SCOTT A. THOMPSON
Executive Director

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

MARY FALLIN
Governor

September 18, 2015

CERTIFIED MAIL RETURN RECEIPT REQUESTED

Mr. Ron Curry, Regional Administrator
U.S. Environmental Protection Agency, Region 6
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202-2733

Subject: Evaluation and Information Supporting Oklahoma's Designation Recommendation for 2010 Sulfur Dioxide NAAQS for Noble, Choctaw, and Muskogee Counties in Oklahoma

Dear Administrator Curry:

As referenced in Governor Fallin's letter of August 17, 2015, attached is our evaluation and information to support the State's recommendation for the U.S. Environmental Protection Agency to consider for designation of the affected areas. One hard copy of all documents is included, along with one DVD that contains an electronic (.pdf) copy of all documents, as well as a copy of the modeling files.

If you desire additional information, or you have any questions concerning this matter, please contact me, at 405-702-4100.

Sincerely,

Eddie Terrill, Director of Air Quality Division
Oklahoma Department of Environmental Quality

cc: Michael Teague, Secretary of Energy and Environment
Scott Thompson, Executive Director, Department of Environmental Quality
Guy Donaldson, Chief, Air Planning Section, US EPA 6
Carrie Paige, Air Planning Section, US EPA 6
Dayana Medina, Air Planning Section, US EPA 6

OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR QUALITY DIVISION

2015

Technical Analyses and Information Supporting the Designation Recommendation for Oklahoma

2010 Sulfur Dioxide Primary NAAQS
for
Noble, Choctaw, and Muskogee Counties
In Oklahoma

Submitted to EPA
September 2015

2010 Primary Sulfur Dioxide (SO_2)
National Ambient Air Quality Standard (NAAQS)

Technical Analyses and Information Supporting the Designation Recommendation for Oklahoma

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LIST OF ATTACHMENTS

- Cover Letter (from Director) – September 18, 2015
- Introduction and Summary
- Correspondence
    - Governor's letter -- May 27, 2011, Designation Recommendation
    - Governor's letter – August 17, 2015. Affirmation of Designation Recommendation for 2010 Sulfur Dioxide NAAQS for Noble, Choctaw, and Muskogee Counties in Oklahoma
    - EPA letter to Scott Thompson – March 20, 2015
- Modeling Report -- Modeling Compliance with the 1-Hour SO2 NAAQS
- Technical Evaluation
    - Modeling Analysis Report -- Source-Oriented SO2 Monitoring Placement for the Area of Muskogee, Oklahoma
    - Comparison of Modeled and Monitored SO2 Concentrations in Muskogee, Oklahoma
    - Effects of Terrain on Wind Speeds
    - OG&E's Public Statements on the Conversion of Muskogee Units 4 & 5 to Natural Gas
- List of Modeling Files Included in Zip File "Modeling.7z" on DVD

2010 Primary Sulfur Dioxide (SO_2) National Ambient Air Quality Standard (NAAQS)

Technical Analyses and Information Supporting the Designation Recommendation for Oklahoma

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Introduction and Summary

Air Quality Division

Oklahoma Department of Environmental Quality

September 18, 2015

Introduction, Summary, and State Recommendation

In 2010, the U.S. Environmental Protection Agency (EPA) promulgated a new National Ambient Air Quality Standard (NAAQS) for sulfur dioxide (SO_2) of 75 parts per billion (ppb) on a 1-hour average. In response, Governor Mary Fallin submitted a letter dated May 27, 2011 providing the State of Oklahoma's recommendations for designations under the new NAAQS. The State recommended a designation of unclassifiable for Muskogee and Tulsa counties, and attainment for all the other 75 counties within the state. EPA identified areas of the U.S. with monitored violations of the 2010 SO_2 NAAQS, designated those areas as nonattainment in July 2013, and deferred designations for remaining areas. No areas in Oklahoma were included in the July 2013 designations.

On March 2, 2015, the U.S. District Court for the Northern District of California entered a federal consent decree between EPA and Sierra Club (SC) and Natural Resources Defense Council (NRDC), which resolved litigation over the deadline for EPA's completion of designations. The court order established that EPA must complete designations in three additional rounds. The first round of designations must be completed by July 2, 2016, and must be made for 1) areas that have newly monitored violations of the 2010 SO_2 standard and 2) areas that contain any stationary source that according to the EPA's Air Markets Database either emitted more than 16,000 tons of SO_2 in 2012 or emitted more than 2,600 tons of SO_2 and had an emission rate of at least 0.45 lbs SO_2/MMBTU in 2012 and that has not been announced for retirement (as of March 2, 2015).

In a letter dated March 20, 2015 to Scott Thompson, Executive Director, Oklahoma Department of Environmental Quality (DEQ), EPA Acting Assistant Administrator Janet McCabe identified three affected electric power plant sources in Oklahoma that meet the criteria for designation by July 2, 2016: Western Farmers Electric Cooperative (WFEC) Hugo Generating Station in Choctaw County, Oklahoma Gas and Electric (OG&E) Sooner Generating Station in Noble County, and OG&E Muskogee Generating Station in Muskogee County. EPA stated that the most recent information available would be used in making designations and boundary decisions for these areas in Oklahoma, and provided an opportunity for Oklahoma to submit an updated recommendation and supporting information to inform the designations for the affected areas. Any updated recommendation and supporting information was to be submitted to EPA by September 18, 2015, and was to conform to the "Updated Guidance for Area Designation for the 2010 Primary Sulfur Dioxide National Ambient Air Quality Standard, March 20, 2015."

On August 17, 2015 Governor Fallin sent a letter to EPA recommending designations of unclassifiable for Muskogee County and attainment for Noble and Choctaw Counties for the July 2, 2016 designations. That recommendation is based on supporting information contained within this package.

General Overview of Impact Analysis Approach and Modeling Methodology

DEQ evaluated pertinent source-oriented monitoring data and conducted air dispersion modeling for the three affected facilities to determine impacts, and to inform the State's recommendations for the 2010 1-hour SO_2 NAAQS designations.

Ambient impacts of SO_2 are largely source-oriented, meaning the highest concentrations will be exhibited in close proximity to the emitting sources. The 2010 1-hour SO_2 NAAQS replaced the existing annual and 24-hour standards (140 ppb and 30 ppb, respectively) with a one-hour standard of 75 ppb. This substantial change to the form of the standard indicated more focus on short-term exposure to high levels of SO_2. These facts, as well as limited state and federal resources, have led to EPA's "hybrid" approach to attainment designations – relying on modeling to overcome limitations of the SO_2 monitoring network.

40 CFR Part 51, Appendix W, *Guideline on Air Quality Models,* recommends the use of AMS/EPA Regulatory Model (AERMOD), citing the dispersion model's capability to address multiple sources, both rural and urban areas, flat and complex terrain, and surface and elevated emission release points. The enclosed "Modeling Compliance with the 1-Hour SO_2 NAAQS" ("Modeling Report") describes the significant effort DEQ has expended to determine, obtain and refine the data required to complete the modeling analysis. Due to the unique nature of utilizing model predictions as a surrogate to monitored air quality data, model inputs were chosen in a manner that best reflects actual conditions.

The 2010 1-hour SO_2 NAAQS is attained when the three-year average of the 99th percentile of the daily maximum one-hour average does not exceed 75 ppb (or 196.4 $\mu g/m^3$)[1]. The "design value" used to compare to the 75 ppb standard is calculated as the three-year average of the highest fourth highest (H4H) SO_2 value for a particular monitor or modeling receptor. Attainment of the standard would be demonstrated if the modeled cumulative impact of the affected sources and other contributing nearby sources added to the background concentration is less than 75 ppb. The 2012-2014 monitoring design value (9.6 $\mu g/m^3$) from the monitor (ID 40-109-1037) in Oklahoma County was used as a background concentration for the modeling analyses, since it is the only SO_2 monitor located in Oklahoma that is not directly impacted by a large SO_2 emission source.

For each affected facility/area, the Modeling Report describes the determination of the appropriate modeling domain, receptor grid, meteorological and terrain data, ambient monitored background concentrations, and emissions from other contributing nearby sources. Actual source emissions data were gathered or calculated for the years 2012-2014. Hourly emissions data from the affected sources were taken from continuous emissions monitoring systems (CEMS) when available. If CEMS data were unavailable, the emissions were calculated using throughputs and

[1] For all ambient measurements/projections, EPA reference conditions are used in converting between ppb and $\mu g/m^3$ (*see* 40 CFR §50.3).

operational data. Federally enforceable requirements will result in significant SO_2 emissions reductions from the OG&E Sooner and Muskogee Stations within the next five years. As described in more detail below, modeling was also performed using alternate operating scenarios to project the impact of these changes on ambient air quality. Oklahoma DEQ primarily utilized meteorological data from Oklahoma Mesonet sites in combination with data from the National Climatic Data Center's (NCDC) Integrated Surface Hourly Database (ISHD) to generate more representative surface meteorological conditions. For the Muskogee area, only data from the ISHD was utilized. The OG&E Muskogee facility section below, along with the additional documents, discusses questions regarding meteorological data representativeness, effects of complex terrain, and other issues for the Muskogee area. The following additional reports have been prepared and included to support modeling report's conclusions:

1. Comparison of Modeled and Monitored SO_2 Concentrations in Muskogee, Oklahoma
2. Effects of Terrain on Wind Flow in Muskogee, Oklahoma
3. Source-Oriented SO_2 Monitoring Placement for the Area of Muskogee, Oklahoma – Modeling Analysis Report

A description of the three affected electric generating stations and modeling analysis and results for each are described.

Choctaw County WFEC Hugo Generating Station

The WFEC – Hugo Generating Station in Choctaw County is located three miles west of Ft. Towson on US-70, 12 miles east of Hugo, Oklahoma.

The coal-fired complex at the Hugo power plant consists of one main boiler with a maximum heat input of 184 million British thermal units per hour (MMBTU/hr) and an auxiliary boiler unit. The main boiler has a capacity of 446 megawatts (MW) electrical output and primarily combusts sub-bituminous coal to produce steam used to generate electric power (SIC 4911). The flue gas is exhausted through a single 500 foot stack. An auxiliary unit is used as backup during turnaround periods, and is fueled exclusively by No. 2 fuel oil. The Hugo power plant was constructed in 1978 as authorized by Permit Number PSD-OK-053 and has no SO_2 controls installed. The Hugo plant is operating under permit number 2008-337-TVR (M-1), which limits SO_2 emissions to 1.2 lbs/MMBTU, 4,591.8 lbs/hr, and 16,404.1 tons per year.

There is no ambient monitoring site in close proximity to the WFEC Hugo Generating Station. The facility's SO_2 emissions would not be expected to have a significant impact on the Muskogee monitoring site (40-101-0167), which is the Oklahoma monitoring site located closest to the Hugo plant.

DEQ performed modeling to confirm the State's recommended designation of attainment with the new SO_2 standard for the areas affected by the Hugo plant emissions. The modeling utilized actual emissions data for years 2012 through 2014 obtained from EPA's Clean Air Markets Database (CAMD). The modeling demonstrated compliance with the 2010 1-hour SO_2 NAAQS of 75 ppb for the areas surrounding the WFEC Hugo Generating Station, with a three-year average of the H4H daily maximum impacts of 45 ppb (118.2 µg/m^3).(*See* Modeling Report, Section 7.1)

Noble County – OG&E Sooner Generating Station

The OG&E Sooner Generating Station in Noble County is located 19 miles North of Stillwater on US-177, six miles east of Red Rock, Oklahoma. The Sooner Generating Station is a coal-fired steam boiler electric generation facility consisting of two units that use sub-bituminous low-sulfur Wyoming coal as the primary fuel and No. 2 fuel oil as a start-up fuel. Neither boiler is designed to operate on oil continuously.

Both Units 1 and 2 can potentially combust approximately 300 tons per hour of coal to produce 3.8 million pounds per hour of steam each. Both boilers were designed with a maximum heat input of 5,116 MMBTU/hr and a nominal 550 MW electrical output. Flue gas is exhausted through two 500-foot stacks. The Sooner plant currently operates under AQ Permit Number 2010-338-TVR2 (M-2), which limits SO_2 emissions to 1.2 lbs/MMBTU for Units 1 and 2. However, under the Regional Haze Program, the Sooner plant is required to meet limits that represent Best Available Retrofit Technology (BART) to control SO_2 emissions from Units 1 and 2. OG&E Sooner Generating Station is subject to a Federal Implementation Plan (FIP) (40 CFR §52.1923), which requires Units 1 and 2 to meet a SO_2 emission limit of 0.06 lb/MMBTU by January 4, 2019. OG&E has committed[2] to meet the federal BART limit by using flue gas desulfurization to control SO_2 emissions from Units 1 and 2.

There is no ambient monitoring site in close proximity to the OG&E Sooner Generating Station. No violation of the 2010 SO_2 NAAQS has been detected at the Ponca City monitoring site (40-071-0604) in Kay County, which is the site located closest to the Sooner Plant, for the last three years of available certified data. The design value for the Ponca City site for the years 2012 through 2014 is 37 ppb.

DEQ performed modeling to confirm the State's recommended designation of attainment with the new SO_2 standard for the areas affected by the Sooner plant emissions. Since the BART emission reductions will occur after the court-ordered deadline for the designation decision, the air quality analyses for this facility involved three operating scenarios.

For Scenario 1:
Modeled using actual emissions data for OG&E Unit 1 & Unit 2 from EPA's Clean Air Markets Database for years 2012 through 2014.

For Scenario 2:
Modeled potential emissions from OG&E Unit 1 using the BART emission limit (0.06 lb/MMBTU) and projected actual emissions from OG&E Unit 2 using the 2012 through 2014 three year average of the 99th percentile emission rate and heat input.

[2] See "OG&E's Public Statements on Commitments to Meet EPA's Regional Haze FIP Requirements."

For Scenario 3:

Modeled potential emissions from OG&E Unit 1 and Unit 2 using the BART emission limit (0.06 lb/MMBTU).

The modeled three-year average of the H4H daily maximum impacts for each operating scenario are:

Scenario 1 - 52 ppb (136.6 μg/m^3)

Scenario 2 - 62 ppb (161.7 μg/m^3)

Scenario 3 - 17 ppb (43.5 μg/m^3)

The modeling review demonstrated compliance with the 2010 1-hour SO_2 NAAQS of 75 ppb, for the areas surrounding the OG&E Sooner Generating Station, with a three-year average of the H4H daily maximum impact of 62 ppb (161.7 μg/m^3).(*See* Modeling Report, Section 7.3)

Muskogee County – OG&E Muskogee Generating Station

The OG&E Muskogee Generating Station in Muskogee County is located near Muskogee on US-62 on the East bank of the Arkansas River, in Fort Gibson, Oklahoma.

The Muskogee Generating Station is a coal-fired steam boiler electric generation facility consisting of three units (Units 4, 5 and 6) that use sub-bituminous low-sulfur Wyoming coal as the primary fuel and natural gas as a start-up fuel. Units 1, 2, and 3, the oldest units, have been retired.

Units 4, 5, and 6 can each potentially combust approximately 300 tons per hour of coal to produce 3.8 million pounds per hour of steam each. These units each have a nominal capacity of 550 MW electrical output. Units 4 and 5 each have a 350 foot stack, and Unit 6 has a 500 foot stack. The Muskogee plant is operating under AQ Permit Number 2005-271-TVR (M-7), which contains SO_2 emission limits of 1.2 lbs/MMBTU for units 4 and 5, and 1.2 lbs/MMBTU and 6,180.0 lbs/hr for unit 6. However, under the Regional Haze Program, the Muskogee plant is required to meet limits that represent Best Available Retrofit Technology (BART) to control SO_2 emissions from Units 4 and 5. OG&E Muskogee Generating Station is subject to a Federal Implementation Plan (FIP) (40 CFR §52.1923), which requires Units 4 and 5 to meet a SO_2 emission limit of 0.06 lb/MMBTU by January 4, 2019. OG&E has committed[3] to meet the federal BART limit by conversion of Unit 4 and Unit 5 to natural gas.

A source-oriented SO_2 monitoring site (40-101-0167) has been operated in close proximity to the OG&E Muskogee Generating Station since 1981[4]. No violation of the 2010 SO_2 NAAQS has been detected at the Muskogee monitoring site, located 4 km NNW of the facility, for the last

[3] Ibid.

[4] See "Source-Oriented SO_2 Monitoring Placement for the Area of Muskogee, Oklahoma – Modeling Analysis Report"

three years of available certified data. The design value for the Muskogee site for 2012 through 2014 is 49 ppb.

DEQ performed modeling to confirm the State's recommended designation of unclassifiable for the new SO_2 standard for the areas affected by the Muskogee plant emissions. Since the BART emission reductions will occur after the court-ordered deadline for the designation decision, the air quality analyses for this facility involved three operating scenarios. The future operating scenarios were modeled using continuous operation of all the affected emission units.

For Scenario 1:
Modeled using actual emissions data for OG&E Unit 4, Unit 5, & Unit 6 from EPA's Clean Air Markets Database for years 2012 through 2014.

For Scenario 2:

> Modeled potential emissions from OG&E Unit 4 using the natural gas fired emission rate of 0.0006 lb/MMBTU (which is lower than the BART emission limit of 0.06 lb/MMBTU), and projected actual emissions from OG&E Unit 5 & Unit 6 using the 2013 and 2014 two-year average of the 99^{th} percentile emission rate and heat input.

For Scenario 3:

> Modeled potential emissions from OG&E Unit 4 and Unit 5, using the natural gas fired emission rate of 0.0006 lb/MMBTU (which is lower than the BART emission limit of 0.06 lb/MMBTU) and projected actual emissions from OG&E Unit 6, using the 2013 and 2014 two-year average of the 99^{th} percentile emission rate and heat input.

The modeled three-year average of the H4H daily maximum impacts for each operating scenario are:

Scenario 1 - 85 ppb (223.6 $\mu g/m^3$)

Scenario 2 - 72 ppb (189.5 $\mu g/m^3$)

Scenario 3 - 50 ppb (129.7 $\mu g/m^3$)

The modeling review demonstrated compliance with the 2010 1-hour SO_2 NAAQS of 75 ppb (196.4 $\mu g/m^3$) for the areas surrounding the OG&E Muskogee Generating Station for Scenarios 2 and 3. However, the modeling review was not able to demonstrate compliance for Scenario 1. Under a certain combination of meteorological and operating conditions, a potential violation was modeled for a small area (approximately one quarter-section). (*See* Modeling Report, Section 7.2)

Uncertainty for the Muskogee Area Modeling and Monitoring

DEQ's assessment for the Muskogee area reinforces the premise that, although both source-oriented monitoring sites and dispersion modeling are valuable evaluation tools, neither is *definitive* in characterizing ambient air quality conditions for NAAQS designation purposes. Despite the considerable efforts of DEQ and others, much uncertainty remains as to whether there is a potential for a NAAQS violation within a small area during the relatively short window of time before BART is fully implemented. The modeling analysis for domain ID 36 (Muskogee) raised significant questions regarding representativeness of available meteorological data, effects of complex terrain, and other issues. These questions must be taken into account if modeling is used as a decision-making tool in the attainment status designation process for the areas surrounding the OG&E Muskogee Generating Station. This is particularly important since a designation of “nonattainment” is unlikely to have a practical effect on air quality before the implementation of “on-the-books” requirements that will soon remove the concern.

While under Scenario 1, modeling indicated there is a small area near the OG&E Muskogee Generating Station with potential impacts greater than the 2010 1-hour SO_2 NAAQS, under Scenarios 2 and 3 the modeling demonstrates compliance with the 2010 1-hour SO_2 NAAQS. The federally enforceable BART reductions reflected in Scenarios 2 and 3 are to be obtained on or before January 4, 2019. The last three years of certified monitoring data indicate compliance with the standard. Based on the Monitor vs. Model Report[5], DEQ determined that terrain effects on wind direction and speed in the area surrounding the modeling domain were not adequately characterized by the available meteorological data. The modeling results did not correlate well with monitored values; therefore, there is uncertainty regarding the modeling results.

The modeling of the OG&E Muskogee area was first performed using the Porter Mesonet site for meteorological data. Those modeling results provided insight as to how sensitive the model was to topographic features near the plant, which explain in part why the SO_2 concentrations predicted by the model do not reflect the lower concentrations recorded at the monitor for the same time period. See the separate DEQ report[6] on effects of terrain on wind speeds for more information. For the final modeling analysis, the nearest National Weather Service meteorological site available (KMKO) was used. KMKO is located 13 kilometers SSW of the OG&E Muskogee Generating Station. The results of the final modeling analysis show that the hourly modeling outputs do not correlate well with the actual hourly impacts recorded at the monitor (40-101-0167). The lack of correlation is a result of how the model attempts to replicate atmospheric stability (See Model vs. Monitor Report[7]).

Modeling for the area surrounding the OG&E Muskogee Generating Station, using the described meteorological data, can demonstrate attainment by assuming BART emission reductions that are federally enforceable, but are not required to be fully implemented until after EPA’s court-ordered deadline for final designation action.

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[5] “Comparison of Modeled and Monitored SO_2 Concentrations In Muskogee, Oklahoma”
[6] “Effects of Terrain on Wind Speeds in and near Muskogee, Oklahoma”
[7] Comparison, op cit.

Conclusion

Choctaw County, including the area surrounding WFEC Hugo Generating Station, should be designated as “attainment” for 2010 1-hour SO_2 NAAQS, based on the modeling results and no available monitoring data indicating a contrary conclusion. Noble County, including the area surrounding OG&E Sooner Generating Station, should be designated as “attainment” for 2010 1-hour SO_2 NAAQS, based on monitoring data and modeling results. Muskogee County, including the area surrounding OG&E Muskogee Generating Station, should be designated as “unclassifiable” or “unclassifiable/attainment” based on the current monitoring data, which indicates compliance with the standard, and other important considerations. OG&E Muskogee Generating Station is already under legal obligation to make SO_2 reductions that would essentially remove all concerns over a potential violation of the 2010 SO_2 NAAQS. Also, additional questions regarding meteorological data representativeness and the ability of the model to accurately determine the atmospheric stability cast doubt over whether a significant potential for such a violation even exists under current operations and conditions.

Mary Fallin
Governor

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EXTERNAL AFFAIRS DIVISION

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control

May 27, 2011

Dr. Alfredo Armendariz, Regional Administrator
U.S. Environmental Protection Agency, Region 6
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202-2733

Subject: Designation Recommendation for 2010 Sulfur Dioxide NAAQS

Dear Dr. Armendariz:

On June 2, 2010, the U.S. Environmental Protection Agency (EPA) strengthened the National Ambient Air Quality Standard for sulfur dioxide (SO_2). The final rule, published in the Federal Register on June 22, 2010 (75 FR 35520), sets a new 1-hour SO_2 NAAQS of 75 parts per billion (ppb). As required by Section 107 (d) (1) (A) of the federal Clean Air Act, my recommendations for Oklahoma's initial designations under the new SO_2 standard are outlined below. This recommendation is based on an evaluation of actual monitored SO_2 data collected by the Department of Environmental Quality (DEQ) in Oklahoma during the last ten (10) years with emphasis given to 2008-2010.

Monitored 1 hour exceedances of the standard at monitors in Tulsa and Muskogee Counties indicate the possibility of violating the standard, therefore, I recommend that these areas be designated as unclassifiable. Based on existing monitored data, I recommend a designation of "attainment" for all other 75 counties in Oklahoma.

Oklahoma disagrees with EPA's position that modeling data should be used in the recommendation of nonattainment designations. As a result, the DEQ has prepared a Brief of Amicus Curiae in support of Petitioners' Petition for Review of the Final Rule issued by EPA ("Primary National Ambient Air Quality Standard for Sulfur Dioxide; Final Rule" 75 Fed. Reg. 35520 (June 22, 2010)), to be filed in the case of National Environmental Development Association's Clean Air Project, *et al.* v. United States Environmental Protection Agency, Docket No. 10-1252 (and consolidated cases) before the United States Court of Appeals for the District of Columbia Circuit. In the brief, ODEQ states that by promulgating the Final Rule EPA has acted in violation of the federal Clean Air Act, as well as arbitrarily and capriciously under the federal Administrative Procedures Act, because EPA (1) denied the public notice and opportunity to comment on the implementation approach (i.e., modeling) for the revised SO_2 NAAQS and (2) promulgated an SO_2 NAAQS that is more stringent than necessary under the

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CAA. The ODEQ believes the designation recommendations made herein are consistent with the statements made in the Brief of Amicus Curiae filed by ODEQ in the above-cited case.

If you desire additional information, or you have any questions on this matter, please contact Eddie Terrill at 405-702-4100.

Sincerely,

Mary Fallin

Thank you for your help.

Mary Fallin

cc: Gary Sherrer, Secretary of Environment
Steven Thompson, Executive Director, Oklahoma Department of Environmental Quality
Eddie Terrill, Director of Air Quality, Oklahoma Department of Environmental Quality

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAR 2 0 2015

OFFICE OF
AIR AND RADIATION

The Honorable Scott Thompson
Executive Director
Oklahoma Department of Environmental Quality
707 N Robinson
Oklahoma City, Oklahoma 73102

Dear Mr. Thompson:

I am writing to update you on the status of the U.S. Environmental Protection Agency's progress in implementing the primary National Ambient Air Quality Standard (NAAQS) for sulfur dioxide (SO_2) set in 2010 at 75 parts per billion (ppb) as a 1-hour average. In July 2013, the EPA identified areas in 16 states as nonattainment and expressed the intent to address designations for the remainder of the country in separate future actions.

On March 2, 2015, the U.S. District Court for the Northern District of California accepted as an enforceable order an agreement between the EPA and Sierra Club and Natural Resources Defense Council to resolve litigation concerning the deadline for completing the designations. The court's order directs the EPA to complete designations in three additional rounds: the first round by July 2, 2016, the second round by December 31, 2017, and the final round by December 31, 2020. The EPA will complete these designations by designating areas as either nonattainment, unclassifiable/attainment, or unclassifiable.

In the first round of designations, the EPA will designate two groups of areas: 1) areas that have newly monitored violations of the 2010 SO_2 standard, and 2) areas that contain any stationary source that according to the EPA's Air Markets Database either emitted more than 16,000 tons of SO_2 in 2012 or emitted more than 2,600 tons of SO_2 and had an emission rate of at least 0.45 lbs SO_2/mmbtu in 2012 and that has not been announced (as of March 2, 2015) for retirement. In the enclosure to this letter, the EPA provides the schedule we intend to follow to meet the July 2, 2016, deadline.

The EPA has identified the following electric power plant sources in your state as meeting the criteria established in the court's order:

Internet Address (URL) ● http://www.epa.gov
Recycled/Recyclable ● Printed with Vegetable Oil Based Inks on 100% Postconsumer, Process Chlorine Free Recycled Paper

State	County	Facility Name	2012 SO_2 Emissions (tons)	2012 SO_2 Emissions Rate (lb/mmbtu)
OK	Muskogee	Muskogee Generating Station	22,647	0.496
OK	Noble	Sooner Generating Station	15,029	0.499
OK	Choctaw	Hugo Plant	8,066	0.603

The EPA will use the most recent available information when making designation and boundary decisions for the indicated areas. If you would like to submit an updated recommendation and supporting information for the EPA to consider for the affected areas in your state, we request that you do so by September 18, 2015.

The EPA has updated its March 24, 2011, designation guidance for the 2010 SO_2 standard to support analysis of designations and boundaries for these next rounds of designations. The updated guidance can be found on the EPA's website at *http://epa.gov/airquality/sulfurdioxide/guidance.html.* The EPA has also provided two technical assistance documents that provide advice on the use of modeling and monitoring data when determining if an area is meeting or not meeting the 2010 SO_2 standard. These documents can be found on the EPA's website at *http://epa.gov/airquality/sulfurdioxide/implement.html.*

The court's order directs the EPA to complete the second round of area designations by December 31, 2017. These designations would address areas where states have not installed and begun operating a new SO_2 monitoring network meeting the EPA's specifications referenced in our proposed rule titled, "Data Requirements Rule for the 1-hour SO_2 primary NAAQS". This rule, which was proposed in the *Federal Register* on May 13, 2014, would direct state and tribal air agencies to provide data to characterize current air quality in areas with large sources of SO_2 if such areas do not have sufficient air quality monitoring in place to identify maximum SO_2 concentrations. The data collected as a result of this proposed rule would be used in the designations process. Lastly, the court's order directs the EPA to designate all remaining areas by December 31, 2020. The EPA will provide states with additional information on the designations process associated with these later deadlines at a later date.

We look forward to continued dialogue with you and your staff as we work together to implement the 2010 SO_2 standard and achieve its intended public health protection. For additional information regarding designations for the 2010 SO_2 standard, please visit our website at *www.epa.gov/so2designations*. Should you have any questions, please do not hesitate to call me or Scott Mathias of my staff at 919-541-5310 and *mathias.scott@epa.gov*.

Sincerely,

Janet G. McCabe
Acting Assistant Administrator

Enclosure

cc: Ron Curry
EPA Region 6 Administrator

ENCLOSURE

TIMELINE FOR 2010 PRIMARY SO_2 NAAQS DESIGNATION PROCESS FOR AREAS ASSOCIATED WITH JULY 2, 2016, COURT-ORDERED DEADLINE*	
Milestone	**Date****
Court Order	March 2, 2015
States may submit updated recommendations and supporting information for area designations to the EPA	No later than September 18, 2015
The EPA notifies states concerning any intended modifications to their recommendations (120-day letters)	o/a January 22, 2016, but absolutely no later than 120 days prior to final designations, *i.e.*, March 2, 2016
The EPA publishes public notice of state recommendations and the EPA's intended modifications and initiates 30-day public comment period	o/a February 3, 2016
End of 30-day public comment period	o/a March 4, 2016
States provide additional information to demonstrate why an EPA modification is inappropriate	o/a April 8, 2016
The EPA promulgates final SO_2 area designations (no later than 16 months from Court Order)	No later than July 2, 2016

* The court's order directs the EPA to promulgate additional rounds of designations by December 31, 2017, and by December 31, 2020.

** o/a = on or about

2010 Primary Sulfur Dioxide (SO_2)
National Ambient Air Quality Standard (NAAQS)

Technical Analyses and Information Supporting the Designation Recommendation for Oklahoma

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Modeling Compliance with the 1-Hour SO_2 NAAQS

Modeling Report

Prepared by the Engineering Section of the Permitting Unit
Air Quality Division
Oklahoma Department of Environmental Quality

September 8, 2015

OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

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APPENDICES

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1. WHAT IS THE BACKGROUND FOR THE MODELING?

On June 22, 2010, the U.S. Environmental Protection Agency (EPA) revised the primary sulfur dioxide (SO_2) National Ambient Air Quality Standard (NAAQS). The EPA promulgated a new 1-hour annual primary SO_2 standard at a level of 75 parts per billion (ppb), based on the 3-year average of the annual 99th percentile of the daily maximum 1-hour average concentrations. The area designation process typically relies on air quality concentrations characterized by ambient monitoring data to identify areas that are either meeting or violating the relevant standard. However, a hybrid approach using modeling and monitoring for the designation process was proposed because of the following:

- SO_2 impacts are considered to be "source-oriented" rather than "regional" (peak concentrations of SO_2 are commonly caused by one or a few major point sources in an area and peak concentrations are typically observed relatively close to the source);
- Ambient SO_2 concentrations can be modeled accurately using well understood air quality modeling tools; and
- Only approximately 35% of the monitoring network was addressing locations of maximum (highest) concentrations of specific sources or groups of sources.

On March 2, 2015, a Consent Decree (CD) was filed requiring the EPA to sign for publication in the Federal Register no later than sixteen (16) months from March 2, 2015, a notice of EPA's promulgation of designations for the 2010 revised primary SO_2 NAAQS, pursuant to Section 107(d) of the CAA, and within ten (10) business days following such signature, deliver the notice to the Office of the Federal Register for review and prompt publication, for undesignated areas which:

1) Based on air quality monitoring in the three (3) full calendar years preceding such deadline have monitored violations of the 2010 revised primary SO_2 NAAQS; or
2) Contain any stationary source that has not been "announced for retirement" by the date of this Consent Decree, and that, according to the data in EPA's Air Markets Database, either
    a. Emitted more than 16,000 tons of SO_2 in 2012, or
    b. Emitted more than 2,600 tons of SO_2 and had an annual average emission rate of 0.45 lbs SO_2/MMBTU or higher in 2012.

By September 18, 2015, the State of Oklahoma may submit to EPA additional information regarding the affected facilities and for which updated air quality analyses have been used to characterize the air quality around the source either through monitoring, modeling, or a combination of modeling and monitoring.

1.1 Which sources are affected sources?

Based on the consent decree, the following sources are the affected sources:

Table 1.1-1. Affected Sources

Company	Facility/Emission Unit	County	2012 Emissions (TPY)	Avg. Emission Rate (lb/MMBTU)
Oklahoma Gas and Electric	Muskogee Generating Station	Muskogee	22,647	
	Unit 4		7,356	0.48
	Unit 5		7,328	0.47
	Unit 6		7,963	0.54
Oklahoma Gas and Electric	Sooner Generating Station	Noble	15,884	
	Unit 1		8,591	0.56
	Unit 2		7,293	0.49
Western Farmers Electric Coop	Hugo Generating Station	Choctaw		
	Unit 1		8,066	0.60

There were two other facilities Grand River Dam Authority (GRDA) Grand River Energy Center (Unit 1) in Mayes county and Public Service Company (PSO) Northeast (Unit 3313 & Unit 3314) in Rogers County which had an average emissions rate greater than 0.45 lb/MMBTU but which had "announced for retirement" the affected units at their facility prior to March 2, 2015.

1.2 Which sources will shut down or have proposed to shut down?

There are two facilities which are scheduled or anticipated to shut down or cease operations by January 1, 2017, or which will limit emissions to below the applicability threshold. These facilities and their circumstances are shown in Sections 1.2.1 and 1.2.2.

1.2.1 What will happen to the GRDA Grand River Energy Center?

GRDA has proposed shutting down Unit No. 1 and reducing operation of Unit No. 2. The shut down of Unit No. 1 should be completed by April 2016. Construction Permit No. 2009-179-C (M-3) was issued on August 21, 2014, authorizing the construction of a natural gas fired combustion turbine, installation of activated carbon injection on Unit 2, and either shutting down Unit No. 1 or conversion of Unit No. 1 to natural gas by the Mercury and Air Toxics Standards (MATS) compliance date of April 2016. Therefore, Unit No. 1 was excluded from the requirements of the CD. Unit 2's average emission rate during 2012 was 0.2 lb/MMTBTU which is why it was excluded.

1.2.2 What will happen to the PSO NE Power Station?

PSO has proposed shutting down Unit No. 3314 and reducing operation of Unit No. 3313. Permit No. 2009-179-TVR (M-5) was issued on November 20, 2013, authorizing the installation of an activated carbon injection system on Unit 3313 and either shutting down Unit 3314 or conversion of Unit No. 3314 to natural gas by the MATS compliance date of April 2016. The shutdown of Unit No. 3314 should be completed by April 2016. Therefore, Unit No. 3314 was excluded from the requirements of the CD. By April 2016, Unit 3313 must meet emission limits of 0.4 lb/MMBTU which is why it was excluded.

1.3 Which sources were modeled?

There are three affected facilities for which air dispersion modeling was conducted to determine impacts and to help with recommendations for the 2010 1-hour SO_2 designations. These facilities and their circumstances are shown in the following sections.

1.3.1 How was the OG&E Muskogee Generating Station modeled?

OG&E is required by the Regional Haze Program to install Best Available Retrofit Technology (BART) on Unit 4 and Unit 5 (40 CFR § 52.1923). OG&E has committed to meeting the federal emission limit of 0.06 lb/MMBTU by January 4, 2019, by conversion of Unit 4 and Unit 5 to natural gas. Since the conversion will occur sometime in the future, the air quality analyses for this facility involved three operating scenarios:

1) Modeling of current actual emissions for Unit 4, Unit 5, & Unit 6;
2) Modeling of Unit 4 using the BART emission limit and Unit 5 & Unit 6 using the maximum actual emission rate during 2012 through 2014; and
3) Modeling of Unit 4 & Unit 5 using the BART emission limit & Unit 6 using the maximum actual emission rate during 2012 through 2014.

1.3.2 How was the OG&E Sooner Generating Station modeled?

OG&E is required by the Regional Haze Program to install BART on Unit 1 and Unit 2 (40 CFR § 52.1923). OG&E has committed to meeting the federal emission limit of 0.06 lb/MMBTU by January 4, 2019, by controlling Unit 1 and Unit 2 using flue gas scrubbing or by converting the units to natural gas. Since the emission reduction will occur sometime in the future, the air quality analyses for this facility involved two operating scenarios:

1) Modeling of current actual emissions for Unit 1 & Unit 2; and
2) Modeling of Unit 1 using the BART emission limit and Unit 2 using the maximum actual emission rate during 2012 through 2014.

1.3.3 How was the WFEC Hugo Generating Station modeled?

WFEC is required to comply with 40 CFR Part 63, NESHAP, Subpart DDDDD and will install an activated carbon injection (ACI) system by April 16, 2016. While there will be a small reduction in SO_2 emissions resulting from the installation of the ACI, the air quality analysis for this facility only involves one operating scenario:

1) Modeling of current actual emissions for Unit 1.

2. WHAT MODELING PROGRAMS WERE USED FOR THE MODELING ANALYSIS?

2.1 What is the recommended air dispersion model?

Given the source-oriented nature of SO_2, dispersion models are appropriate air quality modeling tools to predict the near-field concentrations. For area designations under the 2010 1-hour SO_2

primary NAAQS, the AMS/EPA Regulatory Model (AERMOD) was used as outlined in the August 23, 2010, clarification memo, “Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 NAAQS.” AERMOD is the preferred air dispersion model, because it is capable of handling rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources (including point, area, and volume sources), to address ambient impacts for the designations process.

The AERMOD modeling system includes the following components:

- AERMOD (Version 14134): the dispersion model;
- AERMAP (Version 11103): the terrain processor for AERMOD; and
- AERMET (Version 14134): the meteorological data processor for AERMOD.

Other components that may be used, depending on the application, are:

- BPIPPRIME (Version 04274): the building input processor;
- AERMINUTE (Version 14337): a 1-minute Automated Surface Observing System (ASOS) winds pre-processor to AERMET;
- AERSURFACE (Version 13016): the surface characteristics processor for AERMET;
- AERSCREEN (Version 14147): a screening version of AERMOD;

2.2 Was screening modeling used?

Screening modeling analyses provide conservative estimates of source impacts with a minimum of input. AERSCREEN is the screening model for AERMOD. AERSCREEN will produce worst-case estimates of 1-hour impacts for a single source using default meteorological data and actual terrain data. Ambient impacts from natural gas fired sources were analyzed using AERSCREEN to show that they do not have significant impacts within the domains and scenarios modeled.

3. HOW WERE THE MODELING DOMAINS ESTABLISHED FOR THE MODELING ANALYSES?

3.1 How were the modeling domains setup?

Domains were assigned to each facility. The modeling domains are centered over the affected sources. The following table shows the affected sources, assigned domains, and corresponding Oklahoma Mesonet meteorological data site.

Table 3.1-1 Domain ID, Mesonet Site, & Affected Facility

ID	Mesonet Site	Company	Facility
20	Hugo	Western Farmers Electric Coop	Hugo Generating Station
36	Porter	Oklahoma Gas and Electric	Muskogee Generating Station
39	Redrock	Oklahoma Gas and Electric	Sooner Generating Station

Based on EPA guidance, the general guideline for determining the distance between an affected source and its maximum ground level concentration is generally 10 times the stack height in flat terrain. However, the potential influence of terrain can impact the location and magnitudes of significant concentration gradients. The following table shows each emission unit at an affected facility, the stack height for the emissions unit, and the expected distance to the expected maximum ground level concentration in flat terrain.

Table 3.1-2 Calculated Distance for Maximum Concentration

ID	Mesonet Site	Company/Facility	Stack	Stack Ht. (ft)	Distance (km)
20	Hugo	WFEC/Hugo Generating Station	Unit 1	500	1.52
36	Porter	OG+E/Muskogee Generating Station	Unit 4	350	1.07
			Unit 5	350	1.07
			Unit 6	500	1.52
39	Redrock	OG+E/Sooner Generating Station	Unit 1	500	1.52
			Unit 2	500	1.52

Since the maximum impact is expected to be between 0.5 km and 2 km, a domain of 10 km is expected to be of sufficient size to determine the ambient air impacts from the affected sources unless there is significant terrain. In domains where there is significant terrain (Domain 36), the domain was extended to 15 km.

3.2 How were the receptor grids established?

The modeling receptor grid is unique to the particular situation and is dependent on the size of the modeling domain, the number of modeled sources, and complexity of the terrain. For the purposes of modeling for the 2010 1-hour SO_2 designations, receptor placement differs since the modeling is acting as a surrogate for monitoring. In areas where it is not feasible to place a monitor (water bodies, etc.), receptors were not placed in these locations.

Receptor placement was of sufficient density to provide the resolution needed to detect significant concentrations gradients, with receptors placed closer together near the source to detect local gradients and placed farther apart away from the source. In addition, receptors were placed at key locations such as existing monitoring sites (for comparison of modeled concentrations to monitored concentrations), sensitive locations (for determining impacts in special areas), and along facility fence lines (the ambient air boundary of the affected sources). The total number of receptors varies based on the specific domain and areas of maximum impact.

For the fine grid, a 100 meter spacing was utilized. The receptor spacing increases as the distance from the affected facilities increases. The fine receptor grid was extended out far enough to determine the maximum impact from the affected sources. A fine grid extending out to 2 km was used to identify the areas of maximum concentration based on the review of the stack heights for the affected sources. A generalized rectangular receptor grid for each domain was generated using the following:

- Receptors spaced at 100 m along the fence line of the affected sources;
- Receptors spaced at 100 m from the fence line out to 2 km;
- Receptors spaced at 250 m from 2 km out to 3 km;
- Receptors placed at 500 m from 3 km to 5 km; and
- Receptors spaced at 1 km from 5 km out to edge of domain (~10 km).

Aerial photos of the domain with the receptors are included in Appendix A.

Appendix W to 40 CFR Part 51 indicates maximum impacts occur on calm days as the plumes encounter hills at or near the same height as the stacks. Terrain surrounding a facility was evaluated to determine if there were hills in the area at or above stack height and the domain was extended to include these areas. When high impacts are determined in these areas, a fine grid was placed over them to determine the maximum impact.

3.3 What terrain data was utilized for the modeling analyses?

Terrain data was included in all 2010 1-hour SO_2 designations modeling analyses. Terrain data was obtained from the USGS Seamless Data Server at http://viewer.nationalmap.gov/viewer/. The 1/3 arc-second NED data was obtained in the GeoTIFF format for use in AERMAP. Interpolation of receptor and source heights from the 1/3 arc-second NED elevation data was based on the current AERMAP guidance in Section 4.4 of the *User's Guide for the AERMOD Terrain Preprocessor (AERMAP)* (EPA-454/B-03-0003, 10/2004). AERMAP uses a distance weighted bilinear interpolation method.

Oklahoma has three UTM zones (zones 13, 14, and 15). None of the modeling domains for the affected sources crossed a UTM zone. All coordinates were based on the North American Datum (NAD) 1983 (NAD83).

3.4 What were the domain classifications: rural or urban?

Dispersing plumes encounter more turbulence in urban areas than in rural areas due to building wakes as well as warmer temperatures. The higher dispersion in urban areas causes plumes to spread more rapidly. The areas of maximum impact in urban areas occur closer to the source. Determination of whether or not the domain of an affected source should be classified as urban or rural was based mainly on land use (the preferred method). However, the urban heat island affect was reviewed for those affected sources located in metropolitan areas (OG&E Muskogee). Determinations of the domain classification are shown below.

Table 3.4-1 Domain Classifications

ID	Mesonet Site	Company/Facility	Urban/Rural
20	Hugo	WFEC/Hugo Generating Station	Rural
36	Porter	OG+E/Muskogee Generating Station	Rural/Urban
39	Redrock	OG+E/Sooner Generating Station	Rural

Aerial photos indicating the area surrounding the facility are included in Appendix B.

4. WHAT SOURCE DATA WAS USED IN THE MODELING ANALYSIS?

4.1 What are the affected source configurations and source types?

Accurate characterization of the affected sources is critical to air quality characterization utilizing modeling. All of the affected sources are point sources. Stack parameters and facility data (building and fence line data) were submitted by each affected facility. The facility data was then reviewed and checked for consistency with emission inventory data and aerial images including location (i.e. latitude and longitude or Universal Transverse Mercator (UTM) coordinates and datum) of the emission unit stacks relative to the nearby buildings or structures.

Aerial photos indicating the facility data superimposed onto the aerial photos are included in Appendix C.

4.2 What nearby sources were included in the modeling domains?

When determining which sources should be included in the modeling domains for each affected source all nearby sources were evaluated. Nearby sources are those sources that are within 20 km of the affected sources and that could cause or contribute to a NAAQS violation in the vicinity of the affected source. All natural gas fired sources were excluded from the 2010 1-hour SO_2 designations modeling analyses because of the following:

- They do not cause a significant concentration gradient;
- They are not expected to cause or contribute to a NAAQS violation;
- They are represented via the background concentrations.

All other sources of SO_2 were included in the 2010 1-hour SO_2 designations modeling analyses. A list of all sources in the nearby source inventory for each domain is included in Appendix D.

4.3 How were intermittent emission sources addressed?

For area designations under the 2010 1-hour SO_2 primary NAAQS, modeling of intermittent emissions sources, such as emergency generators and limited intermittent startup/shutdown emissions were not included based on the recommendations in the March 1, 2011 memorandum "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard."

4.4 What are the affected source emissions inputs?

For the 2010 1-hour SO_2 designations, modeling can be used as a surrogate to ambient monitoring to characterize air quality for the designations process. Because designations are intended to address current actual air quality (*i.e.*, modeling simulates a monitor), SO_2 designation modeling was based on modeling of actual emissions data. Also, since the standard is based on a 3 year average, modeling for air quality designations was based on the most recent 3 years of actual emissions using concurrent meteorological data. Modeling of 3 years of actual emissions with concurrent meteorological data is the best representation of the impacts that would be monitored in a 3-year monitoring data set.

4.4.1 How were hourly emissions from the affected sources determined?

Actual emission data for input into AERMOD was generated for each affected source. Most electric generating units (EGU) have continuous emissions monitoring systems (CEMS). In the absence of CEMS data, simply dividing the annual emissions by the number of hours in the year is not an accurate representation of actual emissions. For affected sources without CEMS data, actual emissions were based on actual throughputs and the calculated SO_2 emissions generally based on a mass balance. For sources that vary their operation throughout the year, AERMOD input variables were used to represent their actual operation throughout the year. Use of AERMOD input variables such as hour of day (HROFDY), hour of day and day of week (HRDOW), and monthly hour of day and day of week (MHRDOW) were utilized to represent actual operation for those sources without CEMS data. Varying emissions were based on the available information such as production logs, fuel usage information, operating schedules, etc. CEMS data was used to generate hourly emissions files for the affected sources using the following methodology:

Step 1: The emission data was downloaded from the Clean Air Markets Database (CAMD).

Step 2: The monthly data was combined generating annual emission data files for each source at an affected facility with CEMS data.

Step 3: The three variables used in an hourly emission file are emissions, velocity, and temperature. These hourly values were generated from the CAMD datasets and formatted into the units used by AERMOD. The emissions were converted from lb/hr values into g/s. The heat input given in the CAMD data was used with Method 19, CO_2 concentration, moisture concentration, and stack temperature from recent relative accuracy test audits (RATA), to generate the flow rate and resultant velocity. If a unit was operating it was assigned the normal stack temperature.

Step 4: The data was then reviewed for continuity and for missing data. If there was a single hour of missing data, it was replaced with the average of surrounding non-missing hours. If there are periods of missing data with more than a single missing value, operational data from the affected facility was reviewed to fill the missing hours.

4.4.2 What operational data was used from the RATA?

The stack parameters used to generate the hourly emission file for AERMOD from the RATA are listed below. The values are based on the average of all values recorded during the RATA.

