

***National Ambient Air Quality Standards-Sulfur Dioxide***

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Sulfur dioxide (SO<sub>2</sub>) forms in the atmosphere as a result of the release of emissions from the combustion of fossil fuels, other combustion processes, ore extraction and diesel engines. SO<sub>2</sub> also contributes to the secondary formation of fine particulate matter in the form of sulfates.

On June 2, 2010, the Environmental Protection Agency substantially strengthened the SO<sub>2</sub> National Ambient Air Quality Standards (NAAQS) through the establishment of a new 1-hour standard of 75 parts per billion. This standard is in addition to the existing, 3-hour SO<sub>2</sub> standard that is being retained at 0.5 parts per million. Both the 24-hour and annual NAAQS were revoked in the final SO<sub>2</sub> rule that was published on June 22, 2010; however, NAAQS compliance must continue to be evaluated for a period of one year after the issuance of the final SO<sub>2</sub> area designations became effective on October 4, 2013.

Both the 3-hour and 24-hour NAAQS are deterministically based standards that allow for one exceedance per year; unlike the annual standard which does not allow for any exceedances. The new 1-hour standard is a statistical standard that is based upon the three-year average of the 99<sup>th</sup> percentile of the annual distribution of daily maximum 1-hour average concentrations, refer to Table 1.

<b>Table 1 SO<sub>2</sub> NAAQS</b>			
<b>Pollutant</b>	<b>Averaging Time</b>	<b>NAAQS (<math>\mu\text{g}/\text{m}^3</math>)</b>	<b>Comment</b>
SO <sub>2</sub>	1-Hour	195.75 (75 parts per billion)	3-year average of the 99 <sup>th</sup> percentile of the annual distribution of the daily maximum 1-hour concentrations
SO <sub>2</sub>	3-Hour	1300	Not to be exceeded more than once per year
SO <sub>2</sub>	24-Hour	365	Not to be exceeded more than once per year
SO <sub>2</sub>	Annual	80	Not to be exceeded

If a facility is required to conduct an air quality analysis for SO<sub>2</sub>, the analysis must include the emissions from the proposed source, existing “interactive” sources and monitored background concentrations. The modeled emission rates must reflect the maximum allowable operating conditions for each source based upon federally enforceable emission limits and operating level(s).

For the annual averaging period, the maximum, annual concentration predicted by the dispersion model should be compared to the NAAQS of 80  $\mu\text{g}/\text{m}^3$ . Compliance with the 3-hour and 24-hour standards is demonstrated when the second highest concentration over the five year period under consideration is less than 1300 and 365  $\mu\text{g}/\text{m}^3$ , respectively.

Unlike the existing short term standards, in order to demonstrate compliance with the 1-hour NAAQS, the applicant must show that the 5-year average of the 99<sup>th</sup> percentile of the annual distribution of the daily maximum 1-hour concentrations is less than 75 parts per billion. It should be noted that the modeled compliance demonstration is based upon a five-year average, rather than the 3-year average noted in Table 1. The requirements within Section 1(c) (2) of Appendix S to 40 CFR Part 50 states that the 1-hour monitored design value should be based upon a 3-year average, as noted for the form of the



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standard. For modeling purposes, [Section 8.3.1.2 of Appendix W to Part 51](#) states “[T]he use of 5 years of NWS [National Weather Service] meteorological data or at least 1 year of site specific data is required.” The Environmental Protection Agency has indicated that the use of the five years of data does not result in biased model results and should be used for NAAQS compliance purposes, refer to the guidance document entitled “[Guidance Concerning the Implementation of the 1-hour SO<sub>2</sub> NAAQS for the Prevention of Significant Deterioration Program.](#)”

Based upon the form of the new 1-hour standard, the modeled design value is the five year average of the fourth highest, daily maximum, 1-hour concentrations. It should be noted that the Environmental Protection Agency has updated AERMOD to allow the user to more easily calculate the design value for the new 1-hour SO<sub>2</sub> standard through the use of additional model options in the output pathway.

If the predicted impact due to the proposed source, interactive sources and the monitored background value is below the NAAQS for each applicable averaging period, compliance has been demonstrated and no further analysis for NO<sub>2</sub> is necessary.

