Appendix G

Precursor Demonstration

San Joaquin Valley Air Pollution Control District
2018 PM2.5 SIP

Precursor Demonstrations for Ammonia, SOx, and ROG

Appendix: Precursor Demonstrations for Ammonia, SOx, and ROG
San Joaquin Valley PM2.5 SIP

INTRODUCTION

Fine particulate matter ($PM_{2.5}$) is made up of many constituent particles that are either directly emitted, such as soot and dust, or formed through complex reactions of gases in the atmosphere. Oxides of nitrogen (NOx), sulfur dioxide (SO_2), volatile organic compounds (VOCs), and ammonia (NH_3) are gases that are precursors to $PM_{2.5}$, transforming into particles through physical and chemical atmospheric processes.

The United States Environmental Protection Agency (U.S. EPA) finalized a $PM_{2.5}$ State Implementation Plan (SIP) Requirements Rule[1] (Rule) that identifies the four $PM_{2.5}$ precursor pollutants—NOx, SO_2, VOCs, and ammonia—that "must be evaluated for potential control measures in any $PM_{2.5}$ attainment plan."[2] The Rule permits air agencies to "submit an optional precursor demonstration designed to show that for a specific $PM_{2.5}$ nonattainment area, emissions of a particular precursor from sources within the nonattainment area do not or would not contribute significantly to $PM_{2.5}$ levels that exceed" the National Ambient Air Quality Standards (NAAQS).[3] If the agency's demonstration is approved by U.S. EPA, the attainment plan "may exclude that precursor from certain control requirements under the Clean Air Act."[4]

This appendix includes precursor demonstrations for three $PM_{2.5}$ precursors: ammonia, oxides of sulfur (SOx), and reactive organic gases (ROG). The California Air Resources Board (CARB) inventory tracks SOx rather than SO_2 specifically, but SOx consists mostly of SO_2. ROG is similar, although not identical, to U.S. EPA's term "VOC."[5] CARB's inventory tracks ROG as a subset of total organic gases (TOG). This appendix does not include a precursor demonstration for NOx, since NOx is an important and significant precursor to $PM_{2.5}$ and is controlled extensively in the SIP, and because reductions of NOx emissions are essential to the attainment strategy for the San Joaquin Valley (Valley).

Following U.S. EPA guidance, the three precursor demonstrations analyze "the relationship between precursor emissions and the formation of secondary $PM_{2.5}$ components"[6] using an air quality model, and take into consideration additional relevant factors.

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[1] 81 FR 58010 (August 24, 2016)

[2] United States Environmental Protection Agency. *$PM_{2.5}$ Precursor Demonstration Guidance: Draft for Public Review and Comment*. 17 Nov. 2016. Web. 3 Oct. 2017. <www.U.S. EPA.gov/sites/production/files/2016-11/documents/transmittal_memo_and_draft_pm25_precursor_demo_guidance_11_17_16.pdf>. Page 7

[3] Ibid. 7

[4] Ibid. 7

[5] See: California Air Resources Board. "FACT SHEET #1: Development of Organic Emission Estimates For California's Emission Inventory and Air Quality Models." Aug. 2000. Web. 24 May 2018. <www.arb.ca.gov/ei/speciate/factsheetsmodeleispeciationtog082000.pdf>
See also: California Air Resources Board. "Definitions of VOC and ROG." Jan. 2009. Web. 24 May 2018. <www.arb.ca.gov/ei/speciate/voc_rog_dfn_1_09.pdf>

[6] U.S. EPA. *$PM_{2.5}$ Precursor Demonstration Guidance: Draft for Public Review and Comment*. Page 26

U.S. EPA $PM_{2.5}$ PRECURSOR DEMONSTRATION GUIDANCE

In November 2016, U.S. EPA published a draft guidance document to "assist air agencies who may wish to submit $PM_{2.5}$ precursor demonstrations."[7] The document provides recommendations or guidelines, as authorized under the Clean Air Act, "that will be useful to air agencies in developing the precursor demonstrations by which the EPA can ultimately determine whether sources of a particular precursor contribute significantly to $PM_{2.5}$ levels that exceed the standard in a particular nonattainment area."[8] Recommendations include modeling procedures for conducting the required analysis and contribution thresholds to determine the impact of a precursor on $PM_{2.5}$ levels.[9] The guidance also describes an analytical process to perform the precursor demonstration, involving a sensitivity-based analysis followed by a consideration of additional information.

Sensitivity-Based Analysis

The evaluation of the precursors begins with a sensitivity-based analysis to determine whether precursor emissions contribute to total $PM_{2.5}$ concentrations. According to the guidance:

> This modeling analysis examines the sensitivity of ambient $PM_{2.5}$ concentrations in the nonattainment area to certain amounts of decreases in the precursor emissions in the area…. Where decreases in emissions of the precursor result in negligible air quality impacts (i.e., the area is "not sensitive" to decreases), such a small degree of impact is not significant and can be considered to not "contribute" to $PM_{2.5}$ concentrations for the purposes of determining whether control requirements should apply.[10]

Generally, U.S. EPA recommends that the precursor demonstration "should be based on current conditions to demonstrate that precursor emissions do not contribute significantly to $PM_{2.5}$ concentrations in the nonattainment area."[11] This means evaluating emissions in a selected base year, which may be the present or a previous year.

For each existing $PM_{2.5}$ monitor location in the area,[12] the first step for estimating $PM_{2.5}$ impacts from ammonia, SOx, or ROG in the base year is to estimate the average $PM_{2.5}$ concentration on an annual and 24-hour basis. The second step is to calculate the annual and 24-hour average $PM_{2.5}$ concentration at each monitor with a specified percent reduction in precursor emissions, still in the base year.[13] The difference between these two calculated $PM_{2.5}$ values is the impact on $PM_{2.5}$ levels from precursor emissions reductions.[14] Note that "precursor demonstrations do not examine changes in emissions *between a base year and a future year*. Instead, the calculation of relative

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[7] Ibid. 7
[8] Ibid. 7-8
[9] Ibid. 9
[10] Ibid. 25
[11] Ibid. 33
[12] Ibid. 16
[13] Ibid. 36
[14] Ibid. 36

changes in $PM_{2.5}$ concentrations occur *between a modeled case with all emissions and a modeled case with reduced precursor emissions*" (emphasis added).[15] In addition, U.S. EPA recommends modeling reductions of between 30 and 70 percent of precursor emissions.[16]