Table 4.3.2-1 Operational Stack Data from RATA

		Stack Temp			**% Moisture**			**% CO_2**		
Station	**Unit**	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
Hugo	Unit 1	313	323	292	11.75	11.80	12.01	12.15	11.81	11.22
Muskogee	Unit 4	336	327	320	12.46	13.30	13.51	11.90	11.40	11.76
	Unit 5	311	313	315	11.48	12.19	12.00	11.50	11.32	11.40
	Unit 6	299	290	294	11.63	11.89	12.46	11.40	11.67	11.48
Sooner	Unit 1	305	315	320	10.81	11.11	12.60	11.56	11.20	11.72
	Unit 2	312	290	301	11.24	10.47	10.23	11.38	11.70	11.95

4.5 How was GEP stack height addressed?

Good Engineering Practice (GEP) stack height is the minimum stack height needed to prevent the stack exhaust plume from being entrained in the wake of nearby obstructions. For the 2010 1-hour SO_2 NAAQS designations process, actual stack heights were used for modeling actual emissions rather than following the GEP stack height policy. The GEP stack height policy uses GEP stack height for stack heights exceeding GEP and actual stack height for stacks below GEP. The use of actual stack heights in the modeling analysis more closely represents actual ambient air quality conditions from the affected sources. Because the purpose of the 2010 1-hour SO_2 NAAQS designation modeling is to act as a surrogate for monitoring, if a monitor were located in the area around the affected sources, the concentrations detected at the monitor would be reflective of the effect of emissions from the actual stack heights of influencing sources.

4.6 Was building downwash included in the modeling analyses?

When one or more structures interrupt the wind flow, an area of turbulence called building downwash is created. Pollutants emitted at a fairly low level (e.g., a roof, vent or short stack) can be caught in this turbulence, affecting their dispersion. Modeling that includes calculations for building downwash gives a more accurate representation of pollutant impacts than does modeling that omits consideration of downwash effects.

A building is any physical obstruction to airflow at the modeled facility. A structure is a building or group of buildings determined to be important in downwash considerations. The dominant downwash structure is the structure that renders the highest GEP recommended stack height. If a stack is at GEP or higher, then downwash is not a factor. GEP stack height is calculated according to the following equation.

$$H = h + 1.5L$$

where: H = Recommended stack height.
h = The distance from the highest point on a tier or building to ground level.
L = The lesser of the height or projected width for a particular tier or structure.

Not only are accurate stack parameters important but so are accurate building parameters. Building parameters include location and orientation relative to stacks and building size. Other parameters include tier heights and coordinates. These parameters are input into BPIP-PRIME to calculate building parameters for AERMOD. Affected facilities have submitted information regarding buildings located on their property. This data was reviewed and included in the modeling analyses.

5. WHAT METEOROLOGICAL DATA WAS USED IN THE MODELING ANALYSIS?

5.1 What meteorological data was used?

2012-2014 meteorological data was utilized for the 2010 1-hour SO_2 primary NAAQS designations modeling. The State of Oklahoma utilizes Oklahoma Mesonet surface data, along with National Climatic Data Center (NCDC) Integrated Surface Hourly Database (ISHD) surface data and National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) Global Systems Division (GSD) formerly Forecast Systems Laboratory (FSL) Upper Air (UA) data, with all air dispersion modeling. Oklahoma Mesonet data is incorporated to help make more accurate forecasts of ambient impacts from the affected sources. Use of the Oklahoma Mesonet data also promotes use of more recent, more accurate, and more representative data. Processed Oklahoma Mesonet surface data is combined with ISHD surface data and ESRL UA radiosonde data using AERMET to produce the surface and profile files used by AERMOD. However, if the ISHD station is closer to the facility being modeled and the station is an ASOS station with sub-hourly observations, Mesonet data is not utilized with the modeling since the ISHD surface data would be more representative.

5.2 What surface data was used?

For each affected source domain a specific meteorological data set was developed based on spatial and climatological (temporal) representativeness. The representativeness of the specific meteorological data set to the affected source domain was based mainly on proximity and terrain. Representativeness of the surface characteristics (albedo, Bowen ratio, and surface roughness) were also reviewed when assigning a specific metrological data set to an affected source domain.

5.2.1 How were sites from the ISHD evaluated?

There are approximately 83 ISHD automated weather stations in and around Oklahoma that were evaluated for combining with Oklahoma Mesonet data to accurately represent the individual modeling domains. These stations usually take atmospheric measurements once every hour. The ISH data files were downloaded from the NCDC ISHD web site: ftp://ftp.ncdc.noaa.gov/pub/data/noaa. Some of the sites are ASOS stations with continuous sub-hourly values.

The ISH data sites were reviewed for completeness by evaluating the number of hours that were recorded at each site. If a specific site contained a significant amount of missing hours, then those specific sites were not considered when assigning ISH sites to specific Oklahoma Mesonet sites. Since data from the Oklahoma Mesonet is combined with the ISHD data, there is generally no need to replace missing values for individual variables. One of the main variables utilized from the ISH data is cloud cover (GF1). For each ISHD data file, the specific number of missing cloud cover values was also evaluated. If a specific site had a significant number of missing cloud cover values, it was also excluded.

5.2.1.1 Was AERMINUTE utilized in the modeling analysis?

The NCDC began archiving 1-minute ASOS wind data (TD-6405), beginning January 2000 for first-order NWS ASOS stations, and beginning March 2005 for all other ASOS stations. For those ASOS sites, AERMINUTE data was used to incorporate continuous sub-hourly wind data. The ASOS (6405) files were downloaded and then processed using AERMINUTE. The ASOS 1-minute files were downloaded from http://www1.ncdc.noaa.gov/pub/data/ for each year and applicable ASOS station. There were two ASOS sites (KMKO and KSWO) near the affected facilities (OG&E Muskogee and OG&E Sooner) with sub-hourly data.

5.2.2 What is Oklahoma Mesonet data and how is it used?

The Oklahoma Mesonet is a world-class network of meteorological monitoring stations. The Oklahoma Mesonet is unique in its capability to measure a large variety of meteorological conditions at so many sites across an area as large as Oklahoma. Oklahoma Mesonet data is provided courtesy of the Oklahoma Mesonet, a cooperative venture between Oklahoma State University (OSU) and the University of Oklahoma (OU) and supported by the taxpayers of Oklahoma. At each site, the meteorological conditions are continuously measured and packaged into 5-minute observations. These 5-minute observations from the Oklahoma Mesonet were processed into an AERMET acceptable format. No missing data interpolation was performed for the 5-minute data sets.

Specific NCDC ISHD data sites and ESRL UA rawinsonde observation (RAOB) data sites were assigned to each Oklahoma Mesonet site based on distance and representativeness. Appendix E lists the Oklahoma Mesonet sites used in the ambient air quality analyses and the assigned NCDC ISHD data site and ESRL UA RAOB data site for each Oklahoma Mesonet site. Since the NCDC ISHD Station KMKO was closer to the Muskogee modeling domain and is more representative than the closest Mesonet Station (Porter) only data from the NCDC ISHD Station was utilized when modeling the Muskogee area. Wind roses for the specific domains are contained in Appendix F.

5.3 What upper air data was used?

The ESRL operates nine RAOB weather stations in and around Oklahoma. These stations usually take soundings twice a day. The ESRL data files were downloaded from the ESRL RAOB web site: http://esrl.noaa.gov/raobs/.

The UA data was reviewed for missing soundings. A single missing sounding will cause a whole day (24 hours) of missing meteorological data values. To reduce the number of missing meteorological data, replacement soundings were substituted for the missing soundings. The replacement soundings were selected from a site with similar thermodynamic profiles. Each UA data station was assigned a primary and a secondary replacement UA station. The primary station is basically the station that is closest to the station being reviewed. Each replacement sounding was documented.

5.4 How were surface characteristics of the meteorological sites determined?

When using AERMET, to prepare the meteorological data for AERMOD, three surface characteristics (Albedo, Bowen Ratio, and Surface Roughness Length) must be determined for each surface site. Albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux. Surface roughness length relates the height of obstacles to the wind flow and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer. Albedo and Bowen Ratio are used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

AERSURFACE uses land cover data from the U.S. Geological Survey (USGS) National Land Cover Data 1992 archives (NLCD92) to determine the land cover types for a specified location.

AERSURFACE matches the NLCD92 land cover categories to seasonal values of Albedo, Bowen Ratio, and Surface Roughness and then calculates the surface characteristics for input into AERMET. NLCD92 data in GeoTIFF format was downloaded from the Multi-Resolution Land Characteristics (MRLC) Consortium at the following link: http://www.mrlc.gov/viewerjs/. The surface characteristics of the individual domains are included in Appendix G.

5.4.1 What was used to determine the surface moisture conditions?

The monthly rainfall since establishment of the Mesonet program (approximately 20 years) has been analyzed for each Mesonet site. The surface moisture conditions (Average, Wet, Dry) for each of the Oklahoma Mesonet stations for each month were then determined using the monthly rainfall amounts compared to the average rainfall. These determinations were based on the guidance contained in the AERSURFACE Users Guide. The Bowen Ratio was then assigned based on the monthly surface moisture conditions for each Oklahoma Mesonet station.

6. WHAT BACKGROUND MONITORING DATA WAS USED IN THE MODELING ANALYSES?

6.1 What background monitoring data is utilized?

Background concentrations were added to 2010 1-hour SO_2 designations modeling analyses. Monitoring data was obtained from the EPA air data web site: http://www.epa.gov/air/data/index.html. Background concentrations were based on the most recent complete year(s) of available monitoring data in the form of the standard indicated below. Only data meeting the minimum data collection requirements or the minimum percent observations were used when determining the design values.

Pollutant	Averaging Period	Basis of Design Value
SO_2	1-hour	3 year average of 99^{th} Percentile 1-hour daily maximum

The inclusion of ambient monitored background concentrations in the model results is important in determining the projected cumulative impact of the affected sources and other contributing nearby sources impacts. A uniform monitored background concentration based on the monitored design values for the latest 3-year period was based on a “regional site” (i.e., a site that is located away from the areas of interest but is impacted by similar natural and distant man-made sources). All of the monitoring sites in the state of Oklahoma and their related design concentrations are shown below.

Table 6.1-1 2012-2014 Monitoring Design Values

Monitor ID	**County**	**Latitude**	**Longitude**	**Conc. µg/m³**
40-001-9009	Adair	35.75074	-94.66970	39.5
40-071-0604	Kay	36.69727	-97.08130	99.5
40-101-0167	Muskogee	35.79313	-95.30220	129.2
40-109-1037	Oklahoma	35.61413	-97.47510	9.6
40-143-0175	Tulsa	36.14988	-96.01170	100.4

40-143-0179	Tulsa	36.15483	-96.01580	72.0
40-143-0235	Tulsa	36.12695	-95.99890	46.3
40-143-1127	Tulsa	36.20490	-95.97650	36.0

All of the monitoring sites are impacted by large SO_2 sources except for the monitor located in Oklahoma County. The monitors in Tulsa County are impacted by the Holly Tulsa Refinery and the PSO Northeast Power Station. The Monitor located in Muskogee County is impacted by the OG&E Muskogee Generating Station and the Georgia Pacific Muskogee Mill. The monitor in Kay County is impacted by the Phillips 66 Ponca City Refinery. The monitor in Adair County is impacted by the Flint Creek Power Plant. Therefore, the impacts from the Oklahoma County monitor were used to represent background impacts from area sources for all modeling domains.

7. WHAT ARE THE MODELED FACILITY IMPACTS?

7.1 What were the modeled impacts for the domain which included the WFEC Hugo Generating Station?

The table below shows the results of the air quality analysis for the WFEC Hugo Generating Station. The results of the modeling are the three year average of the highest fourth highest (H4H) daily maximum impact or the three year average of the 99^{th} percentile daily maximum impact. The three year average of the H4H daily maximum impact for each of the facilities included in the modeling analysis are also listed to show the impacts from each facility on the modeling domain. However, the impacts listed do not occur at the same location or at the same time as the maximum impact.

Table 7.1-1 Domain 20 Modeling Impacts

Domain	Source Group	Modeled Impact (μg/m^3)	Background (μg/m^3)	Total Impact (μg/m^3)
D20	ALL	108.6	9.6	118.2
	HUGO	108.5		
	IP	2.5		
	BDM	9.9		

Based on the modeling review, the domain would be in compliance with the 2010 1-hour SO_2 NAAQS of 75 ppb (196.4 μg/m^3 based on EPA Reference Conditions, 40 CFR §50.3).

7.2 What were the modeled impacts for the domain which included the OG&E Muskogee Generating Station?

The table below shows the results of the air quality analysis for the OG&E Muskogee Generating Station. The results of the modeling are the three year average of the H4H daily maximum impact. The three year average of the H4H daily maximum impact for each of the facilities included in the modeling analysis are also listed to show the impacts from each facility on the modeling domain. However, the impacts listed do not occur at the same location or at the same time as the maximum impact.

OG&E is required by the Regional Haze Program to install BART on Unit 4 and Unit 5. OG&E has committed to meeting the federal emission limit of 0.06 lb/MMBTU by January 4, 2019, by conversion of Unit 4 and Unit 5 to natural gas. Since the conversion will occur sometime in the future, the air quality analyses for this facility involved three operating scenarios. The future operating scenarios were modeled using continuous operation of all the affected emission units.

For Scenario 1:

Actual emissions from CEM data was used for OG&E Unit 4, Unit 5, & Unit 6;

For Scenario 2:

Modeled potential emissions from OG&E Unit 4 using the natural gas fired emission rate of 0.0006 lb/MMBTU (which is lower than the BART emission limit of 0.06 lb/MMBTU) and projected actual emissions from OG&E Unit 5 & Unit 6 using the 2013 and 2014 two year average of the 99th percentile emission rate and heat input shown below. The emission rates and heat input from 2012 were not used since they were not representative of future operation.

Table 7.2-1 99th Percentile Emission Factor & Heat Input for OG&E Muskogee Generating Station

	2013		2014		Average	
Unit	lb/MMBTU	MMBTUH	lb/MMBTU	MMBTUH	lb/MMBTU	MMBTUH
4	N/A	5,669	N/A	6,023	N/A	5,800
5	0.544	5,845	0.576	5,465	0.560	5,655
6	0.549	5,950	0.587	5,939	0.568	5,945

The emission factors and heat input used in the current permit to calculate emissions are listed below. These emission factors and heat inputs are below those used for the modeling so the emissions used in the modeling should be a conservative analysis of the future air quality.

Table 7.2-2 Emission Factors & Heat Inputs Listed in Permit No. 2005-271-TVR (M-7) for OG&E Muskogee Generating Station

Unit	lb/MMBTU	MMBTUH
4	0.53	5480
5	0.51	5480
6	0.53	5150

For Scenario 3:

Potential emissions from OG&E Unit 4 and Unit 5 using the natural gas fired emission rate of 0.0006 lb/MMBTU (which is lower than the BART emission limit of 0.06 lb/MMBTU) and projected actual emissions from OG&E Unit 6 using the 2013 and 2014 two year average of the 99th percentile emission rate and heat input shown above were modeled. The emission rates and heat input from 2012 were not used since they were not representative of future operation.

Since the only variables in the domain for the different modeling scenarios were the emissions related to the OG&E Muskogee Generating Station, only the overall domain impacts and the impacts from the OG&E Muskogee Generating Station are listed for Scenario 2 and 3.

Table 7.2-3 Domain 36 Modeling Impacts Scenario 1

		Modeled Impact	Background	Total Impact
Domain	Source Group	(µg/m^3)	(µg/m^3)	(µg/m^3)
D36	ALL	214.0	9.6	223.6
	OGE	201.4		
	GEORG	120.1		
	DALTIA	1.4		
	BORAL	56.3		
	OWENS	49.4		
	GRDA	23.5		
	USLIME	3.5		

Table 7.2-4 Domain 36 Modeling Impacts Scenario 2 (Potential Future Impacts)

			Modeled Impact	Background	Total Impact
Domain	Source Group	Units	(µg/m^3)	(µg/m^3)	(µg/m^3)
D36	ALL		179.9	9.6	189.5
	OGE	ALL	168.7		
		Unit 4	0.2		
		Unit 5	115.3		
		Unit 6	77.6		

Table 7.2-5 Domain 36 Modeling Impacts Scenario 3 (Potential Future Impacts)

			Modeled Impact	Background	Total Impact
Domain	Source Group	Units	(µg/m^3)	(µg/m^3)	(µg/m^3)
	ALL		120.1	9.6	129.7
	OGE	ALL	77.7		
		Unit 4	0.2		
		Unit 5	0.2		
		Unit 6	77.6		

Based on the modeling review, the domain would not be able to demonstrate compliance with the 2010 1-hour SO_2 NAAQS of 75 ppb (196.4 µg/m^3 based on EPA Reference Conditions) for Scenario 1. However, the domain will be able to demonstrate compliance for Scenarios 2 and 3. After analyzing the MAXDCONT output files for Scenario 1, it was determined that there were 113 potential violations at 62 receptors. There are 62 violations based on the H4H, 37 potential violations based on the H5H, and 13 violations based on the H6H. There were no additional violations after the H6H.

At all 62 receptors, OG&E Muskogee Generating Station was the single largest contributor with some contributions from Georgia Pacific Muskogee Mill.

7.3 What were the modeled impacts for the domain which included the OG&E Sooner Generating Station?

The table below shows the results of the air quality analysis for the OG&E Sooner Generating Station. The results of the modeling provided are the H4H impacts. The maximum impacts for each facility included in the modeling analysis are also listed to show the impacts from each facility on the modeling domain. However, the impacts listed do not occur at the same location or at the same time as the maximum impact.

OG&E is required by the Regional Haze Program to install BART on Unit 1 and Unit 2. OG&E has committed to meeting the federal emission limit of 0.06 lb/MMBTU by January 4, 2019, by controlling Unit 1 and Unit 2 using flue gas scrubbing or by converting the units to natural gas. Since the emission reduction will occur sometime in the future, the air quality analyses for this facility involved three operating scenarios.

For Scenario 1:

Actual emissions from CEM data was used for OG&E Unit 1 & Unit 2.

For Scenario 2:

Modeled potential emissions from OG&E Unit 1 using the BART emission limit (0.06 lb/MMBTU) and projected actual emissions from OG&E Unit 2 using the 2012 through 2014 three year average of the 99^{th} percentile emission rate and heat input shown below. The emission factor for 2013 (0.54) was not used since it was not representative of future operation.

Table 7.3-1 99^{th} Percentile Emission Factor & Heat Input for OG&E Sooner Generating Station

	2012		2013		2014		Average	
Unit	lb/MMBTU	MMBTUH	lb/MMBTU	MMBTUH	lb/MMBTU	MMBTUH	lb/MMBTU	MMBTUH
1	N/A	5,455	N/A	5,337	N/A	5,419	N/A	5,405
2	0.715	5,490	---	5,311	0.708	5,234	0.712	5,345

For Scenario 3:

Potential emissions from OG&E Unit 1 and Unit 2 using the BART emission limit (0.06 lb/MMBTU) were modeled.

Since the only variable in the domain for the different modeling scenarios is the emissions related to the OG&E Sooner Generating Station, only the overall domain impacts and the impacts from the OG&E Sooner Generating Station are listed.

Table 7.3-2 Domain 39 Modeling Impacts Scenario 1

Domain	Source Group	Modeled Impact (µg/m^3)	Background (µg/m^3)	Total Impact (µg/m^3)
D39	ALL	127.0	9.6	136.6
	OGE	126.8		
	CONT	33.5		
	PHILLIPS	1.8		

Table 7.3-3 Domain 39 Modeling Impacts Scenario 2 (Potential Future Impacts)

Domain	Source Group	Units	Modeled Impact ($\mu g/m^3$)	Background ($\mu g/m^3$)	Total Impact ($\mu g/m^3$)
D39	ALL		152.1	9.6	161.7
	OGE	ALL	151.8		

Table 7.3-4 Domain 39 Modeling Impacts Scenario 3 (Potential Future Impacts)

Domain	Source Group	Units	Modeled Impact ($\mu g/m^3$)	Background ($\mu g/m^3$)	Total Impact ($\mu g/m^3$)
D39	ALL		33.9	9.6	43.5
	OGE	ALL	23.4		

Based on the modeling review, the domain would be able to demonstrate compliance with the 2010 1-hour SO_2 NAAQS of 75 ppb (196.4 $\mu g/m^3$ based on EPA Reference Conditions) for Scenario 1. In addition, the impacts for Scenarios 2 and 3 demonstrate of compliance with the 2010 1-hour SO_2 NAAQS. The impacts for Scenario 2 are higher than the impacts for Scenario 1 since the emissions are based on projected heat input for Unit 2 and projected lb/MMBTU. Also, Scenario 2 represents continuous operation of both units.

8. WHAT IS THE SUMMARY OF THE MODELING RESULTS?

8.1 What areas demonstrate compliance with the 2010 1-hour SO_2 NAAQS using modeling?

The areas surrounding the WFEC Hugo Generating Station and the OG&E Sooner Generating Station can demonstrate compliance with the 2010 1-hour SO_2 NAAQS using the modeling.

8.2 What areas do not currently demonstrate compliance with the 2010 1-hour SO_2 NAAQS using modeling?

While the modeling air quality analysis under Scenario 1 for the area surrounding the OG&E Muskogee Generating Station does not demonstrate compliance with the 2010 1-hour SO_2 NAAQS, the modeling air quality analyses under Scenarios 2 and 3 do demonstrate compliance with the 2010 1-hour SO_2 NAAQS. The federally enforceable BART reductions reflected in Scenarios 2 and 3 are to be achieved by January 4, 2019.

Current ambient monitoring data indicates compliance with the 2010 1-hour SO_2 NAAQS. The predicted impacts at the monitoring site using modeling do not correlate well with the ambient monitoring data which raises questions regarding meteorological data representativeness. Additional studies of the modeling analyses should be conducted to examine the issues related to correlation of predicted modeling impacts and actual monitor impacts. Also, additional meteorological data (e.g. on-site), which is more representative of the modeling domain, should be collected to generate modeling which accurately represents the area impacted by the OG&E Muskogee Generating Station.

8.2.1 What area has potential impacts greater than the 2010 1-hour SO_2 NAAQS that were predicted under Scenario 1 for the OG&E Muskogee Generating Station?

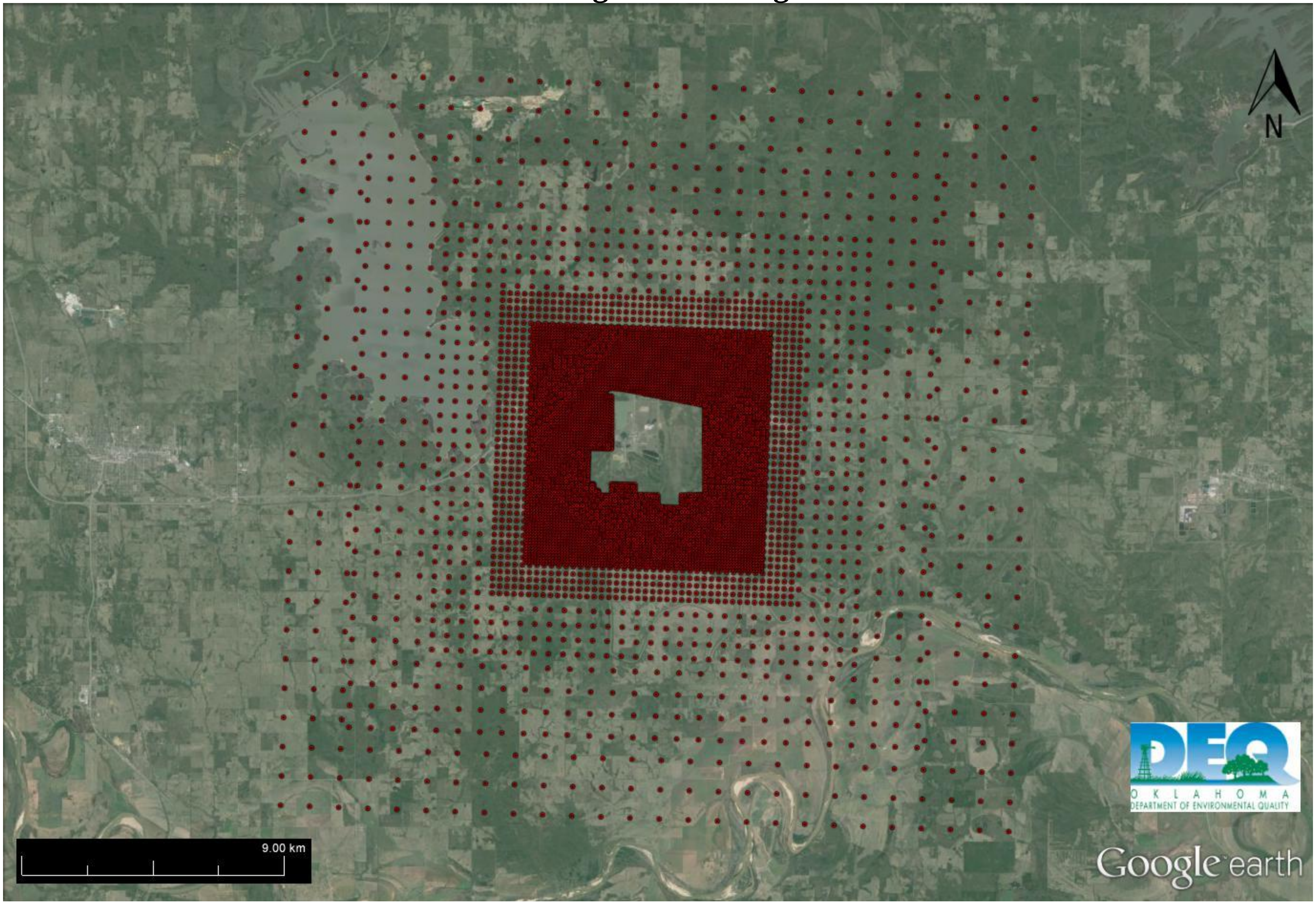
The area with the modeled impacts greater than the 2010 1-hour SO_2 NAAQS are encompassed within a single Township (Township 15N, Range 19E) in Muskogee County. The two largest SO_2 sources in Muskogee County are also located within this township. The two largest SO_2 sources in Muskogee County and the area with modeled impacts greater than the 2010 1-hour SO_2 NAAQS are contained within eight sections of Township 15N, Rage 19E: Sections 15 (NE Corner), 16 (NW Corner), 21, 22, 27, 28, 33 (SW Corner), and 34 (SE Corner). The area with predicted impacts greater than the 2010 1-hour SO_2 NAAQS are contained within a small area within two sections of Township 15N, Rage 19E: Section 15 (80%) and Section 16 (20%).

9. WHAT REFERENCES WERE USED?

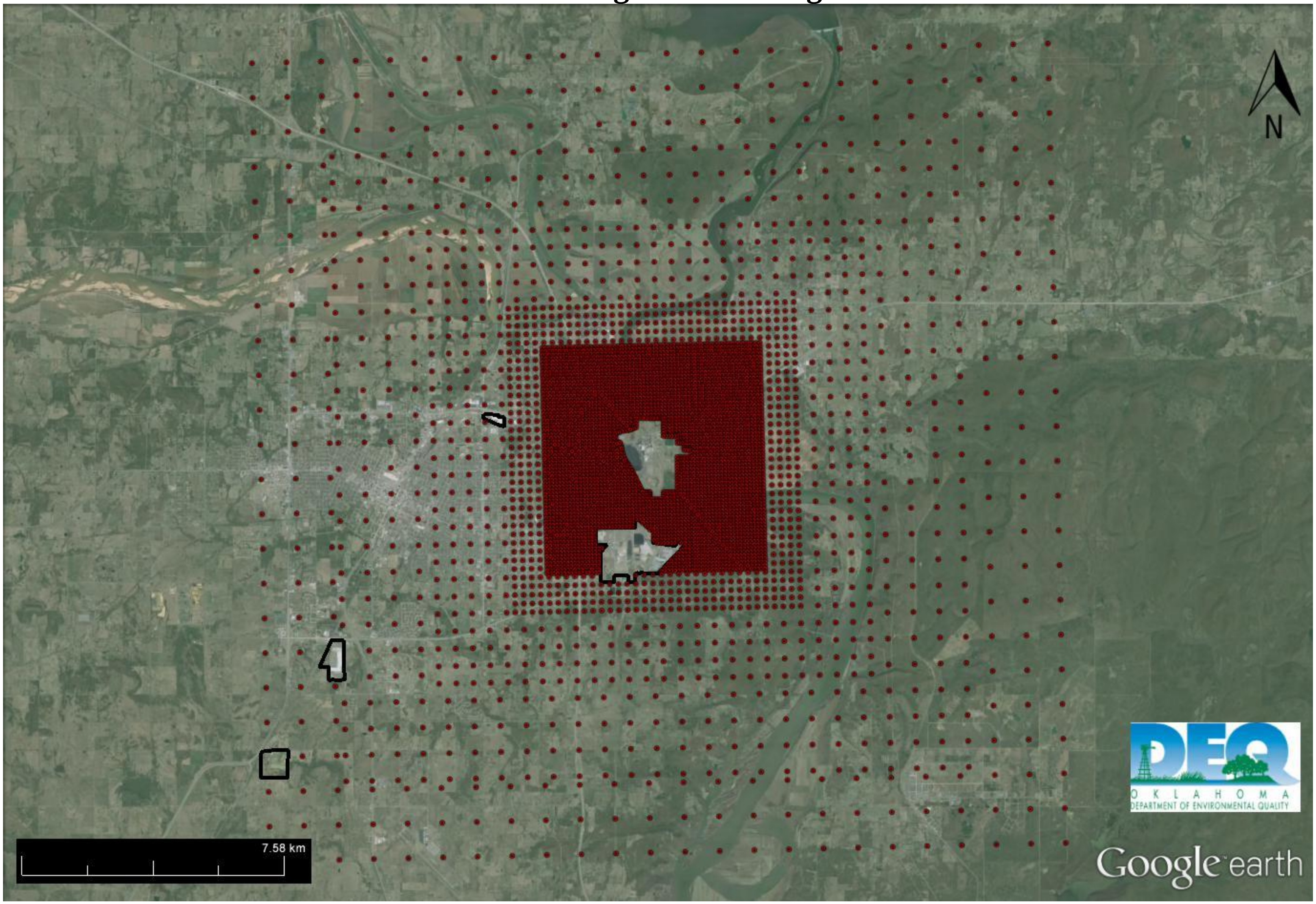
- *Additional Clarification Regarding Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS* (March 1, 2011);
  - http://www.epa.gov/ttn/scram/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf
- *Guidance Concerning the Implementation of the 1-hour SO_2 NAAQS for the Prevention of Significant Deterioration Program* (August 23, 2010);
  - http://www.epa.gov/region07/air/nsr/nsrmemos/appwso2.pdf
- *Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 NAAQS* (August 23, 2010);
  - http://www.epa.gov/ttn/scram/guidance/clarification/ClarificationMemo_AppendixW_Hourly-SO2-NAAQS_FINAL_08-23-2010.pdf
- *SO_2 NAAQS Designations Modeling Technical Assistance Document* (December 2013);
  - http://www.epa.gov/oaqps001/sulfurdioxide/pdfs/SO2ModelingTAD.pdf
- Guidance for 1-Hour SO2 NAAQS SIP Submissions (September 22, 2011);
  - http://www.epa.gov/oaqps001/sulfurdioxide/pdfs/DraftSO2Guidance_9-22-11.pdf
- User's Guide for the AMS/EPA Regulatory Model - AERMOD
  - http://www.epa.gov/ttn/scram/models/aermod/aermod_userguide.zip.
- User's Guide for the AERMOD Meteorological Data Preprocessor (AERMET)
  - http://www.epa.gov/ttn/scram/7thconf/aermod/aermet_userguide.zip.
- AERMINUTE User's Instruction
  - http://www.epa.gov/ttn/scram/7thconf/aermod/aerminute_14337.zip.
- AERSURFACE User's Guide
  - http://www.epa.gov/ttn/scram/7thconf/aermod/aersurface_userguide.pdf.

Appendix A – Facility Domains with Receptors

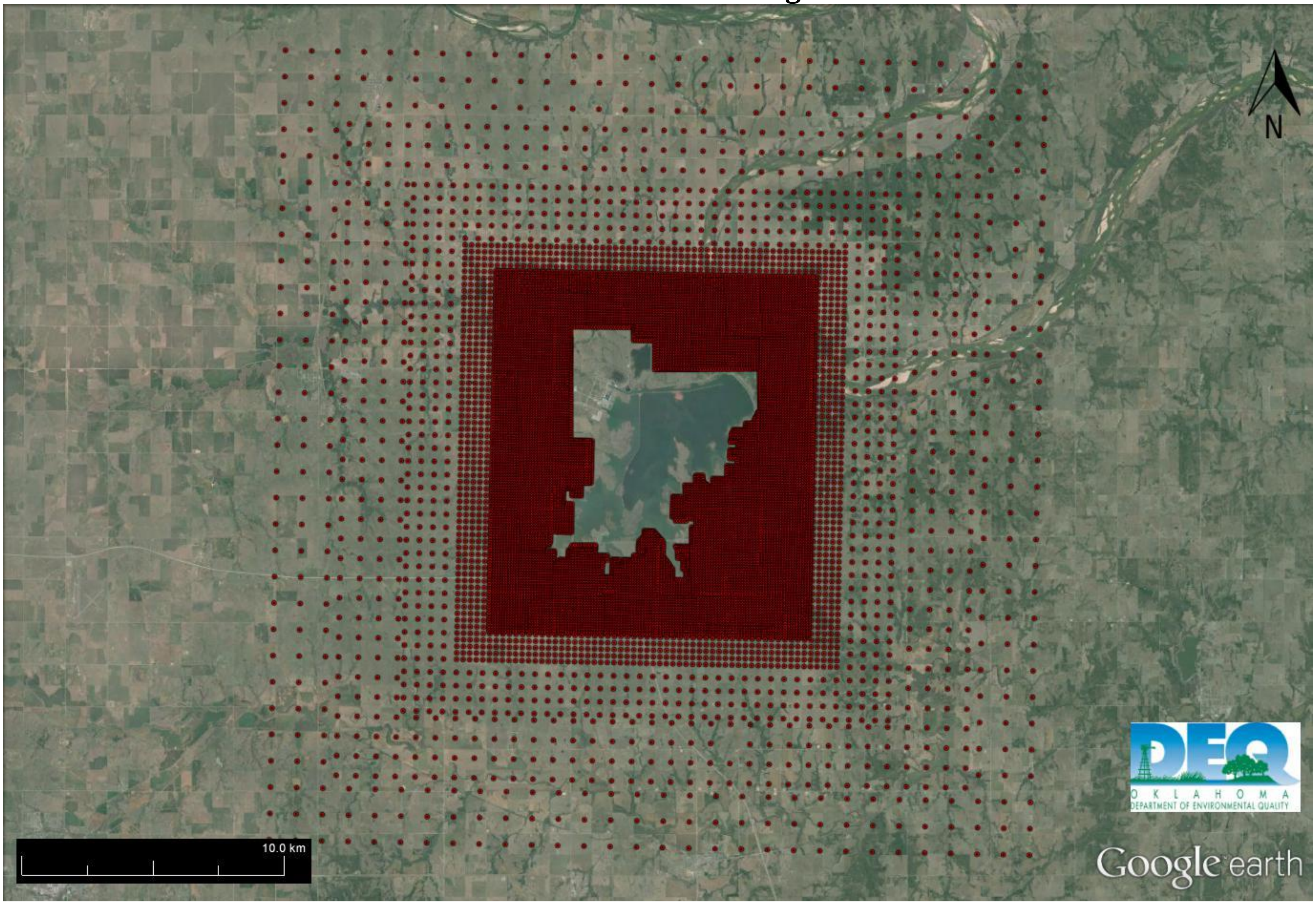
WFEC – Hugo Generating Station



OG&E – Muskogee Generating Station

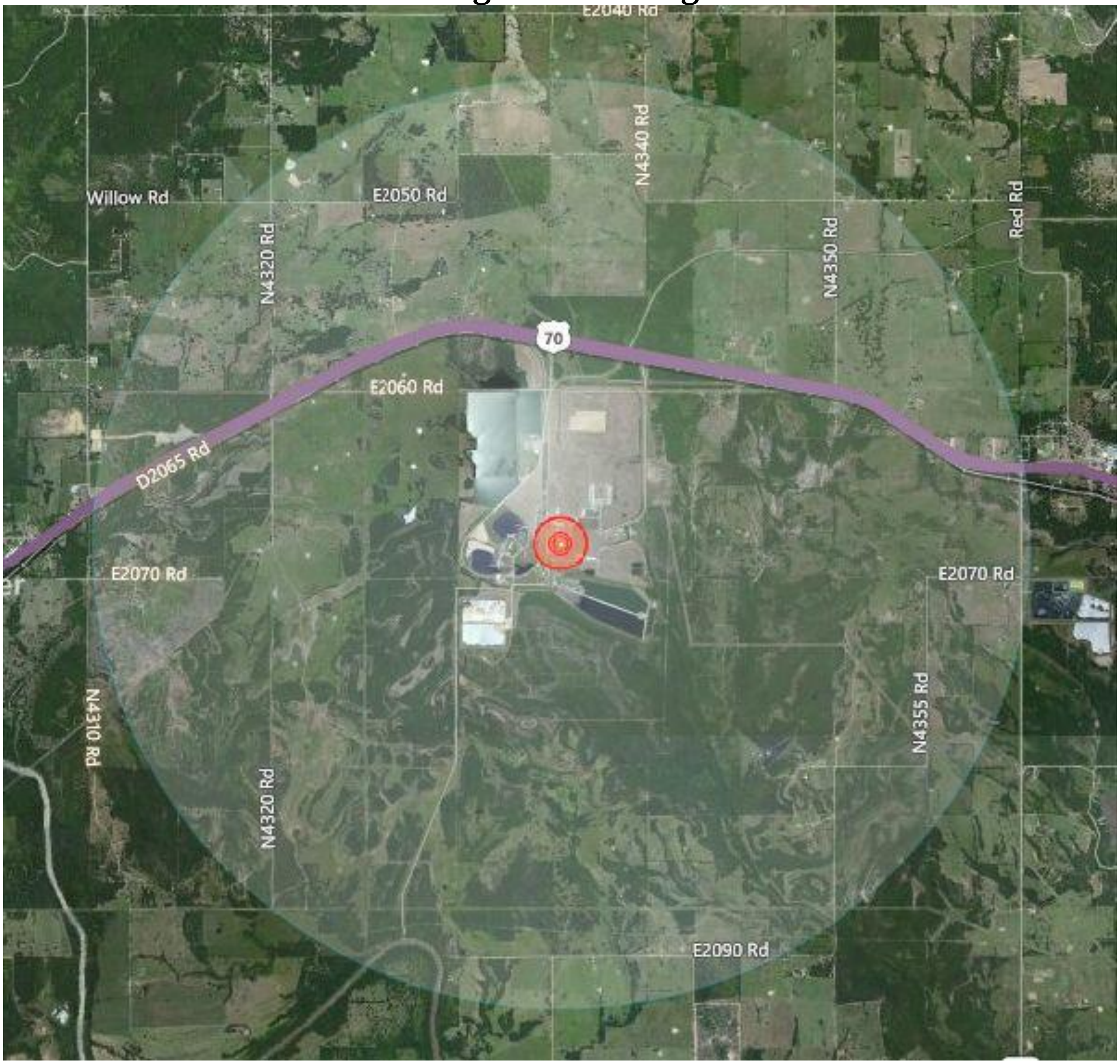


OG&E – Sooner Generating Station

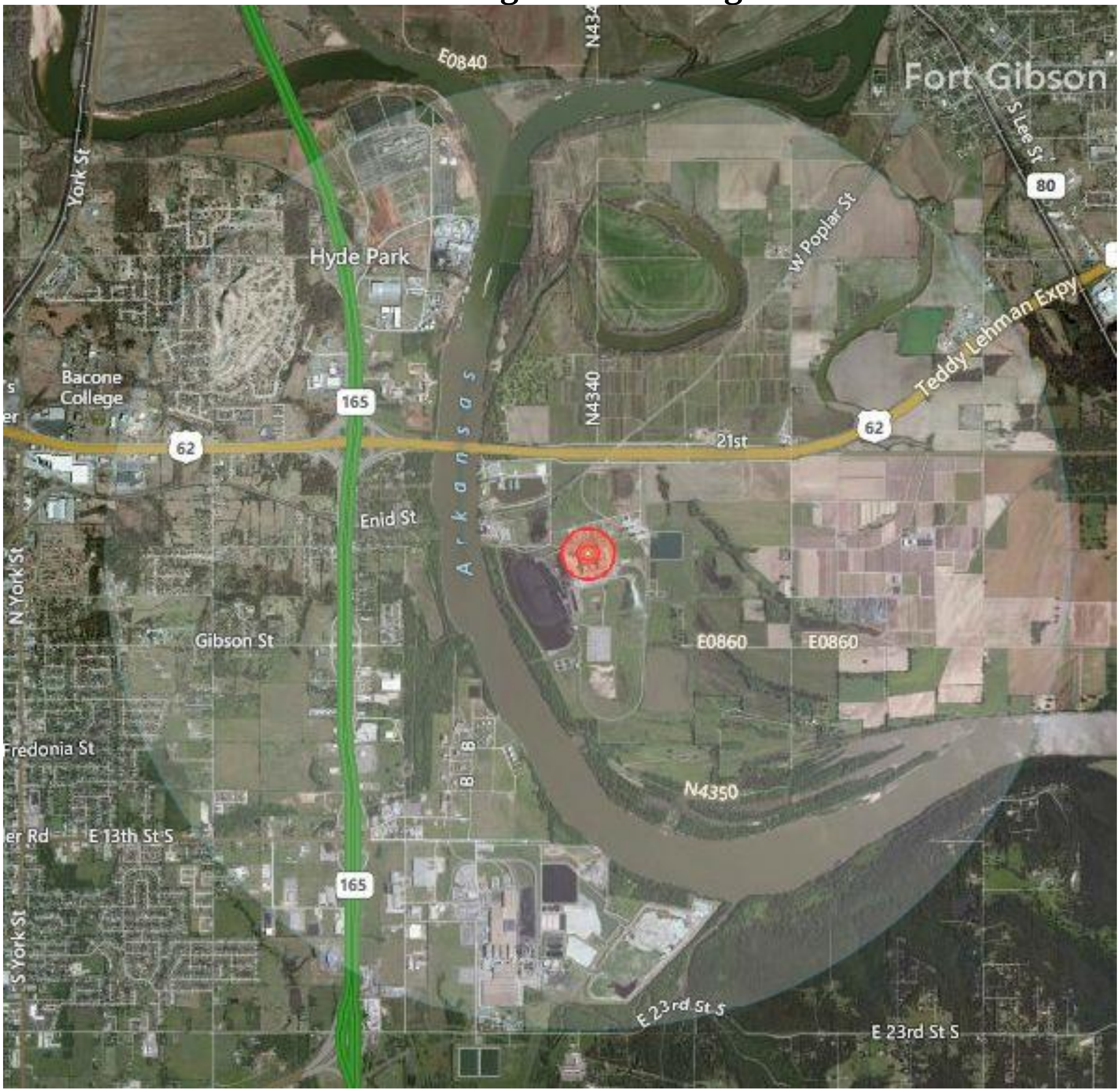


Appendix B – Land Use/Land Cover Aerial Photos

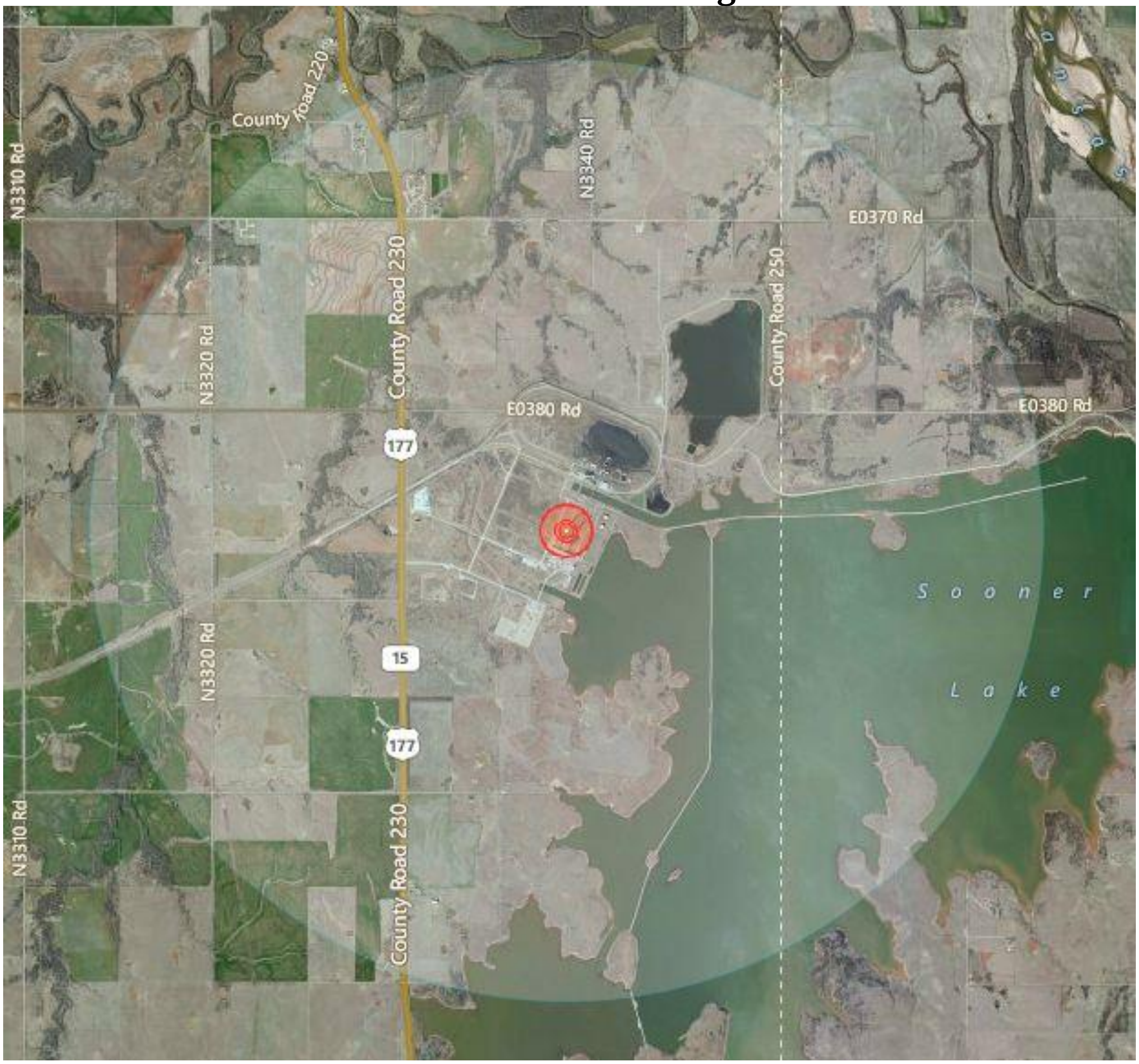
WFEC – Hugo Generating Station



OG&E – Muskogee Generating Station

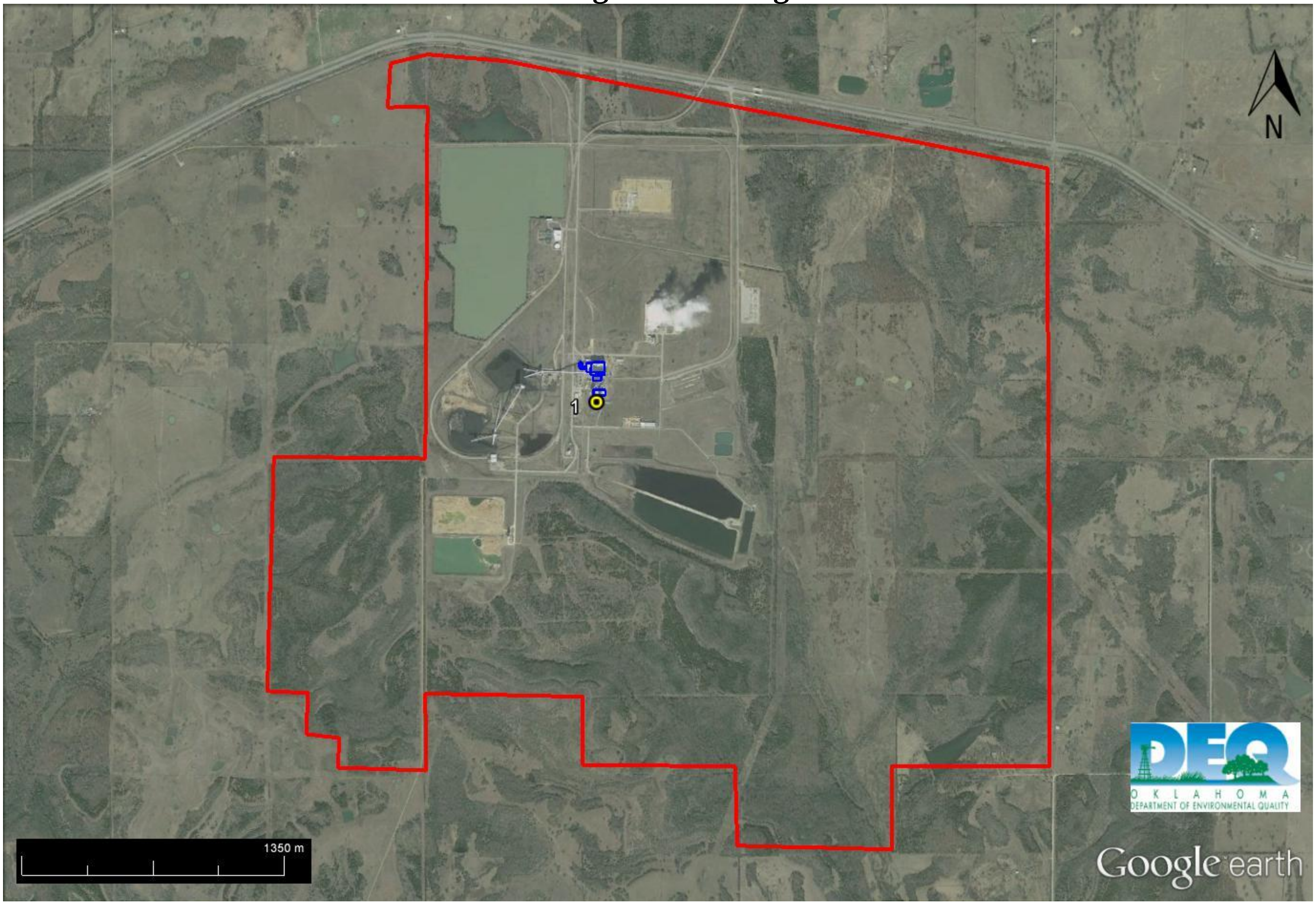


OG&E – Sooner Generating Station



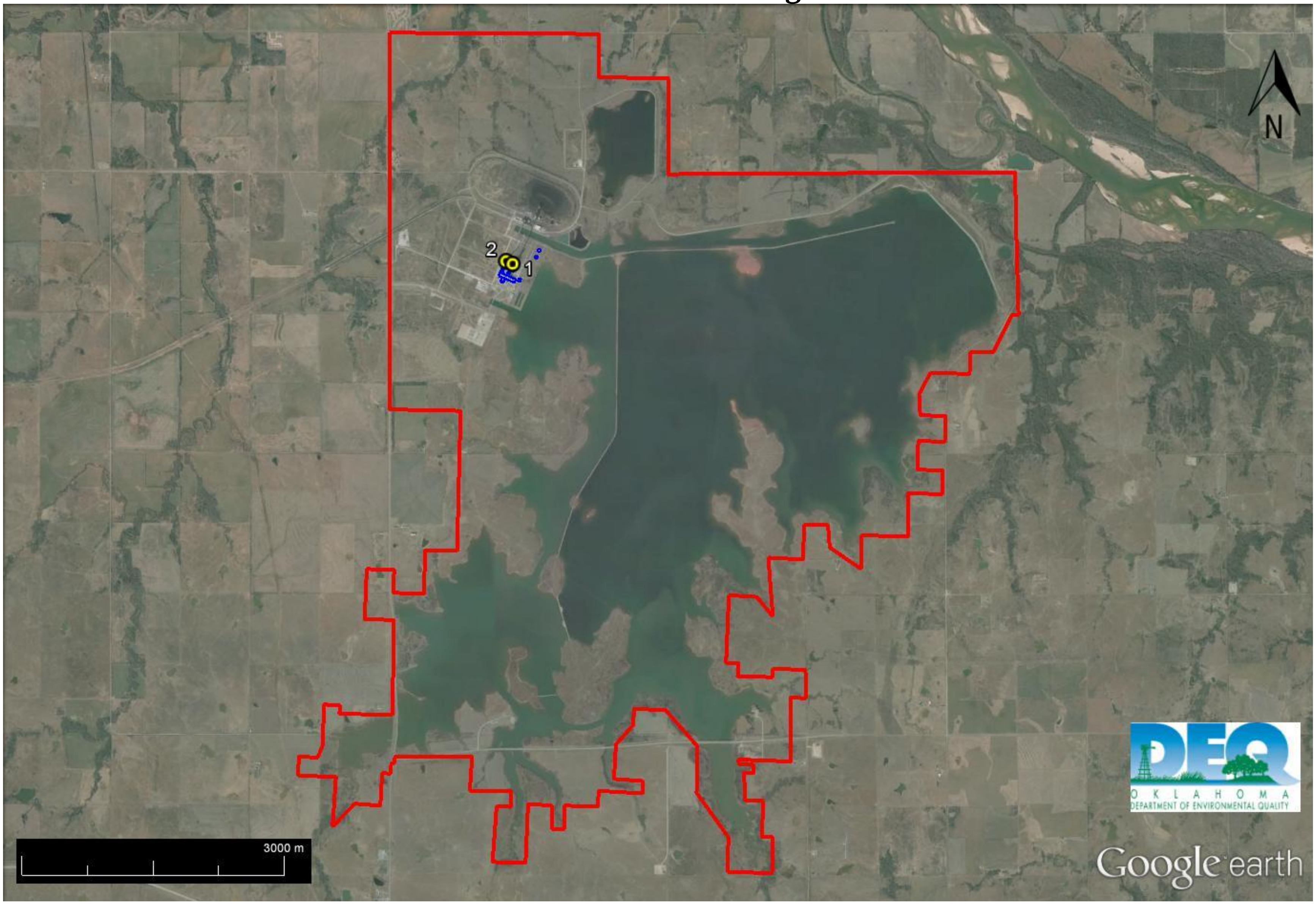
Appendix C – Aerial Photo Overlaid With Facility Data

WFEC – Hugo Generating Station



OG&E – Muskogee Generating Station

OG&E – Sooner Generating Station



Appendix D – Source Data

Domain 20 Source Data

Source ID	Facility	Easting (m)	Northing (m)	Elevation (m)	Stk Ht (ft)	Stk Temp (°F)	Velocity (fps)	Stk Dia (ft)	SO_2 (lb/hr)
UNIT 1	WFEC – Hugo	839782.8	3769894.6	147.1	500.0	260	47.00	26.0	2,391.03
PLT76[1]	BDM Eng	834500.0	3780048.7	156.3	25.0	160	96.67	3.0	8.98
IPBRKBLR	International Paper	859439.4	3768633.0	151.3	246.0	133	42.60	11.0	4.62
IPPRBLR	International Paper	859435.2	3768628.3	151.2	296.0	439	88.80	14.5	8.55
IPNRFN	International Paper	859499.9	3768626.1	152.5	296.0	439	88.80	14.5	32.60
IPLIMEKILN	International Paper	859486.6	3768587.3	152.6	148.0	469	44.70	5.8	0.36

[1] - Emissions from the plant were limited based on operational data from the facility. The emissions were limited using the Seasonal Hour Day of Week emission factor command (SHRDOW). Emissions from this facility were limited to Spring, Summer, and Fall; Monday through Friday; between the hours of 9 a.m. and 5 p.m. The actual average number of hours operated from 2012-2014 were 550 hours per year with a maximum of 950 hours in a single year.

