Supplemental SO_2 NAAQS Compliance Modeling Protocol for the Indiana, PA SO_2 Non-Attainment Area - Focus on Areas Near the Conemaugh and Seward Generating Stations – Revision No. 2 – October 2019

Keystone-Conemaugh Projects, LLC and Seward Generation, LLC

Quality information

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1. Introduction

1.1 Background

The United States Environmental Protection Agency (EPA) promulgated a 1-hour National Ambient Air Quality Standard (NAAQS) for SO_2 in 2010. The 1-hour SO_2 NAAQS has a level set at 75 ppb and the form of the standard is the average of the 99th percentile of the daily maximum 1-hour average concentrations realized in each of three consecutive calendar years (the "design value," or DV) at any one location.

In July 2013, EPA designated Indiana County, PA and a portion of neighboring Armstrong County as non-attainment for the 1-hour SO_2 NAAQS. This designation was based on ambient air monitoring data collected from 2009 through 2011 at a Pennsylvania Department of Environmental Protection (PA DEP) monitoring site (Strongstown) located in eastern Indiana County and EPA's Five-Factor Analysis[1]. Per EPA, "a non-attainment area [NAA] should contain the area violating the NAAQS (e.g., the area around a violating monitor) as well as any adjacent areas (e.g., counties or portions thereof) that contain emissions sources contributing to the violation."[2] Figure 1-1 shows the NAA (shaded in blue), the location of the violating monitor, and the location of SO_2-emitting sources within and close to the NAA at the time of the designation. EPA included all of Indiana County and a portion of nearby Armstrong County surrounding the Keystone Generating Station in the non-attainment area.

Pennsylvania is required to prepare and submit a State Implementation Plan (SIP) to EPA that demonstrates the steps taken to achieve attainment of the NAAQS. The SIP includes a dispersion modeling study that indicates the expected SO_2 emission reductions required to bring the entire NAA into attainment. In November 2014, PA DEP requested the four major SO_2 sources within the NAA (Keystone, Homer City, Conemaugh, and Seward Generating Stations) to prepare a dispersion modeling analysis/compliance demonstration in support of the subject SIP. NRG Energy, the parent company of the owner and/or operator of the four above-mentioned stations at that time, had previously contracted AECOM to assist in this effort. Currently, NRG Energy is (i) no longer affiliated with the Keystone and Conemaugh Stations and (ii) the contract operator of the Homer City and Seward Stations.

While this modeling study was ongoing, implementation of flue gas desulfurization (FGD) controls on Homer City Units 1 and 2 were operational by the second quarter of 2016, although further adjustments of the FGD system were made during 2016. As a result, the 99th percentile peak daily 1-hour maximum monitored concentrations in recent years at the Strongstown monitor have been reduced to levels below half of the 75 ppb SO_2 NAAQS, as listed in Table 1-1. It is reasonable to conclude that the non-attainment issue that was triggered by that monitor has been addressed by the Homer City FGD controls.

The planning for modeling to address the non-attainment area was initiated in 2015, using EPA's guideline model, AERMOD. Consistent with permitting done for the Homer City FGD project, the meteorological data used for the NAA were obtained from the Johnstown, PA (Cambria County) airport as they were considered to be representative for the designated NAA.

[1] Designations guidance was issued by EPA through a March 24, 2011 memorandum from Stephen D. Page, Director, U.S. EPA, Office of Air Quality Planning and Standards, to Air Division Directors, U.S. EPA Regions I-X. This memorandum identifies factors EPA evaluated in determining boundaries for areas designated non-attainment. These 5 factors include: 1) air quality data; 2) emissions and emissions-related data (location of sources and potential contribution to ambient SO_2 concentrations); 3) meteorology (weather/transport patterns); 4) geography/topography (mountain ranges or other air basin boundaries); and 5) jurisdictional boundaries (e.g., counties, air districts, pre-existing non-attainment areas, reservations, metropolitan planning organization), among any other information deemed relevant to establishing appropriate area designations and boundaries for the 1-hour SO_2 NAAQS.

[2] EPA Memorandum – Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards – March 24, 2011.

Figure 1-1: Indiana, PA Non-attainment Area and Major SO_2 Sources as of 2013

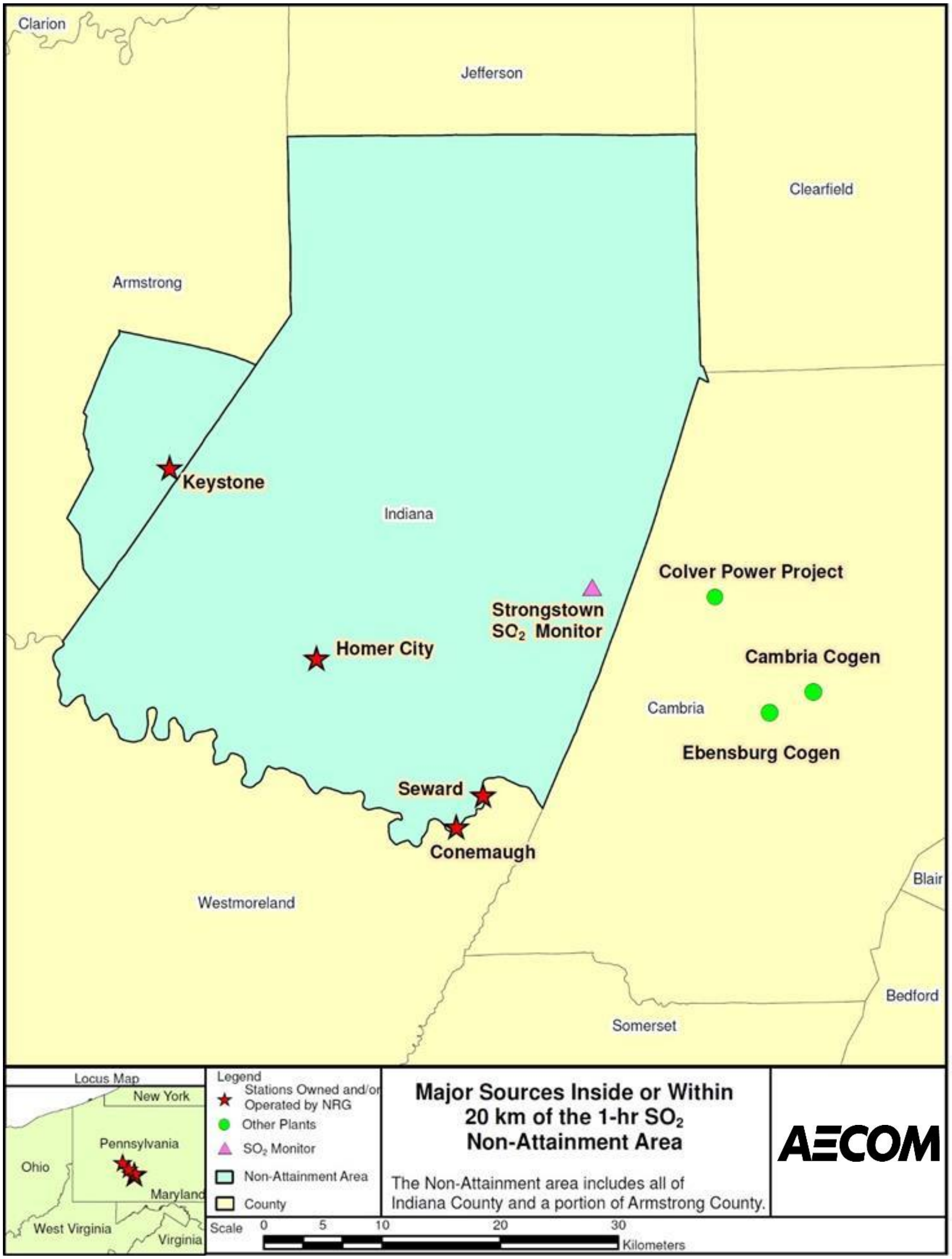

Table 1-1: 99th Percentile of the Daily 1-hour Maximum SO_2 Concentrations at the Strongstown, PA Monitor

Year	99th Percentile of the Daily 1-hour Maximum Concentrations (ppb)[3]	3-Year Average Design Values (ppb)
2009	82	--
2010	95	--
2011	68	82
2012	70	78
2013	66	68
2014	71*	69*
2015	73	70*
2016	39	61*
2017	24	45
2018	28	30

* Because 1 quarter of 2014 data reported less than the data completeness criteria, an annual design value for 2014-2016 cannot be determined. Therefore, the 3-year averages are unofficial values, but indicative of a trend below the NAAQS during that period that was evident once the 2013 data were certified.

The modeling demonstration for the NAA that used the Johnstown, PA airport data was performed in accordance with the modeling protocol submitted to and approved by the PA DEP and EPA. The final summary report ("Phase 1 Report") for the modeling demonstration was submitted to PA DEP in July 2017. PA DEP provided a proposed SIP submittal to EPA based in part on this modeling analysis on October 11, 2017. EPA proposed[4] the SIP submittal for public review and comment on July 13, 2018. Among the comments to this proposed SIP were those submitted by the "Conservation Organizations." A key comment was a finding that with alternative model receptors (i.e., those located using a methodology that differed from that specified in the approved protocol) placed just within the county line on Laurel Ridge north of the Conemaugh River (and using the same modeling approach as that done by AECOM), a single receptor showed a predicted value above the NAAQS when the Critical Emission Values were run as emission inputs to the modeling (see the red dot in Figure 1-2). This was not expected because the two local generating stations (Seward and Conemaugh) do not line up toward the location of the red dot, which is on high terrain on nearby Laurel Ridge.

In April 2019, PA DEP requested Conemaugh and Seward stations to perform a supplemental modeling analysis focusing on the area near Conemaugh and Seward stations within the NAA to address the finding from the modeling study performed by the Conservation Organizations. An initial modeling protocol was provided to the PA DEP and EPA in mid-June 2019, and comments were received from the reviewing agencies in late July 2019. A revised (No. 1) protocol was prepared in September 2019 to address the reviewing agencies' comments for modeling the areas within the NAA. Additional agency comments to the modeling protocol were received in late September 2019; this revised (No. 2) protocol has been prepared to address those comments. The region within the NAA to be modeled for this analysis is shown in Figure 1-3 and it will utilize multi-level site-specific meteorological data that were generated during the period from August 2015 through August 2016 to address modeling in this more focused region within the NAA. The modeling demonstration for the entire NAA did not utilize the site-specific meteorological data because these data were generated primarily in support of other activities that are beyond the scope of this supplemental modeling analysis.

[3] Data source: https://www.epa.gov/outdoor-air-quality-data
[4] The EPA docket that contains the supporting records associated with this SIP proposal can be accessed at www.regulations.gov at docket EPA-R03-OAR-2017-0615.

A protocol for the purpose of acquiring a full year of site-specific meteorological data was approved by PA DEP and EPA in Spring 2015 for a 100-m meteorological tower, supplemented by a Doppler SODAR, at a site adjacent to the Conemaugh River halfway between the Conemaugh and Seward Stations, as shown in the photos in Figure 1-4 and on the cover page. The monitoring program began in August 2015 and extended through August 2016, and the data have been submitted to PA DEP.

1.2 Document Organization

Section 2 provides a discussion of SO_2 emission sources that will be included in the supplemental modeling demonstration for areas in the NAA close to the Conemaugh and Seward stations. Section 3 discusses the on-site meteorological data to be used in the modeling. Section 4 provides the modeling procedures. The first step in the modeling is to determine 1-hour Critical Emission Values that show 1-hour SO_2 NAAQS compliance using the full year of on-site meteorological data, as discussed in Section 4.

EPA's SIP development guidance for non-attainment areas[5] allows for the consideration of longer-term (e.g., 30-day) average emission rates that provide for comparable stringency with the critical emissions values. Section 5 provides an overview of procedures that can be used to establish longer-term average emission limits, as appropriate, for the major SO_2 sources in the NAA. The application of the EPA's non-attainment guidance (the Appendix B Randomly Reassigned Emissions (RRE) approach) to Seward's emissions is discussed in Section 6. Section 7 briefly discusses the documentation that will be provided to the reviewing agencies to support the modeling results. Appendix A provides documentation regarding an anomalous SODAR wind direction interference issue caused by the Conemaugh Station cooling tower plumes. Appendix B provides details about updates to the regional background concentrations, and Appendix C contains emission time series plots for the 100 planned RRE simulations.

[5] Available at http://www.epa.gov/airquality/sulfurdioxide/pdfs/20140423guidance.pdf.

Figure 1-2: SO_2 Design Concentrations Predicted by the Conservation Organizations Modeling of the Critical Emission Rates Near the Conemaugh and Seward Stations

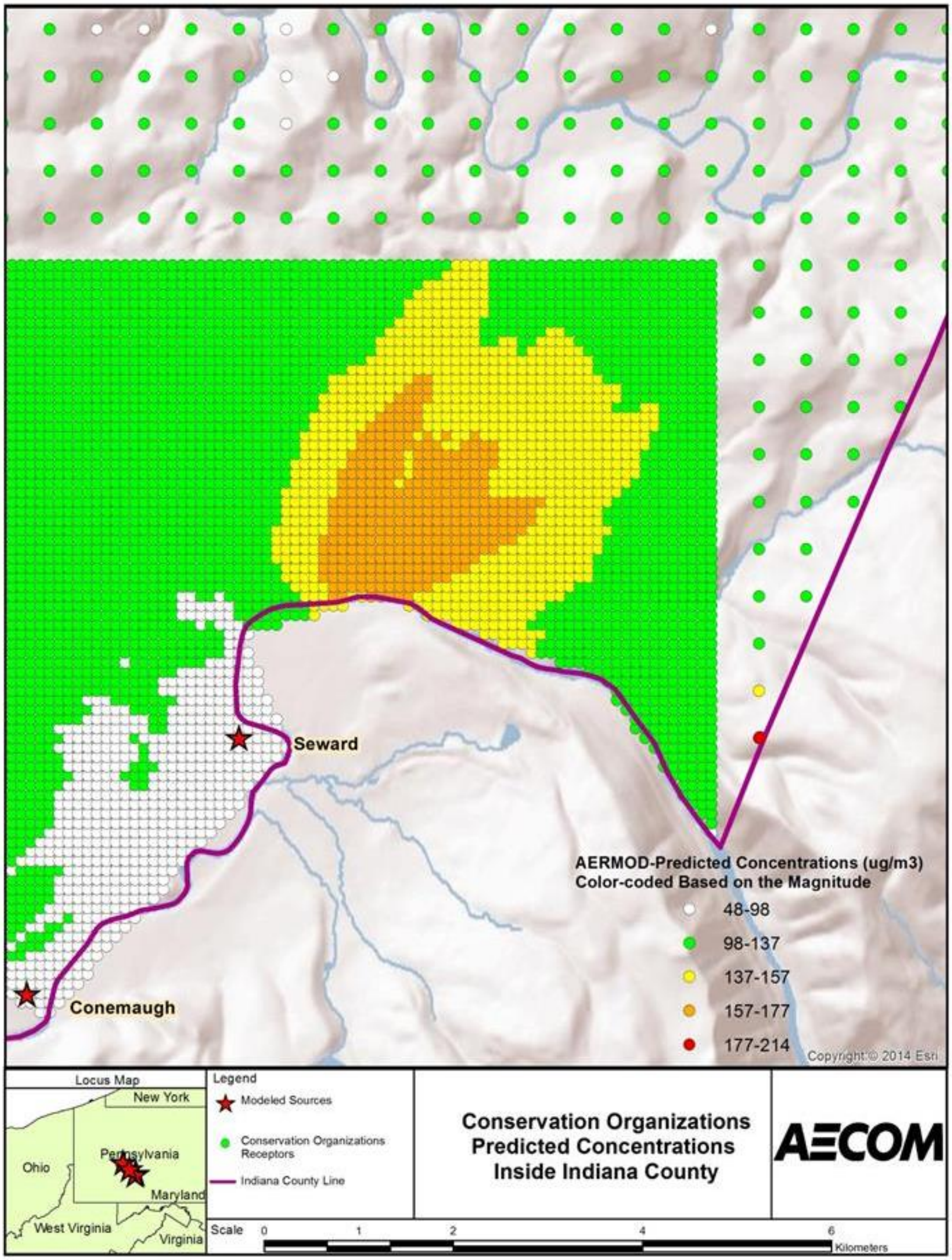

Figure 1-3: Area to be Modeled to Demonstrate Maintenance of the SO_2 NAAQS Near Conemaugh and Seward Stations

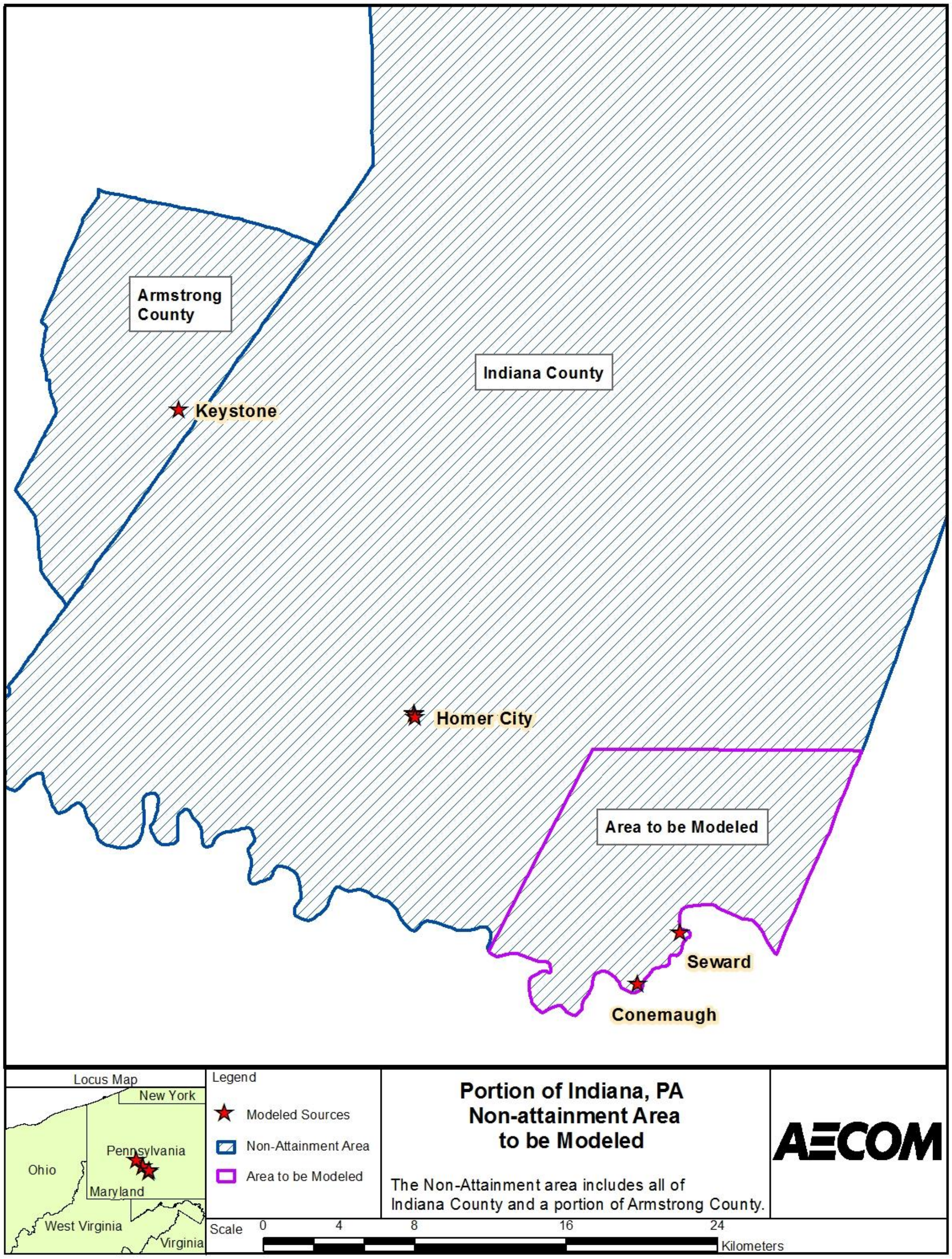

Figure 1-4: View of Seward and Conemaugh Stations and the Site of the Meteorological Tower

2. Emission Source Inventory

2.1 Sources to be Modeled

This study will supplement the modeling submitted in 2017 (see EPA docket EPA-R03-OAR-2017-0615-0018) to focus on the area in the NAA near Conemaugh and Seward stations. In this new modeling, the "AERMOIST" procedure for moist plumes will not be used. The assumption of "dry" plumes will provide conservatively high AERMOD predictions for this modeling analysis because wet flue gas desulfurization (FGD) pollution controls used at the sources being modeled are known to increase moisture content in the exiting plume as compared to a unit without such control devices. Plumes with significant moisture content will realize additional buoyancy as compared with dry plumes. This issue of AERMOD not accounting for plume moisture content is mentioned as part of EPA's white paper compilation[6].

Figure 1-1 shows the sources located within and near the Indiana, PA NAA. The main boilers at the four electric generating stations – Seward Generating Station, Homer City Generating Station, Keystone Generating Station, and Conemaugh Generating Station, which are within the NAA, are included in this modeling study. The main boilers/cogeneration units at three additional sources outside the NAA – Colver Power Project, Cambria Cogeneration Plant, and Ebensburg Cogeneration Plant – are not included in this modeling study. This is because the predominant wind flow is from the west, so that sources to the east of the NAA are not expected to substantially affect air quality in the NAA. In addition, the Cambria Cogeneration Plant deactivated on September 17, 2019, according to the PJM Deactivation List available at https://www.pjm.com/planning/services-requests/gen-deactivations.aspx. Colver Power Project requested a deactivation date of September 1, 2020.

Homer City has performed separate air quality analyses, including air dispersion modeling in support of its combined SO_2 emission limit of 6,360 lb/hr over all 3 units[7]. These dispersion modeling studies incorporated this emission limit as approved by the PA DEP (Air Quality Plan Approval Nos. PA-32-00055H and PA-32-00055I). Other information for stack parameters is provided below.

- Conemaugh – Units 1 and 2 each exhaust through their own flue (internal exit diameter = 28 feet each). Both flues are contained within the same chimney (height as reported in the June 2017 modeling protocol), and the flue gas streams merge upon discharge to the atmosphere. The reported stack exit diameter is the calculated equivalent stack diameter for the combined stack areas. The flue gas temperature and exit velocity as reported in the protocol were derived via examination of data collected using the certified flue gas flow monitor installed in the exhaust stack.
- Keystone – Units 1 and 2 each exhaust through their own flue (internal exit diameter = 33 feet each). Both flues are contained within the same chimney (height as reported in the June 2017 modeling protocol), and the flue gas streams merge upon discharge to the atmosphere. The reported stack exit diameter is the calculated equivalent stack diameter for the combined stack areas. The flue gas temperature and exit velocity as reported in the protocol were derived via examination of data collected using the certified flue gas flow monitor installed in the exhaust stack.
- Seward – Units 1 and 2 exhaust to a common stack with height and internal exit diameter as reported in the June 2017 modeling protocol. The flue gas temperature and exit velocity as reported in the protocol were derived via examination of data collected using the certified flue gas flow monitor installed in the exhaust stack.
- Homer City – the exhaust parameters are the same as those used in the SO_2 dispersion modeling reports prepared in support of the FGD system installation for Units 1 and 2.

[6] EPA White Paper on Planned Updates to AERMOD Modeling System. September 19, 2019. Available at: https://www3.epa.gov/ttn/scram/models/aermod/20170919_AERMOD_Development_White_Papers.pdf

[7] Alternative emission limits apply for periods in which (i) Unit 1 or Unit 2 is operating in startup mode, or (ii) the Novel Integrated Desulfurization (NID) systems installed on Unit 1 or Unit 2 are operating in transition mode.

Table 2-1 lists the coal-fired boiler ratings and the allowable SO_2 emissions for the sources that will be modeled for this supplemental analysis, with an update for Keystone as listed in the proposed SIP. These emission rates are federally enforceable. This modeling analysis will retain the allowable SO_2 emissions for Keystone, Homer City, and Conemaugh, and review the allowable rolling 30-day SO_2 emissions for Seward.

Table 2-1: Coal-fired Boiler Ratings and Current Allowable SO_2 Emissions for Major Sources in the NAA

<table>
<tr><th rowspan="2">Unit IDs</th><th rowspan="2">Rated Heat Input (MMBtu/hr)</th><th colspan="2">SO_2 Emission Limit Parameters</th></tr>
<tr><th>lb/hr</th><th>Averaging Period</th></tr>
<tr><td>Conemaugh 1 & 2</td><td>8,280 each</td><td>3,312 combined for both units</td><td>3-hour block</td></tr>
<tr><td>Keystone 1 & 2</td><td>8,717 each</td><td>9,600 combined for both units</td><td>24-hour block</td></tr>
<tr><td>Seward 1 & 2</td><td>2,532 each</td><td>3,038.4 combined for both units</td><td>30-day rolling</td></tr>
<tr><td>Homer City 1</td><td>6,792</td><td rowspan="3">6,360 for all 3 units</td><td rowspan="3">1-hour block, applicable except during limited periods of transient operating conditions at Units 1 or 2</td></tr>
<tr><td>Homer City 2</td><td>6,792</td></tr>
<tr><td>Homer City 3</td><td>7,260</td></tr>
</table>

2.2 Stack Input Data for NAA Modeling

Table 2-2 lists the stack parameters for each source included in the proposed supplemental modeling analysis. For the stack heights listed in Table 2-2, much of the information for the stack height credit is provided in a 2003 TRC report (page 9) entitled, "AERMOD Modeling Analyses for SO_2 NAAQS Compliance for Power Plants in the Laurel Ridge and Chestnut Ridge Region of Pennsylvania". The Seward stack was built to a height exceeding Good Engineering Practice (GEP) formula height, but a fluid modeling study determined that a 600-ft height is creditable, so the latter value will be used in modeling. The GEP height for the Homer City stacks is 853 feet (260 m) based upon aerodynamic effects of the cooling towers (stack heights for Units 1 and 2 are 800 feet). These documents were provided in the modeling archive submitted to the PA DEP in 2017. The Conemaugh and Keystone stacks were constructed to the formula GEP heights of 525 feet (160 m) and 562.5 feet (171.45 m), respectively, to service their scrubber installations.

For this updated modeling analysis, recent years (2016-2018) of the Conemaugh and Seward stack parameters from Continuous Emissions Monitors (CEMs) were reviewed and updated. The stack parameters and Critical Emission Values (CEV) to be used for the modeling in the non-attainment area in the vicinity of the Conemaugh and Seward stations are listed in Table 2-2.

Table 2-2: Stack Parameters and Emission Rates for Input to AERMOD for NAA Modeling

Stack	Stack Height (m)	Exit Diameter (m)	Exit Temperature (deg K)	Exit Velocity (m/s)	SO_2 Emission 1-hr Rate (CEV) (g/s)*	(lb/hr)
Seward	182.88	5.26	362.59	40.23	566.99	4500.0
Homer City1	243.84	7.32	342.26	28.05	195.30	1550.0
Homer City2	243.84	7.32	342.26	28.05	195.30	1550.0
Homer City3	259.99	8.23	320.93	17.65	410.75	3260.0
Keystone	171.45	14.22	324.82	16.46	1223.6	9711.3
Conemaugh	160.00	12.07	325.37	21.24	426.00	3381.0

* Conversion factor used for grams per pound is 453.59237; emission rates are reported to 5 significant digits.

3. Description of the Site-Specific Meteorological Database for Model Input

3.1 Meteorological Monitoring Network Design

The plan for site-specific meteorological measurements led to an agency-approved meteorological monitoring protocol in the spring of 2015, and the installation of a 100-meter height meteorological tower equipped with multiple levels of meteorological sensors (at 2, 10, 50, 75, and 100 m) along with a SOnic Detection And Ranging (SODAR) wind profiler system (with measurements starting at 50 m and extending upward in 50-m increments to 500 m)[8,9]. The location of the meteorological measurement site relative to the Conemaugh and Seward stations is shown in Figure 3-1. AERMOD was specifically designed to accommodate multiple levels of meteorological data to more accurately estimate vertical profiles of meteorological variables used in the modeling. For the monitoring program, the EPA Guidelines for Air Quality Modeling (40 CFR Part 51, Appendix W[10]) and EPA's meteorological monitoring guidance[11] provided the general guidance for sensor and parameter selection and siting of the tower and SODAR.

NRG submitted a quality assurance plan for the meteorological monitoring to PA DEP and EPA on February 6, 2015. Comments were received from PA DEP and EPA, and NRG responded to comments on March 10, 2015 and provided a revised monitoring plan. PA DEP approved the meteorological monitoring plan in a letter dated April 3, 2015. The meteorological data collection spanned the 13-month period of August 1, 2015 through August 31, 2016. Due to better SODAR data capture percentages for the September 1, 2015 through August 31, 2016 period, this 12-month period is proposed for this supplemental modeling analysis. It is also noteworthy that as a result of an independent audit of the entire system performed on August 26, 2015 (which has been provided to PA DEP), AECOM replaced some sensors and made other adjustments to respond to the audit findings. Therefore, the 12-month period ending August 31, 2016 is the most appropriate period to use for modeling.

Table 3-1 provides a list of the meteorological parameters included in the field study. As indicated in the monitoring plan reviewed and approved by PA DEP and EPA, input to AERMET was designed to consist of parameters measured on the 100-m tower up to the 100-m level, and at incremental 50-m levels from 150 m to 500 m from the SODAR. SODAR data from the 50-m and 100-m levels were available for comparison to the tower data. AECOM's data and calibration reports associated with this meteorological monitoring study have been separately provided to PA DEP. The SODAR inherently measures only vector-averaged wind measurements, while the tower recorded only scalar wind averages, consistent with EPA guidance[11]. However, at the elevated SODAR levels, the wind speeds are usually sufficiently high enough so that the difference between vector and scalar wind speeds is well within the error tolerance of the measurements.

The system's data capture statistics were documented in previous reports submitted to PA DEP. The meteorological tower parameters generally had data captures well above 90% for each month of the monitoring program. The data capture for the September 1, 2015 to August 31, 2016 measurement period for the meteorological tower parameters was well above 90% (and often at 100%) for each parameter. The tower data capture alone fulfilled the model input data requirements of having at least one level of wind and temperature data.

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[8]AECOM. 2015. Summary Meteorological Monitoring Program Data Report. Conemaugh and Seward Generating Stations Indiana County, Pennsylvania. September 2015 - August 2016. AECOM Project Number: 60341515. March 2015.
[9]PA DEP. 2015. DEP Acceptance of Meteorological Monitoring Plan. NRG Energy Inc. Conemaugh Generating Station, West Wheatfield Township, Indiana County Seward Generating Station, East Wheatfield Township , Indiana County. April 3, 2015.
Indiana County, Pennsylvania. September 2015 - August 2016. AECOM Project Number: 60341515. March 2015.
[10] Available at http://www.epa.gov/ttn/scram/guidance_permit.htm#appw.
[11] U.S. EPA. Meteorological Monitoring Guidance for Regulatory Modeling Applications. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA 454/R 99 005. February 2000. Available at http://www.epa.gov/scram001/guidance/met/mmgrma.pdf.