The third step in the sensitivity-based analysis is to compare the modeled impact on $PM_{2.5}$ levels from a decrease in ammonia, SOx, or ROG emissions to contribution thresholds for annual and 24-hour $PM_{2.5}$.[17] U.S. EPA recommends values for these thresholds, or air quality concentrations below which air quality impacts are not statistically significantly different from "the inherent variability in the measured atmospheric conditions," and thus do not contribute to $PM_{2.5}$ concentrations that exceed the NAAQS.[18] These thresholds are 0.2 micrograms per cubic meter ($\mu g/m^3$) for the annual $PM_{2.5}$ standard, and 1.3 $\mu g/m^3$ for the 24-hour $PM_{2.5}$ standard.[19] If the calculated $PM_{2.5}$ impact is greater than 0.2 $\mu g/m^3$ for the annual standard or greater than 1.3 $\mu g/m^3$ for the 24-hour standard, then $PM_{2.5}$ levels are sensitive to the modeled percent reduction in ammonia, SOx, or ROG emissions.

Consideration of Additional Information

To supplement modeling analysis, U.S. EPA guidance also allows an air agency to consider additional information, assessing the significance of a precursor "'based on the facts and circumstances of the area.'"[20] The guidance states:

> If the estimated air quality impact exceeds the recommended contribution thresholds…, this fact does not necessarily preclude approval of the precursor demonstration. There may be cases where it could be determined that precursor emissions have an impact above the recommended contribution thresholds, yet do not "significantly contribute" to levels that exceed the standard in the area.[21]

In these cases, an air agency may "provide the [U.S.] EPA with information related to other factors they believe should be considered in determining whether the contribution of emissions of a particular precursor to levels that exceed the NAAQS is 'significant' or not."[22] Such factors may include: trends in emissions of other precursors such as NOx,[23] anticipated growth or loss of emissions sources,[24] and the consequent appropriateness of modeling impacts in a future year instead of a base year;[25] "available emissions controls,"[26] and "the severity of nonattainment at relevant monitors."[27] These factors are discussed in the context of the precursor analyses for the Valley in the subsequent sections.

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[15] Ibid. 34
[16] Ibid. 29
[17] Ibid. 25
[18] Ibid. 14, 15
[19] Ibid. 15-16
[20] Ibid. 17
[21] Ibid. 17
[22] Ibid. 17
[23] Ibid. 17
[24] Ibid. 17
[25] Ibid. 33
[26] Ibid. 29
[27] Ibid. 17

Other factors the agency may consider are: the amount by which a precursor's contribution exceeds the recommended contribution thresholds; source characteristics (e.g., source type, stack height, location); analyses of speciation data and precursor emission inventories; chemical tracer studies; and special intensive measurement studies to evaluate specific atmospheric chemistry in an area. The agency may also provide other information not listed here.[28]

The following sections contain sensitivity-based analyses and supplemental information demonstrating that ammonia, SOx, and ROG are not significant precursors to $PM_{2.5}$ in the Valley.

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[28] Ibid. 17

AMMONIA ANALYSIS

Ammonium nitrate (NH_4NO_3) is a constituent of $PM_{2.5}$, making up about 40 percent of fine particulate matter mass in the Valley. Ammonium nitrate forms when nitrogen dioxide (NO_2) reacts with highly oxidizing species in the atmosphere to form nitric acid (HNO_3). Nitric acid then reacts with ammonia (NH_3) to yield ammonium nitrate as a particle. Since ammonia reacts chemically in this way to form a particle, ammonia is a precursor to $PM_{2.5}$.

Lowering $PM_{2.5}$ concentrations to levels that meet the NAAQS will rely upon an effective control strategy for ammonium nitrate. The amount of ammonium nitrate that can form in the atmosphere is limited by whichever precursor, either NOx or ammonia, is in least supply, and research studies confirm that there are relatively fewer NOx molecules in the air in the Valley than ammonia. This implies that reducing NOx, the limiting precursor in this case, is more effective for reducing ammonium nitrate concentrations and thus improving $PM_{2.5}$ air quality.

Following the analytical process outlined in the U.S. EPA precursor demonstration guidance and summarized above, CARB has evaluated ammonia in the Valley. The results of the sensitivity-based analysis and consideration of additional information are presented below.

Sensitivity-Based Analysis

CARB staff used an air quality model to estimate the $PM_{2.5}$ design value for the annual and 24-hour standards in the base year of 2013 at each Valley monitor. Then, CARB staff applied the recommended lower bound of a 30 percent reduction to ammonia emissions and used the air quality model to estimate the $PM_{2.5}$ design values, as shown in Table 1. The difference between the two design values represents the modeled impact on $PM_{2.5}$ levels of a 30 percent reduction in ammonia emissions in 2013. This is the value that is compared to U.S. EPA's recommended contribution thresholds of 0.2 $\mu g/m^3$ for the annual standard and 1.3 $\mu g/m^3$ for the 24-hour standard to establish if $PM_{2.5}$ levels are sensitive to this level of ammonia reduction.

Table 1. Base Year 2013 $PM_{2.5}$ – 30 Percent Ammonia Reduction

	Annual			24-Hour		
Site*	**2013 Baseline DV**	**2013 DV with 30% Ammonia Reduction[+]**	**Difference**	**2013 Baseline DV**	**2013 DV with 30% Ammonia Reduction**	**Difference**
Bakersfield-Planz	17.19	16.76	0.43	55.5	53.3	2.2
Madera	16.93	16.29	0.64	51.0	49.2	1.7
Hanford	16.54	15.82	0.72	60.0	57.8	2.1
Visalia	16.20	15.82	0.38	55.5	53.5	2.0
Clovis	16.12	15.80	0.32	55.8	54.0	1.9
Bakersfield-California	16.02	15.58	0.44	64.1	60.8	3.3
Fresno-Garland	14.98	14.69	0.29	60.0	58.0	2.0
Turlock	14.88	14.46	0.42	50.7	49.3	1.5
Fresno-HW	14.22	13.95	0.27	59.3	57.4	2.0
Stockton	13.14	12.84	0.30	42.0	41.0	1.0
Merced-S Coffee	13.10	12.65	0.45	41.1	40.0	1.1
Modesto	13.03	12.66	0.37	47.9	46.5	1.5
Merced-M	10.97	10.77	0.20	46.9	45.9	1.0
Manteca	10.09	9.85	0.24	36.9	36.0	0.9
Tranquility	7.72	7.33	0.39	29.5	27.2	2.2

* The site at Corcoran does not have a valid design value because of missing data, and is thus excluded from all precursor analyses.

