Maryland
Department of
the Environment

Larry Hogan
Governor

Boyd Rutherford
Lieutenant Governor

Ben Grumbles
Secretary

April 14, 2016

Mr. Shawn M. Garvin
Regional Administrator
USEPA Region 3
1650 Arch Street
Mail Code: 3RA00
Philadelphia, PA 19103-2029

Dear Mr. Garvin:

I am writing to you regarding the 1-hour SO_2 Characterization Modeling for the area around the H.A. Wagner and Brandon Shores power plants air quality modeling protocol that was recently submitted to the Maryland Department of the Environment (MDE), Air and Radiation Management Administration (ARMA). This modeling protocol was prepared to describe the approach being taken to demonstrate that the H.A. Wagner (Wagner) power plant located in Anne Arundel County, Maryland would be in attainment of the 1-hour SO_2 National Ambient Air Quality Standard (NAAQS).

On March 20, 2015, EPA informed Maryland that the Wagner Power Plant would be part of the expedited round of designations under the 1-hour SO_2 NAAQS due to terms of the SO_2 Consent Decree negotiated between the Sierra Club and EPA (Sierra Club *v.* McCarthy). The EPA intends to designate the Wagner Power Plant area as either unclassifiable/attainment, nonattainment or unclassifiable by July 2, 2016 after a review of available modeling or monitoring data to support the SO_2 concentration characterization.

The model selected for this modeling application is the EPA American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) modeling system version 15181, including the American Meteorological Society/Environmental Protection Agency Regulatory Improvement Committee (AERMIC) meteorological (AERMET) non-regulatory default/beta ADJ_U* option (EPA,2015a). EPA has indicated support for this change as part of their July 29, 2015 Appendix W proposal. In addition, Roger Brode's (USEPA) Proposed Updates to AERMOD Modeling System presentation (EPA, 2015b) delivered at the 11th Modeling Conference on August 12, 2015 indicated that the ADJ_U* option be incorporated into the regulatory versions of AERMOD and AERMET in the notice of proposed rulemaking (NPRM).

Section 3.2.2.b of Appendix W to 40 CFR Part 51, ("Revision to the Guideline on Air Quality Models", November 9, 2005), details the approach for approval of an alternative model. Specially, the request must meet one of the following three conditions:

1. If a demonstration can be made the model produces concentrations estimates equivalent to the estimates obtained using a preferred model;
2. If a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the alternative model performs better for the given application than a comparable model; or
3. If the preferred model is less appropriate for the specific application, or there is no preferred model.

The Wagner power plant request falls under condition 3.

Appendix W (Section 3.2.2.e) states that for condition 3 in paragraph b of section 3.2.2 of Appendix W to 40CFRPart 51, "an alternative refined model may be used provided that:

1. The model has received a scientific peer review;
2. The model can be demonstrated to be applicable to the problem on a theoretical basis;
3. The databases which are necessary to perform the analysis are available and adequate;
4. Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates; and,
5. A protocol on methods and procedures to be followed has been established."

These five (5) points are discussed below separately.

Condition 1: The model has received a scientific peer review

EPA has acknowledged poor AERMOD performance during low wind-speed conditions (Robinson and Brode 2007). The proposed AERMET formulation changes to the friction velocity computation for low wind speeds are referenced in a Boundary-Layer Meteorology Qian and Venkatram (2011) peer-reviewed paper which demonstrated that the AERMOD meteorological preprocessor (AERMET) tends to grossly under-predict surface friction velocity (u*) under low wind-speed conditions (less than two meters per second). When simulating emission sources with AERMOD, the under-prediction of u* leads to inappropriately low mechanical mixing heights, consequently resulting in overly conservative (excessively high) ambient concentration estimations (EPA 2015c; Paine and Connors 2013; Qian and Venkatram 2011, Robert Paine 2015).

Qian and Venkatram (2011) suggested a new method for calculating u* and showed results that support improved u* and model concentration predictions in the low wind-speed regime. EPA has incorporated this calculation methodology in AERMET as ADJ_U* (EPA 2013), most recently in AERMET version 15181. The ADJ_U* method is a processing option for calculating u* for low wind speeds during stable (nighttime) conditions (EPA 2015a). Several study results support the conclusion that the application of the ADJ_U* option significantly improves
AERMOD performance for low wind-speed conditions while maintaining a conservatively

high bias in predicted concentrations (EPA 2013; EPA 2015c; EPA 2014; Paine and Connors 2013).
These studies indicate that the ADJ_U* option has been sufficiently peer-reviewed.

Condition 2: The model can be demonstrated to be applicable to the problem on a theoretical basis

There is no theoretical limitation to the application of the AERMET ADJ_U* - it is generally applicable. The current default algorithm in AERMET has been demonstrated to be faulty and needs to be replaced by the ADJ_U* approach.

Condition 3: The databases which are necessary to perform the analysis are available and adequate

The necessary data needed for implementing ADJ_U* within the AERMOD modeling system is routine meteorological data are already available and are sufficient for exercising this low wind option. The use of the Baltimore Washington International Thurgood Marshall Airport (BWI) National Weather Service (NWS) data is sufficient. There are no special database requirements for the use of the ADJ_U* option.

Condition 4: Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates

There have been many model evaluation studies that illustrate improved performance of the AERMOD modeling system with the use of the ADJ_U* option. Most notably is the performance evaluation referenced in Appendix F of the AERMOD User's Guide (EPA 2015c) that was conducted by EPA. This performance evaluation performed by EPA utilizes three evaluation databases: (1) Idaho Falls (NOAA Technical Memorandum ERL ARL-52, August 1974), (2) Oak Ridge (NOAA Technical Memorandum ERL ARL-61, August 1976), and (3) Lovett. The first two databases were part of the API-sponsored evaluation of AERMOD conducted by AECOM, that were submitted as part of API's public comments on EPA's 10th Conference on Air Quality Models held in March 2012. The two NOAA field studies were low-level, non-buoyant tracer releases with three arcs of samplers located at 100 m, 200 m, and 400 m from the release point. The Idaho Falls study was located in a flat terrain, while Oak Ridge was located in complex terrain.

The third database utilized by EPA to evaluate the ADJ_U* option presented in Appendix F of the AERMOD User's Guide (EPA 2015c) was the Lovett database. Lovett is a historical AERMOD evaluation database and features a single 145 meter stack located within a few kilometers of complex terrain. The Lovett field study was a year-long SO_2 field program with monitors located on the primary terrain features to the north of the stack.

