Big Brown Steam Electric Station

Fairfield, Texas

Evaluation of Compliance with the 1-hour NAAQS for SO_2

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1. Introduction

Wingra Engineering, S.C. was hired by Sierra Club to conduct an air modeling impact analysis to help the U.S. Environmental Protection Agency (USEPA), state and local air agencies identify facilities that are likely causing exceedances of the 1-hour sulfur dioxide (SO_2) national ambient air quality standard (NAAQS). This document describes the results and procedures for an evaluation of the Big Brown Steam Electric Station located in Fairfield, Texas.

This analysis supplements the evaluation described in the December 15, 2015 report prepared on behalf of the Sierra Club. To improve the accuracy, this analysis used actual hourly emissions and stack exhaust flow rates for the 2013-15 period. This analysis also incorporates a lower background concentration than the previous December 2015 modeling.

The dispersion modeling analysis predicted ambient air concentrations for comparison with the 1-hour SO_2 NAAQS. The modeling was performed using the most recent version of AERMOD, AERMET, and AERMINUTE, with data provided to Sierra Club by regulatory air agencies or obtained through other publicly-available sources as documented below. The analysis was conducted in adherence to all available USEPA guidance for evaluating source impacts on attainment of the 1-hour SO_2 NAAQS via aerial dispersion modeling, including the AERMOD Implementation Guide; USEPA's Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010; modeling guidance promulgated by USEPA in Appendix W to 40 CFR Part 51; USEPA's March 2011 Modeling Guidance for SO_2 NAAQS Designations; [1] and, USEPA's December 2013 SO_2 NAAQS Designations Technical Assistance Document.[2]

It was determined that based on measured actual emissions, the Big Brown Steam Electric Station is estimated to create SO_2 concentrations which exceed the 1-hour NAAQS.

2. Compliance with the 1-hour SO_2 NAAQS

2.1 1-hour SO_2 NAAQS

The 1-hour SO_2 NAAQS takes the form of a three-year average of the 99^{th}-percentile of the annual distribution of daily maximum 1-hour concentrations, which cannot exceed 75 parts per billion (ppb).[3] Compliance with this standard was verified using USEPA's AERMOD air dispersion model, which produces air concentrations in units of $\mu g/m^3$. The 1-hour SO_2 NAAQS of 75 ppb equals

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[1] http://www.epa.gov/scram001/so2_modeling_guidance.htm
[2] http://www.epa.gov/oaqps001/sulfurdioxide/pdfs/SO2ModelingTAD.pdf
[3] USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010.

196.2 µg/m^3, and this is the value used for determining whether modeled impacts exceed the NAAQS.[4] The 99th-percentile of the annual distribution of daily maximum 1-hour concentrations corresponds to the fourth-highest value at each receptor for a given year.

2.2 Modeling Results

Modeling results for Big Brown Steam Electric Station are summarized in Table 1. It was determined that based on measured actual emissions, the Big Brown Steam Electric Station is estimated to create downwind SO_2 concentrations which exceed the 1-hour NAAQS. "Actual" represents the emissions which occurred during each hour of the 2013-15 period. Actual emission measurements were taken from two databases, USEPA *Clean Air Markets Program Data (CAMD)* [5] and the Emissions Modeling Clearinghouse State-Level Hourly Sulfur Dioxide (SO_2) Data. [6]

To more accurately predict the dispersion of emissions, hourly exit velocities were used. Continuous emissions monitor measurements were not publicly available for this analysis so exit velocities were derived from the hourly flow rates and heat input in the USEPA Clearinghouse and CAMD databases. The Clearinghouse emissions and exit velocities for 2013-14 were supplemented with CAMD emissions for 2015. The velocities for 2015 were derived from the hourly heat input reported in CAMD.

Air quality impacts in Texas are based on a background concentration of 5.2 µg/m^3. This is the 2012-14 design value for El Paso, Texas—the lowest measured background concentration in the state. This is the most recently available design value. See Section 5 for further discussion of the background concentrations used for this analysis.

