AERMOD Modeling of NO_2 Impacts of the Barto Compressor Station

Final Report

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I. INTRODUCTION

This document presents the methodologies and results of an application of the AERMOD model to predict the air quality impacts of nitrogen dioxide (NO_2) emitted by the Barto Compressor Station. The Barto plant is owned and operated by Chief Gathering, LLC (CG) in Penn Township, Lycoming County (Figure 1). It consists of nine gas-fired internal combustion engines and is designed to move up to 150 million cubic feet a day of natural gas produced in the Marcellus area. NO_2 impacts are predicted by the AERMOD model and compared against the 1-hour NO_2 National Ambient Air Quality Standard (NAAQS) of 100 ppb (or 188 ug/m3) which was promulgated in January 2010 by the U.S. Environmental Protection Agency (EPA).

Figure 1. Barto Compressor Station
(source: http://www.chiefog.com/cstations.html)

II. MODELING METHODOLOGIES

This section documents the methodologies and assumptions used in the generation of modeling inputs such as source emissions, stack parameters, receptors and meteorological data.

A. Model Version

Version 12060 of the AERMOD model has been used in the modeling study. It is currently the latest version of the model that has been approved by the US Environmental Protection Agency (USEPA, 2012). It predicts the 1-hour NO_2 concentrations using multi-year meteorological data that can be compared against the 1-hour NAAQS of 100 ppb (or 188 ug/m3) (USEPA, 2011).

B. Source Emissions

The facility's permit has recently been issued in February 2012 by PA DEP (Plan Approval No. 41-00078C). According to this permit, two compressor engines (P105 and P106) are rated at 1,380 brake horsepower (bhp) each. The remaining seven engines (P101, P102, P103, P107, P108, P109 and P110) are rated at 2,370 bhp each. Nitrogen oxides (NO_x) are allowed to be emitted at the hourly rate of 1.52 lb/hour for the P105 and P106 engines while the other engines are subjected to the hourly limit of 2.61 lb/hour. Total hourly NO_x emissions are 21.31 lbs/hr.

C. Stack Parameters

Stack emissions and parameters (stack height, diameter, temperature and exit velocity) for the modeled nine stacks are shown in Table 1. They are taken from the PA DEP database.

Table 1. Plant NO_x Allowable Emissions & Stack Parameters

Engine Stack	Allowable NOx (g/s)	Height (m)	Diameter (m)	Temperature (K)	Velocity (m/s)
P 101	0.32886	6.55	0.3048	807	59.03
P102	0.32886	6.55	0.3048	807	59.03
P103	0.32886	7.62	0.6096	732	6.53
P105	0.19152	7.62	0.6096	732	6.53
P106	0.19152	7.62	06096	732	6.53
P107	0.32886	7.62	0.6096	732	6.53
P108	0.32886	7.62	0.6096	732	6.53
P109	0.32886	7.62	0.6096	732	6.53
P110	0.32886	7.62	0.6096	732	6.53

D. Receptors

The current AERMOD modeling uses a Cartesian grid of discrete receptors that are located within a radius of 5 km around the Barto plant. The receptor grid has varying resolutions: 50 m within the first two km and 100 m between 2 km and 5 km. A total of 16,733 receptors have been used in the AERMOD modeling. The preprocessor AERMAP has been employed to obtain terrain elevations at these receptors using the National Elevation Data (NED) data.

E. Meteorological Data

The AERMOD modeling uses the 2006-2010 surface meteorological data from Williamsport and upper-air data from Pittsburgh International Airport. Processed by PA DEP, this dataset has 2,558 calm hours and 1,379 hours with missing data (3.15% of

possible 43,824 hours). The wind rose in Figure 2 indicates that winds are predominantly from the northwest and west.

F. Background Concentration

For comparison with the NO_2 1-hour NAAQS, background concentrations at a representative monitoring station are added to the concentrations predicted by the AERMOD model. Monitoring data during 2009-2011 from the EPA AirData website indicate that an average 98th percentile of 34.7 ppb (65.2 ug/m3) was measured at State College (36 ppb in 2011, 33 ppb in 2010 and 35 ppb in 2009). This average value is used as background in this modeling analysis.

