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Subject: Air Quality Analysis Using Sulfur Dioxide (SO_2) Air Quality Data

This document was prepared by staff from the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency. Questions related to this document should be addressed to U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, C439-02, Research Triangle Park, North Carolina 27711 (email: oaqpseconomics@epa.gov).

Introduction

The EPA is proposing to revise the secondary sulfur dioxide (SO_2) national ambient air quality standards (NAAQS) (see Table 1 for a summary of the current primary 1-hour SO_2 and secondary 3-hour SO_2 NAAQS, as well as the proposed secondary annual SO_2 NAAQS). This memorandum presents an air quality analysis the EPA prepared using SO_2 air quality data from the Agency's air quality system (AQS). Based on the analysis, we estimate no additional emissions reductions would be needed, at any monitor sites, to meet the proposed secondary annual SO_2 NAAQS after the sites record concentrations that meet the current primary SO_2 NAAQS.

Table 1. Current Primary and Proposed Secondary SO_2 NAAQS

	Level	Averaging Time, Form
Current Primary SO_2	75 ppb	1 hour, annual 99th percentile of daily maximum 1-hour concentrations, averaged over 3 years
Current Secondary SO_2	0.5 ppm (500 ppb)	3 hours, not to be exceeded more than once per year
Proposed Secondary SO_2	10-15 ppb	1 year, annual mean, averaged over 3 years

The remainder of this memorandum provides background information, a description of the analysis, and overall conclusions from the analysis.

Background

When the EPA reviews and proposes to revise a NAAQS, many areas are continuing to implement an existing, or current, NAAQS. In analyzing a proposed revision, to avoid double counting potential emissions reductions, costs, and benefits associated with meeting a current NAAQS, we assume areas meet the current standards, even if areas have not fully implemented necessary programs and policies to meet those NAAQS. Then, for a revision we estimate whether any additional emissions reductions would be needed to meet a revised NAAQS beyond the *baseline* levels reflecting assumed compliance with current NAAQS.

To assess whether any additional emissions reductions might be needed to meet the proposed secondary annual SO_2 NAAQS of 10-15 ppb, we prepared an air quality analysis for all monitor sites with SO_2 data in AQS.[1] We used certified AQS data from 2017 through 2022, where available. For monitors with 1-hour DVs below 75 ppb, the estimated 3-year annual average values for the most recent design value (DV) period for each monitor ranged from 0.01 ppb to 4.39 ppb, with 99.5 percent below 3 ppb.[2] For these monitors, no emissions reductions would be needed to meet either the current primary and secondary SO_2 standards or the proposed SO_2 annual secondary

[1] For this analysis, we did not include monitoring sites located in Hawaii since our focus was on anthropogenic emissions and potential costs or benefits associated with reductions in those emissions. Yet, had we included those sites with the contribution of nonanthropogenic volcanic emissions, our results and overall conclusions would not have changed.

[2] Where possible, this summary reflects the estimated 3-year annual average value for the most recent DV period (2020-2022). If there was incomplete data for a monitor, we included the estimated 3-year annual average value for the most recent DV period for which complete data was available.

standard. Also, during this period, and excluding the monitoring sites in Hawaii, there were no monitors that had violations of the current SO_2 secondary standard.

There are 21 monitor sites with DVs above 75 ppb for the average of the four most recent DV periods (2017-2019 to 2020-2022) or for the most recent DV period (2020-2022). We focused additional analysis on the monitors with DVs above 75 ppb and manually adjusted, or *rolled back*, the DVs at those monitors to reflect meeting the current primary 1-hour SO_2 NAAQS.[3] This approach simulates how an annual average value might change in response to emissions reductions needed to meet the current 1-hour primary standard. To reflect the relationship between the air quality concentrations associated with the current primary and proposed secondary standards, we calculated *peak-to-mean* ratios for each monitor site for each relevant DV period and then calculated an average of those ratios for each site.[4]

We applied the *average* ratio for each site to the *rolled back*, current primary 1-hour SO_2 NAAQS of 75 ppb or to a mean 1-hour DV to estimate the site-specific 3-year annual average value associated with the proposed secondary annual SO_2 NAAQS. For each site, we compared the estimated site-specific 3-year annual average value to the proposed secondary annual SO_2 NAAQS range of 10-15 ppb; the estimated values at all monitor sites analyzed are well below the proposed range. A more detailed description of the analysis is below.