If, on the other hand, violations of the SO<sub>2</sub> NAAQS are predicted to occur at one or more receptors, the applicant will be required to determine if the proposed project or modification has a significant ambient impact. If the source can demonstrate that it does not have a significant impact on a violating receptor(s), measured in time and space, a permit can be issued without further review. If the source cannot demonstrate less than significant impacts, the facility must consider emission limits, the installation of controls or other measures in order to reduce its ambient impact at all violating receptors.

Unlike the 3-hour and the 24-hour averaging periods, the determination of significant impact for the 1-hour averaging period must consider the source’s impact for each instance where the cumulative impact exceeds the NAAQS at or below the 99<sup>th</sup> percentile. Because this analysis can become complicated, the Environmental Protection Agency developed an output option in the AERMOD system that compares the contribution from the proposed project to the cumulative impact at each receptor paired in time and space, MAXDCONT. If insignificant impacts are predicted to occur, in time and space, no further analysis for the 1-hour averaging period is necessary and the permit review can move forward.

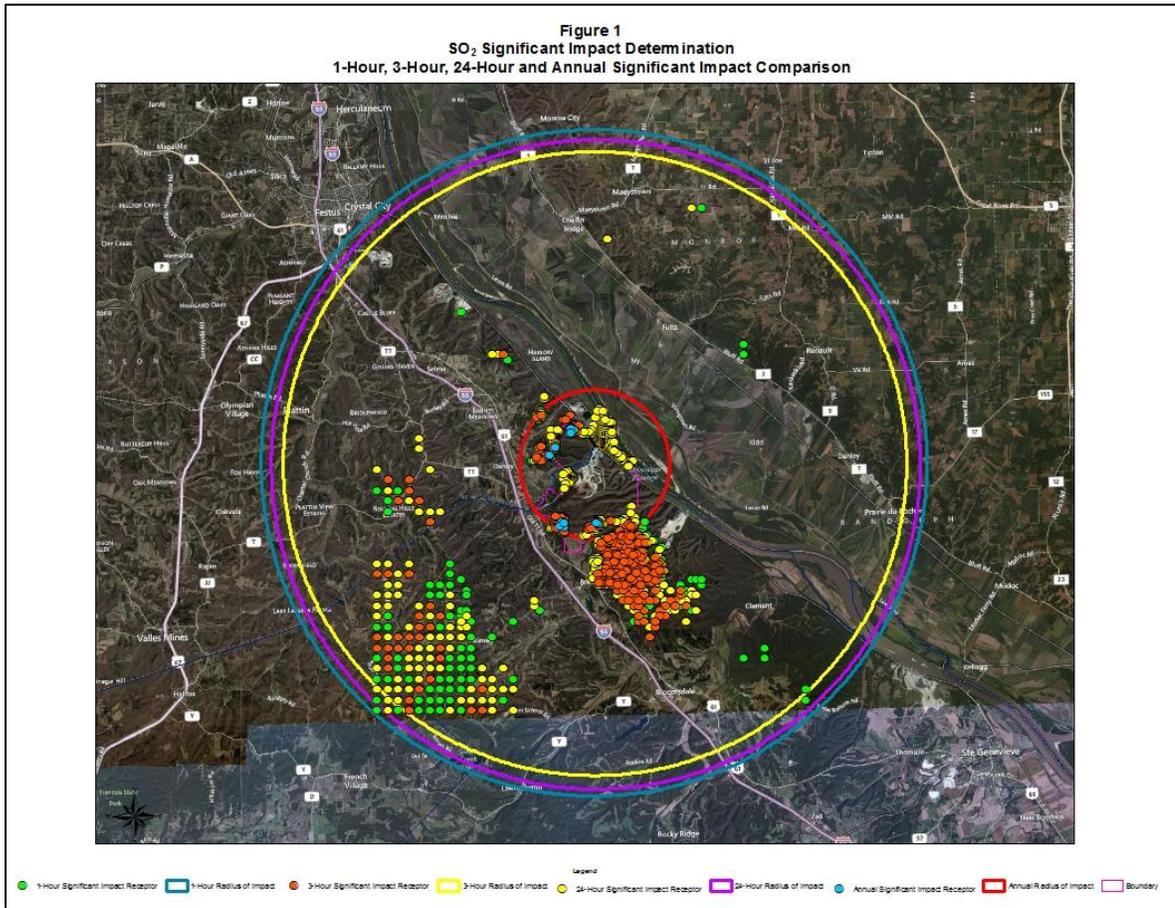
The following paragraphs provide a hypothetical example of a NAAQS evaluation for SO<sub>2</sub>. The data describes a basic situation and is not meant to address all modeling scenarios and/or issues that might arise during the review process.