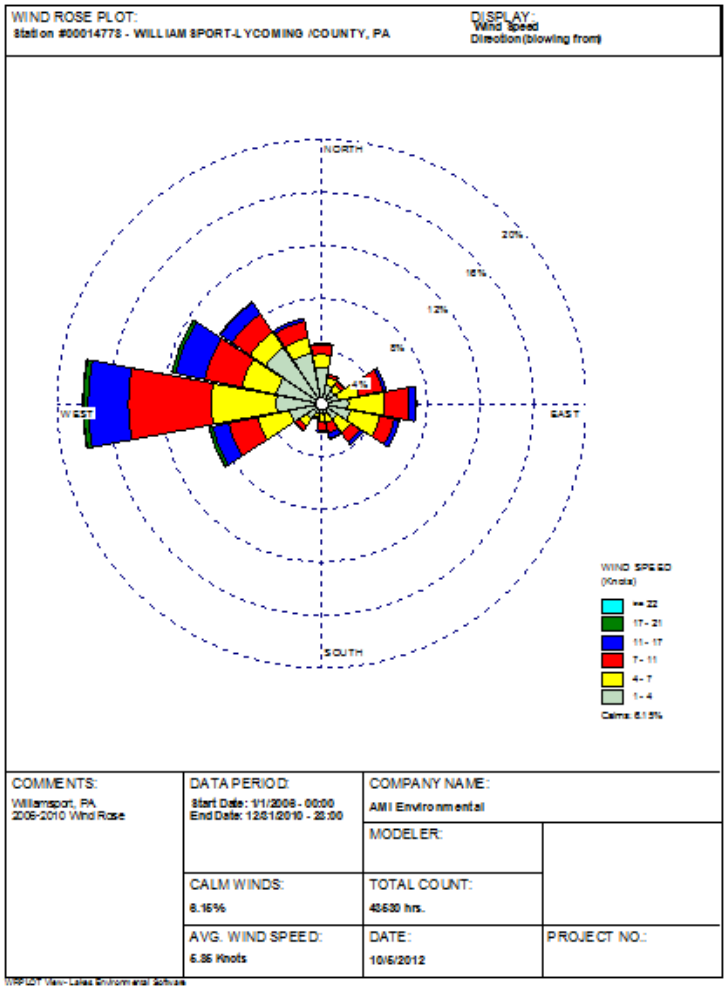

Figure 2. Wind Rose of Williamsport 2006-2010 Data

III. MODELING RESULTS

In January 2010, US EPA announced a new 1-hour NAAQS which is attained when the 3-year average of the 98th percentile of the daily maximum 1-hour NO_2 concentrations does not exceed 100 ppb (or 188 ug/m3) at each monitor within an area. Subsequently, US EPA issued in June 2010 a modeling guidance for using the AERMOD model with one year or five years of meteorological data (USEPA, 2010). According to the US EPA, the 8th highest maximum daily 1-hour concentration obtained with one year of onsite data or averaged over five years of offsite data should be used in the NAAQS comparison.

For 1-hour NO_2 modeling, US EPA has recommended several techniques that can be divided into three tiers:

1. Tier 1: Full conversion where the NO_x emissions are assumed to be 100% converted into NO_2,

2. Tier 2: The Tier 2 technique is known as the Ambient Ratio Method (ARM). In this technique, a default conversion rate of 0.80 recommended in the US EPA March 2011 guidance is applied to the predicted NO_x concentrations, and

3. Tier 3: Two Tier 3 techniques known as Ozone Limiting Method (OLM) and Plume Volume Molar Ratio Method (PVMRM) are currently available in the AERMOD model. These techniques are considered to be non-regulatory default and their use requires the approval of US EPA and state agencies on a case by case basis.

The current modeling study used three modeling techniques: Tier 1 with full conversion; Tier 2 with 80% conversion; and PVMRM with a NO/NO_2 in-stack ratio of 0.2. This in-stack ratio is taken from the US EPA In-Stack Ratio (ISR) database for gas-fired engines (http://www.epa.gov/ttn/scram/no2_isr_database.htm).

An AERMOD modeling run with the 2006-2010 meteorological data and maximum allowable emissions was performed using Tier 1 and Tier 2 techniques which are fully approved by the US EPA. NO_2 modeling results for Tier 1 are summarized in Appendix A and presented in Table 2. The AERMOD model has predicted the 8th highest (98th percentile) concentrations of 644.5 ug/m3 (Tier 1) and 515.6 ug/m3 (Tier 2) from the plant emissions alone. These concentrations largely exceed, by more than a factor of 2, the NAAQS of 188 ug/m3. With the added background of 65.2 ug/m3, the maximum total 8th highest concentrations are 278% (Tier 1) and 209% (Tier 2) above the 1-hour NAAQS of 188 ug/m3. These maximum impacts have been predicted to occur at about 0.4 km east of the plant. A plot of the contour of 188 ug/m3 is shown in Figure 3. Concentrations exceeding 188 ug/m3, i.e. violating the 1-hr NAAQS due to the plant emissions alone, occur about one mile southeast of the plant.