Domain 36 Source Data

Source ID	Facility	Easting (m)	Northing (m)	Elevation (m)	Stk Ht (ft)	Stk Temp (°F)	Velocity (fps)	Stk Dia (ft)	SO_2 (lb/hr)
UNIT 4	OG&E Muskogee	293116.7	3959729.8	156.2	350.0	264	44.96	24.0	2,010.98
UNIT 5	OG&E Muskogee	293172.0	3959739.3	156.8	350.0	264	41.80	24.0	1,912.21
UNIT 6	OG&E Muskogee	293240.4	3959757.7	157.0	500.0	264	55.01	21.5	2,206.57
DAL20	Dalitalia	284208.4	3953784.7	171.2	46.3	130	29.80	4.95	0.11
DAL23	Dalitalia	284164.9	3953711.7	170.8	46.0	130	45.08	2.70	0.05
DAL29	Dalitalia	284093.8	3953787.7	171.0	51.3	130	24.10	5.36	0.09
BORSCRUB	Boral	282161.2	3951159.0	183.5	70.0	355	36.29	6.2	43.60
GPSTACK1	Georgia Pacific	292555.0	3956494.1	161.9	260.0	353	28.46	10.0	85.33
GPSTACK3	Georgia Pacific	292594.0	3956513.0	162.0	260.0	306	28.24	13.8	412.56
OBFURNA	Owens Brockway	288620.7	3960596.6	179.6	150.0	918	29.16	5.3	9.30
OBFURNB	Owens Brockway	288656.6	3960582.4	180.0	80.0	389	28.89	7.1	18.61
M1	US Lime	334096.8	3940641.2	203.6	150.0	266	57.09	5.3	20.31
K1	US Lime	334000.6	3940571.3	204.5	96.0	155	31.20	7.0	0.17
UNIT 1	GRDA	294138.0	4007357.0	189.5	504.0	300	68.14	20.0	2,881.26
UNIT 2	GRDA	294211.0	4007262.0	188.8	507.0	190	90.98	20.0	922.97

Domain 39 Source Data

		Easting	Northing	Elevation	Stk Ht	Stk Temp	Velocity	Stk Dia	SO_2
Source ID	**Facility**	**(m)**	**(m)**	**(m)**	**(ft)**	**(°F)**	**(fps)**	**(ft)**	**(lb/hr)**
Unit 1	OG&E Sooner	674572.1	4036106.8	286.1	500.0	264	60.05	20.0	2,012.10
Unit 2	OG&E Sooner	674497.9	4036137.0	286.2	500.0	264	59.04	20.0	1,841.85
TO4	Continental Carbon	672587.8	4059257.6	293.2	213.3	1817	159.90	7.0	447.12
TO12	Continental Carbon	672416.8	4059290.6	293.4	150.0	1671	109.00	11.5	629.15
TO3	Continental Carbon	672538.8	4059261.6	293.6	150.0	1601	104.00	9.5	340.00
NO.4FCC	Phillips Refinery	671244.4	4062452.8	300.7	175.0	423	81.30	4.5	1.12
NO.5FCC	Phillips Refinery	671146.1	4061061.4	307.0	175.0	147	46.30	8.5	8.24
FLARESP	Phillips Refinery	671369.5	4060672.6	301.0	199.0	1832	65.30	3.0	1.02
FLARECC	Phillips Refinery	670807.4	4061307.2	301.3	150.0	1832	65.60	2.5	10.63
FLAREEP	Phillips Refinery	671187.6	4062248.4	296.1	245.0	1832	65.60	2.5	3.13
B0008	Phillips Refinery	670832.1	4061973.3	304.6	162.0	336	12.60	8.0	1.43
B9/B10	Phillips Refinery	670828.5	4062066.5	304.9	89.0	305	31.80	11.8	1.85

Appendix E – 2012-2014 Oklahoma Mesonet Sites & Associated ISH & ESRL Stations

Oklahoma Mesonet Sites & Associated ISH & ESRL Stations

STID	NAME/City	COUNTY	LAT	LONG	ELEV	SFCS	LAT	LONG	ELEV	USAF #	UAS	LAT	LONG
HUGO	Hugo	Choctaw	34.0308	-95.5401	175	KHHW[1]	34.0314	-95.5398	177.7	720559	FWD	32.80	-97.30
PORT[2]	Porter	Wagoner	35.8257	-95.5598	193	KMKO	35.6577	-95.3658	183.5	723556	OUN	35.23	-97.47
REDR	Red Rock	Noble	36.3559	-97.1531	293	KSWO	36.1624	-97.0893	293.8	723545	OUN	35.23	-97.47

[1] - KHHW started on 2/2012, replaced 2011 with data from KPRX.

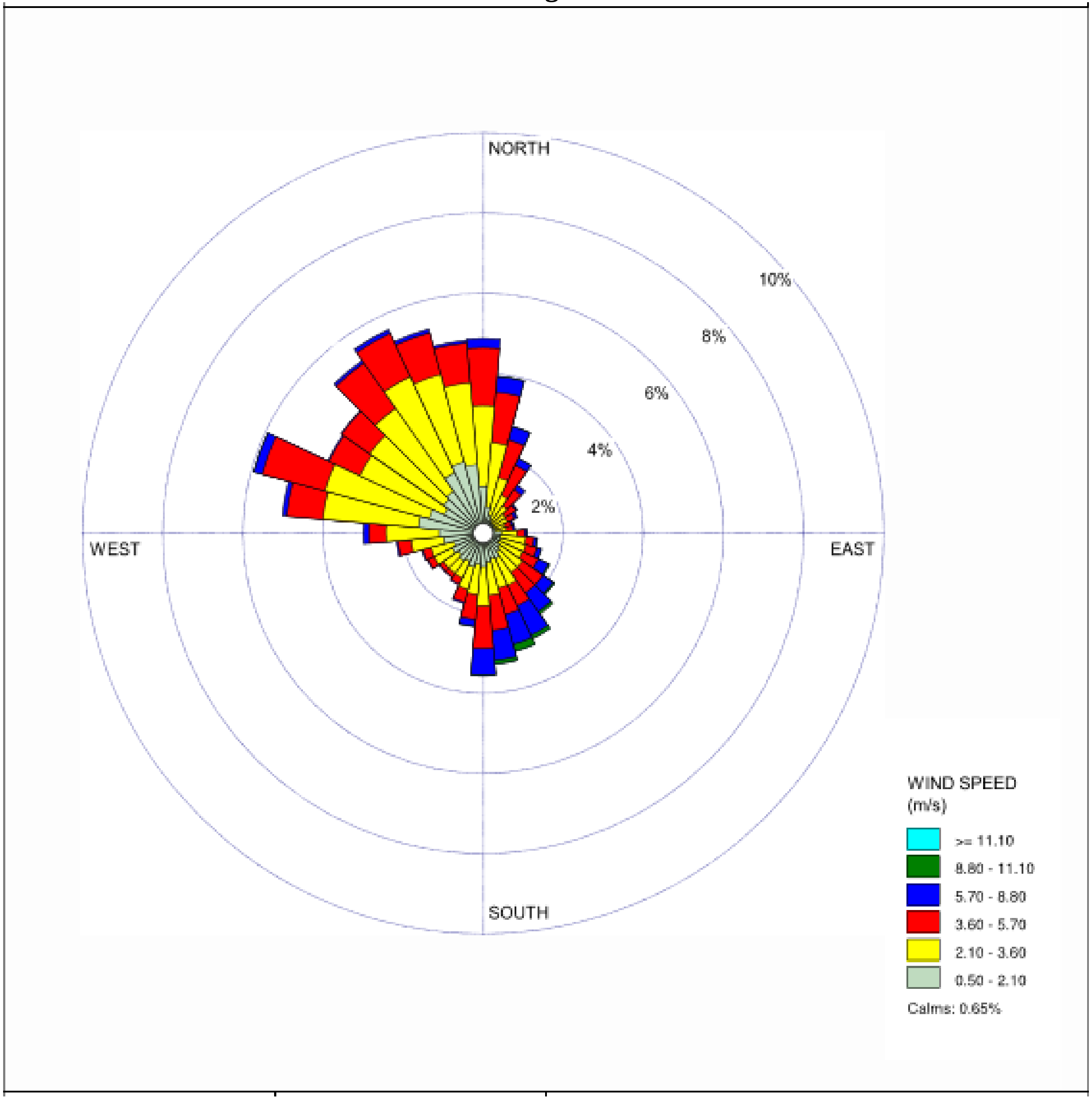
[2] - KMKO is closer to the Muskogee area and is an ASOS station with sub-hourly wind data and is more representative of the Muskogee area. Therefore, the PORT Mesonet data was not utilized in the modeling analyses.

<u>Abbreviations</u>

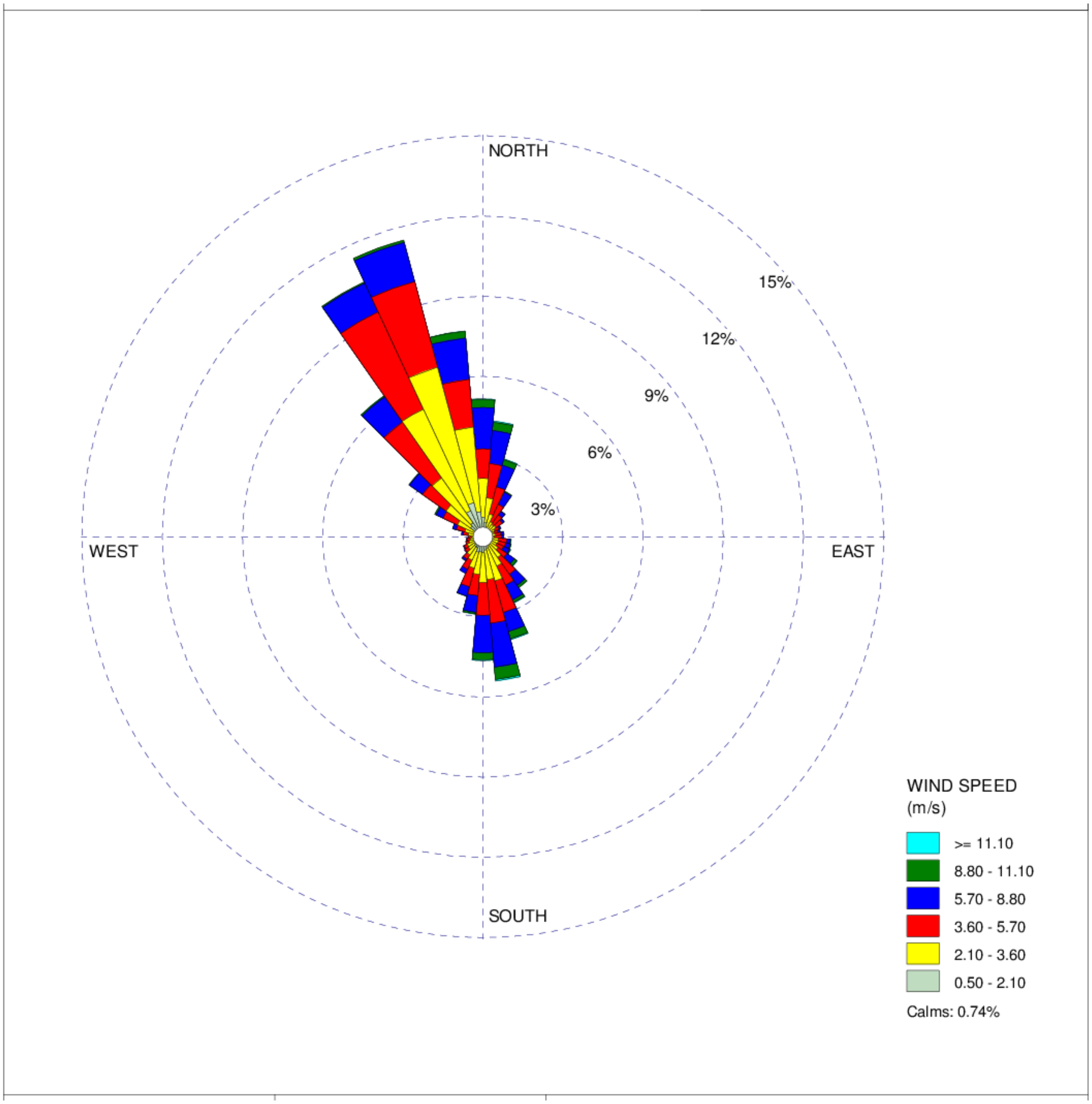
STID – Oklahoma Mesonet Station ID;
LAT, LONG – Latitude and Longitude in NAD83;
ELEV – Elevation is in meters;
SFCS – ISH Surface Station Call Identifier;
UAS – Upper Air Station Call Identifier.

Appendix F – Wind Roses

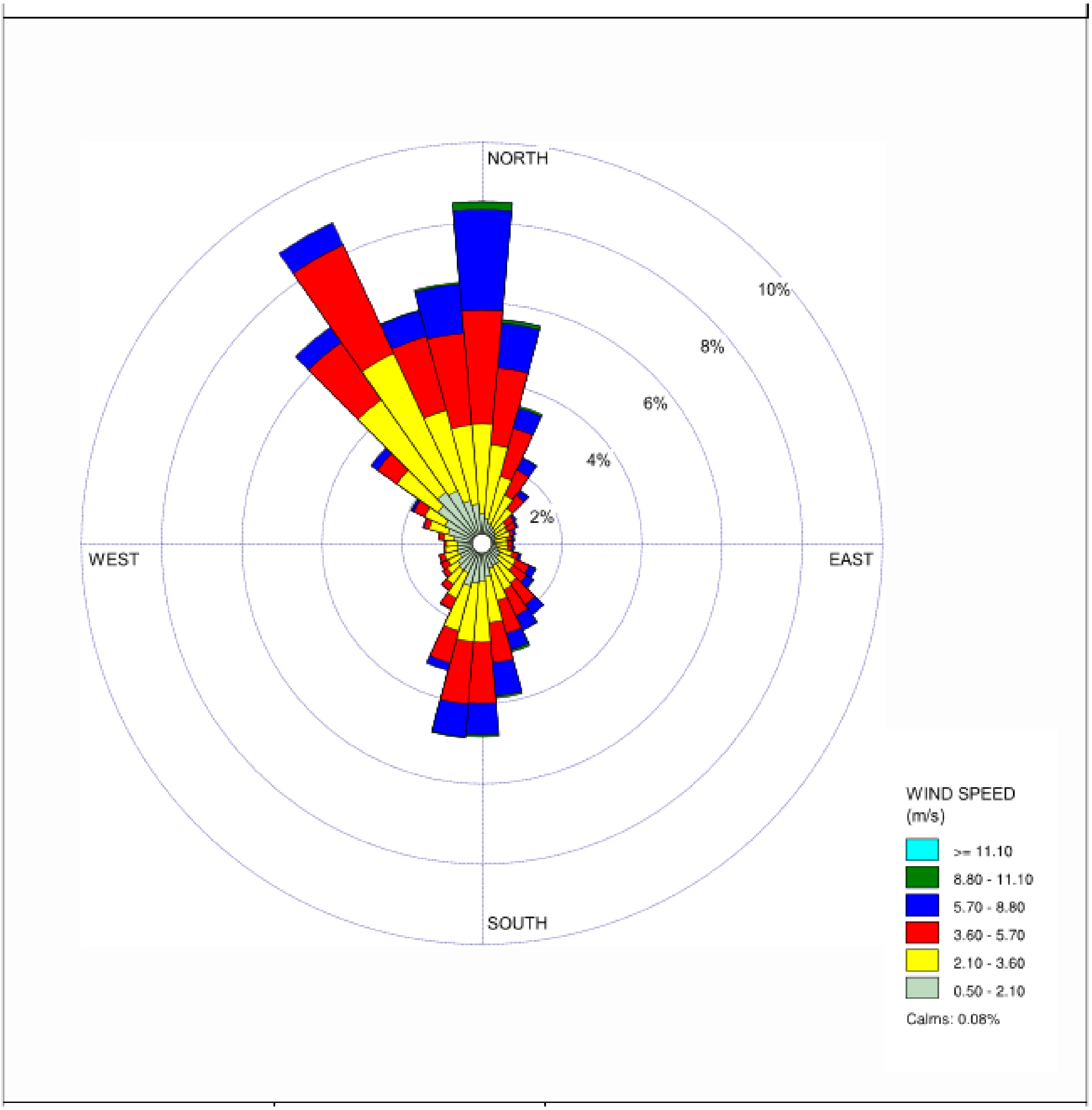
2012-2014 Hugo Wind Rose



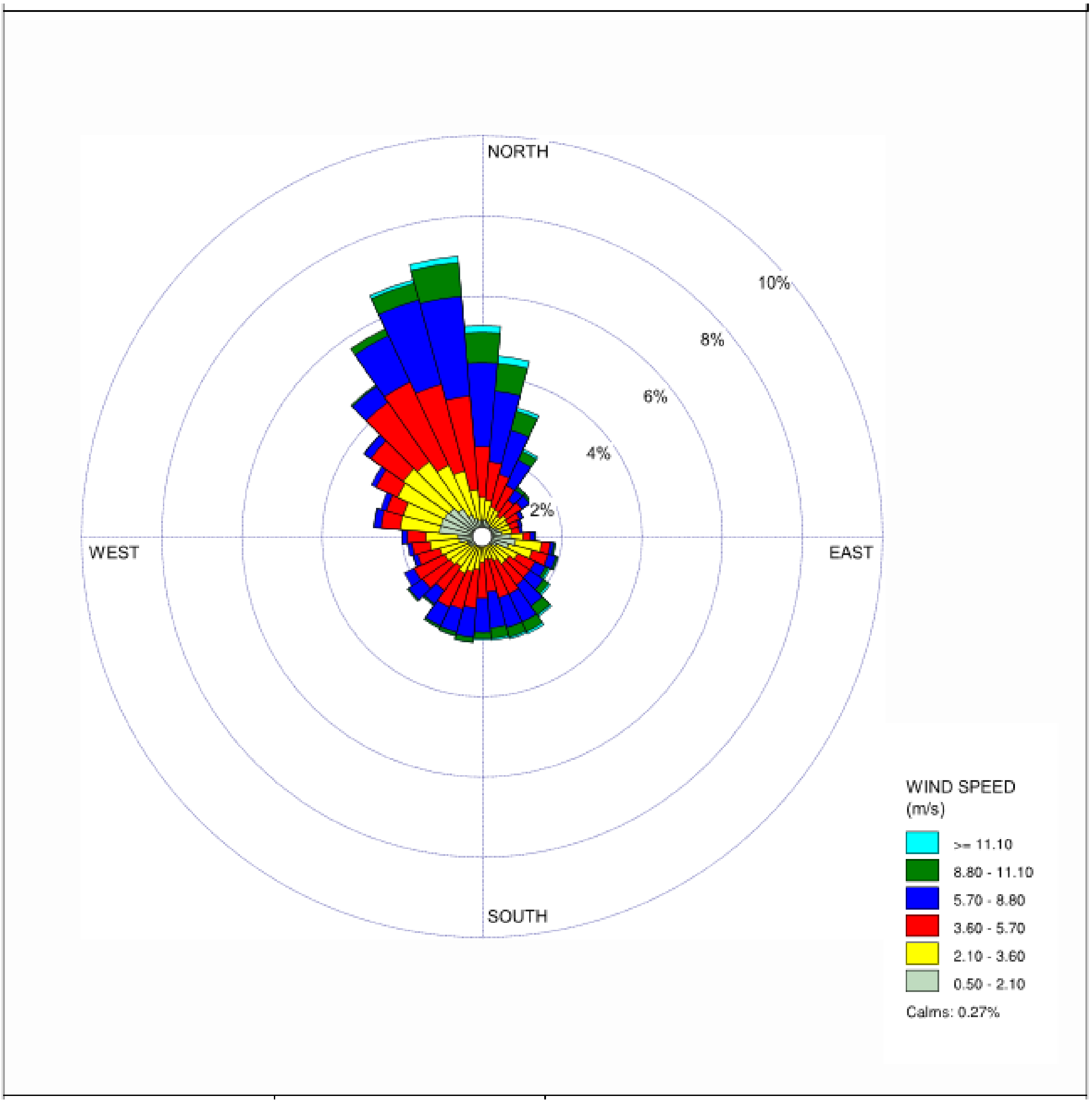
2012-2014 KMKO Wind Rose



2012-2014 Porter Wind Rose



2012-2014 Red Rock Wind Rose



Appendix G – Surface Characteristics

Domain 20 Surface Characteristics

HUGO	Albedo	AVG	Wet	Dry	Surface
Winter	0.18	0.81	0.43	1.95	0.022
Spring	0.15	0.40	0.26	1.12	0.039
Summer	0.18	0.53	0.32	1.37	0.142
Fall	0.18	0.81	0.43	1.95	0.142
KHHW					
Winter	0.18	0.81	0.43	1.95	0.022
Spring	0.15	0.40	0.26	1.12	0.039
Summer	0.18	0.53	0.32	1.37	0.144
Fall	0.18	0.81	0.43	1.95	0.144
KPRX					
Winter	0.18	0.72	0.40	1.91	0.016
Spring	0.14	0.34	0.22	1.04	0.023
Summer	0.19	0.47	0.29	1.31	0.039
Fall	0.19	0.72	0.40	1.91	0.032
KAQR[1]					
Winter	0.18	0.84	0.42	1.90	0.044
Spring	0.15	0.44	0.26	1.14	0.092
Summer	0.18	0.47	0.29	1.14	0.189
Fall	0.18	0.84	0.42	1.90	0.189

[1] – 2011 Run

Domain 36 Surface Characteristics

	Albedo	AVG	Wet	Dry	Surface
PORT					
Winter	0.18	0.73	0.39	1.77	0.026
Spring	0.15	0.36	0.23	1.01	0.042
Summer	0.18	0.45	0.28	1.16	0.183
Fall	0.18	0.73	0.39	1.77	0.183
KMKO					
Winter	0.18	0.72	0.41	1.94	0.016
Spring	0.14	0.33	0.22	1.03	0.023
Summer	0.19	0.50	0.30	1.42	0.037
Fall	0.19	0.72	0.41	1.94	0.031
0167					
Winter	0.17	0.64	0.37	1.47	0.021
Spring	0.14	0.37	0.24	0.93	0.027
Summer	0.18	0.43	0.28	1.01	0.064
Fall	0.18	0.67	0.37	1.47	0.064

Domain 39 Surface Characteristics

REDR	Albedo	AVG	Wet	Dry	Surface
Winter	0.19	0.87	0.46	1.77	0.014
Spring	0.17	0.37	0.26	1.01	0.050
Summer	0.18	0.65	0.35	1.16	0.112
Fall	0.18	0.87	0.46	1.77	0.112
KSWO					
Winter	0.19	0.91	0.48	2.00	0.017
Spring	0.16	0.47	0.31	1.18	0.051
Summer	0.18	0.63	0.37	1.54	0.095
Fall	0.18	0.91	0.48	2.00	0.095

2010 Primary Sulfur Dioxide (SO_2) National Ambient Air Quality Standard (NAAQS)

Technical Analyses and Information Supporting the Designation Recommendation for Oklahoma

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Comparison of Modeled and Monitored SO_2 Concentrations

In Muskogee, Oklahoma

Prepared by the Engineering Section of the Permitting Unit
Air Quality Division
Oklahoma Department of Environmental Quality

August 26, 2015

OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

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APPENDICES

1. WHAT IS THE PURPOSE OF THIS REPORT?

On June 22, 2010, the Environmental Protection Agency (EPA) revised the primary sulfur dioxide (SO_2) National Ambient Air Quality Standard (NAAQS). The EPA promulgated a new 1-hour annual primary SO_2 standard at a level of 75 parts per billion (ppb), based on the 3-year average of the annual 99th percentile of the daily maximum 1-hour average concentrations. The area designation process typically relies on air quality concentrations characterized by ambient monitoring data to identify areas that are either meeting or violating the relevant standard. However, a hybrid approach using modeling and monitoring for the designation process was proposed because of the following:

- SO_2 impacts are considered to be "source-oriented" rather than "regional" (peak concentrations of SO_2 are commonly caused by one or a few major point sources in an area and peak concentrations are typically observed relatively close to the source);
- Ambient SO_2 concentrations can be modeled accurately using well understood air quality modeling tools; and
- Only approximately 35% of the monitoring network was addressing locations of maximum (highest) concentrations of specific sources or groups of sources.

On March 2, 2015, a Consent Decree (CD) was filed requiring the EPA to sign for publication in the Federal Register no later than sixteen (16) months from March 2, 2015, a notice of EPA's promulgation of designations for the 2010 revised primary SO_2 NAAQS, for undesignated areas which:

1) Based on air quality monitoring in the three (3) full calendar years preceding such deadline have monitored violations of the 2010 revised primary SO_2 NAAQS; or
2) Contain any stationary source that has not been "announced for retirement" by the date of this Consent Decree, and that, according to the data in EPA's Air Markets Database, either
    a. Emitted more than 16,000 tons of SO_2 in 2012, or
    b. Emitted more than 2,600 tons of SO_2 and had an annual average emission rate of 0.45 lbs SO_2/MMBTU or higher in 2012.

By September 18, 2015, the state may submit to EPA additional information regarding the affected facilities and for which updated air quality analyses have been used to characterize the air quality around the source either through monitoring, modeling, or a combination of modeling and monitoring. To support the designations previously submitted by the State of Oklahoma, an air quality analysis utilizing modeling was conducted to characterize the air quality of the areas containing affected sources. Modeling of the area surrounding the OG&E Muskogee Generating Station was one of the air quality analyses which were conducted. The area containing the OG&E Muskogee Generating Station is unique because it also has an ambient SO_2 monitor which can also be utilized to characterize the area. However, when comparing modeled impacts to the monitored values from the Muskogee monitor (40-101-0167), there was poor correlation between the modeled impacts and the monitored values. This report discusses the analyses conducted concerning the modeling and trying to determine what may be contributing to the poor correlation between the modeled impacts and the monitored values.

2 HOW WAS AREA SURROUNDING THE OG&E MUSKOGEE GENERATING STATION MODELED?

Modeling of the area surrounding the OG&E Muskogee Generating Station was conducted utilizing 2012 to 2014 meteorological data and 2012 to 2014 actual emissions. The modeling was conducted in accordance with the *SO_2 NAAQS Designations Modeling Technical Assistance Document* (December 2013).

2.1 What air dispersion model was utilized for the modeling air quality analysis?

Given the source-oriented nature of SO_2, dispersion models are appropriate air quality modeling tools to predict the near-field concentrations. Therefore, for the area designations under the 2010 1-hour SO_2 primary NAAQS, the AMS/EPA Regulatory Model (AERMOD) was used to conduct the air quality analysis. AERMOD is the preferred air dispersion model, because it is capable of handling rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources (including, point, area, and volume sources).

The AERMOD modeling system includes the following components:

- AERMOD (Version 15181): the dispersion model;
- AERMAP (Version 11103): the terrain processor for AERMOD; and
- AERMET (Version 15181): the meteorological data processor for AERMOD.

For the OG&E Muskogee Generating Station these additional components were used in the modeling analysis:

- BPIPPRIME (Version 04274): the building input processor;
- AERMINUTE (Version 14337): a 1-minute ASOS winds pre-processor to AERMET;
- AERSURFACE (Version 13016): the surface characteristics processor for AERMET;

2.2 What receptors were utilized in the modeling air quality analysis?

To simplify the comparison of predicted impacts from the modeling and the monitored concentrations, a single receptor at the location of the monitor was used. The monitor is located 3.7 km north-northwest (341 degrees from the North) of the OG&E Muskogee facility.

2.3 What terrain data was utilized for the modeling air quality analysis?

Terrain data was obtained from the USGS Seamless Data Server at http://viewer.nationalmap.gov/viewer/. The 1/3 arc-second NED data was obtained in the GeoTIFF format for use in AERMAP. Interpolation of receptor and source heights from the 1/3 arc-second NED elevation data was based on the current AERMAP guidance in Section 4.4 of the *User's Guide for the AERMOD Terrain Preprocessor (AERMAP)* (EPA-454/B-03-0003, 10/2004). AERMAP uses a distance weighted bilinear interpolation method. The area surrounding the OG&E Muskogee Generating Station is located in UTM Zone 15. All coordinates in the model were based on the North American Datum (NAD) 1927 (NAD27).

2.4 What domain classification was utilized for the modeling air quality analysis?

Determination of the whether or not the domain should be classified as urban or rural was based mainly on land use which is the preferred method. The land use in the area surrounding the OG&E Muskogee Generating Station is mainly classified as rural. Therefore, the modeling analysis utilized a rural classification. However, the potential effects of the "urban heat island affect" were reviewed because the OG&E Muskogee Generating Station is located next to a metropolitan area. An Aerial photo of the area surrounding the OG&E Muskogee Generating Station is included in Appendix B.

2.5 What sources were included in the modeling air quality analysis?

When determining which affected sources should be included in the modeling air quality analysis, all nearby sources were evaluated. Nearby sources are those sources within 50 km of the OG&E Muskogee Generating Station that could cause or contribute to a NAAQS violation in the vicinity of the OG&E Muskogee Generating Station. All natural gas fired sources were excluded from the modeling air quality analysis because they do not cause a significant concentration gradient at the monitor location. The modeling air quality analysis did not include intermittent emissions sources, such as emergency generators based on the recommendations in the March 1, 2011 memorandum "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard."

All other sources of SO_2 were included in the modeling air quality analysis. A list of all sources in the modeling air quality analysis is given below.

Table 2.5-1. Location, Elevation, & Emissions of Modeled Sources

Source ID	Facility	Easting (m)	Northing (m)	Elevation (m)	SO_2 (lb/hr)
UNIT 4	OG&E Muskogee	293116.7	3959729.8	156.2	2,010.98
UNIT 5	OG&E Muskogee	293172.0	3959739.3	156.8	1,912.21
UNIT 6	OG&E Muskogee	293240.4	3959757.7	157.0	2,206.57
DAL20	Dalitalia	284208.4	3953784.7	171.2	0.11
DAL23	Dalitalia	284164.9	3953711.7	170.8	0.05
DAL29	Dalitalia	284093.8	3953787.7	171.0	0.09
BORSCRUB	Boral	282161.2	3951159.0	183.5	43.60
GPSTACK1	Georgia Pacific	292555.0	3956494.1	161.9	85.33
GPSTACK3	Georgia Pacific	292594.0	3956513.0	162.0	412.56
OBFURNA	Owens Brockway	288620.7	3960596.6	179.6	9.30
OBFURNB	Owens Brockway	288656.6	3960582.4	180.0	18.61
M1	US Lime	334096.8	3940641.2	203.6	20.31
K1	US Lime	334000.6	3940571.3	204.5	0.17
UNIT 1	GRDA	294138.0	4007357.0	189.5	2,881.26
UNIT 2	GRDA	294211.0	4007262.0	188.8	922.97

Table 2.5-2. Stack Parameters of Modeled Sources

Source ID	Facility	Stack Height (ft)	Stack Temp. (°F)	Stack Velocity (fps)	Stack Diameter (ft)
UNIT 4	OG&E Muskogee	350.0	264	44.96	24.0
UNIT 5	OG&E Muskogee	350.0	264	41.80	24.0
UNIT 6	OG&E Muskogee	500.0	264	55.01	21.5
DAL20	Dalitalia	46.3	130	29.80	5.0
DAL23	Dalitalia	46.0	130	45.08	2.7
DAL29	Dalitalia	51.3	130	24.10	5.4
BORSCRUB	Boral	70.0	355	36.29	6.2
GPSTACK1	Georgia Pacific	260.0	353	28.46	10.0
GPSTACK3	Georgia Pacific	260.0	306	28.24	13.8
OBFURNA	Owens Brockway	150.0	918	29.16	5.3
OBFURNB	Owens Brockway	80.0	389	28.89	7.1
M1	US Lime	150.0	266	57.09	5.3
K1	US Lime	96.0	155	31.20	7.0
UNIT 1	GRDA	504.0	300	68.14	20.0
UNIT 2	GRDA	507.0	190	90.98	20.0

2.5.1 How were hourly emissions from the modeled sources determined?

Actual emission data for input into AERMOD was generated for each source included in the modeling analysis. Most electric generating units (EGU) have continuous emissions monitoring systems (CEMS). In the absence of CEMS data, simply dividing the annual emissions by the number of hours in the year is not an accurate representation of actual emissions. For affected sources without CEMS data, actual emissions were based on actual throughputs and the calculated SO_2 emissions generally based on a mass balance. For sources that vary their operation throughout the year, AERMOD input variables were used to represent their actual operation throughout the year. Use of AERMOD input variables such as hour of day (HROFDY), hour of day and day of week (HRDOW), monthly hour of day and day of week (MHRDOW), were utilized to represent actual operation for those sources without CEMS data. Varying emissions were based on the available information such as production logs, fuel usage information, operating schedules, etc. CEMS data was used to generate hourly emissions files for those sources with CEMS using the following methodology:

Step 1: The emission data was downloaded from the Clean Air Markets Database (CAMD).

Step 2: The monthly data was combined generating annual emission data files for each source at an affected facility with CEMS data.

Step 3: There are three variables used in an hourly emission file, emissions, velocity, and temperature. These hourly values were generated from the CAMD datasets and formatted into the units used by AERMOD. The emissions were converted from the CAMD data lb/hr values into g/s. The heat input given in the CAMD data was used with Method 19, the CO_2 concentration, and stack temperature from recent relative accuracy test audits (RATA), to generate the flow rate and resultant velocity. If a unit was operating it was assigned the normal stack temperature determined from RATA. For the

OG&E Muskogee Generating Station hourly velocity and temperature data from the CEMS was used.

Step 4: The data was then reviewed for continuity and for missing data. If there was a single hour of missing data, it was replaced with the average of surrounding non-missing hours. For periods of missing data with more than a single missing value, operational data from the facility was reviewed to fill the missing hours.

2.5.1.1 What operational data was used from the RATA?

The stack parameters used to generate the hourly emission file for AERMOD from RATA are listed below. Only RATA data from the nearby EGU located at Grand River Dam Authority (GRDA) was utilized in generating the hourly emission file.

Table 2.7-1 Operational Stack Data from RATA

		Stack Temp			% Moisture			% CO_2		
Station	**Unit**	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
GRDA	Unit 1	312	297[1]	281	11.72	11.86[1]	12.00	13.26	13.06[1]	12.86
GRDA	Unit 2	192	198	193	15.93	15.86	15.05	12.21	11.71	10.85

[1] - The average of 2012 and 2014.

2.5.2 How was GEP stack height addressed?

Good Engineering Practice (GEP) stack height is the minimum stack height needed to prevent the stack exhaust plume from being entrained in the wake of nearby obstructions. For the modeling analysis, actual stack heights were used rather than following the GEP stack height policy. The GEP stack height policy uses GEP stack height for stack heights exceeding GEP and actual stack height for stacks below GEP. The use of actual stack heights in the modeling analysis more closely represents actual ambient air quality conditions from the modeled sources and the concentrations detected at the monitor would be reflective of the effect of emissions from the actual stack heights.

2.6 Was building downwash included in the modeling analyses?

Modeling that includes calculations for building downwash gives a more accurate representation of pollutant impacts than does modeling that omits consideration of downwash affects. Therefore, building downwash was included in the modeling analysis for the on-site buildings.

Not only are accurate stack parameters important but so are accurate building parameters. Building parameters include location and orientation relative to stacks and building size. Other parameters include tier heights and coordinates. These parameters are input into BPIP-PRIME to calculate building parameters for AERMOD. Facility data was reviewed and included in the modeling analyses.

2.7 What meteorological data was utilized in the modeling air quality analysis?

The 2012-2014 meteorological data from the National Weather Service (NWS) Automated Surface Observation Station (ASOS) located at the Davis Field Airport (KMKO) in Muskogee was utilized for the 2010 1-hour SO_2 primary NAAQS designations modeling.

When conducting air dispersion modeling, the state of Oklahoma generally utilizes meteorological data from the following:

- Oklahoma Mesonet Surface Data;
- National Centers for Environmental Information (NCEI), formerly National Climatic Data Center (NCDC), Integrated Surface Hourly Database (ISHD) Surface Data; and
- Earth System Research Laboratory (ESRL) Global Systems Division (GSD), formerly Forecast Systems Laboratory (FSL), Upper Air (UA) data.

Oklahoma Mesonet data is usually incorporated to help make more accurate forecasts of ambient impacts from modeled sources. Incorporation of Oklahoma Mesonet data makes the AERMET processed meteorological data more accurate because the datasets contain sub-hourly values and the sites are usually closer to the areas being modeled. Standard ISHD surface data usually only contains a single two minute average recorded during an hour whereas Oklahoma Mesonet datasets contain twelve five minute averages for each hour. There are a large number of Oklahoma Mesonet stations which increases the potential of an Oklahoma Mesonet meteorological station being closer to the area being modeled. Generally, the closer a meteorological station is to an area, the more representative the meteorological data is to the area being modeled.

There are two types of ISHD surface stations ASOS and Automated Weather Observation Stations (AWOS). All ASOS stations started recording continuous sub-hourly (2-minute averages) wind data in 2005. However, sub-hourly wind data for AWOS stations is not available. If an ASOS station is closer or more representative than the nearest Oklahoma Mesonet station, data from the Oklahoma Mesonet is not incorporated into the AERMET processed meteorological data. Oklahoma Mesonet meteorological data was not utilized with the Muskogee area ambient air quality modeling analysis because the ISHD ASOS KMKO Station data is closer to and more representative than the nearest Oklahoma Mesonet Station and sub-hourly wind data is available for the KMKO Station. A wind rose for the KMKO station is contained in Appendix F.

2.7.1 How was the ISHD data processed?

The ISH data files were downloaded from the NCDC ISHD web site: ftp://ftp.ncdc.noaa.gov/pub/data/noaa. The ISH data was reviewed for completeness by evaluating the number of hours that were recorded and the number of cloud cover (GF1) values that were recorded. The data from KMKO did not have a significant number of missing values for individual variables. Therefore, no missing data replacement was performed.

2.7.2 Was AERMINUTE utilized in the modeling analysis?

For this ASOS site, AERMINUTE data was utilized to incorporate continuous sub-hourly wind data. The ASOS (6405) files were downloaded and then processed using AERMINUTE. The ASOS 1-minute files were downloaded from http://www1.ncdc.noaa.gov/pub/data/ for each year.

2.7.3 What is Oklahoma Mesonet data and how was it utilized?

The Oklahoma Mesonet is a world-class network of meteorological monitoring stations. The Oklahoma Mesonet is unique in its capability to measure a large variety of meteorological conditions at so many sites across an area as large as Oklahoma. Oklahoma Mesonet data is provided courtesy of the Oklahoma Mesonet, a cooperative venture between Oklahoma State University (OSU) and the University of Oklahoma (OU) and supported by the taxpayers of Oklahoma. At each site, the meteorological conditions are continuously measured and packaged into 5-minute observations. These 5-minute observations from the Oklahoma Mesonet were processed into an AERMET acceptable format. The meteorological data from sites surrounding KMKO were utilized to evaluate the wind flow patterns in the Muskogee area.

The five closest Mesonet sites in and around the Muskogee area are listed below. Wind roses for the specific stations are contained in Appendix F.

Table 2.7.3-1 Oklahoma Mesonet Stations Near Muskogee, Oklahoma

STNM	ID	Name	City	County	LAT	LON	ELEV (m)	DIST[1] (km)
118	PORT	Porter	Clarksville	Wagoner	35.8257	-95.5598	193	25.5
44	HASK	Haskell	Haskell	Muskogee	35.7480	-95.6405	183	31.8
132	WEBR	Webbers Falls	Webbers Falls	Muskogee	35.4890	-95.1233	145	33.8
92	TAHL	Tahlequah	Tahlequah	Cherokee	35.9724	-94.9867	290	35.8
31	COOK	Cookson	Marble City	Cherokee	35.6800	-94.8490	299	40.7

[1] - Distance from the OG&E Muskogee Generating Station (35.79194, -95.28794).

2.7.4 What upper air data was used?

There are three ESRL RAOB weather stations within 300 km of the Muskogee area. These stations usually take soundings twice a day. The ESRL data files were downloaded from the ESRL ROAB web site: http://esrl.noaa.gov/raobs/. The specific sites and distance from the Muskogee area are shown below. The RAOB data from the Max Westheimer Airport (OUN) located in Norman, Oklahoma was the upper air data utilized in the modeling analysis. The OUN site is the closest station to the Muskogee area. However, other ESRL stations (LZK) were evaluated to determine if they were more representative in terms of determining impacts within the Muskogee area.

Table 2.7.4-1 Upper Air Station Location and Elevation and Distance to Muskogee[1]

Location	Call Sign	LAT	LON	ELEV (m)	DIST (km)
Norman	OUN	35.23	-97.47	362	196
Springfield	SGF	37.23	-93.40	394	247
Little Rock	LZK	34.83	-92.27	172	295

[1] - Distance from the KMKO Meteorological Station (35.6577, -95.3658).

The UA data was reviewed for missing soundings. A single missing sounding will cause a whole day (24 hours) of missing meteorological data values. To reduce the number of missing meteorological data, replacement soundings were substituted for the missing soundings. The replacement soundings were selected from a site with similar thermodynamic profiles. Each UA data station was assigned a primary and a secondary replacement UA station. The primary station is basically the station that is closest to the station being reviewed. Each replacement sounding was documented.