AERMOD accepts data from multiple levels, and the measurement program was designed to accommodate the tower data with supplemental data from the SODAR. Data capture for the reported SODAR data was generally 90% or greater up to around 300 meters except for some periods affected by natural events and noise interference issues. Although the SODAR reports sigma-theta data, this parameter will not be used in modeling because of recommendations in EPA's meteorological monitoring guidance document[12].

Figure 3-1: Location of Meteorological Tower and SODAR Relative to Conemaugh and Seward

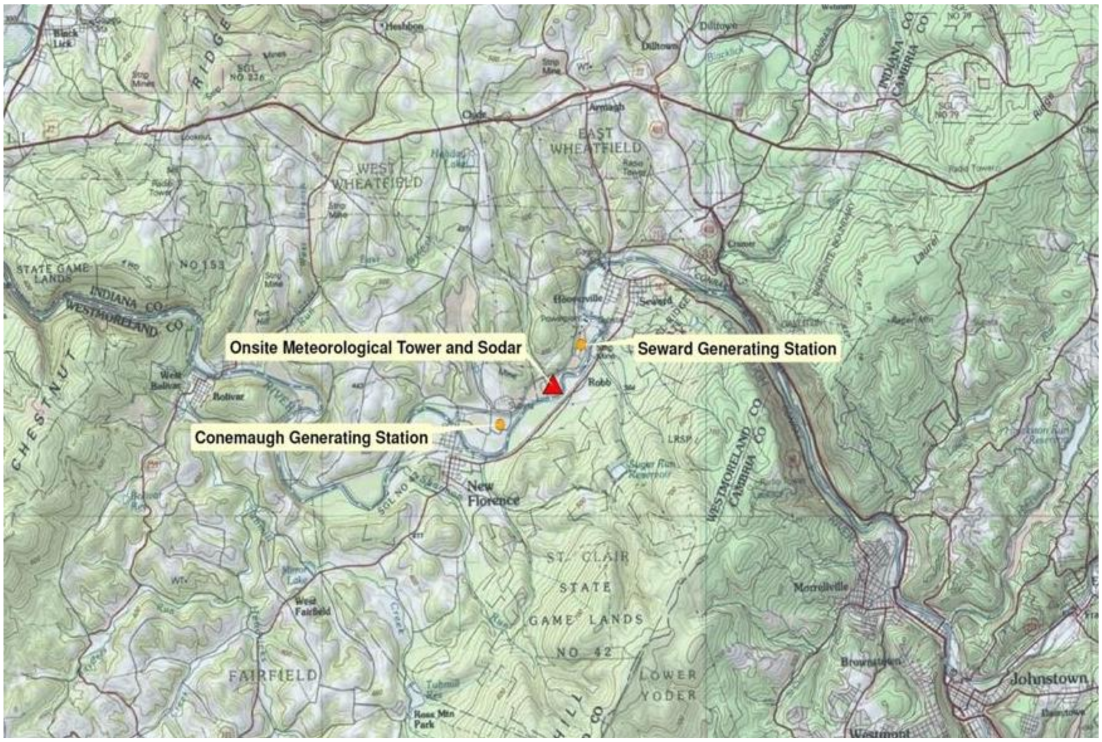


Table 3-1: Overall Data Capture Summary for On-site Meteorological Data

Parameter(s)	Data Capture (%)
Tower	Parameters > 90%
Other – Barometric Pressure and Precipitation	Parameters > 90%
SODAR	Parameters > 90% through 250 m height

3.2 SODAR Wind Direction Interferences

At the request of the PA DEP, AECOM conducted a recent in-depth review of the on-site SODAR wind profiler system deployed from August 2015 through August 2016. Input to AERMET will consist of parameters measured on the 100-m tower up to the 100-m level, and at incremental 50-m levels from 150 m to 500 m from the SODAR. SODAR data from the 50-m and 100-m levels were available for comparison to the tower data during the field measurement program, but are not being used in the modeling due to the presence of the

[12] EPA, 2000. Meteorological Monitoring Guidance for Regulatory Modeling Applications. EPA-454/R-99-005. Available at https://www3.epa.gov/ttn/scram/guidance/met/mmgrma.pdf. The discussion about SODAR sigma-theta indicates in its Section 9.1.1 that due to two wind components used for the horizontal turbulence, differences in time and space between the sampling of the two components may be affected by aliasing. This would not apply to the vertical wind speed standard deviation, which involves only one sampling component.

tower data at those levels. The tower data at these lower levels have a higher data capture than the SODAR, so the SODAR data were used at levels above the 100-m level, up to a height of 500 meters.

While the SODAR data capture was greater than 90% through a height of 250 meters for all parameters and each quarter of the 12-month period, an unusual behavior in the wind direction pattern was recently noticed by PA DEP through a detailed wind rose analysis which required further investigation. Appendix A consists of a technical discussion that analyzed the unusual SODAR wind direction behavior from this dataset and provides a recommended revised approach for use of the on-site SODAR and 100-meter tower data for modeling applications.

PA DEP found in their 36-sector wind rose analysis that the frequency of the SODAR winds in the 230° – 260° sector was noticeably lower than those in the adjacent sectors, and that the winds from that sector appeared to be re-allocated to adjacent sectors. There were no adverse findings in the SODAR wind distributions for the remaining wind sectors.

The directions involved in this SODAR anomaly (winds generally in the 230° – 260° sector) correspond to flow from the Conemaugh Generating Station toward the SODAR. While noise from the station is probably not an issue due to the distance involved (approximately 1.5 kilometers), a unique feature of that station is the presence of two tall (approximately 100-meters high) hyperbolic cooling towers with the attendant vapor and liquid droplet-laden plumes. For winds from the southwest, moist plumes from these cooling towers would have likely advected toward the SODAR site.

The moist plumes represent a unique enhanced environment for sharply increased reflectivity for sonic signals from the SODAR. However, because the moist plumes have a finite size relative to the volume sampled by the SODAR, the result is often a large gradient of reflectivity for the SODAR sampling volume. As further discussed in Appendix A, the effect on SODAR measurements is that the range placement of the returned sound is distorted by the large reflectivity gradient. The placement distortion results in a computed error in the reported SODAR wind direction (and no other reported SODAR parameter), which is exactly what has been found in this case. It is also notable that anomalies with the SODAR wind direction are not evident when the flow toward the SODAR is from directions other than that from the Conemaugh Generating Station.

For this modeling application, we propose to set aside for modeling purposes reported SODAR wind directions in the sector affected by the range displacement issue caused by the cooling towers. A review of the operating data for the period September 1, 2015 through August 31, 2016 showed that there were no hours in which both Conemaugh Station cooling towers were off-line. Consequently, the inadvertent impact of the cooling tower plume on the SODAR data was potentially present during all hours in which the site-specific meteorological dtaa were collected.

The detailed analysis reported in this supplemental SODAR wind direction interference technical paper (Appendix A) results in a recommendation that the wind sector for this adjustment is in the range of 235° and 290°. For any reported SODAR wind direction in this range, the data value for input to AERMET at that level will be replaced by a default negative number that indicates a missing value. For those hours with SODAR data set to missing, the tower winds will still be available for modeling. As noted in EPA's comments on the initial supplemental modeling protocol, the amount of wind data that will be marked as missing (and interpolated from available tower data) ranges from approximately 19% to 27%, depending upon the SODAR level.

4. Proposed Modeling Procedures Using On-Site Meteorological Data

4.1 Dispersion Model Selection

The proposed supplemental modeling analysis will utilize the version of the AERMOD dispersion model[13] (Version 19191), current as of August 2019, to evaluate air quality impacts from the emission sources of interest. The AERMOD modeling system consists of two preprocessors and the dispersion model. AERMET is the meteorological pre-processor component and AERMAP is the terrain pre-processor component that characterizes the terrain and generates receptor elevations along with critical hill heights for those receptors.

4.2 Land Use Classification

One of the factors affecting input parameters to dispersion models is the selection of either rural or urban conditions near the source site and the meteorological site(s). The choice of rural or urban for dispersion conditions at the source site depends upon the land use characteristics within 3 kilometers of the facility being modeled (Appendix W to 40 CFR Part 51)[14]. Factors that affect the rural/urban choice, and thus the dispersion, include the extent of vegetated surface area, the water surface area, types of industry and commerce, and building types and heights within this area.

According to Section 7.2.1.1 of EPA's Appendix W, either a land use (Auer method) or a population density procedure should be used in determining the selection of urban vs. rural dispersion. For this application, the Auer method has been applied. This land-use approach classifies an area according to 12 land-use types. In this scheme, areas of industrial, commercial, and compact residential land use are designated urban. According to EPA modeling guidelines, if more than 50 percent of an area within a three-kilometer radius of a facility is classified as rural, then rural dispersion coefficients are to be used in the dispersion modeling analysis. For this analysis, AECOM inspected satellite imagery (using Google Earth) showing the 3-kilometer area surrounding each facility to be modeled (see Figures 4-1 through 4-3) which shows that the dispersion environment around all of the stations is rural. Therefore, AERMOD will be run with rural dispersion coefficients for all sources.

4.3 Good Engineering Practice (GEP) Analysis

Federal stack height regulations limit the stack height used in performing dispersion modeling to predict the air quality impact of a source. Sources must be modeled at the actual physical stack height unless that height exceeds the Good Engineering Practice (GEP) formula stack height. In any case, the potential for the source's plume to be affected by aerodynamic wakes created by the building(s) must be evaluated in the dispersion modeling analysis.

A GEP formula stack height analysis has been performed for sources of interest located at the Keystone, Conemaugh, Seward, and Homer City Generating Stations in accordance with the EPA's "Guideline for Determination of Good Engineering Practice Stack Height" (EPA, 1985)[15]. In the absence of a case-specific fluid modeling study, a GEP stack height is defined as the greater of 65 meters (213 feet), measured from the ground elevation of the stack, or the formula height (H_g), as determined from the following equation:

$$H_g = H + 1.5\,L$$

where

H is the height of the nearby structure which maximizes H_g, and

L is the lesser dimension (height or projected width) of the building.

[13] See the AERMOD system documentation at https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#aermod.
[14] EPA's Guideline on Air Quality Models, available at https://www3.epa.gov/ttn/scram/guidance/guide/appw_17.pdf.
[15] Available at http://www.epa.gov/scram001/guidance/guide/gep.pdf.

For a squat structure, i.e., height less than projected width, the formula reduces to:

$H_{GEP} = 2.5H_B$

In the absence of influencing structures, a "default" GEP stack height is credited up to 65 meters (213 feet).

Both the height and the width of buildings near each stack are determined through a vertical cross-section perpendicular to the wind direction. In all instances, the GEP formula height is based upon the highest value of H_g as determined from H and L over all nearby buildings over the entire range of possible wind directions. For the purposes of determining the GEP formula height, only buildings within 5L of the source of interest are considered.

The Seward stack was built after 1970 and it exceeds the GEP formula height of 478.8 ft. The Seward stack was built to a height of 604 feet. Since a CPP fluid modeling study[16] showed that a 600-foot stack was creditable due to nearby terrain, AECOM will use 600 feet for the Seward stack height in the modeling.

The GEP analyses were conducted with the regulatory-approved version of the US EPA's Building Profile Input Program software (BPIP-PRIME version 04274). The locations and dimensions of the buildings/structures relative to the exhaust stacks for Keystone, Conemaugh, Seward, and Homer City Generating Stations are depicted in Figures 4-4 through 4-7. The input stack heights for Keystone, Conemaugh, and Homer City[17] correspond to the GEP formula height or to a fluid modeling-determined height.

4.4 Meteorological Data Processing

The meteorological data required for input to AERMOD will be processed with the latest version of AERMET (19191) using regulatory options. One year (September 2015 – August 2016) of hourly surface observations from the on-site meteorological tower and SODAR along with one year of concurrent cloud cover data from Cambria County Airport (KJST) and upper air data from Pittsburgh International Airport, PA will be used as input to AERMET. Figure 3-1 provides a map showing the location of the on-site meteorological tower relative to Seward and Conemaugh stations.

To prepare the on-site meteorological data for model input, the raw data will be extracted and formatted for use in AERMET. There are two separate sets of data (tower and SODAR) that will be merged for the modeling input. Meteorological measurements taken at the 100-m tower were made at 5 levels: 2 m, 10 m, 50 m, 75 m, and 100 m. A SODAR collected upper level data beginning at 50-m at 50-m increments up to 500 m. More information on the multi-level tower and SODAR data (wind direction, wind speed, temperature, solar radiation, relative humidity, and turbulence) was discussed in Section 3.

The ADJ_U* option will be used in AERMET to process the meteorological data. Therefore, the site-specific turbulence data (sigma-theta and sigma-w) will be withheld from the processing from both the tower and SODAR levels, as recommended by EPA in Appendix W.

AERMET creates two output files for input to AERMOD:

- SURFACE: a file with boundary layer parameters such as sensible heat flux, surface friction velocity, convective velocity scale, vertical potential temperature gradient in the 500-meter layer above the planetary boundary layer, and convective and mechanical mixing heights. Also provided are values of Monin-Obukhov length, surface roughness, albedo, Bowen ratio, wind speed, wind direction, temperature, and heights at which measurements were taken.

- PROFILE: a file containing multi-level meteorological data with wind speed, wind direction, temperature, sigma-theta (σ_θ) and sigma-w (σ_w) when such data are available. In this application, the turbulence data will not be provided as input due to the use of the ADJ_U* option.

[16] "GEP Stack Height Evaluation for Pennsylvania Electric Company's Seward Plant", CPP Project 86-0336. January 26, 1989.

[17] Homer City Unit 3 GEP height is controlled by the station's cooling tower structures.

For all meteorological data parameters included in the modeling, the hourly-averaged values reported by the data loggers will be used as input to AERMET. For modeling purposes, no replacements of calms will be attempted; the meteorological tower instrumentation had a starting threshold level of 0.25 mph (0.11 m/s) and this information will be provided as input to AERMET.

AERMET requires specification of site characteristics including surface roughness (z_o), albedo (r), and Bowen ratio (B_o). These parameters will be developed according to the guidance provided by EPA in the recently revised AERMOD Implementation Guide[18] (AIG). The AIG provides the following recommendations for determining the site characteristics:

1. The determination of the surface roughness length should be based on an inverse distance weighted geometric mean for a default upwind distance of 1 kilometer relative to the measurement site. Surface roughness length may be varied by sector to account for variations in land cover near the measurement site; however, the sector widths should be no smaller than 30 degrees.

2. The determination of the Bowen ratio should be based on a simple un-weighted geometric mean (i.e., no direction or distance dependency) for a representative domain, with a default domain defined by a 10-km by 10-km region centered on the measurement site.

3. The determination of the albedo should be based on a simple un-weighted arithmetic mean (i.e., no direction or distance dependency) for the same representative domain as defined for Bowen ratio, with a default domain defined by a 10-km by 10-km region centered on the measurement site.

At the request of PA DEP, the AERMET Stage 3 processing includes the keyword “METHOD TEMP SUB_TT”, so that substitution for ambient temperature, when missing from the tower, can be provided from Johnstown airport data.

The AIG recommends that the surface characteristics should be determined based on digitized land cover data. EPA has developed a tool called AERSURFACE that can be used to determine the site characteristics based on digitized land cover data in accordance with the recommendations from the AIG discussed above. AERSURFACE[19] incorporates look-up tables of representative surface characteristic values by land cover category and seasonal category. AERSURFACE will be applied with the instructions provided in the AERSURFACE User’s Guide.

A new draft version of AERSURFACE (19039) has been released, but it is still undergoing initial review. Therefore, AECOM proposes the use of AERSURFACE version 13016, which supports the use of land cover data from the USGS National Land Cover Data 1992 archives[20] (NLCD92). The NLCD92 archive provides data at a spatial resolution of 30 meters based upon a 21-category classification scheme applied over the continental U.S. The AIG recommends that the surface characteristics be determined based on the land use surrounding the site where the surface meteorological data were collected.

As recommended in the AIG for surface roughness, the 1-km radius circular area centered at the meteorological station site can be divided into sectors for the analysis; the default 12 sectors are being proposed to be used for this analysis. The 12 sectors are shown on the aerial photo (Figure 4-8) and on the land cover imagery (Figure 4-9).

In AERSURFACE, the various land cover categories are linked to a set of seasonal surface characteristics. As such, AERSURFACE requires specification of the seasonal category for each month of the year. The following five seasonal categories are supported by AERSURFACE, with the applicable months of the year specified for this site.

1. Midsummer with lush vegetation (June-August).
2. Autumn with un-harvested cropland (September-October).
3. Late autumn after frost and harvest, or winter with no snow (November-December, and March)
4. Winter with continuous snow on ground (January-February).
5. Transitional spring with partial green coverage or short annuals (April-May).

[18] Available at https://www3.epa.gov/ttn/scram/models/aermod/aermod_implementation_guide.pdf.
[19] Documentation available at http://www.epa.gov/ttn/scram/dispersion_related.htm#aersurface.
[20] See additional information at http://landcover.usgs.gov/natllandcover.php.

For Bowen ratio, the land use values are linked to three categories of surface moisture corresponding to average, wet, and dry conditions. The surface moisture condition for the site may vary depending on the meteorological data period for which the surface characteristics will be applied. AERSURFACE applies the surface moisture condition for the entire data period. Therefore, if the surface moisture condition varies significantly across the data period, then AERSURFACE can be applied multiple times to account for those variations.

As such, the surface moisture condition for each season will be determined by comparing precipitation for the period of data to be processed to the 30-year climatological record, selecting "wet" conditions if precipitation is in the upper 30th-percentile, "dry" conditions if precipitation is in the lower 30th-percentile, and "average" conditions if precipitation is in the middle 40th percentile. At the request of PA DEP, the 30-year precipitation data set (1981-2010) for Pennsylvania Climate Division 9 that will be used in this modeling is taken from the National Climatic Data Center[21]. Precipitation data for the modeled period (9/1/2015-8/31/2016) will be obtained from the on-site meteorological tower observations. The monthly designations of surface moisture that will be input to AERSURFACE are summarized in Table 4-1. The closest available snow cover data that will be used to determine winter months with snow versus winter months without snow was retrieved from the Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) website[22]. The station that will be used is called the "Belmont 0.1 NE" site (also known as PA-CM-4 on the CoCoRaHS website) is located approximately 18 km southeast of Seward and Conemaugh, and approximately 5.3 km southwest of Johnstown Regional Airport (Figure 4-10).

Table 4-1: AERSURFACE Bowen Ratio Condition Designations

Month, Year	Bowen Ratio Category
September, 2015	Average
October, 2015	Average
November 2015	Dry
December, 2015	Wet
January, 2016	Dry
February, 2016	Dry
March, 2016	Dry
April, 2016	Dry
May, 2016	Average
June, 2016	Average
July, 2016	Dry
August, 2016	Wet

4.5 Model Receptors

Receptors for the modeling will cover the area of focus as shown in Figure 4-11. AERMAP (version 18081) will be used to generate receptors for this modeling study. Receptors in areas expected to be associated with peak modeled impacts will be placed at 25-m intervals, as shown in the figure. The location shown in Figure 1-2 associated with the Conservation Organization's peak receptor location will also be included. Furthermore, an additional line of receptors (at 25-m spacing) will be placed just east of the Indiana and Westmoreland County line east of Conemaugh and Seward in areas of high terrain, as shown in Figure 4-12. This will provide additional assurance that all areas in the high terrain on the county line are addressed in this modeling analysis. In other areas, the receptor spacing will be 100 m.

Elevations and receptor height scales (used in AERMOD) are developed by AERMAP, the terrain preprocessor for AERMOD, which requires processing of terrain data files. The height scale is the terrain elevation in the vicinity of a

21 ftp://ftp.ncdc.noaa.gov/pub/data/cirs/climdiv/
22 http://www.cocorahs.org/

receptor that has the greatest influence on dispersion at that location and is used in AERMOD's predictions for complex terrain receptors.

The current version of AERMAP has the ability to process USGS National Elevation Dataset (NED) data in place of Digital Elevation Model files. The appropriate file for 1/3-arc-second, or 10-m, NED data has been obtained from the Multi-Resolution Land Characteristics Consortium (MRLC) link at http://www.mrlc.gov/viewerjs/.

4.6 Model Configurations and Options

AERMET (Version 19191) will be run with the adjusted u-star (ADJ U*) regulatory option for the modeling in the non-attainment area, without observed turbulence data used in the meteorological input. Although there is no use of AERMOIST, the modeled plumes have moisture that AERMOD is not taking into account. As a result, the modeling results will be conservatively high.

The VECTORWS option is activated in AERMOD for cases in which the input wind speed data consists of vector averages. The combination of tower and SODAR levels presents a complication because the tower data are reported as scalar averages (as recommended by EPA guidance[23]), but the SODAR data is inherently vector-averaged. As discussed in Section 3, the wind speeds at the elevated SODAR levels are usually sufficiently high enough so that the difference between vector and scalar wind speeds is well within the error tolerance of the measurements. The procedure proposed, similar to that used for Eastman Chemical modeling with a comparable issue, is to run AERMOD for the Critical Emission Value NAAQS modeling with the VECTORWS option both on and off. The modeling result with the higher design concentration will be selected for the choice of the option for all of the AERMOD modeling for this application.

4.7 Background Concentrations

The South Fayette, PA monitor, which is located about 62 km to the west-southwest of the Indiana County NAA, has been used to determine the uniform regional background component for the NAAQS SO_2 modeling. Details involved with the processing of this database for the most recent 3-year period (2016-2018) are provided in Appendix B.

[23] The citation is in Section 6.9 at https://www3.epa.gov/scram001/guidance/met/mmgrma.pdf (Meteorological Monitoring Guidance for Regulatory Modeling Applications, 2000).

Figure 4-1: 3-km Land Use Circle Centered at Keystone Generating Station

Figure 4-2: 3-km Land Use Circles Centered at Seward and Conemaugh Generating Stations

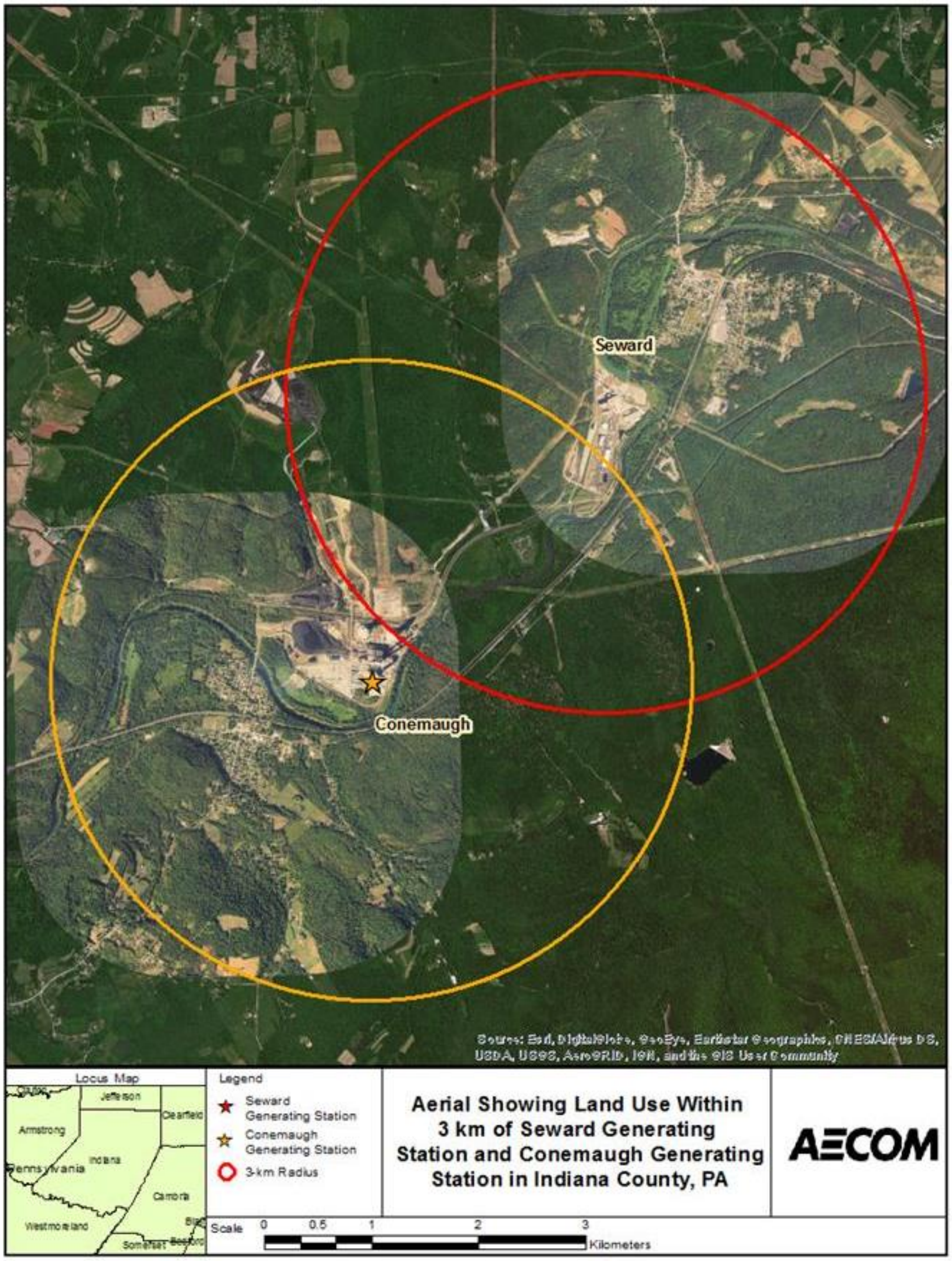


Figure 4-3: 3-km Land Use Circle Centered at Homer City Generating Station

Figure 4-4: Stacks and Buildings to Be Used in the GEP Analysis for Keystone Generating Station

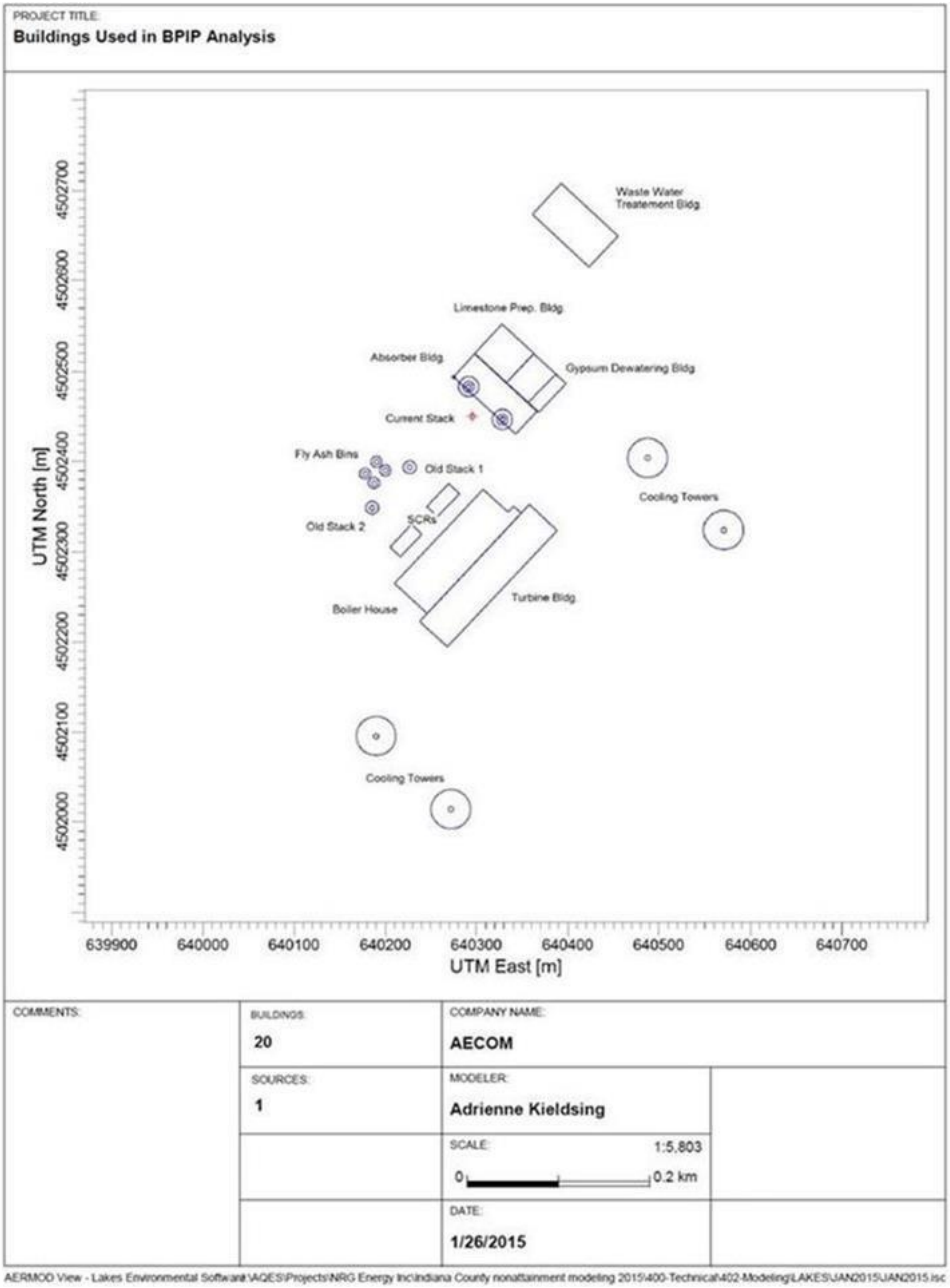


Figure 4-5: Stacks and Buildings to Be Used in the GEP Analysis for Seward Generating Station