#### **Example NAAQS Demonstration**

Facility A is proposing to install a coal-fired boiler at a greenfield site. Based upon the emissions from the worst case operating load, the preliminary impact analysis indicates that Facility A’s radius of impact extends 15.6-kilometers beyond the center of the proposed facility, refer to Figure 1.

Because the ambient impact due to the proposed construction exceeds the 1-hour, 3-hour, 24-hour and annual significant impact thresholds, a full impact analysis is required and must include an evaluation of compliance with the NAAQS.

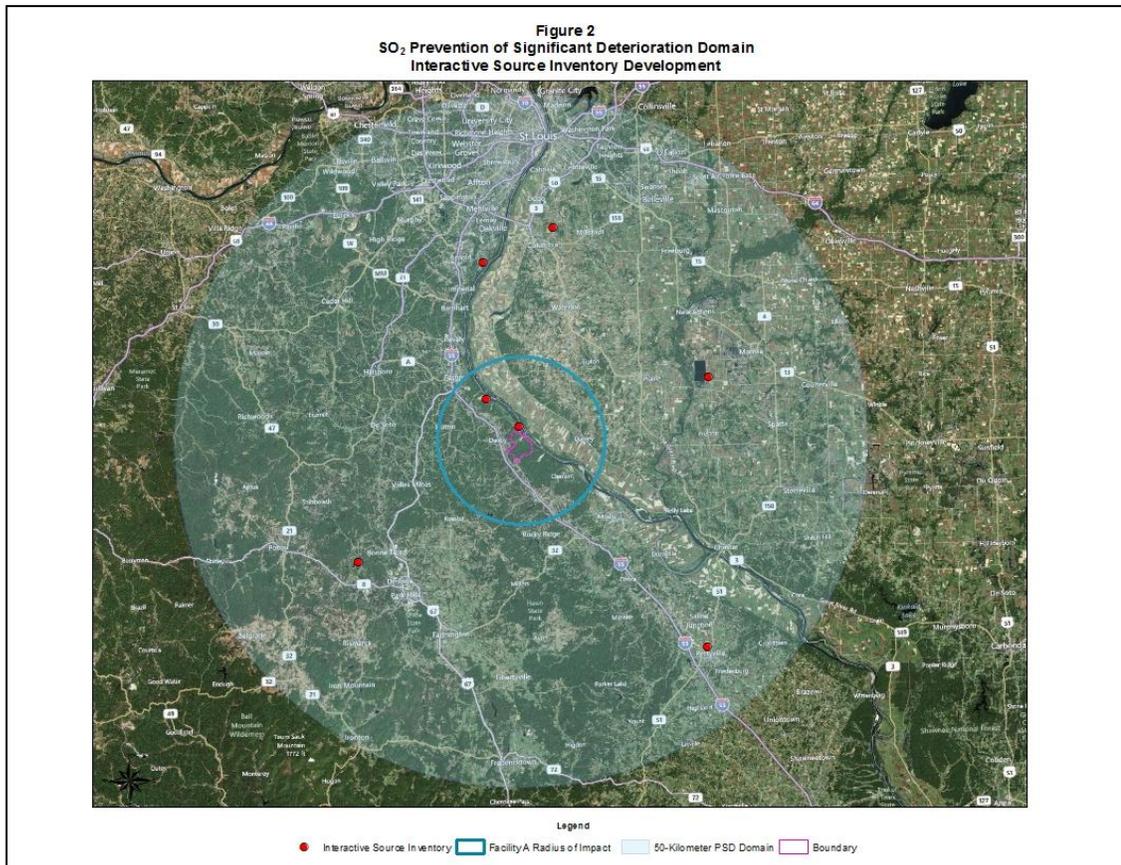
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As noted in the introduction, NAAQS compliance is based upon the impact due to the combination of the emissions from the proposed source, existing “interactive” sources and monitored background concentrations. In order to determine the impact due to the proposed source and interactive sources, the emissions from Facility A and existing SO<sub>2</sub> sources were explicitly modeled. The monitored background value was obtained from a representative monitoring site.