2.7.5 How were surface characteristics determined?

When using AERMET, to process meteorological data for AERMOD, three surface characteristics (Albedo, Bowen Ratio, and Surface Roughness Length) must be determined for the meteorological station. Albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux. Surface roughness length is related to the height of obstacles to the wind flow and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer. Albedo and Bowen Ratio are used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

AERSURFACE uses land cover data from the U.S. Geological Survey (USGS) National Land Cover Data 1992 archives (NLCD92) to determine the land cover types for a specified location. AERSURFACE matches the NLCD92 land cover categories to seasonal values of Albedo, Bowen Ratio, and Surface Roughness and then calculates the surface characteristics for input into AERMET. NLCD92 data in GeoTIFF format was downloaded from the Multi-Resolution Land Characteristics (MRLC) Consortium at the following link: http://www.mrlc.gov/viewerjs/. When determining the surface roughness the default distance of 1 km was utilized. The surface characteristics of the individual stations are included in Appendix G.

2.7.6 What was used to determine the surface moisture conditions?

The monthly rainfall for each Mesonet site was analyzed from the beginning of the establishment of the Mesonet program (approximately 20 years). The surface moisture conditions (Average, Wet, Dry) for each of the Oklahoma Mesonet stations for each month were then determined using the monthly rainfall amounts compared to the average rainfall. These determinations were based on the guidance contained in the AERSURFACE Users Guide. The Bowen Ratio was then assigned as either average, dry, or wet based on the monthly surface moisture conditions for each Oklahoma Mesonet station. The surface moisture conditions for the ISHD stations were attributed to the surface moisture conditions of the nearest Oklahoma Mesonet station.

2.8 Was background monitoring data utilized in the modeling air quality analysis?

When evaluating modeled source impacts at the monitor to the monitored impacts, background concentrations were not added to modeled impacts. The main SO_2 sources contributing to the impacts at the monitor were explicitly included in the modeling. Smaller sources of SO_2 emissions such as natural gas fired sources do not have a significant concentration gradient and will not significantly impact the monitor. Therefore, background concentrations from another monitor representative of area sources of SO_2 were not added to the modeled concentrations.

3. WHAT WERE THE MONITORED IMPACTS?

Monitoring data from the Muskogee monitor (40-101-0167) in the form of the standard is shown below. Only data meeting the minimum data collection requirements or the minimum percent observations were used when determining the design value.

Table 3-1 Monitor Site Location and Elevation

Location	ID	LAT	LON	ELEV (m)
Muskogee	0167	35.79313	-95.30228	158.5

Table 3-2 Monitoring Design Value

Pollutant	Averaging Period	Basis of Design Value
SO_2	1-hour	3 year average of 99th Percentile 1-hour daily maximum

Table 3-3 Monitoring Site 40-101-0167 Design Value

Monitor ID	2012			2013			2014			3 Year
	OBS	99th	ppb	OBS	99th	ppb	OBS	99th	ppb	Avg.
40-101-0167	285	H3H	63	365	H4H	37	357	H4H	48	49.3

The 2012 to 2014 three year average of the 99th percentile 1-hour daily maximum values is 49.3 ppb which is approximately 129.2 µg/m^3. The monitored concentration is approximately 66% of the NAAQS (75 ppb).

4. WHAT WERE THE MODELED IMPACTS AT THE MONITOR?

The modeled 2012 to 2014 three year average of the 99th percentile 1-hour daily maximum values is 149.5 µg/m^3 which is approximately 57.1 ppb. The modeled concentration is approximately 76% of the NAAQS (75 ppb). However, the modeled concentration is 15.7% different than the monitored concentration.

5 WHAT STEPS WERE TAKEN TO EVALUATE THE DIFFERENCE OF THE MONITORED IMPACTS AND THE MODELED IMPACTS?

5.1 Was Representativeness of the Surface Meteorological Data Evaluated?

The 2012-2014 wind roses for the five surrounding Oklahoma Mesonet meteorological stations, the ISHD KMKO meteorological station, and the ambient air monitoring site (40-101-0167) were reviewed to determine the general wind pattern for the area. The majority of the wind roses for Oklahoma represent a N-S wind flow pattern. In the summer, the wind out of the S to SE dominates. In the winter, the wind out of the N to NW dominates. A small percentage of the time the wind flows in an E-W direction.

However, due to terrain affects, there is a shift in the wind flow pattern south of Muskogee, Oklahoma from a N-S wind flow to an E-W wind flow. This can be seen in the Weber Falls, Oklahoma (WEBR) wind rose where the main wind flow comes from the ESE to SE direction and NW to NNW direction. As the wind moves toward Muskogee, the wind flow pattern is shifted back to the normal Oklahoma wind flow pattern as seen in the Davis Field (KMKO) wind rose where it comes from the SE to SSE direction and NNW to N direction. As the wind continues to move across the plains, the wind flow pattern spreads out as can be seen in the Porter, Oklahoma (PORT) and Haskell, Oklahoma (HASK) wind roses where the flow changes to a SSW to SE direction and NNE to NNW direction.

The Tahlequah, Oklahoma (TAHL) wind rose also shows a wider spreading of the wind pattern as the wind comes out onto the plains off the Cookson Hills. A similar affect can be seen in the wind flow pattern for the Muskogee ambient air monitor (0167).

The Cookson, Oklahoma (COOK) meteorological station located in the Cookson Hills has less of a spread than the sites located in the plains with the wind flow pattern from the SE to SSE direction and the NW to N direction. The general wind flow pattern for COOK is similar to the KMKO Station.

The meteorological data collected at the monitoring site does not meet the standard meteorological data collection requirements and was therefore not considered except as a means to compare and evaluate the KMKO station meteorological data. Based on a review of modeling conducted with the 0167 meteorological data, there was less correlation between the modeling results using the 0167 meteorological data than the meteorological data from the KMKO Station.

The Muskogee ambient air monitor (0167) is actually located slightly below the surrounding terrain at 520 feet with the wind measurement instrument located at a height of 20 feet. The surrounding terrain within 1 mile of the monitor ranges from 490 feet to 550 feet. The hills surrounding the area reach heights of 800 feet.

5.2 Were the Effects of Terrain Evaluated?

Muskogee, Oklahoma lies in a river valley and has a low elevation compared to the surrounding area. The Muskogee area is unique in that it is located north of the west end of the Arkansas Valley and is nestled in the hook of the west end of the Cookson Hills (Lower Buffalo Mountains). The Ozarks are made up of the Boston Mountains (Upper and Lower) and define the northern portion of the Arkansas River Valley. The Ouachita Mountains make up the southern portion of the Arkansas Valley. The Cookson Hills are flat-topped remnants of ancient plateaus and the Ouachita's are folded ridges. To the east of Muskogee, the land opens up into prairie grassland. As the wind flows through the west end of the Arkansas River Valley, it meets the northern edge of the Ouachita Mountains and starts to flow toward the northwest in the open plains.

In the northeast corner of Muskogee, is the Three Rivers Area which is the confluence of the Arkansas River, the Neosho River, and the Verdigris River. The three rivers converge and continue on as the Arkansas River, which winds through the Cookson Hills. The east side of Muskogee is bordered by the Arkansas River and the Cookson Hills. In the southeast corner of Muskogee, the Arkansas River is bounded by local terrain (Devil's Peak and Braggs Mountain) creating a small gap through which the surface wind is funneled.

The wind speed from each meteorological station varies and is mainly due to the surface roughness of the terrain surrounding the meteorological station. As the surface wind comes across rugged terrain, the average wind speed will be reduced as seen in the difference in the average wind speed of the KMKO Station and the COOK Station. However, terrain features can have other effects on wind speed such as funneling of surface winds between two hills and dropping of surface winds from mountainous areas into open plains.

The surface roughness of the individual meteorological stations was compared to the surface roughness of the facility being modeled. The surface roughness of the KMKO meteorological station was lower than the surface roughness generated by AERSURFACE for the facility. The surface roughness of all of the Oklahoma Mesonet stations was larger than the surface roughness generated by AERSURFACE for the facility. In order to review the surface roughness determination for the KMKO meteorological station, the area used to determine the surface roughness was expanded out to two kilometers (km). At 2 km, the surface roughness of the KMKO meteorological station closely resembled the surface roughness of the OG&E Muskogee facility.

5.3 Were the Sources of Upper Air Data Evaluated?

The three closest meteorological stations where upper air data is recorded are located approximately 200, 250 and 300 km from the Muskogee area. Muskogee is almost located equidistance between these locations. These large distances can lead to distinct differences when determining the structure of the atmosphere for the Muskogee area.

The meteorological station that has the closest elevation to the Muskogee area (~160 to 180 meters above sea level) is Little Rock, Arkansas (LZK). However, LZK is the farthest site from the Muskogee area. The Springfield, Missouri station (SGF) and the Norman, Oklahoma station (OUN) are at approximately the same elevation and are about 200 meters higher than the Muskogee area. However, SGF is 30 meters higher and 50 km distant than OUN. These larges differences in elevation can also lead to differences when determining the characteristics of the upper air in the Muskogee area.

Depending on the wind patterns for specific days one upper air station may be more representative than another upper air station (e.g. OUN may be more representative in the winter and LZK may be more representative in the summer). Therefore, use of a single location for a whole year may not yield representative modeling results which can lead to differences in modeled and monitored ambient impacts.

5.4 How were the Modeled Ambient Impacts Compared to the Monitored Ambient Impacts?

To review the correlation between the modeled and monitored ambient impacts, additional modeling was conducted changing a single variable to determine which variable had the most influence and brought the modeled ambient impacts closer to the monitored ambient impacts. The modeled ambient impacts were generated using the following combinations of meteorological data:

- KMKO Surface Data W/OUN Upper Air Data,
- KMKO Surface Data combined with wind data from the 40-101-0167 Monitoring Station W/OUN Upper Air Data;
- KMKO Surface Data W/LZK Upper Air Data;
- KMKO Surface Data W/SGF Upper Air Data;
- KMKO Surface Data W/OUN Upper Air Data W/2 km Surface Roughness;

- KMKO Surface Data W/LZK Upper Air Data W/2 km Surface Roughness;
- KMKO Surface Data W/OUN Upper Air Data W/ROTANG option at 5 degrees; and
- KMKO Surface Data W/OUN Upper Air Data W/ROTANG option at 10 degrees.

Table 5.5-1 Modeled Impacts Versus Monitored Impacts Using Various Inputs

Surface Station	Upper Air Station	Additional Data	Modeled Impacts (μg/m³)	Monitored Impacts (μg/m³)	% Difference
KMKO	OUN		149.5	129.2	15.7
KMKO	OUN	0167	188.7	129.2	46.1
KMKO	LZK		145.4	129.2	12.5
KMKO	SGF		147.0	129.2	13.8
KMKO	OUN	2 km SR	137.0	129.2	6.0
KMKO	LZK	2 km SR	137.0	129.2	6.0
KMKO	OUN	ROTANG5	138.3	129.2	7.0
KMKO	OUN	ROTANG10	159.0	129.2	23.1

The modeling scenarios closest to representing the design value recorded at the monitor were the modeling scenarios that increased the surface roughness to be more representative of the surface roughness at the site. However, while the three year average of the H4H was very close to the actual monitored impacts, the actual hourly impacts predicted at the monitor were not.

In order to evaluate the differences between and correlate the modeled and monitored ambient impacts on an hourly basis, predicted modeled ambient impacts for each hour were plotted with the monitored ambient impacts for each hour. Based on these graphs, it was determined that there was not a significant correlation between the modeled ambient impacts and the monitored ambient impacts. The modeled ambient impacts for each hour were also plotted using the monitored ambient impacts as the horizontal axis which should have generated a graph which can easily be used to correlate the values. Values that are equivalent will be plotted along a line with a slope of 1 (@ 45°) extending from the origin. Again these plots did not generate a straight line and confirmed that there was no correlation between the hourly modeled and monitored ambient impacts.

Finally, to evaluate what was producing the differences between the monitored concentrations and the modeled hourly concentrations, the meteorological data for the hours when the monitor was predicting high impacts and the hours when the model was predicting high impacts were reviewed. From this review the following was determined:

- The monitor was experiencing high impacts when the wind was blowing directly from the OG&E facility towards the monitor at 162 degrees.
- The monitor was experiencing high impacts when the average wind speed was approximately 5.2 m/s (Slightly Unstable to Neutral Conditions).
- The model was predicting high impacts at the monitor when the wind was blowing directly from the OG&E facility towards the monitor at 162 degrees.
- The model was predicting high impacts at the monitor when the average wind speed was approximately 2.2 m/s (Very Unstable to Unstable Conditions).

The modeling scenarios that predicted the highest impact were run with downwash and without downwash. Removing downwash from the model did not change the predicted design value of the model. However, removing downwash from the model did reduce the correlation between the modeled and monitored hourly values.

The surface roughness, wind speed, and wind direction significantly affect the modeling results. The inability of the AERMOD model to predict on an hour-by-hour basis what is occurring at the monitor suggests that there is some doubt concerning the representativeness of the meteorological data used in the modeling analysis.

6. WHAT IS THE SUMMARY OF THE REVIEW OF MONITORED IMPACTS AND MODELED IMPACTS?

The area surrounding the OG&E Muskogee Generating Station is not adequately characterized by the available meteorological data. The terrain effects on the wind direction and speed of the area surrounding the modeling domain are not adequately characterized by the area surrounding the NWS Station (KMKO). Also, the surface roughness at the NWS Station (KMKO) is not representative of the surface roughness of the modeling domain. Additional meteorological monitoring in the area of the OG&E Muskogee Generating Station is needed to address questions regarding meteorological data representativeness.

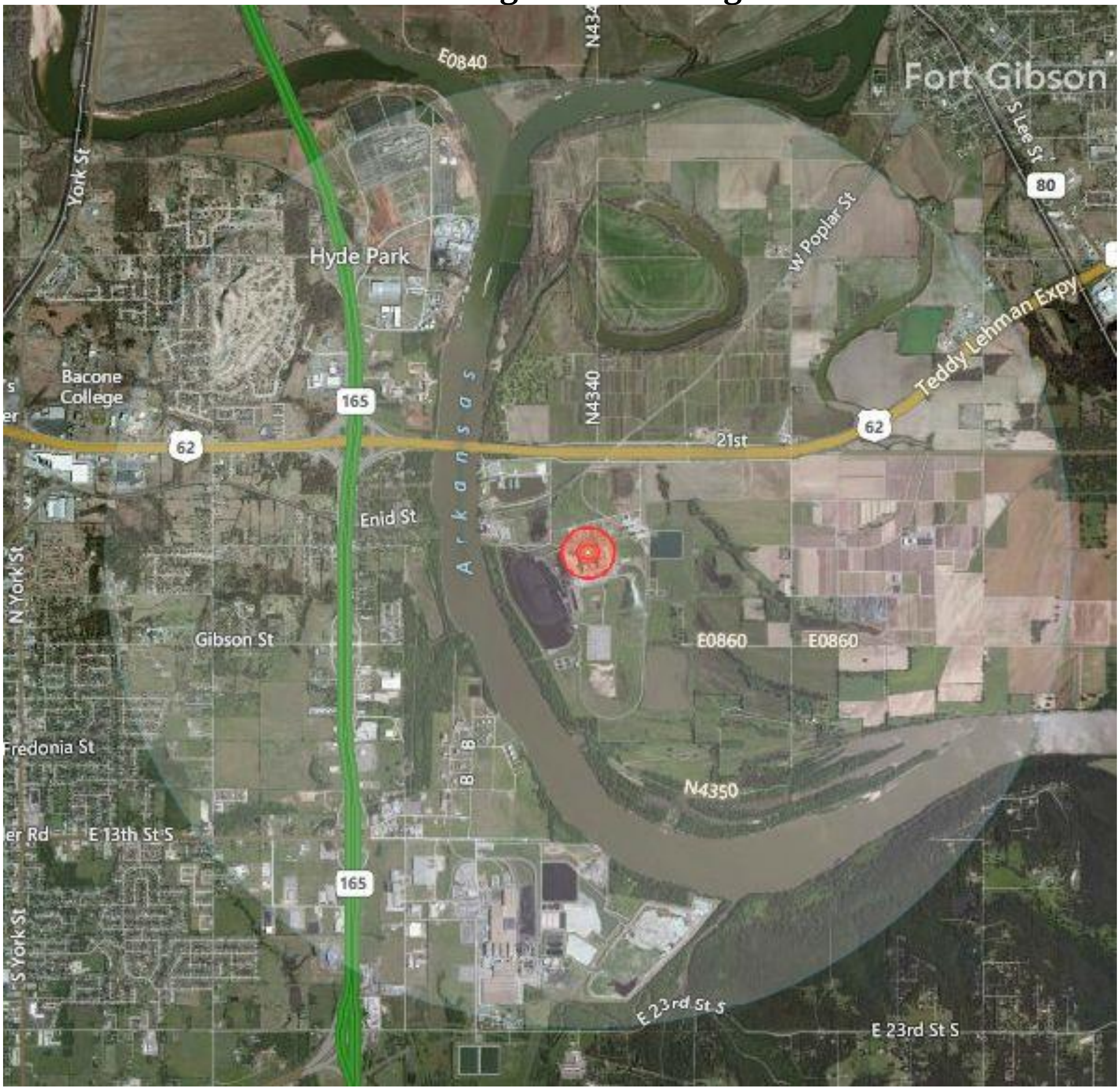
A meteorological station located at or near the center of the domain would enhance the accuracy of the modeling. The meteorological data should include upper air data to characterize the atmospheric conditions within the modeling domain. The station should be equipped with a meteorological tower of sufficient height to characterize the vertical structure of the atmosphere (100 m) or a SODAR (SOnic Detection And Ranging) instrument, radar wind profiler (RWP), radio acoustic sounding systems (RASS), or similar instrument to characterize the thermodynamic structure of the lower layer of the atmosphere.

7. WHAT REFERENCES WERE USED?

- *Additional Clarification Regarding Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS* (March 1, 2011);
  - http://www.epa.gov/ttn/scram/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf
- *Guidance Concerning the Implementation of the 1-hour SO_2 NAAQS for the Prevention of Significant Deterioration Program* (August 23, 2010);
  - http://www.epa.gov/region07/air/nsr/nsrmemos/appwso2.pdf
- *Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 NAAQS* (August 23, 2010);
  - http://www.epa.gov/ttn/scram/guidance/clarification/ClarificationMemo_AppendixW_Hourly-SO2-NAAQS_FINAL_08-23-2010.pdf
- *SO_2 NAAQS Designations Modeling Technical Assistance Document* (December 2013);
  - http://www.epa.gov/oaqps001/sulfurdioxide/pdfs/SO2ModelingTAD.pdf
- Guidance for 1-Hour SO2 NAAQS SIP Submissions (September 22, 2011);
  - http://www.epa.gov/oaqps001/sulfurdioxide/pdfs/DraftSO2Guidance_9-22-11.pdf
- User's Guide for the AMS/EPA Regulatory Model - AERMOD
  - http://www.epa.gov/ttn/scram/models/aermod/aermod_userguide.zip.
- User's Guide for the AERMOD Meteorological Data Preprocessor (AERMET)
  - http://www.epa.gov/ttn/scram/7thconf/aermod/aermet_userguide.zip.
- AERMINUTE User's Instruction
  - http://www.epa.gov/ttn/scram/7thconf/aermod/aerminute_14337.zip.
- AERSURFACE User's Guide
  - http://www.epa.gov/ttn/scram/7thconf/aermod/aersurface_userguide.pdf.

Appendix A – Land Use/Land Cover Aerial Photo

OG&E – Muskogee Generating Station

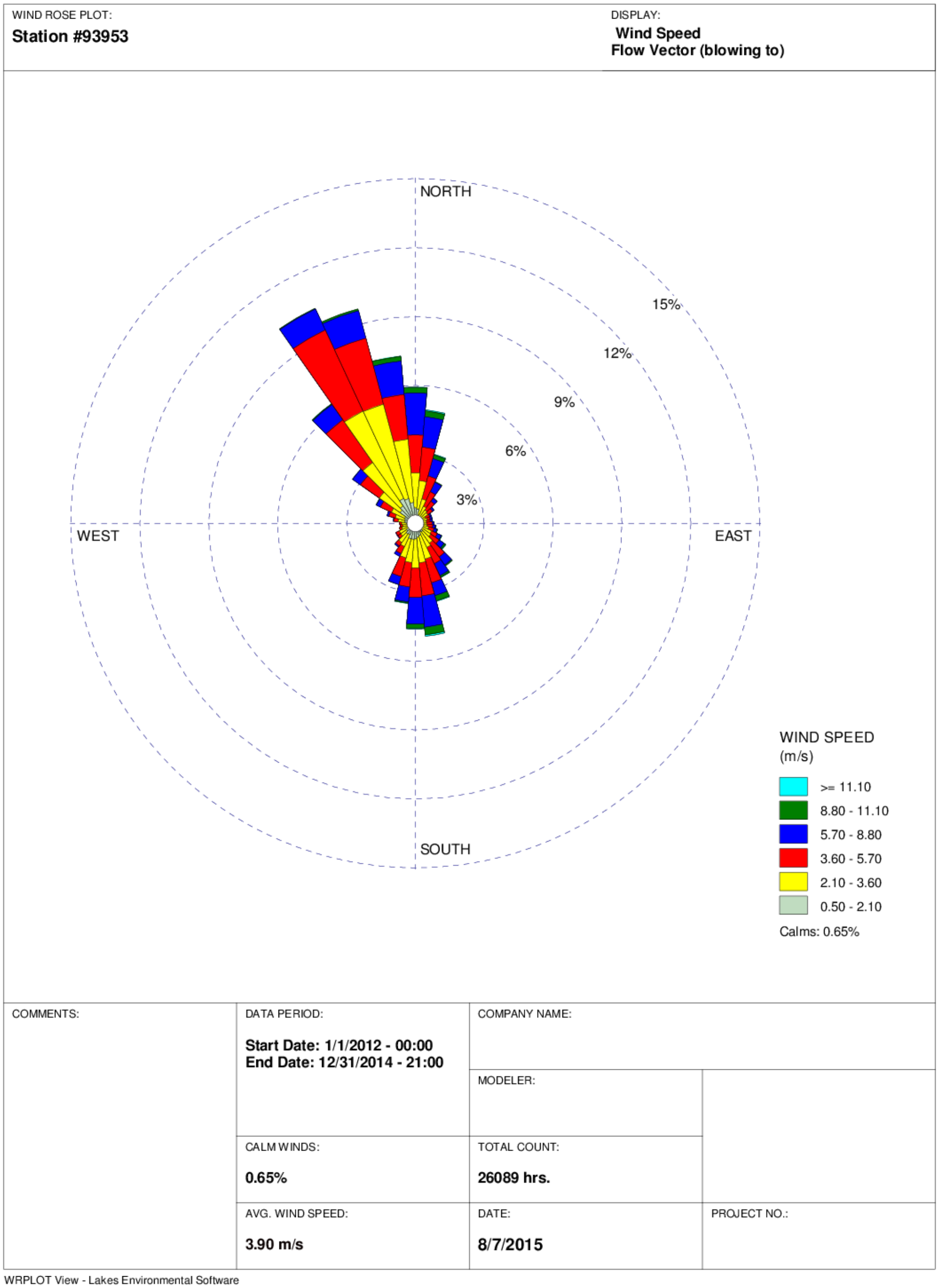


Appendix B – Aerial Photo Overlaid With Facility Data

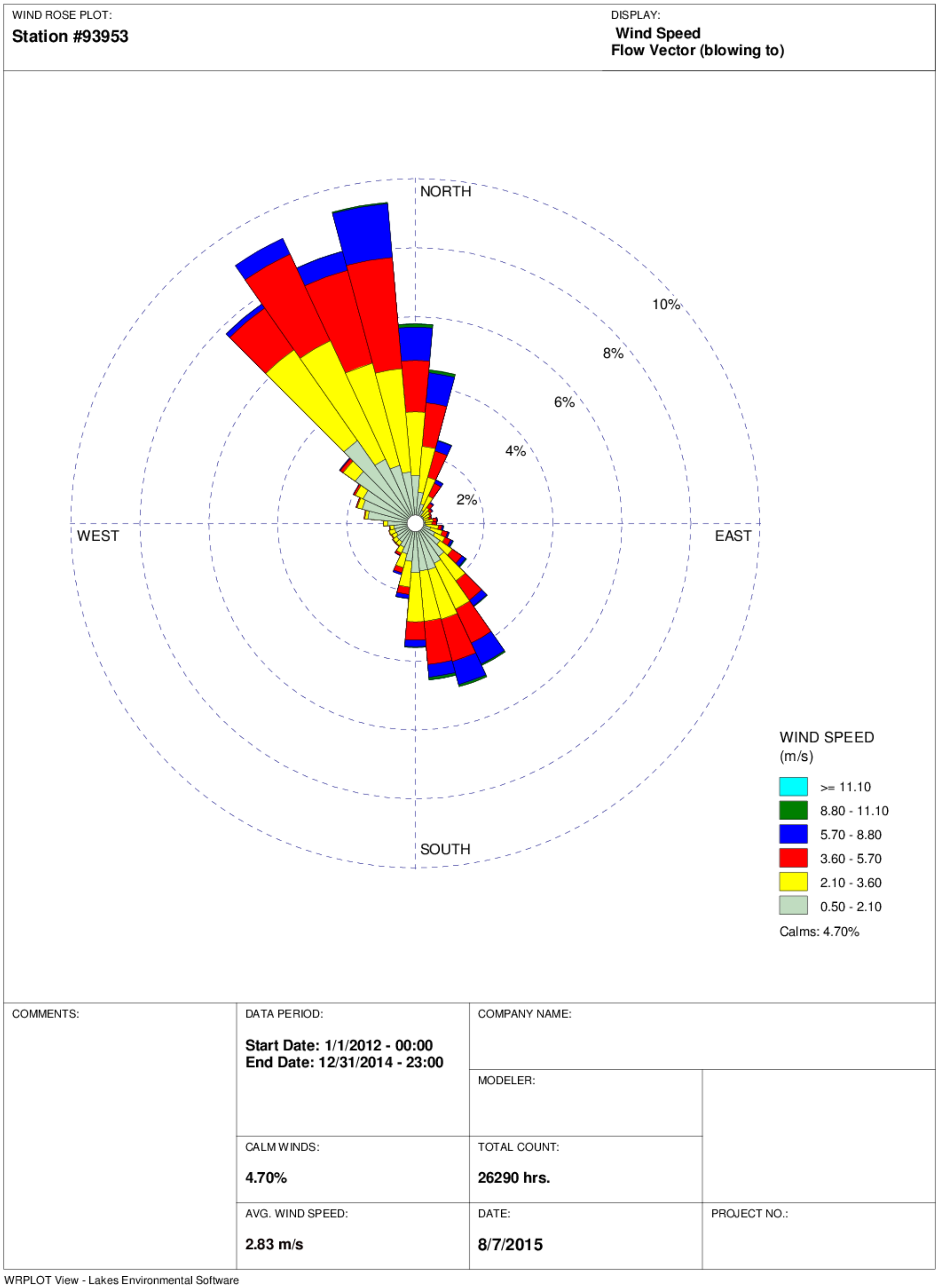
OG&E – Muskogee Generating Station

Appendix C – Wind Roses (Blowing To)

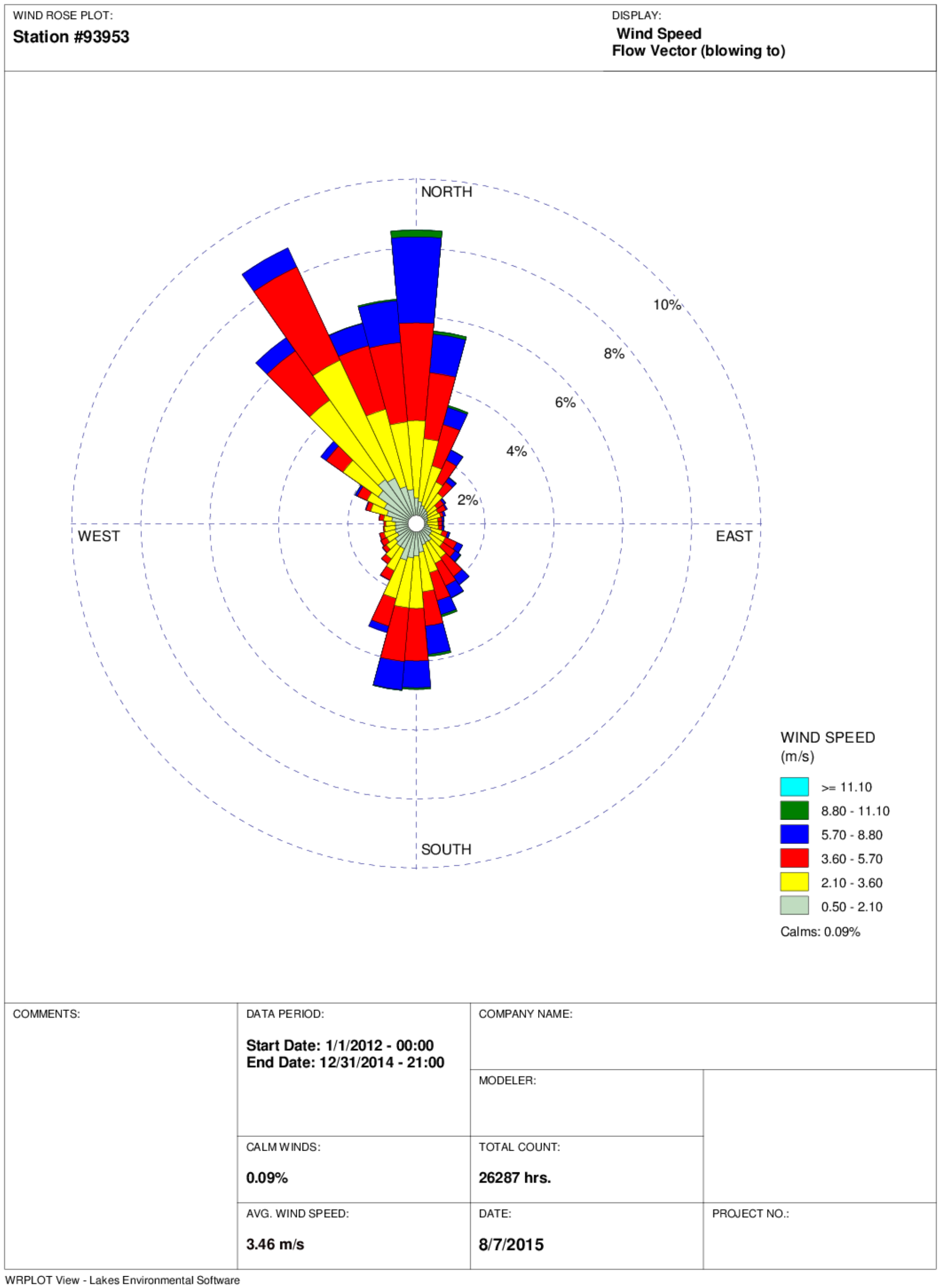
2012-2014 KMKO Wind Rose (Blowing To)



2012-2014 0167 Wind Rose (Blowing To)



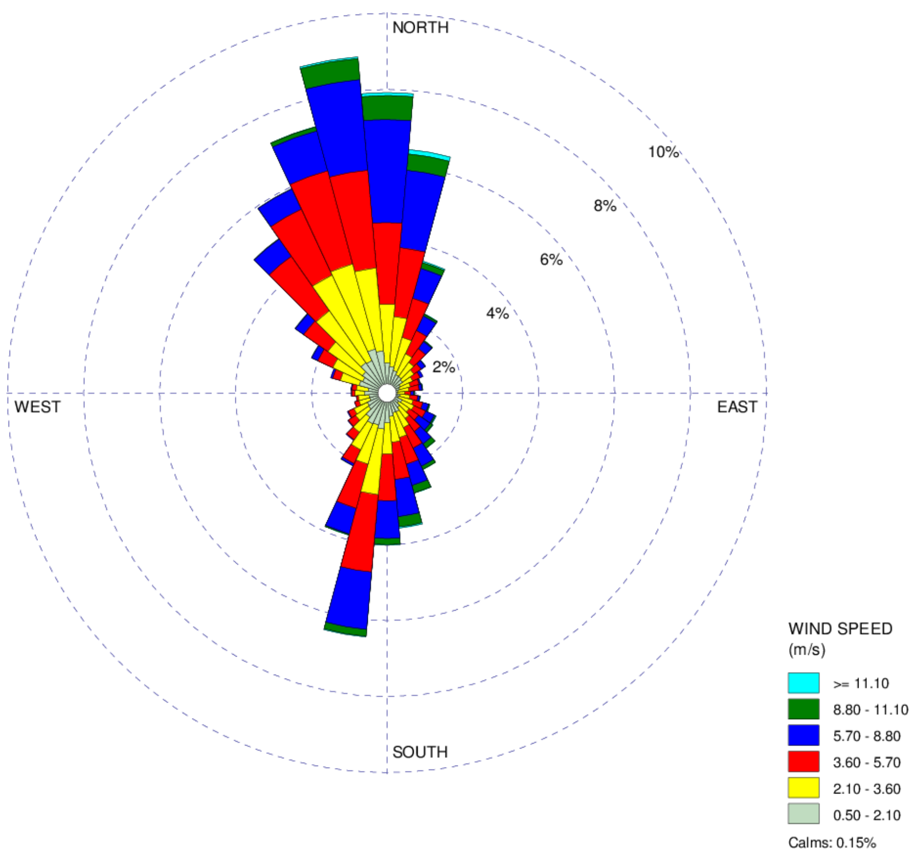
2012-2014 PORT Wind Rose (Blowing To)



2012-2014 HASK Wind Rose (Blowing To)

WIND ROSE PLOT:
Station #93953

DISPLAY:
Wind Speed
Flow Vector (blowing to)



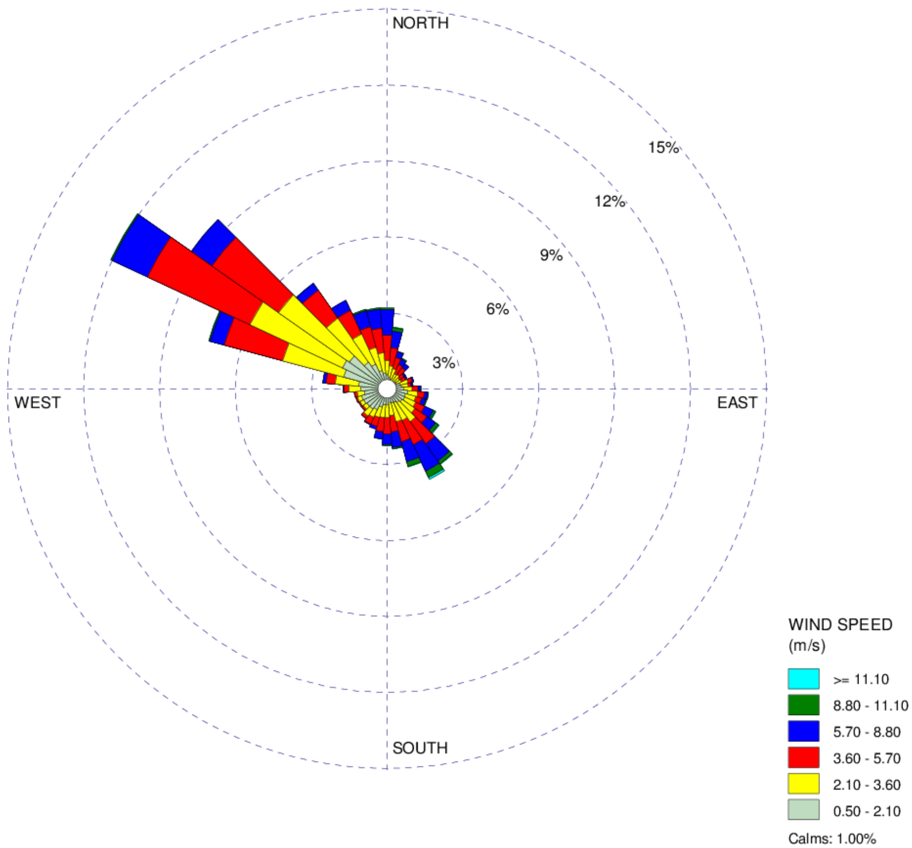
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	Start Date: 1/1/2012 - 00:00 **End Date: 12/31/2014 - 21:00**	MODELER:	
	CALM WINDS: **0.15%**	TOTAL COUNT: **26289 hrs.**	
	AVG. WIND SPEED: **3.96 m/s**	DATE: **8/13/2015**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

2012-2014 WEBR Wind Rose (Blowing To)

WIND ROSE PLOT:
Station #93953

DISPLAY:
Wind Speed
Flow Vector (blowing to)



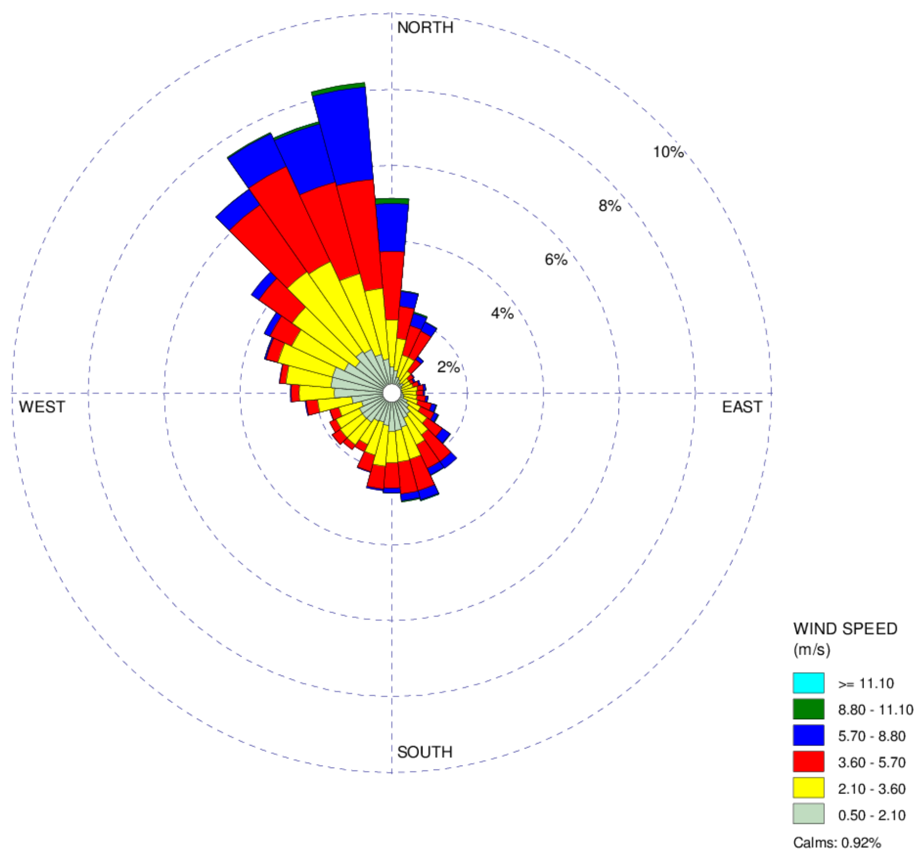
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	Start Date: 1/1/2012 - 00:00 **End Date: 12/31/2014 - 21:00**	MODELER:	
	CALM WINDS: **1.00%**	TOTAL COUNT: **26211 hrs.**	
	AVG. WIND SPEED: **3.48 m/s**	DATE: **8/7/2015**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

2012-2014 TALH Wind Rose (Blowing To)

WIND ROSE PLOT:
Station #93953

DISPLAY:
Wind Speed
Flow Vector (blowing to)

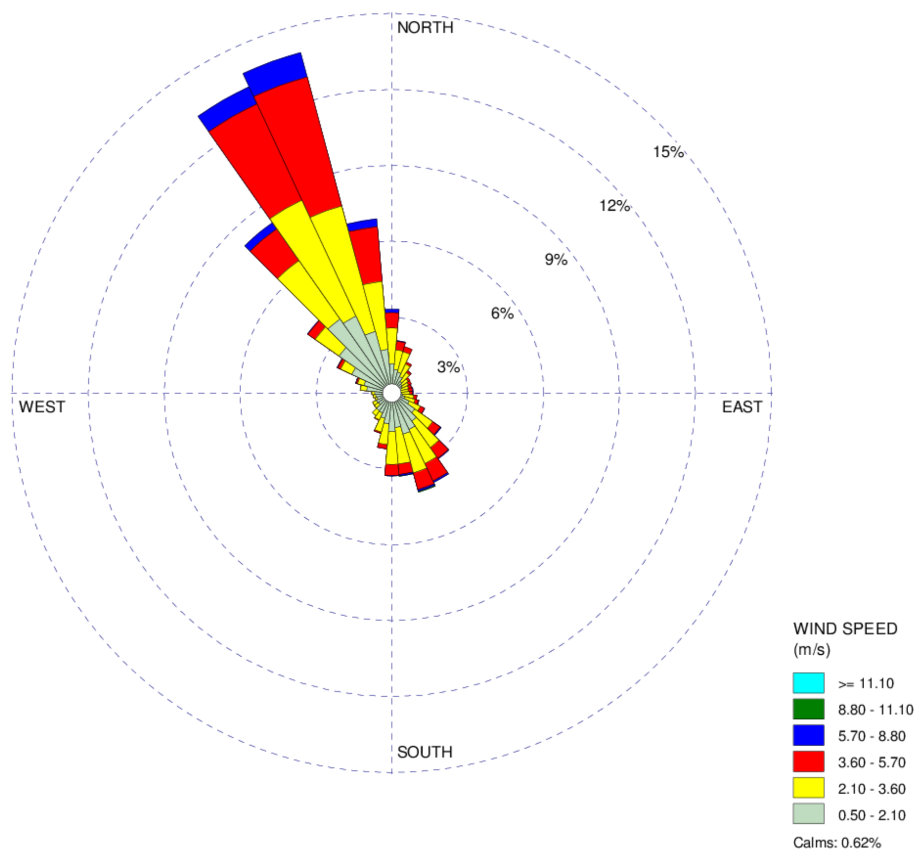


COMMENTS:	DATA PERIOD: **Start Date: 1/1/2012 - 00:00** **End Date: 12/31/2014 - 18:00**	COMPANY NAME:	
		MODELER:	
	CALM WINDS: **0.92%**	TOTAL COUNT: **26285 hrs.**	
	AVG. WIND SPEED: **3.24 m/s**	DATE: **8/14/2015**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

2012-2014 COOK Wind Rose (Blowing To)

WIND ROSE PLOT:	DISPLAY:
Station #93953	**Wind Speed** **Flow Vector (blowing to)**



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	Start Date: 1/1/2012 - 00:00 **End Date: 12/31/2014 - 21:00**	MODELER:	
	CALM WINDS: **0.62%**	TOTAL COUNT: **26289 hrs.**	
	AVG. WIND SPEED: **2.59 m/s**	DATE: **8/7/2015**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

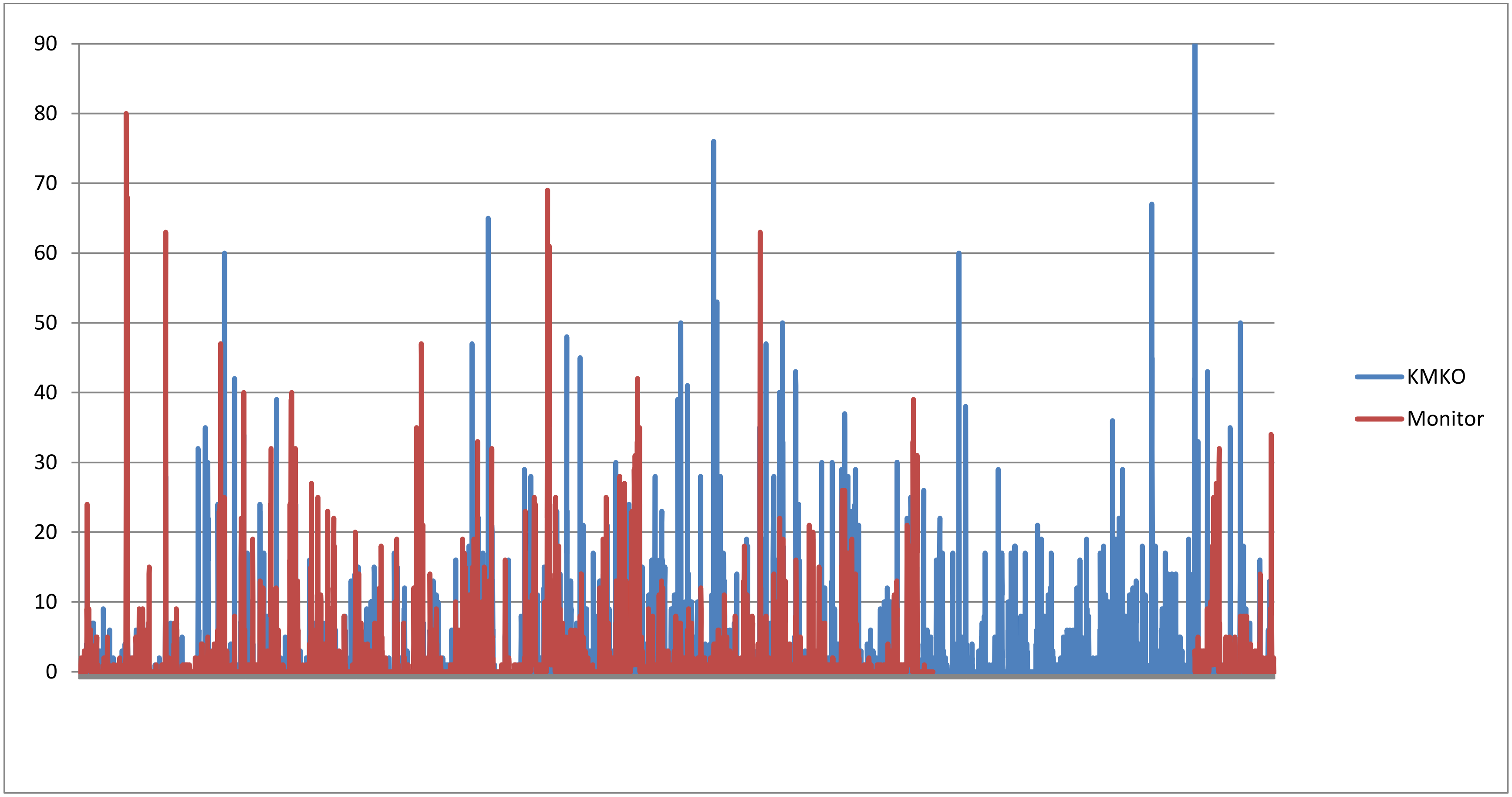
Appendix D – Surface Characteristics

Surface Characteristics

	Albedo	AVG	Wet	Dry	Surface
OG&E					
Winter	0.17	0.65	0.39	1.85	0.043
Spring	0.14	0.39	0.24	1.12	0.051
Summer	0.17	0.44	0.26	1.01	0.065
Fall	0.17	0.65	0.39	1.85	0.060
KMKO					
Winter	0.18	0.72	0.41	1.94	0.016
Spring	0.14	0.33	0.22	1.03	0.023
Summer	0.19	0.50	0.30	1.42	0.037
Fall	0.19	0.72	0.41	1.94	0.031
0167					
Winter	0.17	0.64	0.37	1.47	0.021
Spring	0.14	0.37	0.24	0.93	0.027
Summer	0.18	0.43	0.28	1.01	0.064
Fall	0.18	0.67	0.37	1.47	0.064
PORT					
Winter	0.18	0.73	0.39	1.77	0.026
Spring	0.15	0.36	0.23	1.01	0.042
Summer	0.18	0.45	0.28	1.16	0.183
Fall	0.18	0.73	0.39	1.77	0.183
HASK					
Winter	0.18	0.72	0.39	1.78	0.023
Spring	0.15	0.35	0.22	1.00	0.035
Summer	0.19	0.46	0.28	1.22	0.157
Fall	0.19	0.72	0.39	1.78	0.157
WEBR					
Winter	0.16	0.58	0.32	1.24	0.022
Spring	0.14	0.31	0.20	0.77	0.032
Summer	0.17	0.38	0.24	0.83	0.170
Fall	0.17	0.58	0.32	1.24	0.170
TAHL					
Winter	0.17	0.79	0.40	1.98	0.036
Spring	0.15	0.41	0.24	1.16	0.053
Summer	0.18	0.43	0.27	1.13	0.219
Fall	0.18	0.79	0.40	1.98	0.219
COOK					
Winter	0.17	0.95	0.40	1.97	0.090
Spring	0.15	0.63	0.29	1.44	0.139
Summer	0.16	0.33	0.22	0.70	0.382
Fall	0.16	0.95	0.40	1.97	0.382

