD, receptors were not located in an area where it is not technically feasible to locate a monitor.

Receptor density was setup to detect the significant concentration gradient. Typically, the receptor spacing is closer near the source and further apart farther from the source. Receptor elevations were included in the modeling analysis. The receptor elevations were determined by AERMAP processing of 1-arc-second resolution terrain data from the USGS National Elevation Dataset (NED). Flagpole receptor height for this analysis was set at 0 meters. Figure 6 shows the placement of receptors modeled around Duke-Marshall.

The grid receptor spacing for the area of analysis is as follows:

- Receptors along the fence line every 50 meters
- Receptors every 100 meters from fence line to 3 km
- Receptors every 250 meters from 3 km to 5 km
- Receptors every 500 meters from 5 km to 10 km
- Receptors every 1000 meter from 10 km to 20 km
- Receptors every 2000 meter from 20 km to 50 km

Figures 7 and 8 show receptor grids overlaying townships and counties depicted at both smaller and larger scales, respectively. Figure 7 captures receptor grids extending out to 5 km. Figure 8 captures all receptor grids extending out to 50 km. The receptor grids, as shown, cover all or portions of the following North Carolina counties: Caldwell, Burke, Wilkes, Alexander, Catawba, Lincoln, Cleveland, Gaston, Iredell, Davie, Yadkin, Rowan, Mecklenburg, Cabarrus, Union, Forsyth, Davidson, and Stanly.