The most representative field program that could be used to predict the performance of ADJ_U* for a modeling study at the Wagner power plant is the Lovett field program.

Overall for Lovett, the Q-Q plots on pages F-35 through F-37 (EPA 2015c) demonstrate that the inclusion of the ADJ_U* option improves model performance. Whether the ADJ_U* option is correcting an under-prediction bias as shown on page F-35 (Figure 1) or an over-prediction bias as shown on pages F-36 (Figure 2) and F-37 (Figure 3), the model performance is better.

In Attachment A (Modeling Analysis to Support Use of ADJ_U* Option) of this letter is an additional analysis completed to demonstrate that the model using ADJ_U* is not biased toward underestimate. In addition, the modeling files used in this analysis to support the use of ADJ_U* are also enclosed.

In the proposed revisions to the Guideline (EPA 2015d), EPA intends for the ADJ_U* option to be part of the regulatory default AERMOD modeling system. EPA made this proposal in the preamble to the proposed changes to the Guideline, referred to below as NPRM.

Due to several initial comments from stakeholders, members of the EPA modeling group provided clarifications (EPA 2015e and 2015f) that reinforced EPA's intent to include ADJ_U* as a regulatory default option. These clarifications were provided during EPA's 11th Conference on Air Quality Modeling and Public Hearing for the Proposed Revisions to the Guideline held on August 12–13, 2015 (2015 Conference). EPA's statements regarding the ADJ_U* option as presented in the NPRM and the 2015 Conference are provided below.

From NPRM section IV.A.2., "Updates to EPA's AERMOD Modeling System" (EPA 2015g):

> *"Based on studies presented and discussed at the Tenth Modeling Conference, and additional relevant research since 2010, the EPA and other researchers have conducted additional model evaluations and developed changes to the model formulation of the AERMOD modeling system to improve model performance in its regulatory applications. We propose the following updates to the AERMOD modeling system to address a number of technical concerns expressed by stakeholders:*
>
> 1. *A proposed option incorporated in AERMET to adjust the surface friction velocity (u*) to address issues with AERMOD model over prediction under stable, low wind speed conditions. This proposed option is selected by the user with the METHOD STABLEBL ADJ_U* record in the AERMET Stage 3 input file."*

As presented on the public record at the 2015 Conference by Tyler Fox in his presentation "Overview of Proposed Revisions to Appendix W" (EPA 2015e):

> *"In the NPRM, EPA has proposed to incorporate specific updates to the regulatory version that are the subject of public review and comment and then would be codified as part of the final rule action, as appropriate.*

– These options have thus remained "beta" in v15181 to allow for public testing & evaluation"

As presented on the public record at the 2015 Conference by Roger Brode in his presentation
"Proposed Updates to AERMOD Modeling System" (EPA 2015f):

"EPA has proposed in the NPRM that the ADJ_U option (with or without BULKRN) be incorporated into the regulatory version of AERMET."*

It is clear that EPA, pending review and comments during the public comment period, intends to incorporate ADJ_U* as a regulatory default option. At this time, ADJ_U* remains a nondefault option and requires approval from EPA for use in modeling compliance demonstrations. According to statements at the 2015 Conference, the proposed revisions to the Guideline are expected to be finalized by the spring of 2016 (EPA 2015e).

MDE/ARMA believes that these evaluations satisfy this condition.

Condition 5: A protocol on methods and procedures to be followed has been established

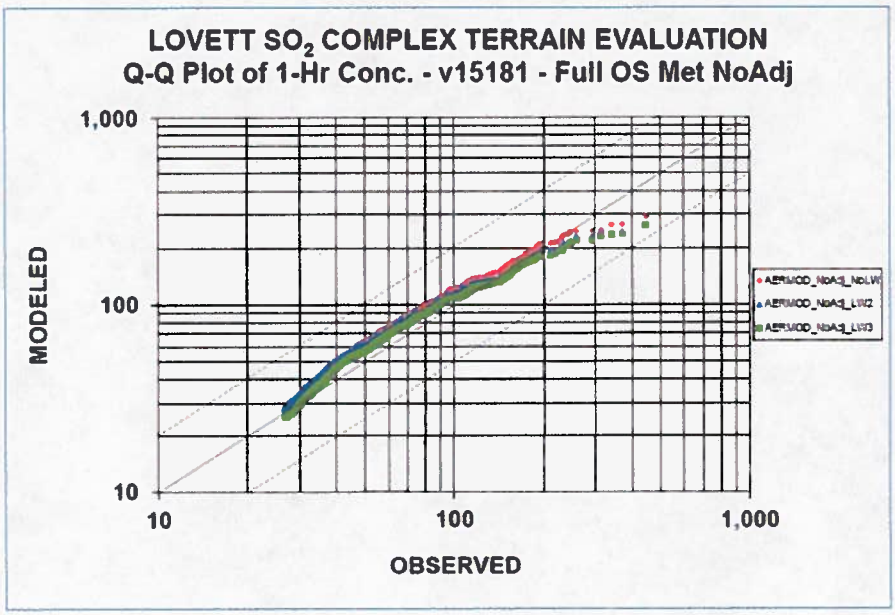
A modeling protocol addressing the 1-hour SO_2 characterization of the Wagner area was prepared by AECOM and submitted to EPA Region 3 in February 2016. Comments on the modeling protocol were received from EPA Region 3 in March 2016. MDE/ARMA has reviewed the modeling protocol prepared for utilizing ADJ_U* and EPA Region 3 comments and the implementation of the ADJ_U* in the application, and we believe that the comments have been adequately addressed.

MDE/ARMA believes for the reasons described previously that the ADJ_U* option is justified for use in the 1-hour SO_2 characterization air quality modeling for the Wagner power plant. If there are any specific questions related to the technical aspects of this air modeling issue, please contact Mr. Michael Woodman of MDE/ARMA at (410) 537-3229.