[+] Numbers may not sum exactly due to rounding.

For completeness, CARB staff repeated this analysis, applying instead the U.S. EPA-recommended upper bound of a 70 percent reduction to ammonia emissions in the base year, as shown in Table 2.

Table 2. Base Year 2013 $PM_{2.5}$ – 70 Percent Ammonia Reduction

	Annual			24-Hour		
Site	**2013 Baseline DV**	**2013 DV with 70% Ammonia Reduction**	**Difference**	**2013 Baseline DV**	**2013 DV with 70% Ammonia Reduction**	**Difference**
Bakersfield-Planz	17.19	15.72	1.47	55.5	46.5	9.0
Madera	16.93	14.81	2.12	51.0	43.4	7.6
Hanford	16.54	14.24	2.30	60.0	50.6	9.4
Visalia	16.20	14.80	1.40	55.5	45.8	9.7
Clovis	16.12	14.95	1.17	55.8	47.0	8.8
Bakersfield-California	16.02	14.47	1.55	64.1	51.7	12.4
Fresno-Garland	14.98	13.91	1.07	60.0	52.5	7.5
Turlock	14.88	13.46	1.42	50.7	44.4	6.3
Fresno-HW	14.22	13.17	1.05	59.3	49.7	9.6
Stockton	13.14	12.10	1.04	42.0	37.9	4.1
Merced-S Coffee	13.10	11.60	1.50	41.1	36.6	4.5
Modesto	13.03	11.78	1.25	47.9	41.6	6.4
Merced-M	10.97	10.23	0.74	46.9	41.9	5.0
Manteca	10.09	9.27	0.82	36.9	33.4	3.5
Tranquility	7.72	6.46	1.26	29.5	20.7	8.8

From this analysis, the estimated air quality impact of reducing ammonia emissions by the lower bound of 30 percent in the base year exceeds U.S. EPA's recommended thresholds at all but a few Valley monitors, for both the annual and 24-hour standards. Reducing emissions by the upper bound of 70 percent also shows impacts above the thresholds.

It is not possible, however, to conclude from this analysis that emissions of ammonia "significantly contribute." In this case, ammonia emissions have an impact above the recommended contribution thresholds even at the lower bound, but, as the U.S. EPA guidance indicates, this does not necessarily mean the precursor contributes significantly to $PM_{2.5}$ levels that exceed the NAAQS. Making the appropriate determination about the ammonia emission reduction impact requires further analysis of additional factors.

Consideration of Additional Information

To supplement modeling analysis, U.S. EPA guidance also allows an air agency to consider additional information, assessing the significance of a precursor "'based on the facts and circumstances of the area.'"[29] CARB staff believes that there are several critical factors that must be considered in determining whether ammonia is a significant precursor to $PM_{2.5}$ in the Valley.

Emissions Trends and Studies

CARB has an extensive suite of measures in place to reduce NOx emissions from mobile sources that reduce ammonium nitrate. Between 2013 and 2020—the attainment year for the 1997 annual and 24-hour $PM_{2.5}$ standards—total NOx emissions are expected to decline 36 percent, and between 2013 and 2024—the attainment year for the 2006 24-hour $PM_{2.5}$ standard—total NOx emissions are projected to decline 53 percent. Meanwhile, total ammonia emissions are expected to remain flat, as shown in Figure 1. The San Joaquin Valley Air Pollution Control District (District) adopted four rules[30] between 2004 and 2011 with measures that provided ammonia emissions reductions in the Valley of approximately 50 tons per day (tpd); however, reductions from these existing control measures are already accounted for in the inventory, prior to the base year of 2013. In the future, emissions from the main sources of ammonia—dairies, fertilizer, and non-dairy livestock operations—are not anticipated to either increase or decrease substantially.

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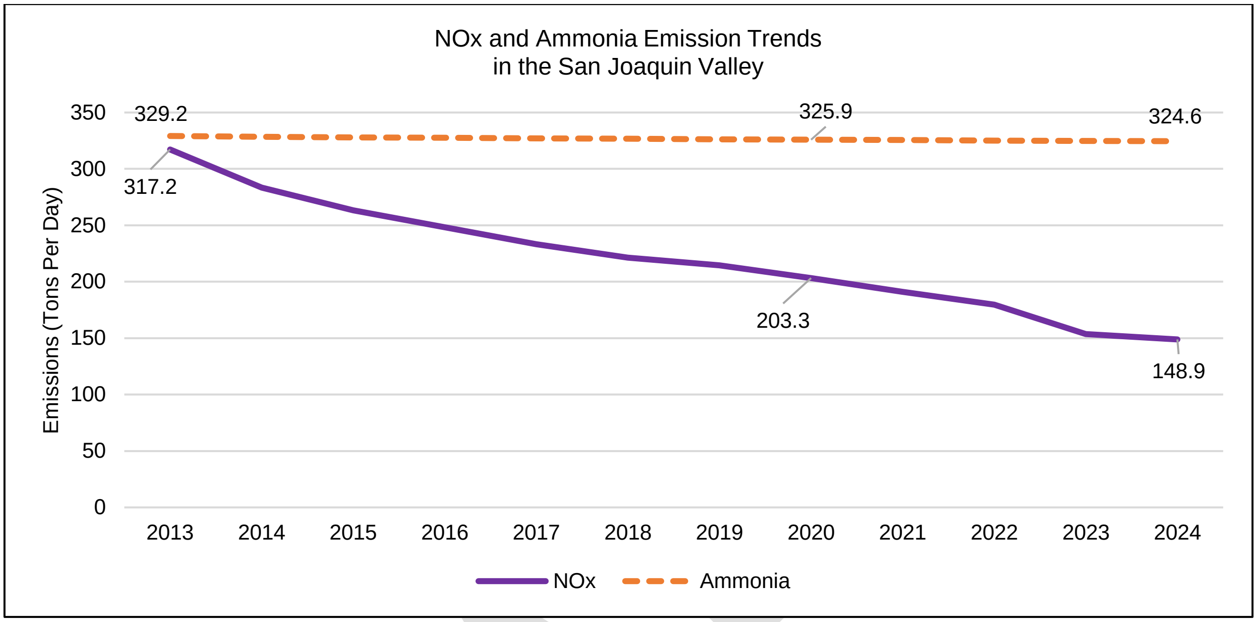
[29] Ibid. 17