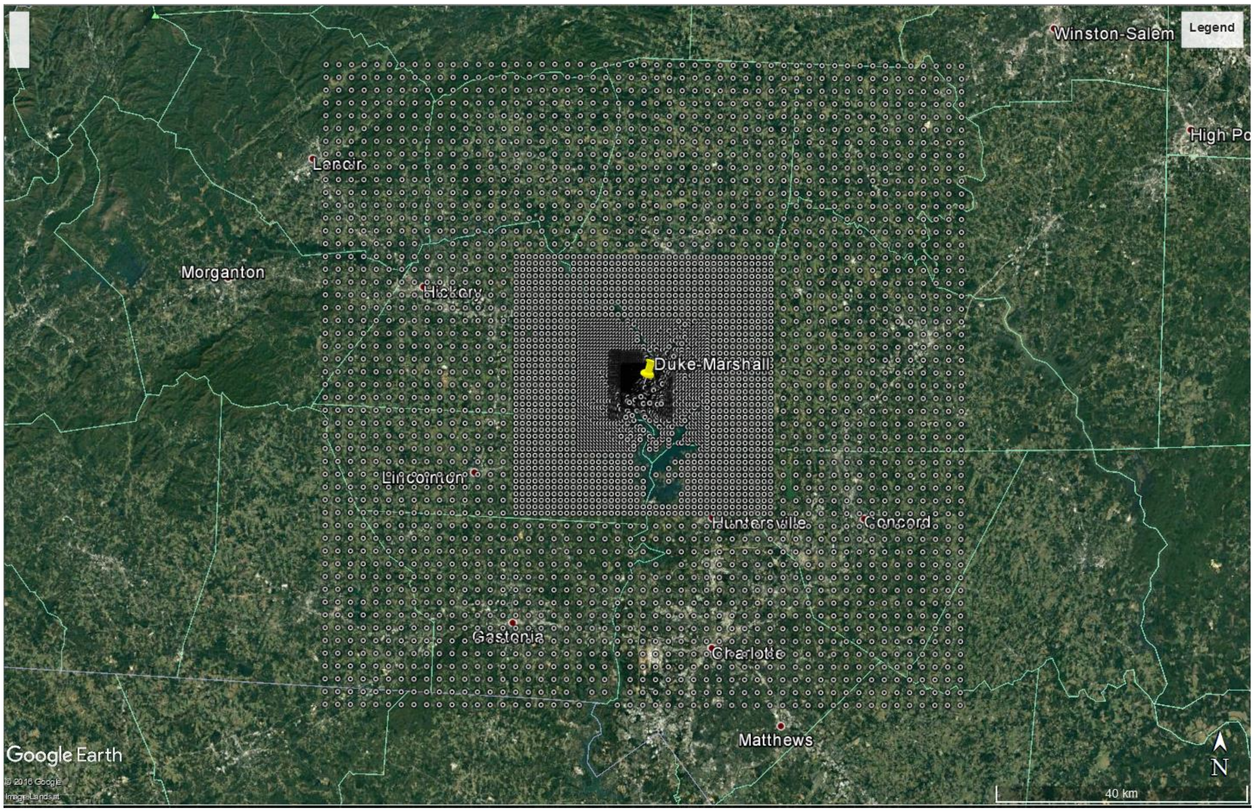

Figure 6. Receptor Layout and Nearby Emissions Sources in Duke-Marshall Analysis

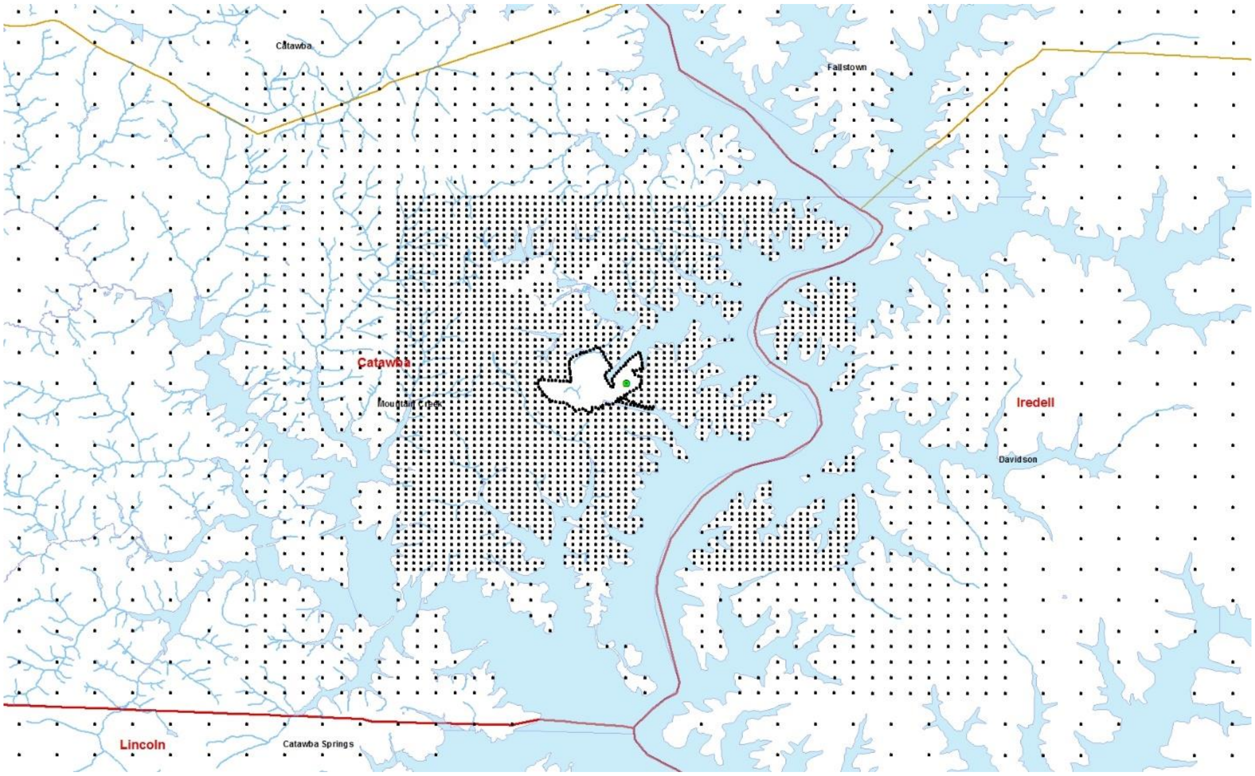

Figure 7. Receptor Grids Extending 5 km Overlaying Counties and Townships.

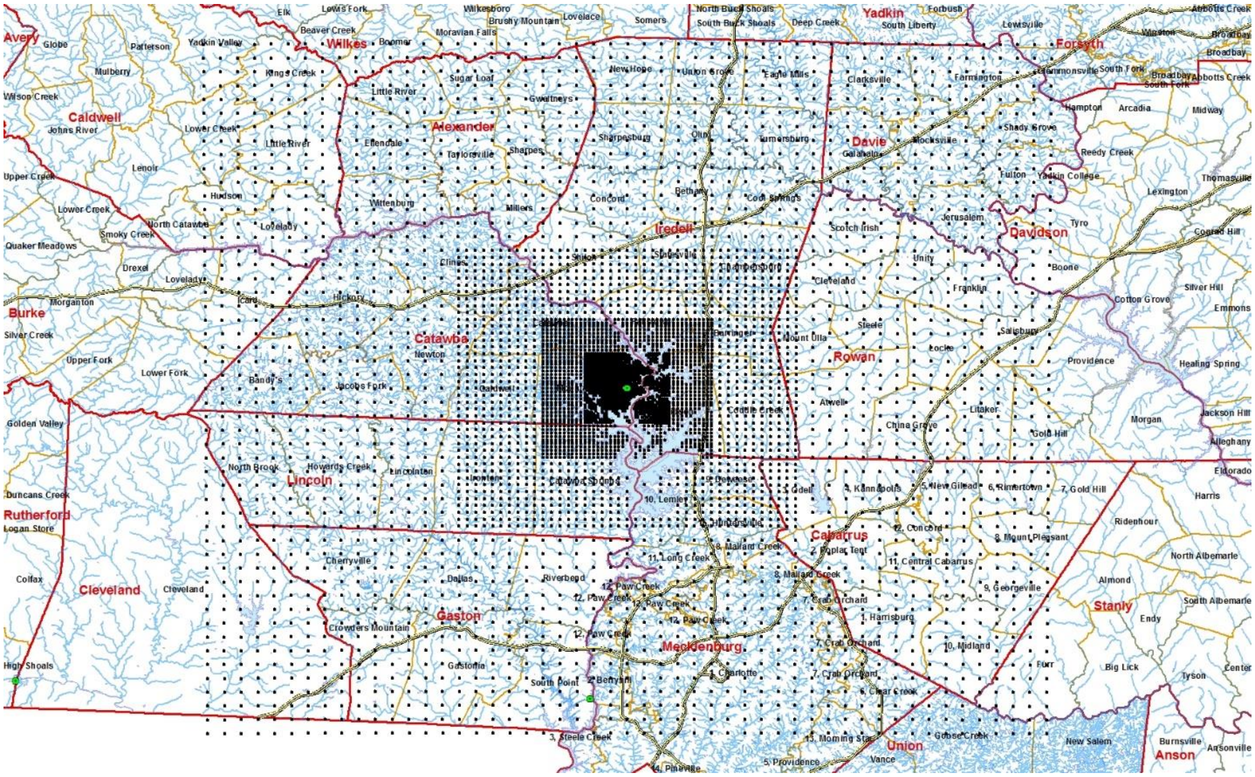

Figure 8. Receptor Grids Extending 50 km Overlaying Counties and Townships

11. Meteorological Data

For the purpose of modeling for attainment designation demonstration, three years of National Weather Service (NWS) data was used. The years used in the analysis were 2013-2015. The NWS surface and upper air observation sites used in the analysis are spatially and climatologically representative of the Marshall Station. Representativeness of observation sites was determined based on similarities in surrounding terrain, proximity, climatology, and availability of meteorological data meeting modeling application quality objectives and completeness criteria as specified by U.S. EPA guidance.[6] Thus, surface observation site data from the Gastonia Municipal Airport, located approximately 45 kilometers south of Marshall, was selected for dispersion modeling applications at the Marshall Station using AERMOD. Upper air data from the Greensboro Airport was selected for dispersion modeling applications using AERMOD based on comparable surrounding terrain and similar relative proximity of the Appalachian Mountains to the west and the Atlantic Ocean coast to the east.