Sincerely,

Ben Grumbles
Secretary

cc: Tim Leon Guerrero, U.S. EPA Region III (e-mail)
George (Tad) S. Aburn, Jr., MDE
Enclosures



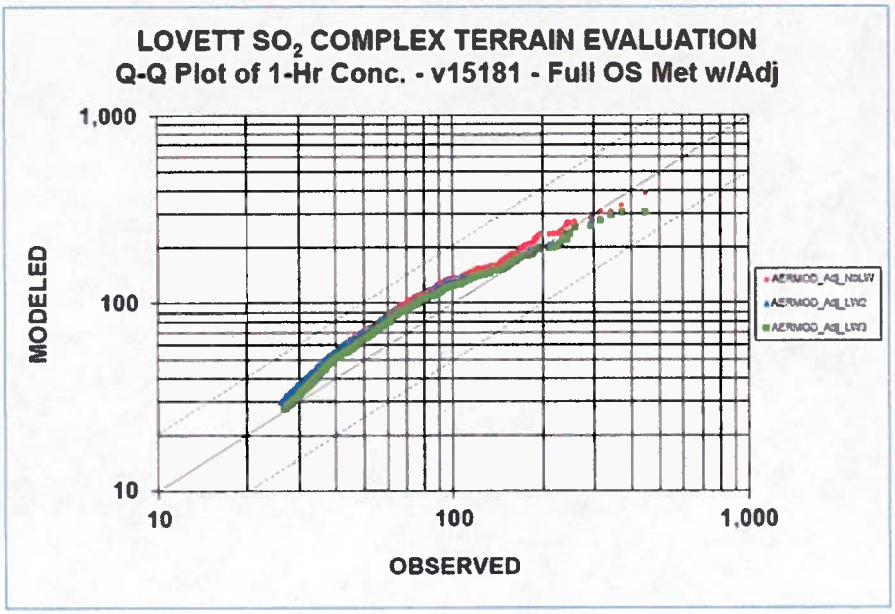
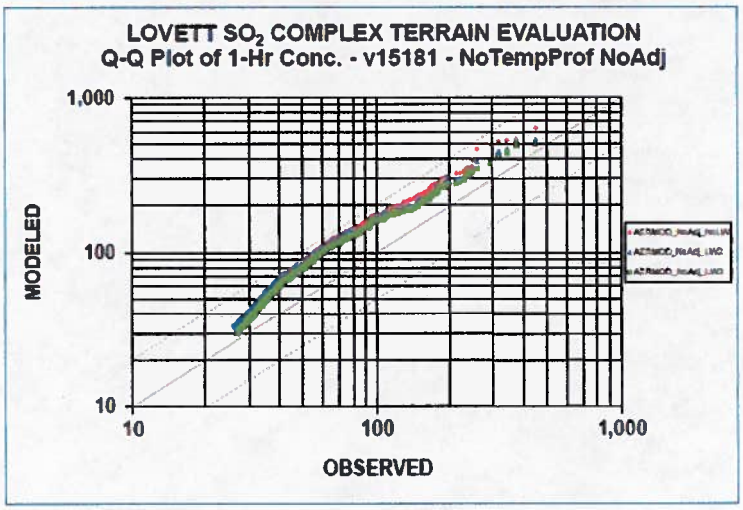


Figure 1. EPA AERMOD Evaluation Results for Lovett
(From page F-35 (EPA2015c))



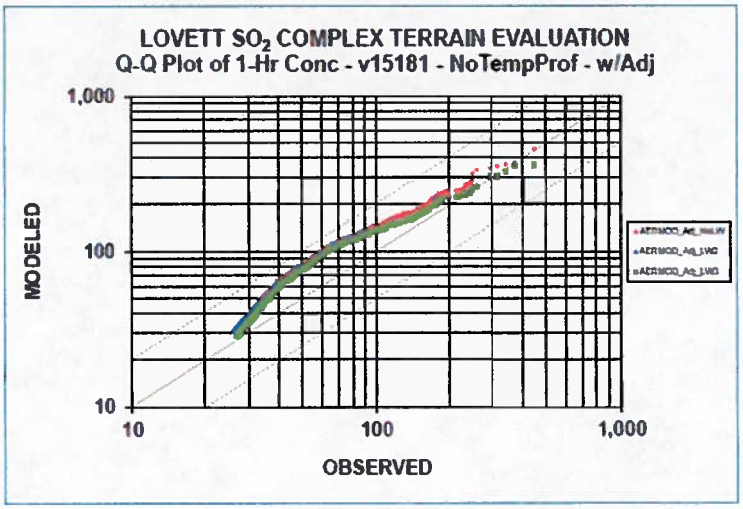
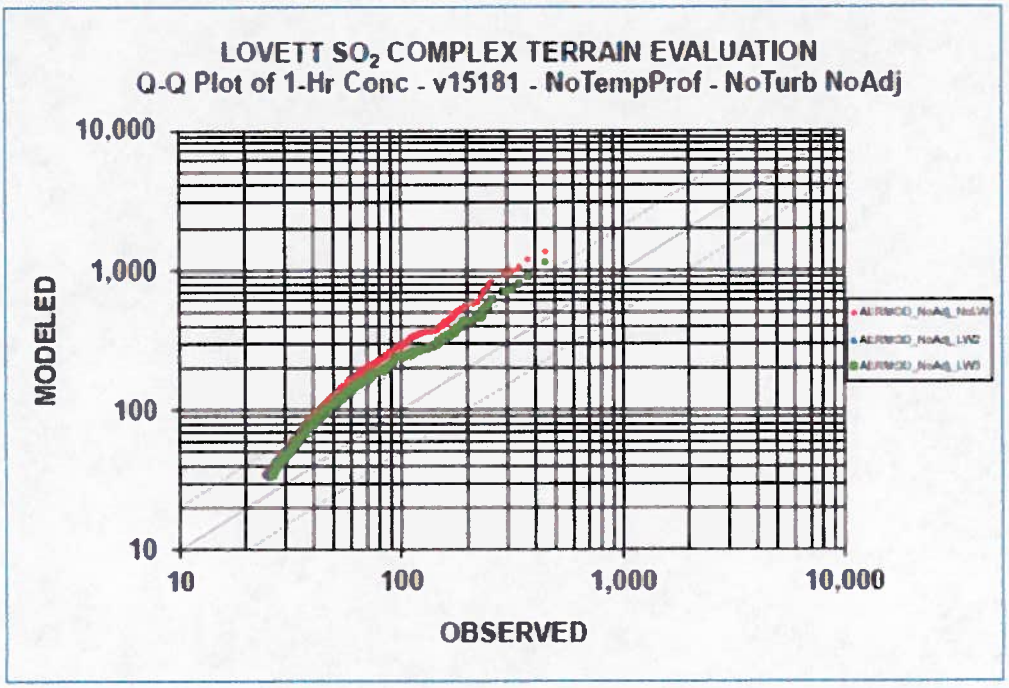