[30] District Rule 4550: Conservation Management Practices (adopted 2004); Rule 4565: Biosolids, Animal Manure, and Poultry Litter Operations (adopted 2007); Rule 4566: Organic Material Composting Operations (adopted 2011); and Rule 4570: Confined Animal Facilities (adopted 2006, amended 2010)

Figure 1. NOx and ammonia emission trends in the San Joaquin Valley between 2013 and 2024



Source: CEPAM Inventory version 1.05

The steep downward trend of NOx emissions and the stability of ammonia emissions between 2013 and 2024 lead CARB staff to conclude that modeling the impact of ammonia emissions reductions in the future, rather than the base year, is appropriate and more representative of the Valley's emissions conditions. U.S. EPA guidance states that, in some situations, it may be "more appropriate to model future conditions that provide a more representative sensitivity analysis."[31] This approach is applicable in the Valley. Although emissions of NOx and ammonia are of roughly similar magnitude in the base year, thereby leading to some modeled sensitivity of $PM_{2.5}$ levels to a 30 percent reduction in ammonia emissions, these conditions do not persist and are not representative in the future.

Recent research further supports the fact that ammonia emissions are already in excess in the Valley. Field study measurements conducted during the 2013 DISCOVER-AQ study indicate that ammonia is in excess of NOx on peak $PM_{2.5}$ days in the Valley, as illustrated in Figure 2. These data imply that ammonium nitrate formation in the Valley is limited by the amount of NOx present in the air.

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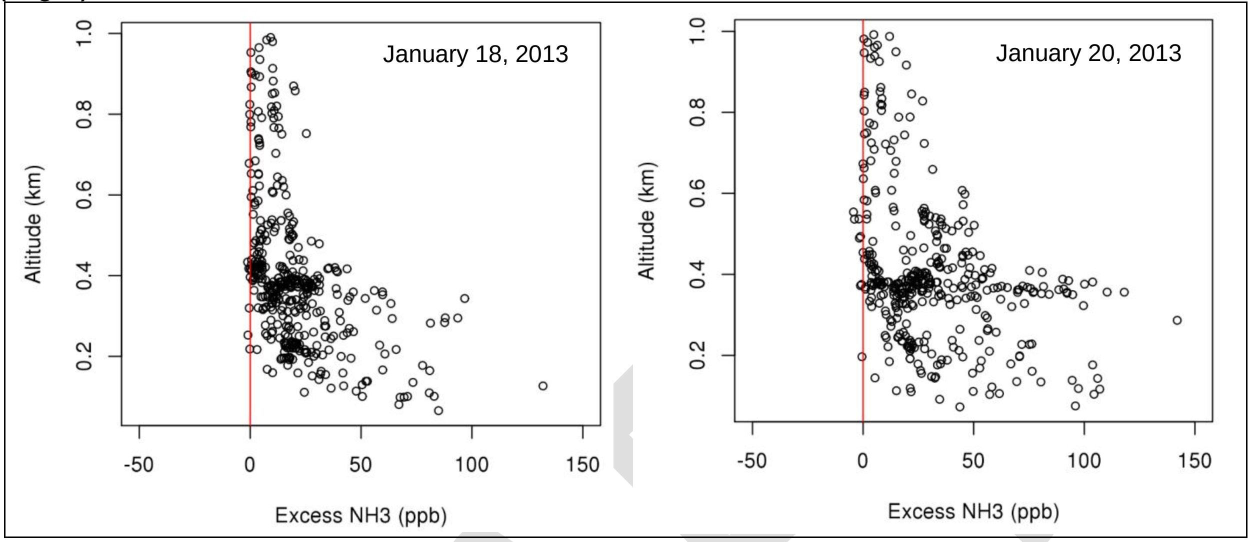
[31] U.S. EPA. *$PM_{2.5}$ Precursor Demonstration Guidance: Draft for Public Review and Comment*. Page 33

Figure 2. Excess ammonia (NH_3) in the San Joaquin Valley on Jan 18 (Left) and Jan 20 (Right) based on NASA aircraft measurements in 2013



This finding that nitrate formation in the Valley is in a NO_x-limited regime is consistent with previous research. For instance, Lurmann et al. (2006) note that "[t]he consistent excess of NH_3 over nitric acid levels indisputably shows that secondary ammonium nitrate formation is more limited by nitric acid availability than NH_3 within the SJV and in the foothills."[32] Since ammonium nitrate formation is limited by NOx, reducing NOx emissions is the more effective strategy for reducing ammonium nitrate and $PM_{2.5}$. Other research has found that ammonia concentrations in the San Joaquin Valley have increased, further confirming that NOx reductions are the most effective path to reducing $PM_{2.5}$.

Future Year Modeling

CARB staff therefore repeated the sensitivity-based analysis of ammonia for the future attainment years of 2020 and 2024.[33] Staff used an air quality model to estimate the $PM_{2.5}$ design value for the annual and 24-hour standards in 2020 and 2024 at each Valley monitor. Then, CARB staff applied a 30 percent reduction to ammonia emissions and used the air quality model to estimate the $PM_{2.5}$ design values in 2020 and 2024, shown in Tables 3 and 4 respectively. The difference between the two design values represents the modeled impact on $PM_{2.5}$ levels of a 30 percent reduction in ammonia emissions in each attainment year.

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[32] Lurmann et al. "Processes influencing secondary aerosol formation in the San Joaquin Valley during winter." Journal of the Air & Waste Management Association. 2006. Web. 3 Oct. 2017. <http://www.tandfonline.com/doi/pdf/10.1080/10473289.2006.10464573>. Page 1688

[33] CARB did not conduct sensitivity analysis for the 2025 attainment year for the 2012 annual $PM_{2.5}$ standard due to the close proximity of the attainment years for the 2012 and 2006 standards. Precursor sensitivities in 2025 are assumed to be very similar to those modeled in 2024.