Another AERMOD modeling run was performed using the PVMRM technique. Modeling results for this Tier 3 technique are provided in Appendix B. Table 2 shows the 8th highest concentration of 288.9 ug/m3 predicted for the plant emissions alone also exceeds the 1-hour NAAQS. With the added background of 65.2 ug/m3, the total concentration of 354.1 ug/m3 exceeds the NAAQS by 88%. Figure 4 shows this maximum concentration occurs about 0.1 km northwest of the plant.

The emission reduction required to mitigate the NAAQS exceedances can be calculated from the formula R = [C-(188-B)]/C where C is the plant 8th highest concentration and B is the background. With C=515.6 ug/m3 and B=65.2 ug/m3 for Tier 2, the required emission reduction is R= 0.76 or 76%. This 76% reduction will decrease the allowable emissions from 21.31 lbs/hr to 5.11 lbs/hr. Similarly, Tier 3 (with C=288.9 ug/m3) requires an emission reduction of 0.58 or 58% that will decrease the allowable emissions from 21.31 lbs/hr to 8.95 lbs/hr.

Table 2. Predicted 1-Hour NO_2 Impacts by Allowable Emissions of the Barto Compressor Station

Modeling Method	Project Conc. (ug/m3)	Backgr. Conc. (ug/m3)	Total Conc. (ug/m3)	NAAQS (ug/m3)	NAAQS Exceed	Percent Over NAAQS
Tier 1 -100%	644.5	65.2	709.7	188	**YES**	**278%**
Tier 2 - 80%	515.6	65.2	580.8	188	**YES**	**209%**
Tier 3-PVMRM	288.9	65.2	354.1	188	**YES**	**88%**

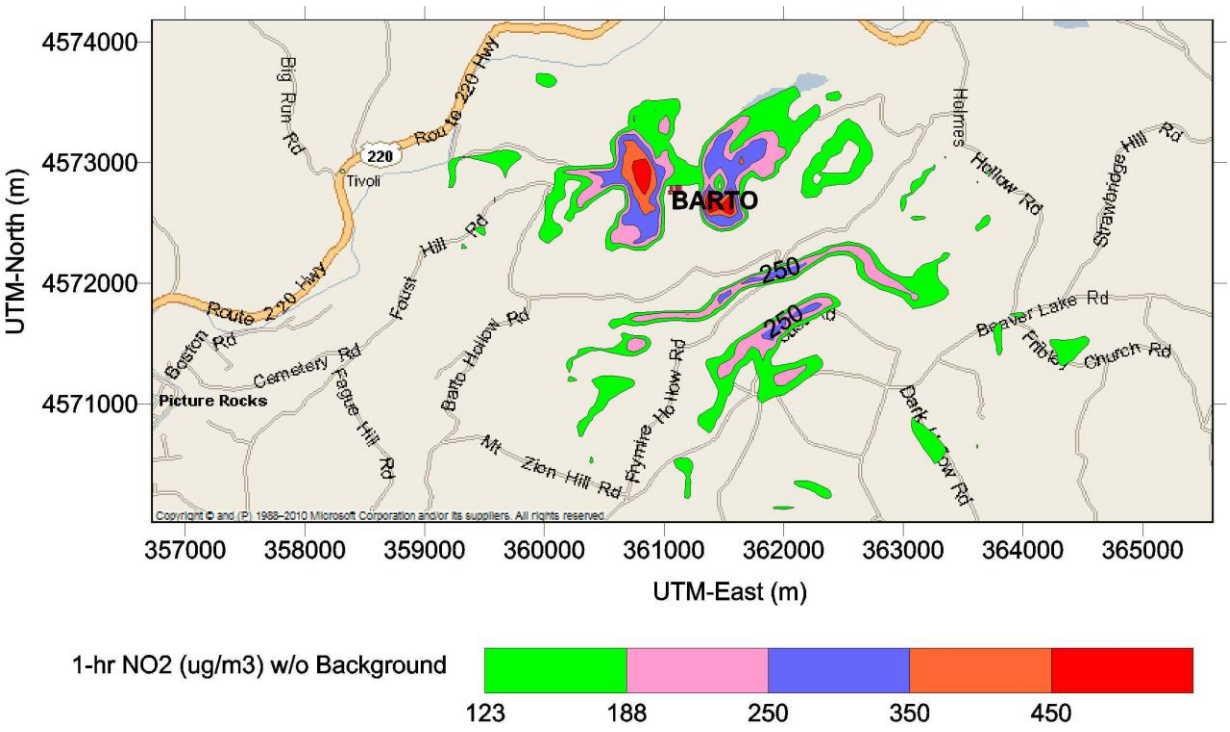

Figure 3. Area with 8th Highest NO_2 Concentrations (Tier 1-Full Conversion) Exceeding the 1-Hour NAAQS of 188 ug/m3 by Plant Allowable Emissions Alone