Figure 2. EPA AERMOD Evaluation Results for Lovett
(From page F-36 (EPA2015c))



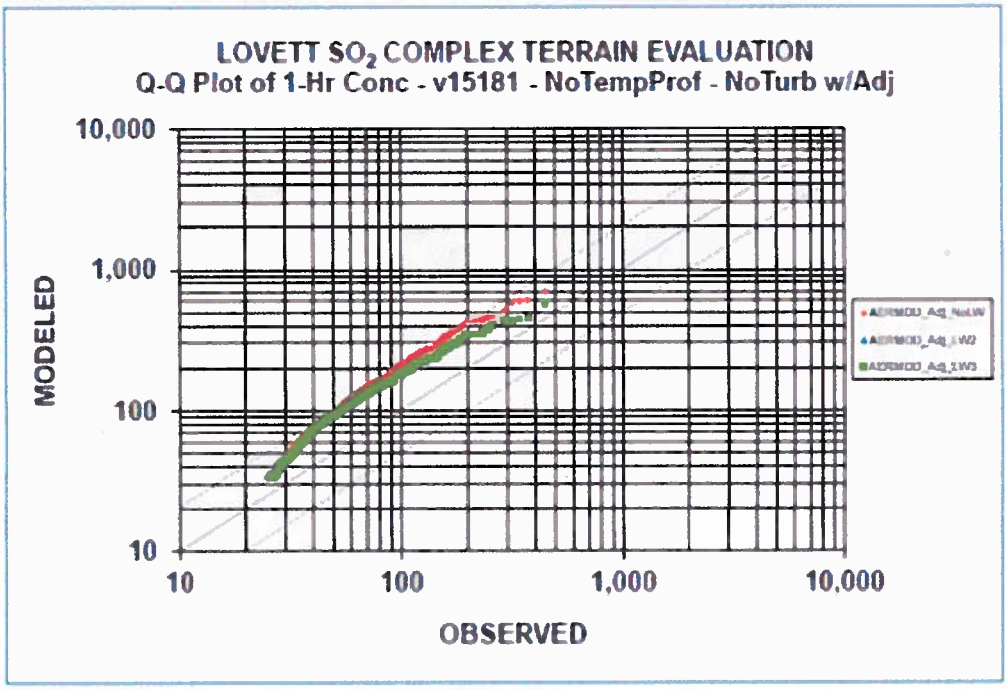


Figure 3. EPA AERMOD Evaluation Results for Lovett
(From page F-36 (EPA2015c))

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Attachment A
Modeling Analysis to Support Use of ADJ_U* Option

This AERMOD modeling analysis was completed to demonstrate that use non-regulatory ADJ_U*is applicable in this instance.

1-hour SO_2 modeling completed using AERMOD with regulatory default options and variable hourly emissions resulted in modeled 4^{th} high 1-hour SO_2 concentrations nearby the Wagner power plant (Wagner) area and approximately 35 km to the northwest of the Wagner area in Baltimore County (Figure 1A).

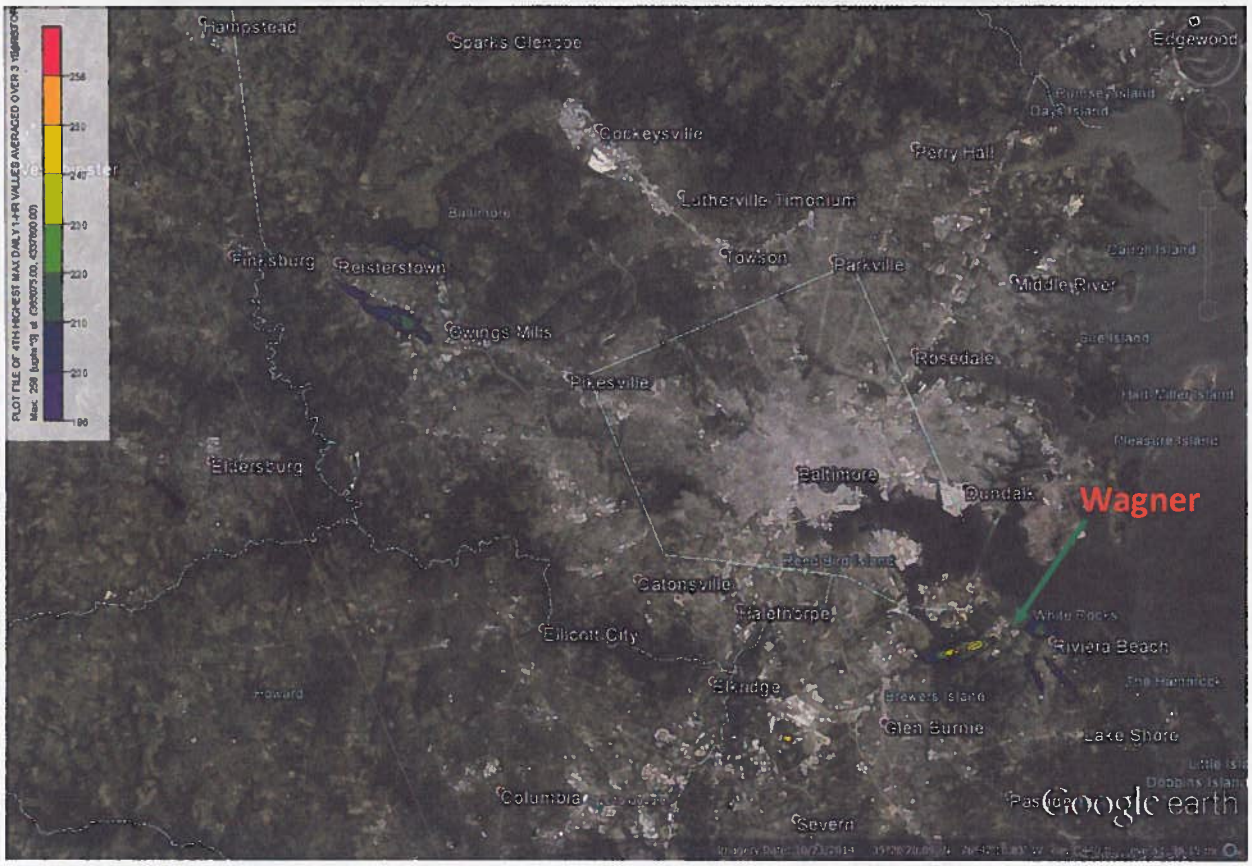

Figure 1A. Modeled 4th High 1-hour SO_2 Concentrations

Within each of these areas of modeled 4^{th} high 1-hour SO_2 concentrations, one or two of the highest reading receptors were chosen and closely looked at. The areas to the northwest of the Wagner area were assigned the letters A – H to represent the various modeled 4th high 1-hour SO_2 concentration areas. The group A-G receptors are shown in Figure 2A and Figure 3A shows the receptor group H. The receptors that will be further analyzed are represented by red dots. Areas of modeled 4^{th} high 1-hour SO_2 concentrations located in the Wagner area are represented by receptor group's I-N as seen in Figure 4A.