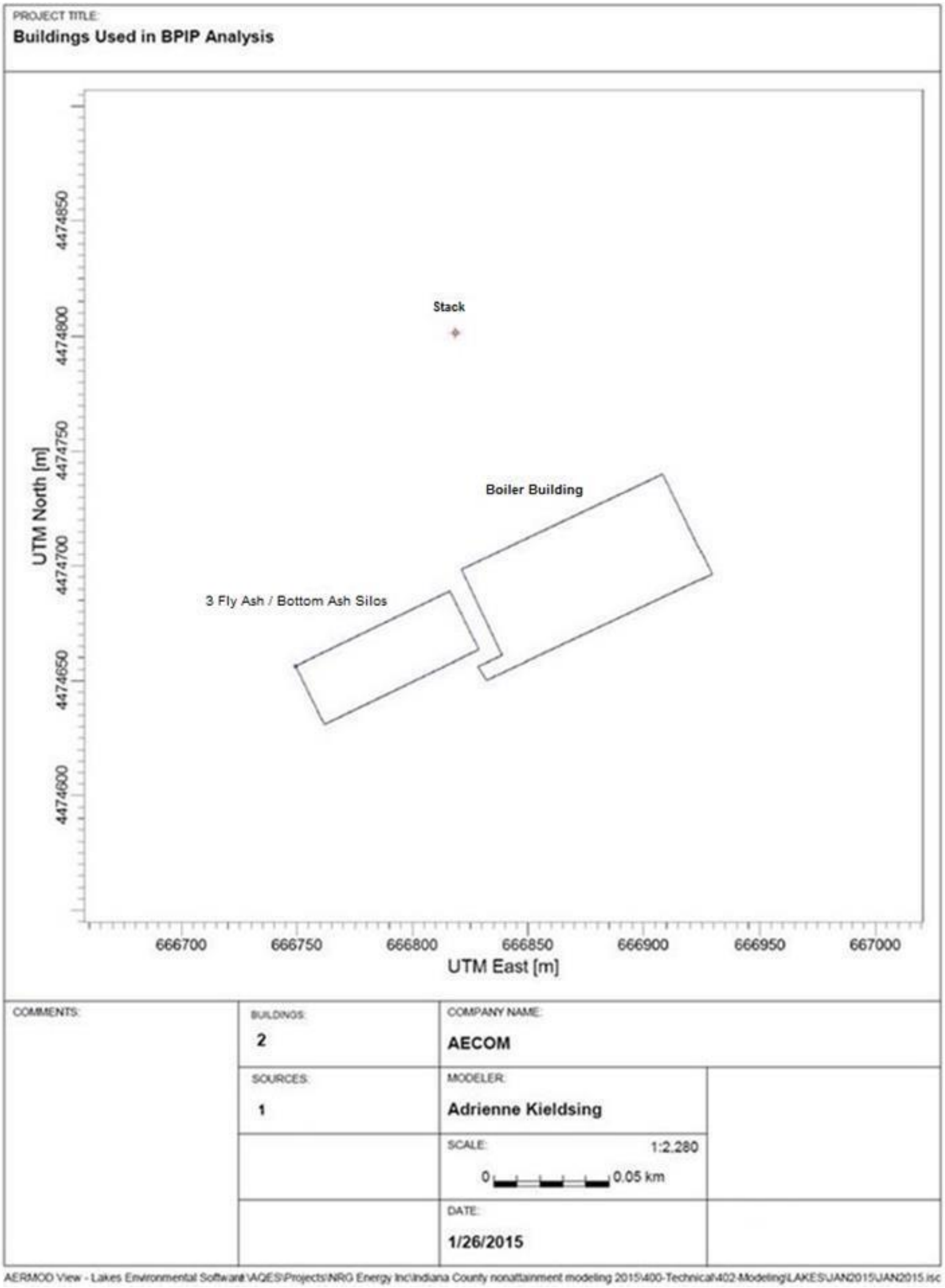


Figure 4-6: Stacks and Buildings to Be Used in the GEP Analysis for Conemaugh Generating Station

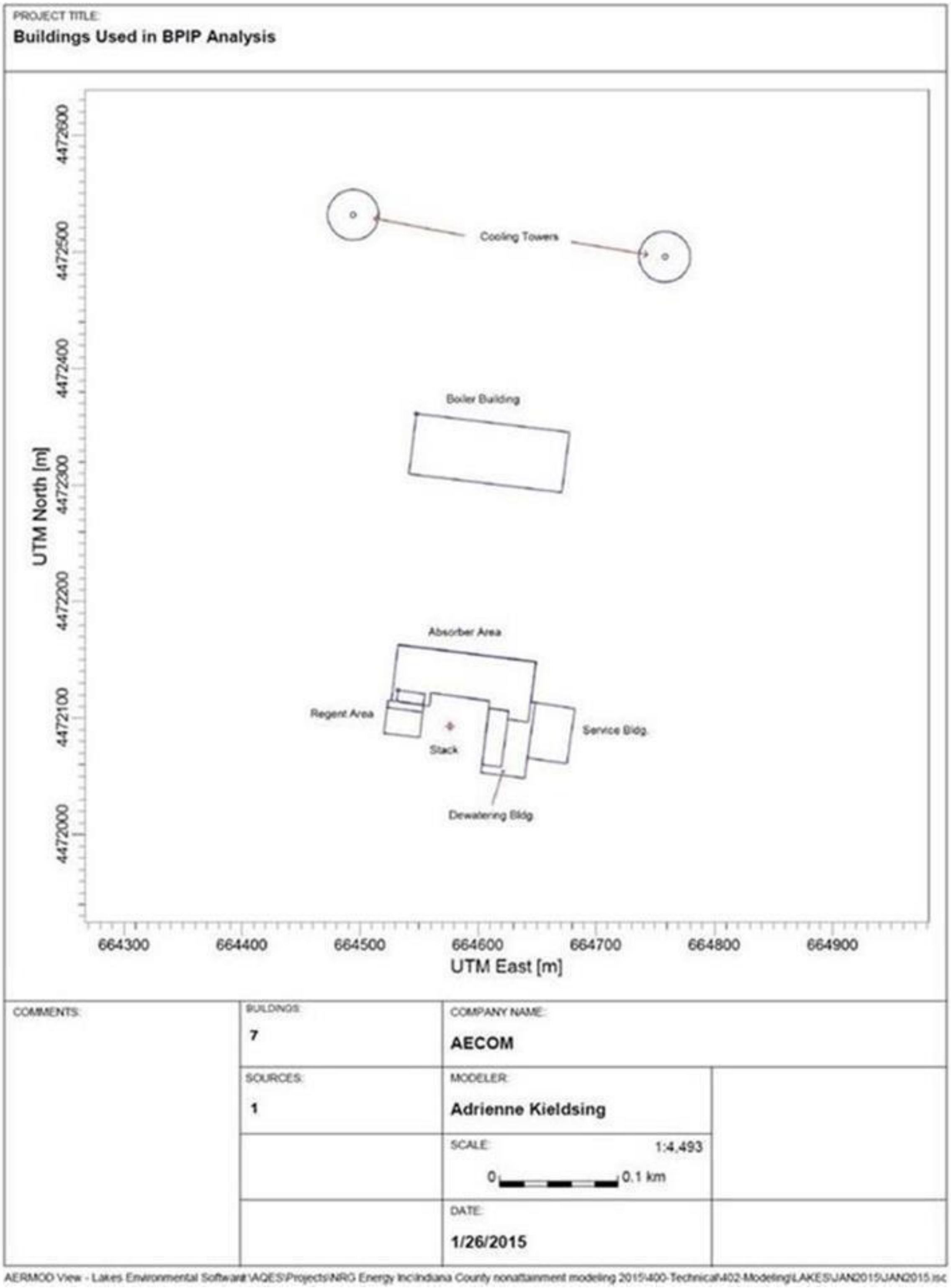


Figure 4-7: Stacks and Buildings to Be Used in the GEP Analysis for Homer City Generating Station

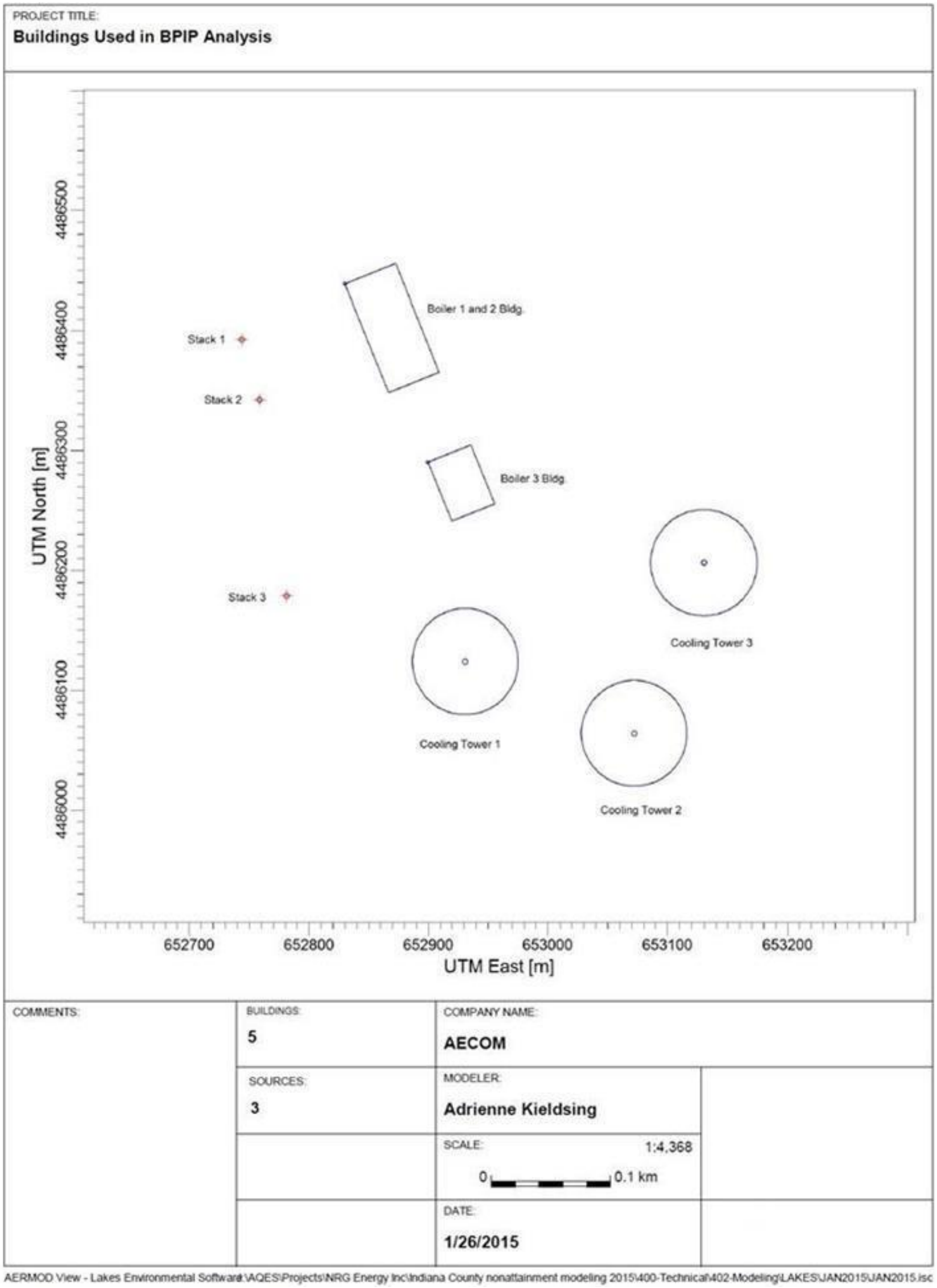


Figure 4-8: 1-km Radius Around the On-site Meteorological Tower and SODAR Location with Surface Roughness Sectors Shown on Aerial Photo

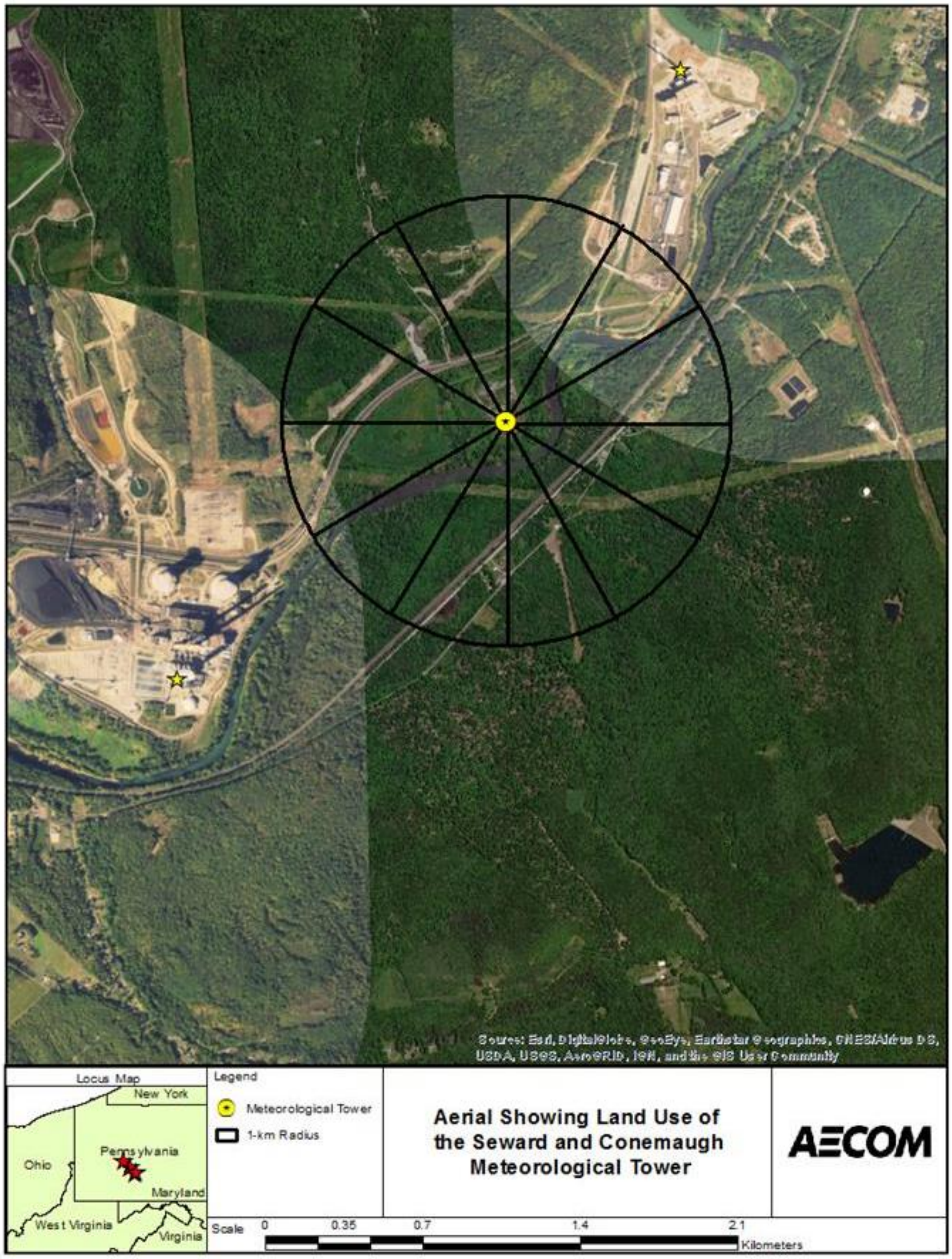


Figure 4-9: 1-km Radius Around the On-site Meteorological Tower and SODAR Location with Surface Roughness Sectors Shown on Land Use Imagery

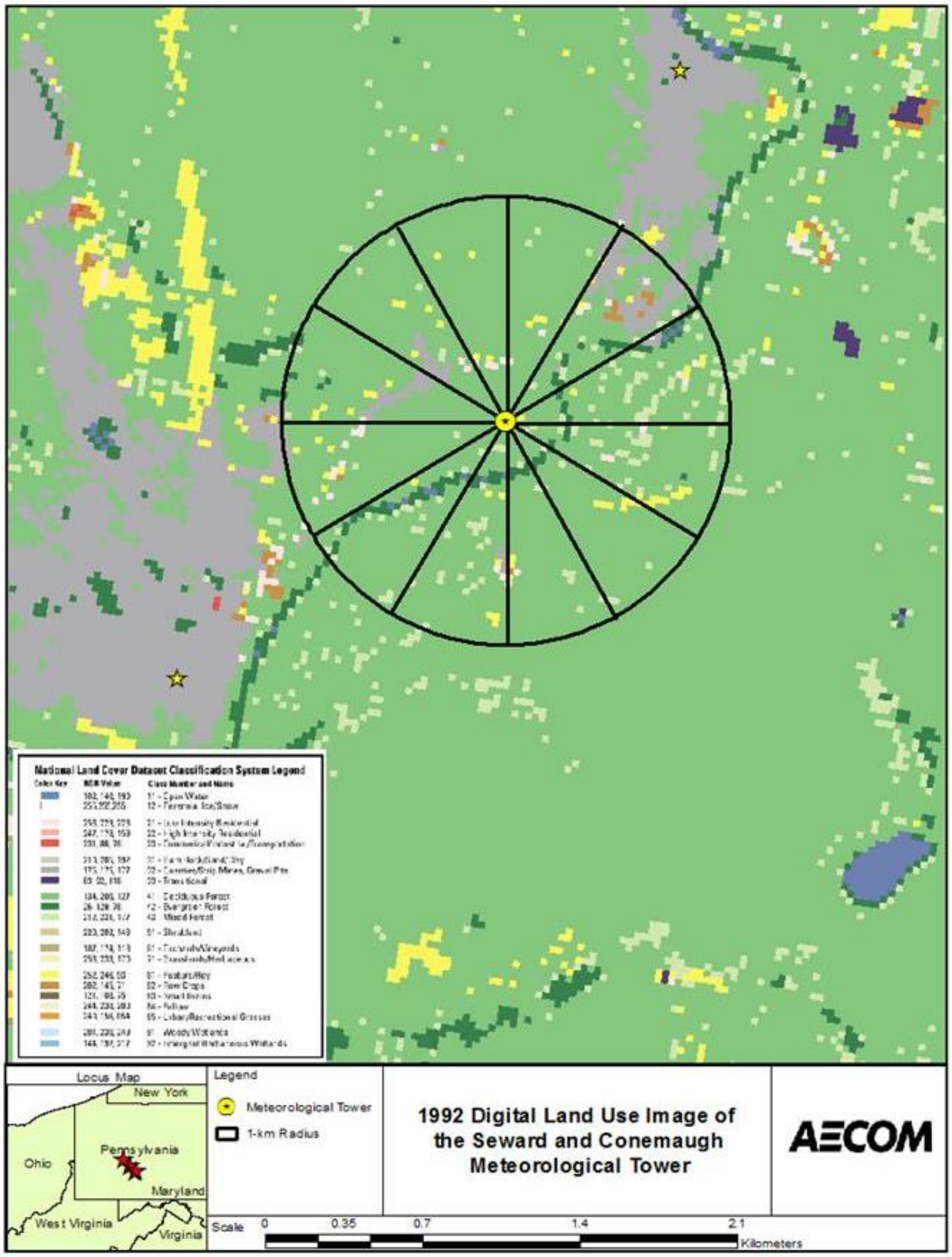


Figure 4-10: Location of Snow Cover Observation Station

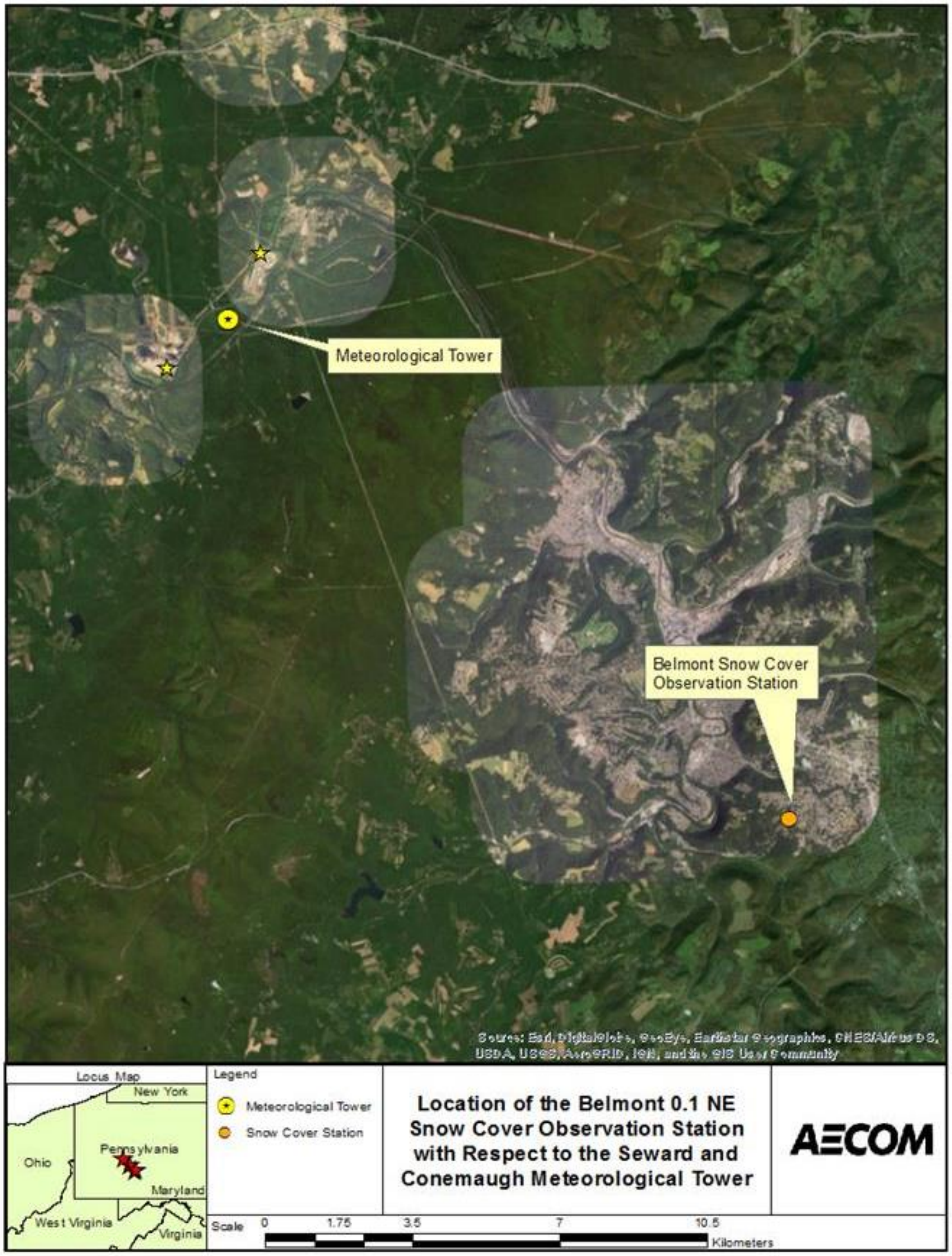


Figure 4-11: Receptor Grid Proposed for NAA Focus Area Modeling

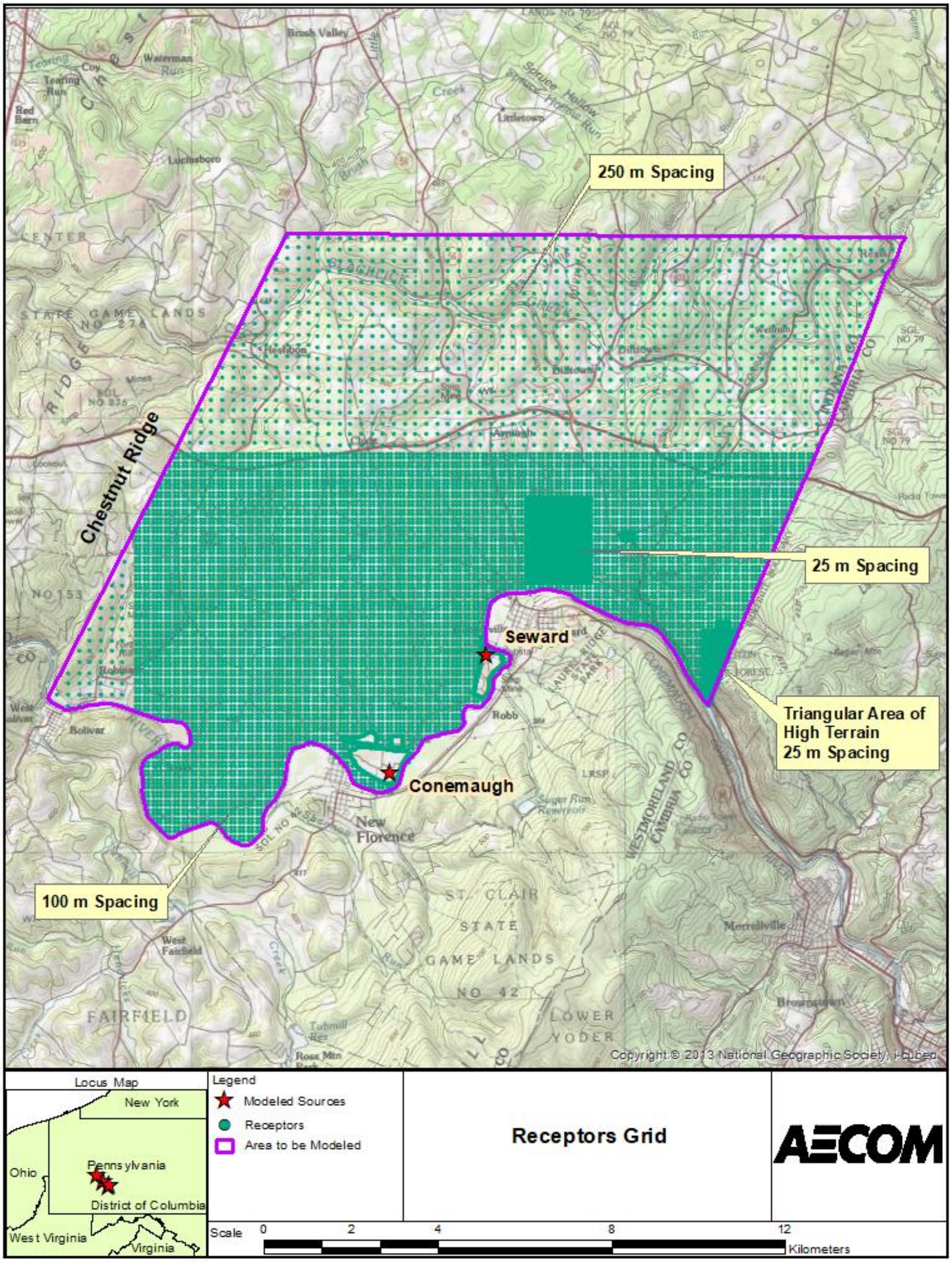
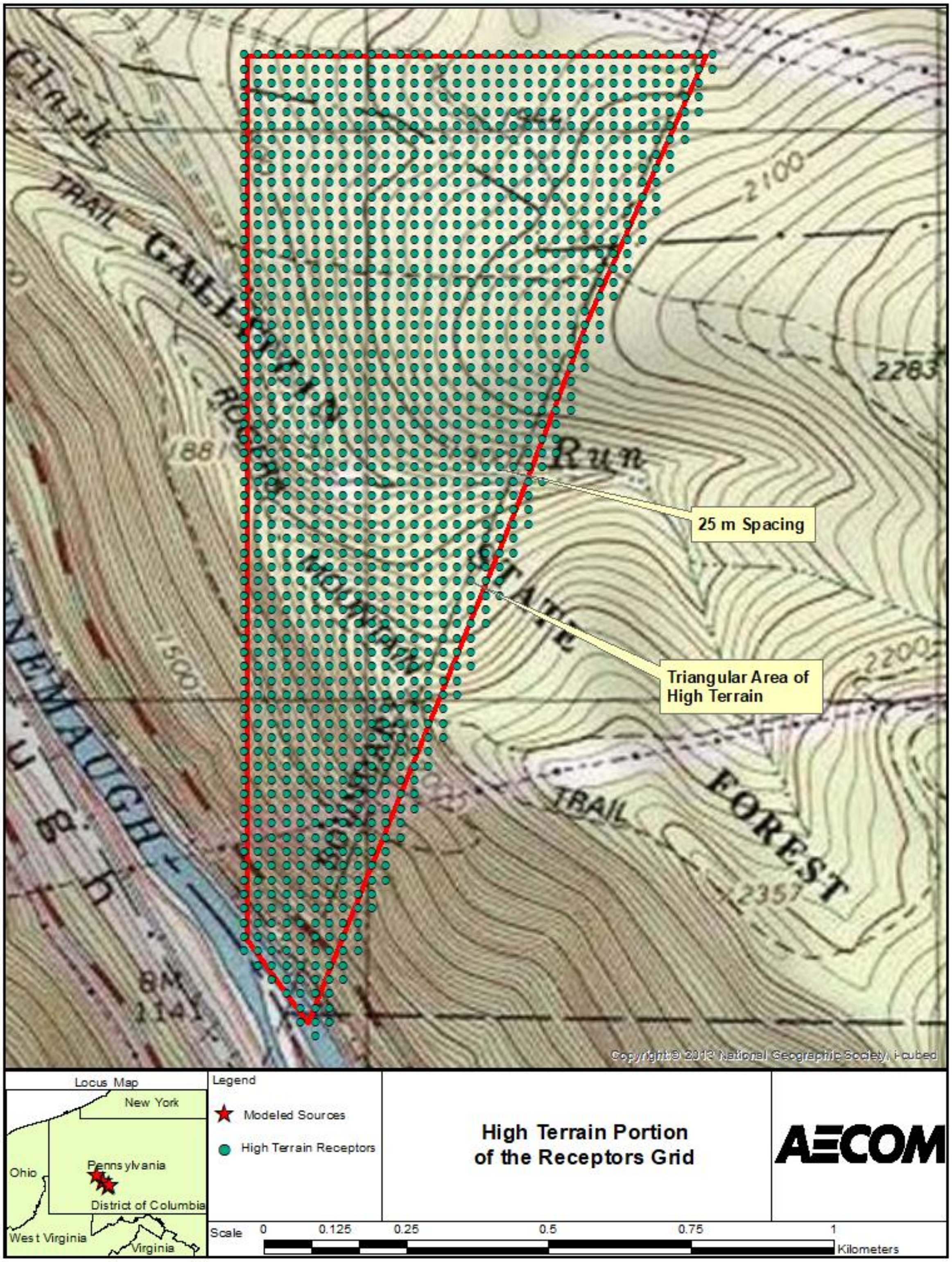


Figure 4-12: Triangular Portion of the Receptor Grid Proposed for NAA Focus Area Modeling



5. Overview of Modeling for Longer Averaging Periods

EPA's April 23, 2014 guidance[24] for resolving SO_2 non-attainment areas acknowledges "that it may be possible in specific cases for states to develop control strategies that account for variability in 1-hour emissions rates through emission limits with averaging times that are longer than 1 hour, using averaging times as long as 30-days, but still provide for attainment of the 2010 1-hour SO_2 NAAQS." EPA's general expectation is that for infrequent periods of hourly emissions above the critical emission value, "these periods would be unlikely to have a significant impact on air quality, insofar as they would be very unlikely to occur repeatedly at the times when the meteorology is conducive for high ambient concentrations of SO_2. EPA considers this option to be an "appropriate balance between providing a strong assurance that the NAAQS will be attained and maintained, while still acknowledging the necessary variability in source operations and the impairment to source operations that would occur under what could be in some cases an unnecessarily restrictive approach to constraining that variability" (emphasis added). All of the sources included in this modeling study are equipped and are operated with SO_2 emissions control devices. For such sources seeking alternate or longer-term emission limits, EPA's guidance notes that:

> "Sources with emission control equipment may be especially prone to periodic occurrences of high emissions, arising on occasions when the control equipment is not operating or operating at reduced efficiency. Therefore, the EPA finds it advisable that longer term average limits for sources that meet these limits through the use of emission control equipment be subject to supplemental limits that serve to constrain the frequency and/or magnitude of occasions of elevated emissions. Establishment of such supplemental limits as part of a longer-term averaging approach is especially important in cases with significant potential for frequent and/or high magnitude occasions of elevated emissions, including, but not limited to, sources using emissions control equipment."

Conemaugh Units 1 and 2, Keystone Units 1 and 2 and Homer City Units 1, 2, and 3 are very large pulverized bituminous coal-fired boilers (see heat input ratings in Table 3-1). For such large units, process upset conditions that could potentially result in infrequent elevated SO_2 emission spikes (e.g., loss of a spray pump in the flue gas desulphurization module) may be difficult to address within a one-hour period in a manner that restores operations to those that preceded the upset condition. These units are operated in a manner that avoids unplanned or abrupt changes in generating load. Consequently, establishing alternate SO_2 emission limits is appropriate for these sources, and similarly for Seward Generating Station. In general, EPA expects that any emission limit with an averaging time longer than 1 hour would need at least a slight downward adjustment to compensate for the loss of stringency inherent in applying a longer-term average limit.