Description of Air Quality Analysis and Results

We reviewed historical SO_2 concentrations in AQS to assess how the ratio of the 1-hour DV to the 3-year annual average value associated with the proposed secondary annual SO_2 NAAQS changed over time. Because SO_2 concentrations have generally decreased over time and we want to reflect concentrations that are representative of recent years, we chose to focus this analysis on the last four DV periods when the ratios appear to stabilize. Specifically, for this analysis we examined data for the following DV periods: 2017-2019, 2018-2020, 2019-2021, and 2020-2022.

For each monitor site with either (i) an average DV above 75 ppb for the four most recent DV periods (2017-2019 to 2020-2022) or (ii) a DV above 75 ppb for the most recent DV period (i.e., 2020-2022)[5,6] (see Table 2), we calculated a *peak-to-mean* ratio for each DV period (1-hour DV/3-year annual average value based on the proposed secondary annual SO_2 NAAQS) from 2017 to 2022 (by monitor, Table 3 shows the 3-year annual average values for each DV period that were used to calculate the *peak-to-mean* ratios, and Table 4 includes the *peak-to-mean* ratios for each DV period). We then calculated an average of those ratios for each monitor site (see Table 5). For 19 monitor sites with an average DV above 75 ppb for the four most recent DV periods, we applied the *average* ratio to a *rolled back* 1-hour DV of 75 ppb to estimate what the 3-year annual average value would be after *rolling back* the 1-hour DV. Effectively, the calculation is 75 divided by the site-specific *average* ratio. For two monitor sites with a 1-hour DV above 75 ppb for the most recent DV period (2020-2022), we applied the *average* ratio to the mean, or average, 1-hour DV over that period. In addition, for those two monitors we also applied the *average* ratio to the DVs for the most recent DV period; those estimated 3-year annual average values were 2.5833 and 2.7449, respectively. For all 21 monitors, see Table 5 for the estimated 3-year annual average values.

Among all the monitor sites, the highest 3-year annual average concentration was 5.25 ppb, which would round to 5 ppb, well below the proposed range of 10-15 ppb.

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[3] For monitors with DVs slightly under 75 ppb, we did not find any that have *peak-to-mean* ratios that would result in estimated 3-year annual average values above the proposed secondary annual SO_2 NAAQS range of 10-15 ppb.

[4] A *peak-to-mean* ratio describes the relationship between a "peak" statistic (or high value) versus a "mean" statistic (or average value). In the context of this analysis, the peak statistic is the 3-year average of the 99th percentile of daily maximum 1-hour values (the design value for the current primary 1-hour SO_2 NAAQS), and the mean statistic is the 3-year annual average value (which is associated with the proposed secondary annual SO_2 NAAQS). The peak-to-mean ratio is simply the peak statistic divided by the mean statistic.

[5] We computed an average 1-hour DV for each monitor site to incorporate any additional monitors with relatively high DVs in more recent years that were not above 75 ppb in the most recent DV period.

[6] Several monitors have an average DV above 75 ppb for the four most recent DV periods and a DV above 75 ppb for the most recent DV period.

Conclusions

For monitors with 1-hour DVs below 75 ppb, the estimated 3-year annual average values for those sites ranged from 0.01 ppb to 4.39 ppb, with 99.5 percent below 3 ppb. For these monitors, no emissions reductions would be needed to meet either the current primary and secondary SO_2 standards, the proposed SO_2 annual secondary standard of 10-15 ppb, or an annual secondary SO_2 standard with a level within the range of 5-10 ppb. The additional air quality analysis demonstrates that monitor sites either with DVs above 75 ppb for the average of the four most recent DV periods or for the most recent DV period are estimated to meet a proposed secondary annual SO_2 NAAQS as low as 5 ppb, after simulating emissions reductions needed to meet the current primary standard. As such, no additional emissions reductions beyond any needed to meet the current primary 1-hour SO_2 NAAQS would be expected to be necessary to meet the proposed secondary annual SO_2 NAAQS of 10-15 ppb or an annual secondary SO_2 standard with a level within the range of 5-10 ppb, resulting in no costs or benefits associated with pollution controls for this proposed NAAQS revision, if finalized.