The radius of impact due to the proposed project determined what sources were explicitly modeled for compliance purposes. Facility A is undergoing a Prevention of Significant Deterioration (PSD) review and; as such, the air quality analysis considered any emission source that could significantly impact the air quality within the region of Facility A, i.e. 50-kilometers beyond the furthest extent of the significant impact area, refer to Figure 2.

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Emission rates and release parameters for each source within the inventory were input into the air quality model. The combined ambient impact due to the modeled sources were calculated and output on a receptor by receptor basis for use in the compliance demonstration. It is important to note that the model outputs do not include the monitored background concentration; this value must be added to the model predictions prior to determining compliance with the NAAQS. Table 2 contains the model outputs for a sampling of receptors that were evaluated for this example.



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Table 2 SO <sub>2</sub> NAAQS Compliance Determination											
1-Hour Averaging Period (NAAQS = 195.75 µg/m <sup>3</sup> )											
Easting (Meters)	Northing (Meters)	Elevation (Meters)	Hill (Meters)	2003 (µg/m <sup>3</sup> ) (Fourth)	2004 (µg/m <sup>3</sup> ) (Fourth)	2005 (µg/m <sup>3</sup> ) (Fourth)	2006 (µg/m <sup>3</sup> ) (Fourth)	2007 (µg/m <sup>3</sup> ) (Fourth)	5-Yr Average (µg/m <sup>3</sup> ) (Fourth)	Background (µg/m <sup>3</sup> ) (Monitored)	NAAQS (µg/m <sup>3</sup> ) (Fourth)
740600.00	4216100.00	221.68	256.53	175.85	141.26	202.83	210.66	195.25	185.17	16.00	201.17
736000.00	4209500.00	211.75	264.29	225.88	135.71	188.57	160.00	212.97	184.63	16.00	200.63
730000.00	4219500.00	217.26	237.88	133.60	193.94	207.73	207.82	175.55	183.73	16.00	199.73
734000.00	4212000.00	223.91	262.01	161.08	140.01	222.03	184.27	210.18	183.51	16.00	199.51
750500.00	4211000.00	219.38	227.29	143.11	201.06	230.75	127.82	212.79	183.11	16.00	199.11
735500.00	4213000.00	225.93	225.93	157.71	130.69	202.35	167.58	235.77	178.82	16.00	194.82
743400.00	4216500.00	227.79	227.79	179.23	124.24	181.60	191.32	214.60	178.20	16.00	194.20
3-Hour Averaging Period (NAAQS = 1300.00 µg/m <sup>3</sup> )											
Easting (Meters)	Northing (Meters)	Elevation (Meters)	Hill (Meters)	2003 (µg/m <sup>3</sup> ) (H2H)	2004 (µg/m <sup>3</sup> ) (H2H)	2005 (µg/m <sup>3</sup> ) (H2H)	2006 (µg/m <sup>3</sup> ) (H2H)	2007 (µg/m <sup>3</sup> ) (H2H)	2 <sup>nd</sup> High (µg/m <sup>3</sup> ) (H2H)	Background (µg/m <sup>3</sup> ) (Monitored)	NAAQS (µg/m <sup>3</sup> ) (H2H)
736500	4224600	142.97	178.22	710.5445	1326.871	982.8688	1001.854	1167.854	1326.871	20	1346.871
734000	4230500	119.47	215.52	1306.857	1143.88	1122.576	1160.534	1087.667	1306.857	20	1326.857
732000	4228000	161.6	213.63	325.1832	1283.438	541.7934	620.7989	446.3225	1283.438	20	1303.438
734750	4225750	154.93	178.28	338.6089	1277.693	1200.174	829.0852	364.9815	1277.693	20	1297.693
736300	4224700	148	177.83	260.8049	1118.494	894.0372	1273.523	1059.191	1273.523	20	1293.523
738400	4224400	144.14	221.61	399.5267	941.2688	1263.832	1041.944	826.4292	1263.832	20	1283.832
733500	4228500	169.76	250.63	1256.374	730.2394	835.6376	724.0187	895.0649	1256.374	20	1276.374
24-Hour Averaging Period (NAAQS = 365.00 µg/m <sup>3</sup> )											
Easting (Meters)	Northing (Meters)	Elevation (Meters)	Hill (Meters)	2003 (µg/m <sup>3</sup> ) (H2H)	2004 (µg/m <sup>3</sup> ) (H2H)	2005 (µg/m <sup>3</sup> ) (H2H)	2006 (µg/m <sup>3</sup> ) (H2H)	2007 (µg/m <sup>3</sup> ) (H2H)	2 <sup>nd</sup> High (µg/m <sup>3</sup> ) (H2H)	Background (µg/m <sup>3</sup> ) (Monitored)	NAAQS (µg/m <sup>3</sup> ) (H2H)
733000	4230500	115.12	219.05	273.565	234.9758	293.6315	200.0028	379.5032	379.5032	10	389.5032
731000	4227500	148.27	163.98	128.7416	189.2691	367.0073	206.4564	336.5694	367.0073	10	377.0073
734000	4230500	119.47	215.52	340.5528	320.7333	272.4852	292.4935	347.2039	347.2039	10	357.2039
731000	4229000	138.48	191.08	250.5889	221.3721	344.8047	286.7255	301.7097	344.8047	10	354.8047
731500	4229500	136.87	208.49	268.192	283.1724	328.9346	296.4578	304.991	328.9346	10	338.9346
734000	4227500	138.89	209.92	315.3038	229.922	267.4879	180.1948	229.3696	315.3038	10	325.3038
733500	4228500	169.76	250.63	271.2274	228.1864	300.3058	194.9318	236.0701	300.3058	10	310.3058
Annual Averaging Period (NAAQS = 80.00 µg/m <sup>3</sup> )											
Easting (Meters)	Northing (Meters)	Elevation (Meters)	Hill (Meters)	2003 (µg/m <sup>3</sup> ) (H1H)	2004 (µg/m <sup>3</sup> ) (H1H)	2005 (µg/m <sup>3</sup> ) (H1H)	2006 (µg/m <sup>3</sup> ) (H1H)	2007 (µg/m <sup>3</sup> ) (H1H)	Max (µg/m <sup>3</sup> ) (H1H)	Background (µg/m <sup>3</sup> ) (Monitored)	NAAQS (µg/m <sup>3</sup> ) (H1H)
734000	4229500	114.4	250.63	65.96769	82.418	89.48804	78.59625	79.48997	89.48804	3	92.48804
732500	4229000	148.56	208.98	22.61656	56.92957	66.55613	50.60294	48.12312	66.55613	3	69.55613
734000	4230000	114.29	250.63	55.70069	53.29164	62.25663	52.94081	61.28596	62.25663	3	65.25663
731000	4230000	149.75	257.81	11.86281	25.90944	42.67803	25.00151	23.00302	42.67803	3	45.67803
732500	4228500	139.64	213.81	38.69583	25.00575	39.11903	24.88653	42.61016	42.61016	3	45.61016
733000	4229000	125.3	250.63	39.30284	26.35946	40.738	39.02798	40.42813	40.738	3	43.738
734500	4229500	114.29	250.63	38.75287	31.05034	31.56057	34.05512	38.87486	38.87486	3	41.87486