Table 3. Future Year 2020 $PM_{2.5}$ – 30 Percent Ammonia Reduction

	Annual			24-Hour		
Site	**2020 Baseline DV**	**2020 DV with 30% Ammonia Reduction**	**Difference**	**2020 Baseline DV**	**2020 DV with 30% Ammonia Reduction**	**Difference**
Bakersfield-Planz	14.58	14.34	0.24	41.2	39.8	1.4
Madera	14.15	13.79	0.36	38.9	37.8	1.0
Hanford	13.30	12.88	0.42	43.7	42.3	1.4
Visalia	13.51	13.28	0.23	42.8	41.5	1.3
Clovis	13.43	13.25	0.18	41.1	40.3	0.9
Bakersfield-California	13.48	13.24	0.24	47.6	45.7	1.9
Fresno-Garland	12.42	12.25	0.17	44.3	43.2	1.1
Turlock	12.47	12.20	0.27	37.8	36.8	1.0
Fresno-HW	11.86	11.70	0.16	45.6	44.5	1.1
Stockton	11.43	11.23	0.20	33.5	32.8	0.7
Merced-S Coffee	10.86	10.60	0.26	30.0	29.4	0.5
Modesto	10.97	10.74	0.23	35.8	34.9	0.9
Merced-M	9.34	9.22	0.12	32.9	32.3	0.6
Manteca	8.67	8.51	0.16	30.1	29.6	0.5
Tranquility	6.40	6.19	0.21	21.5	20.3	1.2

In 2020, the modeled air quality impact of reducing ammonia emissions by 30 percent falls under U.S. EPA's recommended threshold at all but four Valley monitors for the 24-hour standard. The air quality impact remains above U.S. EPA's recommended annual threshold at most sites.

Table 4. Future Year 2024 $PM_{2.5}$ – 30 Percent Ammonia Reduction

	Annual			24-Hour		
Site	**2024 Baseline DV**	**2024 DV with 30% Ammonia Reduction**	**Difference**	**2024 Baseline DV**	**2024 DV with 30% Ammonia Reduction**	**Difference**
Bakersfield-Planz	12.03	11.79	0.12	30.0	29.2	0.7
Madera	11.98	11.77	0.21	30.2	29.5	0.7
Hanford	10.52	10.26	0.26	30.1	29.1	1.0
Visalia	11.09	10.97	0.12	30.2	29.4	0.8
Clovis	11.37	11.27	0.10	30.7	30.0	0.7
Bakersfield-California	11.01	10.78	0.12	33.3	32.2	1.0
Fresno-Garland	10.43	10.33	0.10	32.8	32.1	0.7
Turlock	11.14	10.95	0.19	30.2	29.5	0.7
Fresno-HW	10.02	9.92	0.10	35.1	34.4	0.8
Stockton	10.66	10.50	0.16	28.6	28.1	0.5
Merced-S Coffee	9.65	9.47	0.18	24.2	23.8	0.4
Modesto	9.97	9.79	0.18	29.1	28.5	0.6
Merced-M	8.61	8.53	0.08	27.4	27.0	0.5
Manteca	7.97	7.85	0.12	25.8	25.4	0.4
Tranquility	5.54	5.42	0.12	16.2	15.6	0.6

In 2024, the modeled air quality impact of reducing ammonia emissions by 30 percent falls under U.S. EPA's recommended annual threshold at all but two Valley monitors, and falls under the 24-hour threshold at all sites.

For completeness, CARB staff repeated this analysis, applying instead the U.S. EPA-recommended upper bound of a 70 percent reduction to ammonia emissions in 2020 and 2024, as shown in Tables 5 and 6.

Table 5. Future Year 2020 $PM_{2.5}$ – 70 Percent Ammonia Reduction

	Annual			**24-Hour**		
Site	**2020 Baseline DV**	**2020 DV with 70% Ammonia Reduction**	**Difference**	**2020 Baseline DV**	**2020 DV with 70% Ammonia Reduction**	**Difference**
Bakersfield-Planz	14.58	13.79	0.79	41.2	35.8	5.4
Madera	14.15	12.97	1.18	38.9	35.2	3.6
Hanford	13.30	12.00	1.30	43.7	39.1	4.6
Visalia	13.51	12.72	0.79	42.8	37.0	5.8
Clovis	13.43	12.79	0.64	41.1	36.4	4.7
Bakersfield-California	13.48	12.66	0.82	47.6	41.2	6.4
Fresno-Garland	12.42	11.82	0.60	44.3	39.7	4.6
Turlock	12.47	11.62	0.85	37.8	34.5	3.2
Fresno-HW	11.86	11.23	0.63	45.6	39.8	5.8
Stockton	11.43	10.77	0.66	33.5	31.4	2.1
Merced-S Coffee	10.86	10.02	0.84	30.0	27.8	2.2
Modesto	10.97	10.22	0.75	35.8	32.5	3.3
Merced-M	9.34	8.93	0.41	32.9	30.6	2.3
Manteca	8.67	8.15	0.52	30.1	28.5	1.6
Tranquility	6.40	5.76	0.64	21.5	17.6	4.0