Table 1 - SO_2 Modeling Results for Big Brown Steam Electric Station

Emission Rates	Averaging Period	99th Percentile 1-hour Daily Maximum (µg/m^3)				Complies with NAAQS?
		Impact	Background	Total	NAAQS	
Actual 2013-15	1-hour	316.1	5.2	321.3	196.2	No

[4] The ppb to µg/m^3 conversion is found in the source code to AERMOD v. 15181, subroutine Modules. The conversion calculation is 75/0.3823 = 196.2 µg/m^3.
[5] http://ampd.epa.gov/ampd/
[6] https://www3.epa.gov/ttn/chief/emch/so2naaqs/index.html

Figure 1 shows the extent of NAAQS violations based on actual hourly emissions for the 2013-15 period.

2.3 Conservative Modeling Assumptions

A dispersion modeling analysis requires the selection of numerous parameters which affect the predicted concentrations. For the enclosed analysis, several parameters were selected which under-predict facility impacts.

Assumptions used in this modeling analysis which likely under-estimate concentrations include the following:

- No consideration of building or structure downwash. These downwash effects typically increase predicted concentrations near the facility.
- No consideration of off-site sources. These other sources of SO_2 will increase the predicted impacts.
- Air quality impacts are based on a background SO_2 concentration of 5.2 $\mu g/m^3$, which is the lowest measured background concentration in the state. Given the proximity to other major sources of SO_2, the actual background concentration is likely much higher.
- No evaluation has been conducted to determine if the stack height exceeds Good Engineering Practice or GEP height. If the stack height exceeds GEP, the predicted concentrations will increase.