Discussions for the proposed SO_2 emission limits and approaches to determine these emission limits for each station were documented in the previously submitted SIP, and there are no changes in the emission limits proposed for Keystone, Homer City, and Conemaugh. This supplemental modeling analysis is expected to result in a lower CEV emission rate for Seward than that reported in the 2017 modeling report, but it is expected that the equivalent 30-day rolling emission level as modeled will be higher than its current limit. This is due to the fact that Seward has improved its emissions management operations, especially during startup in recent years. Therefore, the peak SO_2 emission events are much less frequent. The proposed modeling approach involves CEV modeling of Keystone, Conemaugh, Seward, and Homer City at the emission rates listed in Table 2-2. Then, the next step is to characterize the emissions from Seward for a 30-day rolling average emission limit using a "Randomly Reassigned Emissions" approach discussed in the next section.

In EPA's 2014 SO_2 non-attainment guidance document (EPA's Appendix B), a discussion of the effect of infrequent emissions above the Critical Emission Value was given (excerpts provided below).

> "Exceedances of the SO_2 NAAQS occur when emissions from relevant sources are sufficiently high on occasions when the meteorology is conducive for those emissions to cause elevated SO_2 concentrations. An illustrative example would be a case in which a single source has a dominant impact on area concentrations, and the source only causes an exceedance at a particular location with light southwest winds with limited dispersion. In this example, the likelihood of an exceedance at that location will be a function of the likelihood of elevated emissions occurring during times of light

[24] http://www3.epa.gov/airquality/sulfurdioxide/pdfs/20140423guidance.pdf

southwest winds with limited dispersion. Stated more generally, the likelihood of an exceedance is a function of the likelihood of emissions being high when the meteorology is conducive for the source to cause an exceedance. By extension, the likelihood of a violation is a function of the likelihood of emissions being high on a sufficient number of times with meteorology conducive to having exceedances to have the average of the 99^{th} percentile daily maximum values exceed the NAAQS. Viewed another way, the occasions when the meteorology is conducive for the source to cause an exceedance at a particular location are likely to be infrequent, and high concentrations are contingent on both emissions being sufficiently high and the meteorology being sufficiently conducive. The NAAQS itself is based on relatively rare occurrences, being based on the 99^{th} percentile of daily maximum concentrations. Nevertheless, the point here is that the occurrence of high emissions will not cause an exceedance if it does not occur when meteorology is conducive to having an exceedance. Furthermore, a source with rare occurrences of high emissions and with much more frequent occurrences of moderate emissions is more likely to have moderate emissions on those occasions with meteorology conducive for exceedances, and the design value for the source may be more prone to reflect the moderate emissions than the high emissions."

EPA's 2014 SO_2 non-attainment guidance document establishes a procedure in their Appendix B for showing that a longer-term emission limit (with a downward adjustment factor applied to the CEV) can be protective of the 1-hour SO_2 NAAQS. The discussion on page 25 of this guidance further discusses this approach.

"Appendix B documents analyses that the EPA has conducted to evaluate the extent to which longer term average limits that have been adjusted to have comparable stringency to 1-hour limits at the critical emission value provide for attainment. In brief, while a longer-term average limit as contemplated here would allow occasions when emissions exceed the critical emission value, the use of a lower limit compensates by requiring most values to be lower than they are required to be with a 1-hour limit at the critical emission value. The EPA expects that a common net result will be that the comparably stringent limit will provide a sufficient constraint on the frequency and magnitude of occurrences of elevated emissions (especially if supplemented with more direct limits on these occurrences) that a control strategy based on such limits would reasonably provide for attainment."

Once a 1-hour emission limit (assuming constant operation) at the critical emission value is established based on the traditional modeling approach, the critical emission value could then be used as the baseline for establishing a longer-term averaged emission limit. Historical emissions can be analyzed to determine a representative future emission scenario and then scaled as needed to fit the longer-term average emission limit. A source could be expected to experience occasional hourly emission rates greater than the longer-term average emission limit with the likelihood that such infrequent emissions do not result in a NAAQS exceedance, as discussed above.

In their Appendix B of the 2014 SO_2 non-attainment guidance, EPA has outlined a procedure to conduct modeling of a highly variable source as well as a site-specific modeling approach for demonstrating through a large number of modeling runs that a specific emissions distribution can be shown to protect the 1-hour SO_2 NAAQS. This "Randomly Reassigned Emissions" (RRE) procedure is discussed further in the next section for Seward Station.

6. Randomly Reassigned Emissions Modeling for Seward

The procedures outlined in Appendices B and C of the April 23, 2014 Guidance for 1-hour SO_2 Non-attainment Area SIP Submission Memorandum discuss how to calculate a longer-term emission limit based upon probabilistic modeling that shows that the longer-term emission rate will still result in 1-hour SO_2 NAAQS compliance. Establishing a longer-term average limit is most appropriate if the frequency and magnitude of such occasions of elevated emissions will be relatively low (typically no more than 5% of the time). EPA's Appendix B procedure for determining a suitable longer-term average limit consists of the following steps for a variable emission source such as Seward.

1. Conduct dispersion modeling to determine 1-hour CEV based on a level of emissions that shows NAAQS compliance; this emission rate is lower than the emission rate of infrequent elevated emission hours (for Seward, this is projected to occur no more than 2.5% of the time).
2. Derive an estimate of the distribution of future emission from statistical analysis of a set of representative recent emissions data (i.e., CEMS) that reflects the emissions variability that the source is expected to exhibit in the future. This emission distribution can be expressed as a cumulative frequency distribution and can also be expressed as a set of discrete emission "bins" that approximate (or that provide a slightly higher set of emissions than) the cumulative emissions curve. The distribution will include "normal" emission levels at or below the CEV (for about 97.5% of the hours modeled) and the high emission events above the CEV (about 2.5% of the hours modeled).
3. Create a large number (e.g., 100) emission data sets (full years of hourly emissions data that reflect the emissions distribution) by randomly assigning hourly emission values from the scaled emissions.
4. Establish an emissions "rule" that accommodates the 1-hour emissions peaks, but sets the 30-day (monthly) emission averages to a level that is less than Seward's CEV value. The peak 1-hour emission rates are accommodated in discrete emission "events" that are representative of actual periods that match the actual emissions behavior.
5. Create a large number (100) of emission data sets (full years of hourly emissions data that reflect the entire emissions distribution) by randomly assigning hourly emission values from the emissions bins throughout the year accounting for the high emission event "rules".
6. Conduct 100 sets of AERMOD simulation runs (with a 1-year meteorological data set with the on-site data) using the randomly assigned hourly emission values using the "rules" established above to obtain the average 99^{th} percentile of daily maximum concentrations. Determine the 99^{th} percentile statistic at each receptor in preparation for the next step.
7. Compare the modeled design concentration obtained from the 100 model simulations to the 1-hour SO_2 NAAQS. A successful outcome is that <u>all</u> of the 100 model simulations show NAAQS compliance. The design concentration for each of the RRE runs is within a 25-m receptor grid area by design, so the peak concentration is adequately resolved.
8. The 30-day rolling average permit limit will be consistent with the modeled monthly emission rates in the RRE modeling. This limit will be below the CEV as modeled (a fraction of 3,044/4,500, or 0.676, and, as demonstrated by the large number of RRE modeling runs, will be adequately protective of the NAAQS. The current emission limit of 3,038.4 lb/hr is equivalent to a fraction of 0.675 relative to a target CEV of 4,500 lb/hr.

6.1 Emission Bins to be Used for Seward RRE Modeling

A representative emission distribution is proposed for the randomly reassigned modeling runs based on the 2016-2018 actual emissions for Seward. The distribution accounts for the frequency and duration observed during actual station operations, and this operation is expected to continue in a similar manner for future years. For conservatism, the “binned” or step-wise modeled hourly emissions are fit to a frequency curve that includes slightly higher rates compared to the smoothed frequency distribution of the actual emissions. The emission cumulative frequency plots guide the analysis and are used for the basis of the emission bins for the 100 modeling runs. Figures 6-1 through 6-3 provide annual times series of Seward SO_2 emissions for years 2016, 2017, and 2018, respectively, with a horizontal line indicating the CEV. Figure 6-4 shows a cumulative distribution of hourly emissions (2016-2018) and Figure 6-5 focuses on the top 10% of the cumulative frequency distribution. A comparison of the previously modeled Seward RRE emissions (based upon 2014-2016 emissions) to the proposed RRE emissions for the highest percentile values shows that the updated peak emission rates are generally lower than the previously modeled RRE peak emission rates (see Figure 6-6).

A total of 13 emission bins (provided in Table 6-1) are proposed to represent this emissions distribution for Seward, with emission rates ranging from 2,000 lb/hr to 20,000 lb/hr. Approximately 97.5% of the hours are set at or below a reference emission rate of 4,500 lb/hr, which is the target CEV. The remaining 2.5% of the hours contain hourly emission rates greater than this reference rate. The infrequent and higher magnitude emission rates that make up the 2.5% of the hours from Table 6-1 will be modeled as groups, or events, that correspond to typical clustering of higher emission hours in terms of magnitude and frequency. Such prescribed events are characterized by a sequence of emissions with values greater than the short-term critical emission value lasting for durations that are representative of the actual emission behavior. Based upon 2016-2018 actual emissions, these prescribed events are provided in Table 6-2.

As shown in Table 6-1, the weighted hourly emission rate (annual average) is equal to 3,088 lb/hr, which is also the target equivalent rolling 30-day NAAQS-compliant mass emission rate for Seward used in the RRE modeling. This emission rate is approximately 50 lb/hr higher than the current Seward rolling 30-day emission limit of 3,038.4 lb/hr.

The process for building 365-day randomly reassigned emission sets will be repeated 100 times in order to develop the hourly emission files for the 100 AERMOD simulations. Appendix C shows time series plots of the 100 simulated years of the hourly emissions.

The 100 AERMOD simulations using randomly reassigned 1-hour emission rates for Seward will be run with a constant CEV 1-hour emission rate for Conemaugh, Homer City and Keystone, plus regional background (South Fayette monitor for 2016-2018 as discussed in Appendix B). The 99^{th} percentile peak daily 1-hour maximum at each receptor for each of the 100 AERMOD simulations is compared against the 1-hour SO_2 NAAQS. For a demonstration of compliance with the SO_2 NAAQS, each simulation must show that the 99^{th} percentile peak daily 1-hour maximum (with regional background included) is below 196.4 µg/m^3.

Table 6-3 lists the long-term average emission rates (representative of a 30-day average) determined for each of the proposed 100 model simulations that are based on the average of the randomly reassigned hourly emission distribution for that simulation year. Some slight variability from the target equivalent rolling 30-day average of 3,088 lb/hr is expected given that the hourly-varying emissions are randomly assigned and the distribution may vary slightly from year to year. The data from Table 6-3 are plotted in Figure 6-7 to provide a visual representation of the dataset.

6.2 Load-Varying Temperature and Velocity for Seward RRE Modeling

To ensure that appropriate gas exhaust parameters (temperature and velocity) are accounted for in the Randomly Reassigned Emissions modeling for varying emission loads, representative values have been calculated based on recent operational data for Seward. In the Spring of 2018, repairs were done to address boiler air in-leakages. The completion of this work resulted in slightly higher temperature and velocity exhaust measurements. As a result of this change, load-varying temperature and velocity for the RRE modeling are based upon 2018 data.

The average gas exit temperature for Seward does have some variability based upon emission rate, as shown in Figure 6-8. The average stack temperature is determined to be 193°F (362.59 K) and is representative for all operating loads modeled in the RRE analysis.

The velocity exhaust parameter for Seward does vary significantly with operating load. For emission rates at and above the target CEV (4,500 lb/hr), the exit velocity is 40.23 m/s, which will also be used in the CEV modeling. There are 4 RRE bins that fall below the CEV (2000, 2500, 3000 and 3500 lb/hr). These 4 bins use the average velocity for emissions halfway from the previous bin and to the next bin (i.e. +/-250 lb/hr). This exception to this rule is for the emission bin of 3,500 lb/hr, which goes halfway to the target CEV at 4,000 lb/hr to analyze the average velocity. Table 6-5 summarizes the median velocities for each these bins (less than the CEV).

6.3 Seward SO_2 Emission Limits

The air operating permit for Seward specifies that SO_2 emissions from Units 1 and 2 each shall not exceed a mass rate of 3038.4 lb/hr (0.6 lb/MMBtu times the rated combined heat input for Units 1 and 2 of 5,064 MMBtu/hr) on a 30-day rolling average basis. As noted in Section 3.1 of this protocol, because the flue gases from Units 1 and 2 are exhaust to a common exhaust stack, for modeling purposes, Units 1 and 2 are configured as a single source.

Seward proposes that attainment with the 1-hour SO_2 NAAQS in the Indiana, PA NAA can be assured via compliance with the use of a 30-day rolling average limit that will be calculated using EPA's Appendix B procedure as outlined above. A representative emission distribution modeled for the RRE modeling runs, as described above, is based on the 2016-2018 actual emission dataset for Seward (provided by Seward), although the frequency of peak emissions has decreased in the past 2 years, so this is a conservative emissions distribution. The RRE distribution accounts for the frequency and duration observed during actual station operations, and this operation is expected to continue in the same manner for future years. The "binned" or step-wise modeled hourly emissions, when compared to a frequency curve of expected emissions, show that the stepwise RRE emissions have slightly higher rates compared to the frequency distribution of the actual emissions for the recent 3-year period.

The 100 AERMOD simulations using randomly reassigned 1-hour emission rates for Seward will be run with a constant CEV 1-hour emission rate for Conemaugh, Homer City, and Keystone (as noted above) using the same receptor grid as the CEV run (as described in Section 4.5).

The modeling is designed to confirm that the emission values and averaging times listed in Table 6-4 are demonstrated through modeling to be protective of the 1-hour SO_2 NAAQS in the Indiana, PA non-attainment area.

Table 6-1: SO_2 Emissions Distribution for Randomly RRE Model Simulation Runs for Seward

Emission Bin	Hourly SO_2 Emission Rate (lb/hr)	Fraction of Occurrence in 366-Days	Cumulative Fraction of Occurrence	Weighted Hourly Rate (lb/hr)*	No. of Hours
1	2000	0.22495	0.22495	449.91	1976
2	2500	0.22495	0.44991	562.39	1976
3	3000	0.20002	0.64993	600.07	1757
4	3500	0.15005	0.79998	525.16	1318
5	**4500**	0.17498	0.97495	787.40	1537
6	5000	0.01275	0.98770	63.75	112
7	6000	0.00410	0.99180	24.59	36
8	7000	0.00273	0.99454	19.13	24
9	8000	0.00273	0.99727	21.86	24
10	10000	0.00137	0.99863	13.66	12
11	12000	0.00068	0.99932	8.20	6
12	15000	0.00034	0.99966	5.12	3
13	20000	0.00034	1.00000	6.83	3
Long-Term Avg. SO_2 Emission Rate/Total Hours Per Year				3088.06	8784

* The weighted average is the emission rate times the fraction of the year that it is occurring. The sum of the weighted averages is the total long-term emission rate.
Bold value represents the 1-hour CEV emission rate.

Table 6-2: High Emission Events Simulated for RRE Modeling for Seward

Event	Duration (hr)	Sequence of Emissions (lb/hr)	Frequency
Event 1	4	5000, 8000, 6000, 5000	Twice per month
Event 2	7	5000, 5000, 7000, 10000, 7000, 5000, 5000	Monthly
Event 3	11	5000, 5000, 6000, 6000, 12000, 20000, 12000, 6000, 5000, 5000, 5000, 5000	Every 6 months Jan/Jul during years 1, 7, 13… Feb/Aug during years 2, 8, 14… Mar/Sep during years 3, 9, 15… Apr/Oct during years 4, 10, 16… May/Nov during years 5, 11, 17… Jun/Dec during years 6, 12, 18…
Event 4	14	5000, 5000, 6000, 6000, 12000, 15000, 15000, 20000, 15000, 12000, 6000, 6000, 6000, 6000, 5000, 5000	Once per year

Table 6-3: Long-Term Average Emission Rates for Seward

Year (Iteration)	Average SO_2 Emission Rate (lb/hr)	Year (Iteration)	Average SO_2 Emission Rate (lb/hr)	Year (Iteration)	Average SO_2 Emission Rate (lb/hr)
1	3091.02	36	3079.41	71	3092.38
2	3092.84	37	3093.01	72	3078.10
3	3089.25	38	3085.50	73	3085.04
4	3074.62	39	3089.08	74	3096.65
5	3067.91	40	3074.34	75	3068.88
6	3077.53	41	3089.65	76	3089.99
7	3094.21	42	3095.63	77	3087.20
8	3099.95	43	3085.15	78	3074.00
9	3092.84	44	3094.21	79	3082.54
10	3105.87	45	3084.93	80	3098.30
11	3080.71	46	3076.33	81	3080.43
12	3086.18	47	3089.37	82	3076.39
13	3088.06	48	3092.55	83	3095.51
14	3077.53	49	3068.76	84	3081.68
15	3094.83	50	3088.46	85	3087.32
16	3081.34	51	3084.07	86	3077.81
17	3089.42	52	3091.93	87	3090.73
18	3079.86	53	3092.73	88	3075.93
19	3100.18	54	3079.18	89	3095.63
20	3081.34	55	3083.96	90	3092.67
21	3091.13	56	3078.32	91	3101.32
22	3097.28	57	3069.84	92	3093.29
23	3071.89	58	3077.36	93	3084.19
24	3088.97	59	3101.26	94	3075.31
25	3082.99	60	3066.88	95	3108.44
26	3087.09	61	3085.67	96	3089.03
27	3090.79	62	3095.86	97	3092.78
28	3091.30	63	3101.04	98	3085.67
29	3086.69	64	3080.49	99	3083.50
30	3081.97	65	3083.50	100	3094.66
31	3099.39	66	3096.20		
32	3095.97	67	3092.33		
33	3092.27	68	3089.08		
34	3086.69	69	3086.46		
35	3107.18	70	3082.14		

Table 6-4: Critical Emission Values and Averaging Times for Emission Limits

Source	Critical Emission Value – 1-hour SO_2 Emission Rates to Show NAAQS Compliance (lb/hr)	Permit SO_2 Emission Limits for Indicated Averaging Time (lb/hr)	Averaging Time for Allowable SO_2 Emission Limits
Seward	4,500.0	3,038.4	Rolling 30-day
Homer City 1	1,550.0	1,550.0	1 hour
Homer City 2	1,550.0	1,550.0	1 hour
Homer City 3	3,260.0	3,260.0	1 hour
Keystone	9,711.3	9,600.0	24-hour block
Conemaugh	3,381.0	3,312.0	3-hour block

Figure 6-1: 2016 Actual Hourly Emission Rates for Seward Compared to Short-Term Critical Emission Value

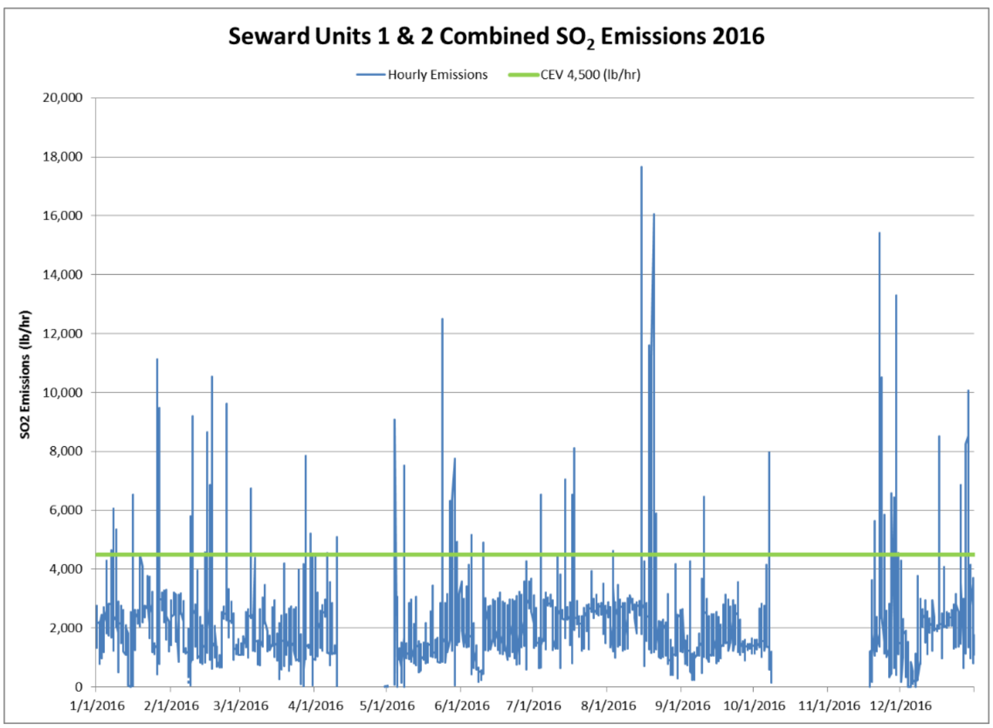


Figure 6-2: 2017 Actual Hourly Emission Rates for Seward Compared to Short-Term Critical Emission Value

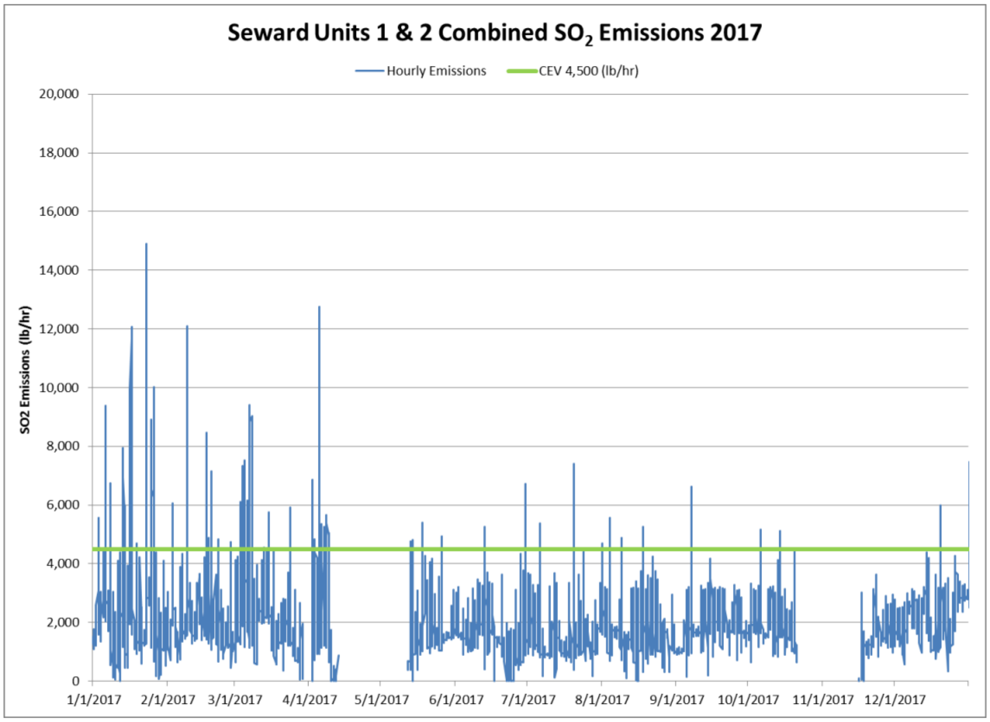


Figure 6-3: 2018 Actual Hourly Emission Rates for Seward Compared to Short-Term Critical Emission Value

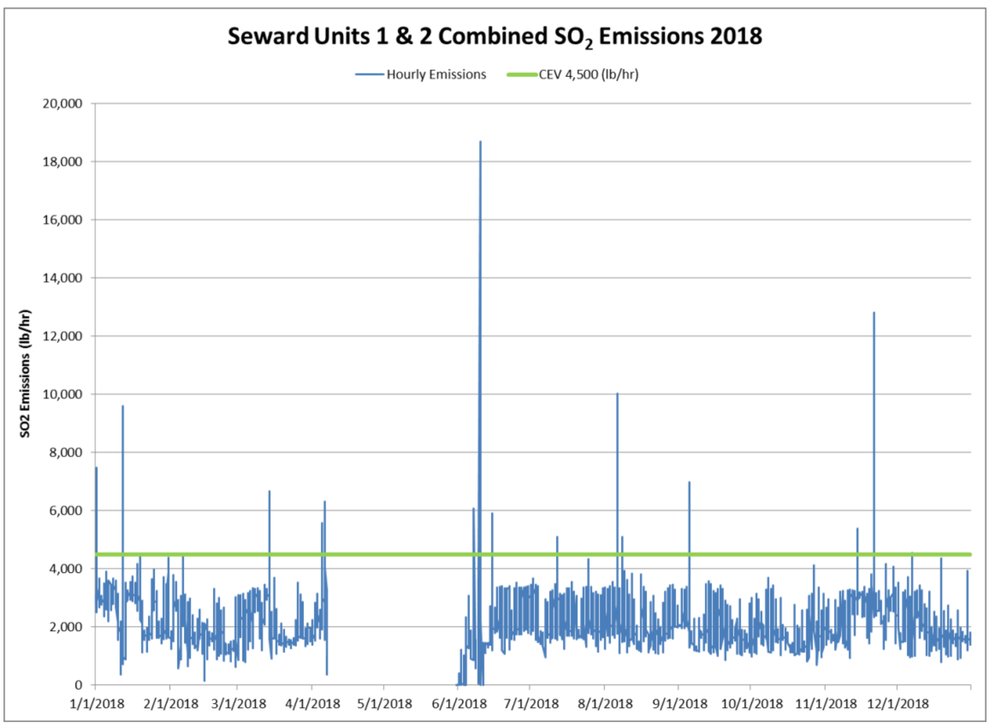


Figure 6-4: Cumulative Emission Plot for Randomly Reassigned Emissions Compared to 2016-2018 Actual Hourly Emissions at Seward

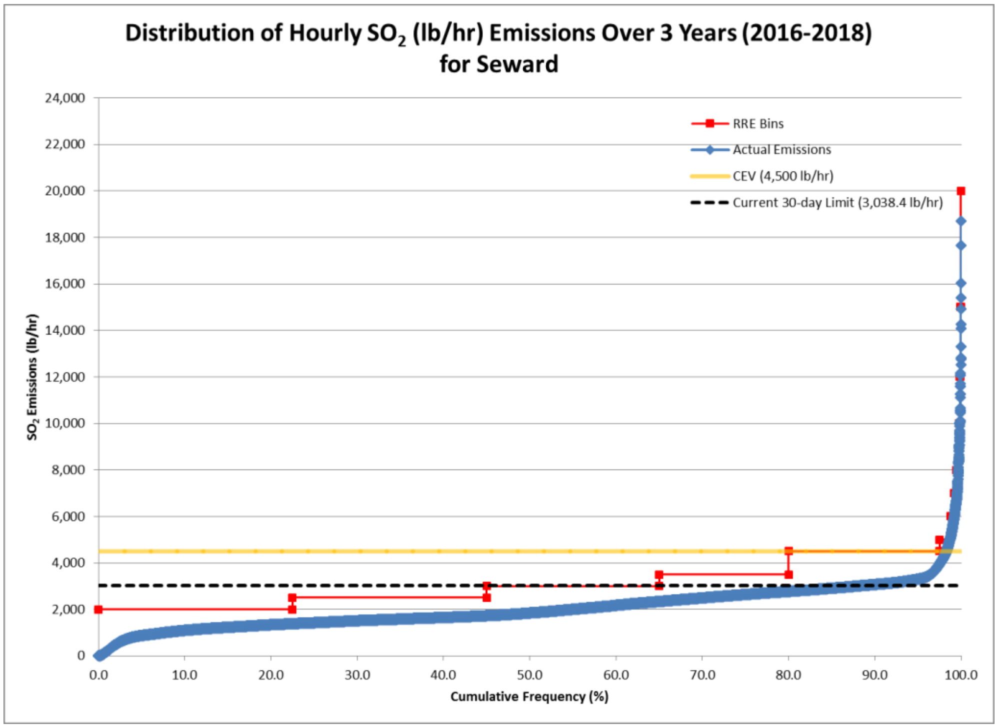


Figure 6-5: Top 10% of the Cumulative Emission Plot for Randomly Reassigned Emissions Compared to 2016-2018 Actual Hourly Emissions at Seward

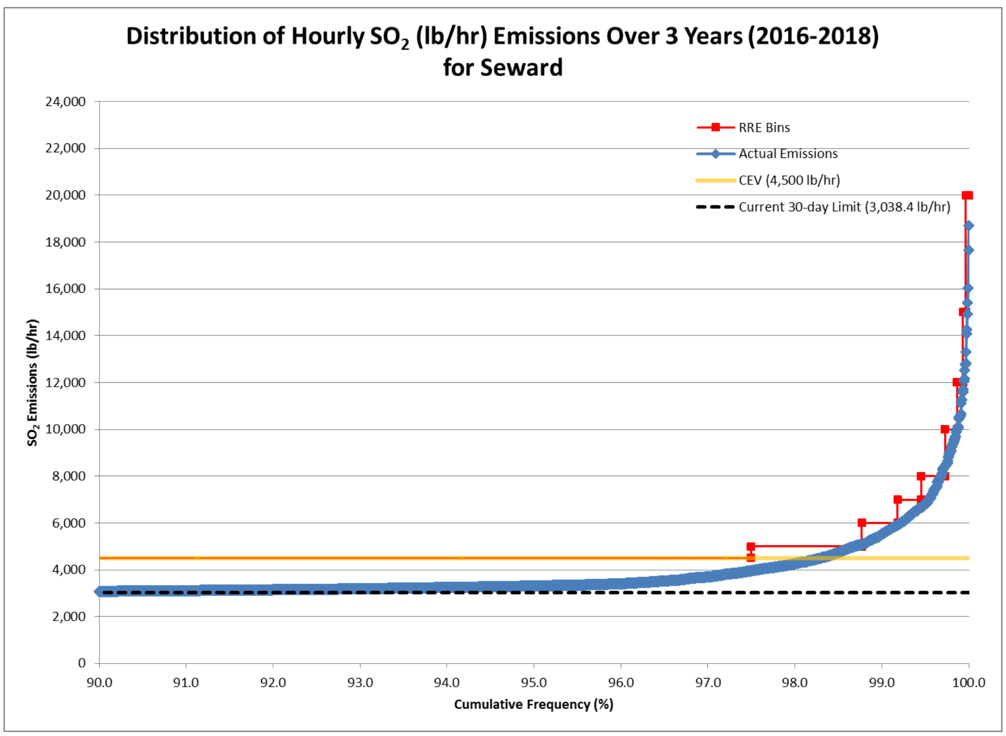


Figure 6-6: Comparison of Peak Seward RRE Emission Bins for Modeling Efforts Conducted in 2017 and 2019