Further, as no revisions are proposed to the standards for nitrogen dioxide (NO_2) or particulate matter with mass median aerodynamic diameter less than 2.5 microns ($PM_{2.5}$), EPA did not prepare a regulatory impact analysis or analysis of the potential need for emissions reductions for those pollutants. We observe, however, that the conclusion of no additional emissions reductions beyond any needed to meet the existing primary SO_2 NAAQS is also true for the standard ranges for the secondary NO_2 and $PM_{2.5}$ standards on which we are soliciting comment. As presented in Figure 7-9 of the *Policy Assessment for the Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen, Oxides of Sulfur and Particulate Matter*, 3-year average annual average NO_2 concentrations in recent years (e.g., since 2017) at monitors across the U.S. are below 35 ppb (we are soliciting comment on the range of 35-40 ppb). Also, sites with $PM_{2.5}$ concentrations that meet the newly revised annual $PM_{2.5}$ primary standard (of 9 $\mu g/m^3$) or the prior primary standard (12 $\mu g/m^3$) will have 3-year annual average $PM_{2.5}$ concentrations at or below 12 $\mu g/m^3$.

Table 2. By Monitor Site, SO_2 1-hour DVs for DV Periods 2017-2019, 2018-2020, 2019-2021, and 2020-2022 and Mean 1-hour DV

AQS ID	EPA Region	County	City	AQS CBSA Name/State	SO2 1 hr DV 2017-2019	SO2 1 hr DV 2018-2020	SO2 1 hr DV 2019-2021	SO2 1 hr DV 2020-2022	Mean 1 hr DV, 2017-2022
Mean 1 hr DV, 2017-2022 > 75 ppb									
04-007-0011	09	Gila	Not in a City	Payson, AZ	172	105	90	63	107.50
04-007-0012	09	Gila	Miami	Payson, AZ	111	87	56	50	76.00
04-007-1001	09	Gila	Hayden	Payson, AZ	226	134	65	3	107.00
21-101-1011	04	Henderson	Not in a City	Evansville, IN-KY	98	91	80	71	85.00
24-001-8881	03	Allegany	Westernport	Cumberland, MD-WV	89				89.00
24-001-8882	03	Allegany	Westernport	Cumberland, MD-WV	156				156.00
29-143-9001	07	New Madrid	Not in a City	MO	202	320	376	417	328.75
29-143-9002	07	New Madrid	Not in a City	MO	268	361	333	291	313.25
36-089-0004	02	St. Lawrence	Not in a City	Ogdensburg-Massena, NY	86	86	88	86	86.50
37-087-0013	04	Haywood	West Canton	Asheville, NC	152	90	36	37	78.75
42-003-0064	03	Allegheny	Liberty	Pittsburgh, PA	109	85	59	56	77.25
47-163-6003	04	Sullivan	Kingsport	Kingsport-Bristol-Bristol, TN-VA			87	71	79.00
48-227-1072	06	Howard	Big Spring	Big Spring, TX	89	93			91.00
48-233-1073	06	Hutchinson	Borger	Borger, TX	209	185	183	163	185.00
48-349-1081	06	Navarro	Richland	Corsicana, TX	165	172	159	115	152.75
48-375-1077	06	Potter	Amarillo	Amarillo, TX	114	107	104	125	112.50
48-401-1082	06	Rusk	Tatum	Longview, TX		103	93	81	92.33
51-071-0007	03	Giles	Not in a City	Blacksburg-Christiansburg-Radford, VA	203	97	107	101	127.00
54-057-8883	03	Mineral	Keyser	Cumberland, MD-WV	175				175.00
At least one 1 hr DV from 2017-2019, 2018-2020, 2019-2021, or 2020-2022 > 75 ppb									
26-147-0005	05	St. Clair	Port Huron	Detroit-Warren-Dearborn, MI	67	74	70	85	74.00
29-143-9003	07	New Madrid	Not in a City	MO	47	68	83	95	73.25

Table 3. By Monitor Site, SO_2 3-year Annual Average Values for DV Periods 2017-2019, 2018-2020, 2019-2021, and 2020-2022