The Charlotte International Airport surface data was reviewed for its appropriateness for use in dispersion modeling applications at the Marshall Station. However, the modelling results using

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[6] U.S. Environmental Protection Agency. 2000. “Meteorological Monitoring Guidance for Regulatory Modeling Applications.” EPA-454/R-99-005, February 2000.

the Charlotte data were less conservative than results using the Gastonia data. Thus, selection of Gastonia surface data over the Charlotte data was reaffirmed based on representativeness and conservatism.

AERMET (version 15181) was used to process, quality assure, and merge surface and upper air meteorological data. AERMET pre-processes the surface and upper air data to produce hourly surface and vertical profile meteorological and turbulence parameter inputs to AERMOD for calculation of air pollutant concentrations.

Hourly surface meteorological data collected at the Gastonia Municipal Airport site was obtained from the U.S. National Climatic Data Center (NCDC) for the modeling period 2013-2015 in the standard integrated surface hourly data (ISHD) format, and processed by AERMET.[7] The hourly data was supplemented, as recommended by the U.S. EPA, with TD-6405 format (so-called "1-minute") wind data also from the archives[8] and processed using the latest version of the AERMINUTE pre-processing tool (version 15272).

In addition to surface meteorological data, AERMET requires the use of data from an upper air sounding to estimate mixing heights and other boundary layer turbulence parameters. Upper air data from the nearest U.S.NWS radiosonde equipped station was utilized in the modeling analysis. In this case, upper air data from Greensboro was obtained from the National Oceanic and Atmospheric Administration (NOAA) in Forecast Systems Laboratory (FSL) format and used in the analysis.[9]

12. Land Use Analysis

AERMET requires land use parameters to derive wind and temperature vertical profiles that directly influence the dispersive capacity of the atmosphere and resultant model concentrations. These land use parameters include surface roughness, Bowen ratio, and albedo. Surface roughness is more important to characterization of mechanical turbulence under stable atmospheric conditions (e.g., calm winds during daytime or nighttime), whereas Bowen ratio and albedo are more important to characterization of convective turbulence under neutral and/or unstable atmospheric conditions (e.g., windy, daytime). In general, AERMOD is formulated to predict higher concentrations under stable atmospheric conditions, and thus, surface roughness is generally the most important of the three land use parameters in terms of determining the highest hourly concentrations.

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[7] ftp://ftp.ncdc.noaa.gov/pub/data/noaa/

[8] ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin

[9] http://www.esrl.noaa.gov/raobs/

The methodology outlined in Section 3.1.2 and 3.1.3 of the AERMOD Implementation Guide (AIG)[10] was applied using AERSURFACE (version 13016)[11] to determine surface roughness, Bowen ratio and albedo. AERSURFACE reads digital land cover data obtained from the USGS. USGS land cover data inputs to AERSURFACE were taken from the National Land Cover Dataset 1992 (NLCD92). AERSURFACE converts this data to the surface parameters listed above. These surface parameters are ultimately used by AERMET and AERMOD in calculation of hourly vertical wind and temperature profiles that are needed for calculation of hourly ambient concentrations at each receptor.

AERSURFACE processed NLCD land use data using location coordinates for the NWS surface site, seasonal defaults, 12 flow sectors of 30 degrees each, and airport location characterization. Surface roughness was analyzed for each of the 12 flow sectors within a 1 km radius circular land use area. Albedo and Bowen ratio were analyzed based on a 10 km by 10 km square land use area centered on the surface meteorological station. The surface moisture at the NWS surface site was classified as "wet" based on comparison of the model period (2013-2015) monthly precipitation totals to the statistical distribution of 30-year precipitation data. The surface moisture classification is used to adjust the seasonal Bowen ratios estimated by AERSURFACE.

Some land use surface characteristics found at the selected airport meteorological station are different than those found surrounding the model application site (Marshall Steam Station). Land use characteristics at the airport and facility are shown in Figures 9 and 10, respectively. The U.S. EPA recommends that these differences be evaluated to determine representativeness of the surface characteristics and to determine influences of surface characteristics on model concentrations.[12] EPA further recommends that consideration of surface roughness is most important due to model sensitivities to that particular surface parameter under stable atmospheric conditions. Differences between albedo and Bowen ratio are less significant than surface roughness in terms of influencing the highest hourly model concentrations due to the intrinsic role of albedo and Bowen ratio characterizing dispersion under neutral and/or unstable atmospheric conditions, when hourly model concentrations are expected to be relatively lower.

Differences in surface characteristics at the meteorological observation site and modeling application site were reviewed and compared to evaluate representativeness of the surface characteristics values. Seasonal surface characteristic values calculated by AERSURFACE at the airport and facility for each flow sector are provided in Table 4. As shown, the seasonal

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[10] US Environmental Protection Agency. 2015 "AERMOD Implementation Guide" revised August 3,2015. Available online https://www3.epa.gov/ttn/scram/7thconf/aermod/aermod_implmtn_guide_3August2015.pdf

[11] U.S. Environmental Protection Agency. 2013. "AERSURFACE User's Guide." EPA-454/B-08-001, Revised 01/16/2013. Available Online: http://www.epa.gov/scram001/7thconf/aermod/aersurface_userguide.pdf

[12] https://www3.epa.gov/ttn/scram/7thconf/aermod/aermod_implmtn_guide_3August2015.pdf, Section 3.1.

albedo and Bowen ratio values are similar, and therefore, are not expected to bias model predictions during unstable and/or neutral atmospheric conditions. Therefore, albedo and Bowen ratio values taken from the airport land use data are representative at the facility.

The overall average surface roughness values at the airport are similar to those estimated by AERSURFACE at the facility. The lower surface roughness values at the airport are expected to influence decreased dispersion and higher model concentrations, based on AERMOD conservative formulations applied under stable atmospheric conditions. Thus, lower surface roughness values at the airport introduce a degree of conservatism to the modeled concentrations predicted under stable atmospheric conditions. Figures 11 and 12 show surface roughness values at the airport and facility, respectively, during summertime when differences in surface roughness are greatest. The largest differences in surface roughness at the airport compared to the facility occur in the northeastern and northwestern quadrants where there is notable disparity in the spatial distribution of land and water. However, prevailing winds in the area are primarily observed from the south and southwest where surface roughness at the airport and facility are very similar. Model design concentrations and upper distribution of predicted concentrations were found to coincide with prevailing wind directions where dispersion calculations rely on upwind surface roughness values derived from the south and southwestern flow sectors. As such, airport surface roughness values were determined to be representative at the facility owing to the similar influence of prevailing upwind surface roughness values on model design concentrations occurring predominantly downwind of the facility.