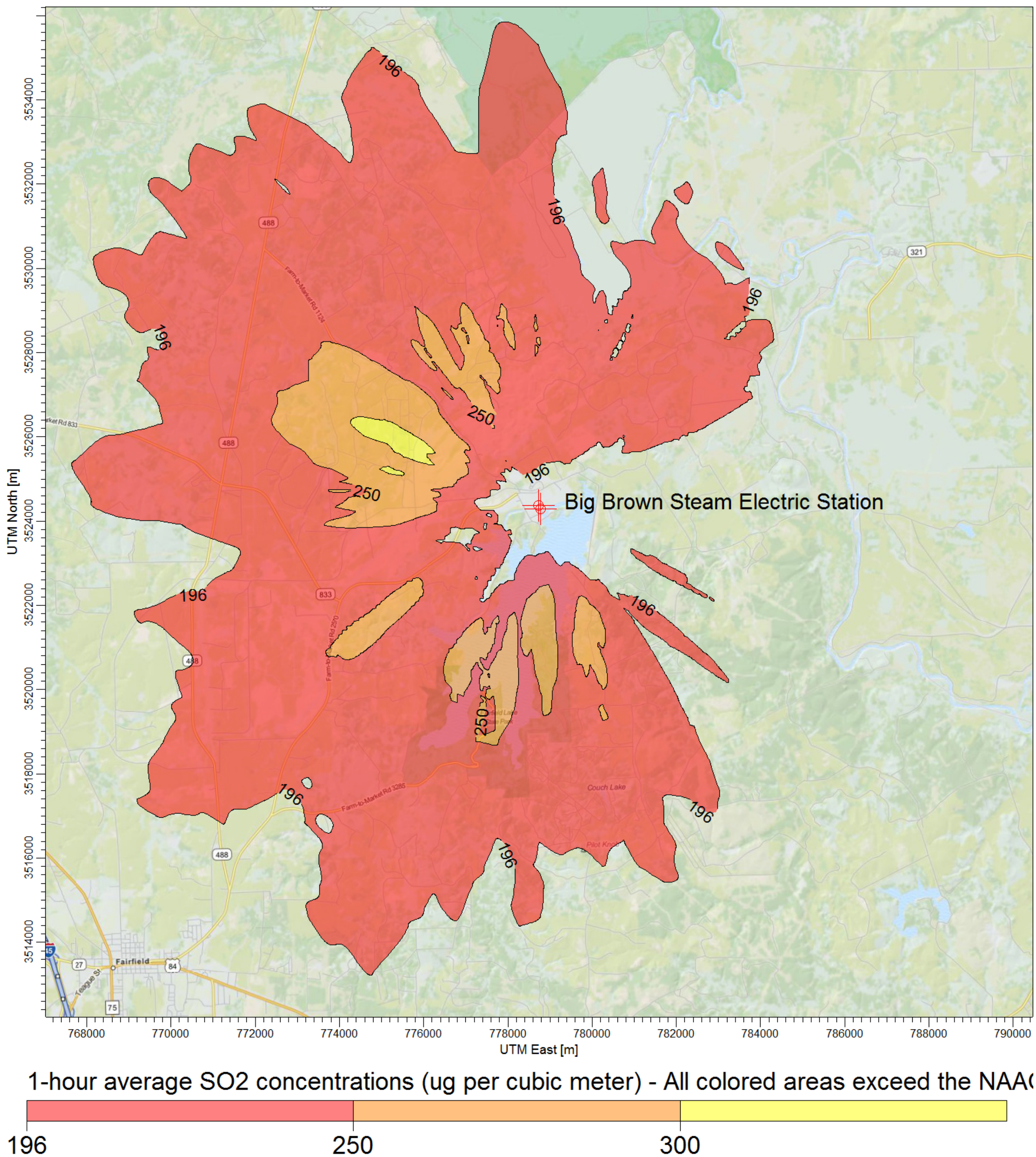

Figure 1 - Impacts Based on Actual Emissions & Exit Velocities from Big Brown Steam Electric Station

3. Modeling Methodology

3.1 Air Dispersion Model

The modeling analysis used USEPA's AERMOD program, v. 15181. AERMOD, as available from the Support Center for Regulatory Atmospheric Modeling (SCRAM) website, was used in conjunction with a third-party modeling software program, *AERMOD View*, sold by Lakes Environmental Software.

3.2 Control Options

The AERMOD model was run with the following control options:

- 1-hour average air concentrations
- Regulatory defaults
- Flagpole receptors

To reflect a representative inhalation level, a flagpole height of 1.5 meters was used for all modeled receptors. This parameter was added to the receptor file when running AERMAP, as described in Section 4.4.

An evaluation was conducted to determine if the modeled facility was located in a rural or urban setting using USEPA's methodology outlined in Section 7.2.3 of the Guideline on Air Quality Models.[7] For urban sources, the URBANOPT option is used in conjunction with the urban population from an appropriate nearby city and a default surface roughness of 1.0 meter. Methods described in Section 4.1 were used to determine whether rural or urban dispersion coefficients were appropriate for the modeling analysis.

3.3 Output Options

The AERMOD analysis was based on three years of recent meteorological data. The modeling analyses used one run with three years of sequential meteorological data from 2013-2015. Consistent with USEPA's Modeling Guidance for SO_2 NAAQS Designations, AERMOD provided a table of fourth-high 1-hour SO_2 impacts concentrations consistent with the form of the 1-hour SO_2 NAAQS.[8]

Please refer to Table 1 for the modeling results.

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[7] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005.
[8] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, pp. 24-26.

4. Model Inputs

4.1 Geographical Inputs

The "ground floor" of all air dispersion modeling analyses is establishing a coordinate system for identifying the geographical location of emission sources and receptors. These geographical locations are used to determine local characteristics (such as land use and elevation), and also to ascertain source to receptor distances and relationships.

The Universal Transverse Mercator (UTM) NAD83 coordinate system was used for identifying the easting (x) and northing (y) coordinates of the modeled sources and receptors. Stack locations were obtained from facility permits and prior modeling files provided by the state regulatory agency. The stack locations were then verified using aerial photographs.

The facility was evaluated to determine if it should be modeled using the rural or urban dispersion coefficient option in AERMOD. A Geographic Information System (GIS) was used to determine whether rural or urban dispersion coefficients apply to a site. Land use within a three-kilometer radius circle surrounding the facility was considered. USEPA guidance states that urban dispersion coefficients are used if more than 50% of the area within 3 kilometers has urban land uses. Otherwise, rural dispersion coefficients are appropriate.[9]

USEPA's AERSURFACE v. 13016 was used to develop the meteorological data for the modeling analysis. This model was also used to evaluate surrounding land use within 3 kilometers. Based on the output from the AERSURFACE, approximately 0.8% of surrounding land use around the modeled facility was of urban land use types including Type 21 – Low Intensity Residential, Type 22 – High Intensity Residential and Type 23 – Commercial / Industrial / Transportation.