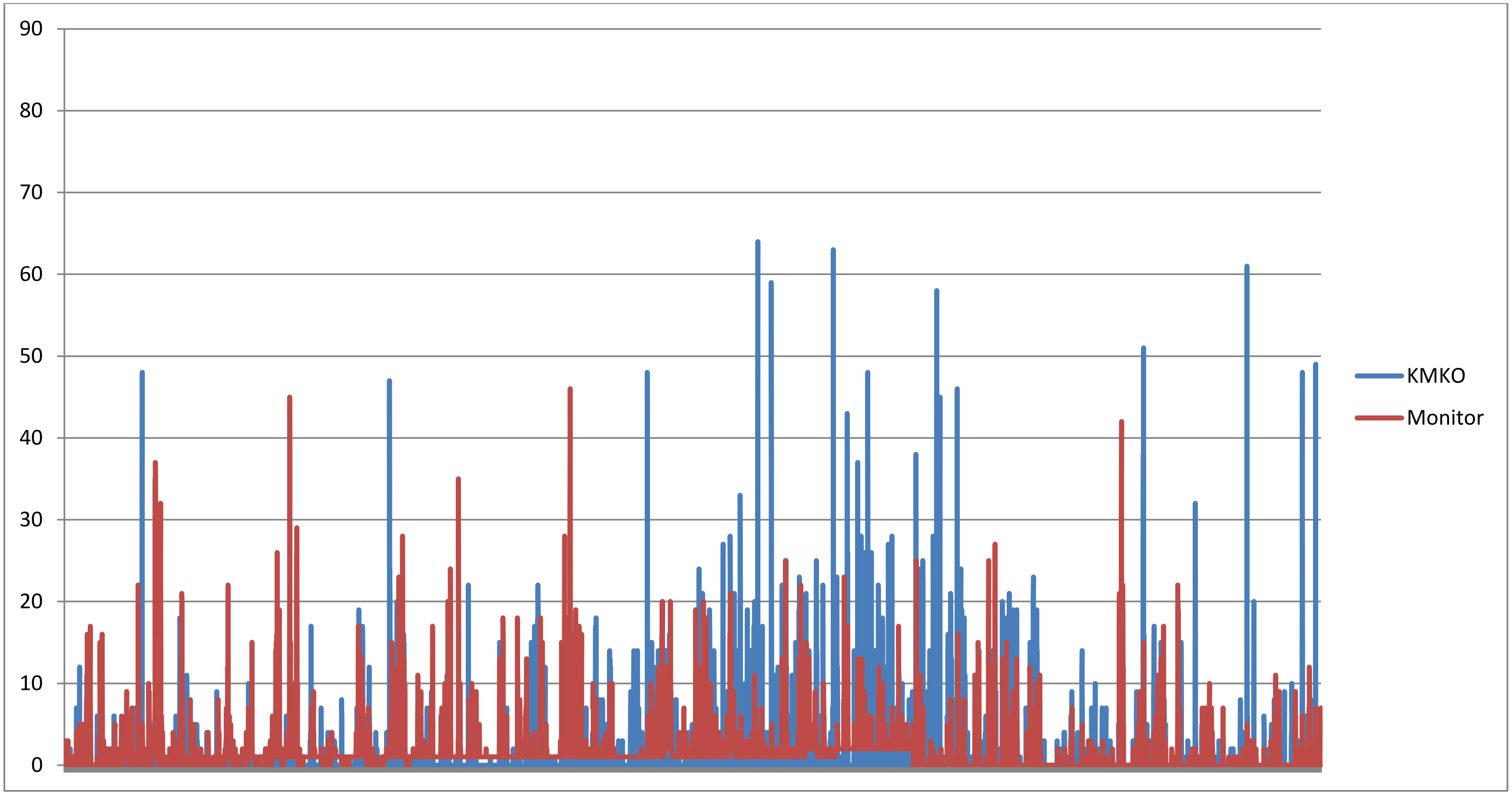
Appendix E – Modeling Versus Monitoring Graphs

2012 Monitor Versus Modeled Impacts (ppb)



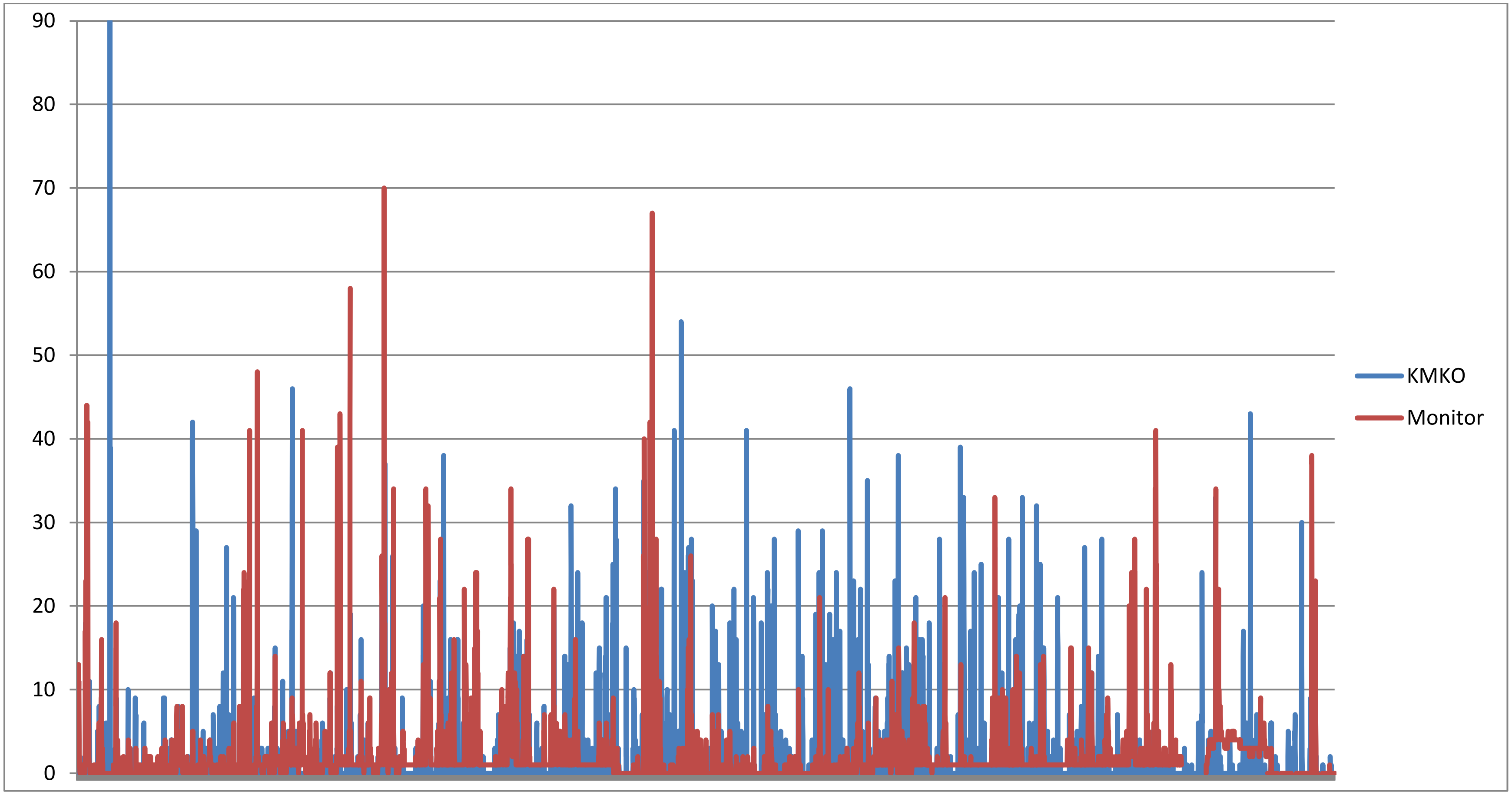
KMKO – Hourly impacts at the monitor site predicted by AERMOD using KMKO meteorological data.
Monitor – Hourly impacts measured at the monitor.

2013 Monitor Versus Modeled Impacts (ppb)

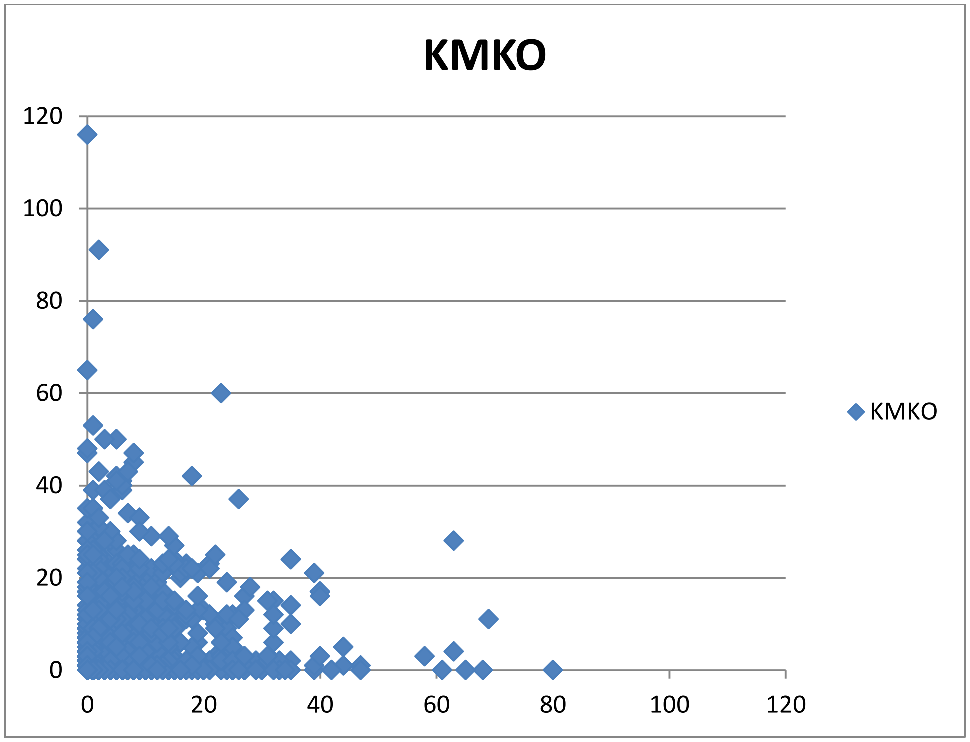


KMKO – Hourly impacts at the monitor site predicted by AERMOD using KMKO meteorological data.
Monitor – Hourly impacts measured at the monitor.

2014 Monitor Versus Modeled Impacts (ppb)



KMKO – Hourly impacts at the monitor site predicted by AERMOD using KMKO meteorological data.
Monitor – Hourly impacts measured at the monitor.



KMKO
120
100
80
60
40
20
0
0
20
40
60
80
100
120
KMKO

Appendix F – Comparison of Hours with High Impacts at the Monitor with Sub-Hourly Impact, Meteorological, and Source Data

2014 Monitor Data for Highest Monitored Impacts & Main Contributing Source Data for the Hour

					Monitor Data			Original 5-Minute On-Site Data				Source Parameters			
				Conc.	5-Min Impact		Missing	WSPD	WDIR	TAIR	RH	ID	Emissions	Temp.	Velocity
Year	Month	Day	Hour	ppbv	Hour	ppbv	Code	MPH	DEG	°F	%		g/s	K	m/s
2014	**3**	**21**	**7**	**42**	6:00	2		5	131	52	33	4	304.2	415	19.56
					6:05	3		7	137	53	33	5	238.6	400	16.45
					6:10	11		8	145	53	32	6	0.0	296	1.50
					6:15	25		9	144	53	32	GP1	0.3	452	3.48
					6:20	50		8	154	54	32	GP2	58.9	416	11.26
					6:25	49		7	154	54	32				
					6:30	44		7	157	54	34				
					6:35	50		6	160	54	35				
					6:40	66		8	154	54	35				
					6:45	66		10	157	54	33				
					6:50	74		10	156	55	33				
					6:55	67		10	156	55	33				
2014	**3**	**21**	**8**	**58**	7:00	59		11	158	55	32	4	304.6	417	21.03
					7:05	65		9	161	55	33	5	237.3	398	17.04
					7:10	49		9	164	55	35	6	0.0	296	0.62
					7:15	24		11	162	55	35	GP1	0.3	452	3.48
					7:20	15		10	162	55	35	GP2	58.9	416	11.26
					7:25	41		8	161	55	35				
					7:30	72		8	153	56	35				
					7:35	82		8	153	56	34				
					7:40	80		9	157	56	34				
					7:45	85		9	157	56	34				
					7:50		AN	7	164	56	35				
					7:55		BA	9	164	56	36				
2014	**3**	**21**	**9**	**BF**	8:00		BA	9	161	56	35	4	300.7	417	20.99
					8:05		BA	11	166	57	35	5	237.9	399	16.84
					8:10		BA	12	166	57	34	6	0.0	296	0.53
					8:15		BA	11	163	57	34	GP1	0.3	452	3.48
					8:20		BA	12	164	58	34	GP2	58.9	416	11.26
					8:25		BA	11	168	58	34				
					8:30		BA	12	164	58	33				
					8:35		BA	11	161	58	33				
					8:40		BA	11	158	58	33				

					Monitor Data			Original 5-Minute On-Site Data				Source Parameters			
				Conc.	5-Min Impact		Missing	WSPD	WDIR	TAIR	RH	ID	Emissions	Temp.	Velocity
Year	Month	Day	Hour	ppbv	Hour	ppbv	Code	MPH	DEG	°F	%		g/s	K	m/s
					8:45		BA	13	168	58	33				
					8:50		BA	13	164	59	33				
					8:55		BA	13	165	59	33				
2014	**3**	**31**	**3**	**10**	2:00	2		11	147	60	43	4	194.1	406	14.77
					2:05	2		14	146	60	43	5	16.1	375	9.19
					2:10	4		12	153	60	43	6	210.6	398	16.12
					2:15	4		11	150	60	43	GP1	17.5	452	15.74
					2:20	3		12	149	60	43	GP2	31.5	416	6.12
					2:25	3		12	152	59	43				
					2:30	5		11	150	59	44				
					2:35	13		11	150	60	44				
					2:40	15		12	149	60	43				
					2:45	14		10	150	60	44				
					2:50	23		10	152	60	44				
					2:55	36		11	152	60	44				
2014	**3**	**31**	**4**	**70**	3:00	40		10	157	60	45	4	197.3	405	14.67
					3:05	59		9	158	60	45	5	76.8	378	10.70
					3:10	72		11	161	60	45	6	211.3	397	16.33
					3:15	73		10	158	60	45	GP1	17.5	452	15.74
					3:20	77		13	157	60	45	GP2	31.5	416	6.12
					3:25	83		11	156	60	46				
					3:30	84		13	158	60	46				
					3:35	84		13	156	60	46				
					3:40	72		12	162	60	47				
					3:45	46		12	163	59	47				
					3:50	71		11	155	59	47				
					3:55	84		11	157	59	47				
2014	**3**	**31**	**5**	**33**	4:00	74		11	162	59	48	4	215.7	404	15.34
					4:05	64		12	159	59	49	5	86.5	386	10.69
					4:10	65		12	158	59	49	6	251.5	395	18.45
					4:15	59		11	164	59	49	GP1	17.5	452	15.74
					4:20	42		11	168	59	50	GP2	31.5	416	6.12
					4:25	26		12	166	59	50				

					Monitor Data			Original 5-Minute On-Site Data				Source Parameters			
				Conc.	5-Min Impact		Missing	WSPD	WDIR	TAIR	RH	ID	Emissions	Temp.	Velocity
Year	**Month**	**Day**	**Hour**	**ppbv**	**Hour**	**ppbv**	**Code**	**MPH**	**DEG**	**°F**	**%**		**g/s**	**K**	**m/s**
					4:30	16		12	164	59	50				
					4:35	10		12	163	58	50				
					4:40	11		14	164	58	50				
					4:45	10		15	166	59	49				
					4:50	8		14	162	58	50				
					4:55	7		13	163	58	50				
2014	**6**	**16**	**21**	**23**	20:00	8		10	150	82	61	4	312.4	435	22.87
					20:05	7		9	154	82	62	5	341.4	424	22.70
					20:10	7		10	148	82	62	6	324.1	430	22.27
					20:15	7		11	152	82	62	GP1	13.2	452	8.80
					20:20	10		11	153	82	63	GP2	51.3	416	9.89
					20:25	11		11	158	82	63				
					20:30	15		11	153	82	62				
					20:35	28		10	155	82	63				
					20:40	35		10	155	82	64				
					20:45	56		11	152	82	64				
					20:50	49		10	152	82	64				
					20:55	48		12	150	82	64				
2014	**6**	**16**	**22**	**58**	21:00	34		11	155	82	64	4	316.7	435	22.85
					21:05	47		11	159	82	65	5	345.7	424	22.72
					21:10	59		13	158	82	65	6	320.0	427	21.93
					21:15	80		10	158	82	65	GP1	13.2	452	8.80
					21:20	70		9	151	82	66	GP2	51.3	416	9.89
					21:25	69		11	156	81	67				
					21:30	64		12	149	81	67				
					21:35	35		12	153	81	67				
					21:40	34		11	157	81	68				
					21:45	50		11	154	81	68				
					21:50	71		10	157	81	68				
					21:55	77		11	155	81	69				
2014	**6**	**16**	**23**	**67**	22:00	80		11	153	81	69	4	316.0	434	22.45
					22:05	91		11	154	81	69	5	365.8	424	22.70
					22:10	89		11	157	81	69	6	322.2	427	21.92

					Monitor Data			Original 5-Minute On-Site Data				Source Parameters			
				Conc.	5-Min Impact		Missing	WSPD	WDIR	TAIR	RH	ID	Emissions	Temp.	Velocity
Year	**Month**	**Day**	**Hour**	**ppbv**	**Hour**	**ppbv**	**Code**	**MPH**	**DEG**	**°F**	**%**		**g/s**	**K**	**m/s**
					22:15	84		10	157	81	70	GP1	13.2	452	8.80
					22:20	79		10	163	81	70	GP2	51.3	416	9.89
					22:25	81		10	159	81	70				
					22:30	89		9	155	80	71				
					22:35	87		9	163	80	71				
					22:40	62		11	168	80	71				
					22:45	30		12	168	80	72				
					22:50	21		13	169	80	72				
					22:55	15		13	167	80	71				
2014	**6**	**16**	**24**	**14**	23:00	12		11	167	80	72	4	351.4	433	22.49
					23:05	11		11	166	80	73	5	382.8	423	22.50
					23:10	9		11	166	80	73	6	247.0	424	17.97
					23:15	9		10	172	80	73	GP1	13.2	452	8.80
					23:20	10		10	163	79	74	GP2	51.3	416	9.89
					23:25	12		12	163	79	74				
					23:30	10		11	161	79	74				
					23:35	11		8	161	79	74				
					23:40	12		5	149	79	75				
					23:45	19		6	149	78	76				
					23:50	26		7	151	78	76				
					23:55	30		7	149	78	77				

WSPD - Wind Speed; WDIR - Wind Direction; TAIR - Temperature of Air; RH - Relative Humidity.
AN – Machine Malfunction.
BA - Maintenance/Routine Repairs.
BF - Precision/Zero/Span
4, 5, 6 - OG&E Electrical Generating Units 4, 5, & 6, respectively.
GP1, GP2 - Georgia Pacific Stacks 1 and 2, respectively.
The hourly values for the monitor data are shifted one hour because the monitor time is 0-23 hours and the modeling time is 1-24 hours.
The data includes the hour prior to and the hour after the highest impacts.
The hours with the highest impacts are highlighted.

2013 Monitor Data for Highest Monitored Impacts & Main Contributing Source Data for the Hour

					Monitor Data			Original 5-Minute On-Site Data				Source Parameters			
				Conc.	5-Min Impact		Missing	WSPD	WDIR	TAIR	RH	ID	Emissions	Temp.	Velocity
Year	**Month**	**Day**	**Hour**	**ppbv**	**Hour**	**ppbv**	**Code**	**MPH**	**DEG**	**°F**	**%**		**g/s**	**K**	**m/s**
2013	**3**	**7**	**10**	**22**	9:00	1		12	164	48	35	4	0.0	282	0.60
					9:05	1		12	154	48	34	5	223.8	402	17.51
					9:10	4		11	156	49	34	6	240.1	410	19.88
					9:15	5		10	162	49	34	GP1	14.1	452	9.37
					9:20	4		12	162	50	33	GP2	49.6	416	9.60
					9:25	11		14	161	50	33				
					9:30	13		13	166	50	33				
					9:35	15		11	163	51	33				
					9:40	30		10	177	51	32				
					9:45	60		10	171	52	32				
					9:50	48		14	180	52	31				
					9:55	70		12	175	52	31				
2013	**3**	**7**	**11**	**45**	10:00	69		13	182	52	31	4	0.0	283	0.44
					10:05	89		15	178	53	30	5	232.5	404	18.11
					10:10	66		13	177	53	31	6	242.5	413	20.22
					10:15	77		13	177	53	30	GP1	14.1	452	9.37
					10:20	59		13	171	53	30	GP2	49.6	416	9.60
					10:25	26		15	180	53	30				
					10:30	52		13	175	53	30				
					10:35	35		12	178	53	31				
					10:40	46		13	179	54	31				
					10:45	11		13	180	54	31				
					10:50	8		15	182	54	30				
					10:55	6		15	189	54	31				
2013	**3**	**7**	**12**	**30**	11:00	11		12	174	54	31	4	0.0	283	0.38
					11:05	16		11	179	55	31	5	238.2	408	19.08
					11:10	31		12	181	55	31	6	244.3	414	20.12
					11:15	51		13	177	55	30	GP1	14.1	452	9.37
					11:20	20		13	182	55	30	GP2	49.6	416	9.60
					11:25	54		12	177	56	30				
					11:30	35		10	168	56	30				
					11:35	27		14	185	56	29				
					11:40	13		12	181	57	30				
					11:45	10		11	169	57	29				

					Monitor Data			Original 5-Minute On-Site Data				Source Parameters			
				Conc.	5-Min Impact		Missing	WSPD	WDIR	TAIR	RH	ID	Emissions	Temp.	Velocity
Year	Month	Day	Hour	ppbv	Hour	ppbv	Code	MPH	DEG	°F	%		g/s	K	m/s
					11:50	32		13	167	57	29				
					11:55	57		14	177	57	29				
2013	**5**	**27**	**22**	**39**	21:00	31		13	158	77	62	4	0.0	308	0.07
					21:05	35		11	158	77	62	5	258.5	429	24.13
					21:10	39		11	159	77	62	6	292.3	416	21.64
					21:15	35		14	165	77	61	GP1	13.5	452	9.01
					21:20	42		15	161	77	61	GP2	61.0	416	11.63
					21:25	46		16	160	77	61				
					21:30	35		15	162	78	61				
					21:35	40		14	160	77	61				
					21:40	45		14	160	77	62				
					21:45	47		11	158	77	62				
					21:50	41		10	153	77	64				
					21:55	34		10	161	76	65				
2013	**5**	**27**	**23**	**46**	22:00	40		12	161	76	64	4	0.0	308	0.00
					22:05	47		13	159	76	64	5	219.5	431	21.13
					22:10	50		14	159	76	63	6	237.5	411	18.88
					22:15	55		14	162	77	62	GP1	13.5	452	9.01
					22:20	52		12	156	77	63	GP2	61.0	416	11.63
					22:25	62		11	160	76	64				
					22:30	57		11	159	77	63				
					22:35	62		10	155	76	64				
					22:40	57		10	154	76	64				
					22:45	31		11	152	76	64				
					22:50	21		14	151	76	64				
					22:55	17		13	149	76	64				
2013	**5**	**27**	**24**	**9**	23:00	12		14	156	76	64	4	0.0	308	0.09
					23:05	11		13	147	76	64	5	176.6	425	18.21
					23:10	9		15	147	76	63	6	165.1	402	15.44
					23:15	7		12	149	76	63	GP1	13.5	452	9.01
					23:20	8		14	154	76	63	GP2	61.0	416	11.63
					23:25	8		11	154	76	63				
					23:30	8		12	155	76	63				
					23:35	9		12	155	76	63				
					23:40	8		10	152	76	63				

					Monitor Data			Original 5-Minute On-Site Data				Source Parameters			
				Conc.	5-Min Impact		Missing	WSPD	WDIR	TAIR	RH	ID	Emissions	Temp.	Velocity
Year	Month	Day	Hour	ppbv	Hour	ppbv	Code	MPH	DEG	°F	%		g/s	K	m/s
					23:45	9		13	154	76	63				
					23:50	10		14	151	76	63				
					23:55	9		11	159	76	62				

WSPD - Wind Speed; WDIR - Wind Direction; TAIR - Temperature of Air; RH - Relative Humidity.
4, 5, 6 - OG&E Electrical Generating Units 4, 5, & 6, respectively.
GP1, GP2 - Georgia Pacific Stacks 1 and 2, respectively.
The hourly values for the monitor data are shifted one hour because the monitor time is 0-23 hours and the modeling time is 1-24 hours.
The data includes the hour prior to and the hour after the highest impacts.
The hours with the highest impacts are highlighted.

2012 Monitor Data for Highest Monitored Impacts & Main Contributing Source Data for the Hour

					Monitor Data			0167 Data		Source Parameters			
				Conc.	5-Min Impact		Missing	WSPD	WDIR	ID	Emissions	Temp.	Velocity
Year	**Month**	**Day**	**Hour**	**ppbv**	**Hour**	**ppbv**	**Code**	**MPH**	**DEG**		**g/s**	**K**	**m/s**
2012	**1**	**15**	**11**	**27**	10:00	2		12	153	4	205.2	396	18.62
					10:05	5				5	221.5	387	15.91
					10:10	7				6	325.4	393	20.59
					10:15	10				GP1	14.0	452	9.31
					10:20	24				GP2	54.6	416	10.52
					10:25	34							
					10:30	31							
					10:35	15							
					10:40	27							
					10:45	75							
					10:50	39							
					10:55	62							
2012	**1**	**15**	**12**	**80**	11:00	66		14	168	4	209.9	396	18.28
					11:05	66				5	223.8	389	15.98
					11:10	68				6	277.6	390	17.45
					11:15	76				GP1	14.0	452	9.31
					11:20	99				GP2	54.6	416	10.52
					11:25	86							
					11:30	70							
					11:35	51							
					11:40	72							
					11:45	79							
					11:50	93							
					11:55	136							
2012	**1**	**15**	**13**	**39**	12:00	89		12	165	4	187.7	398	16.99
					12:05	28				5	184.6	390	15.02
					12:10	25				6	218.2	385	14.42
					12:15	37				GP1	14.0	452	9.31
					12:20	53				GP2	54.6	416	10.52
					12:25	40							
					12:30	23							

					Monitor Data			0167 Data		Source Parameters			
				Conc.	5-Min Impact		Missing	WSPD	WDIR	ID	Emissions	Temp.	Velocity
Year	**Month**	**Day**	**Hour**	**ppbv**	**Hour**	**ppbv**	**Code**	**MPH**	**DEG**		**g/s**	**K**	**m/s**
					12:35	47							
					12:40	6							
					12:45	16							
					12:50	33							
					12:55	77							
2012	**1**	**15**	**18**	**5**	17:00	5		12	154	4	180.3	392	16.55
					17:05	2				5	159.4	387	13.83
					17:10	5				6	193.0	378	12.55
					17:15	17				GP1	14.0	452	9.31
					17:20	10				GP2	54.6	416	10.52
					17:25	16							
					17:30	5							
					17:35	2							
					17:40	2							
					17:45	1							
					17:50	2							
					17:55	2							
2012	**1**	**15**	**19**	**68**	18:00	3		11	157	4	204.0	392	17.47
					18:05	8				5	213.8	387	15.51
					18:10	11				6	246.4	381	15.01
					18:15	18				GP1	14.0	452	9.31
					18:20	98				GP2	54.6	416	10.52
					18:25	91							
					18:30	59							
					18:35	81							
					18:40	105							
					18:45	114							
					18:50	114							
					18:55	115							
2012	**1**	**15**	**20**	**65**	19:00	125		10	162	4	184.2	393	16.97
					19:05	72				5	207.1	390	15.37
					19:10	21				6	212.0	383	13.92

					Monitor Data			0167 Data		Source Parameters			
				Conc.	5-Min Impact		Missing	WSPD	WDIR	ID	Emissions	Temp.	Velocity
Year	Month	Day	Hour	ppbv	Hour	ppbv	Code	MPH	DEG		g/s	K	m/s
					19:15	76				GP1	14.0	452	9.31
					19:20	78				GP2	54.6	416	10.52
					19:25	69							
					19:30	74							
					19:35	66							
					19:40	73							
					19:45	44							
					19:50	35							
					19:55	55							
2012	**1**	**15**	**21**	**27**	20:00	67		9	158	4	171.0	392	16.58
					20:05	55				5	204.3	391	15.25
					20:10	35				6	195.0	381	13.19
					20:15	16				GP1	14.0	452	9.31
					20:20	13				GP2	54.6	416	10.52
					20:25	35							
					20:30	37							
					20:35	19							
					20:40	13							
					20:45	9							
					20:50	8							
					20:55	24							
2012	**5**	**23**	**10**	**22**	9:00	27		13	166	4	202.0	400	16.93
					9:05	12				5	0.0	304	0.00
					9:10	3				6	360.1	422	24.05
					9:15	6				GP1	13.5	452	9.03
					9:20	10				GP2	50.3	416	9.79
					9:25	8							
					9:30	17							
					9:35	20							
					9:40	7							
					9:45	27							
					9:50	66							
					9:55	58							

					Monitor Data			0167 Data		Source Parameters			
				Conc.	5-Min Impact		Missing	WSPD	WDIR	ID	Emissions	Temp.	Velocity
Year	Month	Day	Hour	ppbv	Hour	ppbv	Code	MPH	DEG		g/s	K	m/s
2012	**5**	**23**	**11**	**69**	10:00	98		13	161	4	205.9	402	17.33
					10:05	98				5	0.0	305	0
					10:10	109				6	365.9	361	23.98
					10:15	65				GP1	13.5	452	9.03
					10:20	81				GP2	50.3	416	9.79
					10:25	33							
					10:30	40							
					10:35	64							
					10:40	92							
					10:45	58							
					10:50	42							
					10:55	50							
2012	**5**	**23**	**12**	**32**	11:00	68		13	157	4	206.8	406	17.60
					11:05	84				5	0.0	306	0.0
					11:10	11				6	366.8	423	24.04
					11:15	12				GP1	13.5	452	9.03
					11:20	26				GP2	50.3	416	9.79
					11:25	12							
					11:30	13							
					11:35	44							
					11:40	30							
					11:45	11							
					11:50	23							
					11:55	51							

WSPD - Wind Speed; WDIR - Wind Direction; TAIR - Temperature of Air; RH - Relative Humidity.
4, 5, 6 - OG&E Electrical Generating Units 4, 5, & 6, respectively.
GP1, GP2 - Georgia Pacific Stacks 1 and 2, respectively.
The hourly values for the monitor data are shifted one hour because the monitor time is 0-23 hours and the modeling time is 1-24 hours.
The wind speed data for the monitor was not available in 5-minute intervals for 2012.
The data includes the hour prior to and the hour after the highest impacts.
The hours with the highest impacts are highlighted.

Appendix G – Comparison of Hours with Modeled and Monitored High Impacts

2014 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Sensible Heat flux	Surface Friction Velocity	Convective Velocity Scale	Vertical Potential Temp. Gradient	Height of Convectively Generated Boundary Layer	Height of Mechanically Generated Boundary Layer	Monin-Obukhov Length	Surface Roughness Length
				Modeled	Monitor		H	u*	w*	VPTG	Zic	Zim	L	zo
YR	MO	DY	HR	ppb	ppb	Station	W/m2	m/s	m/s	K/m	m	m	m	m
14	3	21	8	9	58	KMKO	6.6	0.347	0.241	0.007	74	490	-558.5	0.023
						0167	6.4	0.272	0.238	0.016	74	341	-277.2	0.027
14	3	31	4	2	70	KMKO	-35.4	0.327	-9	-9	-999	450	87.2	0.023
						0167	-33.6	0.312	-9	-9	-999	418	79.4	0.027
14	6	16	22	0	58	KMKO	-36.6	0.350	-9	-9	-999	498	104.1	0.037
						0167	-37	0.357	-9	-9	-999	511	108.3	0.064
14	6	16	23	4	67	KMKO	-39.2	0.375	-9	-9	-999	552	119.2	0.037
						0167	-36.3	0.350	-9	-9	-999	497	104.2	0.064

2014 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Bowen Ratio	Albedo	Wind Speed	Wind Direction	Temperature	Relative Humidity	Pressure	Cloud Cover
				Modeled	Monitor		Bo	r	Ws	Wd	temp	rh	pres	ccvr
YR	MO	DY	HR	ppb	ppb	Station			m/s	deg.	K	%	mb	tenths
14	3	21	8	9	58	KMKO	0.33	0.32	5.21	161	284.9	46	990	0
						0167	0.37	0.31	3.94	160	286.2	35	988	9
14	3	31	4	2	70	KMKO	0.33	1	5.44	157	287.5	55	989	0
						0167	0.37	1	5.1	159	288.5	46	988	0
14	6	16	22	0	58	KMKO	0.30	1	5.33	155	299.2	76	991	0
						0167	0.28	1	4.92	155	300.5	67	989	0
14	6	16	23	4	67	KMKO	0.30	1	5.65	160	298.8	81	991	0
						0167	0.28	1	4.84	162	300.1	71	990	0

2013 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Sensible Heat flux	Surface Friction Velocity	Convective Velocity Scale	Vertical Potential Temp. Gradient	Height of Convectively Generated Boundary Layer	Height of Mechanically Generated Boundary Layer	Monin-Obukhov Length	Surface Roughness Length
				Modeled	Monitor		H	u*	w*	VPTG	Zic	Zim	L	zo
YR	MO	DY	HR	ppb	ppb	Station	W/m2	m/s	m/s	K/m	m	m	m	m
13	3	7	11	5	45	KMKO	83.2	0.51	0.806	0.01	225	874	-142.9	0.023
						0167	108.1	0.436	0.936	0.01	270	689	-68.2	0.027
13	5	27	23	0	46	KMKO	-39.4	0.376	-9	-9	-999	553	118.7	0.023
						0167	-35.7	0.342	-9	-9	-999	481	98.7	0.027

2013 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Bowen Ratio	Albedo	Wind Speed	Wind Direction	Temperature	Relative Humidity	Pressure	Cloud Cover
				Modeled	Monitor		Bo	r	Ws	Wd	temp	rh	pres	ccvr
YR	MO	DY	HR	ppb	ppb	Station			m/s	deg.	K	%	mb	tenths
13	3	7	11	5	45	KMKO	0.33	0.15	7.48	153	285.4	37	1002	0
						0167	0.37	0.15	6.03	178	285.1	30	1001	0
13	5	27	23	0	46	KMKO	0.33	1	6.11	154	296.4	78	987	0
						0167	0.37	1	5.49	156	297.7	64	986	0

2012 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Sensible Heat flux	Surface Friction Velocity	Convective Velocity Scale	Vertical Potential Temp. Gradient	Height of Convectively Generated Boundary Layer	Height of Mechanically Generated Boundary Layer	Monin-Obukhov Length	Surface Roughness Length
				Modeled	Monitor		H	u*	w*	VPTG	Zic	Zim	L	zo
YR	MO	DY	HR	ppb	ppb	Station	W/m2	m/s	m/s	K/m	m	m	m	m
12	1	15	12	0	80	KMKO	97.3	0.522	0.781	0.007	175	907	-130.7	0.016
						0167	91.8	0.430	0.759	0.005	171	676	-77.4	0.021
12	1	15	19	0	68	KMKO	-31.8	0.289	-9	-9	-999	373	67.2	0.016
						0167	-31.2	0.284	-9	-9	-999	364	65.3	0.021
12	1	15	20	0	65	KMKO	-31.7	0.287	-9	-9	-999	370	66.5	0.016
						0167	-27.5	0.250	-9	-9	-999	300	50.4	0.021
12	5	23	11	11	69	KMKO	266.4	0.526	1.887	0.005	888	915	-48.0	0.023
						0167	251.6	0.440	1.790	0.005	805	700	-29.8	0.027

2012 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Bowen Ratio	Albedo	Wind Speed	Wind Direction	Temperature	Relative Humidity	Pressure	Cloud Cover
				Modeled	Monitor		Bo	r	Ws	Wd	temp	rh	pres	ccvr
YR	MO	DY	HR	ppb	ppb	Station			m/s	deg.	K	%	mb	tenths
12	1	15	12	0	80	KMKO	0.72	0.21	8.11	143	284.2	40	1000	0
						0167	0.64	0.2	6.26	168	284.9	32	1003	0
12	1	15	19	0	68	KMKO	0.72	1	5.19	155	284.2	46	995	0
						0167	0.64	1	4.92	157	285.9	36	998	0
12	1	15	20	0	65	KMKO	0.72	1	5.17	152	284.2	46	995	0
						0167	0.64	1	4.47	162	285.4	39	998	0
12	5	23	11	11	69	KMKO	1.03	0.14	7.37	152	301.4	48	985	0
						0167	0.93	0.14	5.81	161	299.2	42	988	0

2014 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Sensible Heat flux	Surface Friction Velocity	Convective Velocity Scale	Vertical Potential Temp. Gradient	Height of Convectively Generated Boundary Layer	Height of Mechanically Generated Boundary Layer	Monin-Obukhov Length	Surface Roughness Length
				Modeled	Monitor		H	u*	w*	VPTG	Zic	Zim	L	zo
YR	MO	DY	HR	ppb	ppb	Station	W/m2	m/s	m/s	K/m	m	m	m	m
14	1	10	14	97	0	KMKO	32.9	0.168	0.587	0.017	215	176	-12.5	0.016
						0167	30.0	0.213	0.522	0.016	165	237	-28.3	0.021
14	3	4	13	46	4	KMKO	99.3	0.294	1.054	0.033	420	384	-22.8	0.023
						0167	133.8	0.226	1.19	0.033	448	260	-7.7	0.027
14	6	25	9	54	1	KMKO	73.2	0.222	0.814	0.009	262	251	-13.2	0.037
						0167	71.0	0.221	0.780	0.009	237	250	-13.5	0.037
14	8	13	9	46	1	KMKO	88.7	0.166	0.876	0.006	269	163	-4.6	0.037
						0167	82.1	0.165	0.851	0.006	267	161	-4.9	0.037

2014 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Bowen Ratio	Albedo	Wind Speed	Wind Direction	Temperature	Relative Humidity	Pressure	Cloud Cover
				Modeled	Monitor		Bo	r	Ws	Wd	temp	rh	pres	ccvr
YR	MO	DY	HR	ppb	ppb	Station			m/s	deg.	K	%	mb	tenths
14	1	10	14	97	0	KMKO	1.94	0.21	2.28	162	284.2	100	982	10
						0167	1.47	0.2	2.94	167	284.5	91	980	10
14	3	4	13	46	4	KMKO	0.33	0.15	3.93	161	275.4	49	999	0
						0167	0.37	0.15	2.64	175	275	47	998	0
14	6	25	9	54	1	KMKO	0.30	0.20	2.57	171	299.9	73	996	0
						0167	0.28	0.19	2.57	171	299.8	70	995	0
14	8	13	9	46	1	KMKO	0.50	0.21	1.70	153	296.4	63	999	0
						0167	0.43	0.20	1.70	153	296.0	62	998	0

2013 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Sensible Heat flux	Surface Friction Velocity	Convective Velocity Scale	Vertical Potential Temp. Gradient	Height of Convectively Generated Boundary Layer	Height of Mechanically Generated Boundary Layer	Monin-Obukhov Length	Surface Roughness Length
				Modeled	Monitor		H	u*	w*	VPTG	Zic	Zim	L	zo
YR	MO	DY	HR	ppb	ppb	Station	W/m2	m/s	m/s	K/m	m	m	m	m
13	7	21	11	64	2	KMKO	41.2	0.163	0.740	0.007	347	174	-9.3	0.037
						0167	13.7	0.120	0.422	0.013	193	108	-11.2	0.064
13	7	25	9	59	2	KMKO	96.9	0.194	0.959	0.005	324	204	-6.6	0.037
						0167	36.3	0.179	0.564	0.006	176	181	-13.9	0.037
13	8	12	9	63	2	KMKO	93.8	0.182	0.921	0.005	296	186	-5.7	0.037
						0167	57.6	0.136	0.627	0.005	152	121	-3.9	0.064
13	12	10	13	61	2	KMKO	66.7	0.217	0.776	0.017	252	243	-13.8	0.016
						0167	79.6	0.202	0.848	0.016	275	218	-9.3	0.021

2013 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Bowen Ratio	Albedo	Wind Speed	Wind Direction	Temperature	Relative Humidity	Pressure	Cloud Cover
				Modeled	Monitor		Bo	r	Ws	Wd	temp	rh	pres	ccvr
YR	MO	DY	HR	ppb	ppb	Station			m/s	deg.	K	%	mb	tenths
13	7	21	11	64	2	KMKO	0.50	0.19	1.82	169	299.2	84	992	10
						0167	0.43	0.18	1.21	9	297.6	85	991	10
13	7	25	9	59	2	KMKO	0.50	0.21	2.08	160	298.1	93	996	0
						0167	0.43	0.20	2.08	160	298.8	78	995	9
13	8	12	9	63	2	KMKO	0.50	0.21	1.91	159	300.9	81	995	2
						0167	0.43	0.20	1.18	183	300.8	74	994	8
13	12	10	13	61	2	KMKO	0.41	0.21	2.98	158	272.5	56	1008	0
						0167	0.37	0.20	2.53	183	271.6	52	1006	0

2012 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Sensible Heat flux	Surface Friction Velocity	Convective Velocity Scale	Vertical Potential Temp. Gradient	Height of Convectively Generated Boundary Layer	Height of Mechanically Generated Boundary Layer	Monin-Obukhov Length	Surface Roughness Length
				Modeled	Monitor		H	u*	w*	VPTG	Zic	Zim	L	zo
YR	MO	DY	HR	ppb	ppb	Station	W/m2	m/s	m/s	K/m	m	m	m	m
12	2	14	13	60	23	KMKO	134.0	0.239	0.918	0.016	204	280	-9.0	0.016
						0167	126.2	0.191	0.886	0.017	196	201	-4.9	0.021
12	5	5	8	65	0	KMKO	89.0	0.222	0.851	0.013	244	251	-10.8	0.023
						0167	86.0	0.133	0.836	0.013	241	117	-2.4	0.027
12	7	13	8	76	1	KMKO	105.0	0.158	0.886	0.007	235	151	-3.4	0.037
						0167	91.4	0.156	0.823	0.007	217	148	-3.7	0.037
12	9	26	9	60	0	KMKO	83.2	0.131	0.921	0.014	333	115	-2.4	0.031
						0167	78.7	0.131	0.900	0.014	328	114	-2.5	0.031
12	11	24	10	67	0	KMKO	85.4	0.167	0.768	0.018	190	163	-4.9	0.031
						0167	78.2	0.165	0.730	0.018	179	161	-5.2	0.031
12	12	7	15	91	2	KMKO	21.7	0.117	0.613	0.009	374	97	-6.5	0.016
						0167	19.7	0.116	0.585	0.009	357	96	-7.1	0.016
12	12	7	16	116	0	KMKO	7.0	0.083	0.424	0.009	384	58	-7.3	0.016
						0167	6.3	0.083	0.404	0.009	365	57	-7.9	0.016

2012 Monitored Impact/Modeled Impact at Monitor & Associated Surface Meteorological Data

							Bowen Ratio	Albedo	Wind Speed	Wind Direction	Temperature	Relative Humidity	Pressure	Cloud Cover
				Modeled	Monitor		Bo	r	Ws	Wd	temp	rh	pres	ccvr
YR	MO	DY	HR	ppb	ppb	Station			m/s	deg.	K	%	mb	tenths
12	2	14	13	60	23	KMKO	0.72	0.19	3.15	158	280.4	73	993	5
						0167	0.64	0.18	2.24	182	279.9	67	996	5
12	5	5	8	65	0	KMKO	1.03	0.19	2.78	156	294.2	93	990	0
						0167	0.93	0.19	1.34	142	296.4	68	993	0
12	7	13	8	76	1	KMKO	1.42	0.24	1.55	162	299.9	70	995	0
						0167	1.01	0.23	1.55	162	299.2	67	998	0
12	9	26	9	60	0	KMKO	0.72	0.23	1.28	170	297.5	63	994	5
						0167	0.64	0.22	1.28	170	297.5	63	994	5
12	11	24	10	67	0	KMKO	1.94	0.25	1.79	155	276.4	50	1007	0
						0167	1.47	0.24	1.79	155	276.4	50	1007	0
12	12	7	15	91	2	KMKO	1.94	0.24	1.5	167	287.5	86	987	10
						0167	1.47	0.23	1.5	167	287.5	86	987	10
12	12	7	16	116	0	KMKO	1.94	0.31	1.08	166	288.1	83	988	10
						0167	1.47	0.30	1.08	166	288.1	83	988	10

2010 Primary Sulfur Dioxide (SO_2)
National Ambient Air Quality Standard (NAAQS)

Technical Analyses and Information Supporting the Designation Recommendation for Oklahoma

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Effects of Terrain on Wind Flow in Muskogee, Oklahoma

Prepared by the Technical Resource and Projects Section of the Data and Planning Unit

Air Quality Division

Oklahoma Department of Environmental Quality

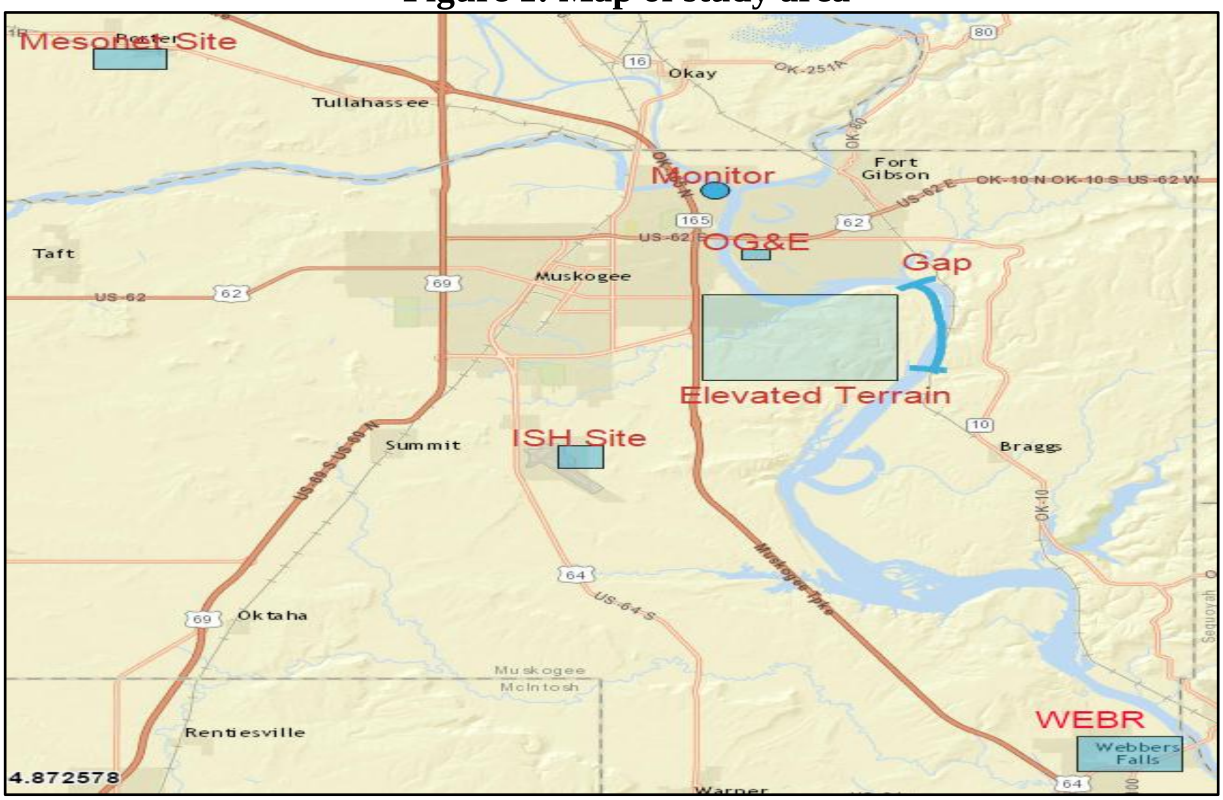
September 10, 2015

OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

Meteorological data used in the modeling analysis

Modeling guidance calls for the use of surface and upper-air data, representative of the modeled facility location, as input. Modeling of the Muskogee area, for the demonstration of compliance with the 2010 1-hour SO_2 NAAQS, used the integrated surface hourly dataset (ISHD) from the automated surface observing system (ASOS) at Davis Field Airport (KMKO) in Muskogee, Oklahoma from the National Center for Environmental Information (NCEI) and upper-air data originating from weather balloons launched twice daily from the National Weather Service (NWS) office at Max Westheimer Airport (OUN) in Norman, Oklahoma. Prevailing winds from the southeast occurred on days with sulfur dioxide (SO_2) measurements greater than 50 parts per billion by volume (ppb) at the monitored location. Comparative analyses were conducted using data from the ambient air monitoring station.