Attachment A
Modeling Analysis to Support Use of ADJ_U* Option

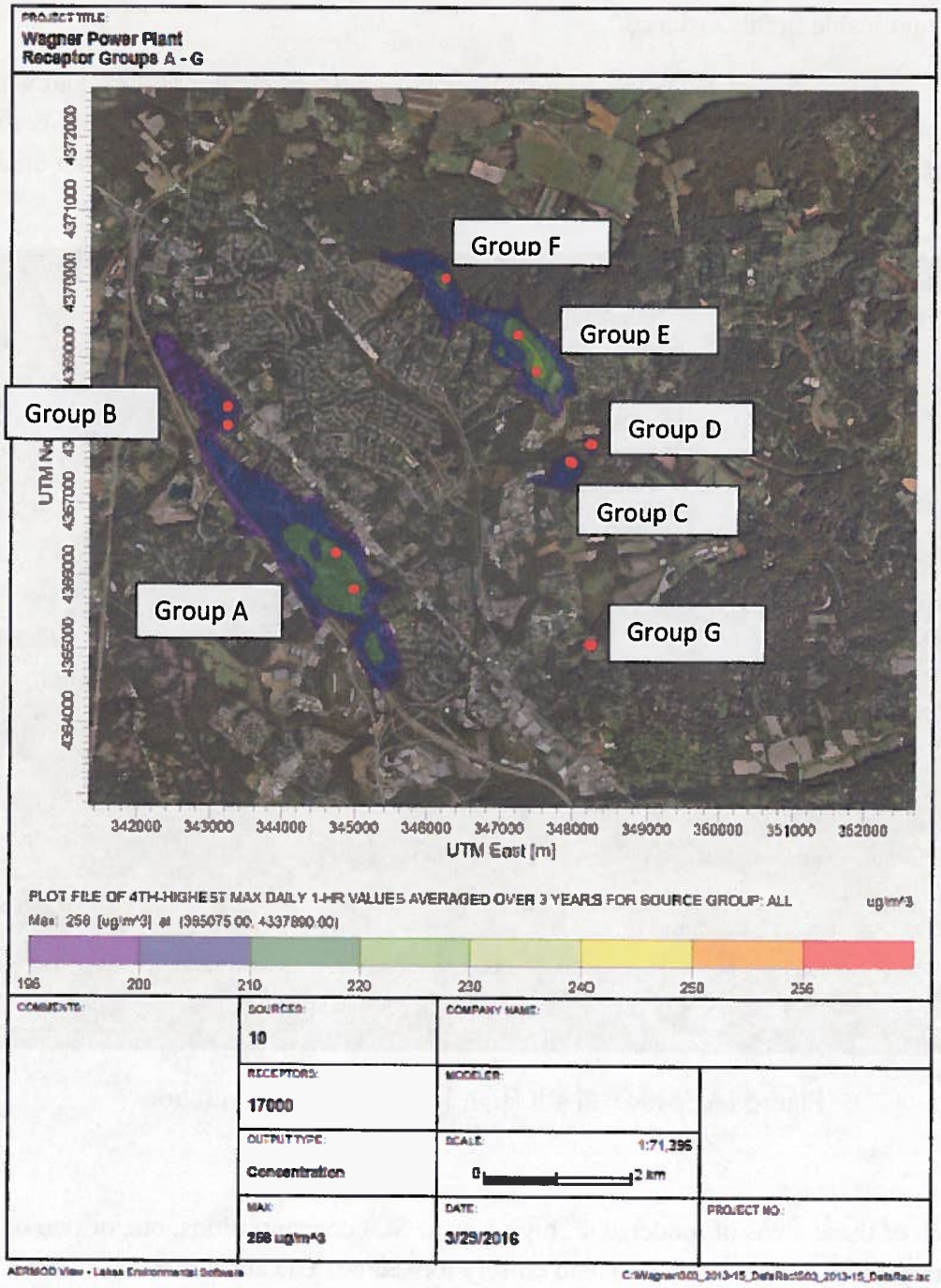

Figure 2A. Receptor Groups A – G

Attachment A
Modeling Analysis to Support Use of ADJ_U* Option

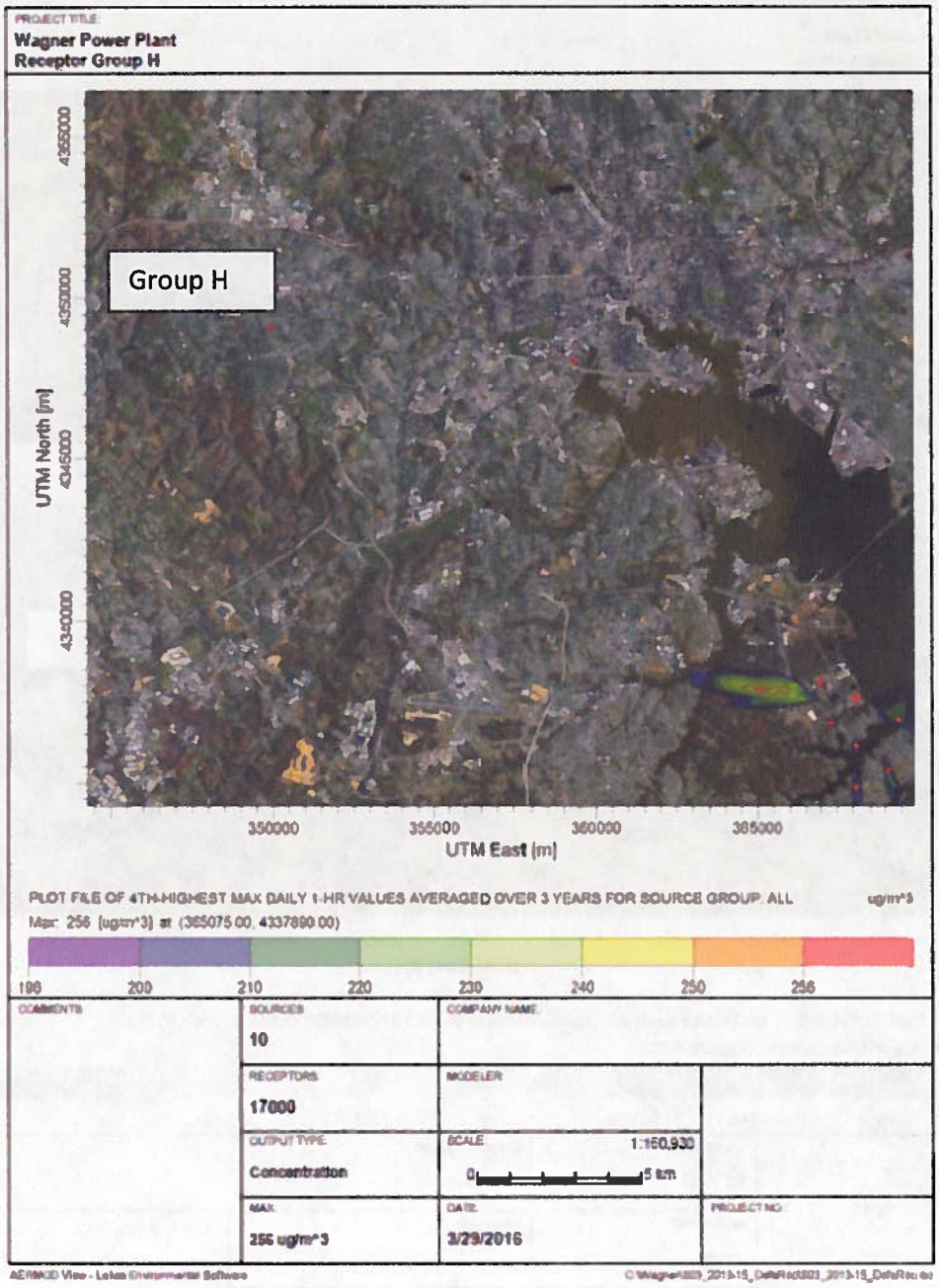

Figure 3A. Receptor Group H

Attachment A
Modeling Analysis to Support Use of ADJ_U* Option