This is less than the 50% value considered appropriate for the use of urban dispersion coefficients. Based on the AERSURFACE analysis, it was concluded that the rural option would be used for the modeling summarized in this report. Please refer to Section 4.5.3 for a discussion of the AERSURFACE analysis.

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[9] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005, Section 7.2.3.

4.2 Emission Rates and Source Parameters

The modeling analyses only considered SO_2 emissions from the facility. Off-site sources were not considered. Stack parameters used for the modeling analysis are summarized in Table 2. The exit temperature was held constant but the hourly exit velocity varied based on flow rate and heat input information provided by USEPA Clearinghouse and CAMD databases.

Table 2 – Facility Stack Parameters[10]

Facility	Big Brown	
Stack	B01	B02
Description	Unit 1	Unit 2
X Coord. [m]	778731.22	778774.22
Y Coord. [m]	3524371.07	3524295.07
Base Elevation [m]	98.61	98
Release Height [m]	122	122
Gas Exit Temperature [°K]	459	459
Inside Diameter [m]	6.77	6.77
Gas Exit Velocity [m/s]	-	-
Actual Emission Rate [g/s]	-	-

The above stack parameters and emissions were obtained from regulatory agency documents and databases identified in Section 2.2. Stack location, height and diameter were verified using aerial photographs, and flue gas flow rate and temperature were verified using combustion calculations.

4.3 Building Dimensions

No building dimensions or prior downwash evaluations were available. Therefore this modeling analysis did not address the effects of downwash and this may under-predict impacts.

4.4 Receptors

For Big Brown Steam Electric Station, three receptor grids were employed:

1. A 100-meter Cartesian receptor grid centered on Big Brown Steam Electric Station and extending out 5 kilometers.
2. A 500-meter Cartesian receptor grid centered on Big Brown Steam Electric Station and extending out 10 kilometers.

[10] Height and exit area were obtained from the USEPA Emissions Modeling Clearinghouse State-Level Hourly Sulfur Dioxide (SO_2) Data. Exit temperatures were obtained from the annual survey compiled by the U.S. Energy Information Administration. http://www.eia.gov/electricity/data/eia860/

3. A 1,000-meter Cartesian receptor grid centered on Big Brown Steam Electric Station and extending out 50 kilometers. 50 kilometers is the maximum distance accepted by USEPA for the use of the AERMOD dispersion model.[11]

A flagpole height of 1.5 meters was used for all these receptors.

Elevations from stacks and receptors were obtained from National Elevation Dataset (NED) GeoTiff data. GeoTiff is a binary file that includes data descriptors and geo-referencing information necessary for extracting terrain elevations. These elevations were extracted from 1 arc-second (30 meter) resolution NED files. The USEPA software program AERMAP v. 11103 is used for these tasks.

4.5 Meteorological Data

To improve the accuracy of the modeling analysis, recent meteorological data for the 2013-2015 period were prepared using the USEPA's program AERMET which creates the model-ready surface and profile data files required by AERMOD. Required data inputs to AERMET included surface meteorological measurements, twice-daily soundings of upper air measurements, and the micrometeorological parameters surface roughness, albedo, and Bowen ratio. One-minute ASOS data were available so USEPA methods were used to reduce calm and missing hours.[12] The USEPA software program AERMINUTE v. 15272 is used for these tasks. AERMET was used to randomize wind directions for NWS wind data if one-minute ASOS wind speeds were not available for any periods.

This section discusses how the meteorological data was prepared for use in the 1-hour SO_2 NAAQS modeling analyses. The USEPA software program AERMET v. 15181 is used for these tasks.

4.5.1 Surface Meteorology

Surface meteorology was obtained for Corsicana Campbell Field located near the Big Brown Steam Electric Station. Integrated Surface Hourly (ISH) data for the 2013-2015 period were obtained from the National Climatic Data Center (NCDC). The ISH surface data was processed through AERMET Stage 1, which performs data extraction and quality control checks.