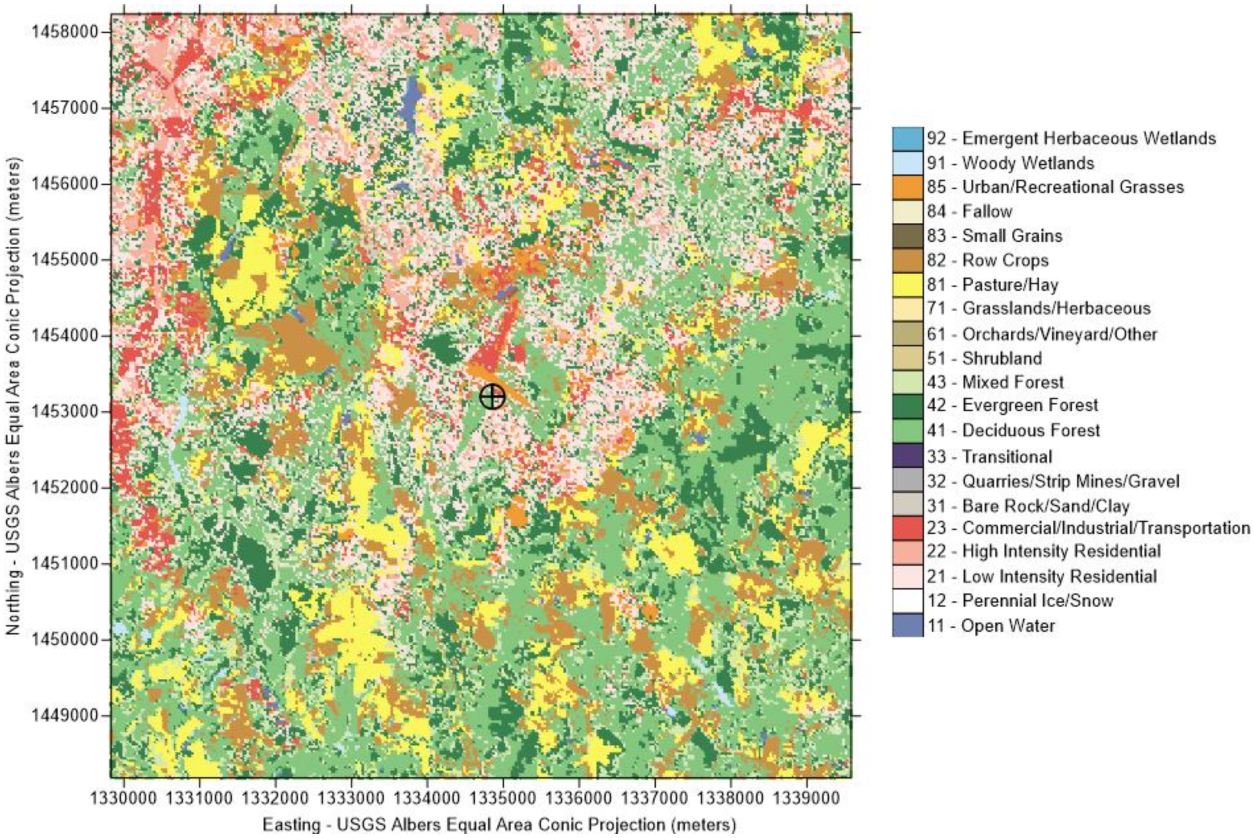

Figure 9. Gastonia Municipal Airport Land Use (10km x 10km Area)