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The first four columns contain information regarding the location of the receptor under review, followed by the predicted concentration from the dispersion model for each year under consideration. For the 1-hour averaging period, the fourth highest, 1-hour value for each year was determined and averaged across the five year period in order to calculate the predicted design value. Prior to comparing the modeled design value to the NAAQS, a monitored background number was added to the five year average. This sum represents the total concentration that should be compared to the NAAQS. Based upon the results contained within Table 2 for the 1-hour averaging period five receptors violate the 1-hour NAAQS.

To determine compliance with the 3-hour and 24-hour standards, the second highest concentration for each year was determined on a receptor by receptor basis. The maximum, second high value that was predicted across the five year period was added to the monitored background number and compared to the NAAQS of 1300 and 365  $\mu\text{g}/\text{m}^3$ , respectively. According to Table 2, a combined total of four receptors exceed the 3-hour and 24-hour NAAQS.

For the annual averaging period, the maximum concentration for the five year period was obtained and added to the monitored background number. The sum represents the total concentration that should be compared to the NAAQS in order to determine compliance. Based upon the results contained within Table 2, one receptor exceeds the NAAQS of 80  $\mu\text{g}/\text{m}^3$ .

Because NAAQS violations are predicted to occur, the applicant must determine if Facility A has a significant impact on a violating receptor, refer to Table 3.