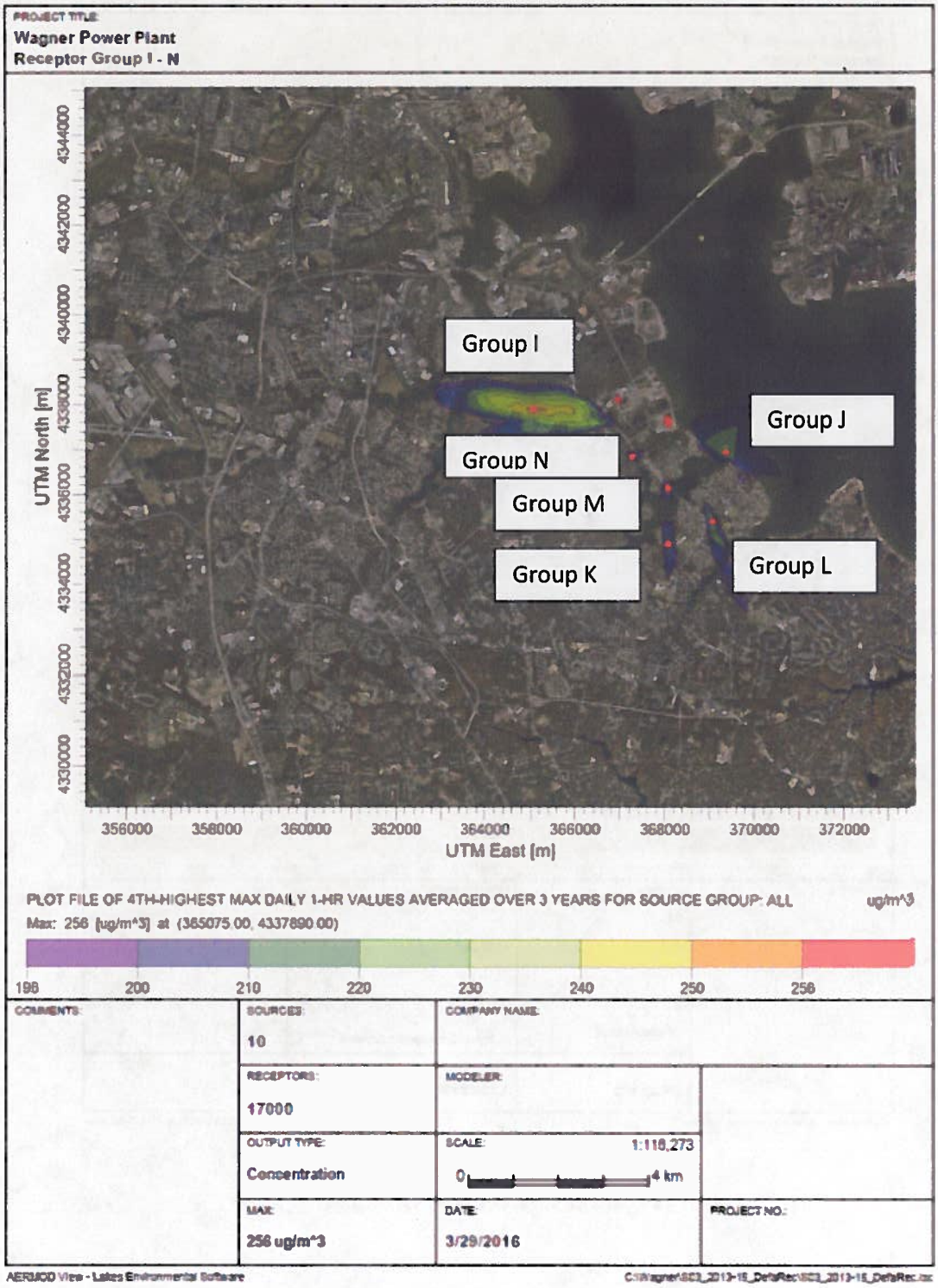

Figure 4A. Receptor Groups I – N

Attachment A
Modeling Analysis to Support Use of ADJ_U* Option

Within the areas A-N a total of 18 receptors were further analyzed. For each of these receptors the elevation, Julian day, hour, surface friction velocity (U*) and wind speed without and with the adjustment to U* are in Table 1A.