AQS ID	EPA Region	County	City	AQS CBSA Name/State	SO2 3-yr Annual Average Value 2017-2019	SO2 3-yr Annual Average Value 2018-2020	SO2 3-yr Annual Average Value 2019-2021	SO2 3-yr Annual Average Value 2020-2022
Mean 1 hr DV, 2017-2022 > 75 ppb								
04-007-0011	09	Gila	Not in a City	Payson, AZ	2.41	2.03	1.83	1.66
04-007-0012	09	Gila	Miami	Payson, AZ	1.61	1.61	1.36	1.32
04-007-1001	09	Gila	Hayden	Payson, AZ	7.06	4.54	2.18	0.71
21-101-1011	04	Henderson	Not in a City	Evansville, IN-KY	2.20	1.93	1.50	1.36
24-001-8881	03	Allegany	Westernport	Cumberland, MD-WV	1.17	1.22	1.16	
24-001-8882	03	Allegany	Westernport	Cumberland, MD-WV	2.76	2.43	1.82	
29-143-9001	07	New Madrid	Not in a City	MO	12.14	19.72	30.11	35.35
29-143-9002	07	New Madrid	Not in a City	MO	11.10	16.12	17.31	15.68
36-089-0004	02	St. Lawrence	Not in a City	Ogdensburg-Massena, NY	4.39	3.92	3.80	3.51
37-087-0013	04	Haywood	West Canton	Asheville, NC	3.83	2.28	0.80	0.92
42-003-0064	03	Allegheny	Liberty	Pittsburgh, PA	4.19	3.42	3.05	2.77
47-163-6003	04	Sullivan	Kingsport	Kingsport-Bristol-Bristol, TN-VA	3.24	2.65	2.61	2.22
48-227-1072	06	Howard	Big Spring	Big Spring, TX	3.83	3.82	3.96	6.46
48-233-1073	06	Hutchinson	Borger	Borger, TX	7.18	6.55	6.31	5.13
48-349-1081	06	Navarro	Richland	Corsicana, TX	2.09	2.04	2.11	2.16
48-375-1077	06	Potter	Amarillo	Amarillo, TX	2.52	2.36	2.29	2.56
48-401-1082	06	Rusk	Tatum	Longview, TX	2.35	2.13	2.07	1.78
51-071-0007	03	Giles	Not in a City	Blacksburg-Christiansburg-Radford, VA	2.60	3.27	3.42	3.25
54-057-8883	03	Mineral	Keyser	Cumberland, MD-WV	2.81	2.81	2.50	
At least one 1 hr DV from 2017-2019, 2018-2020, 2019-2021, or 2020-2022 > 75 ppb								
26-147-0005	05	St. Clair	Port Huron	Detroit-Warren-Dearborn, MI	2.37	2.30	2.20	2.16
29-143-9003	07	New Madrid	Not in a City	MO	1.52	2.15	2.40	2.30

Table 4. By Monitor Site, Ratios of 1-hour DVs to 3-year Annual Average Values for DV Periods 2017-2019, 2018-2020, 2019-2021, and 2020-2022

AQS ID	EPA Region	County	City	AQS CBSA Name/State	Ratio of 1 hr DV to 3-yr Annual Average Value, 2017-2019	Ratio of 1 hr DV to 3-yr Annual Average Value, 2018-2020	Ratio of 1 hr DV to 3-yr Annual Average Value, 2019-2021	Ratio of 1 hr DV to 3-yr Annual Average Value, 2020-2022
Mean 1 hr DV, 2017-2022 > 75 ppb								
04-007-0011	09	Gila	Not in a City	Payson, AZ	71.37	51.72	49.18	37.95
04-007-0012	09	Gila	Miami	Payson, AZ	68.94	54.04	41.18	37.88
04-007-1001	09	Gila	Hayden	Payson, AZ	32.01	29.52	29.82	4.23
21-101-1011	04	Henderson	Not in a City	Evansville, IN-KY	44.55	47.15	53.33	52.21
24-001-8881	03	Allegany	Westernport	Cumberland, MD-WV	76.07			
24-001-8882	03	Allegany	Westernport	Cumberland, MD-WV	56.52			
29-143-9001	07	New Madrid	Not in a City	MO	16.64	16.23	12.49	11.80
29-143-9002	07	New Madrid	Not in a City	MO	24.14	22.39	19.24	18.56
36-089-0004	02	St. Lawrence	Not in a City	Ogdensburg-Massena, NY	19.59	21.94	23.16	24.50
37-087-0013	04	Haywood	West Canton	Asheville, NC	39.69	39.47	45.00	40.22
42-003-0064	03	Allegheny	Liberty	Pittsburgh, PA	26.01	24.85	19.34	20.22
47-163-6003	04	Sullivan	Kingsport	Kingsport-Bristol-Bristol, TN-VA			33.33	31.98
48-227-1072	06	Howard	Big Spring	Big Spring, TX	23.24	24.35		
48-233-1073	06	Hutchinson	Borger	Borger, TX	29.11	28.24	29.00	31.77
48-349-1081	06	Navarro	Richland	Corsicana, TX	78.95	84.31	75.36	53.24
48-375-1077	06	Potter	Amarillo	Amarillo, TX	45.24	45.34	45.41	48.83
48-401-1082	06	Rusk	Tatum	Longview, TX		48.36	44.93	45.51
51-071-0007	03	Giles	Not in a City	Blacksburg-Christiansburg-Radford, VA	78.08	29.66	31.29	31.08
54-057-8883	03	Mineral	Keyser	Cumberland, MD-WV	62.28			
At least one 1 hr DV from 2017-2019, 2018-2020, 2019-2021, or 2020-2022 > 75 ppb								
26-147-0005	05	St. Clair	Port Huron	Detroit-Warren-Dearborn, MI	28.27	32.17	31.82	39.35
29-143-9003	07	New Madrid	Not in a City	MO	30.92	31.63	34.58	41.30