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[11] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, Section A.1.(1), November 9, 2005.

[12] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, p. 19.

4.5.2 Upper Air Data

Upper-air data are collected by a "weather balloon" that is released twice per day at selected locations. As the balloon is released, it rises through the atmosphere, and radios the data back to the surface. The measuring and transmitting device is known as either a radiosonde, or rawindsonde. Data collected and radioed back include: air pressure, height, temperature, dew point, wind speed, and wind direction. The upper air data were processed through AERMET Stage 1, which performs data extraction and quality control checks.

For Big Brown Steam Electric Station, the concurrent 2013-2015 upper air data from twice-daily radiosonde measurements obtained at the most representative location were used. This location was the Fort Worth, Texas measurement station. These data are in Forecast Systems Laboratory (FSL) format and were downloaded in ASCII text format from NOAA's FSL website.[13] All reporting levels were downloaded and processed with AERMET.

4.5.3 AERSURFACE

AERSURFACE is a program that extracts surface roughness, albedo, and daytime Bowen ratio for an area surrounding a given location. AERSURFACE uses land use and land cover (LULC) data in the U.S. Geological Survey's 1992 National Land Cover Dataset to extract the necessary micrometeorological data. LULC data was used for processing meteorological data sets used as input to AERMOD.

AERSURFACE v. 13016 was used to develop surface roughness, albedo, and daytime Bowen ratio values in a region surrounding the meteorological data collection site. AERSURFACE was used to develop surface roughness in a one kilometer radius surrounding the data collection site. Bowen ratio and albedo was developed for a 10 kilometer by 10 kilometer area centered on the meteorological data collection site. These micrometeorological data were processed for seasonal periods using 30-degree sectors. Seasonal moisture conditions were considered average with winter months having no continuous snow cover.

4.5.4 Data Review

Missing meteorological data were not filled as the data file met USEPA's 90% data completeness requirement.[14] The AERMOD output file shows there were 0.99% missing data.

To confirm the representativeness of the airport meteorological data, the surface characteristics of

[13] Available at: http://esrl.noaa.gov/raobs/
[14] USEPA, Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-05, February 2000, Section 5.3.2, pp. 5-4 to 5-5.

the airport data collection site and the modeled source location were compared. Since the Corsicana Campbell Field is located close to Big Brown Steam Electric Station, this meteorological data set was considered appropriate for this modeling analysis.[15] This weather station provided high quality surface measurements for the most recent 3-year time, and had similar land use, surface characteristics, terrain features and climate.

Finally, TCEQ provides pre-processed meteorological data suitable for modeling for each county.[16] For Freestone County, TCEQ recommends using data from the same surface and upper air stations used for this modeling analysis. The TCEQ data were not used for this project because they were not from the most recent years needed for this analysis and had not been processed using the latest versions of USEPA modeling software.

5. Background SO_2 Concentrations

Background concentrations were determined consistent with USEPA's Modeling Guidance for SO_2 NAAQS Designations.[17, 18] To preserve the form of the 1-hour SO_2 standard, based on the 99th percentile of the annual distribution of daily maximum 1-hour concentrations averaged across the number of years modeled, the background fourth-highest daily maximum 1-hour SO_2 concentration was added to the modeled fourth-highest daily maximum 1-hour SO_2 concentration.[19] Background concentrations were based on the 2012-14 design value measured by the ambient monitors located in Texas.[20]

6. Reporting

All files from the programs used for this modeling analysis are available to regulatory agencies. These include analyses prepared with AERSURFACE, AERMET, AERMAP, and AERMOD.

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[15] USEPA, AERMOD Implementation Guide, March 19, 2009, pp. 3-4.
[16] Texas Commission on Environmental Quality, Meteorological Data for Refined Screening with AERMOD, http://www.tceq.texas.gov/permitting/air/modeling/aermod-datasets.html, Last updated November 22, 2013.
[17] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, pp. 20-23.
[18] USEPA, SO_2 NAAQS Designations Modeling Technical Assistance Document, Dec. 2013, section 8.1, pp 27-28.
[19] USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010, p. 3.
[20] http://www.epa.gov/airtrends/values.html