Figure 1: Map of study area



ISH Site - KMKO-Muskogee Airport;
Monitor - SO_2 Ambient Air Monitoring Site;
Mesonet Site - Porter, Oklahoma Mesonet Site;
WEBR – Webbers Falls, Oklahoma Mesonet Site;
OG&E - OG&E Muskogee Generating Station;
Gap - Area where GAP effects could be influencing local meteorology; and
Elevated Terrain – Specific area of terrain which influences local meteorology.

Local terrain

Figure 1 shows the area around the OG&E Muskogee Generating Station. The base elevation of the area is defined by the Arkansas River which flows through the area. The United States Army Corps of Engineers maintains a normal pool elevation of the Webbers Falls Reservoir along the McClellan-Kerr Arkansas River Navigation System at 490 feet above mean sea level. An area of hilly terrain 200 feet to 350 feet above the river (700 to 850 feet above mean sea level) exists about 2 to 5 miles from the south to the east of the OG&E Muskogee Generating Station. The OG&E Muskogee Generating Station emits significant levels of SO_2 from three smokestacks: two at 350 feet and one at 500 feet above ground level. The ground elevation at the OG&E Muskogee Generating Station is approximately 525 feet above mean sea level.

Atmospheric stability

In assessing atmospheric stability([3]), we can determine whether a parcel of air will rise or fall based on the parcel temperature (Tp) in relation to the environmental temperature (Te). This can be further represented in terms of the change in temperature of a parcel of air with respect to the dry adiabatic lapse rate (dalr) of 9.8 K km^{-1} and the environmental lapse rate (elr). If Tp > Te then the parcel of air will keep rising such as in an unstable environment. In a stable environment, were dalr > elr, a parcel of air will sink because the air around it is warmer.

The term “adiabatic” relates to a thermodynamic process occurring without gain or loss of heat. In terms of atmospheric stability, it is used to represent changes in an air parcel’s temperature due to expansion or compression, i.e. no heat is added or taken away from the parcel of air.

“Radiative cooling inversions” form stable layers in the atmosphere. Other inversions occur when cold air advances at low levels or when warm air moves over cold ground. The radiative inversion often occurs at night. In another method for formation of an inversion, a high-pressure system moves into an area. Adiabatic compression increases the temperature of the sinking air that typically accompanies this type of system. Because the upper-level vorticity leads to convergence and sinking air aloft, which creates high pressure at the surface, this sinking takes place. This subsidence warms the top layer of the boundary layer more than the bottom.

Cooling of the air aloft and warming of the surface air destabilizes the atmosphere. Cold air moving aloft from extratropical cyclones or clouds emitting infrared radiation to space cools air aloft. Surface heating warming the surface air, low-level warm-air advection, and cold air moving over a warm surface also destabilize the atmosphere. This destabilization can happen ahead of a cold front or in situations, such as lake-effect snow. In stable atmospheric boundary layer[1], airflow is critical to pollution levels. At the surface, friction and heat fluxes influence the height of the atmospheric boundary layer. Turbulence primarily characterizes the atmospheric boundary layer; temperature gradients can either generate or suppress this turbulence.

The structure of the atmospheric boundary layer changes cyclically throughout the day. The atmospheric conditions around Muskogee during the morning hours typically begin with light winds near the ground level. The first gust of wind comes as the sun rises and heats the ground. During the late morning hours thermals of warm air climb to greater heights, and with this vertical motion horizontal wind speeds increase. The primary static stability conditions for air pollution management are unstable, neutral, and stable conditions. This determines the flow of the atmosphere. Unstable conditions will promote continued acceleration of a parcel of air until it reaches an environment in which it is cooler. These turbulent conditions typically lead to lower pollution levels due to increased mixing.

A parcel of air displaced in a neutral environment will feel no buoyant forces with moderate to strong winds and little heating or cooling from the surface. These occur during overcast conditions, often associated with bad weather. In a stable environment, the parcel will experience buoyant forces opposite to the direction of displacement due to the environmental increase of temperature with height. Stable layers of air, are associated with light winds and a surface that is cooler than the air. In addition to these factors, the height of the boundary layer is important for pollution dispersion throughout the region. Flow can become turbulent in statically stable air if the wind shear is strong enough. Such dynamic stability is indicated by the dimensionless bulk Richardson number. When referenced with the critical Richardson number of 0.25, a $Ri < Ric$ will represent flow that is dynamically unstable and turbulent.

It is the combination of the buoyance and turbulent drag on a parcel that determine the vertical motion of a parcel of air. When this wind approaches an obstacle such as the terrain features of Muskogee, much of the air will flow around this obstacle depending on the stability of the atmosphere which is further explaining through downward momentum transport and gap winds influence airflow near the OG&E Muskogee Generating Station. While emissions out of the top of the stack often have strong internal turbulence, this quickly decays, leaving the majority of the dispersing to the ambient flow. The direction that the plume travels is controlled by the synoptic weather and general circulation. In a given volume of air, the rate of smoke dispersion depends on the velocity variance. Thus, if turbulence is isotropic, then a smoke puff would tend to expand equally in all directions such as in a neutral environment. Anisotropic conditions are prevalent during the daytime over bare land, rising thermals create stronger vertical motions than horizontal. Hence, a smoke puff would disperse more in the vertical. At night, vertical motions are very weak, while horizontal motions can be larger. This causes smoke puffs to fan out horizontally.

Downward momentum transport

On a microscale, these hills, which do not continue westward toward the Davis Field airport, contribute to downslope winds at the SO_2 monitor during prevailing south-southeasterly flow conditions. These winds help to create microscale wind conditions not found over or west of the City of Muskogee in the direction on the mean wind flow. The OG&E facility sits to the lee side of this elevated terrain. After air moves upward over the hills south of the facility, the restoring force of buoyancy acts on the air. In a stable atmosphere, an air parcel originating on the windward side of the formation cools adiabatically as it rises over the hills. Once this air parcel reaches the top of the hills, it descends along the surface toward equilibrium on the lee side of the hills. Momentum can cause higher wind speeds in this local area than in areas without orographic influence. To surmount this orographic feature, air at the surface must exhibit an initial velocity strong enough to overcome gravitational potential energy. This can be represented mathematically in the form of KE/PE > 1, which is the ratio of Kinetic Energy to Potential Energy. In a statically stable atmosphere, the restoring force is the difference between ambient temperature and the temperature after lifting a parcel of air dry-adiabatically to a new height such as the top of mountain. This restoring force of KE/PE is also known as the Froude number Fr. This can further be represented as the cross barrier wind component/Brunt-Vaisalla([2]) frequency x height of mountain = U/h_mN . Given the orography near Muskogee, it is much easier for flow to make it over this obstacle with flow slowing as it ascends and accelerating as it descends the elevated terrain.

Gap winds

Terrain around a narrow channel to the southeast of the monitor rises as high as 800 ft above mean sea level within one mile on both sides of the gap. This gap provides an opportunity for gap winds([4]) to form. The depth of approaching air increases due to blocking effects of the terrain. As wind approaches the gap, the air occupies a decreasing area, causing the wind to slow, resulting in convergence. This convergence creates an area of high pressure at the gap entrance. At the gap exit, flow spreads and thins with divergence; the air occupies an increasing area. This increase results in lower pressure with winds accelerating over the exit region. This thinning enhances the pressure gradient thus increasing wind flow. If there is a strong temperature inversion preventing the depth of flow from changing through the gap, then air volume conservation gives: Vd=Ds/Dd * Vs where D is the width of flow, subscript s represents the upstream flow, and subscript d represents flow in the narrowest part of the mountain pass.

Event analysis

During the period from 2012 to 2014, SO_2 readings on 7 days exceeded 50 ppb during at least one clock hour. Following is a description of the primary meteorological conditions that occurred during each of the 2012 events.

January 15, 2012

The surface chart depicts calm dry winds at the surface prominent throughout the region. A frontal boundary (**Fig. 2**) was situated to the northwest of the state, and was expected to cross the area the following day.

Figure 2: Surface Chart

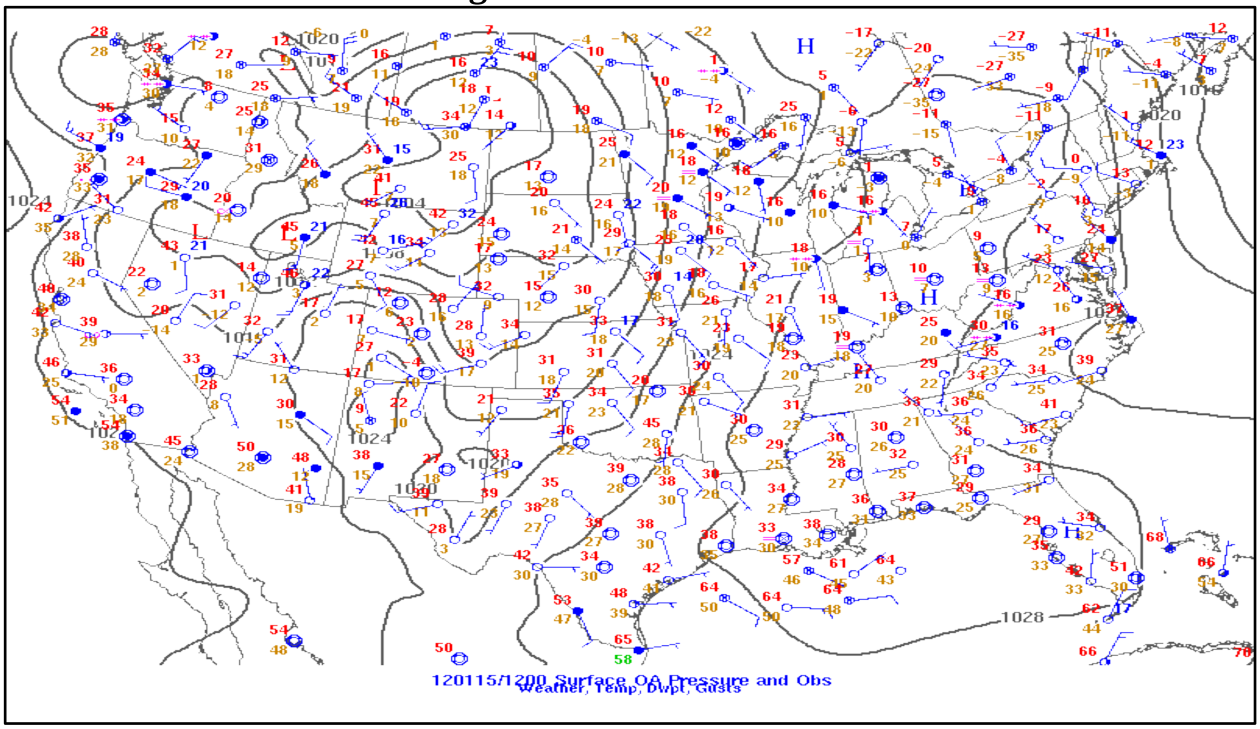
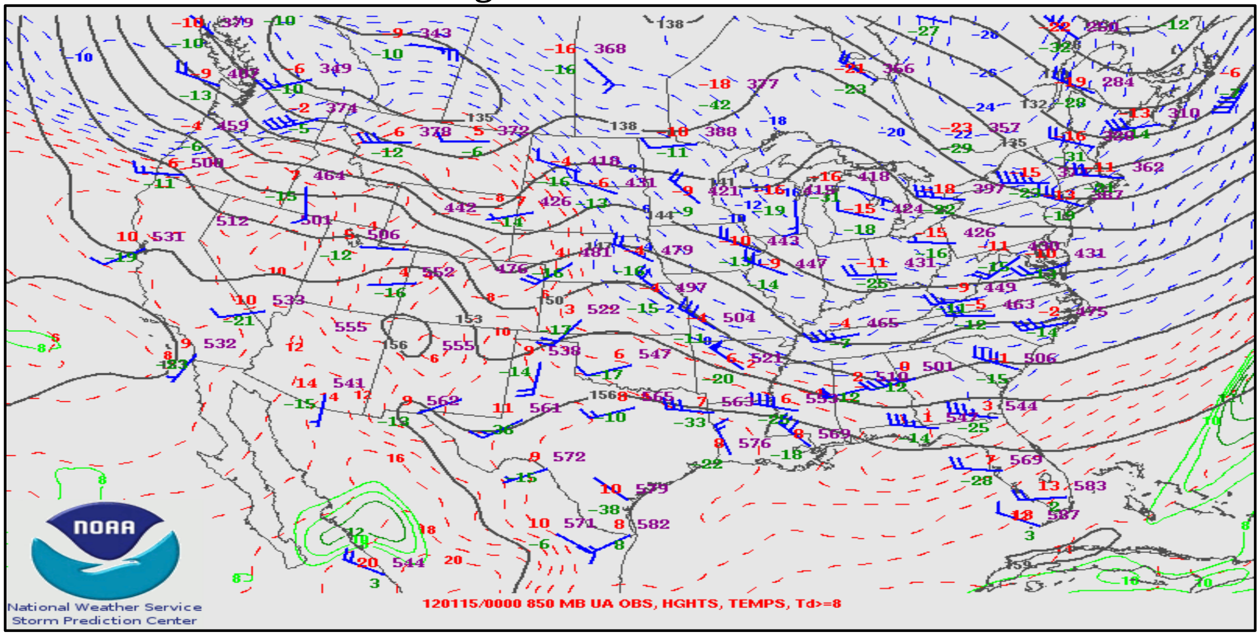
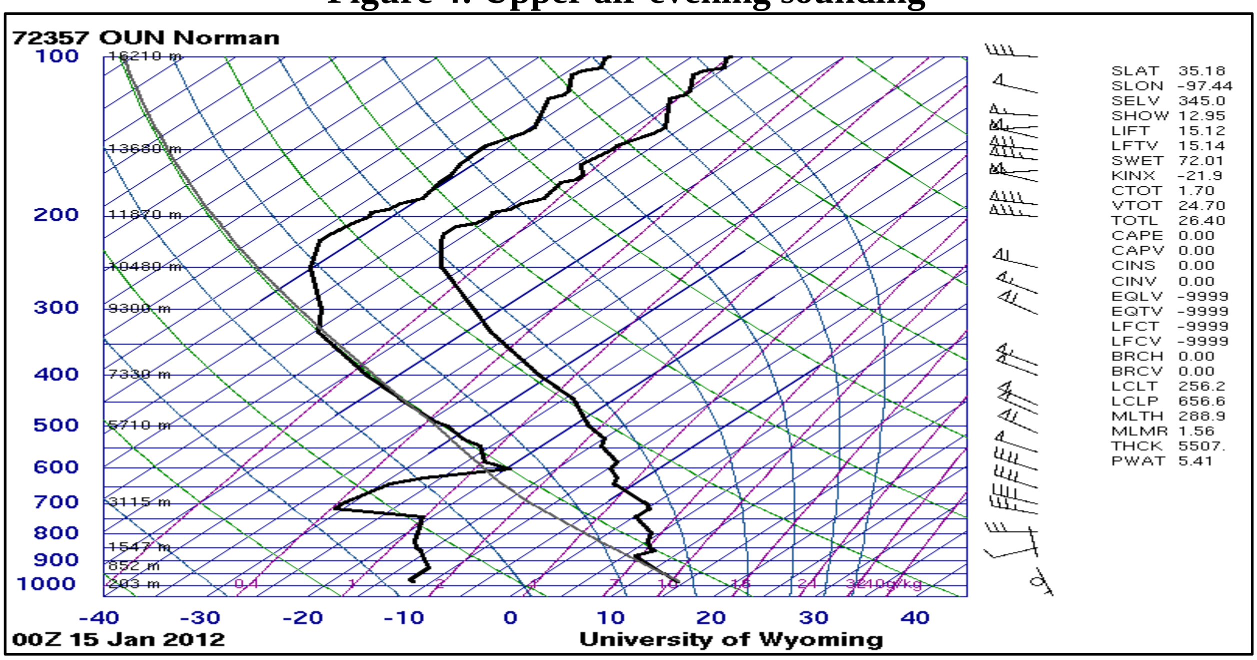


Figure 3: 850-mb chart



A weak low-level ridge (**Fig. 3**) situated over east Texas, and due to the ridge axis location. The previous evening, the surface profile (**Fig. 4**) indicated neutral conditions allowing pollutants that were at higher elevations to be mixed down to the lower levels of the boundary layer.

Figure 4: Upper air evening sounding



Surface winds were also calm over the region at the surface with an absolutely stable morning sounding (**Fig. 5**).

Figure 5: Upper air morning sounding

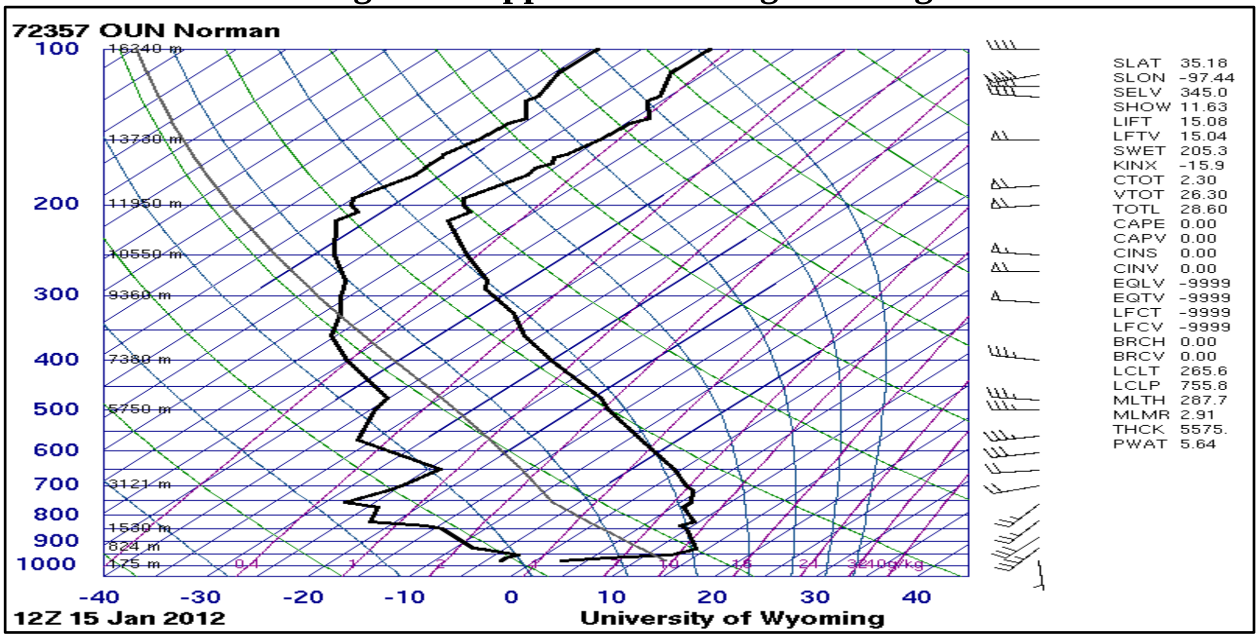
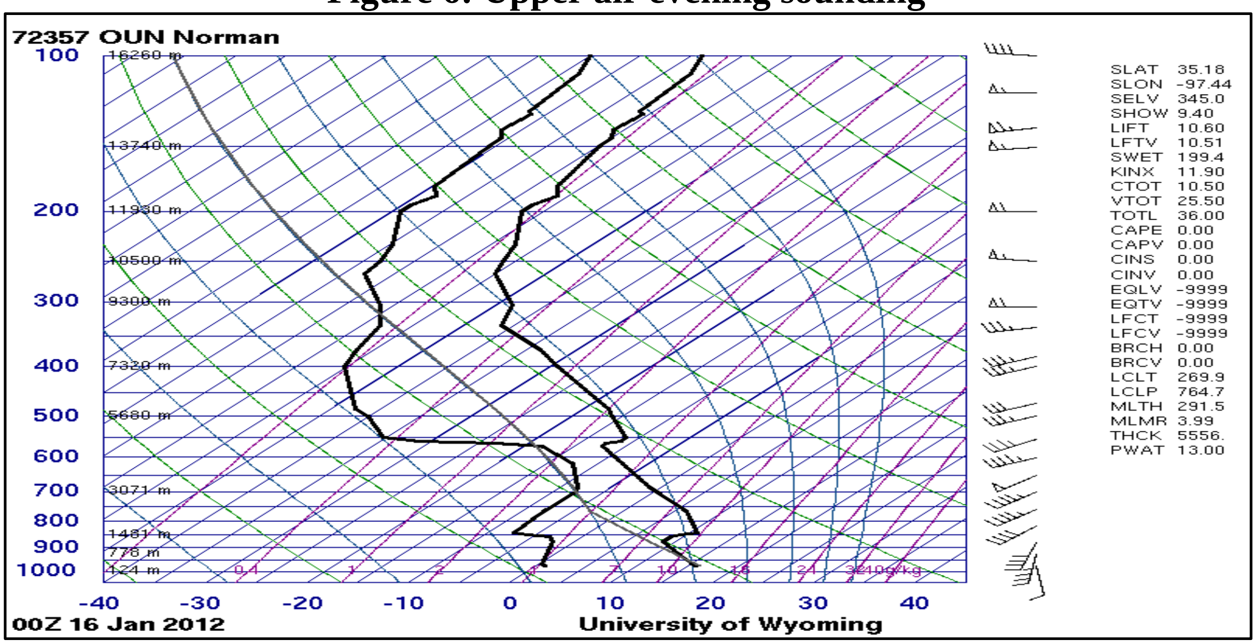


Figure 6: Upper air evening sounding



Neutral conditions returned during the evening with an elevated inversion remaining over the area (**Fig. 6**).

These soundings also indicate low moisture in the morning, which the surface chart confirms, showing low dew points along the Gulf of Mexico. Also, negligible wind speed at the surface indicates little mixing is taking place. With a neutral sounding, one would expect stagnant conditions and fumigation to be occurring.

January 27, 2012

This day is a similar setup to January 15 except that the cold front is closer to the region. Again, there is a stable boundary layer in the morning, but as the surface heats, this layer is gradually eroded and the layer becomes neutral. The upper wave associated with the frontal passage brought some mid-level moisture into the region along with southerly winds. The front did not pass through the area until the early evening, which was a few hours after the high SO_2 event.

May 23, 2012

The chart in **Figure 7** shows calm southerly winds with a slow moving low pressure system positioned over Eastern Colorado. This day followed the previous events with a stable morning sounding become more neutral (**Fig. 8**) as the day progressed.

Figure 7: Surface Chart

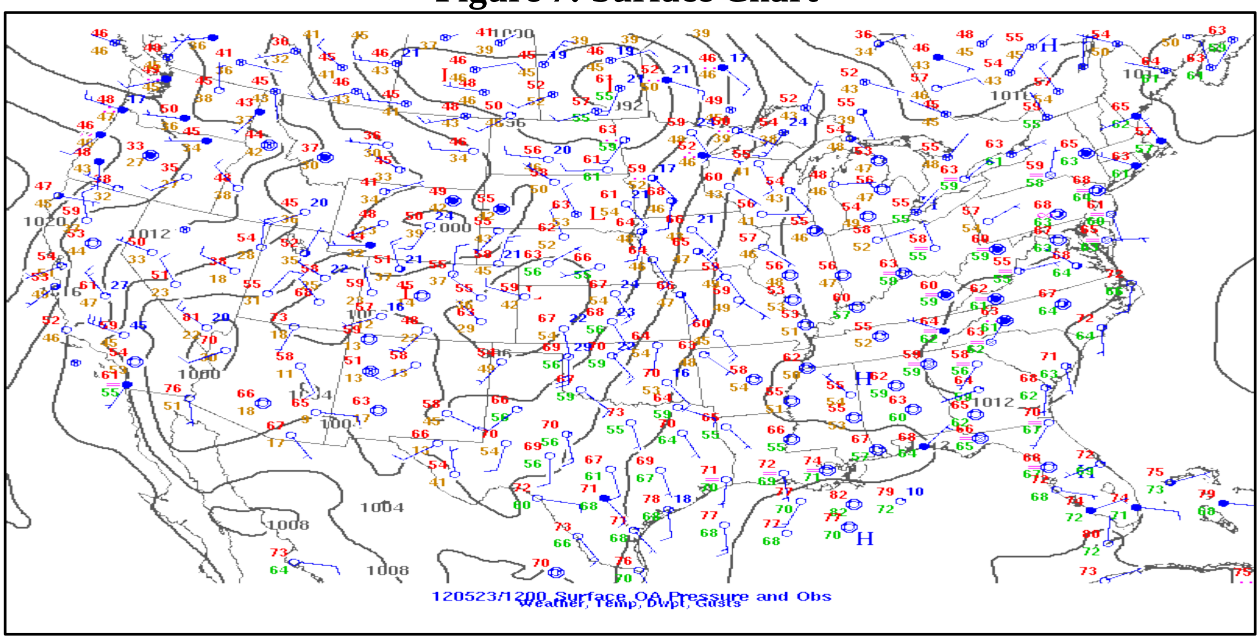
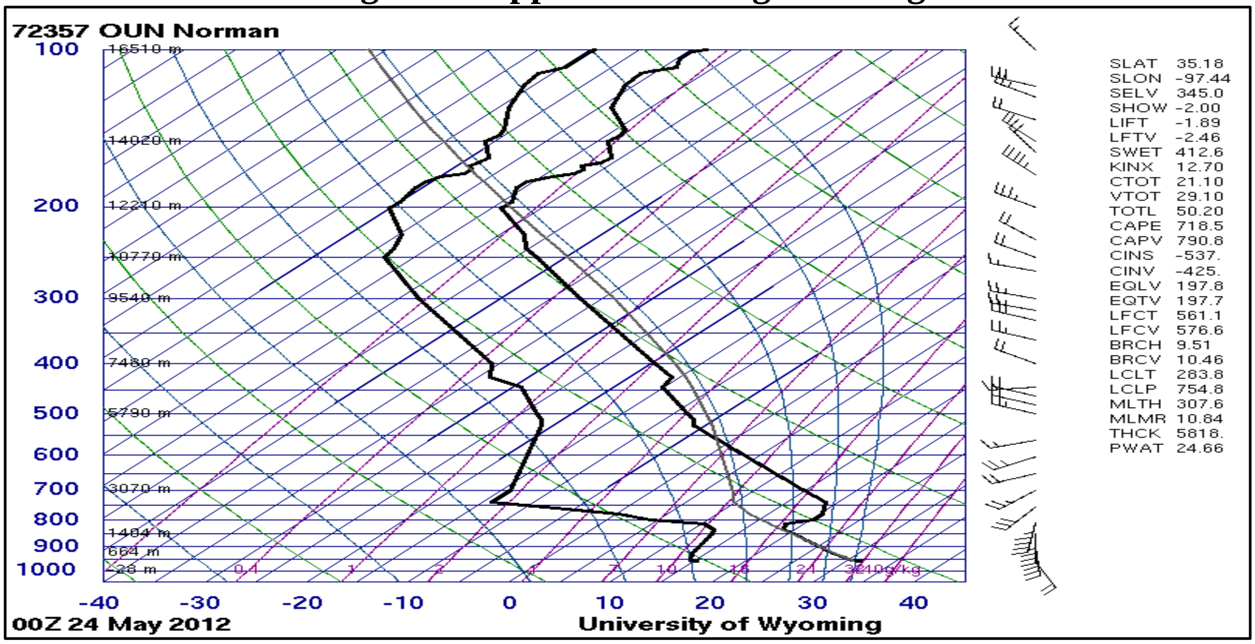


Figure 8: Upper air evening sounding



July 27, 2012

Precipitation on the previous day kept the humidity high (**Fig. 9**) with an upper ridge building back across the Southern Plains (**Fig. 10**).

Figure 9: surface chart

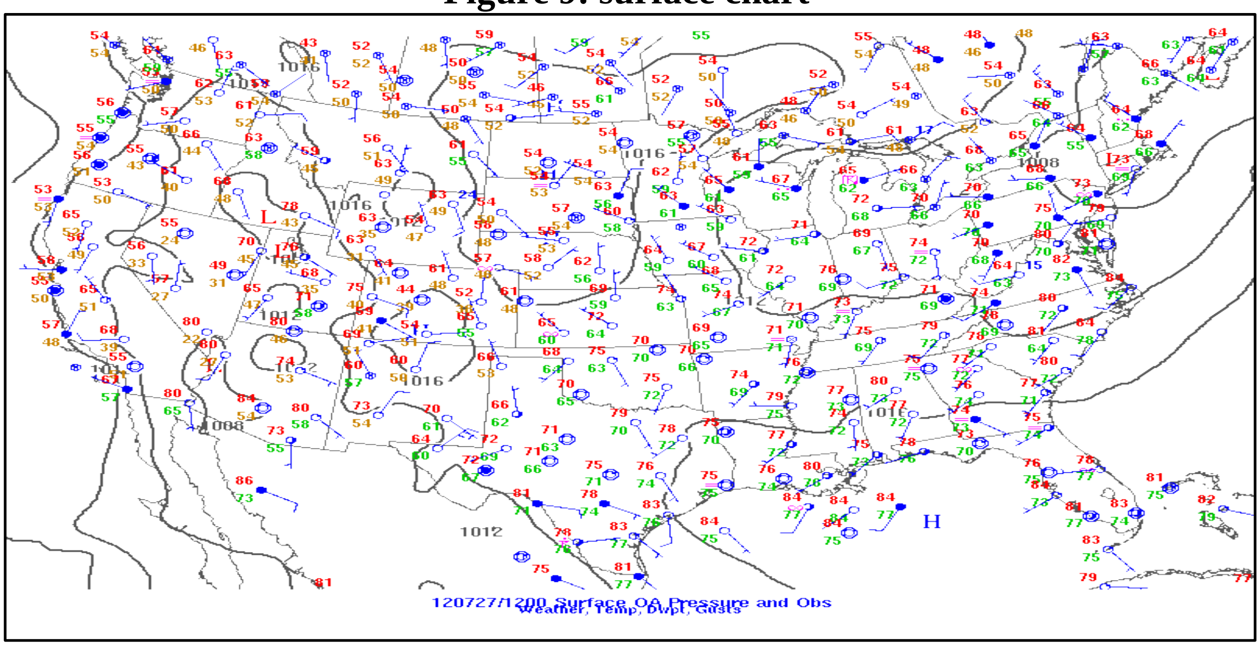
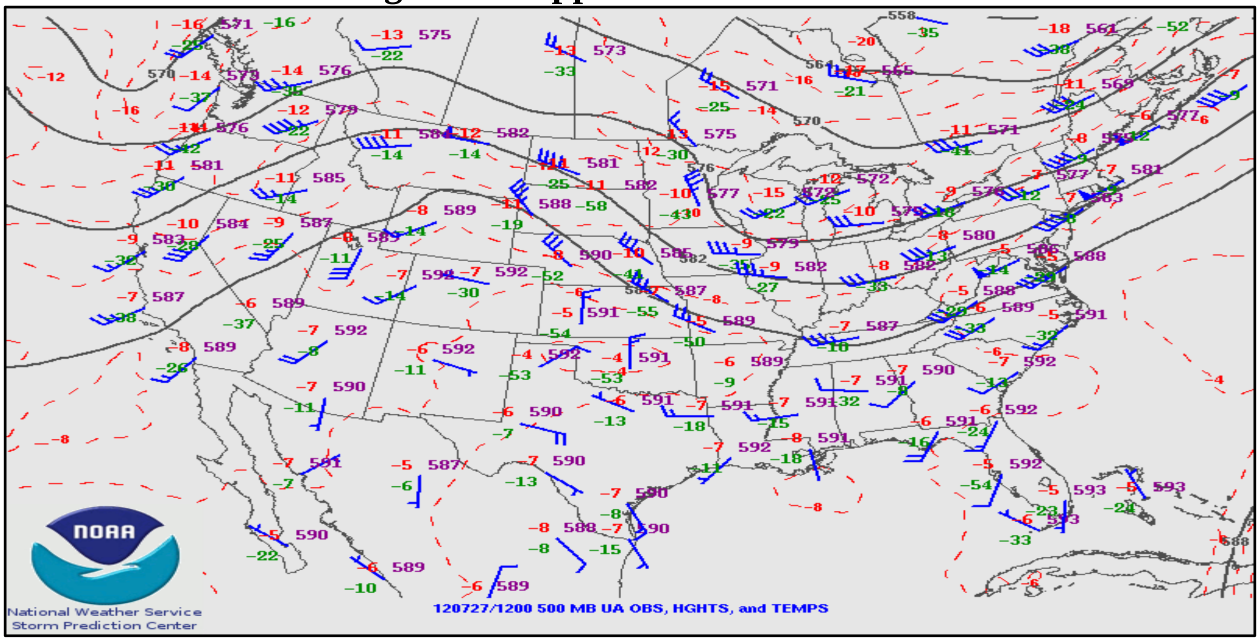
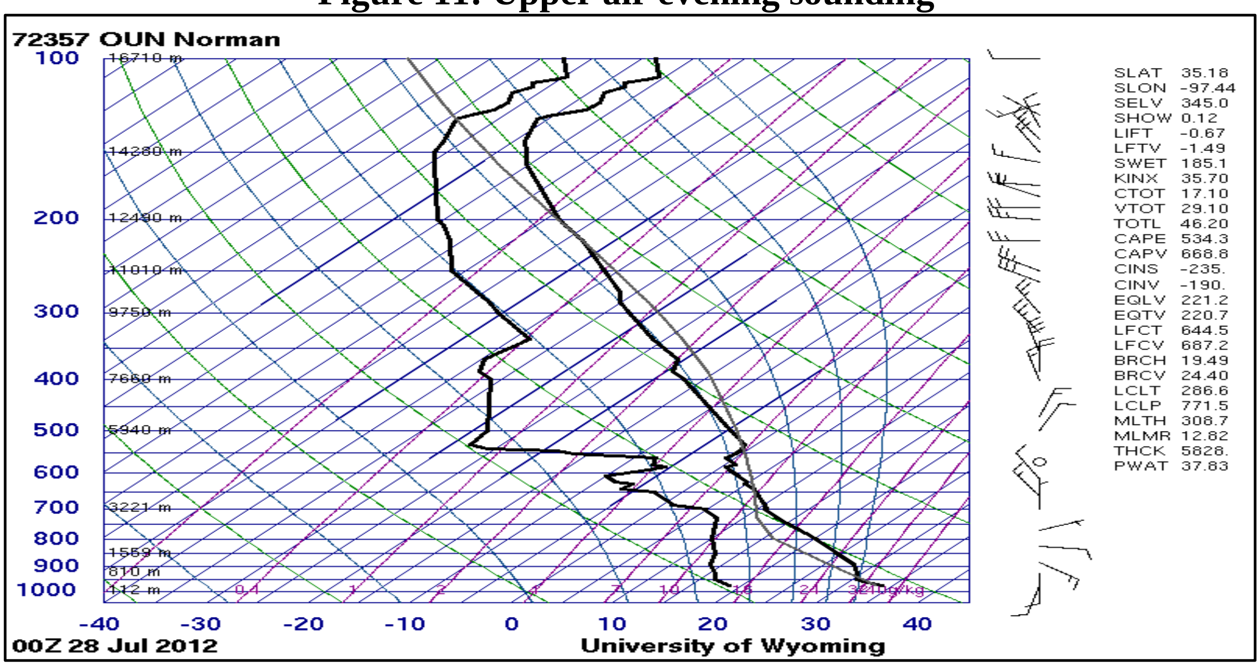


Figure 10: Upper air 500 mb chart



Given no primary upper air driver for the local synoptic conditions, afternoon heating was the main mechanism for any developments. The atmospheric soundings show strong moisture profiles throughout the day with little directional flow at the mid and surface levels.

Figure 11: Upper air evening sounding



The environment became unstable in the evening, which helped decrease the SO_2 readings in the afternoon (**Fig. 11**).

Summary

A common theme amongst the high SO_2 readings are stable atmospheric layers in the morning often associated with a high-pressure system or radiative cooling at night. The environmental profile becomes more neutral throughout the day as the inversion in the boundary layer erodes with increased surface heating. Because of the topography there is significant local terrain influence on wind speeds and direction. If any instability is present in the region, pollutants are quickly mixed into the atmosphere.

Both orographic lift and pressure channeling of the wind can affect the air flow in the vicinity of the OG&E Muskogee Generating Station. During the daytime conditions of free convection and anisotropic conditions, thermals cause a form of dispersion that often brings high concentrations of pollutants close to the ground. At night, turbulence is suppressed in the vertical, causing pollutants to remain aloft. However, if the conditions are neutral with strong winds, turbulence is more isotropic with smoke plumes dispersing at roughly equal rates in the vertical and later directions. Because most pollutants are emitted from near the surface, and most receptors are at the surface, the mean transport and turbulent dispersion of pollutants are primarily controlled by boundary layer characteristic. The nature of the turbulence depends on the radiatively-driven heating, and the dynamic forces and winds. Once emitted, the dispersion depends partly on the static stability of the ambient atmosphere.

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4. E. Aguado & J. Burt, Understanding Weather & Climate, 2nd ed., Prentice Hall, pp. 272.

2010 Primary Sulfur Dioxide (SO_2)
National Ambient Air Quality Standard (NAAQS)

Technical Analyses and Information Supporting the Designation Recommendation for Oklahoma

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Source-Oriented SO_2 Monitoring Placement for the Area of Muskogee, Oklahoma

Modeling Analysis Report

Prepared by the Engineering Section of the Permitting Unit
Air Quality Division
Oklahoma Department of Environmental Quality

September 4, 2015

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Why Is A Monitoring Placement Modeling Analysis Being Conducted?

This analysis is being conducted to identify suitable 1-hour SO_2 source-oriented monitoring site locations for the 2017-2019 monitoring intended to satisfy the Data Requirements Rule in Muskogee County, Oklahoma.

1.2 What Is The Background For The Analysis?

Under the Clean Air Act (CAA), as amended in 1990 under Section 110 of the CAA (40 CFR Part 51, Subparts F & G), each state must develop a State Implementation Plant (SIP) describing how it will attain and maintain the NAAQS, which is required. In general, the SIP is a collection of programs, including:

- a monitoring program, which is a collection of monitoring devices throughout the country which provide actual measurements of the concentrations in the air, to identify whether an area is meeting the air quality standards, and if not, what reductions are needed to meet those standards; and
- air quality calculations and computer modeling, which are used to predict future trends and the effects of emissions reduction strategies.

On June 22, 2010, the United States (US) Environmental Protection Agency (EPA) revised the primary sulfur dioxide (SO_2) National Ambient Air Quality Standard (NAAQS). The EPA promulgated a new 1-hour daily maximum primary SO_2 standard at a level of 75 parts per billion (ppb), based on the 3-year average of the annual 99th percentile of 1-hour daily maximum concentrations.

On May 13, 2014, the EPA proposed the Data Requirements Rule (DRR) for the 1-Hour SO_2 NAAQS. The final DRR was signed on August 10, 2015 and requires states to gather and submit to the EPA additional information characterizing SO_2 air quality in areas with larger sources of SO_2 emissions (79 FR 27445). In the DRR, air agencies have the choice to use either monitoring or modeling to characterize SO_2 air quality in the vicinity of priority SO_2 sources, and submit the modeling and/or monitoring to the EPA on a schedule specified by the rule.

1.3 What Is The Background Of The Current Muskogee SO_2 Monitor?

The current source oriented SO_2 monitoring site (40-101-0167) located in Muskogee, Oklahoma was established at its current location in 1981. EPA Region 6 issued a PSD permit (Permit No. PSD-OK-057) for Unit 6 at the OG&E Muskogee Generating Station on November 30, 1977. Modeling was included in the permit application which utilized the Tennessee Valley Authority (TVA) Climatological Dispersion model and the EPA CRSTER plume dispersion model. Output from these models and the EPA technical document "Optimum Site Exposure Criteria for SO_2 Monitoring" (EPA-450/3-77-013), issued April 1977, were used to inform the Oklahoma State Department of Health, Air Quality Division where to locate the SO_2 monitoring site.

Locations of the maximum concentrations were calculated by the models utilizing representative atmospheric data, and with Units 4, 5, and 6 at 100% of their operating load. The table below shows the distance and direction information presented in the PSD permit application.

Table 1-1: PSD-OK-057 Modeling Results

Model	Averaging Period	Unit 4 & 5		Unit 6	
		Distance (m)	Direction* (°)	Distance (m)	Direction* (°)
TVA Coning	Maximum	2,500	N/A	4,500	N/A
TVA Fumigation	Maximum	7,800	N/A	9,200	N/A
EPA CRSTER	3-hr	800	15	1,800	15
	24-hr	3,500	1	1,300	8

N/A – Not Available.
* Direction is presented in degrees clockwise from north.

The SO_2 monitoring site is currently located 3.7 km at a bearing of N19.1°W from the center of the three stacks for Units 4, 5, and 6 at the OG&E Muskogee Generating Station.

2. AIR DISPERSION MODELING SELECTION

2.1 What Is The Recommended Air Dispersion Model?

As described in the EPA SO_2 NAAQS Designations Source-Oriented Monitoring Technical Assistance Document (Monitoring TAD), modeling to inform monitoring placement should follow the recommendations of the SO_2 NAAQS Designations Modeling Technical Assistance Document (Modeling TAD). The modeling TAD essentially states that given the source-oriented nature of SO_2, dispersion models are appropriate air quality modeling tools to predict the near-field concentrations. Since the purpose of this analysis is to conduct modeling to inform monitor placement, the AMS/EPA Regulatory Model (AERMOD) was used, as suggested in the Monitoring TAD. AERMOD is the preferred air dispersion model because it is capable of handling rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources (including, point, area, and volume sources), to address ambient impacts for the designations process.

The AERMOD modeling system includes the following components:

- AERMOD (Version 14134): the dispersion model;
- AERMAP (Version 11103): the terrain processor for AERMOD; and
- AERMET (Version 14134): the meteorological data processor for AERMOD.

Other components that were used:

- BPIPPRIME (Version 04274): the building input processor;
- AERMINUTE (Version 14337): a 1-minute ASOS winds pre-processor to AERMET;
- AERSURFACE (Version 13016): the surface characteristics processor for AERMET.

3. MODEL DOMAIN SETUP

3.1 How Was The Modeling Domain Established?

The domain is centered over the OG&E Muskogee Generating Station. Based on EPA guidance, the general guideline for determining the distance between an affected source and its maximum ground level concentration is generally 10 times the stack height in flat terrain. However, the potential influence of terrain can impact the location and magnitudes of significant concentration gradients. The following table shows each emissions unit at the affected facility, the stack height for the emissions unit, and the expected distance to the expected maximum ground level concentration in flat terrain.

Table 3-1. Expected Distance to Maximum Modeled Concentrations of Affected Units

Company/Facility	Stack	Stack Height. (ft)	Distance (km)
OG&E/Muskogee Generating Station	Unit 4	350	1.07
	Unit 5	350	1.07
	Unit 6	500	1.52

The example presented in Appendix A of the Monitoring TAD suggests establishing a domain out to 20 km. However, since the maximum impact is expected to be between 1 km and 2 km, a domain of 10 km was established. Figures showing the location of the domain with respect to the state and counties are included in Appendix A.

3.2 How Was The Receptor Grid Established?

A Cartesian receptor grid was generated from the fence line of the OG&E Muskogee Generating Station extended out to a distance of 10 km with a receptor spacing of 250 meters as suggested in the example presented in Appendix A of the Monitoring TAD.

Receptors in the generated grid that were within the fence lines of the modeled facilities and that are in areas not suitable for the placement of a permanent monitor such as open water (i.e., rivers, lakes, streams, ponds, etc.) were removed from the model.

In addition to the Cartesian receptor grid, an additional receptor was placed at the location of the existing 1-hour SO_2 Muskogee monitor. Adding this receptor to the model will enable the analysis to compare the best modeled monitoring site locations with the existing Muskogee monitor location (Site ID 40-101-0167).

Figures showing the generated receptor grid are included in Appendix B.

3.3 What Emission Rates Were Used In The Modeling Analysis?

Following the example in Appendix A of the Monitoring TAD, normalized emission rates were used in the model. Normalizing emissions inputs relies on the linear scalability of emission inputs to modeled concentrations and therefore provides relative model results to assess the location of maximum concentration gradients.

The normalized emission inputs were generated by dividing the actual emission rates of each emission unit by the largest emission rate of all the emission units. Actual emission rates for OG&E were based on the 99th percentile of CEM data from 2012 to 2014. Actual emissions for nearby sources were based on the three year average of actual emission rates from each emission unit from 2012 to 2014.

3.4 What Terrain Was Utilized For The Modeling Analysis?

Terrain data was included in this modeling analysis. Terrain data was obtained from the USGS Seamless Data Server at http://viewer.nationalmap.gov/viewer/. The 1/3 arc-second NED data was obtained in the GeoTIFF format for use in AERMAP. Interpolation of receptor and source heights from the 1/3 arc-second NED elevation data was based on the current AERMAP guidance in Section 4.4 of the *User's Guide for the AERMOD Terrain Preprocessor (AERMAP)* (EPA-454/B-03-0003, 10/2004). AERMAP uses a distance weighted bilinear interpolation method. The domain was located in UTM zone 15. All coordinates were based on the North American Datum (NAD) of 1927 (NAD27).

3.5 What Was The Domain Classification: Rural Or Urban?

Dispersing plumes encounter more turbulence in urban areas than in rural areas due to building wakes as well as warmer temperatures. The higher dispersion in urban areas causes plumes to spread more rapidly. The areas of maximum impact in urban areas occur closer to the source. Determination of whether the domain should be classified as urban or rural was based mainly on land use (the preferred method). However, the urban heat island affect was reviewed for the facility. After an analysis of the domain, it was determined to be predominantly classified as rural. An aerial photo indicating the area surrounding the facility is included in Appendix C.

4. SOURCE DATA

4.1 What Are The Modeled Source Configurations And Source Types?

Accurate characterization of the affected sources is critical to air quality modeling. Stack parameters and physical plant layout (building and fence line data) were submitted by the affected facility and surrounding facilities with significant emissions of SO_2. The submitted data was then reviewed and checked for errors. All of the affected sources are point sources. The location (i.e. latitude and longitude or Universal Transverse Mercator (UTM) coordinates and datum) of the modeled emission unit stacks were also reviewed along with relative location of the stacks to nearby buildings or structures. Additional data required for the model was collected from the AQD Emission Inventory database.

Figures showing the facility data overlaid onto aerial photos are included in Appendix D.

4.2 What Are The Effected Source Emissions Inputs?

In addition to the three coal-fired boilers located at OG&E Muskogee, the modeling domain included all nearby sources within 50 km having significant SO_2 emissions. Since the standard is based on a three year average, modeling was based on the most recent three years of actual emissions. Actual emissions data for input into AERMOD was generated for each source in the model by utilizing the average of the most recent three years of actual emissions and normalizing the values based on the maximum emission rate as suggested in the Monitoring TAD. Ambient impacts from natural gas-fired sources were analyzed using AERSCREEN to show that they do not have a significant concentration gradient within the modeling domain. Source data used in the model is presented in Appendix E.

4.3 How Will GEP Stack Height Be Addressed?

Good Engineering Practice (GEP) stack height is the minimum stack height needed to prevent the stack exhaust plume from being entrained in the wake of nearby obstructions. For the modeling to inform monitor placement process, actual stack heights were used for modeling actual emissions rather than following the GEP stack height policy. The GEP stack height policy uses GEP stack height for stack heights exceeding GEP and actual stack height for stacks below GEP. The use of actual stack heights in the modeling analysis more closely represents actual ambient air quality conditions from the affected sources. Since the purpose of the modeling is to identify the most suitable locations for permanent monitor placement, the model needs to reflect actual stack heights of influencing sources.

4.4 Is Building Downwash Included In The Modeling Analysis?

When one or more structures interrupt the wind flow, turbulent cavities are formed in the downwind side of the building. These cavities can cause a plume from a nearby stack to be forced down to the ground much sooner than it would have if the wind flow were uninterrupted. This effect is called building downwash. Pollutants emitted at a fairly low level (e.g., a roof, vent, or short stack) can be caught in the building downwash, affecting their dispersion. Modeling that includes calculations for building downwash gives a more accurate representation of pollutant impacts than does modeling that omits consideration of downwash effects.