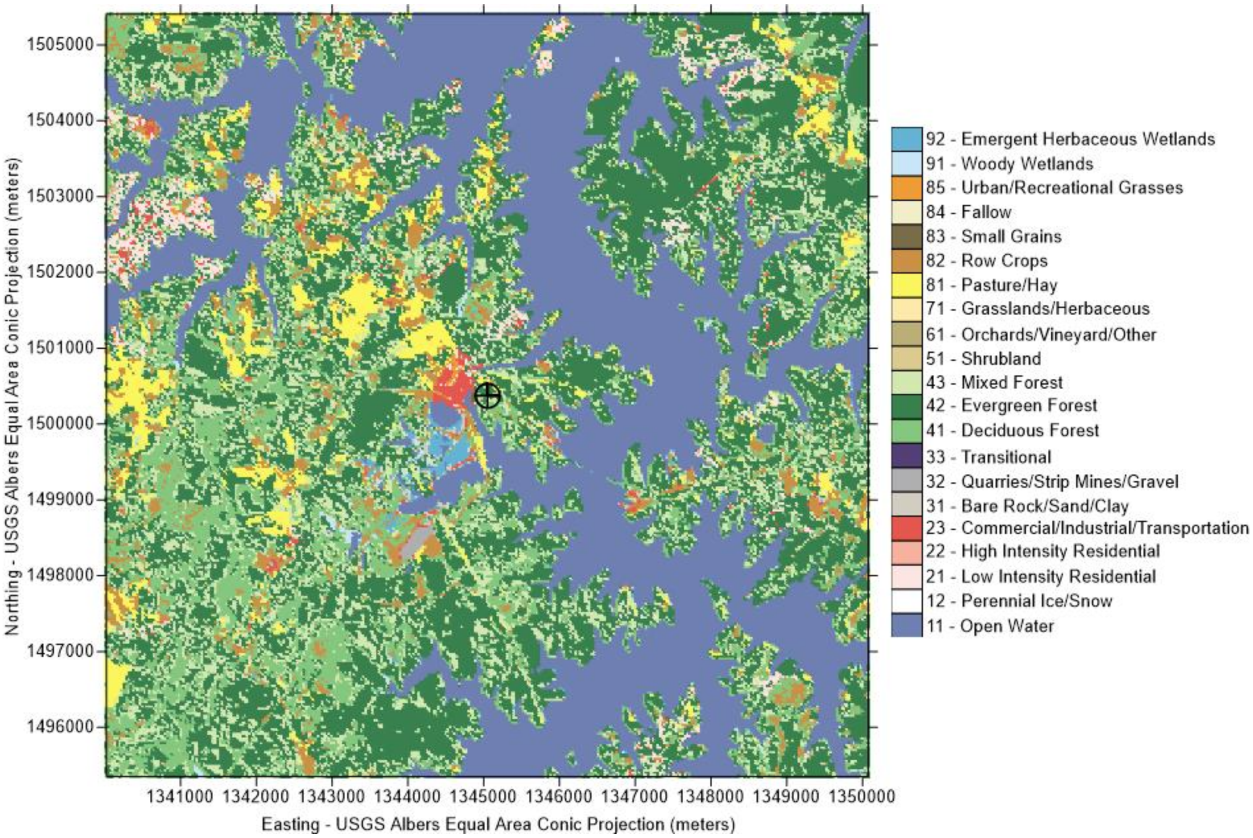

Figure 10. Duke-Marshall Land Use (10km x 10km Area)

Table 4. Surface Characteristics Comparison and Evaluation

		Gastonia Municipal Airport			Marshall Steam Station		
Season	Flow Sector	Albedo	Bowen Ratio	Surface Roughness (m)	Albedo	Bowen Ratio	Surface Roughness (m)
Winter	(0 - 30)	0.16	0.89	0.104	0.13	0.24	0.034
Winter	(30 - 60)	0.16	0.89	0.121	0.13	0.24	0.293
Winter	(60 - 90)	0.16	0.89	0.225	0.13	0.24	0.625
Winter	(90 - 120)	0.16	0.89	0.288	0.13	0.24	0.664
Winter	(120 - 150)	0.16	0.89	0.341	0.13	0.24	0.198
Winter	(150 - 180)	0.16	0.89	0.337	0.13	0.24	0.381
Winter	(180 - 210)	0.16	0.89	0.468	0.13	0.24	0.568
Winter	(210 - 240)	0.16	0.89	0.437	0.13	0.24	0.288
Winter	(240 - 270)	0.16	0.89	0.267	0.13	0.24	0.237
Winter	(270 - 300)	0.16	0.89	0.202	0.13	0.24	0.158
Winter	(300 - 330)	0.16	0.89	0.345	0.13	0.24	0.037
Winter	(330 - 360)	0.16	0.89	0.250	0.13	0.24	0.126
Spring	(0 - 30)	0.15	0.61	0.135	0.13	0.21	0.039
Spring	(30 - 60)	0.15	0.61	0.164	0.13	0.21	0.377
Spring	(60 - 90)	0.15	0.61	0.329	0.13	0.21	0.724
Spring	(90 - 120)	0.15	0.61	0.417	0.13	0.21	0.771
Spring	(120 - 150)	0.15	0.61	0.460	0.13	0.21	0.224
Spring	(150 - 180)	0.15	0.61	0.436	0.13	0.21	0.439
Spring	(180 - 210)	0.15	0.61	0.655	0.13	0.21	0.639
Spring	(210 - 240)	0.15	0.61	0.609	0.13	0.21	0.337
Spring	(240 - 270)	0.15	0.61	0.355	0.13	0.21	0.274
Spring	(270 - 300)	0.15	0.61	0.270	0.13	0.21	0.174
Spring	(300 - 330)	0.15	0.61	0.434	0.13	0.21	0.040
Spring	(330 - 360)	0.15	0.61	0.324	0.13	0.21	0.144
Summer	(0 - 30)	0.16	0.45	0.169	0.13	0.17	0.048
Summer	(30 - 60)	0.16	0.45	0.213	0.13	0.17	0.466
Summer	(60 - 90)	0.16	0.45	0.430	0.13	0.17	0.893
Summer	(90 - 120)	0.16	0.45	0.523	0.13	0.17	0.960
Summer	(120 - 150)	0.16	0.45	0.508	0.13	0.17	0.283
Summer	(150 - 180)	0.16	0.45	0.480	0.13	0.17	0.536
Summer	(180 - 210)	0.16	0.45	0.778	0.13	0.17	0.768
Summer	(210 - 240)	0.16	0.45	0.719	0.13	0.17	0.483
Summer	(240 - 270)	0.16	0.45	0.494	0.13	0.17	0.420
Summer	(270 - 300)	0.16	0.45	0.379	0.13	0.17	0.232
Summer	(300 - 330)	0.16	0.45	0.482	0.13	0.17	0.048
Summer	(330 - 360)	0.16	0.45	0.410	0.13	0.17	0.201
Fall	(0 - 30)	0.16	0.89	0.160	0.13	0.24	0.048

Fall	(30 - 60)	0.16	0.89	0.202	0.13	0.24	0.466
Fall	(60 - 90)	0.16	0.89	0.412	0.13	0.24	0.893
Fall	(90 - 120)	0.16	0.89	0.505	0.13	0.24	0.960
Fall	(120 - 150)	0.16	0.89	0.498	0.13	0.24	0.283
Fall	(150 - 180)	0.16	0.89	0.472	0.13	0.24	0.536
Fall	(180 - 210)	0.16	0.89	0.777	0.13	0.24	0.768
Fall	(210 - 240)	0.16	0.89	0.716	0.13	0.24	0.474
Fall	(240 - 270)	0.16	0.89	0.491	0.13	0.24	0.413
Fall	(270 - 300)	0.16	0.89	0.375	0.13	0.24	0.230
Fall	(300 - 330)	0.16	0.89	0.473	0.13	0.24	0.048
Fall	(330 - 360)	0.16	0.89	0.396	0.13	0.24	0.201
Average:		**0.16**	**0.71**	**0.397**	**0.13**	**0.22**	**0.384**