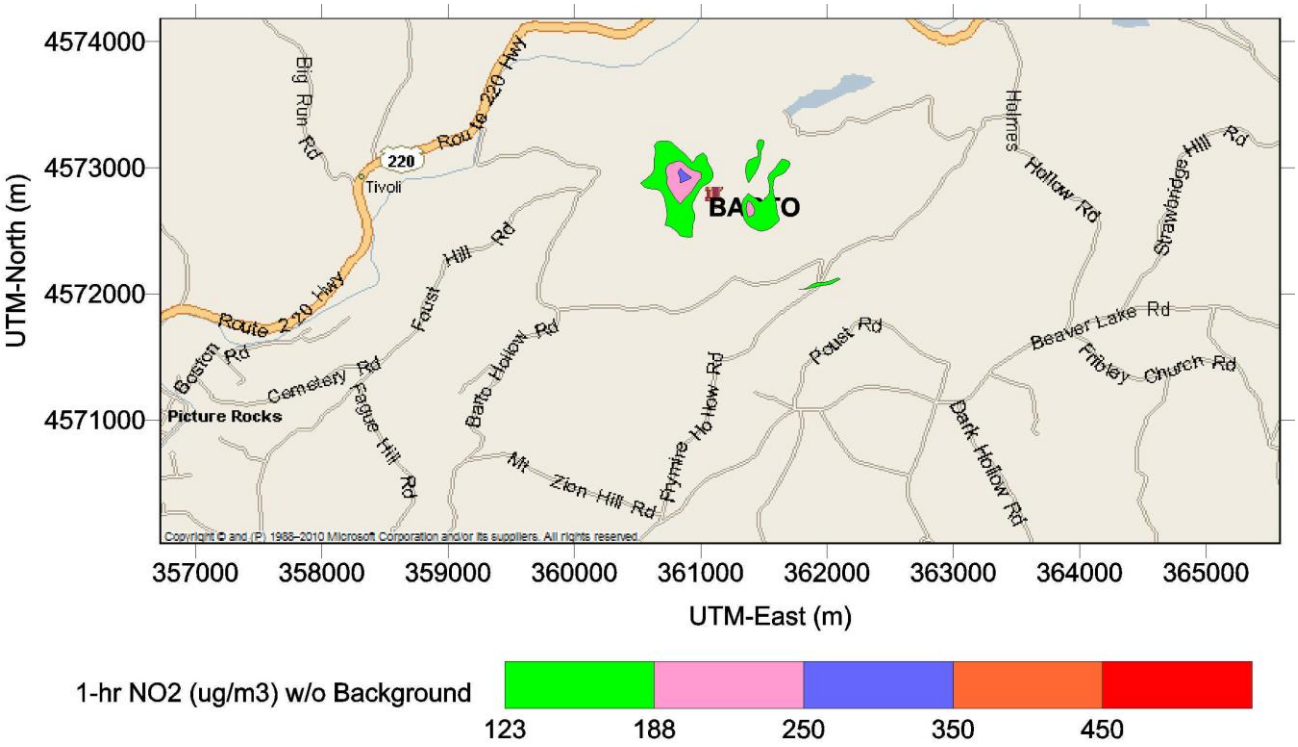

Figure 4. Area with 8th Highest NO_2 Concentrations (Tier 3 – PVMRM) Exceeding the 1-Hour NAAQS of 188 ug/m3 by Plant Allowable Emissions Alone

IV. CONCLUSIONS

Air quality impacts of NO_x emissions from the Barto Compressor Station have been analyzed with the AERMOD model. Using allowable emissions in the PA DEP permit, the 2006-2010 meteorological data and the latest US EPA modeling guidance, the AERMOD model has predicted large exceedances of the NO_2 1-hour NAAQS of 188 ug/m3 for all modeling techniques. For Tiers 1 and 2 techniques, NAAQS exceedances occur within a mile of the plant. Emission reductions of 76% (for Tier 2) and 58% (for Tier 3) are required to mitigate the predicted exceedances. Thus, NO_2 impacts from the Barto plant are very significant since its emissions alone cause large exceedances of the 1-hour NAAQS.