Based on Table 1A, the receptors in groups A-H are all located in areas of complex terrain and the greatest distance from the Wagner area. In addition, hours of the maximum concentrations at these receptors are all between the hours when stable conditions are expected and winds are light. The application of the ADJ_U* option reduces the frequency of low surface friction velocity (U*) values that are known to result in over-predictions of modeled concentrations with AERMOD. Receptors in groups I – N are in the immediate Wagner area and not located in complex terrain. The surface friction velocities are similar during the hours when unstable conditions are expected.

In addition, the data in Table 1A and the fact that the modeled 4th high 1-hour SO_2 concentrations in Baltimore County are located at such a far distance from the Wagner area calls the model's applicability into question.

The Baltimore Washington International Thurgood Marshall (BWI) Airport wind rose (Figure 5A) shows that the prevailing wind direction is from the west and west northwest. Based on the wind rose the frequency of strong winds needed to cause the high concentrations of 1-hour SO_2 to affect an area 35 kilometers away is not supported.

Figure 6A shows the modeling run that was completed using the exact same input parameters, except the non-regulatory ADJ_U* option was used. This particular scenario still resulted in 4th high 1-hour SO_2 modeled concentrations in the immediate Wagner area but the high concentrations approximately 35 kilometers to the northwest of the Wagner area in Baltimore County were no longer present.

Attachment A
Modeling Analysis to Support Use of ADJ_U* Option

Table 1A. Surface Friction Velocity (U*) With and Without the Adjustment

						Without ADJ_U*		With ADJ_U*	
						Surface Friction Velocity (U*)	Wind Speed (Ws)	Surface Friction Velocity (U*)	Wind Speed (Ws)
Group	X	Y	Elevation	Julian Day	Hour	(m/s)	(m/s)	(m/s)	(m/s)
A	344732.83	4366325.66	212.8	247	20	0.081	2.25	0.15	2.25
A	344982.83	4365825.66	209.6	247	20	0.081	2.25	0.15	2.25
B	343232.83	4368325.66	213.7	247	20	0.081	2.25	0.15	2.25
B	343232.83	4368075.66	210.3	55	22	0.026	0.79	0.095	0.79
C	347982.83	4367575.66	209.1	19	5	0.036	1.08	0.095	1.08
C	347953.75	4367592.5	208.34	19	5	0.036	1.08	0.095	1.08
D	348232.83	4367825.66	205.3	60	22	0.031	0.86	0.097	0.86
E	347482.83	4368825.66	217.5	19	5	0.036	1.08	0.095	1.08
E	347232.83	4369325.66	219.5	273	19	0.050	1.37	0.095	1.37
F	346232.83	4370075.66	219.4	19	5	0.036	1.08	0.095	1.08
G	348232.83	4365075.66	201.2	128	20	0.069	1.94	0.126	1.94
H	349953.75	4349092.5	159.13	273	20	0.047	1.30	0.094	1.30
I	365075	4337890	9.39	358	13	0.118	1.55	0.118	1.55
J	369375	4336940	7.69	363	13	0.179	1.99	0.179	1.99
K	368075	4334890	9.16	61	16	0.165	2.04	0.165	2.04
L	369075	4335390	7.84	64	10	0.094	0.69	0.094	0.69
M	368075	4336140	6.51	33	13	0.118	1.30	0.118	1.30
N	367275	4336840	14.04	274	6	0.148	3.00	0.187	3.00