Table 6. Future Year 2024 $PM_{2.5}$ – 70 Percent Ammonia Reduction

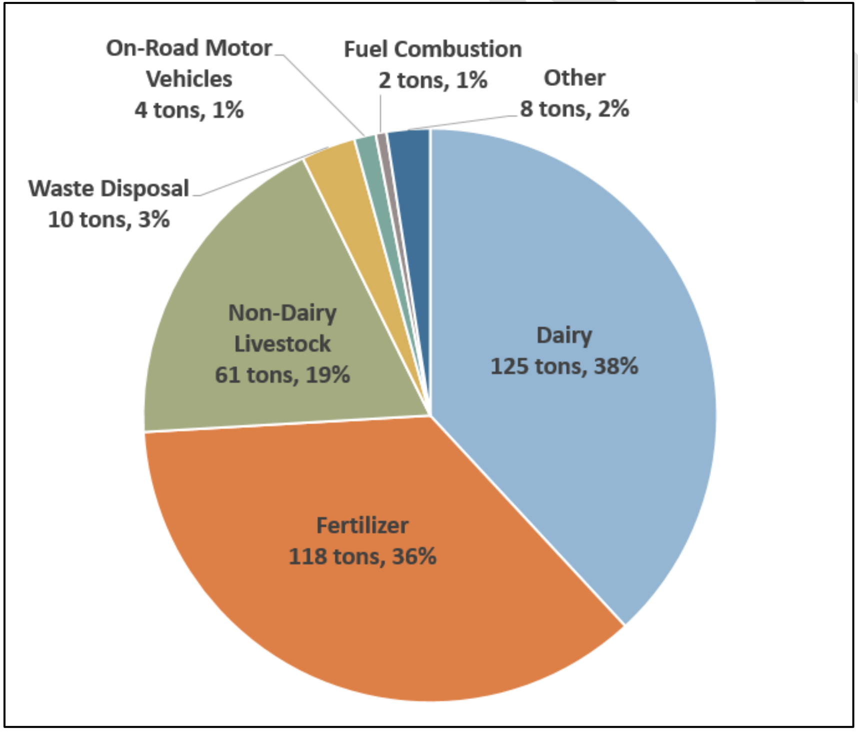
	Annual			**24-Hour**		
Site	**2024 Baseline DV**	**2024 DV with 70% Ammonia Reduction**	**Difference**	**2024 Baseline DV**	**2024 DV with 70% Ammonia Reduction**	**Difference**
Bakersfield-Planz	12.03	11.55	0.36	30.0	27.6	2.2
Madera	11.98	11.32	0.66	30.2	28.6	1.6
Hanford	10.52	9.77	0.75	30.1	27.1	3.0
Visalia	11.09	10.71	0.38	30.2	27.6	2.5
Clovis	11.37	11.05	0.32	30.7	28.4	2.3
Bakersfield-California	11.01	10.54	0.36	33.3	30.3	2.8
Fresno-Garland	10.43	10.22	0.32	32.8	30.9	1.9
Turlock	11.14	10.53	0.61	30.2	28.1	2.1
Fresno-HW	10.02	9.68	0.34	35.1	32.2	2.9
Stockton	10.66	10.14	0.52	28.6	27.1	1.5
Merced-S Coffee	9.65	9.12	0.53	24.2	23.0	1.2
Modesto	9.97	9.41	0.56	29.1	26.9	2.2
Merced-M	8.61	8.35	0.26	27.4	26.0	1.4
Manteca	7.97	7.57	0.40	25.8	24.4	1.4
Tranquility	5.54	5.19	0.35	16.2	14.4	1.8

From this analysis, the estimated air quality impact of reducing ammonia emissions by the upper bound of 70 percent in 2020 and 2024 exceeds U.S. EPA's recommended thresholds for both the annual and 24-hour standards at all sites except one.

Available Emissions Controls

Available emissions controls on ammonia are also relevant to the decision-making process, influencing the extent of reasonable modeled reductions. While U.S. EPA recommends modeling emissions reductions of between 30 and 70 percent to estimate $PM_{2.5}$ impacts,[34] CARB staff have not identified controls that are technologically and economically feasible to achieve reductions even at the low end of the recommended sensitivity range (i.e. 30 percent). Emissions of ammonia in the Valley are approximately 329 tpd, as shown in Figure 3, meaning reductions would need to be in the range of approximately 99 to 230 tpd (30 to 70 percent). The District's existing rules that provide ammonia emissions reductions reflect the best available control measures for ammonia sources in the Valley, and implementation of these measures cannot feasibly reduce emissions by 30 percent. Therefore, CARB staff determined that modeled emissions reductions of 30 percent were an upper bound for potential ammonia reductions.

Figure 3. Sources of ammonia in the Valley, 2013



Source: CEPAM Inventory version 1.05

Relevant Monitors

The impact of ammonia on $PM_{2.5}$ at monitors that form the basis of the attainment finding for the Valley is the focus of this analysis. For purposes of demonstrating

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[34] U.S. EPA. *$PM_{2.5}$ Precursor Demonstration Guidance: Draft for Public Review and Comment*. Page 29

attainment of all three $PM_{2.5}$ NAAQS, the relevant monitor is at the site in Bakersfield which currently records the highest levels. U.S. EPA guidance permits consideration of "the severity of nonattainment at relevant monitors,"[35] and in 2024, $PM_{2.5}$ levels are not sensitive to ammonia reductions at this relevant site.

The sites at Madera and Hanford show an impact over the recommended threshold for the annual standard. Madera's design value, however, is not representative of air quality in the area; CARB has previously documented that this design value is an artifact of inaccurate monitor data. In addition, the Madera monitor is already nearing the 12 $\mu g/m^3$ $PM_{2.5}$ standard. For Hanford, while the impact is over U.S. EPA's recommended significance level, achieving the level of controls needed for a 30 percent reduction of ammonia is not feasible, as discussed above.

Conclusion

CARB has followed U.S. EPA guidance to evaluate whether ammonia contributes significantly to $PM_{2.5}$ levels that exceed the NAAQS. Considering relevant contextualizing information such as emissions, research, and available controls, along with performing sensitivity-based analysis in future years, CARB determined that emissions of ammonia do not contribute significantly to $PM_{2.5}$ levels that exceed the 1997, 2006, or 2012 NAAQS in the area. Therefore, CARB has excluded ammonia from control requirements in the SIP.

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[35] Ibid. 17

SULFUR DIOXIDE ANALYSIS

Ammonium sulfate ($[NH_4]_2SO_4$) is a constituent of $PM_{2.5}$, making up about 10 percent of fine particulate matter mass in the Valley. Sulfur oxides (SOx) emitted from stationary and mobile combustion sources, mostly as sulfur dioxide (SO_2), are oxidized in the atmosphere to ultimately form sulfuric acid (H_2SO_4). Sulfuric acid then combines with ammonia to form ammonium sulfate. Since SOx reacts chemically in this way to form a particle, SOx is a precursor to $PM_{2.5}$.

Following the analytical process outlined in the U.S. EPA precursor demonstration guidance and summarized above, CARB has evaluated SOx in the Valley. The results of the sensitivity-based analysis and consideration of additional information are presented below.