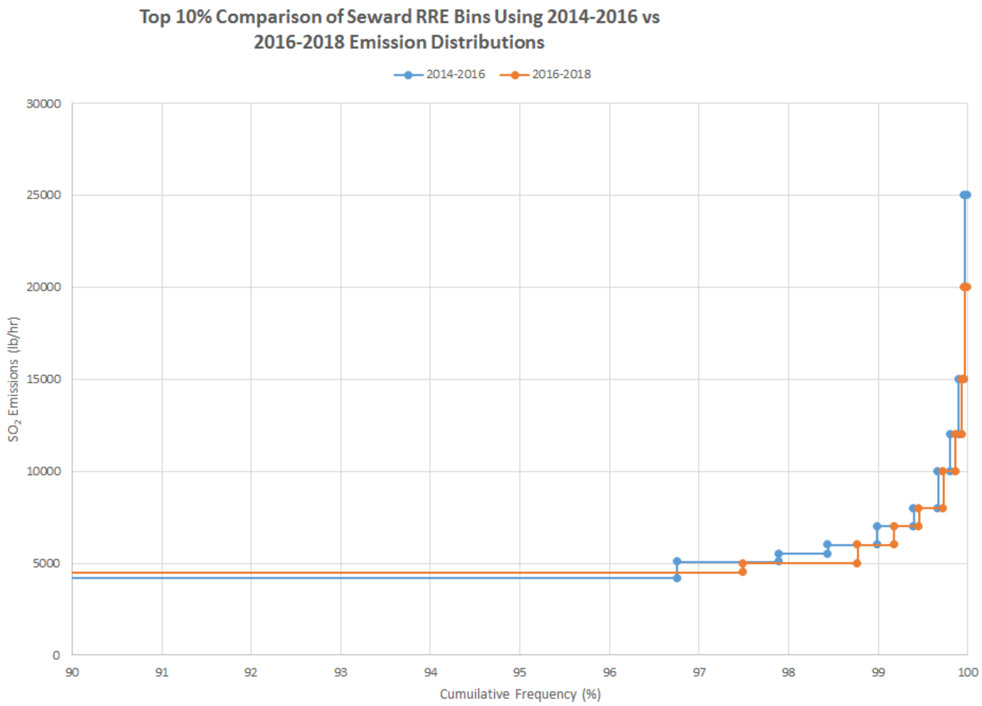


Figure 6-7: Long-Term SO_2 Emission Rate Limit Used in 100 Simulations of Randomly Reassigned Emission Demonstration for Seward

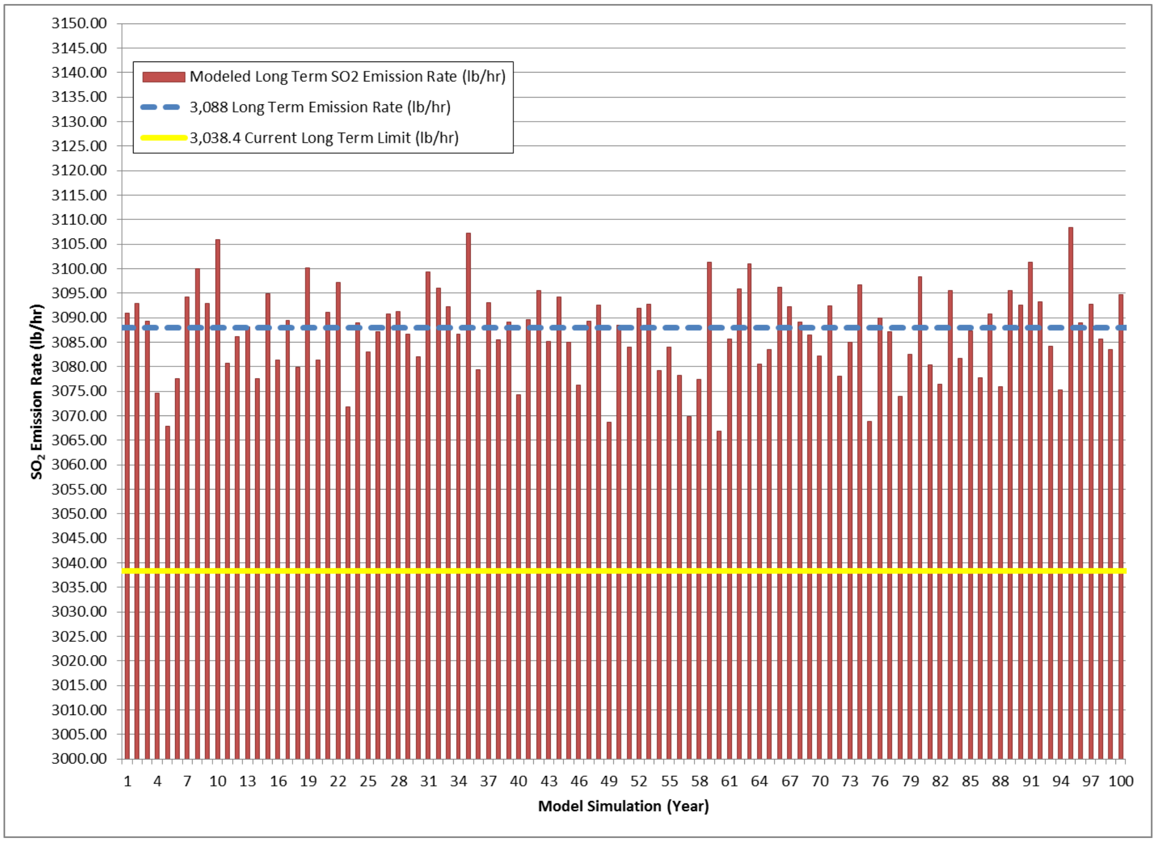


Figure 6-8: Seward Combined Units 1 and 2 Exit Temperatures versus SO_2 Emissions for 2018

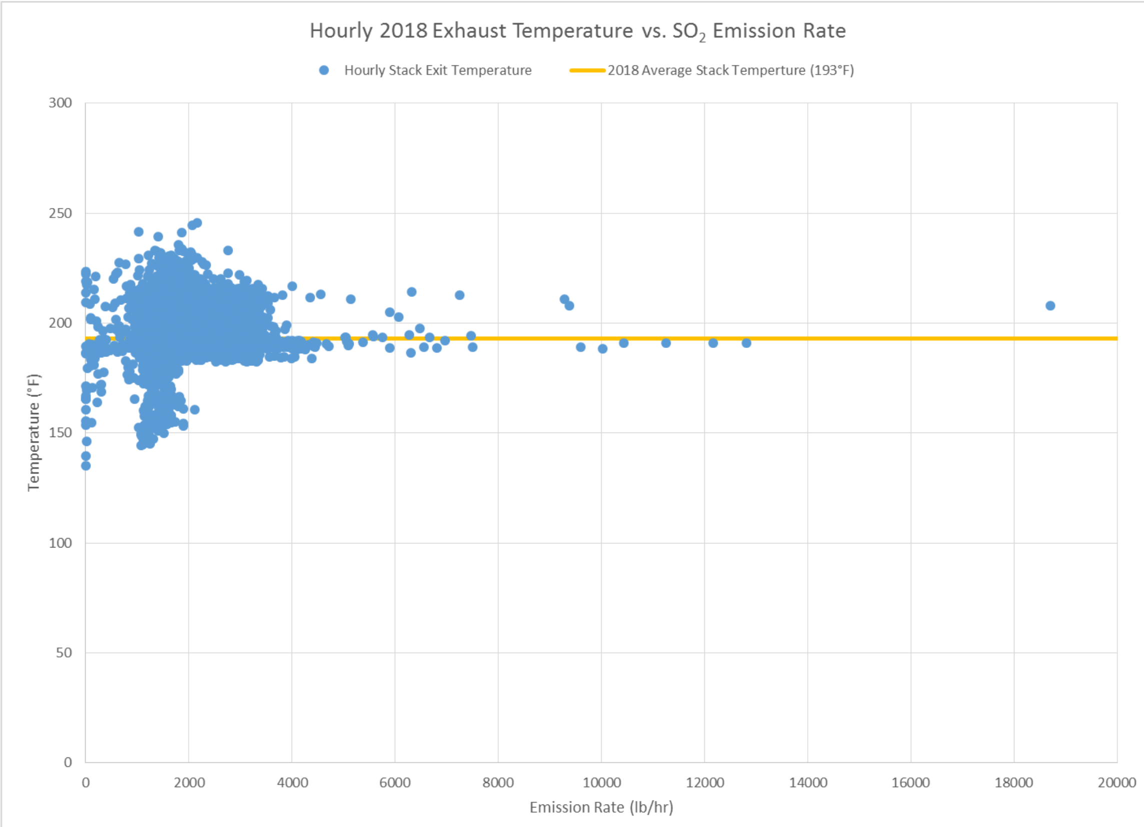


Table 6-5: Seward Combined Units 1 and 2 Average Velocities for RRE Bins

Emission Bin (lb/hr)	Emission Min (lb/hr)	Emission Max (lb/hr)	Average Velocity (m/s)	Modeled Velocity (m/s)
2,000	1,750	2,250	27.83	27.83
2,500	2,250	2,750	35.32	35.32
3,000	2,750	3,250	39.53	39.53
3,500	3,250	3,875	40.56	40.234[2]
CEV[1] and greater	N/A	N/A	N/A	40.234

[1] Critical Emission Value (CEV) = 4,500 lb/hr
[2] Maximum velocity capped at CEV velocity value for modeling.
Note: Emission min and max based upon halfway point to next bin.

7. Documentation for SO_2 NAAQS Compliance Modeling Analysis

A report will be provided that summarizes the procedures followed the emissions modeled (including CEVs and EPA's Appendix B emission data sets) and modeling results including tables and figures. Areas with modeled concentrations that are close to the SO_2 NAAQS will be evaluated using a refined receptor grid spacing of 25 meters. A modeling archive will be provided electronically to PA DEP.

With the use of on-site meteorological data and AERMOD default options, the modeling is expected to confirm that the emission limits specified in Table 6-4 will be protective of the 1-hour SO_2 NAAQS within the designated NAA.

Appendix A SODAR Wind Direction Interference Documentation

Introduction and Background

At the request of the Pennsylvania Department of Environmental Protection (PA DEP), an in-depth review of the on-site Sonic Detection And Ranging (SODAR) wind profiler system deployed from August 1, 2015 through August 30, 2016 was conducted. As discussed in the Indiana Nonattainment SO_2 Supplemental Modeling Protocol, the SODAR was capable quantifying wind measurements starting at 50 meters and extending upward in 50-meter increments to 500 meters[1,2]. As noted in the main document, input to AERMET will consist of parameters measured on the 100-m tower up to the 100-m level, and at incremental 50-m levels from 150 m to 500 m from the SODAR. SODAR data from the 50-m and 100-m levels were available for comparison to the tower data during the field measurement program, but are not being used in the modeling due to the presence of the tower data at those levels. The tower data at these lower levels have a higher data capture than the SODAR, so the SODAR data were used at levels above the 100-m level, up to a height of 500 meters.

While the SODAR data capture was greater than 90% through a height of 250 meters, for all parameters and each quarter of the 12-month period, an unusual behavior in the wind direction pattern that was noticed by PA DEP through a detailed wind rose analysis that required further investigation. This technical discussion analyzes the unusual SODAR wind direction behavior from this dataset, and provides an explanation for the behavior and a recommended revised approach for use of the on-site SODAR and 100-meter tower data for dispersion modeling.

On-site Tower and SODAR Comparison

As shown in Figure A-1, the site location of the tower and SODAR was approximately halfway between the Seward and Conemaugh Generating Stations. The siting of the equipment was carefully planned to minimize potential interference with the measurements from obstructions (such as trees or structures) and to be representative of the wind flow for both the Conemaugh and Seward stations. Quarterly audits were conducted throughout the 13-month campaign, which included qualitative dynamic tests of the measured parameters, as well as visual inspections to ensure no debris or other visual issues were present with the SODAR system.

A 12-sector (30 degrees-wide increment) wind rose analysis for selected levels from the tower and SODAR is shown in Figure A-2**.** PA DEP elected to perform an enhanced wind rose analysis by generating a 36-sector wind rose (with 10 degree-wide increments) for the same data. PA DEP findings included a comment concerning an unusual feature in the SODAR data from the west-southwest (between 230° and 260°) that is not seen in the tower data. This frequency of the SODAR winds in this 30° sector is noticeably lower than those in the adjacent sectors when 10-degree sectors are used in the wind rose analysis. PA DEP recommended that the same enhanced wind rose analysis using a 36-sector wind rose should be conducted by AECOM.

Figure A-3 presents the same tower and SODAR levels as shown in Figure A-2, but with the 36 sectors used. Upon visual inspection, we note that there is a clear and significant drop in the frequency of winds from 230° to 260°. At 50 meters, this feature is not substantially seen in the tower data, being very minimal and confined to just a 10° sector at 100 meters from the tower. A comparison of the wind rose data at the 150, 200 and 250-meter heights as presented in Figures A-2 and A-3 suggests that the SODAR appears to have "reallocated" the winds in the 230° to 260° sector to adjacent sectors. There were no appreciable changes in the wind distributions in the remaining directions (sectors between 300° and 210°).

It is important to highlight the inherent differences between the instrumentation used on the tower and the SODAR system to begin to understand what could be causing this behavior with the SODAR data. On the tower, a cup and vane wind instruments are used. Cup and wind vane measurements are single-level samples taken every second, which equates to 3,600 samples per hour. The SODAR measurements are less frequent

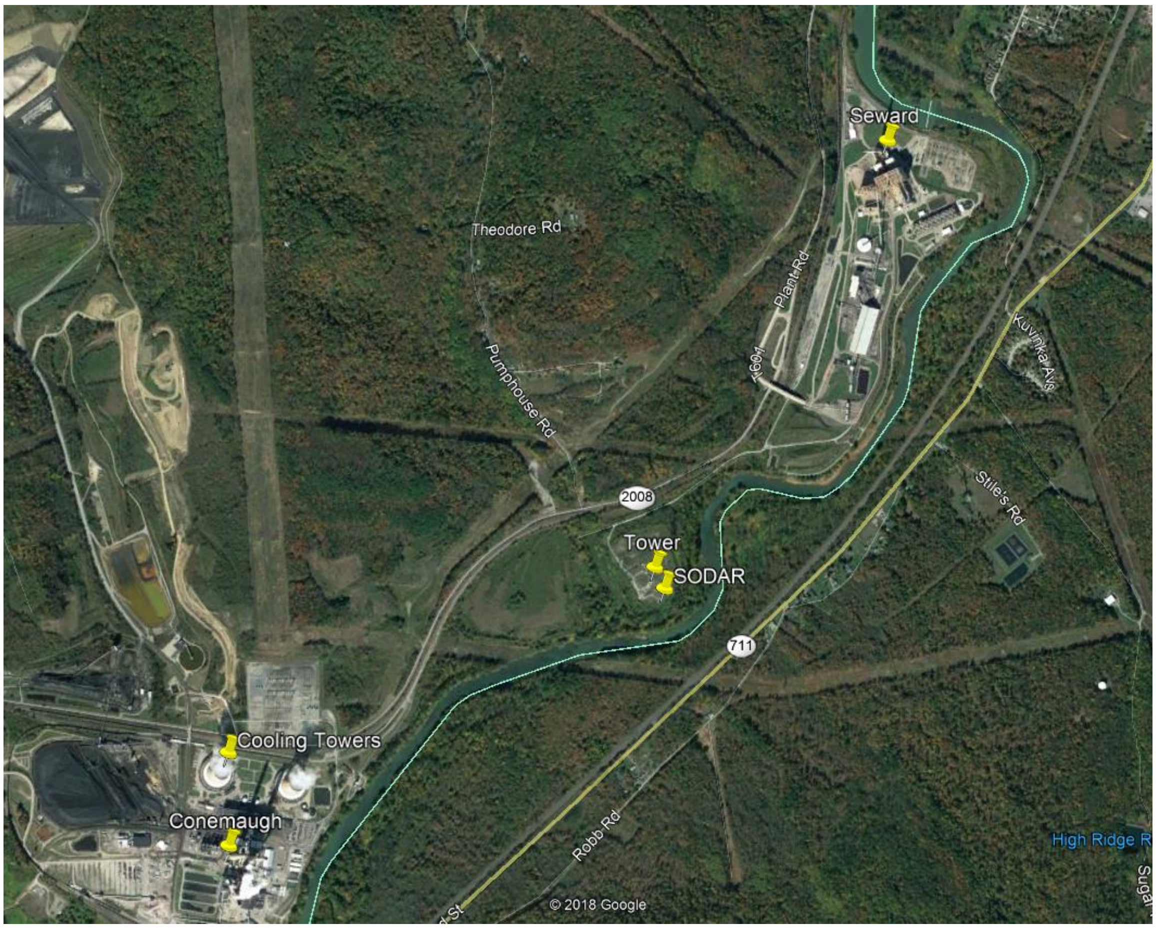
[1]AECOM. 2015. Summary Meteorological Monitoring Program Data Report. Conemaugh and Seward Generating Stations Indiana County, Pennsylvania. September 2015 - August 2016. AECOM Project Number: 60341515. March 2015.
[2]PA DEP. 2015. DEP Acceptance of Meteorological Monitoring Plan. NRG Energy Inc. Conemaugh Generating Station, West Wheatfield Township, Indiana County Seward Generating Station, East Wheatfield Township , Indiana County. April3, 2015.
Indiana County, Pennsylvania. September 2015 - August 2016. AECOM Project Number: 60341515. March 2015.

due to the need for a phased array signal to be sent, and then for the reflected sound to be detected. This process takes several seconds, resulting in fewer samples per hour than the tower data.

In addition to the time sampling difference between the tower and SODAR, another major difference is that for SODAR levels at 50-m intervals, the sampled height range is halfway to the adjacent levels. Therefore, the SODAR data represents a volume average over a 50-m depth centered at the reported height level.

Besides these inherent differences that produce random differences between SODAR and tower hourly averages, there are site-specific issues that can affect SODAR data, such as terrain, vegetation, low clouds and fog, precipitation, etc., as noted by Bradley[3].

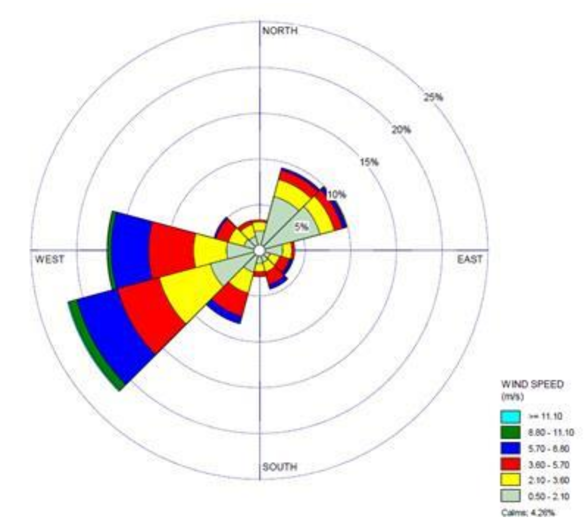
Figure A-1: Location of Tower and SODAR Relative to Seward and Conemaugh Stations



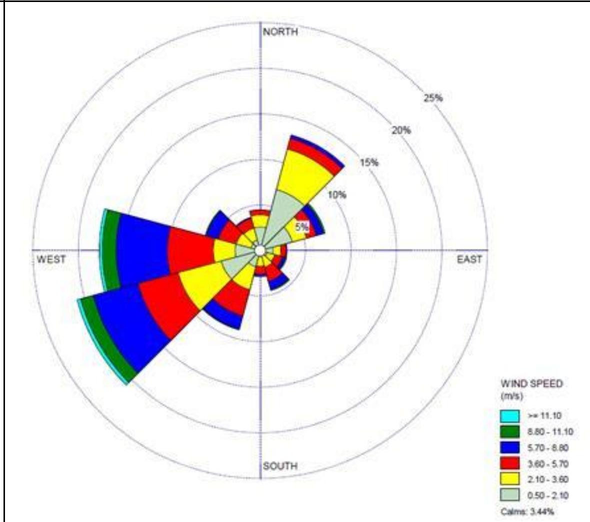
[3] Bradley, Stuart. SODARs (Sound Detection And Ranging). Available at: http://breeze.colorado.edu/ftp/RSWE/Stuart_Bradley.pdf

Figure A-2: Wind Roses for Selected Levels of On-Site Tower and SODAR Measurements – 12 Sectors

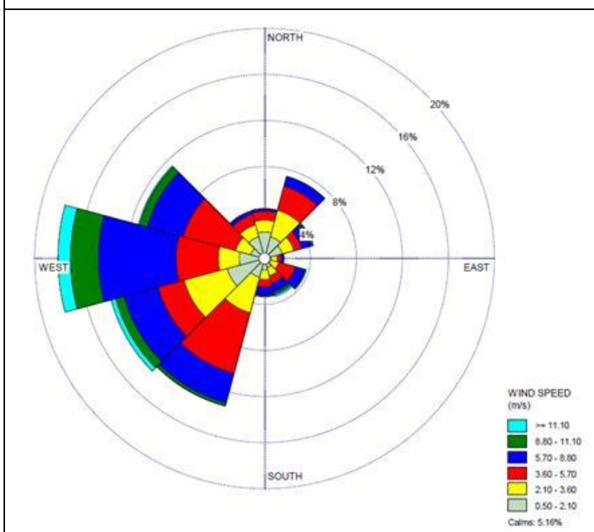
50-meter On-site Tower



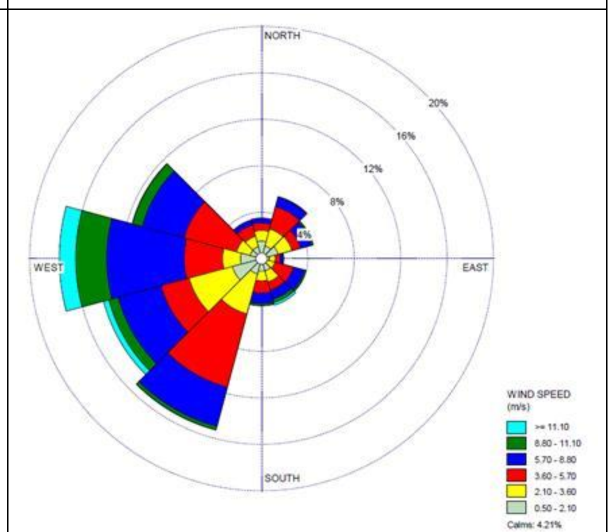
100-meter On-site Tower



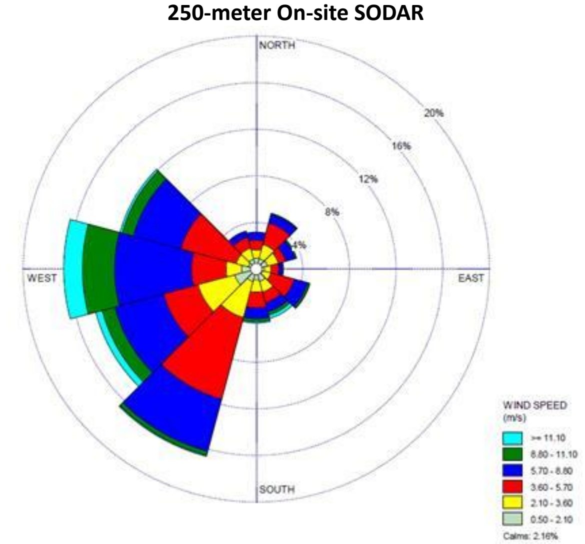
150-meter On-site SODAR



200-meter On-site SODAR



250-meter On-site SODAR



10-meter Johnstown Airport

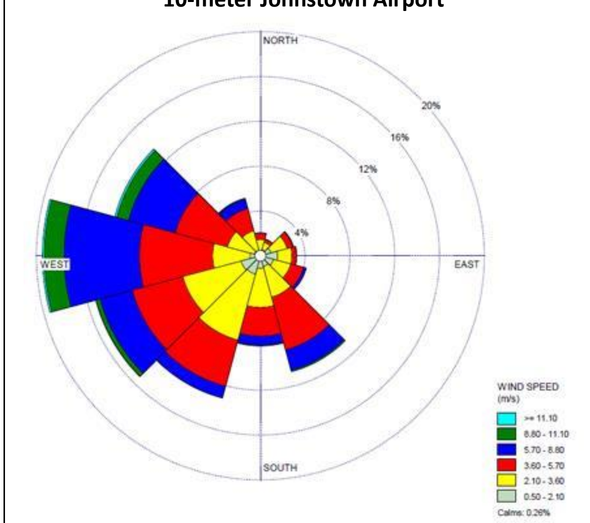
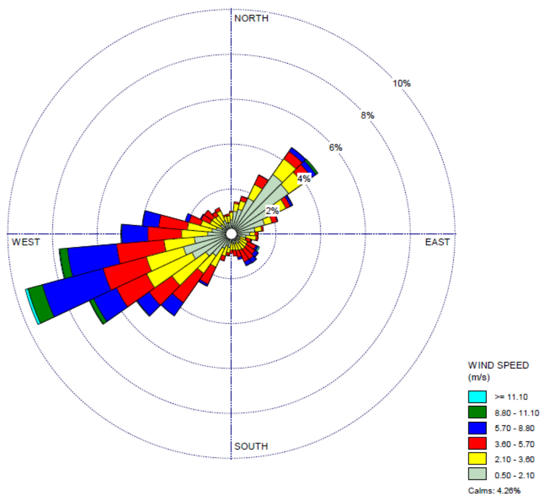
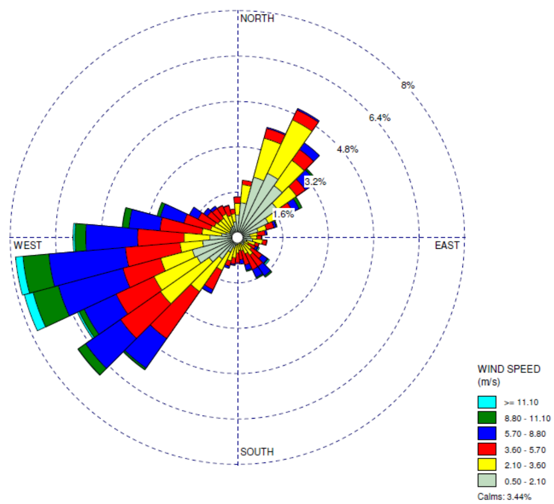


Figure A-3: Wind Roses for Selected Levels of On-Site Tower and SODAR Measurements – 36 Sectors

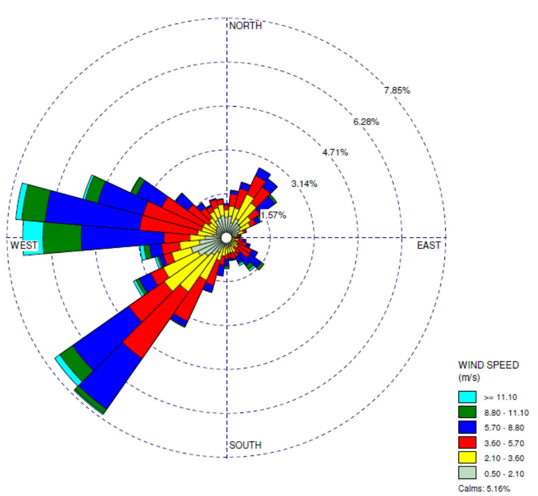
50-meter On-site Tower



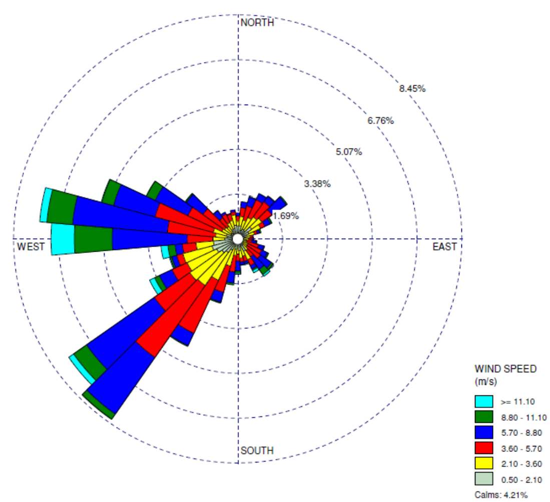
100-meter On-site Tower



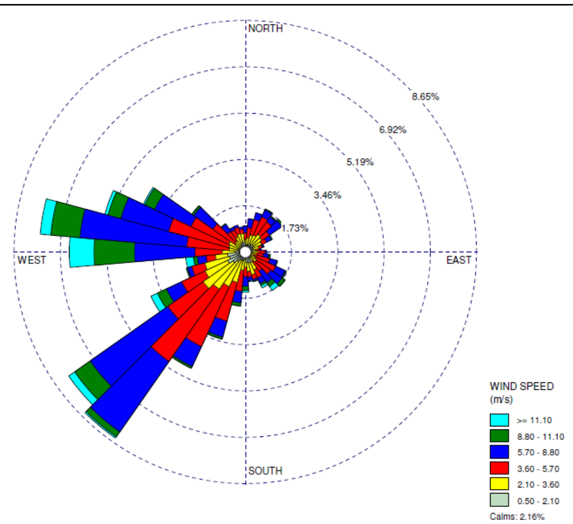
150-meter On-site SODAR



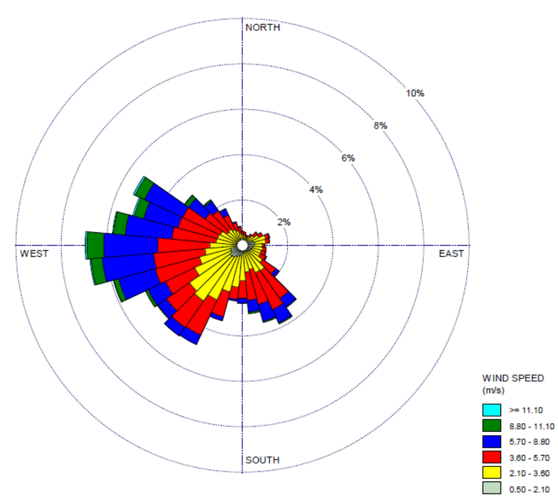
200-meter On-site SODAR



250-meter On-site SODAR



10-meter Johnstown Airport



SODAR Range Displacement Effect

The analysis presented above indicates a reported SODAR wind direction shift as compared to the tower measurements, with the peak shift occurring with a wind direction at about 250°. This direction corresponds to flow from the Conemaugh Generating Station toward the SODAR. While noise from the station is probably not an issue due to the distance involved (approximately 1.5 kilometers), a unique feature of that station is the presence of two tall (approximately 100-meters high) hyperbolic cooling towers with the attendant vapor and liquid droplet-laden plumes (shown in Figure A-4). For winds from the southwest, moist plumes from these cooling towers would have likely advected toward the SODAR site.

The moist plumes represent a unique enhanced environment for sharply increased reflectivity for sonic signals from the SODAR. However, because the moist plumes have a finite size relative to the volume sampled by the SODAR, the result is often a large gradient of reflectivity for the SODAR sampling volume. This has an effect on SODAR measurements as documented by Johnston et al. (2002)[4] in that the range placement of the returned sound is distorted. The placement results in a computed error in the reported SODAR wind direction, which is exactly what has been found in this case. It is also notable that the wind direction error decreases when the flow toward the SODAR is from directions other than that from d the Conemaugh Generating Station (discussed below). While this effect is evident in hindsight, AECOM (and Remtech, the SODAR manufacturer) is not aware of a previous instrument deployment that was found to be affected by moist plumes from hyperbolic cooling towers. However, due to the unique placement of the SODAR in the range of the cooling tower plumes in a relatively narrow wind corridor, the effect in this case is subtle and was not anticipated due to the lack of reported cases of this effect in prior SODAR deployments.