Table 3					
SO <sub>2</sub> NAAQS Violations vs. Significant Impact					
1-Hour NAAQS (195.75 $\mu\text{g}/\text{m}^3$ ) vs. Significance (7.83 $\mu\text{g}/\text{m}^3$ )					
Easting (Meters)	Northing (Meters)	Elevation (Meters)	Hill (Meters)	NAAQS ( $\mu\text{g}/\text{m}^3$ ) (Eighth High)	Significant Impact Concentration ( $\mu\text{g}/\text{m}^3$ ) (H1H)
740600.00	4216100.00	221.68	256.53	201.17	14.86
736000.00	4209500.00	211.75	264.29	200.63	4.24
730000.00	4219500.00	217.26	237.88	199.73	6.92
734000.00	4212000.00	223.91	262.01	199.51	6.42
750500.00	4211000.00	219.38	227.29	199.11	5.45
3-Hour Averaging Period (NAAQS = 1300.00 $\mu\text{g}/\text{m}^3$ ) vs. Significance (25.0 $\mu\text{g}/\text{m}^3$ )					
Easting (Meters)	Northing (Meters)	Elevation (Meters)	Hill (Meters)	NAAQS ( $\mu\text{g}/\text{m}^3$ ) (H2H)	Significant Impact Concentration ( $\mu\text{g}/\text{m}^3$ ) (H1H)
736500	4224600	142.97	178.22	1346.871	18.04297
734000	4230500	119.47	215.52	1326.857	10.14407
24-Hour Averaging Period (NAAQS = 365.00 $\mu\text{g}/\text{m}^3$ ) vs. Significance (5.0 $\mu\text{g}/\text{m}^3$ )					
Easting (Meters)	Northing (Meters)	Elevation (Meters)	Hill (Meters)	NAAQS ( $\mu\text{g}/\text{m}^3$ ) (H2H)	Significant Impact Concentration ( $\mu\text{g}/\text{m}^3$ ) (H1H)
733000	4230500	115.12	219.05	389.5032	1.42036
731000	4227500	148.27	163.98	377.0073	5.15831