A building is any physical obstruction to airflow at the modeled facility. A structure is a building or group of buildings determined to be important in downwash considerations. The dominant downwash structure is the structure that renders the highest GEP recommended stack height. If a stack is at GEP or higher, then downwash is not a factor. GEP stack height is calculated according to the following equation.

$$H = h + 1.5L$$

where: H = Recommended stack height.
h = The distance from the highest point on a tier or building to ground level.
L = The lesser of the height or projected width for a particular tier or structure.

Not only are accurate stack parameters important but so are accurate building parameters. Building parameters include location and orientation relative to stacks and building size. Other parameters include tier heights and coordinates. These parameters are input into BPIP-PRIME to calculate building parameters for AERMOD. Affected facilities have submitted information regarding buildings located on their property. This data was reviewed and included in the modeling analyses.

5. METEOROLOGICAL DATA

5.1 What Meteorology Data Was Used?

The 2012-2014 meteorological data from the National Weather Service (NWS) Automated Surface Observation Station (ASOS) located at the Davis Field Airport (KMKO) in Muskogee was utilized for the 2010 1-hour SO_2 primary NAAQS designations modeling.

When conducting air dispersion modeling, the State of Oklahoma generally utilizes meteorological data from the following:

- Oklahoma Mesonet Surface Data;
- National Centers for Environmental Information (NCEI), formerly National Climatic Data Center (NCDC), Integrated Surface Hourly Database (ISHD) Surface Data; and
- Earth System Research Laboratory (ESRL) Global Systems Division (GSD), formerly Forecast Systems Laboratory (FSL), Upper Air (UA) data.

Oklahoma Mesonet data is usually incorporated to help make more accurate forecasts of ambient impacts from modeled sources. Incorporation of Oklahoma Mesonet data makes the AERMET-processed meteorological data more accurate because the datasets contain sub-hourly values and the sites are usually closer to the areas being modeled. Standard ISHD surface data usually only contains a single two minute average recorded during an hour whereas Oklahoma Mesonet datasets contain twelve five minute averages for each hour. There are a large number of Oklahoma Mesonet stations, which increases the potential of an Oklahoma Mesonet meteorological station being closer to the area being modeled. Generally, the closer a meteorological station is to an area, the more representative the meteorological data is to the area being modeled.

There are two types of ISHD surface stations; ASOS and Automated Weather Observation Stations (AWOS). All ASOS stations started recording continuous sub-hourly (2-minute averages) wind data in 2005. However, sub-hourly wind data for AWOS stations is not available. If an ASOS station is closer or more representative than the nearest Oklahoma Mesonet station, data from the Oklahoma Mesonet is not incorporated into the AERMET processed meteorological data. Oklahoma Mesonet meteorological data was not utilized in this analysis because the ISHD ASOS KMKO Station data is closer to and more representative than the nearest Oklahoma Mesonet station and sub-hourly wind data is available for the KMKO station. Information for the selected sites is included in Appendix F. A wind rose for the KMKO station is contained in Appendix G.

5.1.1 How Were Sites From The ISHD Evaluated?

The ISH data files were downloaded from the NCDC ISHD web site: ftp://ftp.ncdc.noaa.gov/pub/data/noaa. The ISH data was reviewed for completeness by evaluating the number of hours that were recorded and the number of cloud cover values that were recorded. The KMKO ASOS station (at approximately 13.4 km S31.0°W from the center of the domain) was determined to be the most representative site for the domain. The data from KMKO did not have a significant number of missing values for individual variables. Therefore, no missing data replacement was performed.

5.1.2 Was AERMINUTE Utilized In The Modeling Analysis

For this ASOS site, AERMINUTE data was utilized to incorporate continuous sub-hourly wind data. The ASOS (6405) files were downloaded and then processed using AERMINUTE. The ASOS 1-minute files were downloaded from http://www1.ncdc.noaa.gov/pub/data/ for each year.

5.1.3 What Is Oklahoma Mesonet Data And How Was It Utilized?

The Oklahoma Mesonet is a world-class network of meteorological monitoring stations. The Oklahoma Mesonet is unique in its capability to measure a large variety of meteorological conditions at so many sites across an area as large as Oklahoma. Oklahoma Mesonet data is provided courtesy of the Oklahoma Mesonet, a cooperative venture between Oklahoma State University (OSU) and the University of Oklahoma (OU) and supported by the taxpayers of Oklahoma. At each site, the meteorological conditions are continuously measured and packaged into 5-minute observations. These 5-minute observations from the Oklahoma Mesonet were processed into an AERMET acceptable format. The meteorological data from sites surrounding KMKO were utilized to evaluate the wind flow patterns in the Muskogee area. The Porter Oklahoma Mesonet station (at approximately 25.6 km N72.5°W from the center of the domain) was determined to be the most representative Mesonet station for the domain.

5.1.4 What Upper Air Data Was Used?

Selection of appropriate ESRL UA data to use in the meteorological data set was primarily based on proximity to the domain and included a review for missing soundings. The ESRL UA stations usually take soundings twice a day. A single missing sounding can cause a whole day (24 hours) of missing meteorological data values. To reduce the number of missing meteorological data, replacement soundings were substituted for the missing soundings. The replacement soundings were selected from a site with similar thermodynamic profiles. Upper air data from the Norman (OUN) site in Oklahoma (at approximately 206.75 km S75.4°W from the center of the domain) was determined to be the most representative site for the domain.

5.1.5 How Were Surface Characteristics Determined?

When using AERMET, to process meteorological data for AERMOD, three surface characteristics (Albedo, Bowen Ratio, and Surface Roughness Length) must be determined for the meteorological station. Albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux. Surface roughness length is related to the height of obstacles to the wind flow and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer. Albedo and Bowen Ratio are used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

AERSURFACE uses land cover data from the U.S. Geological Survey (USGS) National Land Cover Data 1992 archives (NLCD92) to determine the land cover types for a specified location. AERSURFACE matches the NLCD92 land cover categories to seasonal values of Albedo, Bowen Ratio, and Surface Roughness and then calculates the surface characteristics for input into AERMET. NLCD92 data in GeoTIFF format was downloaded from the Multi-Resolution Land Characteristics (MRLC) Consortium at the following link: http://www.mrlc.gov/viewerjs/. Seasonal surface characteristics are included in Appendix H.

5.1.6 What Was Used To Determine The Surface Moisture Conditions?

The monthly rainfall for each Mesonet site was analyzed from the beginning of the establishment of the Mesonet program (approximately 20 years). The surface moisture conditions (Average, Wet, Dry) for each of the Oklahoma Mesonet stations for each month were then determined using the monthly rainfall amounts compared to the average rainfall. These determinations were based on the guidance contained in the AERSURFACE Users Guide. The Bowen Ratio was then assigned as either average, dry, or wet based on the monthly surface moisture conditions for each Oklahoma Mesonet station. The surface moisture conditions for the ISHD stations were attributed to the surface moisture conditions of the Porter Oklahoma Mesonet station. Moisture conditions for each month are also included in Appendix H.

6. MODEL ANALYSIS

6.1 What Were The Initial Results Utilized In The Analysis?

Results from the model were calculated based on the three year average of each year's 4th daily highest 1-hour maximum concentration (99th percentile of daily 1-hour maximum concentrations). These results are referred to as the normalized design values (NDVs) since normalized emissions were used to calculate these values. The resulting NDVs range from 0.20793 μg/m^3 to 0.63730 μg/m^3. A figure showing a ratio of the NDV of each receptor compared to the overall maximum NDV is included in Appendix I.

From these results, the top 200 receptors were selected for further analysis. The top 200 receptors with the highest NDV were chosen in order to include the receptor at the monitor location in the analysis which had a NDV rank of 127. A figure showing the location of these top 200 receptors in the modeled domain is included in Appendix J. The most distant receptor in the Top 200 is approximately 6.52 km from the center of the three stacks at the OG&E Muskogee Generating Station.

6.2 Why Was Frequency Accounted For In The Analysis?

Simply using the largest NDVs to identify the best monitor locations is not sufficient enough to determine proper placement of a monitor site. Therefore, the number of times, or frequency, each receptor is calculated to have the maximum daily 1-hour concentration was also considered. To account for frequency in the analysis, two separate analyses were conducted on the top 200 receptors. The first analysis utilized the MAXDAILY option in AERMOD to output the maximum 1-hour concentration of each receptor for each day. The second analysis utilized the POSTFILE option in AERMOD to output the maximum 1-hour concentration of each receptor for each hour.

6.3 How Was Frequency Analyzed Utilizing the MAXDAILY Option?

In order to identify favorable locations for a 1-hour SO_2 monitor, the NDV was further analyzed in conjunction with the MAXDAILY output file by using a scoring strategy to create a relative prioritized list of receptor locations. This scoring strategy follows the example in Appendix A of the Monitoring TAD.

In the first step of this analysis, the NDVs were ranked in descending order (with the largest value having a rank of 1). In the second step, the results from the MAXDAILY output option were used to determine the number of days for which each receptor was the overall highest 1-hour concentration for the day for the three modeled years. A figure showing the frequency of receptors having the maximum daily results is included in Appendix K. The receptors were then ranked in descending order (with the largest value having a rank of 1) based on each receptor's frequency of days having the overall highest daily 1-hour concentration. The third step was to add these two ranks together to obtain a score. The scores were then ranked in ascending order, giving the lowest value (having the greatest significance) a rank of 1. This score rank was then utilized to identify the most favorable locations for a permanent 1-hour SO_2 monitoring site.

6.4 How Was Frequency Analyzed Utilizing The POSTFILE Option?

Similarly to the frequency analysis utilizing the MAXDAILY output option in AERMOD, the NDV was further analyzed in conjunction with the POSTFILE output file by utilizing a scoring strategy to create a relative prioritized list of receptor locations.

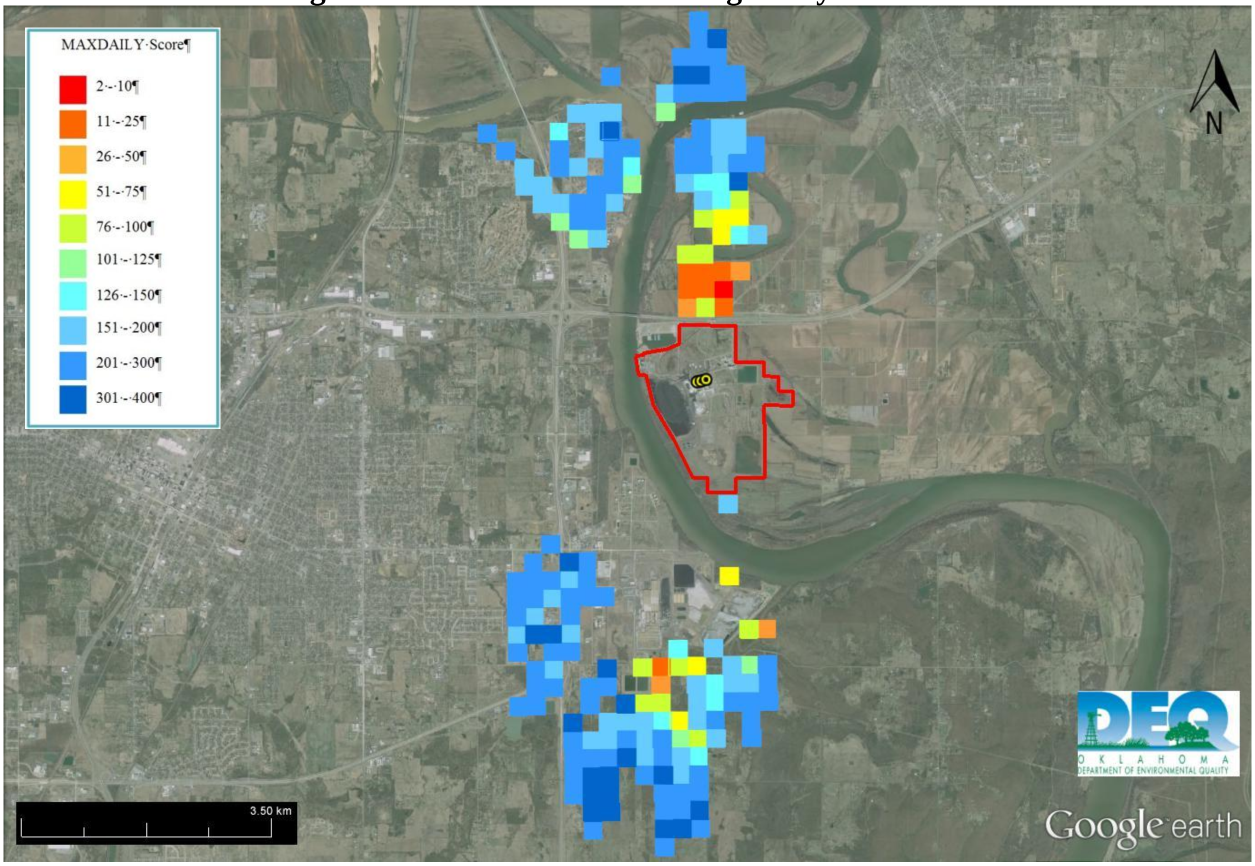
In the first step of this analysis, the NDVs were ranked in descending order (with the largest value having a rank of 1). In the second step, the results from the POSTFILE output option where used to determine the number of hours for which each receptor was the overall highest 1-hour concentration for the hour for the three modeled years. A figure showing the frequency of having the maximum hourly results is included in Appendix L. The receptors were then ranked in descending order (with the largest value having a rank of 1) based on each receptors frequency of hours having the overall highest 1-hour concentration. The third step was to add these two ranks together to obtain a score. The scores were then ranked in ascending order, giving the lowest value (having the greatest significance) a rank of 1. This score rank was then utilized to identify the most favorable locations for a permanent 1-hour SO_2 monitoring site.

7. RESULTS

7.1 What Are The Results From The Daily Scoring Analysis?

The following figure shows the top 200 receptors ranked based on a scoring methodology utilizing the NDV and the frequency of days having the largest 1-hour normalized concentration.

Figure 7-1: MAXDAILY Scoring Analysis Results



A summary of the results from the MAXDAILY output file analysis for the top ten most suitable monitoring locations are presented in the following table. The top 10 receptors are shown simply to illustrate the scoring methodology.

Table 7-1: MAXDAILY Output File Analysis Summary (Rank 1 – 10)

Easting in meters (NAD 27)	Northing in meters (NAD 27)	Distance from Facility[1] (km)	Bearing from Facility[2]	NDV Rank	Daily Max Freq. Count	Daily Max Freq. Rank	Receptor Score	Receptor Score Rank
293500	3961000	1.30	N14.6°E	2	41	2	4	1
293250	3961250	1.51	N3.0°E	1	28	10	11	2
293000	3961000	1.27	N7.8°W	4	29	7	11	3
293500	3960750	1.06	N18.0°E	8	29	8	16	4
293000	3961250	1.52	N6.5°W	6	28	11	17	5
293500	3961250	1.55	N12.2°E	3	22	17	20	6
293250	3961000	1.26	N3.5°E	7	23	15	22	7
292500	3955750	4.05	S9.6°W	16	30	6	22	8
292500	3955500	4.29	S9.0°W	9	12	24	33	9
293750	3961250	1.62	N20.9°E	21	26	12	33	10

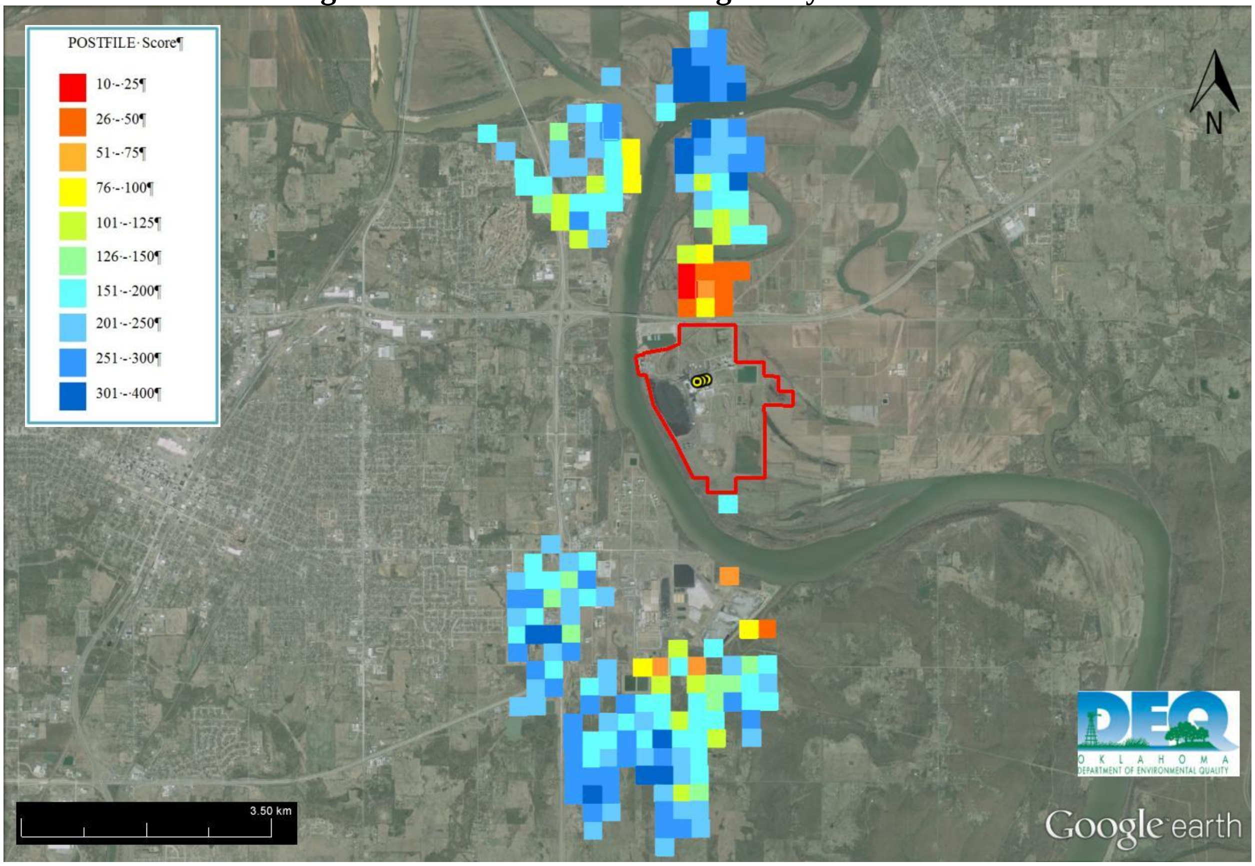
[1] – Distance is measured from the center of the stacks for OG&E Muskogee Units 4, 5, and 6.
[2] – Bearing is measured from the center of the stacks for OG&E Muskogee Units 4, 5, and 6 from the North or South given an “X” amount of degrees toward the East or West direction.

Based on the results presented in the previous table, the top 10 most suitable 1-hour SO_2 monitor locations appear to be within 1.06 km to 1.62 km of the facility and in a median direction between N 12.2°E and N 14.6°E.

7.2 What Are The Results From The Hourly Scoring Analysis?

The following figure shows the top 200 receptors ranked based on a scoring methodology utilizing the NDV and the frequency of having the largest 1-hour normalized concentration.

Figure 7-2: POSTFILE Scoring Analysis Results



A summary of the results from the POSTFILE output file analysis for the top ten most suitable monitoring locations are presented in the following table. The top 10 receptors are shown simply to illustrate the scoring methodology.

Table 7-2: POSTFILE Output File Analysis Summary (Rank 1 – 10)

Easting in meters (NAD 27)	Northing in meters (NAD 27)	Distance from Facility[1] (km)	Bearing from Facility[2]	NDV Rank	Hourly Max Freq. Count	Hourly Max Freq. Rank	Receptor Score	Receptor Score Rank
293000	3961250	1.52	N6.5°W	6	573	7	13	1
293000	3961000	1.27	N7.8°W	4	471	12	16	2
293500	3960750	1.06	N18.0°E	8	355	20	28	3
293250	3961250	1.51	N3.0°E	1	285	29	30	4
294000	3956250	3.59	S13.3°E	28	528	8	36	5
293500	3961250	1.55	N12.2°E	3	250	34	37	6
293500	3961000	1.30	N14.6°E	2	224	37	39	7
293750	3961250	1.62	N20.9°E	21	345	22	43	8
293000	3960750	1.03	N9.7°W	35	454	13	48	9
292500	3955750	4.05	S9.6°W	16	220	38	54	10

[1] – Distance is measured from the center of the stacks for OG&E Muskogee Units 4, 5, and 6.
[2] – Bearing is measured from the center of the stacks for OG&E Muskogee Units 4, 5, and 6 from the North or South given an "X" amount of degrees toward the East or West direction.

Based on the results presented in the previous table, the top 10 most suitable 1-hour SO_2 monitor locations appear to be within 1.06 km to 1.62 km of the facility and in a median direction of N 12.2°E.

7.3 How Does The Monitor Receptor Compare To The Scoring Analysis?

The current SO_2 monitor location can also be compared to the overall scoring analysis results. A summary of the results for the receptor at the current SO_2 monitoring site location are presented in the following table.

Figure 7-3: Results for Monitoring Site Location Receptor

Easting in meters (NAD 27)	Northing in meters (NAD 27)	Distance from Facility[1] (km)	Bearing from Facility[2]	NDV Rank	Max Freq. Count	Max Freq. Rank	Receptor Score	Receptor Score Rank
291960	3963238	3.70	N19.1°W	127	0 Days	150	277	167
291960	3963238	3.70	N19.1°W	127	39 Hours	152	179	171

[1] – Distance is measured from the center of the stacks for OG&E Muskogee Units 4, 5, and 6.
[2] – Bearing is measured from the center of the stacks for OG&E Muskogee Units 4, 5, and 6 from the North or South an "X" amount of degrees toward the East or West direction.

Although a maximum daily concentration does not occur at the monitor location receptor, a maximum hourly concentration did occur at the receptor on 39 hours. The monitor is located 2.72 km N34.5°W of the MAXDAILY Rank 1 receptor location. The monitor is located 2.24 km N27.6°W of the POSTFILE Rank 1 receptor location.

8. SUMMARY

8.1 What Is The Summary Of This Analysis?

The analysis was conducted utilizing the MAXDAILY and the POSTFILE output options in AERMOD. The POSTFILE analysis was conducted in addition to the MAXDAILY option recommended by the Monitoring TAD to compare the frequency of daily maximum 1-hour values to maximum 1-hour values. It is conceivable that a receptor location might observe multiple high concentrations in a single day. The MAXDAILY analysis takes only the highest concentration value for a single day. This analysis gives no additional weight to the receptor for additional highs at that receptor during the same day and can potentially skew the analysis. Analysis of the POSTFILE applies more weight to the frequency consideration in the scoring analysis.

The two analyses might be expected to show different results since different weights are being applied to frequency. It should be noticed that eight (8) of the receptors were ranked in the top 10 favorable receptor locations for both the MAXDAILY and POSTFILE analyses.

Table 8-1: Monitor Locations Ranked in the Top 10 for Both Analyses

Easting in meters (NAD 27)	Northing in meters (NAD 27)	Distance from Facility[1] (km)	Bearing from Facility[2]	NDV Rank	Daily Max Freq. Count	Daily Max Freq. Rank	Hourly Max Freq. Count	Hourly Max Freq. Rank
293250	3961250	1.51	N3.0°E	1	28	10	285	29
293500	3961000	1.3	N14.6°E	2	41	2	224	37
293500	3961250	1.55	N12.2°E	3	22	17	250	34
293000	3961000	1.27	N7.8°W	4	29	7	471	12
293000	3961250	1.52	N6.5°W	6	28	11	573	7
293500	3960750	1.06	N18.0°E	8	29	8	355	20
292500	3955750	4.05	S9.6°W	16	30	6	220	38
293750	3961250	1.62	N20.9°E	21	26	12	345	22

[1] – Distance is measured from the center of the stacks for OG&E Muskogee Units 4, 5, and 6.
[2] – Bearing is measured from the center of the stacks for OG&E Muskogee Units 4, 5, and 6 from the North or South an "X" amount of degrees toward the East or West direction.

Ideally, the most favorable receptor identified in the analysis would have both the highest NVD (a rank of 1) and the highest frequency of maximums (a rank of 1). Adding the NVD rank and maximum frequency rank together (as discussed in Section 6.3) would result in a score of 2, which is the lowest possible score for this analysis.

The scoring analysis for the MAXDAILY output option resulted in a top score of 4 for the most favorable monitoring site location. The scoring analysis for the POSTFILE output option resulted in a score of 13 for the most favorable monitoring site location. This indicates that the most favorable monitoring site location (having a score rank of 1) did not have either the highest

NDV or the highest frequency of maximums for the respective periods; however, the top receptor for both of the analyses were ranked within the top 10 for both frequency and NDV.

8.2 What Can Be Concluded From This Analysis

In general, the results for the top 200 receptors presented in the previous section indicate the most favorable monitoring locations are in the North East direction between 1.06 km to 1.62 km from the center of the three coal-fired unit stacks at the OG&E Muskogee Generating station.

The intention of this analysis was to perform modeling to provide information for favorable monitoring site locations. However, it is not certain the results are truly representative of the small area discussed herein, presently or in the future, for the reasons stated below (specifically, the questionable quality of meteorological data and impending installation of controls at OG&E Muskogee Generating Station). These results should only be considered as part of the evaluation to identify a suitable location for a monitor. Other aspects for proper siting of a monitor should be taken into consideration (such as spacing from potential obstructions, power supply, etc. as well as other considerations stated in 40 CFR Part 58, Subpart G, Appendix E).

Although the meteorological data set was developed using the most representative data available, it may not be truly representative of the overall domain. This is due to complex terrain features, atmospheric stability, and distance and location of the meteorological sites used in the development of the meteorological data set. A meteorological site located at or near the center of the domain would enhance the accuracy of the data. Additionally, modeling utilizing the meteorological data set developed from the 2012 to 2014 data may not be consistent with a meteorological data set utilizing data from past or future years.

The analysis performed is only reflective of the current source configuration for the domain. OG&E is required by the Regional Haze Program to install Best Available Retrofit Technology (BART) on Unit 4 and Unit 5. OG&E has committed to meet the federal emission limit of 0.06 lb/MMBTUH by January 4, 2019, by converting Unit 4 and Unit 5 to natural gas. With the committed changes to these sources occurring in the future, monitor locations sited based on this analysis may not suitably represent the domain after emissions are reduced as a result of BART.

9. REFERENCES

- *SO_2 NAAQS Designations Modeling Technical Assistance Document* (December 2013 Draft);
  - http://www.epa.gov/oaqps001/sulfurdioxide/pdfs/SO2ModelingTAD.pdf

- *SO_2 NAAQS Designations Source-Oriented SO_2 Monitoring Technical Assistance Document* (December 2013 Draft);
  - http://www.epa.gov/oaqps001/sulfurdioxide/pdfs/SO2MonitoringTAD.pdf

- Guidance for 1-Hour SO2 NAAQS SIP Submissions (September 22, 2011);
  - http://www.epa.gov/oaqps001/sulfurdioxide/pdfs/DraftSO2Guidance_9-22-11.pdf

- User's Guide for the AMS/EPA Regulatory Model - AERMOD
  - http://www.epa.gov/ttn/scram/models/aermod/aermod_userguide.zip

- User's Guide for the AERMOD Meteorological Data Preprocessor (AERMET)
  - http://www.epa.gov/ttn/scram/7thconf/aermod/aermet_userguide.zip

- AERMINUTE User's Instruction
  - http://www.epa.gov/ttn/scram/7thconf/aermod/aerminute_14337.zip

- AERSURFACE User's Guide
  - http://www.epa.gov/ttn/scram/7thconf/aermod/aersurface_userguide.pdf

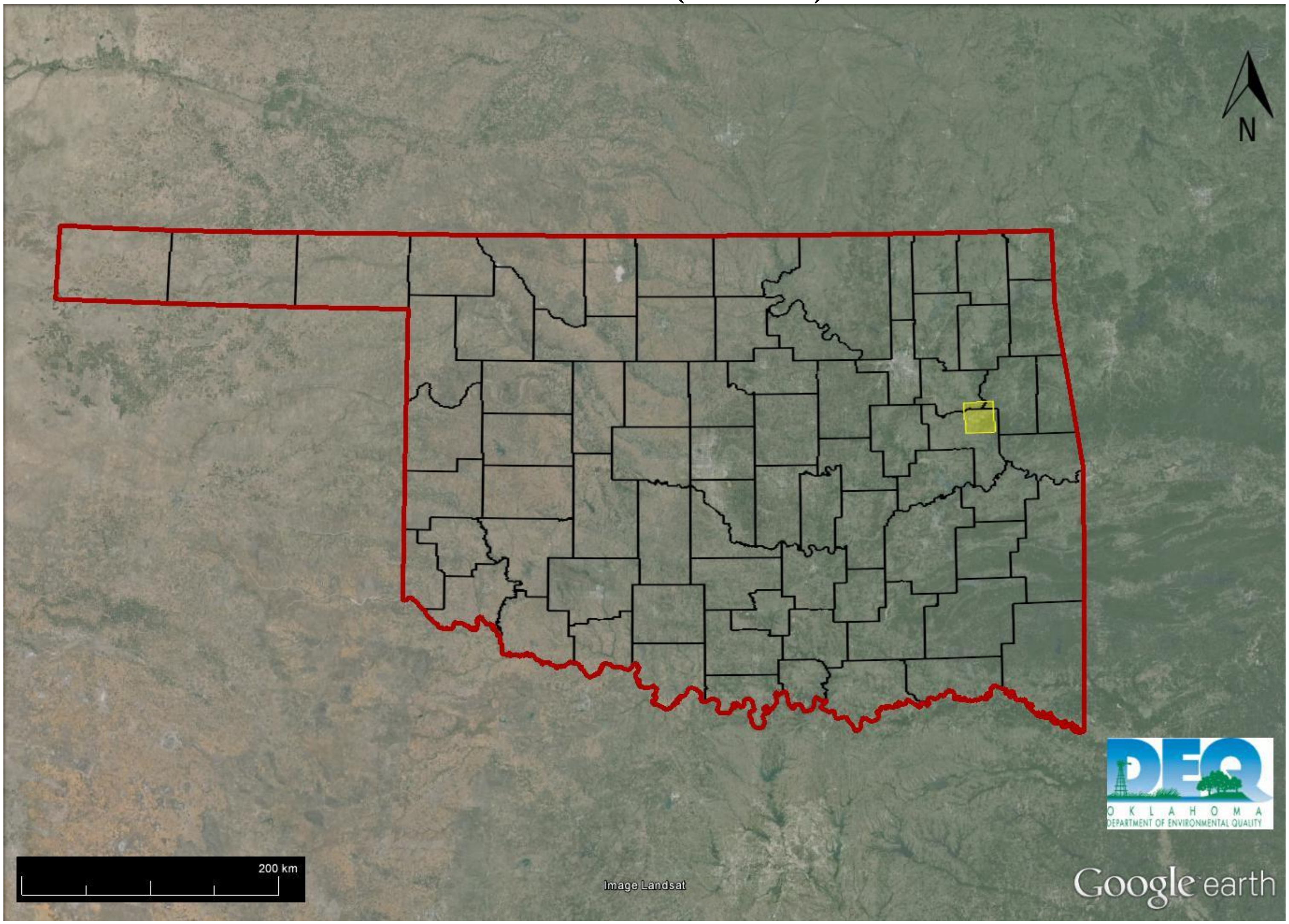
- *Guidance Concerning the Implementation of the 1-hour SO_2 NAAQS for the Prevention of Significant Deterioration Program* (August 23, 2010);
  - http://www.epa.gov/region07/air/nsr/nsrmemos/appwso2.pdf

- *Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 NAAQS* (August 23, 2010);
  - http://www.epa.gov/ttn/scram/guidance/clarification/ClarificationMemo_AppendixW_Hourly-SO2-NAAQS_FINAL_08-23-2010.pdf

- *Data Requirements Rule for the 1-Hour Sulfur Dioxide (SO2) Primary National Ambient Air Quality Standards (NAAQS), Proposed* (May 13, 2014);
  - http://www.gpo.gov/fdsys/pkg/FR-2014-05-13/pdf/2014-09458.pdf

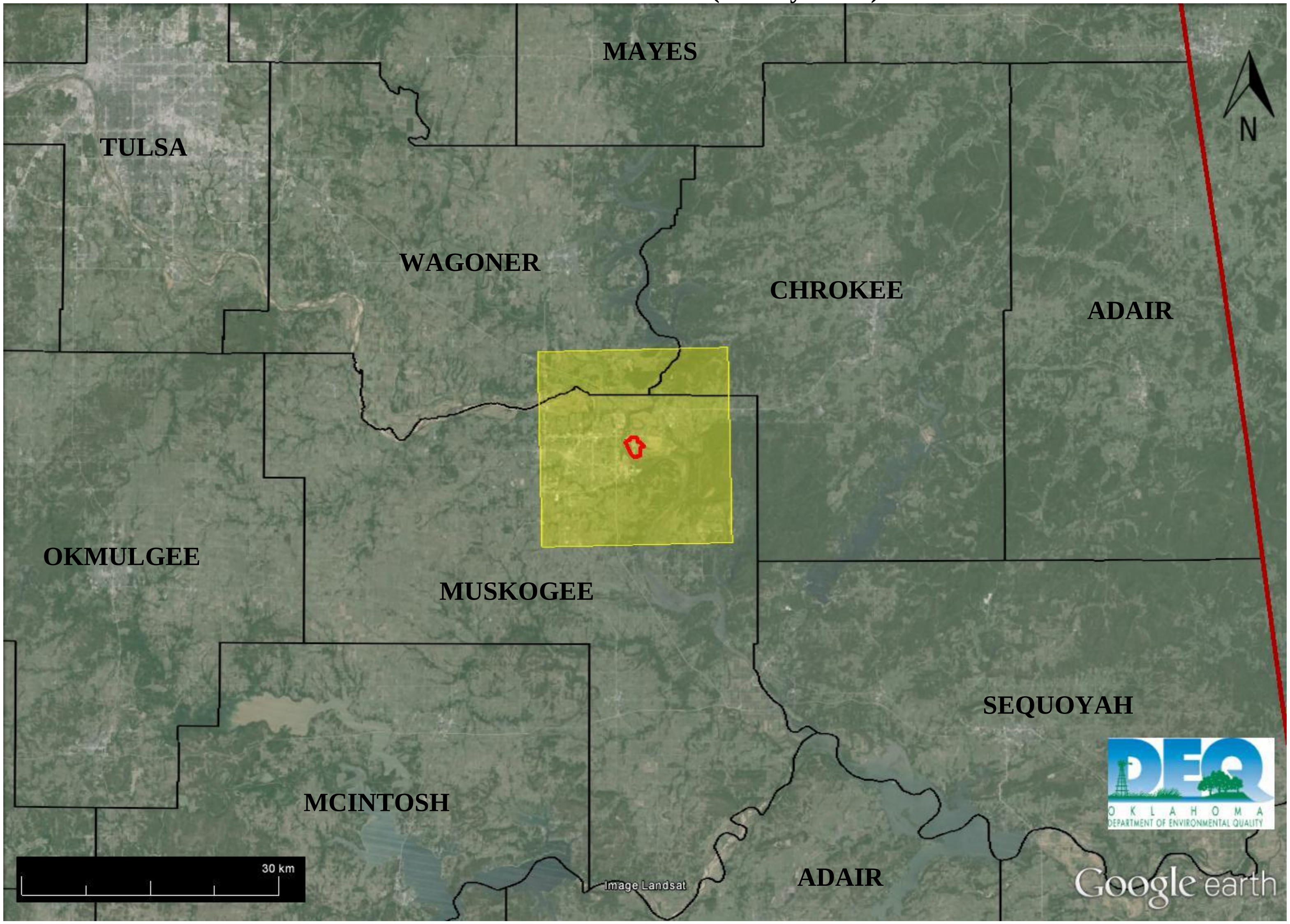
APPENDIX A DOMAIN LOCATION

Domain Location (State Level)



* Boundaries: Red – State of Oklahoma; Black - Oklahoma Counties; Yellow – Modeling Domain.

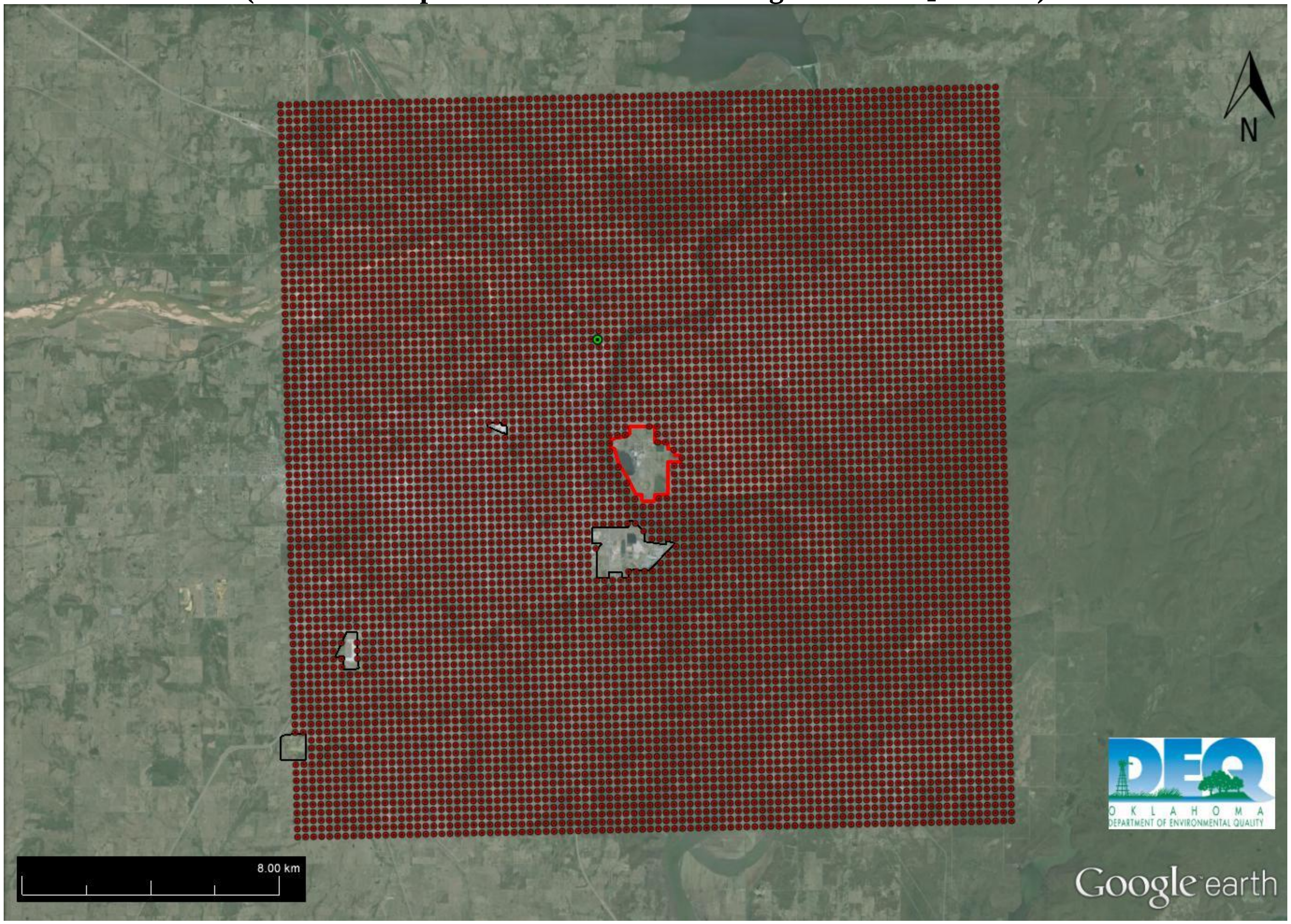
Domain Location (County Level)



* Boundaries: Red – State of Oklahoma; Black - Oklahoma Counties; Yellow – Modeling Domain.
** Red fence line for OG&E Muskogee Generating Station

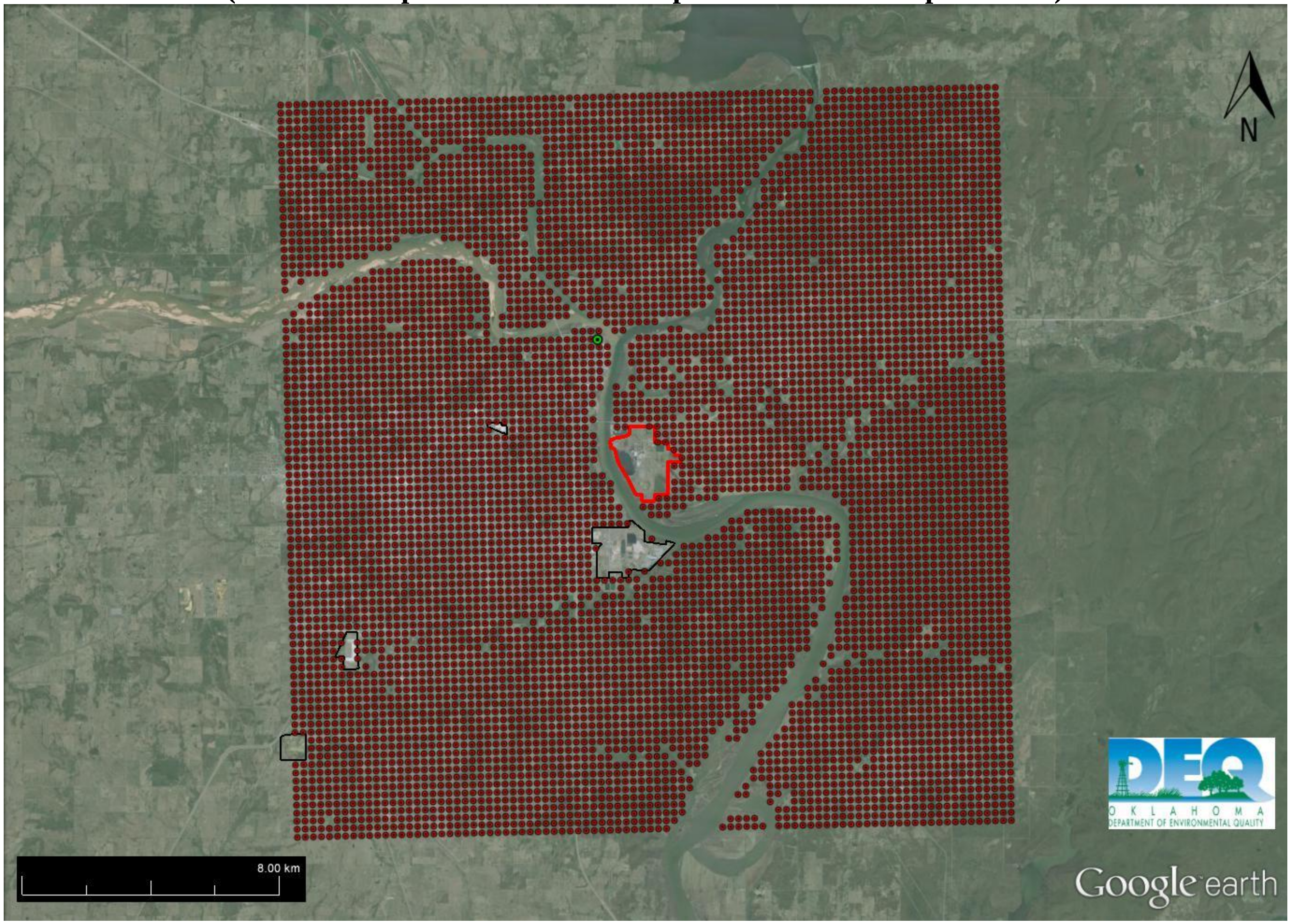
APPENDIX B RECEPTOR GRID

10 km Receptor Grid
(excludes receptors within fence lines of significant SO_2 sources)



* Red fence line identifies OG&E Muskogee Generating Station.
** Black fence lines indicate other significant SO_2 sources within receptor grid.
*** Green receptor located at Muskogee SO_2 monitor location.

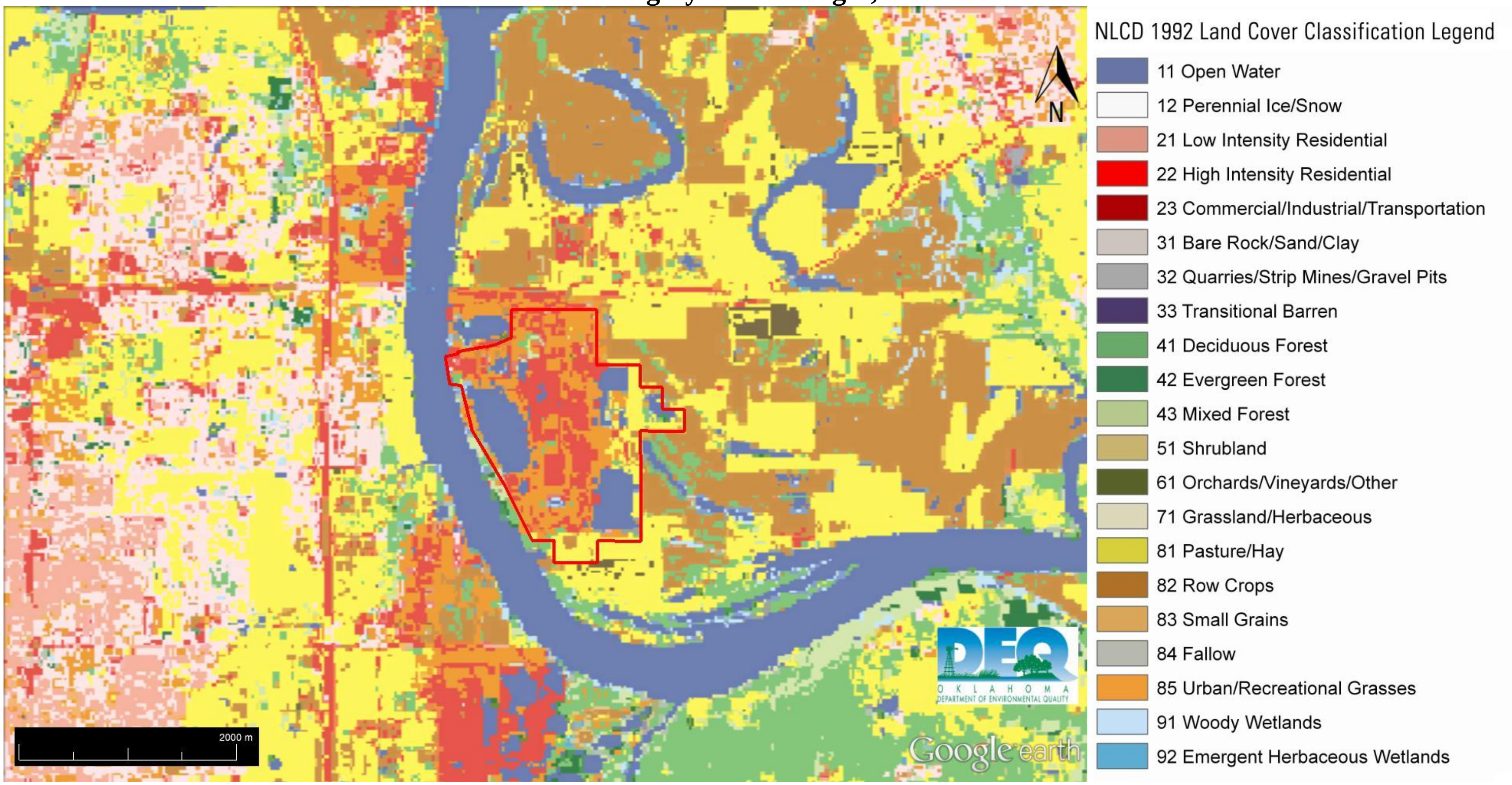
Revised 10 km Receptor Grid
(excludes receptors not suitable for permanent monitor placement)



* Red fence line identifies OG&E Muskogee Generating Station.
** Black fence lines indicate other significant SO_2 sources within receptor grid.
*** Green receptor located at Muskogee SO_2 monitor location.