The Johnston et al. (2001) peer-reviewed paper discusses possible ways to correct for the range placement. The authors conclude that the error could be reduced to some extent, but not entirely eliminated. In the case of the hyperbolic cooling tower plumes, the extent of the vapor and water droplet plumes is a complicated function of temperature, humidity, and wind speed, which further complicates attempts to correct for this effect. Therefore, the most practical approach to be proposed in this revised protocol is to set aside for modeling purposes SODAR wind directions in the sector affected by the range displacement effect caused by the cooling towers.

To determine what directions that range displacement has on this site-specific SODAR between Conemaugh and Seward, an analysis of the 100-meter winds from the tower and SODAR was conducted. A 100° sector from the southwest (between 215° and 315°) was reviewed. To ensure that moist plumes from the cooling towers would advect toward the SODAR, a minimum wind speed threshold of 5 m/s from the tower data was used. Figure A-5 illustrates the difference in the wind direction between the SODAR and tower at 100 meters for tower wind speeds (at 100 meters) above 5 m/s (selecting speeds for which consistency between the tower and SODAR would be expected). To help quantify this difference, the median of the differences for this 100° sector at 5° intervals is plotted in Figure A-6. Figure A-6 shows an abrupt increase in the median difference between SODAR and tower from 245° to 255° where the median difference goes from approximately 5° to about 17°. As the wind become more westerly, the magnitude of the median difference steadily drops as it returns to around +/- 5° at 290°. Therefore, the range displacement effect appears to be between 235° and 290°, where the median difference between the tower and SODAR at 100 meters is greater than 5°[5].

[4] Johnston, Paul & Hartten, Leslie & H. Love, Carl & A. Carter, David & S. Gage, Kenneth. (2002). Range Errors in Wind Profiling Caused by Strong Reflectivity Gradients. Journal of Atmospheric and Oceanic Technology - J ATMOS OCEAN TECHNOL. 19. 10.1175/1520-0426(2002)019<0934:REIWPC>2.0.CO;2. Available at: https://www.researchgate.net/publication/249604685_Range_Errors_in_Wind_Profiling_Caused_by_Strong_Reflectivity_Gradients/link/545949f30cf2cf516483ce86/download.

[5] Five degrees is the tolerance allowed for wind direction measurements according to EPA's Meteorological Monitoring Guidance for Regulatory Modeling Applications (2000), available at https://www3.epa.gov/scram001/guidance/met/mmgrma.pdf.

Figure A-4: Photo taken of Conemaugh Generating Station showing visible plumes from cooling towers

Figure A-5: Difference Between SODAR and Tower Wind Directions at 100 meters for Tower Wind Speeds Above 5 m/s

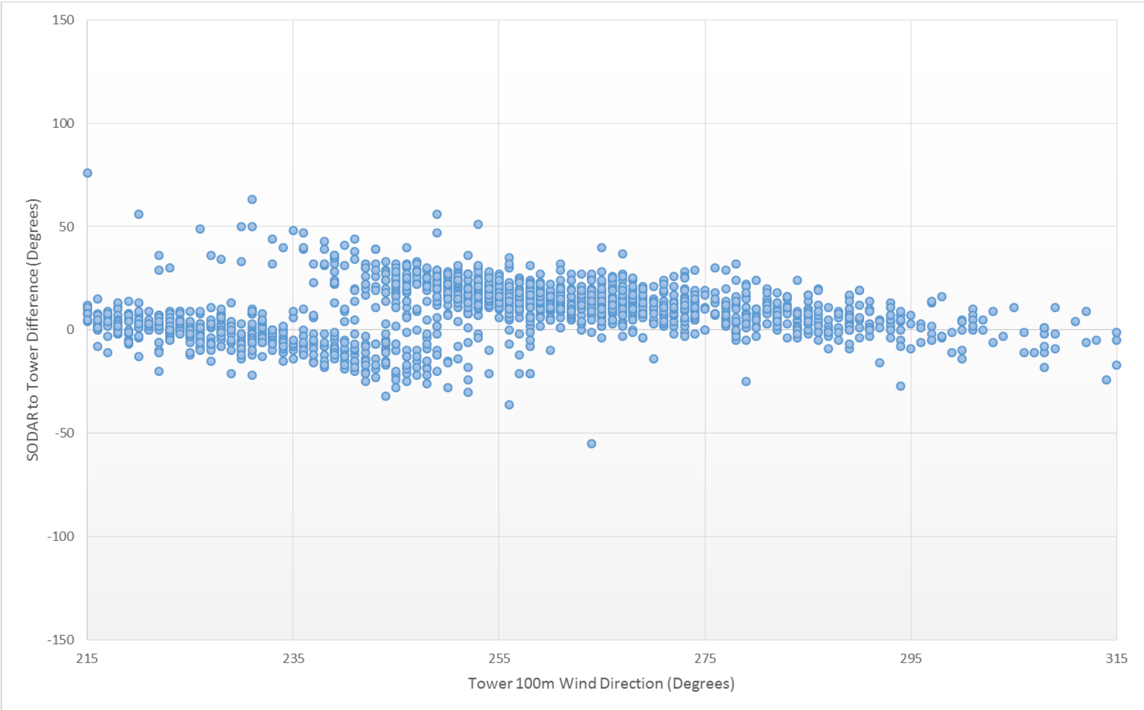
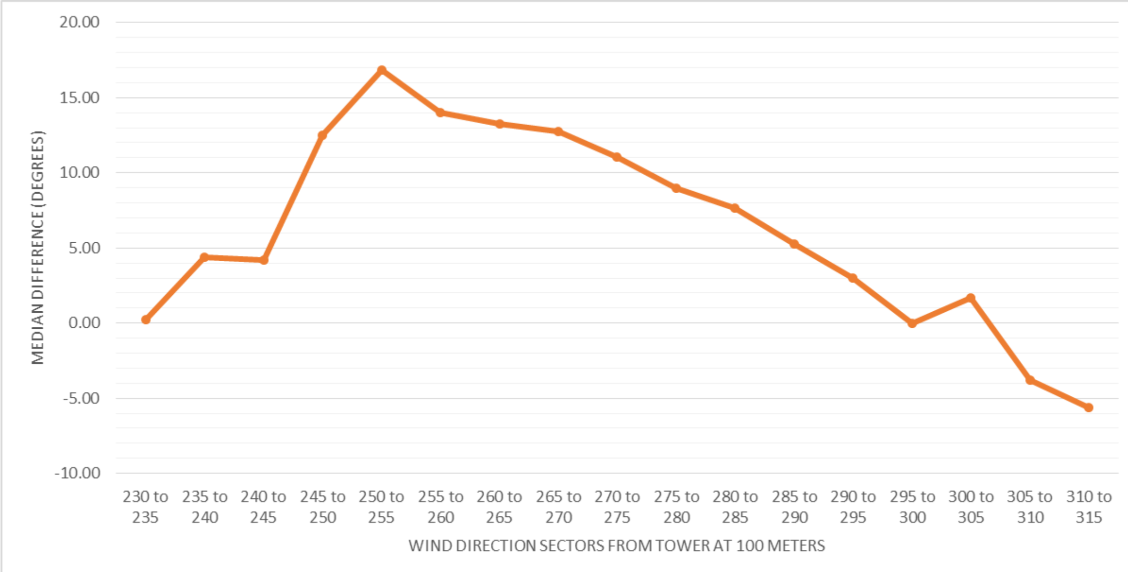


Figure A-6: Median of the Difference Between SODAR and Tower at 100 meters



Recommended Approach for Use in Modeling

Upon further review of the wind direction data collected from the Conemaugh-Seward SODAR, there is an unusual behavior that is not present in similar tower collection levels for winds from the west-southwest. It appears that a range displacement effect caused by the moisture plumes associated with the cooling towers at Conemaugh, located to the west-southwest of the SODAR site, distorted the wind direction sampling of the SODAR. Only the wind direction is affected by this phenomenon, as noted by detailed inspection of profiles of the tower and SODAR parameters of wind direction, wind speed, and sigma-w. As a result, we recommend withholding wind direction data from the SODAR when it reported directions between 235° and 290°. Based on the analysis provided earlier in this paper, this 55° sector is associated with the reflectivity gradient effect due to the Conemaugh hyperbolic cooling tower plumes. All other directions are not (and would not be expected to be affected) and appear to be consistent with the tower measurements.

For modeling, any SODAR wind directions between 235° and 290° would be set as missing. Any wind directions outside of this range would be retained as reported. In the absence of SODAR measurements, such as within the aforementioned 55° sector, AERMOD would persist the tower wind direction data for any given hour affected. All tower data collected would be retained for the 12-month dataset. SODAR wind speed and sigma-w values would be retained as previously proposed.

Appendix B Regional SO_2 Background Concentrations Used in Modeling of the Indiana County SO_2 NAA

Introduction and Background

An extensive review of regional monitors was conducted and documented as part of the modeling demonstration submitted to PA DEP in July 2017. This review concluded that the South Fayette, PA monitor, which is located about 62 km to the west-southwest of the Indiana County Non-attainment Area (NAA), was the most representative. PA DEP concurred with this assessment and provided a proposed SIP submittal to EPA based in part on this modeling analysis on October 11, 2017. EPA proposed[1] the SIP submittal for public review and comment on July 13, 2018.

Since this time, two additional years (2017 and 2018) of monitoring have been recorded. In support of the supplemental SO_2 NAAQS compliance modeling for Conemaugh and Seward Generating Stations, regional monitors have once again been reviewed to determine if the South Fayette monitor is still representative and if more recent years are available to use for updated modeling.

Selection of Representative Regional SO_2 Background Monitor

The closest SO_2 monitor to the NAA is in Johnstown, in nearby Cambria County. However this monitor is close to and impacted by major sources of SO_2 and would be better served as a site to compare against model results. Another candidate monitor located near State College, PA had substantial missing data in 2012-2015 and 2017-2018, which makes it a poor candidate for consideration. The 2017 modeling had also reviewed the Altoona monitoring site, but its data capture prior to 2016 was poor. While the Altoona data capture has improved in more recent years for 2016-2018, meeting EPA's data capture requirements, the 3-year design value is equivalent to South Fayette's for this same period at 9 ppb. In 2018, the 99th percentile value at South Fayette was actually higher (10 ppb) compared to Altoona (7 ppb), so it is likely that South Fayette would be more conservative using a season-hour-of-day approach. Therefore, for continuity with previous modeling submitted for this SIP demonstration, the South Fayette monitor (which had good data capture) will be used to characterize regional background concentrations.

EPA's March 2011 clarification memo[2] regarding 1-hour SO_2 NAAQS modeling allows for an approach using the 99th percentile monitored values whereby the background values vary by season and by hour of the day. AECOM applied this approach, using data from the most recent 3-year period of 2016-2018. These background concentrations were provided by Allegheny County Health Department (ACHD) for use in modeling applications in that county. The ACHD-provided SO_2 concentrations that will be used in this modeling analysis are listed in Table B-1.

Figure B-1 shows the location of the monitor with respect to the NAA and Figure B-2 shows a plot of the hourly background values by season and hour for the 2016-2018 3-year period.

According to the EPA's "Table 5. Monitoring Site Listing for Sulfur Dioxide 1-Hour NAAQS"[3], the completeness criteria for each quarter of 2016-2017 were satisfied. The ACHD determined data completeness for 2018 met completeness criteria. Therefore, the South Fayette 1-hour SO_2 monitoring data from 2016 to 2018 is complete and should be acceptable to use in modeling.

Comparison of 2014-2016 and 2016-2018 3-Year Periods at South Fayette

The previous 2017 analysis used the most recent 3-years (2014-2016) available at the time the modeling was conducted. Now that 2017 and 2018 are available, the 3 most recent year period would include 2016 through 2018. Table B-2 summarizes the design values (99th percentile) since 2009. As illustrated in Figure B-3, the design value at South Fayette has been decreasing, which is likely attributed to the reduction of SO_2 from

[1] The EPA docket that contains the supporting records associated with this SIP proposal can be accessed at www.regulations.gov at docket EPA-R03-OAR-2017-0615.

[2] Available at http://www.epa.gov/ttn/scram/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf.

[3] https://www.epa.gov/sites/production/files/2018-07/so2_designvalues_20152017_final_07_24_18.xlsx.

sources, either by retirement or improved control equipment. The 3-year average design value for 2016-2018 is 9 ppb, which is about a 40% reduction from the 2014-2016 3-year design value used in the previous modeling.

Summary

Regional SO_2 monitors were reviewed for use in supplemental modeling of the Indiana County, PA NAA. As expected, the South Fayette remains the best candidate to represent regional levels of SO_2. The 2016-2018 3-year period at South Fayette agrees well with the Altoona monitor that comes in as a close second now that its data capture has improved and nearby SO_2 sources no longer exist. To supply the model with the most recent data, the 2016-2018 period is proposed to be used for the supplemental SO_2 NAAQS modeling demonstration in support of PA DEP's State Implementation Plan submittal. The 99th percentile monitored values whereby the background values vary by season and by hour of the day (provided in Table B-1) will be included within the AERMOD input file for the modeling.

Figure B-1: Location of Background SO_2 Monitor

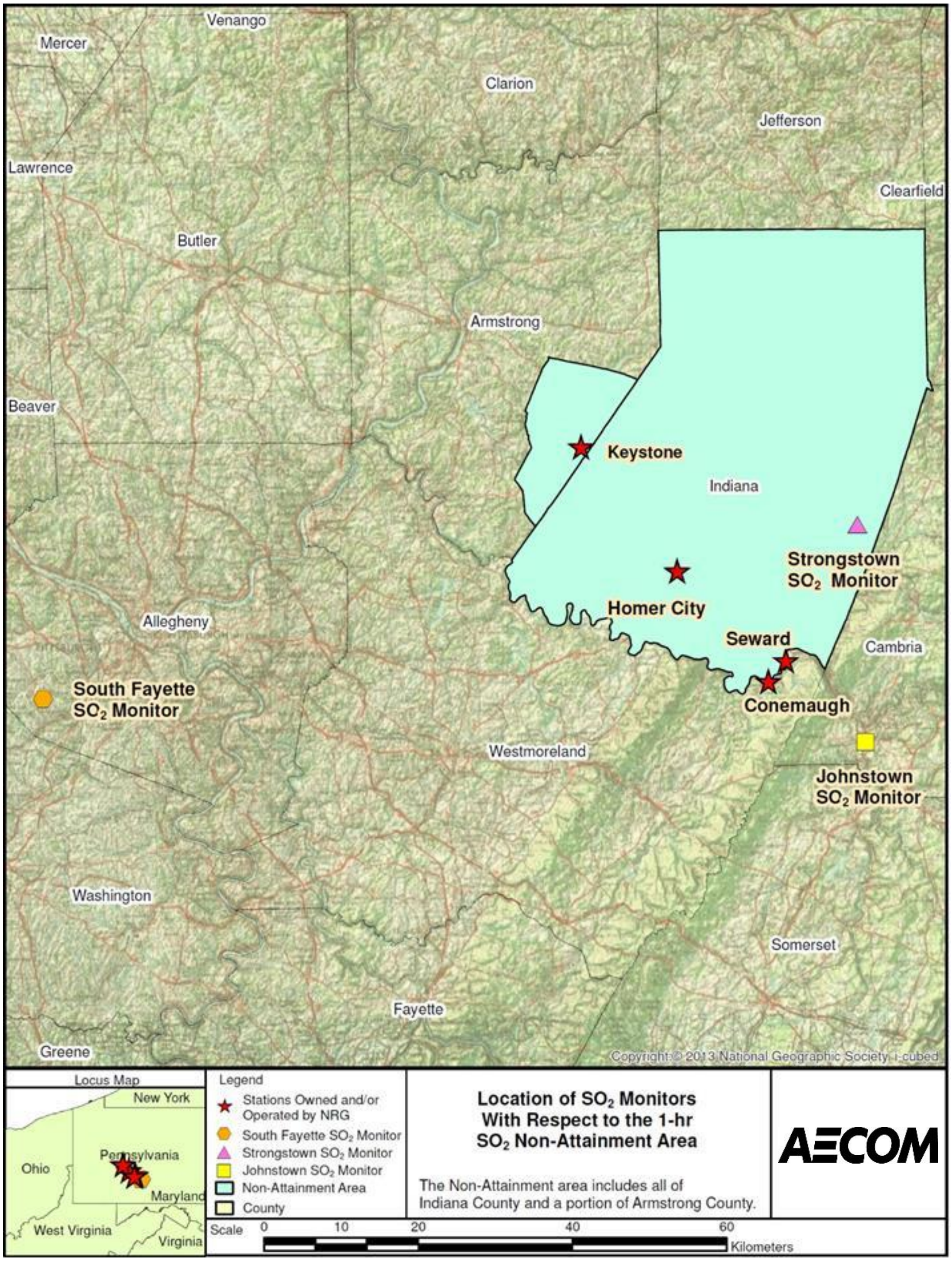


Table B-1: 1-hr SO_2 Ambient Background Concentrations for South Fayette Monitor

Hour Ending	3-Year (2016-2018) Averaged 99th Percentile Hourly Concentrations by Season (ppb)			
	Winter	Spring	Summer	Fall
1	4.00	3.33	2.67	3.33
2	4.00	2.00	3.33	3.33
3	4.33	2.00	1.67	3.00
4	3.33	2.00	1.67	3.00
5	3.67	2.33	1.67	2.33
6	4.00	3.00	2.00	2.33
7	5.00	5.00	2.33	2.33
8	4.33	4.67	3.33	3.00
9	5.33	3.67	3.33	4.33
10	5.33	4.67	4.67	3.33
11	5.00	3.67	3.00	3.33
12	4.33	2.67	3.33	4.00
13	3.33	2.67	3.33	2.67
14	3.33	3.33	3.00	2.67
15	4.00	3.00	4.00	4.00
16	3.33	3.00	4.00	3.67
17	2.67	3.33	3.67	4.33
18	3.33	4.67	3.67	5.00
19	3.33	6.00	4.00	4.00
20	4.00	3.67	4.00	3.67
21	3.33	2.67	2.67	4.00
22	4.00	2.67	2.33	3.33
23	4.33	2.67	2.67	2.67
24	4.00	2.33	2.33	3.33

Figure B-2: 2016-2018 Averaged SO_2 Background Concentrations Varying by Season and Hour-of-Day

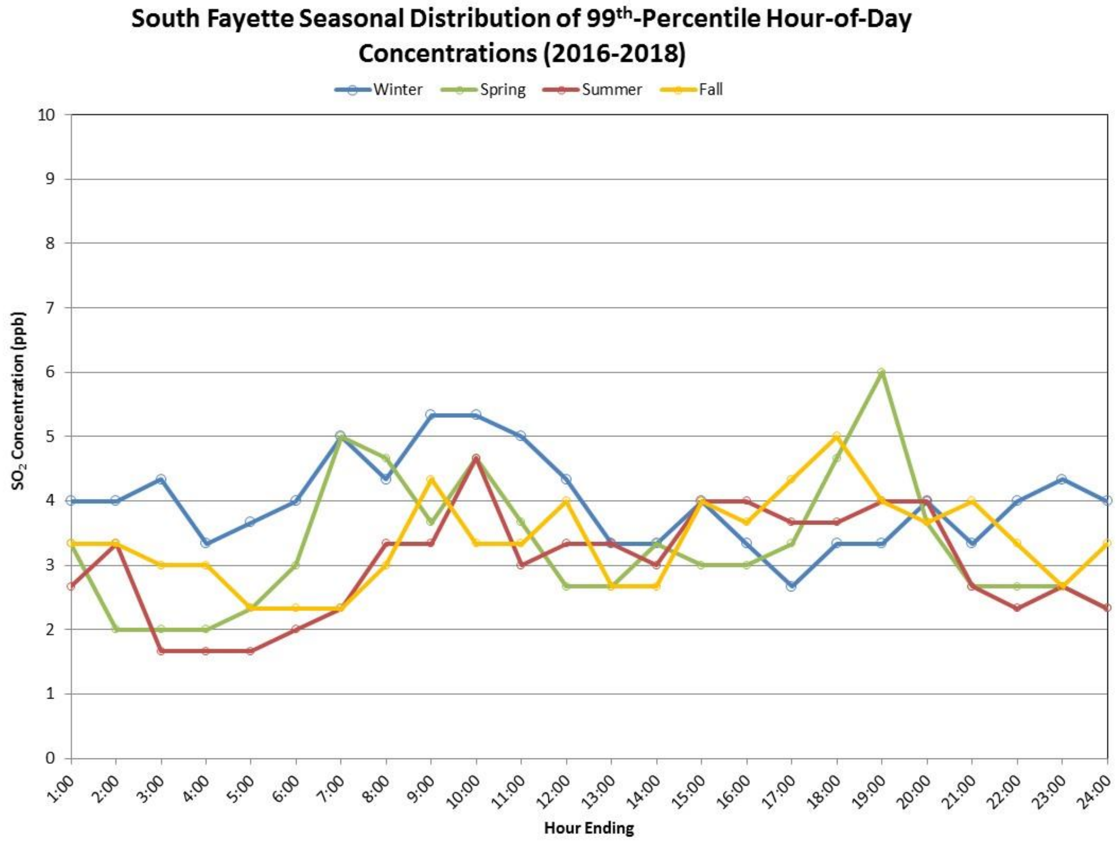
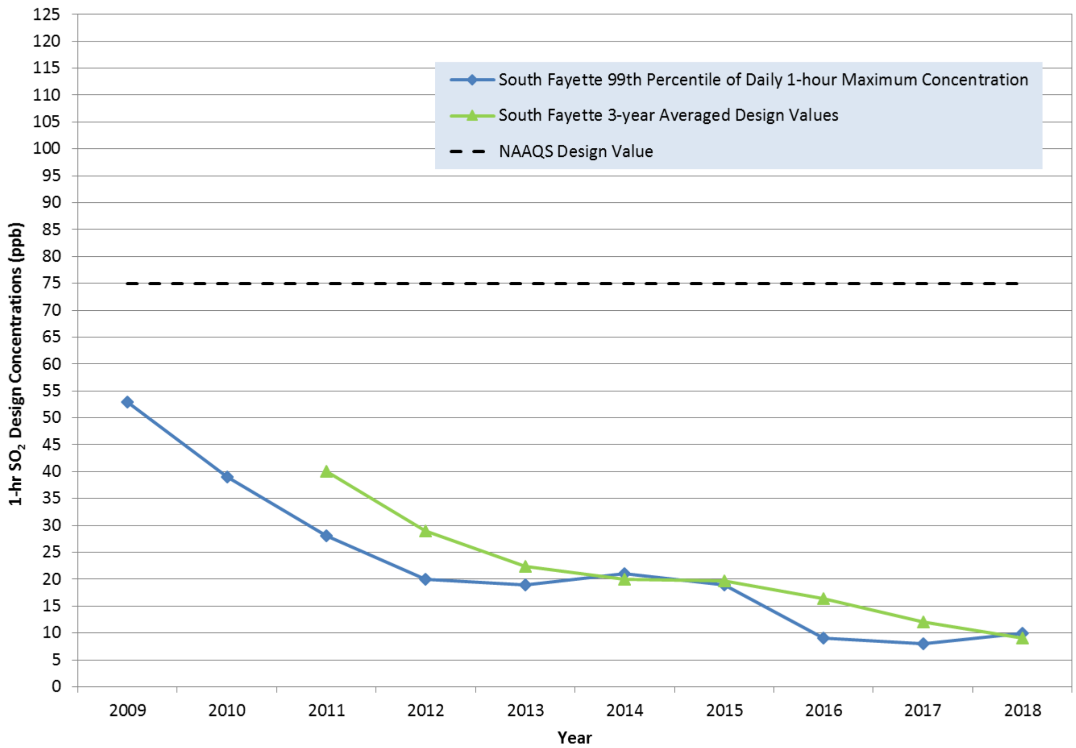


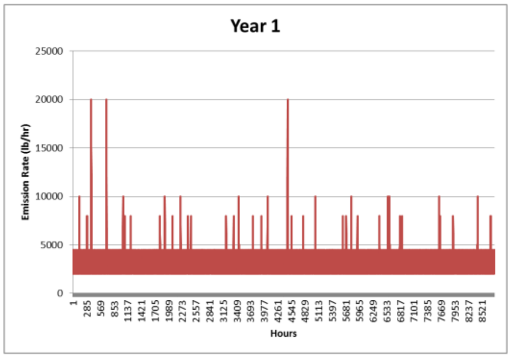
Table B-2: SO_2 Observed Design Value (99th Percentile) Concentrations for South Fayette Monitor Since 2009

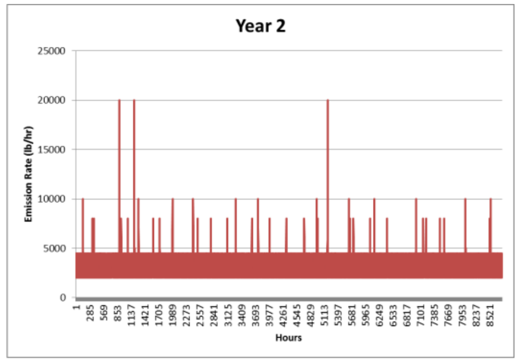
Year	99th Percentile (ppb)	NAAQS (ppb)	3-yr Average (ppb)
2009	53	75	---
2010	39	75	---
2011	28	75	40
2012	20	75	29
2013	19	75	22
2014	21	75	20
2015	19	75	20
2016	9	75	16
2017	8	75	12
2018	10.0	75	9

Figure B-3: South Fayette Monitor Trend of the 1-hour SO_2 99th Percentile Design Concentrations



Appendix C: Emissions Time Series Plots of 100 Simulations Used for RRE Modeling of Seward


Year 1
Emission Rate (lb/hr)
25000 20000 15000 10000 5000 0
1 285 569 853 1137 1421 1705 1989 2273 2557 2841 3125 3409 3693 3977 4261 4545 4829 5113 5397 5681 5965 6249 6533 6817 7101 7385 7669 7953 8237 8521
Hours


Year 2
Emission Rate (lb/hr)
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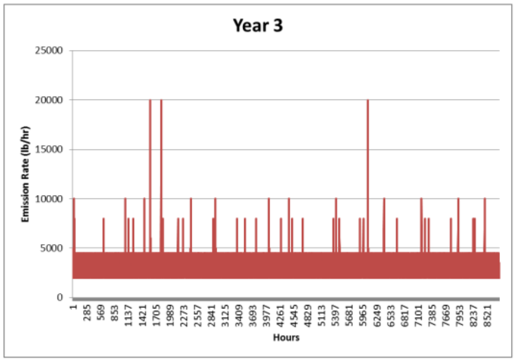
Hours


Year 3
Emission Rate (lb/hr)
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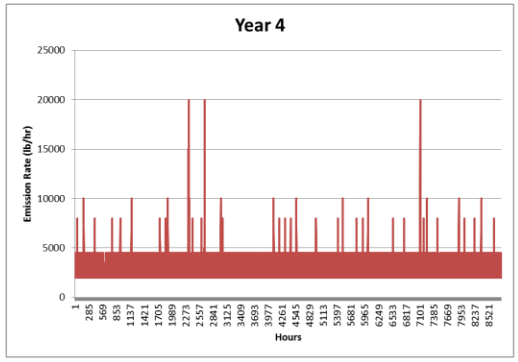
1 285 569 853 1137 1421 1705 1989 2273 2557 2841 3125 3409 3693 3977 4261 4545 4829 5113 5397 5681 5965 6249 6533 6817 7101 7385 7669 7953 8237 8521
Hours


Year 4
Emission Rate (lb/hr)
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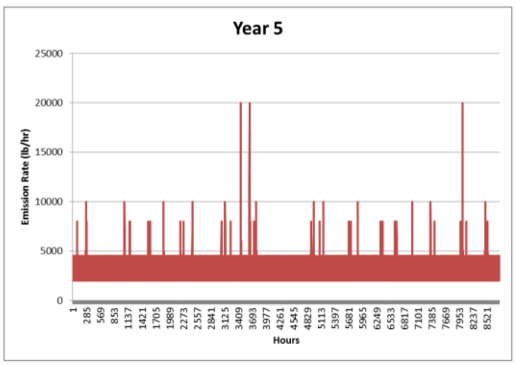
Hours


Year 5
Emission Rate (lb/hr)
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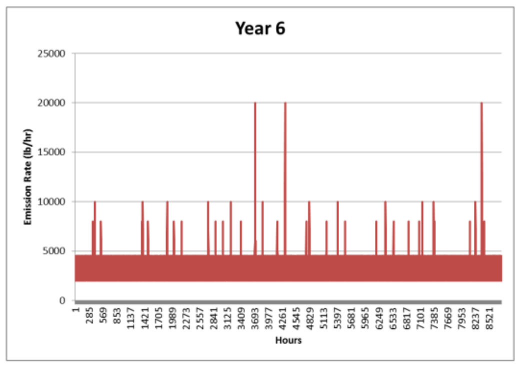
Hours


Year 6
Emission Rate (lb/hr)
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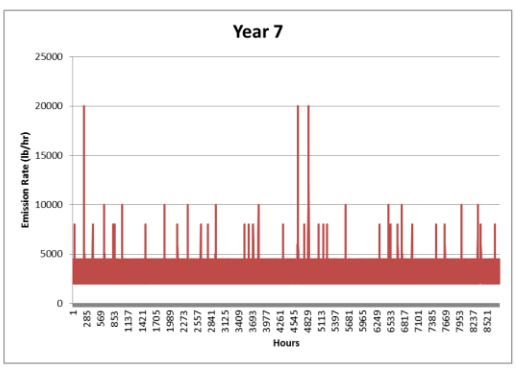
Hours


Year 7
Emission Rate (lb/hr)
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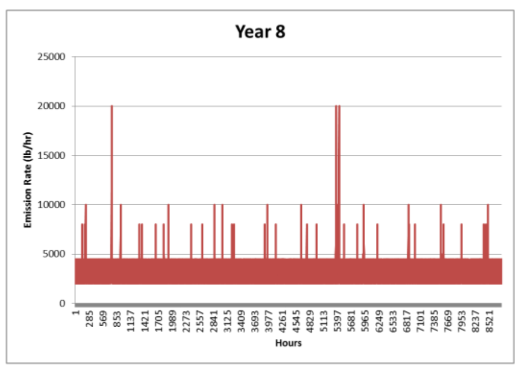
Hours


Year 8
Emission Rate (lb/hr)
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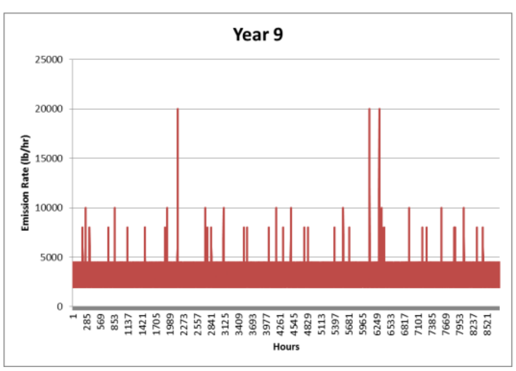
Hours


Year 9
Emission Rate (lb/hr)
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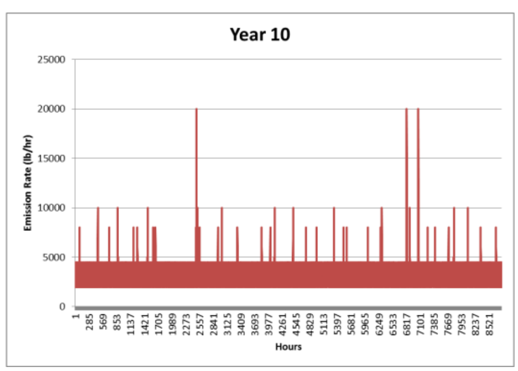
Hours