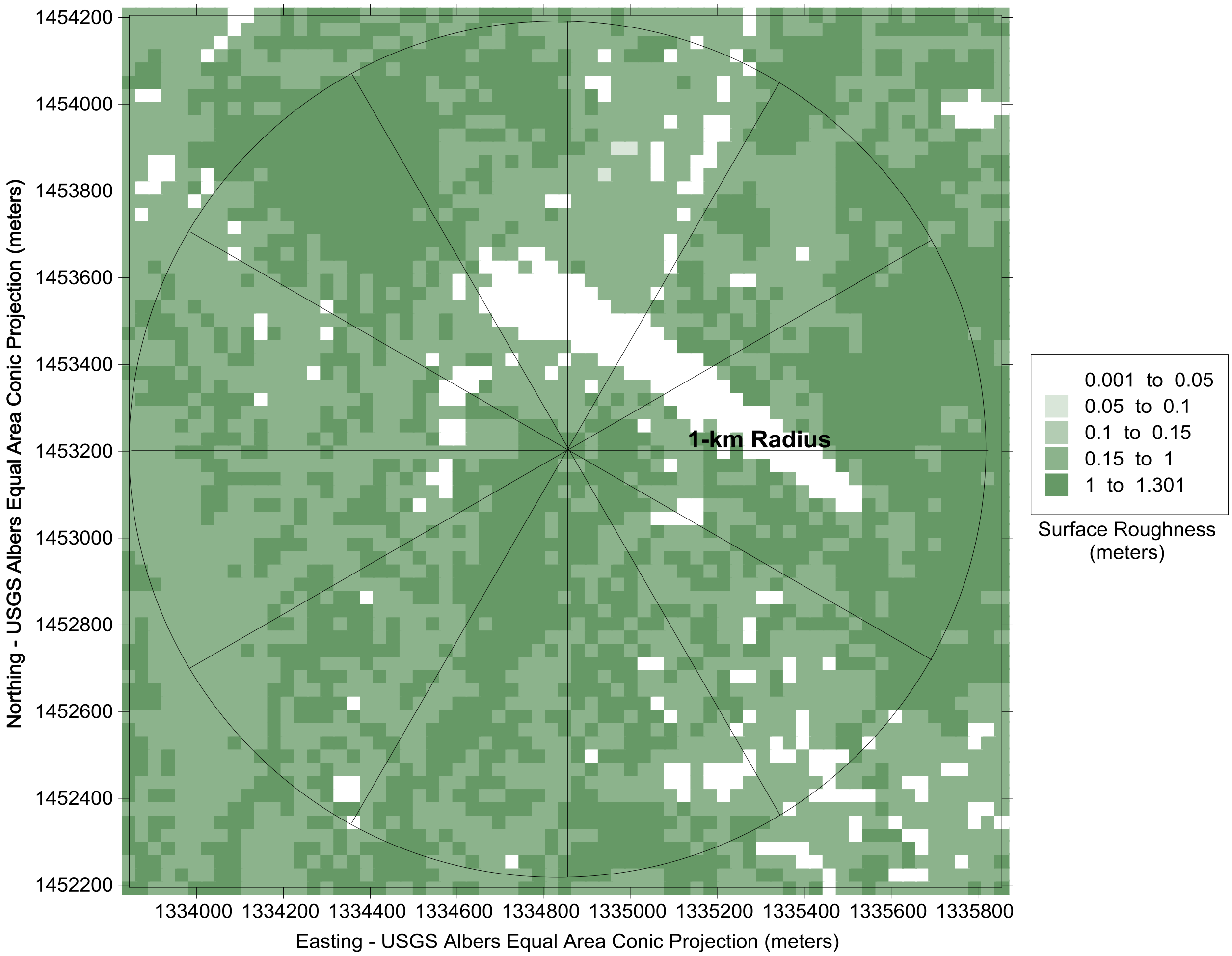

Figure 11. Gastonia Airport Summertime Surface Roughness Analysis Area (12 Sectors, 1km-Radius)