Attachment A
Modeling Analysis to Support Use of ADJ_U* Option

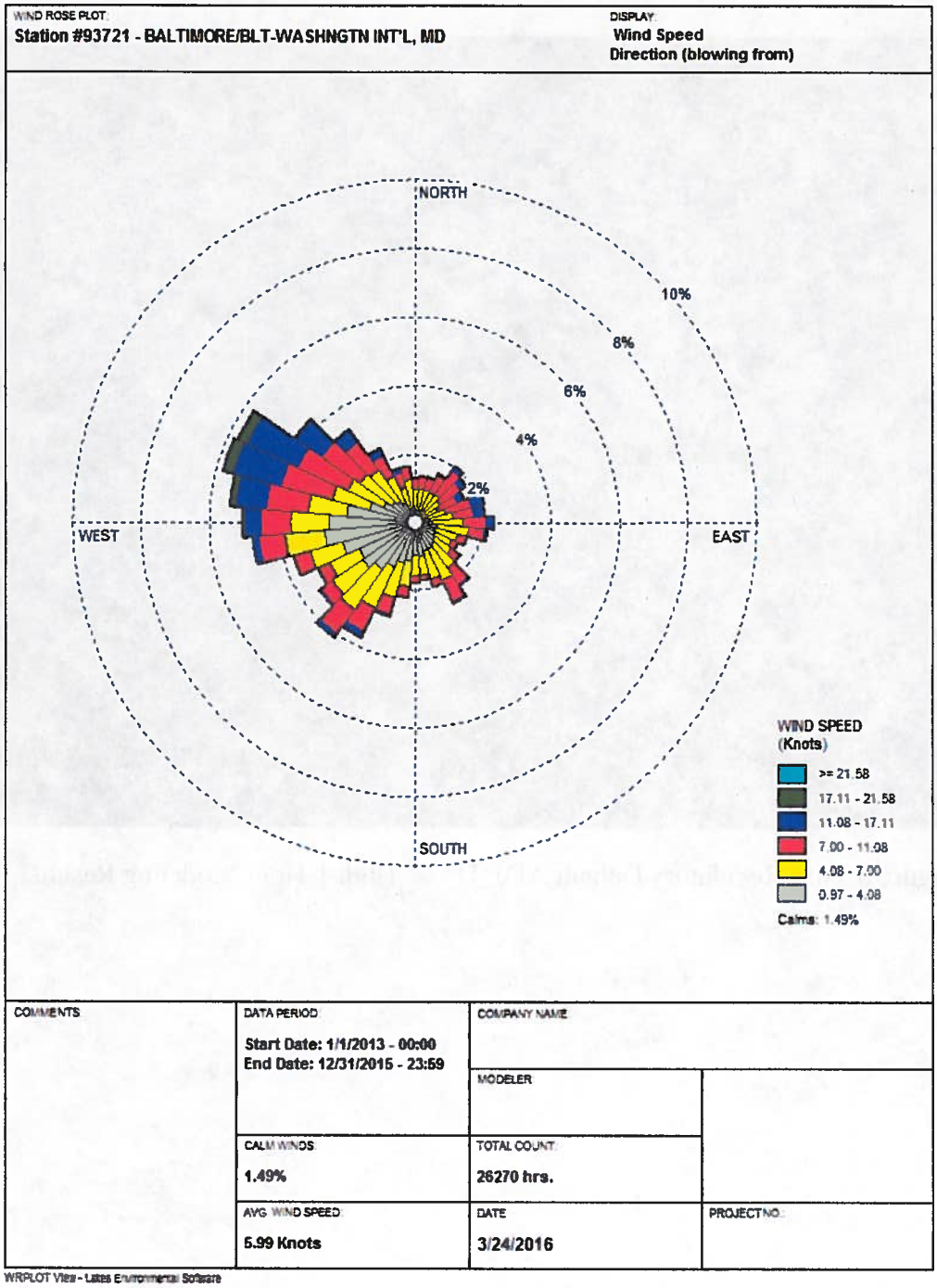

Figure 5A. BWI Airport Wind Rose

Attachment A
Modeling Analysis to Support Use of ADJ_U* Option

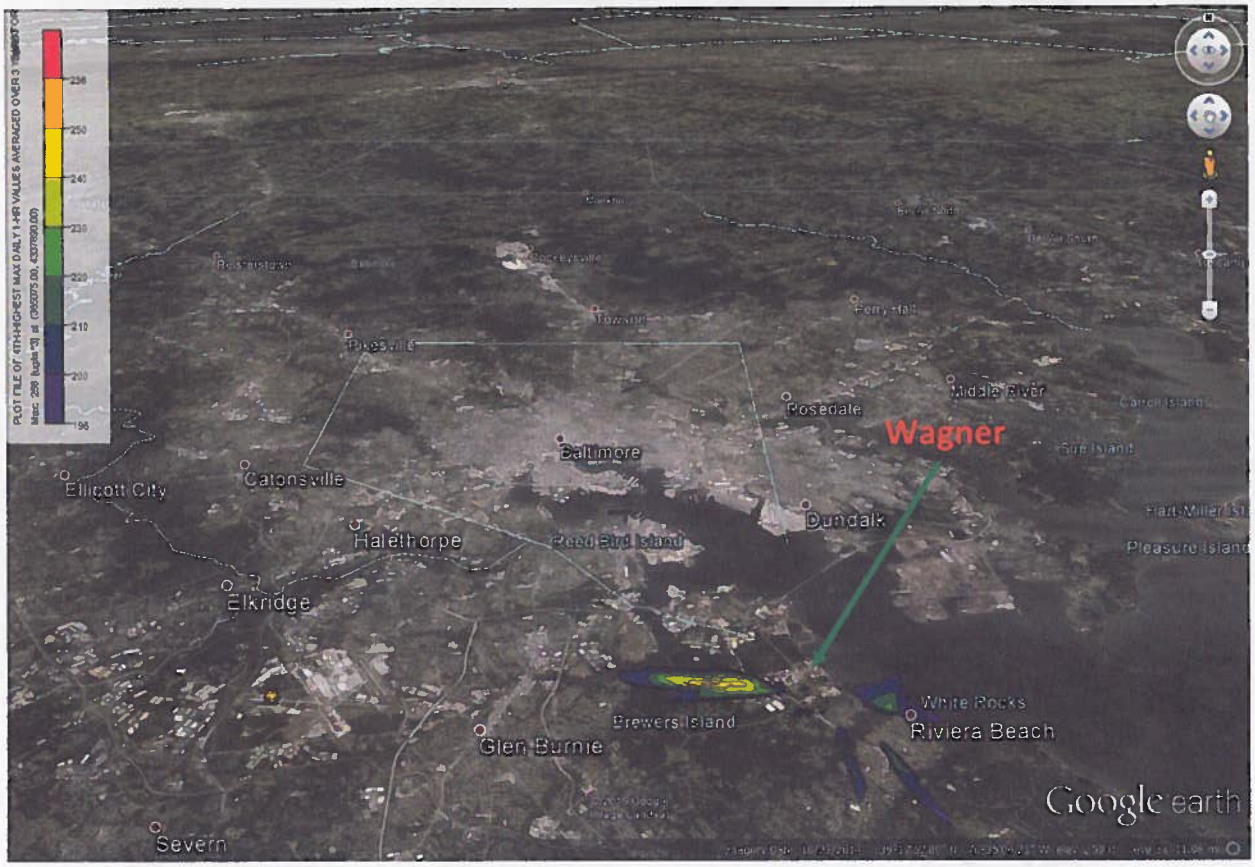

Figure 6. Non-Regulatory Default ADJ_U* 4th High 1-Hour Modeling Results

Attachment A

Modeling Analysis to Support Use of ADJ_U* Option

The completed modeling analysis demonstrates that the use of the regulatory default options and non-regulatory default ADJ_U* option results in very similar modeled 4th high 1-hour SO_2 concentrations. The only difference between the two is that the modeled 4th high 1-hour SO_2 concentrations 35 kilometers away in Baltimore County are no longer present using the non-regulatory default ADJ_U* option. As previously mentioned, the 4th high 1-hour SO_2 modeled concentrations are not highly probable based on the low wind speeds observed during the hours in question based on the available meteorological data. In addition, this same conclusion was reached by Raven Power based on the comments they submitted. In those comments, Raven Power says "it is impossible for the plume to travel that distance within the model's 1-hour averaging time" (Raven Power Comments on EPA's Proposed SO_2 Non-Attainment Designation for H.A. Wagner Power Plant, March 31, 2016). In conclusion, Maryland should be granted approval to use the non-regulatory default ADJ_U* option in this particular instance.

Attachment A
Modeling Analysis to Support Use of ADJ_U* Option

References

Raven Power Comments on EPA's Proposed SO2 Non-Attainment Designation for H.A. Wagner Power Plant, Baltimore, MD, Submitted by Raven Power, A Subsidiary of Talen Energy, March 31, 2016. Docket # EPA-HQ-OAR-2014-0464.