Year 10
Emission Rate (lb/hr)
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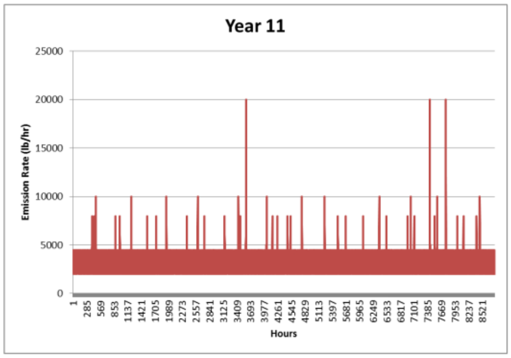
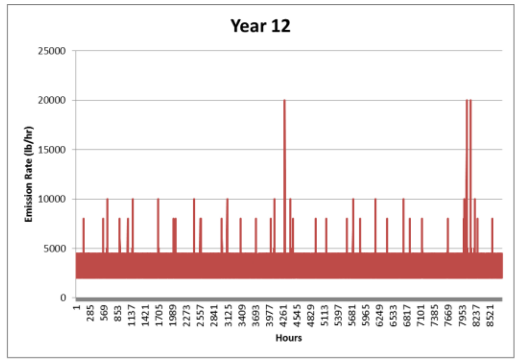
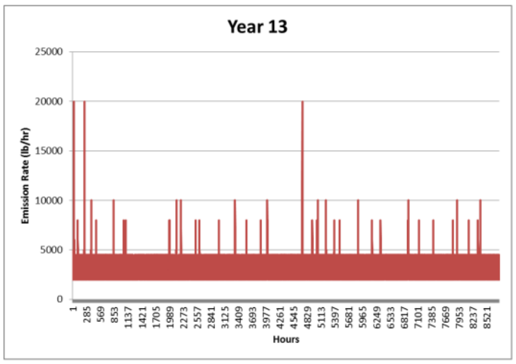
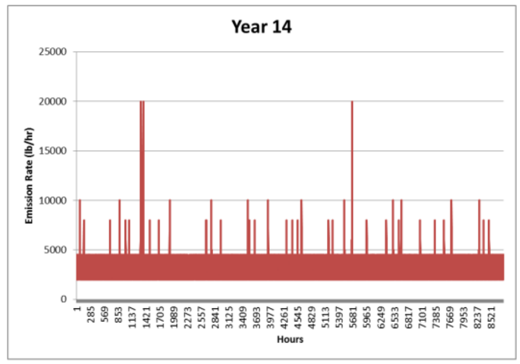
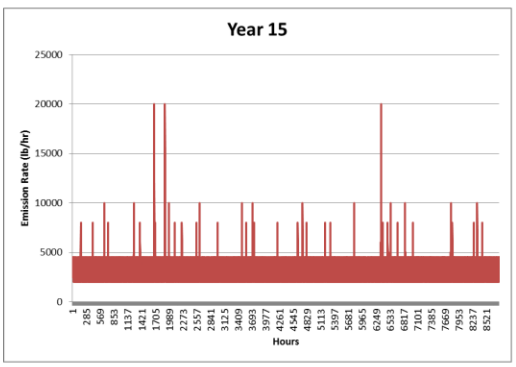
Hours


Year 11
Emission Rate (lb/hr)
Hours


Year 12
Emission Rate (lb/hr)
Hours


Year 13
Emission Rate (lb/hr)
Hours


Year 14
Emission Rate (lb/hr)
Hours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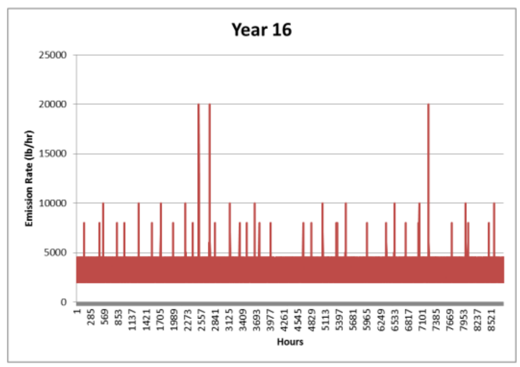
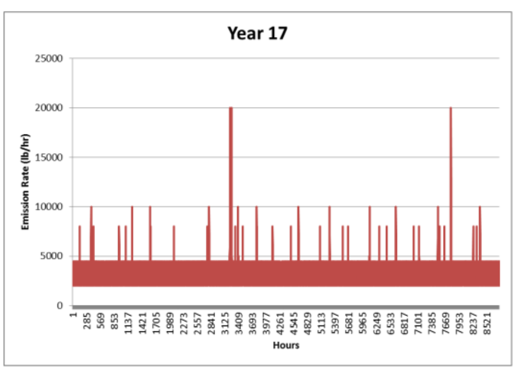
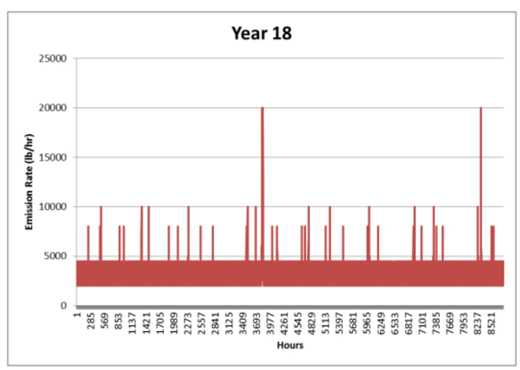
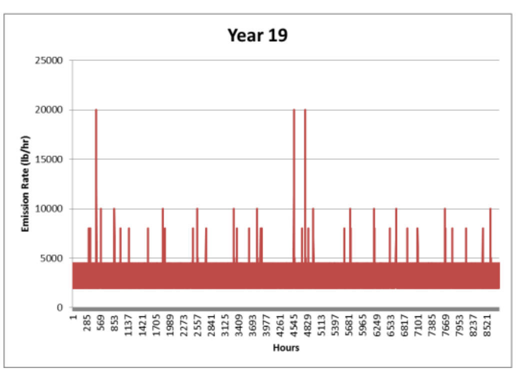
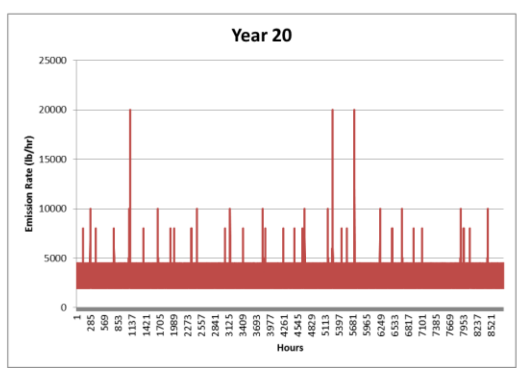
Emission Rate (lb/hr)
Hours

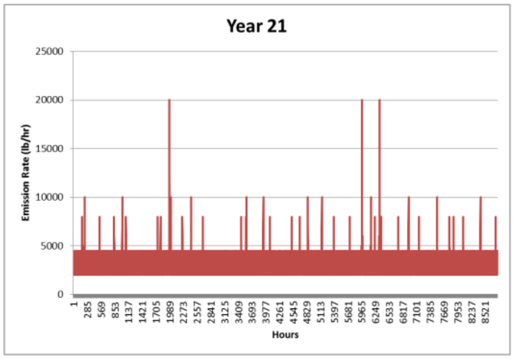

Year 16
Emission Rate (lb/hr)
Hours


Year 17
Emission Rate (lb/hr)
Hours


Year 18
Emission Rate (lb/hr)
Hours


Year 19
Emission Rate (lb/hr)
Hours


Year 20
Emission Rate (lb/hr)
Hours


Year 21
Emission Rate (lb/hr)
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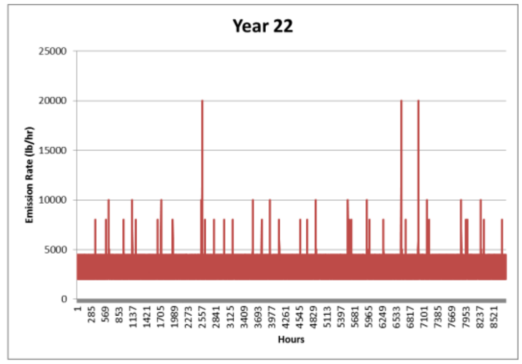
Hours


Year 22
Emission Rate (lb/hr)
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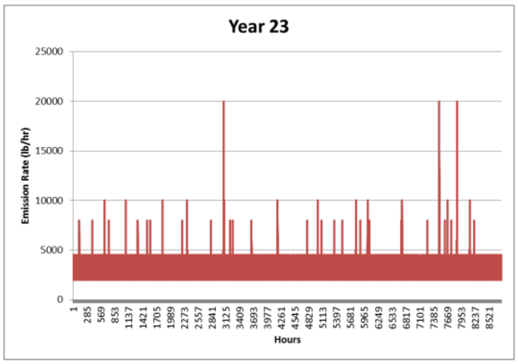
Hours


Year 23
Emission Rate (lb/hr)
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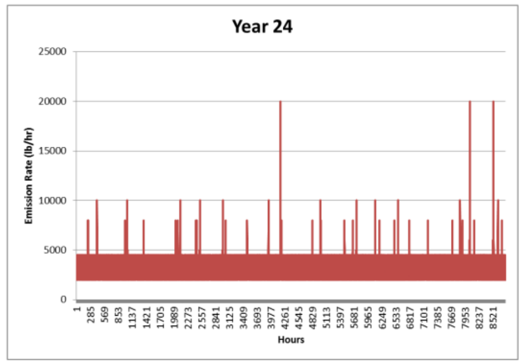
Hours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Emission Rate (lb/hr)
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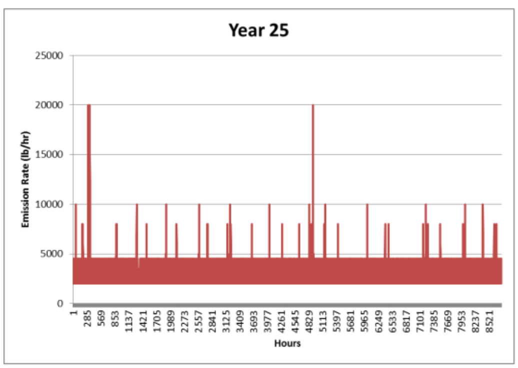
Hours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Emission Rate (lb/hr)
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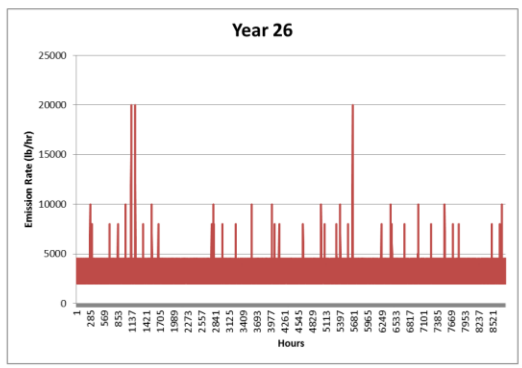
Hours


Year 26
Emission Rate (lb/hr)
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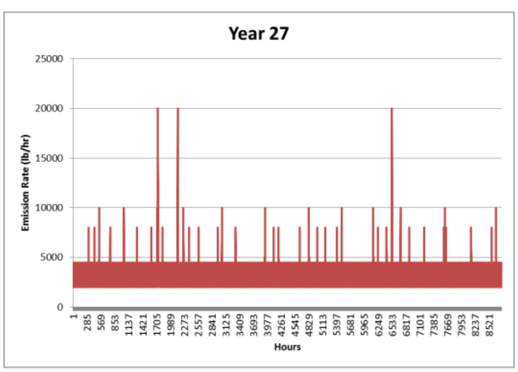
Hours


Year 27
Emission Rate (lb/hr)
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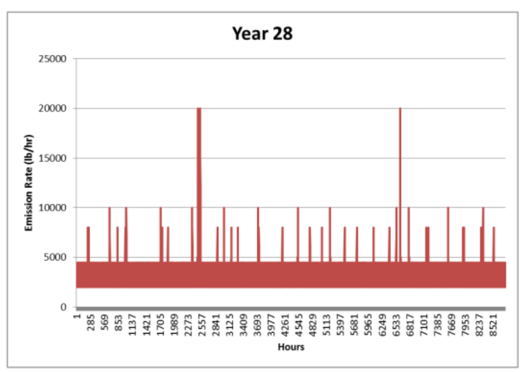
Hours


Year 28
Emission Rate (lb/hr)
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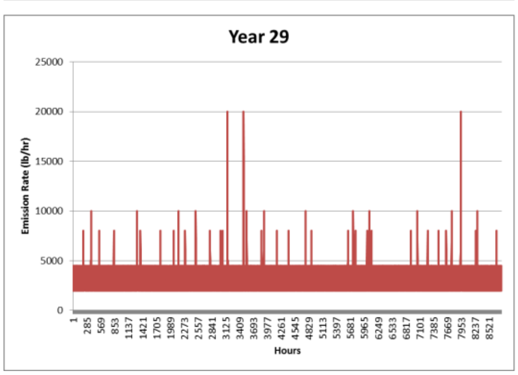
Hours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Emission Rate (lb/hr)
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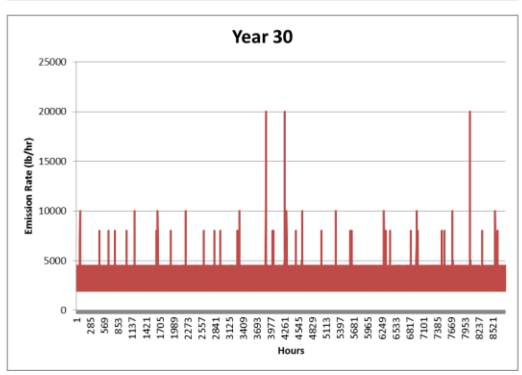
Hours


Year 30
Emission Rate (lb/hr)
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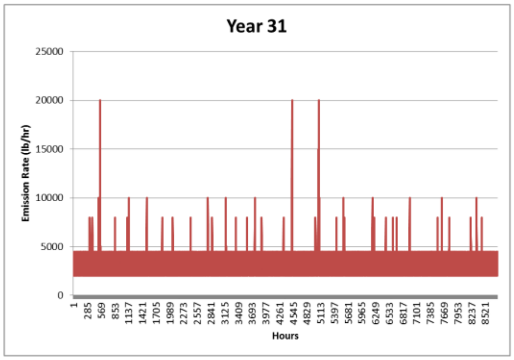
Hours


Year 31
25000
20000
15000
10000
5000
0
Emission Rate (lb/hr)
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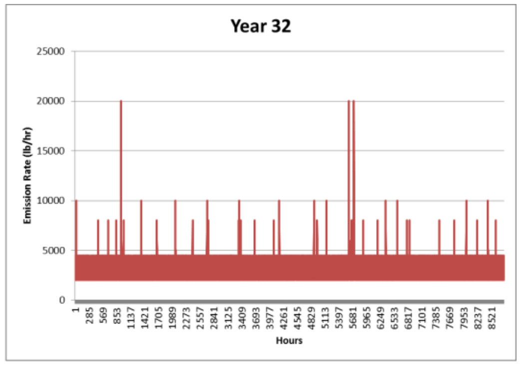
Hours


Year 32
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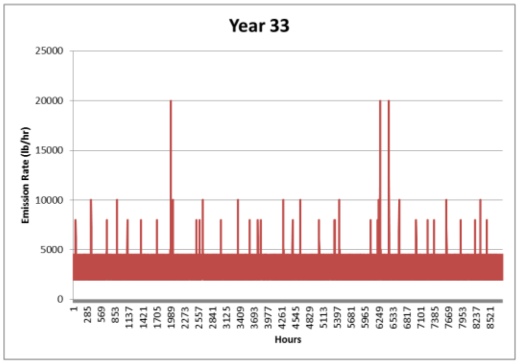
Emission Rate (lb/hr)
1 285 569 853 1137 1421 1705 1989 2273 2557 2841 3125 3409 3693 3977 4261 4545 4829 5113 5397 5681 5965 6249 6533 6817 7101 7385 7669 7953 8237 8521
Hours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Emission Rate (lb/hr)
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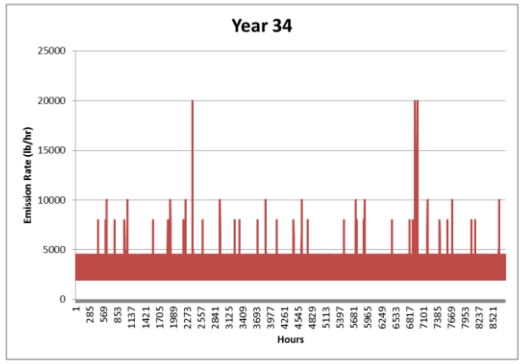
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Emission Rate (lb/hr)
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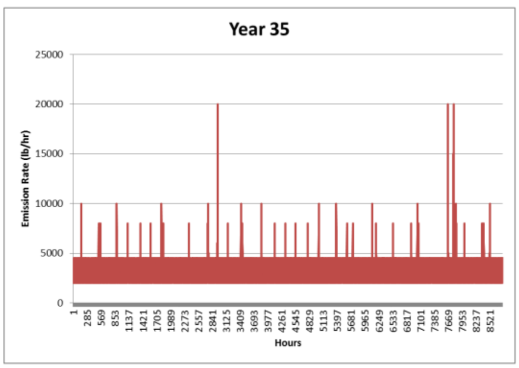
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Emission Rate (lb/hr)
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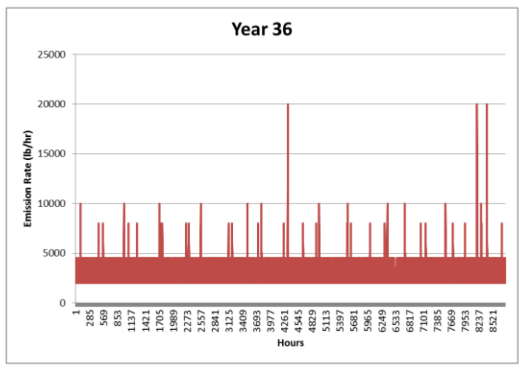
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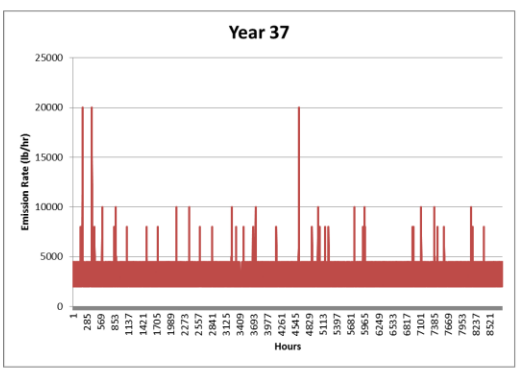
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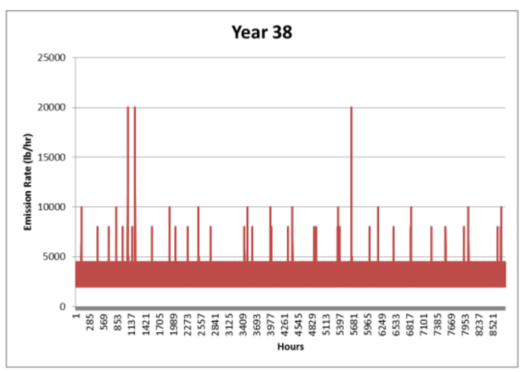
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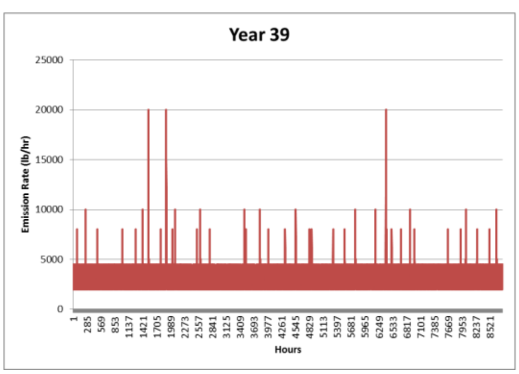
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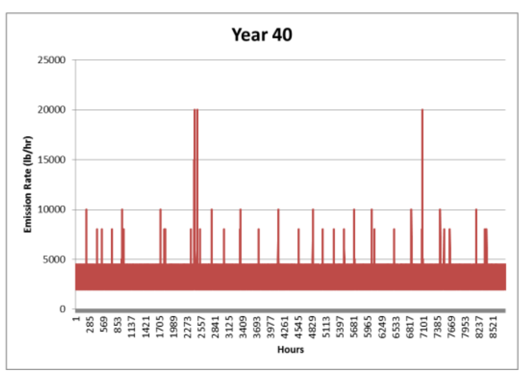
Year 40
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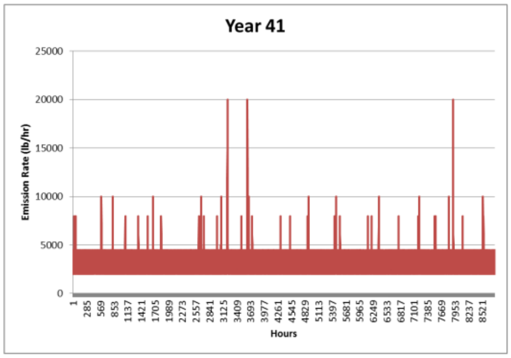
Year 41
Emission Rate (lb/hr)
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20000
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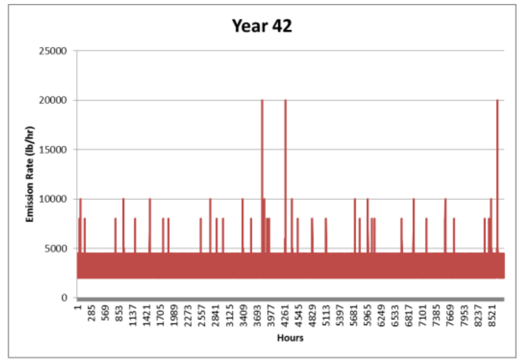
Year 42
Emission Rate (lb/hr)
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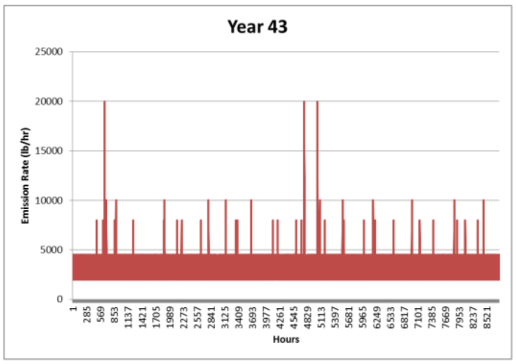
Year 43
Emission Rate (lb/hr)
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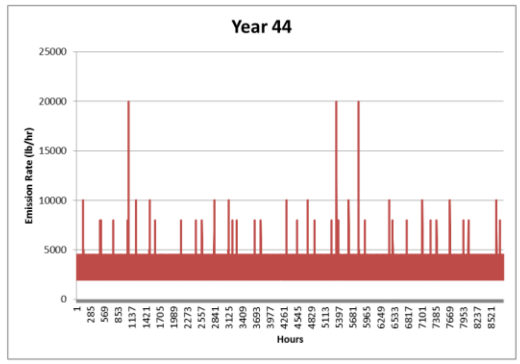
Year 44
Emission Rate (lb/hr)
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20000
25000
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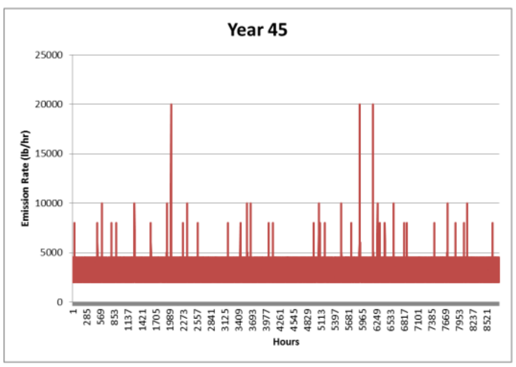
Year 45
Emission Rate (lb/hr)
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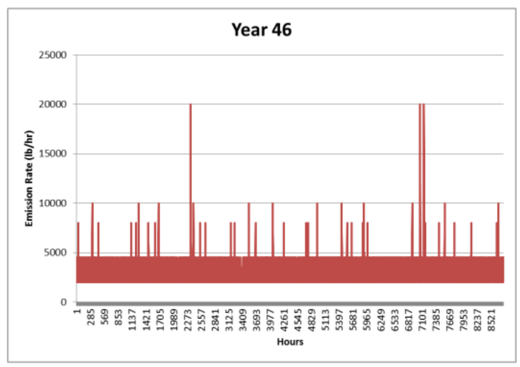
Year 46
Emission Rate (lb/hr)
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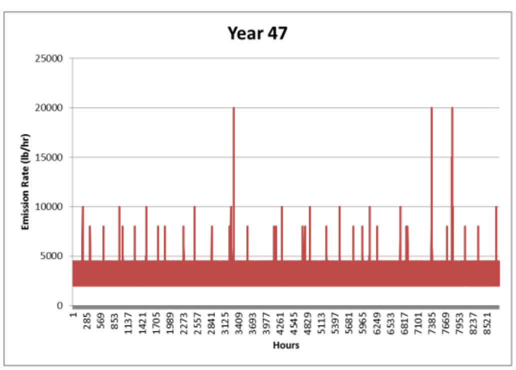
1 285 569 853 1137 1421 1705 1989 2273 2557 2841 3125 3409 3693 3977 4261 4545 4829 5113 5397 5681 5965 6249 6533 6817 7101 7385 7669 7953 8237 8521
Hours


Year 47
Emission Rate (lb/hr)
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15000
20000
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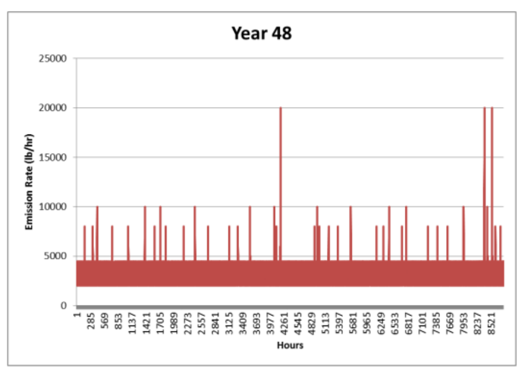
Hours


Year 48
Emission Rate (lb/hr)
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15000
20000
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1 285 569 853 1137 1421 1705 1989 2273 2557 2841 3125 3409 3693 3977 4261 4545 4829 5113 5397 5681 5965 6249 6533 6817 7101 7385 7669 7953 8237 8521
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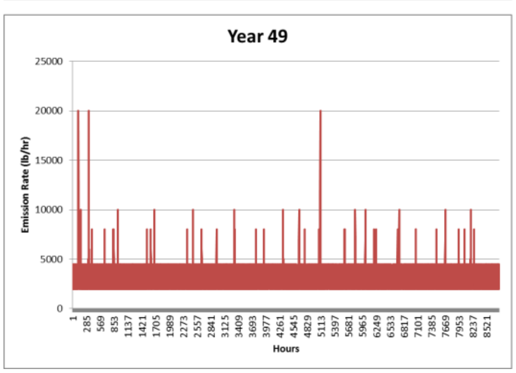
Year 49
Emission Rate (lb/hr)
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20000
25000
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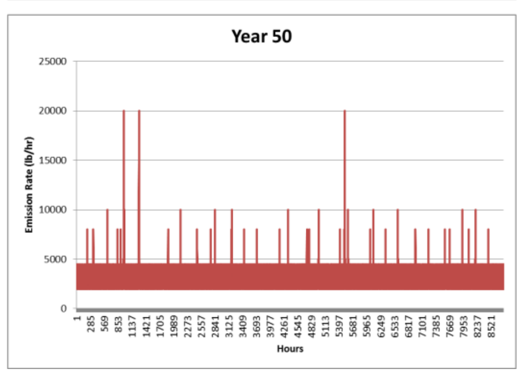
Year 50
Emission Rate (lb/hr)
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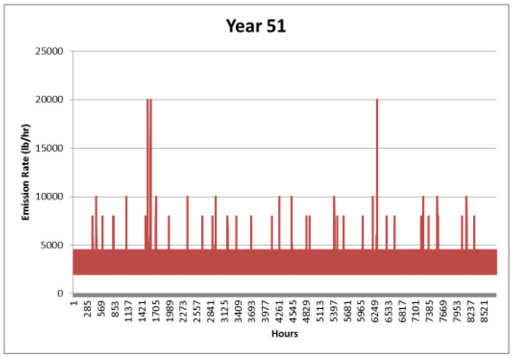
Year 51
Emission Rate (lb/hr)
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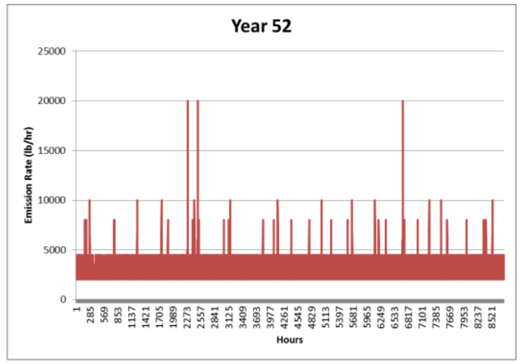
Hours


Year 52
Emission Rate (lb/hr)
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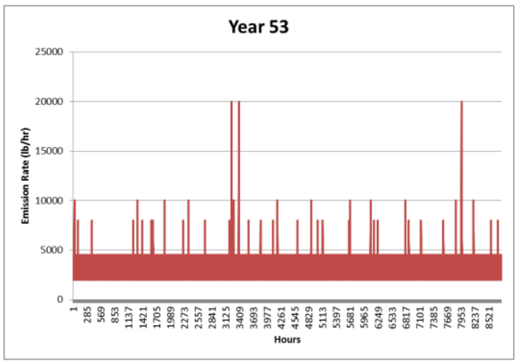
Hours


Year 53
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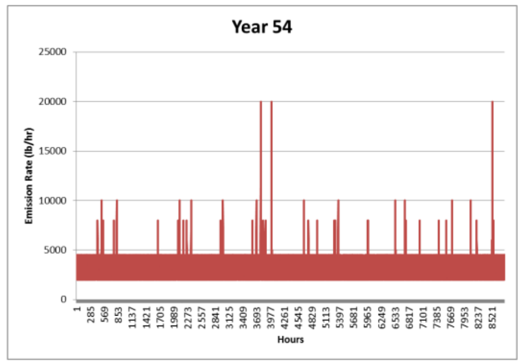
Hours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Emission Rate (lb/hr)
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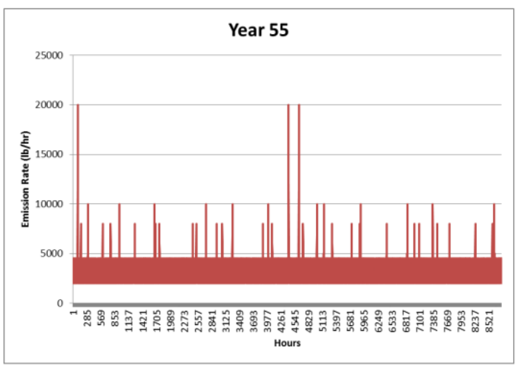
Hours