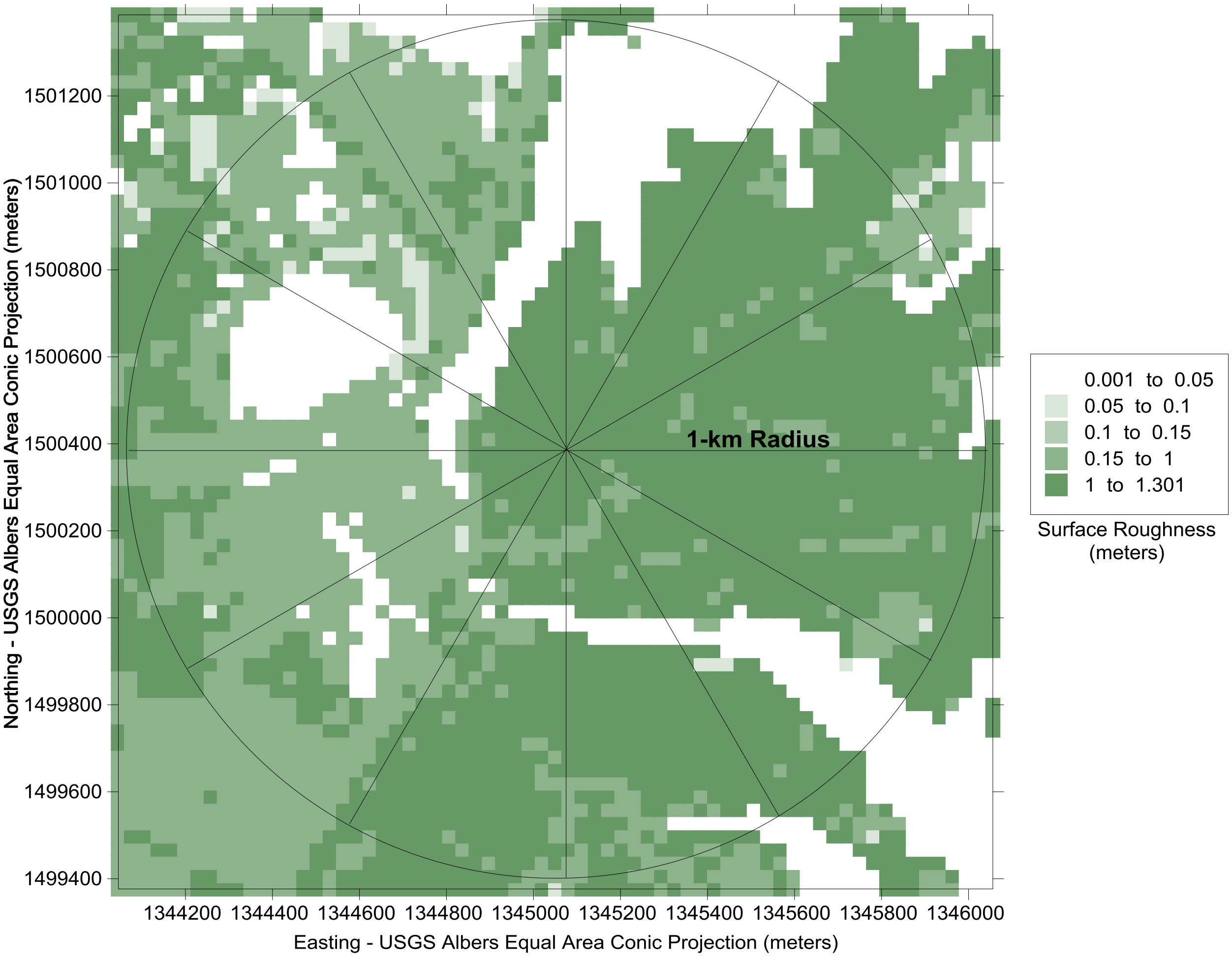

Figure 12. Duke-Marshall Summertime Surface Roughness Analysis Area (12 Sectors, 1km-Radius)

13. Model Results

The model output was configured to generate 1-hour SO2 concentration design values consistent with the 1-hour SO2 NAAQS. As such, the model used the annual 99th percentile daily max 1-hour SO2 values averaged over the 2013-2015 period at each receptor to determine the design concentration values needed for comparison to the 1-hour SO2 NAAQS.

The maximum 1-hour SO2 design concentration for Duke-Marshall emissions alone was modeled at 159.2 µg/m^3. The nearby source Duke-Allen contributes 0.2 µg/m^3 to the max design concentration resulting in a total max 1-hour SO2 design concentration of 159.4 µg/m^3. Figure 13 shows the max design concentration occurs 0.8 km northeast of the Duke-Marshall combined stack location. Figure 14 shows 1-hour SO2 design concentrations for the entire modeling domain. As shown, max 1-hour SO2 design concentrations are well below the 1-hour SO2

NAAQS of 196 µg/m^3. For example, design concentrations throughout the majority of the modeling domain were modeled at less than 60 µg/m^3. Modeled impacts above 60 µg/m^3 extend roughly 10 km from the facility. Note the entire modeling domain extends 50 km from the Duke-Marshall facility in all directions.

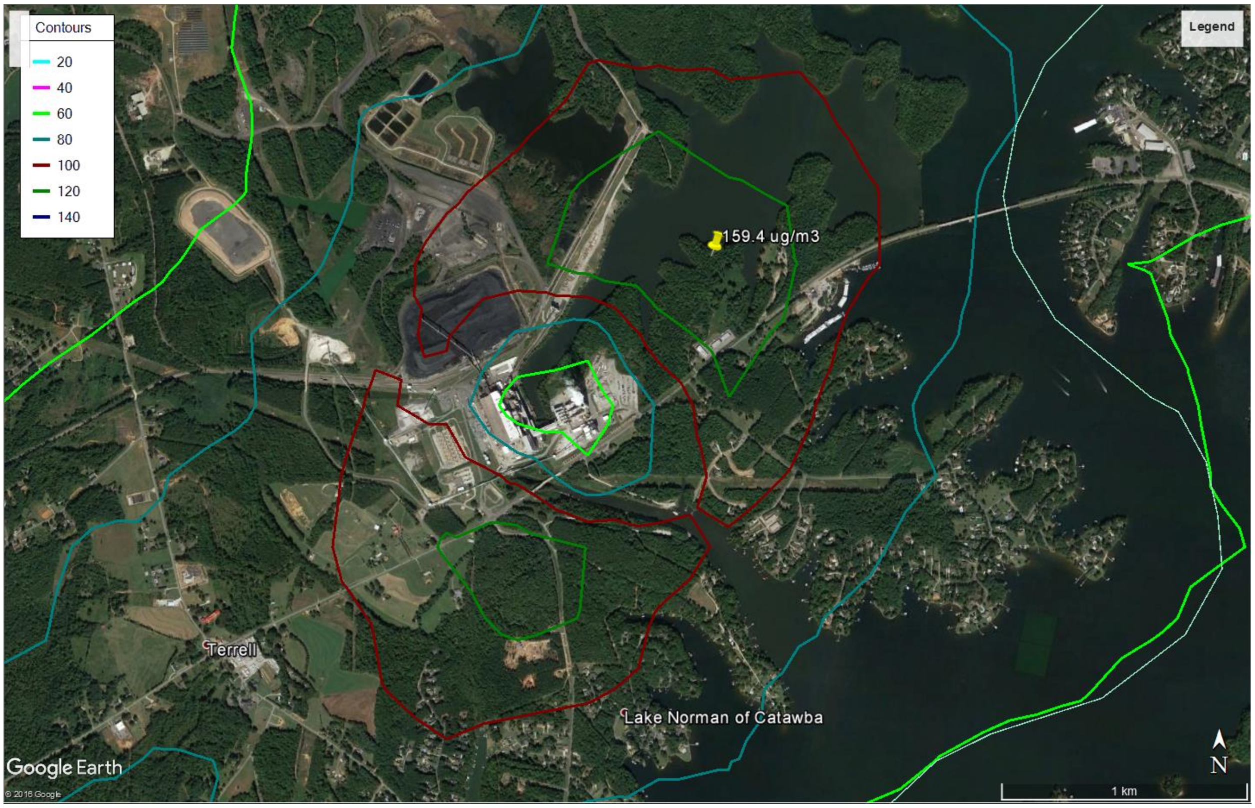

Figure 13. Close-up View of 3-Year Average, Annual 98th Percentile Daily Max 1-Hour SO2 Concentration - Duke-Marshall and Nearby Sources