Table 5. By Monitor Site, Average Ratios of 1-hour DVs to 3-year Annual Average Values and Estimated 3-year Annual Average Values after Rollback

AQS ID	EPA Region	County	City	AQS CBSA Name/State	Average Ratio (1 hr DV/3-yr Annual Average Value), 2017-2022	Rollback of Mean 1 hr DV, 2017-2022 to 75 ppb	After Rollback of Mean 1 hr DV to 75 ppb, Estimated 3-yr Annual Average Value
Mean 1 hr DV, 2017-2022 > 75 ppb							
04-007-0011	09	Gila	Not in a City	Payson, AZ	52.5564	75	1.43
04-007-0012	09	Gila	Miami	Payson, AZ	50.5092	75	1.48
04-007-1001	09	Gila	Hayden	Payson, AZ	23.8922	75	3.14
21-101-1011	04	Henderson	Not in a City	Evansville, IN-KY	49.3087	75	1.52
24-001-8881	03	Allegany	Westernport	Cumberland, MD-WV	76.0684	75	0.99
24-001-8882	03	Allegany	Westernport	Cumberland, MD-WV	56.5217	75	1.33
29-143-9001	07	New Madrid	Not in a City	MO	14.2876	75	5.25
29-143-9002	07	New Madrid	Not in a City	MO	21.0837	75	3.56
36-089-0004	02	St. Lawrence	Not in a City	Ogdensburg-Massena, NY	22.2970	75	3.36
37-087-0013	04	Haywood	West Canton	Asheville, NC	41.0944	75	1.83
42-003-0064	03	Allegheny	Liberty	Pittsburgh, PA	22.6072	75	3.32
47-163-6003	04	Sullivan	Kingsport	Kingsport-Bristol-Bristol, TN-VA	32.6577	75	2.30
48-227-1072	06	Howard	Big Spring	Big Spring, TX	23.7916	75	3.15
48-233-1073	06	Hutchinson	Borger	Borger, TX	29.5321	75	2.54
48-349-1081	06	Navarro	Richland	Corsicana, TX	72.9643	75	1.03
48-375-1077	06	Potter	Amarillo	Amarillo, TX	46.2050	75	1.62
48-401-1082	06	Rusk	Tatum	Longview, TX	46.2633	75	1.62
51-071-0007	03	Giles	Not in a City	Blacksburg-Christiansburg-Radford, VA	42.5260	75	1.76
54-057-8883	03	Mineral	Keyser	Cumberland, MD-WV	62.2776	75	1.20
At least one 1 hr DV from 2017-2019, 2018-2020, 2019-2021, or 2020-2022 > 75 ppb							
26-147-0005	05	St. Clair	Port Huron	Detroit-Warren-Dearborn, MI	32.9035	74.00	2.25
29-143-9003	07	New Madrid	Not in a City	MO	34.6092	73.25	2.12