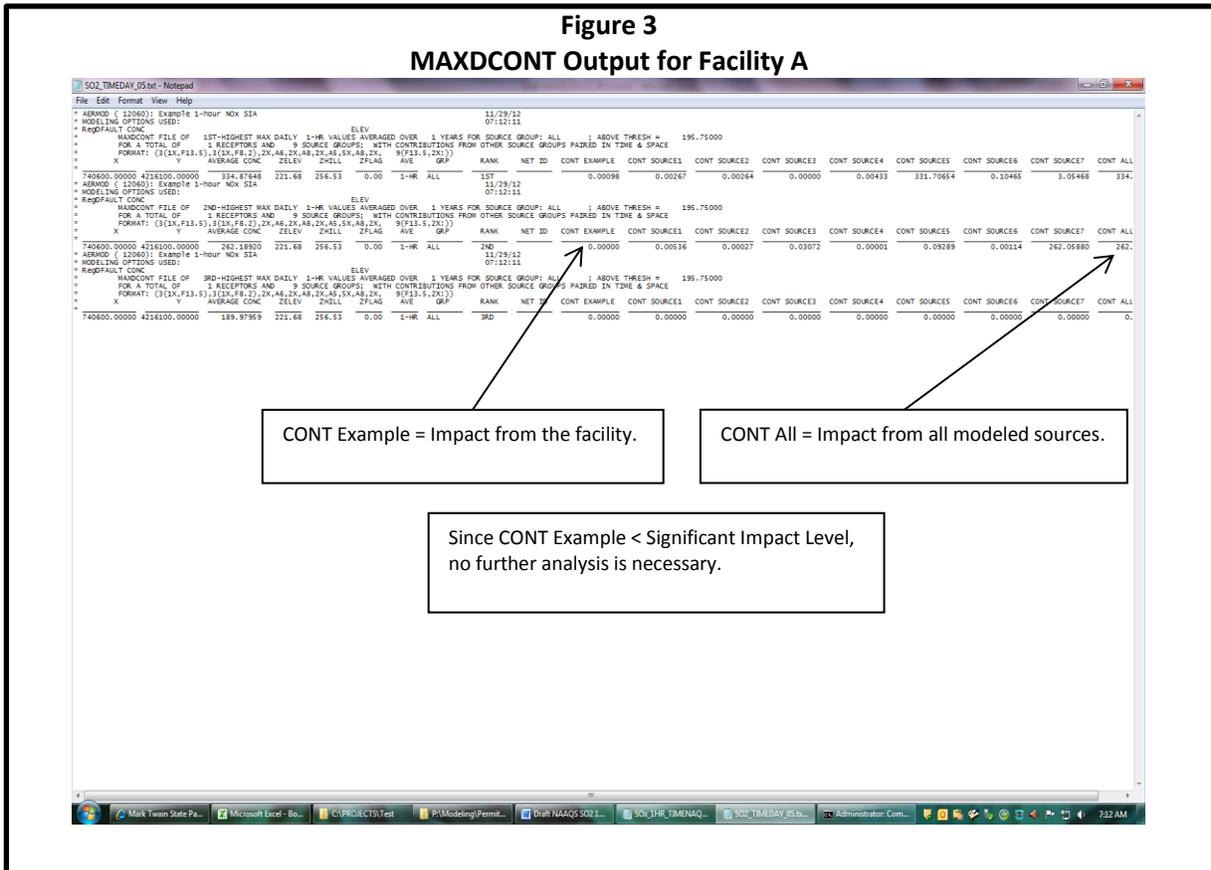


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Annual NAAQS (80.0 µg/m <sup>3</sup> ) vs. Significance (1.0 µg/m <sup>3</sup> )					
Easting	Northing	Elevation	Hill	NAAQS	Significant Impact Concentration
(Meters)	(Meters)	(Meters)	(Meters)	(µg/m <sup>3</sup> )	(µg/m <sup>3</sup> )
				(H1H)	(H1H)
734000	4229500	114.4	250.63	92.48804	0.09185

For the 1-hour and 24-hour averaging periods, Facility A had a significant impact on a portion of the violating receptors; as such, Facility A's compliance with the 1-hour and 24-hour NAAQS has not been demonstrated and additional review is necessary.

In order to demonstrate that a significant impact does not occur at the same time as a violation on a 1-hour basis, the applicant must rank the ambient concentrations from the proposed project and from the NAAQS sources. AERMOD has the capability to rank values from the daily maximum 1-hour concentrations in order to determine significant contributions through the use of the MAXDCONT keyword in the output pathway of the input run script. Figure 3 displays the results from the MAXDCONT analysis. If the facility has a significant impact, in time and space, consideration of additional control measures would have to be made at this juncture.



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The MAXDCONT file contains information on each violating receptor, the concentration that is predicted to occur based upon rank and the contribution from each source group specified in the source pathway of the input run script. If the impact from the proposed project, EXAMPLE in this case, is less than the significant impact level, no further analysis is necessary. Based upon the space and time comparison, for the 1-hour averaging period, Facility A did not have a significant impact at the same time that a violation occurred. Compliance with the 1-hour standard has been demonstrated.

Lastly, as noted above, one receptor from the 24-hour averaging period resulted in a significant impact on a violating receptor. The time of day analysis that is conducted for the 24-hour averaging period is less complex than the analysis that is conducted for the 1-hour averaging period in that it only requires the applicant to determine the ambient concentration for each 24-hour period in the year due to the proposed project (significance analysis) and due to all sources (NAAQS analysis) rather than ranked values based upon a percentile. Table 4 contains sample output from a time of day evaluation.

Table 4 SO <sub>2</sub> 24-Hour Time of Day Evaluation								
Easting	Northing	Elevation	Hill	First High Modeled NAAQS Concentration	Background	NAAQS	Significant Impact Concentration	Date
<i>(Meters)</i>	<i>(Meters)</i>	<i>(Meters)</i>	<i>(Meters)</i>	<i>(µg/m<sup>3</sup>)</i>	<i>(µg/m<sup>3</sup>)</i>	<i>(µg/m<sup>3</sup>)</i>	<i>(µg/m<sup>3</sup>)</i>	<i>(YYMMDDHH)</i>
738185.2	4221700	219.33	226.32	402.92	10	412.92	0.20479	05010124
738185.2	4221700	219.33	226.32	102.33	10	112.33	0.08929	05010224
738185.2	4221700	219.33	226.32	0.154	10	10.154	0.07594	05010324
738185.2	4221700	219.33	226.32	15.546	10	25.546	1.20991	05010424
738185.2	4221700	219.33	226.32	208.02	10	218.02	2.26021	05010524

Based upon the time of day evaluation, Facility A did not have a significant impact at the same time that a violation occurred; as such, no further analysis is necessary and NAAQS compliance has for Facility A has been demonstrated.