APPENDIX C LAND COVER CLASSIFICATION (NLCD 1992)

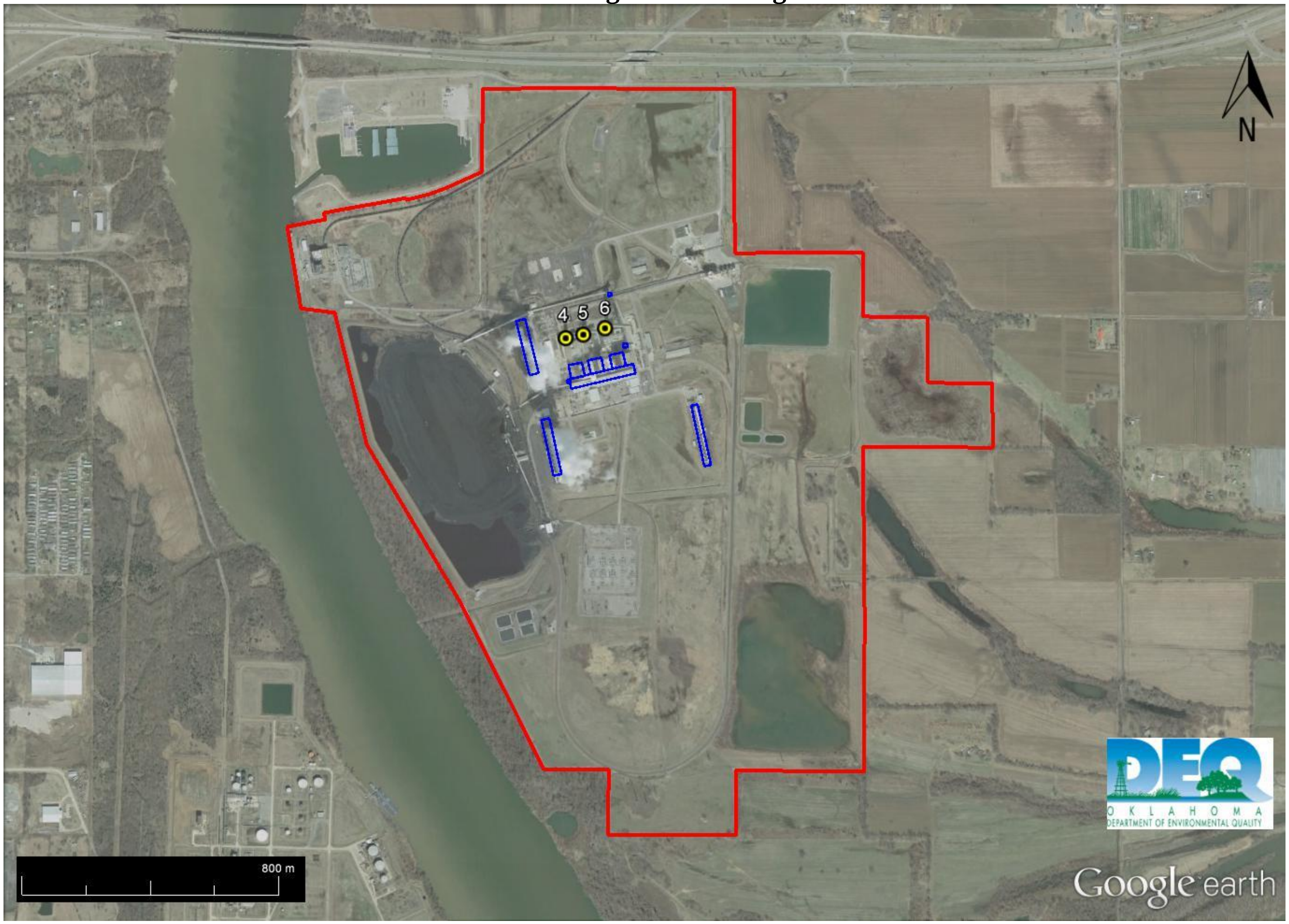
Land Cover Imagery for Muskogee, Oklahoma Area



* Red fence line identifies OG&E Muskogee Generating Station.

APPENDIX D AERIAL IMAGE WITH FACILITY DATA

OG&E – Muskogee Generating Station



* Blue – Buildings; Red – Fence line; Yellow – Point Sources.

APPENDIX E SOURCE DATA

Modeled Emission Points and Stack Parameters

Source ID	Facility	Easting[1] (m)	Northing[1] (m)	Elevation (m)	Stk Ht (m)	Stk Temp (K)	Velocity (m/s)	Stk Dia (m)	SO_2 (g/s)
UNIT 4	OG&E Muskogee	293116.7	3959729.8	156.2	106.68	437.04	26.62	7.32	0.96950
UNIT 5	OG&E Muskogee	293172.0	3959739.3	156.8	106.68	429.26	25.79	7.32	0.93782
UNIT 6	OG&E Muskogee	293240.4	3959757.7	157.0	152.40	418.71	32.35	6.55	1.00000
DAL20	Dalitalia	284208.4	3953784.7	171.2	14.11	336.20	9.08	1.51	0.00000*
DAL23	Dalitalia	284164.9	3953711.7	170.8	10.97	520.20	24.84	0.62	0.00000*
DAL29	Dalitalia	284093.8	3953787.7	171.0	15.64	335.37	7.35	1.63	0.00000*
BORSCRUB	Boral	282161.2	3951159.0	183.5	21.34	452.59	11.06	1.89	0.01291
GPSTACK1	Georgia Pacific	292555.0	3956494.1	161.9	79.25	451.48	8.67	3.05	0.02527
GPSTACK3	Georgia Pacific	292594.0	3956513.0	162.0	79.25	425.37	8.61	4.20	0.12218
OBFURNA	Owens Brockway	288620.7	3960596.6	179.6	45.72	765.37	8.89	1.62	0.00275
OBFURNB	Owens Brockway	288656.6	3960582.4	180.0	24.38	471.48	8.81	2.16	0.00551
M1	US Lime	334096.8	3940641.2	203.6	45.73	403.00	17.40	1.63	0.00601
K1	US Lime	334000.6	3940571.3	204.5	29.27	341.33	9.51	2.13	0.00005
UNIT 1	GRDA	294138.0	4007357.0	189.5	153.62	422.04	20.77	6.10	0.85326
UNIT 2	GRDA	294211.0	4007262.0	188.8	154.53	360.93	27.73	6.10	0.27333

[1] – UTM coordinates (Zone 15) are relative to NAD 27 datum.

* Emissions relative to other facilities within the domain were so small that the normalized emission rates did not register.

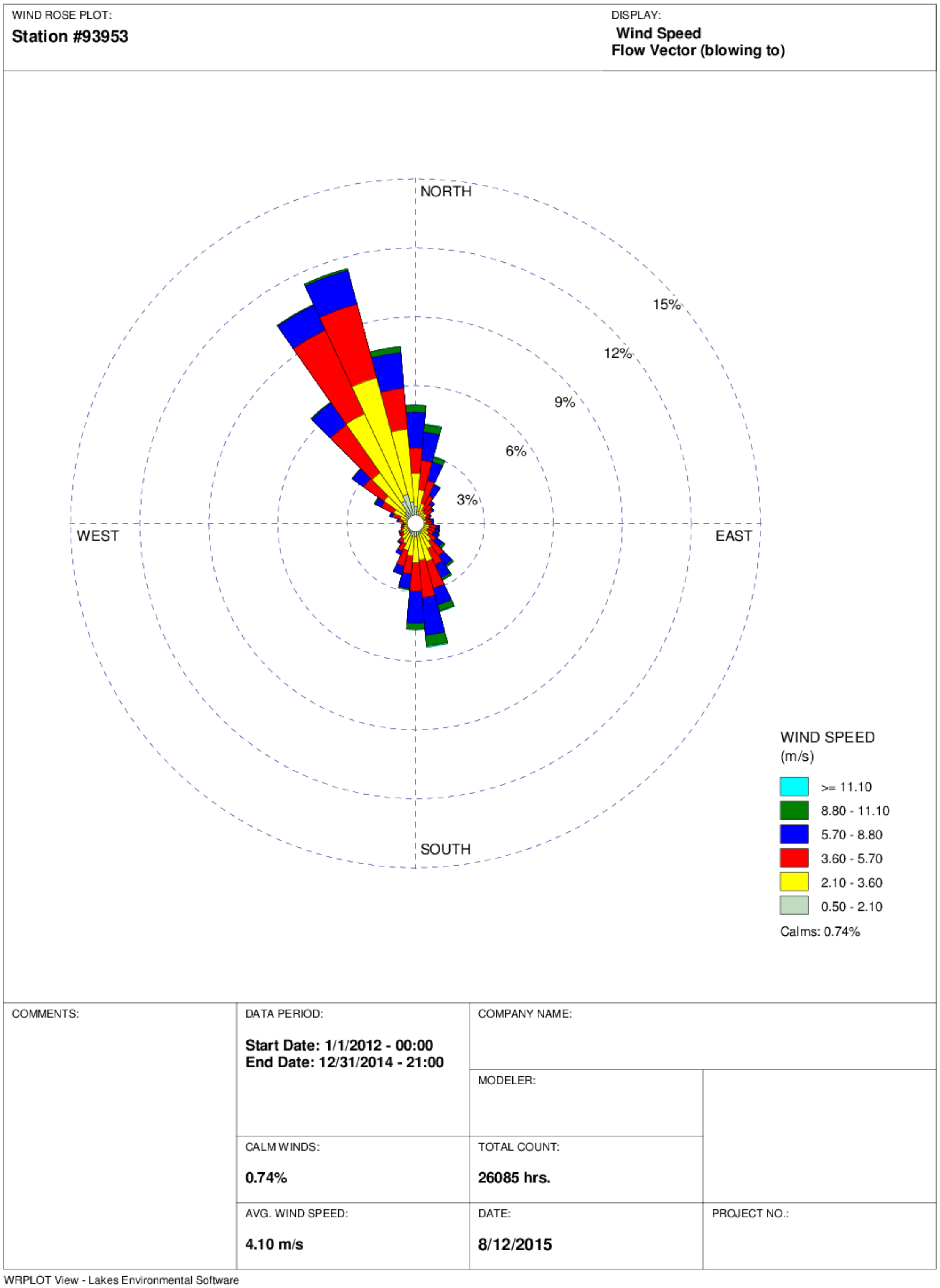
APPENDIX F METEOROLOGICAL DATA

Site and Location Information

Meteorological Network	**Oklahoma Mesonet**	**ISHD**	**ESRL**
Meteorology Type	Surface	Surface	Upper Air
Site Name	Porter	Davis Field/Muskogee	Norman
Site Call Sign	PORT	KMKO	OUN
USAF	---	723556	---
Latitude (NAD 83)	35.8257	35.6577	35.23
Longitude (NAD 83)	-95.5598	-95.3658	-97.47
County	Wagoner County, Oklahoma	Muskogee County, Oklahoma	Oklahoma County, Oklahoma
Elevation (m)	193	183.5	---

APPENDIX G WIND ROSE

2012-2014 KMKO Wind Rose



APPENDIX H SURFACE CHARACTERISTICS

Modeling Domain Surface Characteristics

	Albedo	Bowen Ratio (Average)	Bowen Ratio (Wet)	Bowen Ratio (Dry)	Surface Roughness
KMKO					
Winter	0.18	0.72	0.41	1.94	0.016
Spring	0.14	0.33	0.22	1.03	0.023
Summer	0.19	0.50	0.30	1.42	0.037
Fall	0.19	0.72	0.41	1.94	0.031

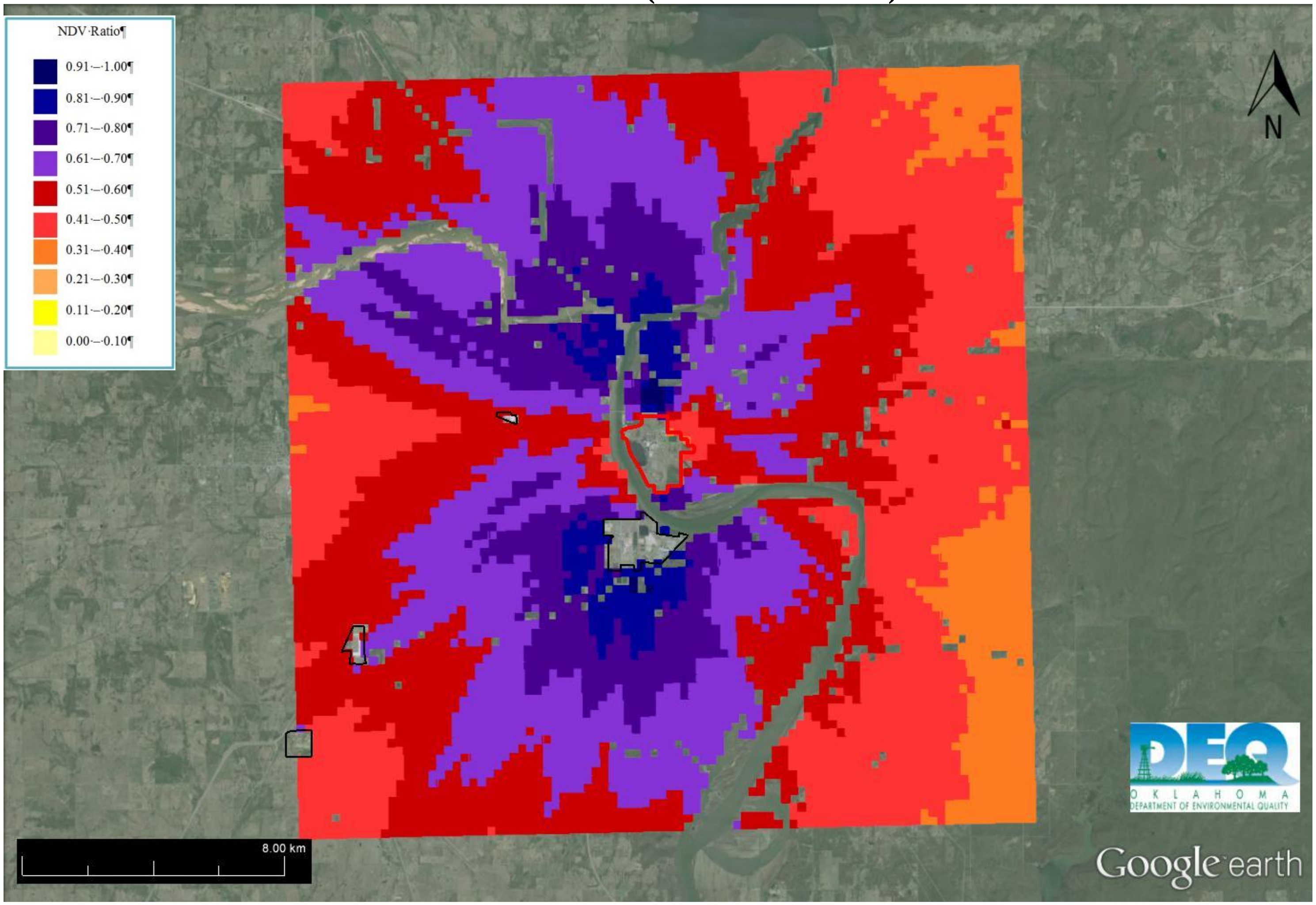
Modeling Domain Moisture Conditions[1]

Year	**2012**	**2013**	**2014**
January	A	W	D
February	A	W	D
March	W	A	A
April	D	W	A
May	D	A	W
June	D	A	W
July	D	A	W
August	A	A	A
September	A	D	A
October	D	A	W
November	D	A	A
December	D	W	A

[1] – Moisture conditions based on rainfall data from the Porter Oklahoma Mesonet station.
A – Average (precipitation in the middle 40th percentile);
D – Dry (precipitation in the lower 30th percentile);
W – Wet (precipitation in the upper 30th percentile).

APPENDIX I NORMALIZED DESIGN VALUE RESULTS

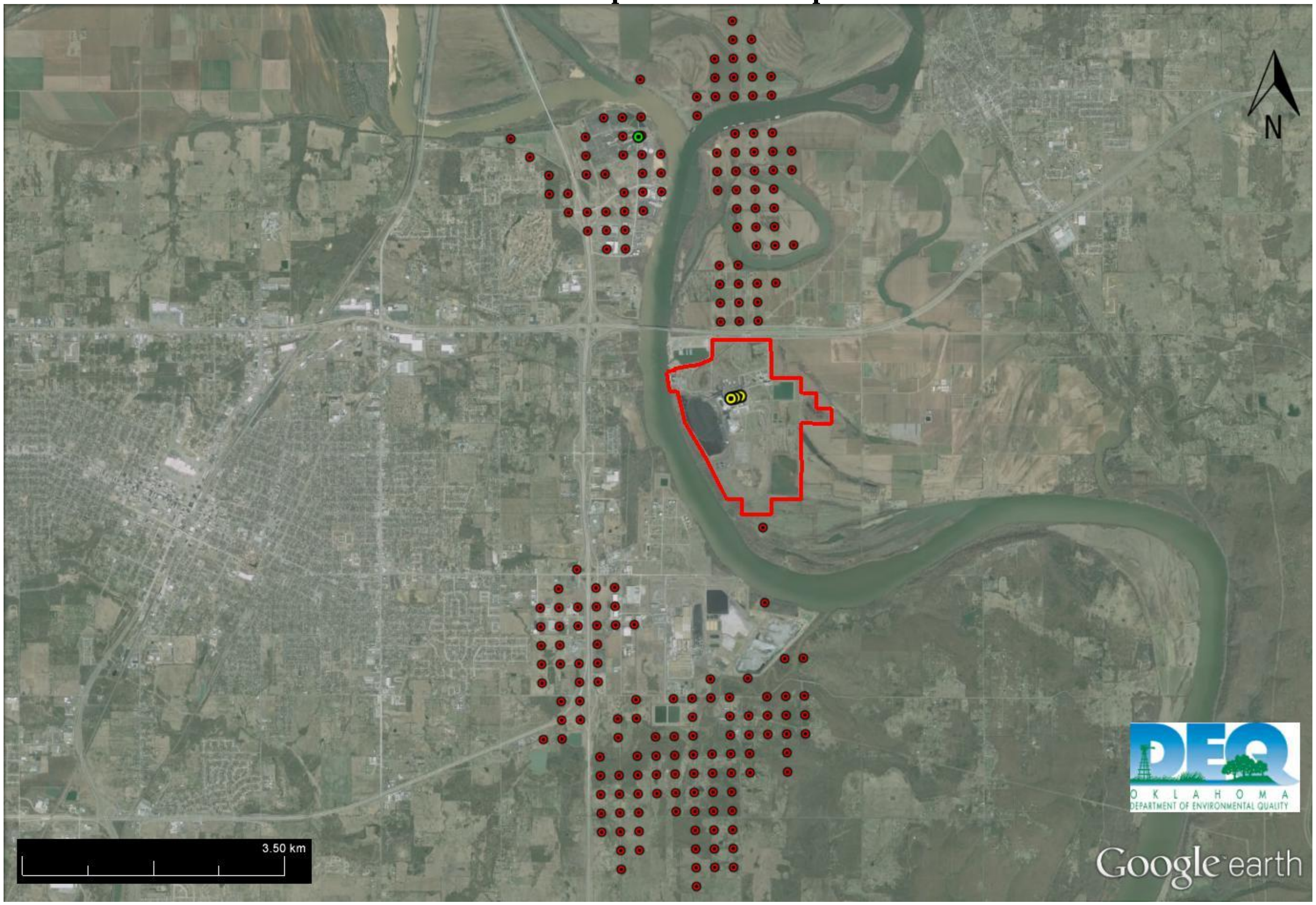
Ratio of the NDVs (based on max NDV)



* Red fence line identifies OG&E Muskogee Generating Station.
** Black fence lines indicate other significant SO_2 sources within receptor grid.

APPENDIX J TOP 200 RECEPTORS

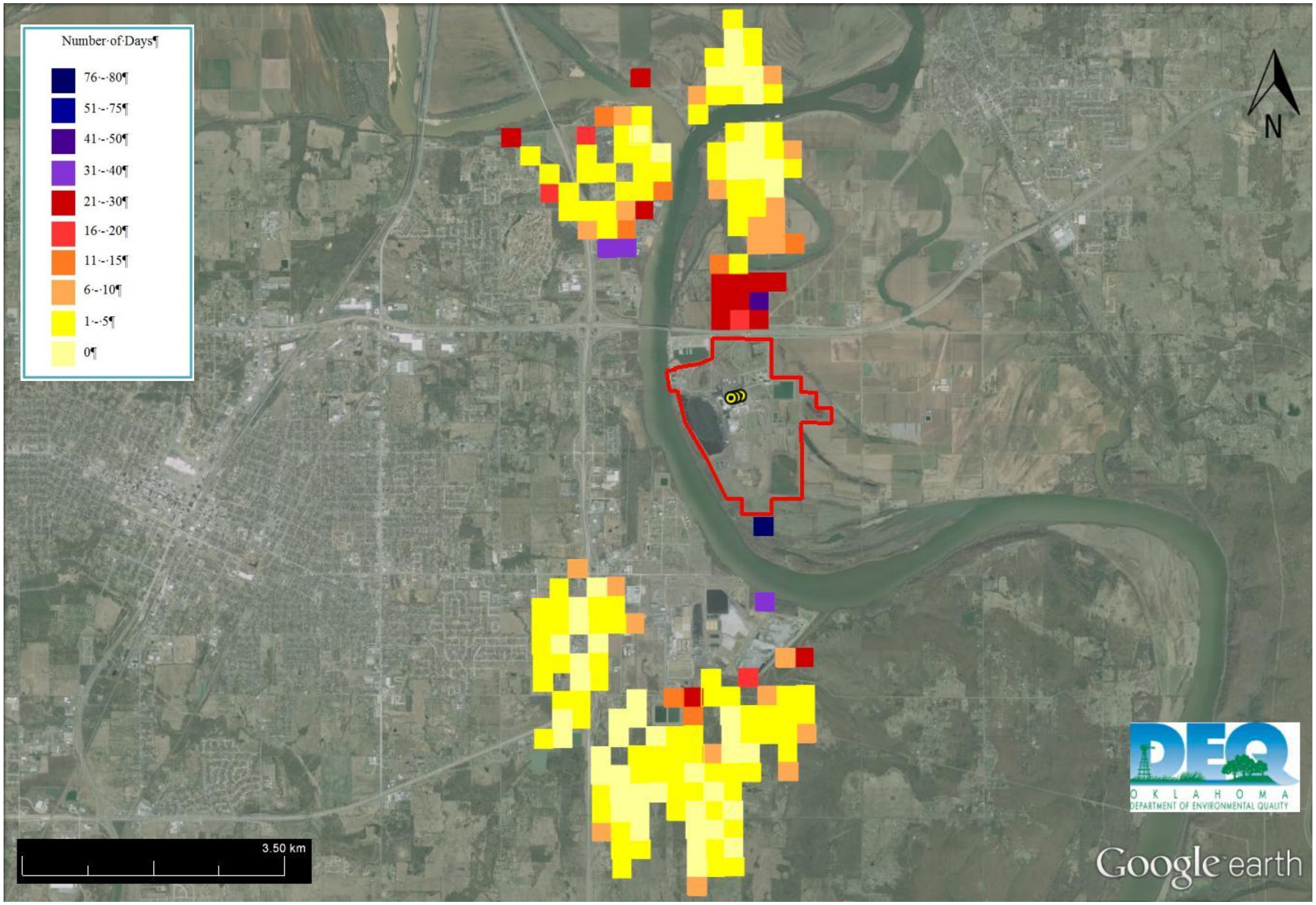
Location of top 200 NDV Receptors



* Red fence line identifies OG&E Muskogee Generating Station.
** Green receptor located at Muskogee SO_2 monitor location.

APPENDIX K MAXIMUM DAILY FREQUENCY

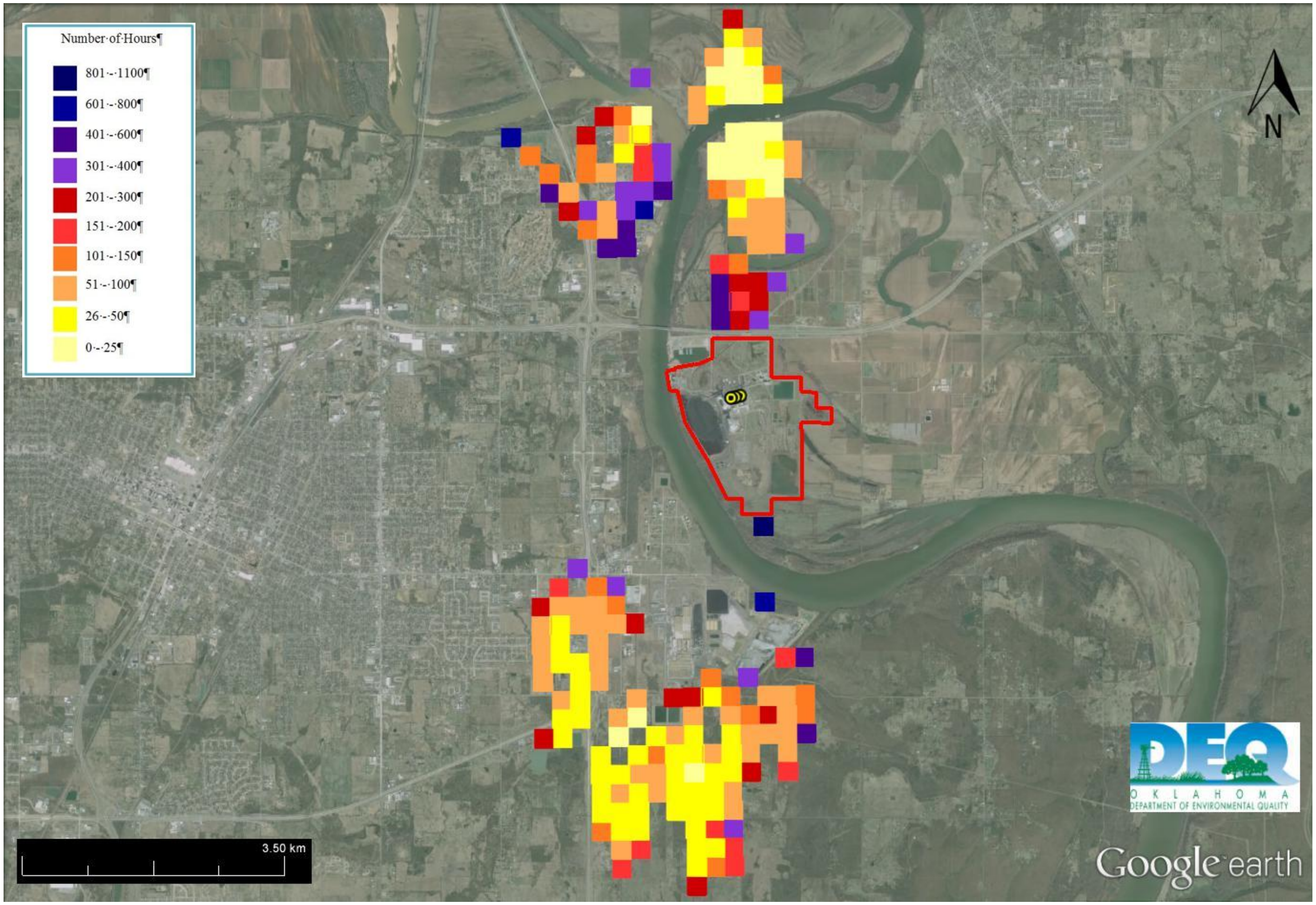
MAXDAILY Maximum 1-Hour Concentration Count



* Red fence line identifies OG&E Muskogee Generating Station.

APPENDIX L MAX HOURLY FREQUENCY

POSTFILE Maximum 1-Hour Concentration Count



* Red fence line identifies OG&E Muskogee Generating Station.

2010 Primary Sulfur Dioxide (SO_2) National Ambient Air Quality Standard (NAAQS)

Technical Analyses and Information Supporting the Designation Recommendation for Oklahoma

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OG&E's Public Statements on Commitments to Meet EPA's Regional Haze FIP Requirements

Muskogee Generating Station: Conversion of Units 4 & 5 to Natural Gas
Sooner Generating Station: Installation of Dry Scrubbers on Units 1 & 2

As Provided by Usha-Maria Turner, Director of Corporate Environmental

Oklahoma Gas and Electric Company

On July 7, 2015

DEQ
OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

OG&E's Public Statements on the Conversion of Muskogee Units 4 & 5 to Natural Gas.

The U.S Environmental Protection Agency (EPA) finalized requirements for certain coal-fired units in Oklahoma under the Regional Haze program on December 28, 2011[1]. In that rule, EPA took final action in disapproving the 2010 State Implementation Plan (SIP) limit for sulfur dioxide (SO_2) and established new limits (rolling, 30-day SO_2 emission limit of 0.06 lbs/mmBtu) under a Federal Implementation Plan (FIP) for these units in Oklahoma including 4 owned and operated by OG&E: Muskogee units 4 & 5; Sooner units 1 & 2.

To comply with the Oklahoma Regional Haze FIP, OG&E plans to install Dry, Flue Gas Desulfurization systems (commonly called dry "scrubbers") along with baghouse/fabric filter technology, on Sooner Units 1 and 2. While installing that same technology at Muskogee Units 4 and 5 would meet the FIP's SO_2 emission limits, OG&E plans to convert the boilers at Muskogee Units 4 and 5 from utilizing low sulfur coal to utilizing natural gas exclusively and will meet the SO_2 limits by ceasing the combustion of sulfur-containing coal at these two units.[2]

OG&E has made this commitment to gas conversion on Muskogee Units 4 & 5 in several public documents including:

1. 10Q filing before the Securities Exchange Commission (SEC)[3].
   "On August 6, 2014, OG&E filed an application with the OCC for approval of its plan to comply with EPA's MATS and Regional Haze FIP while serving the best long-term interests of customers in light of future environmental uncertainties. The application seeks approval of the environmental compliance plan and for a recovery mechanism for the associated costs. The environmental compliance plan includes installing dry scrubbers at Sooner Units 1 and 2 and the conversion of Muskogee Units 4 and 5 to natural gas."

2. Integrated Resource Planning 2014 Update[4] filing with the Oklahoma Corporation Commission (OCC):

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[1]Federal Register. Vol. 76, No. 249. Wednesday, December 28, 2011 p 81728
[2] Direct Testimony of Usha-Maria Turner before the OCC, page 5. Available *at* *http://imaging.occeweb.com/AP/CaseFiles/occ5129575.pdf*
[3] 2nd quarter 2014 10Q. Commission File Number: 1-12579; August 7th 2014. The Company reiterated this plan in the subsequent quarterly SEC 10Q filings as well as in the annual 10K filed with the SEC on February 26, 2015. All filings available at http://phx.corporate-ir.net/phoenix.zhtml?c=106374&p=irol-sec.
[4] Integrated Resource Plan (IRP) – 2014 Update; page 5. Filed August 6, 2014 with the OCC. Available at http://phx.corporate-ir.net/phoenix.zhtml?c=106374&p=irol-utilityreg

"OG&E takes very seriously its responsibility to provide reliable, reasonably priced power produced in an environmentally responsible way. This IRP reflects OG&E's plan to meet federal mandates in a way that minimizes the impact on customers. Unfortunately, all alternatives available to the Company increase customer costs. After carefully considering all these factors, OG&E has decided to convert two coal-fired units at the Muskogee Power Plant to natural gas, add scrubbers to the coal-fired units at the Sooner power plant, and other pollution control equipment…"

3. Testimony of Usha-Maria Turner filed before the Oklahoma Corporation Commission (OCC) cause number PUD 201400229[5]

OG&E plans to convert Muskogee units 4 & 5 to natural gas before the deadline of January 4, 2019 and OG&E plans to submit the permit application to the Oklahoma DEQ closer in time to the need. Prior to the start of operation of these units on natural gas, the pipeline supply to the facility has to be expanded in order to run these two units on solely natural gas.

[5] *Supra at 2*

2010 Primary Sulfur Dioxide (SO_2)
National Ambient Air Quality Standard (NAAQS)

Technical Analyses and Information Supporting the Designation Recommendation for Oklahoma

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List of Modeling Files Included in Zip File "Modeling.7z" on DVD

[Modeling\CEM Data]

{YEAROKMO.zip} - zip files that contain a CSV file with the CEM data for all the CAMD affected sources in the state of Oklahoma for the specified year and month.

[Modeling\CEM Data\2011-2014]

This is the working folder for processing the CAMD CEM data files

[Modeling\CEM Data\2011-2014\GRDA]

This is the working folder for the GRDA CEM data.

{2012-14 GRDA.prn}

Text file containing the 2012 through 2014 continuous hourly input data formatted for AERMOD for each emission unit for the given years.

{2012-14 GRDA.xlsx}

Excel file used to combine data from each year and each emission unit into a single file.

{YEAR-Grand River Dam Authority-#.csv}

CSV file containing the continuous hourly input data formatted for AERMOD for the specific year and emission unit.

{YEAR-Grand River Dam Authority-#-RAW.csv}

CSV file that contains the raw hourly CEM data for the specific year and emission unit.

{YEAR-Grand River Dam Authority-#-RAW Analysis.xlsx}

Excel file used to analyze the CEM data for that specific year and emission unit.

[Modeling\CEM Data\2011-2014\Hugo]

This is the working folder for the HUGO CEM data.

{2012-14 HUGO.prn}

Text file containing the 2012 through 2014 continuous hourly input data formatted for AERMOD for each emission unit for the given years.

{2012-14 HUGO.xlsx}

Excel file used to combine data from each year and each emission unit into a single file.

{YEAR-Hugo-#.csv}

CSV file containing the continuous hourly input data formatted for AERMOD for the specific year and emission unit.

{YEAR-Hugo -#-RAW.csv}

CSV file that contains the raw hourly CEM data for the specific year and emission unit.

{YEAR-Hugo -#-RAW Analysis.xlsx}

Excel file used to analyze the CEM data for that specific year and emission unit.

[Modeling\CEM Data\2011-2014\Muskogee]

This is the working folder for the MUSKOGEE CEM data.

{2012-14 MUSKOGEE.prn}

Text file containing the 2012 through 2014 continuous hourly input data formatted for AERMOD for each emission unit for the given years.

{2012-14 MUSKOGEE.xlsx}

Excel file used to combine data from each year and each emission unit into a single file.

{YEAR-Muskogee-#.csv}

CSV file containing the continuous hourly input data formatted for AERMOD for the specific year and emission unit.

{YEAR-Muskogee -#-RAW.csv}

CSV file that contains the raw hourly CEM data for the specific year and emission unit.

{YEAR-Muskogee -#-RAW Analysis.xlsx}

Excel file used to analyze the CEM data for that specific year and emission unit.

[Modeling\CEM Data\2011-2014\OG&E]

This folder contains operational RATA data from the OG&E facilities.

[Modeling\CEM Data\2011-2014\OG&E\Muskogee]

This folder contains Excel files which contain the OG&E Muskogee CEM temperature and velocity data for each unit.

{YEAR_Stk.xls}

Excel file with temperature and velocity data for each unit for the specific year.

[Modeling\CEM Data\2011-2014\OG&E\Sooner]

This folder contains Excel files which contain the OG&E Sooner CEM temperature and velocity data for each unit.

{YEAR_Stk.xls}

Excel file with temperature and velocity data for each unit for the specific year.

[Modeling\CEM Data\2011-2014\RATA]

This folder contains the Relative Accuracy Test Audit (RATA) reports.

{YEAR Facility Unit #.pdf}

Adobe files of RATA reports for the specific facility, emission unit, and year.

{Facility RATA.xls}

Excel file analyzing RATA data for the specific facility.

[Modeling\CEM Data\2011-2014\Sooner]

This is the working folder for the SOONER CEM data.

{2012-14 SOONER.prn}

Text file containing the 2012 through 2014 continuous hourly input data formatted for AERMOD for each emission unit for the given years.

{2012-14 SOONER.xlsx}

Excel file used to combine data from each year and each emission unit into a single file.

{YEAR-Sooner-#.csv}

CSV file containing the continuous hourly input data formatted for AERMOD for the specific year and emission unit.

{YEAR-Sooner -#-RAW.csv}

CSV file that contains the raw (unprocessed) hourly CEM data for the specific year and emission unit.

{YEAR-Sooner -#-RAW Analysis.xlsx}

Excel file used to analyze the raw (unprocessed) CEM data for that specific year and emission unit.

[Modeling\Domain 20]

This is the working folder for modeling the WFEC Hugo facility.

This folder contains the following files for each modeling run:

AERMOD INPUT {Domain 20CEM_3yrs_SO2.dta}
AERMOD OUTPUT {Domain 20CEM_3yrs_SO2.lst}

AERMAP INPUT {AerMap - Domain 20.map}
AERMAP OUTPUT {AerMap - Domain 20.rcf/srf}

BPIP INPUT {Domain 20CEM.PIP}
BPIP OUTPUT {Domain 20CEM.TAB/SUM/SO}

MAXDCONT Files
{Domain 20CEM_3yrs_SO2_1-hr_ALL_4_10_MAXDCONT##.OUT}

Graphic File {Domain 20CEM_3yrs_SO2.GRF}
Summary File {Domain 20CEM_3yrs_SO2.sum}

This folder contains Excel files of the original data submitted to the AQD from the affected facilities which contain the source, building, and fence line data for the affected facility.
{WEFC Hugo.xlsx} & {International Paper IP Valliant – Zone 14.xlsx}

Excel files with the nearby source data.
{ARIES Data (D20 50km).xls} & {TX Source Data.xlsx}

[Modeling\ Domain 20\NED – Domain 20]

This folder contains folders that contain the National Elevation Dataset (NED) for Domain 20.

[Modeling\ Domain 20\SO2 Actuals]

This folder contains excel files with the actual emissions for the sources within Domain 20.
{Export_FACID.xls}
Actual emission inventory data for the given facility ID.

[Modeling\Domain 36]

This is the working folder for modeling the OG&E Muskogee facility.

This folder contains the following files for each modeling run:

AERMAP INPUT {AerMap Muskogee 1 hr SO2.map}
AERMAP OUTPUT {AerMap Muskogee 1 hr SO2.rcf/srf}

BPIP INPUT {BPIP - Domain 36.PIP}
BPIP OUTPUT {BPIP - Domain 36.TAB/SUM/SO}

<u>Scenario 1</u>

AERMOD INPUT {Domain 36CEM_3yrs_SO2.dta}
AERMOD OUTPUT {Domain 36CEM_3yrs_SO2.lst}

MAXDCONT Files
{Domain 36CEM_3yrs_SO2_1-hr_ALL_4_10_MAXDCONT.OUT}

Graphic File {Domain 36CEM_3yrs_SO2.GRF}
Summary File {Domain 36CEM_3yrs_SO2.sum}

<u>Scenario 2</u>

AERMOD INPUT {Domain 36CEM(4BART)_3yrs_SO2.dta}
AERMOD OUTPUT {Domain 36CEM(4BART)_3yrs_SO2.lst}

MAXDCONT Files
{Domain 36CEM(4BART)_3yrs_SO2_1-hr_ALL_4_10_MAXDCONT.OUT}

Graphic File {Domain 36CEM(4BART)_3yrs_SO2.GRF}
Summary File {Domain 36CEM(4BART)_3yrs_SO2.sum}

<u>Scenario 3</u>

AERMOD INPUT {Domain 36CEM(4&5BART)_3yrs_SO2.dta}
AERMOD OUTPUT {Domain 36CEM(4&5BART)_3yrs_SO2.lst}

MAXDCONT Files
{Domain 36CEM(4&5BART)_3yrs_SO2_1-hr_ALL_4_10_MAXDCONT.OUT}

Graphic File {Domain 36CEM(4&5BART)_3yrs_SO2.GRF}
Summary File {Domain 36CEM(4&5BART)_3yrs_SO2.sum}

This folder contains Excel files of the original data submitted to the AQD from the affected facilities which contain the source, building, and fence line data for the affected facility.
{GPMuskogee.xlsx}, {OG+E Muskogee.xlsx}, & {OwensBrockwayMuskogee.xlsx}

Excel files with the nearby source data.
{ARIES Data (D36 50km).xls}

[Modeling\ Domain 36\34866640]
[Modeling\ Domain 36\80750470]

These folders contain folders that contain the National Elevation Dataset (NED) for Domain 36.

[Modeling\ Domain 36\SO2 Actuals]

This folder contains excel files with the actual emissions for the sources within Domain 36.
{Export_FACID.xls}
Actual emission inventory data for the given facility ID.

[Modeling\Domain 39]

This is the working folder for modeling the OG&E Sooner facility.

This folder contains the following files for each modeling run:

AERMAP INPUT {AerMap D39.map}
AERMAP OUTPUT {AerMap D39.rcf/srf}

BPIP INPUT {BPIP - Domain 39.PIP}
BPIP OUTPUT {BPIP - Domain 39.TAB/SUM/SO}

Scenario 1

AERMOD INPUT {Domain 39CEM_3yrs_SO2.dta}
AERMOD OUTPUT {Domain 39CEM_3yrs_SO2.lst}

MAXDCONT Files
{Domain 39CEM_3yrs_SO2_1-hr_ALL_4_10_MAXDCONT.OUT}

Graphic File {Domain 39CEM_3yrs_SO2.GRF}
Summary File {Domain 39CEM_3yrs_SO2.sum}

Scenario 2

AERMOD INPUT {Domain 39CEM(Unit 1BART)_3yrs_SO2.dta}
AERMOD OUTPUT {Domain 39CEM(Unit 1BART)_3yrs_SO2.lst}

MAXDCONT Files
{Domain 39CEM(Unit 1BART)_3yrs_SO2_1-hr_ALL_4_10_MAXDCONT.OUT}

Graphic File {Domain 39CEM(Unit 1BART)_3yrs_SO2.GRF}
Summary File {Domain 39CEM(Unit 1BART)_3yrs_SO2.sum}

Scenario 3

AERMOD INPUT {Domain 39CEM(Unit 1&2BART)_3yrs_SO2.dta}
AERMOD OUTPUT {Domain 39CEM(Unit 1&2BART)_3yrs_SO2.lst}

MAXDCONT Files
{Domain 39CEM(Unit 1&2BART)_3yrs_SO2_1-hr_ALL_4_10_MAXDCONT.OUT}

Graphic File {Domain 39CEM(Unit 1&2BART)_3yrs_SO2.GRF}
Summary File {Domain 39CEM(Unit 1&2BART)_3yrs_SO2.sum}

This folder contains Excel files of the original data submitted to the AQD from the affected facilities which contain the source, building, and fence line data for the affected facility.

{OG+E Sooner.xlsx}

Excel files with the nearby source data.

{ARIES Data (D39 30km).xls}

[Modeling\ Domain 39\06094179]
[Modeling\ Domain 39\12946169]
[Modeling\ Domain 39\53071583]
[Modeling\ Domain 39\66051945]
[Modeling\ Domain 39\86184492]

These folders contain folders that contain the National Elevation Dataset (NED) for Domain 39.

[Modeling\ Domain 39\SO2 Actuals]

This folder contains excel files with the actual emissions for the sources within Domain 39.

{Export_FACID.xls}

Actual emission inventory data for the given facility ID.

[Modeling\Meteorological Data]

This is the working folder for processing the meteorological data.

[Modeling\Meteorological Data\HUGO]

This is the working folder for processing the meteorological data for the WFEC Hugo modeling domain.

[Modeling\Meteorological Data\HUGO\BEEST]

This is folder contains the GUI files and the AERMET input output files.

{HUGOYR.(IN1/IN2/IN3)

Input files for the specific station and year. IN1/IN2/IN3 designates the AERMET processing stage (1, 2, or 3).

{HUGOYR.(MS1/MS2/MS3)

Message files for the specific station and year. MS1/MS2/MS3 designates the AERMET processing stage (1, 2, or 3).

{HUGOYR.(RP1/RP2/RP3)

Report files for the specific station and year. RP1/RP2/RP3 designates the AERMET processing stage (1, 2, or 3).

{HUGOYR.(SFC/PFL)

AERMET output files containing the processed meteorological data for the specific year and station.

[Modeling\Meteorological Data\HUGO\FSL Data]

This folder contains the ESRL RAOB data files for each year.

{YEAR_FWD.txt}

Text files with the ESRL data for the specific year from FWD station.

[Modeling\Meteorological Data\HUGO\ISH Data]

This folder contains the ISHD data files for each year.

{720559-99999-YEAR} or {720559-00172-YEAR} {USAFID-WBAN#-YEAR}

Text files with the ISHD data for the specific station and year.

[Modeling\Meteorological Data\HUGO\Mesonet Data]

This folder contains the Oklahoma Mesonet data files for each year.

{YEARHUGO.prn}

Text files with the Oklahoma Mesonet Data for the specific year for the HUGO station.

[Modeling\Meteorological Data\KMKO]

This is the working folder for processing the meteorological data for the OG&E Muskogee modeling domain.

[Modeling\Meteorological Data\KMKO\BEEST]

This is folder contains the GUI files and the AERMET input output files.

{KMKOYR.(IN1/IN2/IN3)

Input files for the specific station and year. IN1/IN2/IN3 designates the AERMET processing stage (1, 2, or 3).

{KMKOYR.(MS1/MS2/MS3)

Message files for the specific station and year. MS1/MS2/MS3 designates the AERMET processing stage (1, 2, or 3).

{KMKOYR.(RP1/RP2/RP3)

Report files for the specific station and year. RP1/RP2/RP3 designates the AERMET processing stage (1, 2, or 3).

{KMKOYR.(SFC/PFL)

AERMET output files containing the processed meteorological data for the specific year and station.

[Modeling\Meteorological Data\KMKO\FSL Data]

This folder contains the ESRL RAOB data files for each year.

{YEAR_OUN.txt}

Text files with the ESRL data for the specific year from OUN station.

[Modeling\Meteorological Data\KMKO\ISH Data]

This folder contains the ISHD data files for each year.

{723556-93953-YEAR} {USAFID-WBAN#-YEAR}

Text files with the ISHD data for the specific station and year.

[Modeling\Meteorological Data\KMKO\ISH Data\AERMINUTE]

This folder contains the AERMINUTE data processor files.

{64050KMKOYEARMO.dat}

The 6405 data (AERMINUTE data processor input files) for the KMKO station.

{HourlyYR.txt}

The hourly input file for AERMOD output from AERMINUTE.

{SummaryYR.csv}

The summary output file from AERMINUTE.

[Modeling\Meteorological Data\REDR]

This is the working folder for processing the meteorological data for the OG&E Sooner modeling domain.

[Modeling\Meteorological Data\REDR\BEEST]

This is folder contains the GUI files and the AERMET input output files.

{REDRYR.(IN1/IN2/IN3)

Input files for the specific station and year. IN1/IN2/IN3 designates the AERMET processing stage (1, 2, or 3).

{REDRYR.(MS1/MS2/MS3)

Message files for the specific station and year. MS1/MS2/MS3 designates the AERMET processing stage (1, 2, or 3).

{REDRYR.(RP1/RP2/RP3)

Report files for the specific station and year. RP1/RP2/RP3 designates the AERMET processing stage (1, 2, or 3).

{REDRYR.(SFC/PFL)

AERMET output files containing the processed meteorological data for the specific year and station.

[Modeling\Meteorological Data\REDR\FSL Data]

This folder contains the ESRL RAOB data files for each year.

{YEAR_OUN.txt}

Text files with the ESRL data for the specific year from FWD station.

[Modeling\Meteorological Data\REDR\ISH Data]

This folder contains the ISHD data files for each year.

{723545-03965-YEAR} {USAFID-WBAN#-YEAR}

Text files with the ISHD data for the specific station and year.

[Modeling\Meteorological Data\REDR\Mesonet Data]

This folder contains the Oklahoma Mesonet data files for each year.

{YEARREDR.prn}

Text files with the Oklahoma Mesonet Data for the specific year for the REDR station.

[Modeling\Meteorological Data\REDR\ISH Data\AERMINUTE]

This folder contains the AERMINUTE data processor files.

{64050KSWOYEARMO.dat}

The 6405 data (AERMINUTE data processor input files) for the KSWO station.

{HourlyYR.txt}

The hourly input file for AERMOD output from AERMINUTE.

{SummaryYR.csv}

The summary output file from AERMINUTE.

[Modeling\Meteorological Data\AERSURFACE]

This folder contains all of the AERSURFACE files used in processing the meteorological data.

{CALL_(A/D/W).(log/txt)}

These are the individual AERSURFACE run files (log) and output (txt) for the specific station given by their call signs. They contain the primary and secondary (if used) meteorological data stations. ISHD Stations: (KHHW, KMKO, KPRX, & KSWO); Mesonet Stations (REDR, PORT, & REDR). The A, D, W options are descriptors defining if the AERSURFACE run was conducted using average – A, dry – D, or wet – W conditions when determining the Bowen Ratio.

Names enclosed with **brackets []** are folder names.
Names enclosed with curly brackets {} are file names.

CSV – Comma Separated Value
CAMD – Clean Air Markets Database
CEM – Continuous Emission Monitoring

- Emission unit
Facility – Name of facility.
FACID – Facility ID number (TEAM Database).
YEAR – Specific year which the file contains data (e.g. 2012).
YR – Specific year which the file contains data (e.g. 12).
MO – Specific month for which the file contains data (e.g. 01).

.rcf – Receptor file
.srf – Source file