V. REFERENCES

U.S. EPA, 2012. Addendum to User's Guide of the AMS/EPA Regulatory Model AERMOD version 12060, February 2012. Available at: http://www.epa.gov/ttn/scram/models/aermod/aermod_userguide.zip

U.S. EPA, 2011. *Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO2 NAAQS*. Memorandum issued on March 1st, 2011 from Tyler Fox, Leader of Air Quality Modeling Group, OAQPS. Available at http://www.epa.gov/nsr/documents/20100629no2guidance.pdf

U.S. EPA, 2010. *Applicability of Appendix W Modeling Guidance for the 1-hour NO2 NAAQS*. Memorandum issued on June 28, 2010 from Tyler Fox, Leader of Air Quality Modeling Group, OAQPS. Available at http://www.epa.gov/nsr/documents/20100629no2guidance.pdf

Appendix A

Summary of AERMOD 1-hour Modeling Results (Tier 1-Full Conversion) of Allowable Emissions

**MODELOPTs: CONC ELEV

*** THE SUMMARY OF MAXIMUM 8TH-HIGHEST MAX DAILY 1-HR RESULTS AVERAGED OVER 5 YEARS ***

** CONC OF NO2 IN MICROGRAMS/M**3 **

GROUP ID	AVERAGE CONC	RECEPTOR (XR, YR, ZELEV, ZHILL, ZFLAG)	NETWORK OF TYPE GRID-ID
ALL	1ST HIGHEST VALUE IS	644.47099 AT (361358.00, 4572684.00, 339.65, 369.23, 0.00)	DC
	2ND HIGHEST VALUE IS	635.47566 AT (361408.00, 4572984.00, 348.45, 369.11, 0.00)	DC
	3RD HIGHEST VALUE IS	618.83357 AT (361408.00, 4572634.00, 348.31, 369.23, 0.00)	DC
	4TH HIGHEST VALUE IS	618.83357 AT (361408.00, 4572634.00, 348.31, 369.23, 0.00)	DC
	5TH HIGHEST VALUE IS	617.20937 AT (361408.00, 4572684.00, 349.25, 369.23, 0.00)	DC
	6TH HIGHEST VALUE IS	616.16893 AT (361408.00, 4572584.00, 346.47, 369.23, 0.00)	DC
	7TH HIGHEST VALUE IS	608.69999 AT (361408.00, 4573034.00, 346.41, 367.09, 0.00)	DC
	8TH HIGHEST VALUE IS	608.69999 AT (361408.00, 4573034.00, 346.41, 367.09, 0.00)	DC
	9TH HIGHEST VALUE IS	599.84701 AT (360858.00, 4572984.00, 337.97, 340.25, 0.00)	DC
	10TH HIGHEST VALUE IS	588.75040 AT (361408.00, 4572734.00, 350.34, 369.23, 0.00)	DC

Appendix B

Summary of AERMOD 1-hour Modeling Results (Tier 3-PVMRM) of Allowable Emissions

*** THE SUMMARY OF MAXIMUM 8TH-HIGHEST MAX DAILY 1-HR RESULTS AVERAGED OVER 5 YEARS ***

** CONC OF NO2 IN MICROGRAMS/M**3 **

GROUP ID	AVERAGE CONC	RECEPTOR (XR, YR, ZELEV, ZHILL, ZFLAG)	NETWORK OF TYPE GRID-ID
ALL	1ST HIGHEST VALUE IS	288.87863 AT (360958.00, 4572934.00, 326.26, 343.97, 0.00)	DC
	2ND HIGHEST VALUE IS	283.25208 AT (360858.00, 4572984.00, 337.97, 340.25, 0.00)	DC
	3RD HIGHEST VALUE IS	264.94376 AT (360858.00, 4572884.00, 339.12, 341.26, 0.00)	DC
	4TH HIGHEST VALUE IS	258.44143 AT (360858.00, 4572934.00, 339.02, 339.02, 0.00)	DC
	5TH HIGHEST VALUE IS	256.19565 AT (360908.00, 4572834.00, 337.31, 337.31, 0.00)	DC
	6TH HIGHEST VALUE IS	256.19565 AT (360908.00, 4572834.00, 337.31, 337.31, 0.00)	DC
	7TH HIGHEST VALUE IS	246.13346 AT (360858.00, 4572834.00, 340.89, 340.89, 0.00)	DC
	8TH HIGHEST VALUE IS	241.35612 AT (360908.00, 4572884.00, 334.29, 341.26, 0.00)	DC
	9TH HIGHEST VALUE IS	239.40262 AT (360808.00, 4572984.00, 340.82, 349.48, 0.00)	DC
	10TH HIGHEST VALUE IS	230.24366 AT (360908.00, 4572934.00, 332.25, 342.85, 0.00)	DC