Sensitivity-Based Analysis

CARB staff used an air quality model to estimate the $PM_{2.5}$ design value for the annual and 24-hour standards in the base year of 2013 at each Valley monitor. Then, CARB staff applied the recommended lower bound of a 30 percent reduction to SOx emissions and used the air quality model to estimate the $PM_{2.5}$ design values, as shown in Table 7. The difference between the two design values represents the modeled impact on $PM_{2.5}$ levels of a 30 percent reduction in SOx emissions in 2013. This is the value that is compared to U.S. EPA's recommended contribution thresholds of 0.2 µg/m^3 for the annual standard and 1.3 µg/m^3 for the 24-hour standard to establish if $PM_{2.5}$ levels are sensitive to this level of SOx reduction.

Table 7. Base Year 2013 $PM_{2.5}$ – 30 Percent SOx Reduction

	Annual			24-Hour		
Site	**2013 Baseline DV**	**2013 DV with 30% SOx Reduction**	**Difference**	**2013 Baseline DV**	**2013 DV with 30% SOx Reduction**	**Difference**
Bakersfield-Planz	17.19	17.15	0.04	55.5	55.9	-0.4
Madera	16.93	16.92	0.01	51.0	51.3	-0.3
Hanford	16.54	16.53	0.01	60.0	60.4	-0.4
Visalia	16.20	16.15	0.05	55.5	55.8	-0.3
Clovis	16.12	16.11	0.01	55.8	56.0	-0.2
Bakersfield-California	16.02	15.98	0.04	64.1	64.5	-0.4
Fresno-Garland	14.98	14.95	0.03	60.0	60.1	-0.1
Turlock	14.88	14.83	0.05	50.7	50.8	-0.1
Fresno-HW	14.22	14.18	0.04	59.3	59.4	-0.1
Stockton	13.14	13.07	0.07	42.0	41.8	0.2
Merced-S Coffee	13.10	13.08	0.02	41.1	41.2	-0.1
Modesto	13.03	12.97	0.06	47.9	47.9	0.1
Merced-M	10.97	10.95	0.02	46.9	47.0	-0.1
Manteca	10.09	10.02	0.07	36.9	36.6	0.2
Tranquility	7.72	7.73	-0.01	29.5	29.5	0.0

For completeness, CARB staff repeated this analysis, applying instead the recommended upper bound of a 70 percent reduction to the SOx emissions in the base year, as shown in Table 8.

Table 8. Base Year 2013 $PM_{2.5}$ – 70 Percent SOx Reduction

	Annual			24-Hour		
Site	**2013 Baseline DV**	**2013 DV with 70% SOx Reduction**	**Difference**	**2013 Baseline DV**	**2013 DV with 70% SOx Reduction**	**Difference**
Bakersfield-Planz	17.19	17.11	0.08	55.5	56.5	-1.0
Madera	16.93	16.95	-0.02	51.0	52.2	-1.2
Hanford	16.54	16.54	0.00	60.0	61.4	-1.4
Visalia	16.20	16.10	0.10	55.5	56.3	-0.8
Clovis	16.12	16.10	0.02	55.8	56.4	-0.6
Bakersfield-California	16.02	15.95	0.07	64.1	65.2	-1.1
Fresno-Garland	14.98	14.93	0.05	60.0	60.6	-0.6
Turlock	14.88	14.77	0.11	50.7	51.1	-0.4
Fresno-HW	14.22	14.15	0.07	59.3	59.8	-0.5
Stockton	13.14	12.99	0.15	42.0	41.9	0.2
Merced-S Coffee	13.10	13.08	0.02	41.1	41.4	-0.3
Modesto	13.03	12.90	0.13	47.9	48.0	-0.1
Merced-M	10.97	10.93	0.04	46.9	47.2	-0.3
Manteca	10.09	9.95	0.14	36.9	36.4	0.5
Tranquility	7.72	7.77	-0.05	29.5	29.7	-0.2

From this analysis, the estimated air quality impact of reducing SOx emissions in the base year by the lower bound of 30 percent is well under U.S. EPA's recommended thresholds at all Valley monitors for both the annual and 24-hour standards. In fact, in some cases, the estimated air quality impact is negative, implying that a reduction in SOx emissions would in fact increase the modeled design value at certain sites. Reducing emissions by the upper bound of 70 percent also shows impacts below the recommended thresholds.

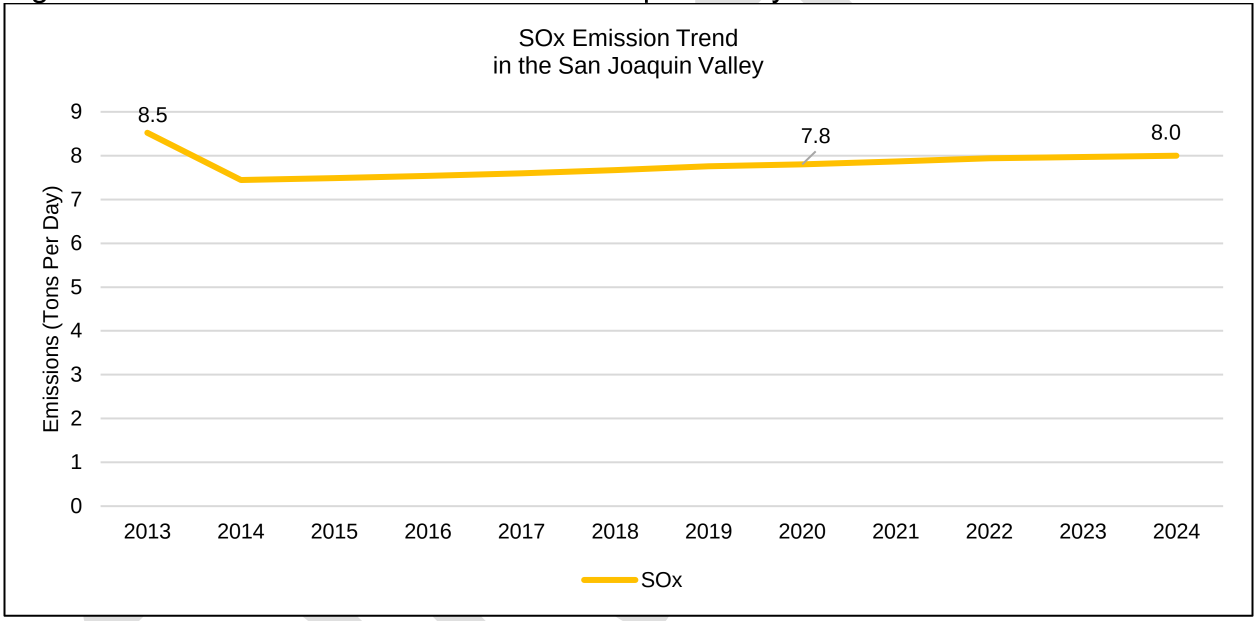
Consideration of Additional Information

To supplement modeling analysis, U.S. EPA guidance also allows an air agency to consider additional information. Accordingly, CARB evaluated the trend of SOx emissions in the Valley to support the sensitivity-based analysis.