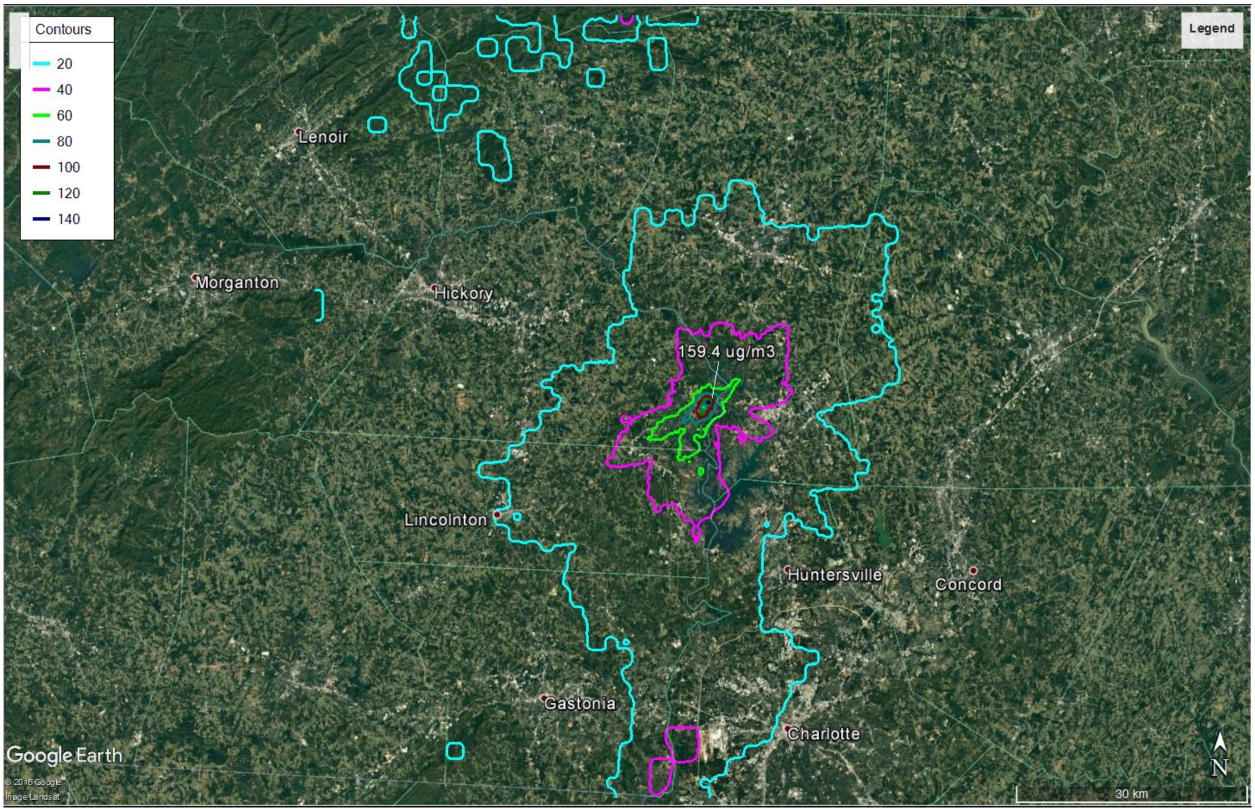

Figure 14. Full Modeling Domain View of 3-Year Average, Annual 98th Percentile Daily Max 1-Hour SO2 Concentration - Duke-Marshall and Nearby Sources

14. Background Concentrations

Background concentrations in the model results are important in determining the impacts from sources of SO$_2$ which are not explicitly included in the model. Background concentrations were evaluated using the EPA's March 1, 2011 memo, "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO$_2$ Ambient Air Quality Standard." Table 5 summarizes the available SO$_2$ monitoring locations surrounding Marshall with their 2013-2015 design values. The Charlotte, NC monitor was selected to represent Marshall since it is the closest, and additionally, may overestimate the background near Marshall since it is located in a more densely populated area. The 2013-2015 design value for the Charlotte monitor was 18 µg/m^3 (7 ppb).

Table 5. Monitor Data Surrounding Duke-Marshall for the 1-hour SO2 NAAQS

Monitor Location	Distance from Marshall (Kilometers)	ID	2013-2015 Design Value $\mu g/m^3$ (ppb)
Charlotte, NC	43	37-119-0041	18 (7)
Winston-Salem, NC	87	37-067-0022	23 (9)
Greenville, SC	160	45-045-0015	10 (4)
Dentsville, SC	174	45-079-0007	26 (10)
Seven Oaks, SC	179	45-063-0008	99 (38)

15. Comparison to Standard

The background concentration was added to the design values and the resulting values were compared to the SO_2 NAAQS of 196 $\mu g/m^3$. Table 6 shows that the sum of the background concentration and max modeled design value is 178 $\mu g/m^3$. Therefore, the total combined impacts as estimated from summation of background concentration, modeled nearby sources, and modeled Duke-Marshall sources are less than the 1-hour SO2 NAAQS. Furthermore, this modeling analysis demonstrates attainment of the 1-hour SO2 NAAQS within the context of the Duke-Marshall 1-hour SO2 impacts to the area of interest surrounding the facility.

Table 6. Comparison of Duke-Marshall Results to the NAAQS

Years Modeled	Max Modeled Design Value ($\mu g/m^3$)	Background Concentration ($\mu g/m^3$)	Background + Modeled ($\mu g/m^3$)	1-hr SO_2 NAAQS ($\mu g/m^3$)	% NAAQS	NAAQS Exceeded?
2013-2015	159	18	178	196	91%	No

The NCDAQ will provide EPA with input/out files necessary to validate the results of the modeling analysis.