Year 55
Emission Rate (lb/hr)
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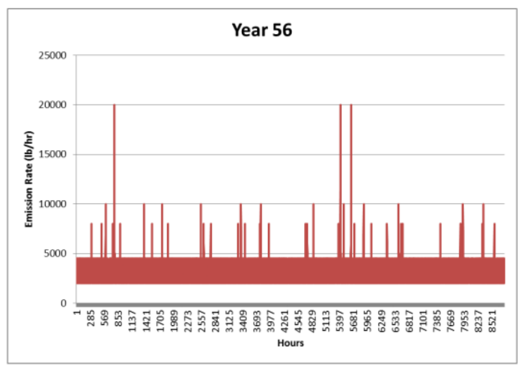
Hours


Year 56
Emission Rate (lb/hr)
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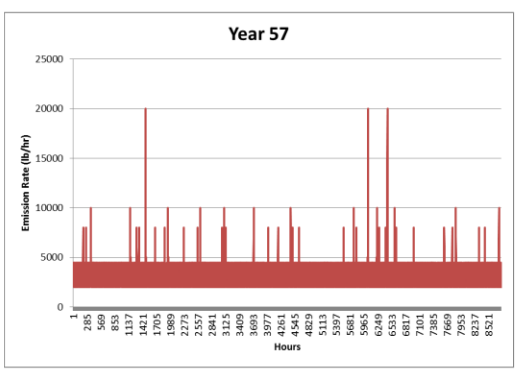
Hours


Year 57
Emission Rate (lb/hr)
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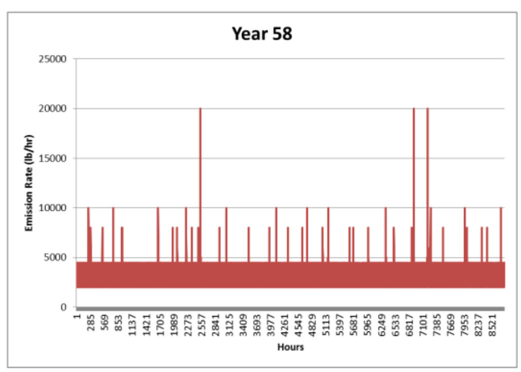
Hours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Emission Rate (lb/hr)
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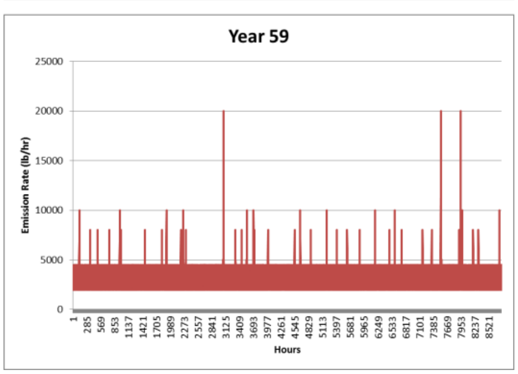
Hours


Year 59
Emission Rate (lb/hr)
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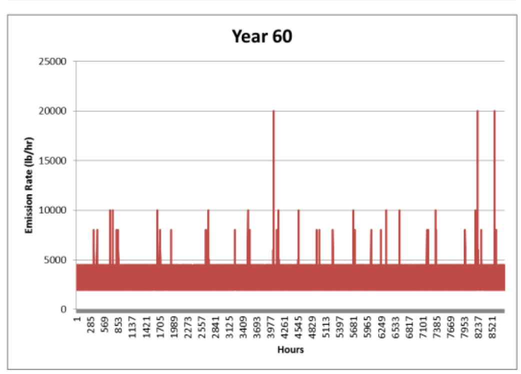
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Emission Rate (lb/hr)
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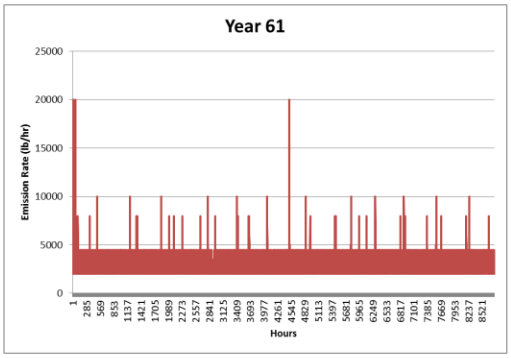
Year 61
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Emission Rate (lb/hr)
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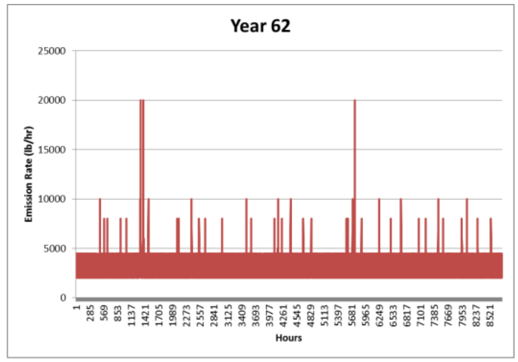
Hours


Year 62
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Emission Rate (lb/hr)
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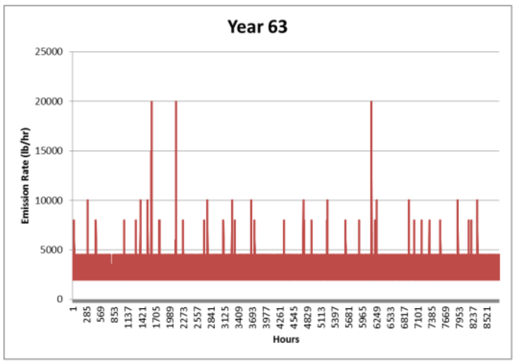
Year 63
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Emission Rate (lb/hr)
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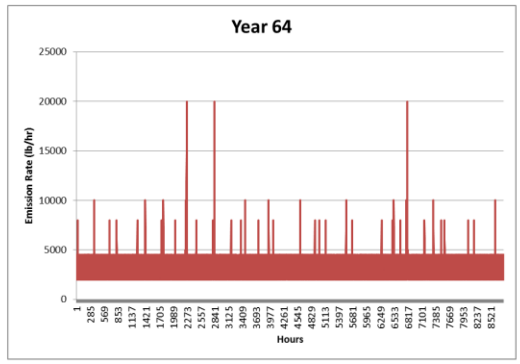
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Emission Rate (lb/hr)
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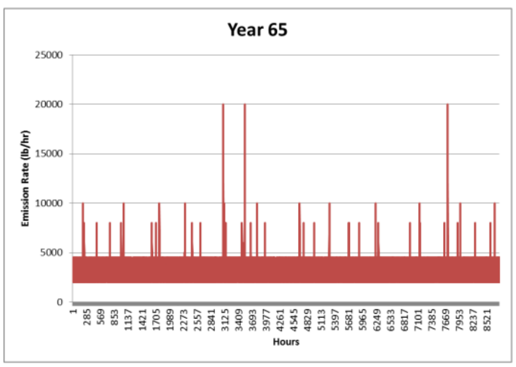
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Emission Rate (lb/hr)
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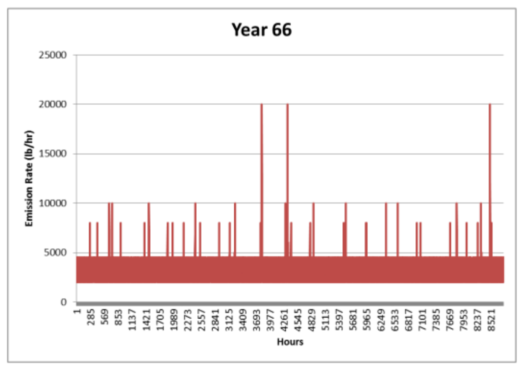
Year 66
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Emission Rate (lb/hr)
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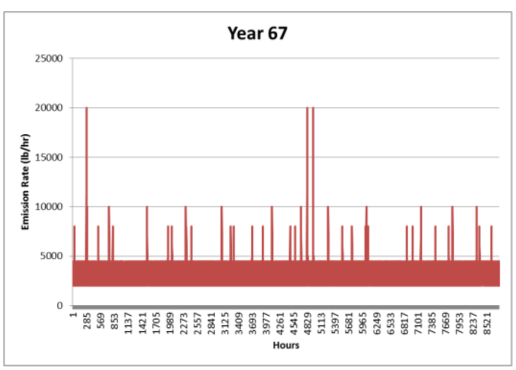
Year 67
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Emission Rate (lb/hr)
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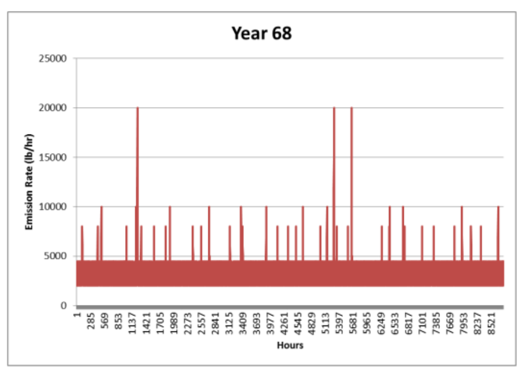
Year 68
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Emission Rate (lb/hr)
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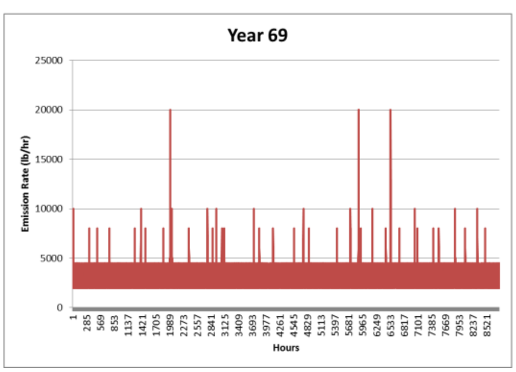
Hours


Year 69
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Emission Rate (lb/hr)
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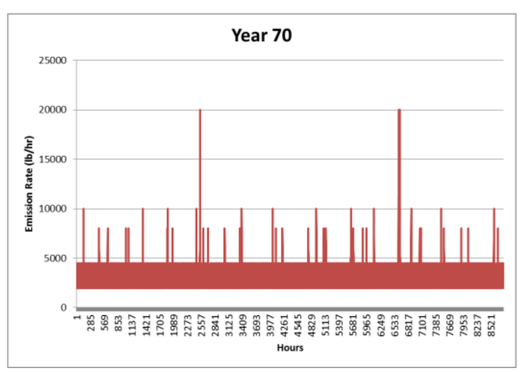
Year 70
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Emission Rate (lb/hr)
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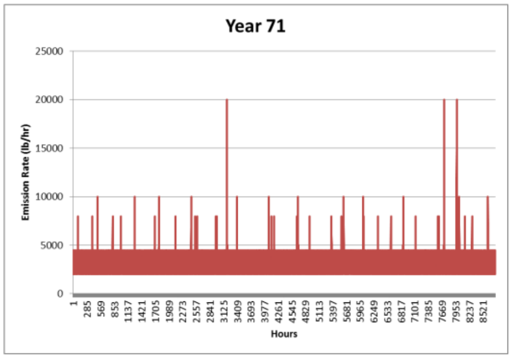
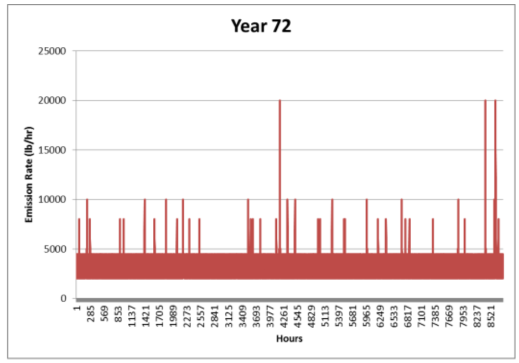
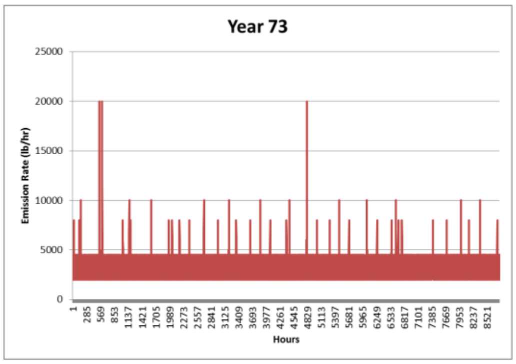
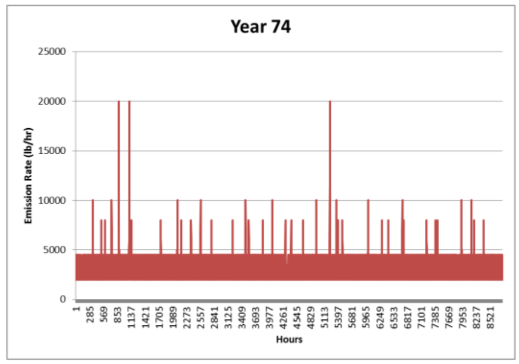
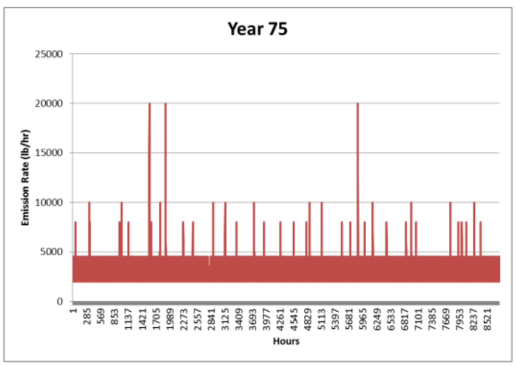
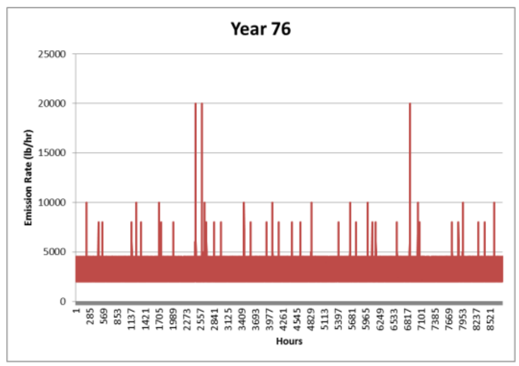

Year 71
Emission Rate (lb/hr)
Hours

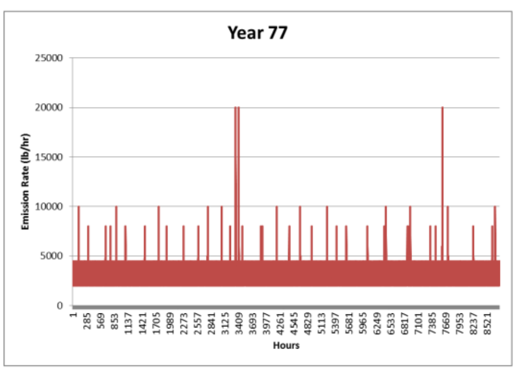

Year 72
Emission Rate (lb/hr)
Hours

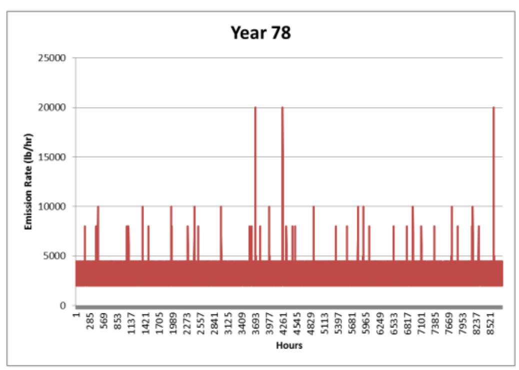

Year 73
Emission Rate (lb/hr)
Hours

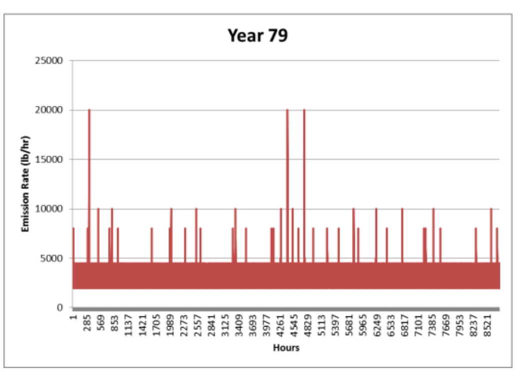

Year 74
Emission Rate (lb/hr)
Hours

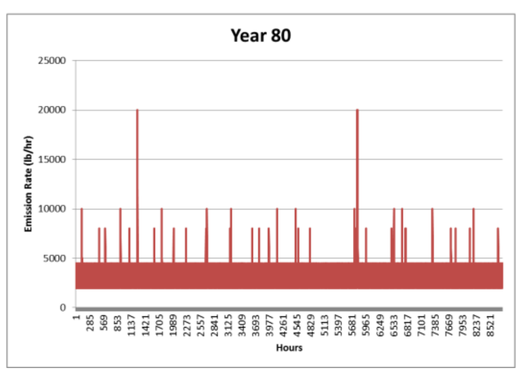

Year 75
Emission Rate (lb/hr)
Hours

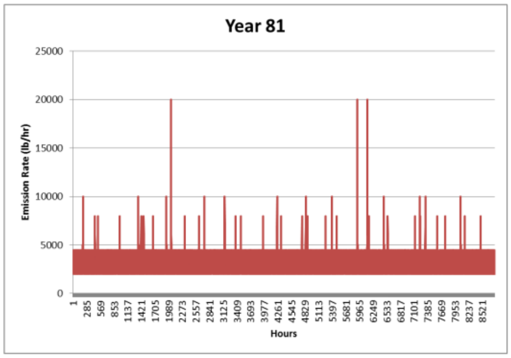

Year 76
Emission Rate (lb/hr)
Hours

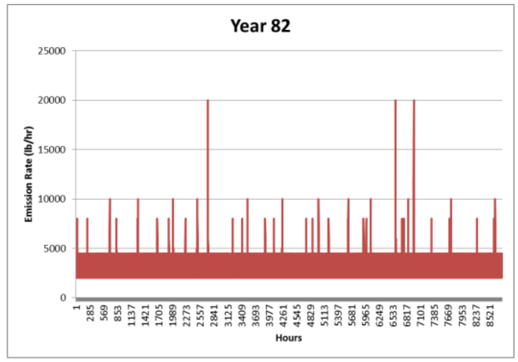

Year 77
Emission Rate (lb/hr)
Hours

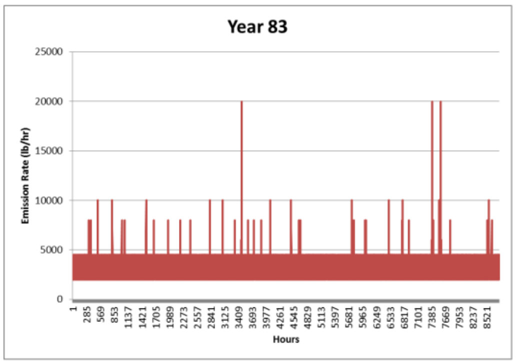

Year 78
Emission Rate (lb/hr)
Hours

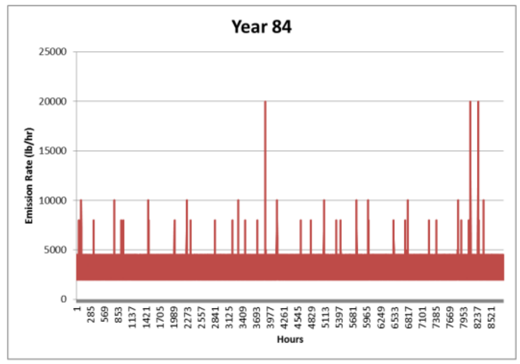

Year 79
Emission Rate (lb/hr)
Hours

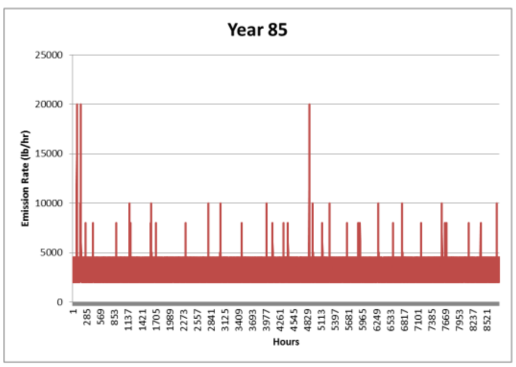

Year 80
Emission Rate (lb/hr)
Hours

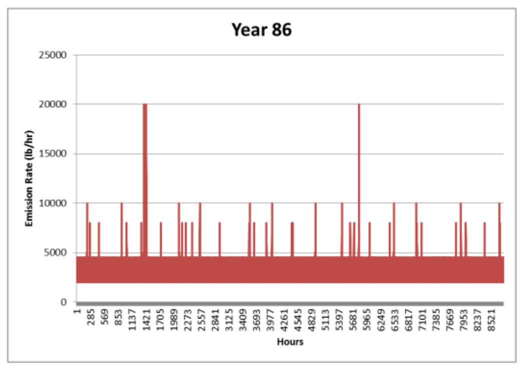

Year 81
Emission Rate (lb/hr)
Hours

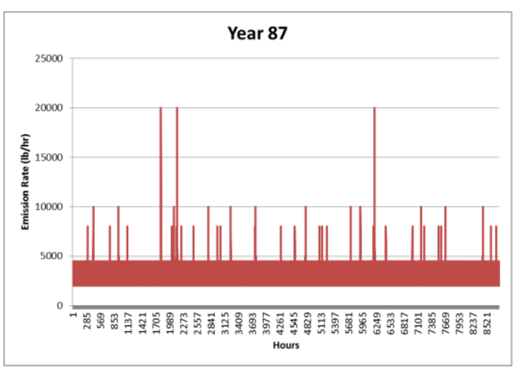

Year 82
Emission Rate (lb/hr)
Hours

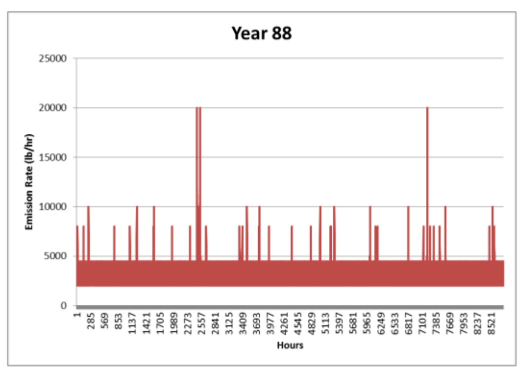

Year 83
Emission Rate (lb/hr)
Hours

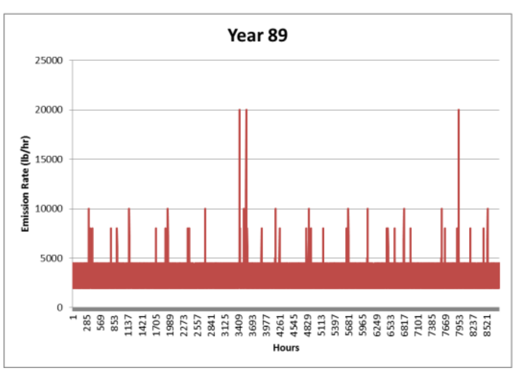

Year 84
Emission Rate (lb/hr)
Hours

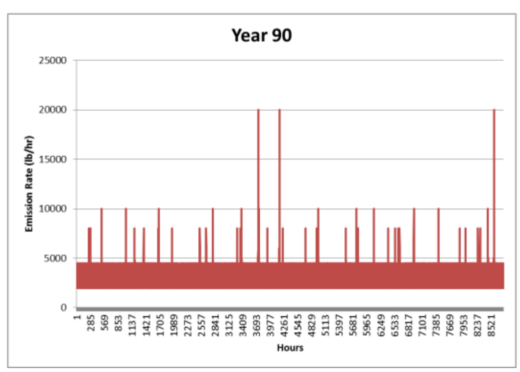

Year 85
Emission Rate (lb/hr)
Hours

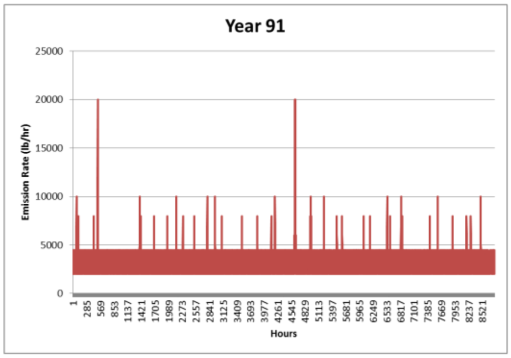

Year 86
Emission Rate (lb/hr)
Hours

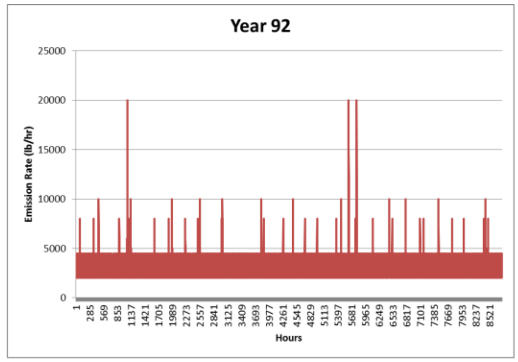

Year 87
Emission Rate (lb/hr)
Hours

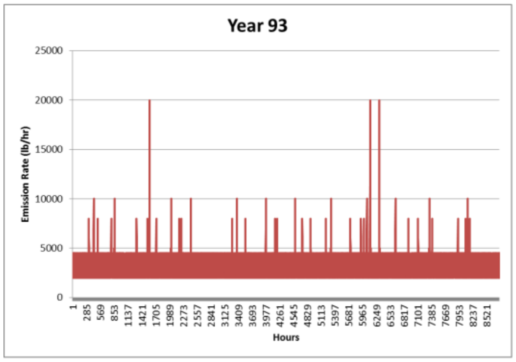

Year 88
Emission Rate (lb/hr)
Hours

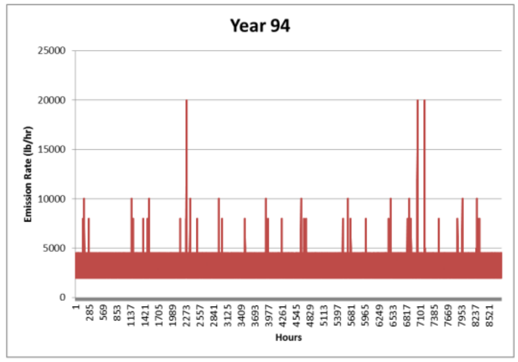

Year 89
Emission Rate (lb/hr)
Hours

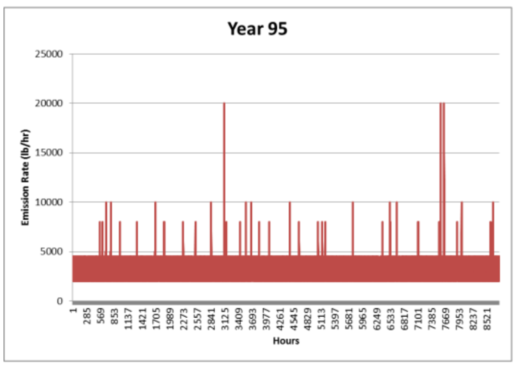

Year 90
Emission Rate (lb/hr)
Hours

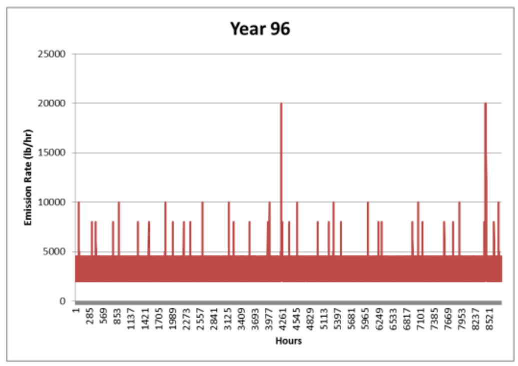

Year 91
Emission Rate (lb/hr)
Hours

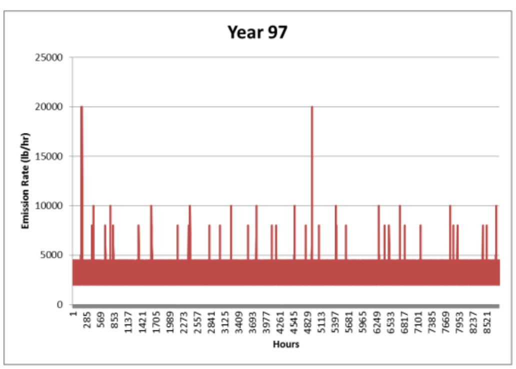

Year 92
Emission Rate (lb/hr)
Hours

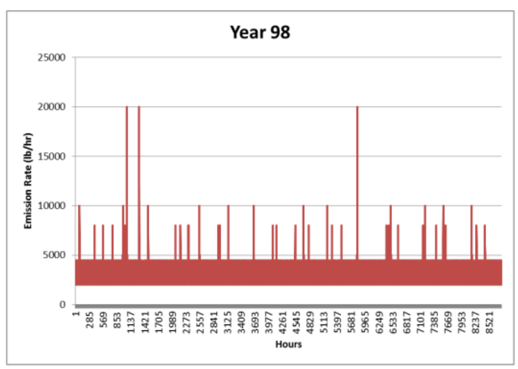

Year 93
Emission Rate (lb/hr)
Hours

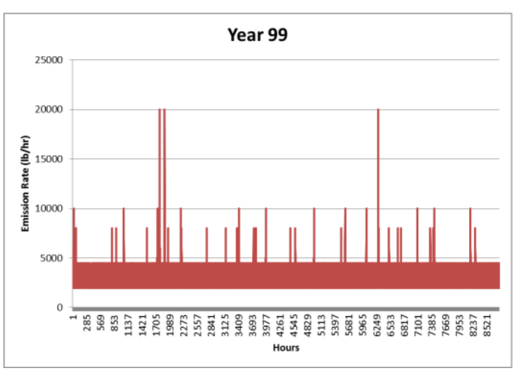

Year 94
Emission Rate (lb/hr)
Hours

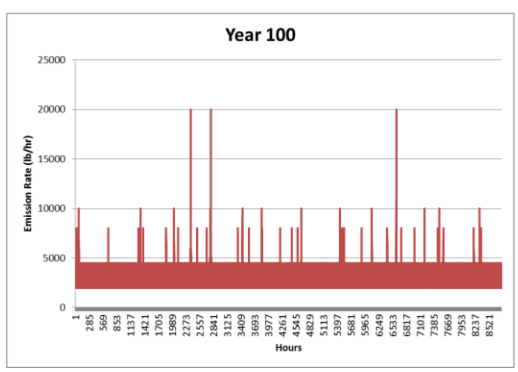

Year 95
Emission Rate (lb/hr)
Hours


Year 96
Emission Rate (lb/hr)
Hours


Year 97
Emission Rate (lb/hr)
Hours


Year 98
Emission Rate (lb/hr)
Hours


Year 99
Emission Rate (lb/hr)
Hours


Year 100
Emission Rate (lb/hr)
Hours