Emissions Trend

CARB's SOx inventory indicates that emissions remain roughly constant between 2013 and 2024, as shown in Figure 4. Ammonia emissions also remain flat over the same time frame, as shown above in Figure 1. Thus, conditions for ammonium sulfate formation are similar in the base and future years, with relative levels of ammonia and SOx remaining the same. The sensitivity-based analysis performed for 2013 and reflected in Tables 7 and 8 above is therefore representative into the future, and it is redundant to additionally model the sensitivity of $PM_{2.5}$ formation to SOx emissions reductions in 2020 or 2024. Precursor sensitivities in the future years are assumed to be very close to those modeled in 2013 due to the similarity of emissions conditions over time, so 2020 and 2024 analyses are not included here.

Figure 4. SOx emission trend in the San Joaquin Valley between 2013 and 2024



Source: CEPAM Inventory version 1.05

Conclusion

CARB has followed U.S. EPA guidance to evaluate whether SOx contributes significantly to $PM_{2.5}$ levels that exceed the NAAQS. Using sensitivity-based analysis in the base year and considering that base year conditions are representative into the future, CARB determined that emissions of SOx do not contribute significantly to $PM_{2.5}$ levels that exceed the 1997, 2006, or 2012 NAAQS in the area. Therefore, CARB has excluded SOx from control requirements in the SIP.

ROG ANALYSIS

Following the analytical process outlined in the U.S. EPA precursor demonstration guidance and summarized above, CARB has evaluated ROG in the San Joaquin Valley. The results of the sensitivity-based analysis and consideration of additional information are presented below.

Sensitivity-Based Analysis

CARB staff used an air quality model to estimate the $PM_{2.5}$ design value for the annual and 24-hour standards in the base year of 2013 at each Valley monitor. Then, CARB staff applied the recommended lower bound of a 30 percent reduction to ROG emissions and used the air quality model to estimate the $PM_{2.5}$ design values, as shown in Table 9. The difference between the two design values represents the modeled impact on $PM_{2.5}$ levels of a 30 percent reduction in ROG emissions in 2013. This is the value that is compared to U.S. EPA's recommended contribution thresholds of 0.2 $\mu g/m^3$ for the annual standard and 1.3 $\mu g/m^3$ for the 24-hour standard to establish if $PM_{2.5}$ levels are sensitive to this level of ROG reduction.

Table 9. Base Year 2013 $PM_{2.5}$ – 30 Percent ROG Reduction

	Annual			**24-Hour**		
Site	**2013 Baseline DV**	**2013 DV with 30% ROG Reduction**	**Difference**	**2013 Baseline DV**	**2013 DV with 30% ROG Reduction**	**Difference**
Bakersfield-Planz	17.19	17.08	0.11	55.5	54.3	1.2
Madera	16.93	16.83	0.10	51.0	50.1	0.9
Hanford	16.54	16.47	0.07	60.0	58.8	1.1
Visalia	16.20	16.04	0.16	55.5	53.6	1.9
Clovis	16.12	16.01	0.11	55.8	54.9	0.9
Bakersfield-California	16.02	15.92	0.10	64.1	62.8	1.4
Fresno-Garland	14.98	14.87	0.11	60.0	59.1	0.9
Turlock	14.88	14.80	0.08	50.7	50.1	0.7
Fresno-HW	14.22	14.10	0.12	59.3	58.2	1.1
Stockton	13.14	13.09	0.05	42.0	41.5	0.5
Merced-S Coffee	13.10	13.04	0.06	41.1	40.7	0.4
Modesto	13.03	12.97	0.06	47.9	47.4	0.6
Merced-M	10.97	10.92	0.05	46.9	46.5	0.4
Manteca	10.09	10.03	0.06	36.9	36.3	0.5
Tranquility	7.72	7.71	0.01	29.5	29.4	0.1

For completeness, CARB staff repeated this analysis, applying instead the U.S. EPA-recommended upper bound of a 70 percent reduction to ROG emissions in the base year, as shown in Table 10.

Table 10. Base Year 2013 $PM_{2.5}$ – 70 Percent ROG Reduction

	Annual			**24-Hour**		
Site	**2013 Baseline DV**	**2013 DV with 70% ROG Reduction**	**Difference**	**2013 Baseline DV**	**2013 DV with 70% ROG Reduction**	**Difference**
Bakersfield-Planz	17.19	16.90	0.29	55.5	52.4	3.0
Madera	16.93	16.69	0.24	51.0	48.8	2.1
Hanford	16.54	16.35	0.19	60.0	56.9	3.0
Visalia	16.20	15.80	0.40	55.5	50.7	4.8
Clovis	16.12	15.84	0.28	55.8	53.6	2.2
Bakersfield-California	16.02	15.76	0.26	64.1	60.5	3.6
Fresno-Garland	14.98	14.73	0.25	60.0	57.7	2.2
Turlock	14.88	14.68	0.20	50.7	49.1	1.6
Fresno-HW	14.22	13.94	0.28	59.3	56.7	2.7
Stockton	13.14	13.01	0.13	42.0	40.7	1.3
Merced-S Coffee	13.10	12.96	0.14	41.1	40.1	1.0
Modesto	13.03	12.88	0.15	47.9	46.7	1.3
Merced-M	10.97	10.85	0.12	46.9	45.9	1.0
Manteca	10.09	9.96	0.13	36.9	35.6	1.2
Tranquility	7.72	7.67	0.05	29.5	29.2	0.2

From this analysis, the estimated air quality impact of reducing ROG emissions in the base year by the lower bound of 30 percent is under U.S. EPA's recommended thresholds at all but two Valley monitors for the 24-hour standard, and falls below the recommended annual threshold at all sites. Reducing emissions by the upper bound of 70 percent shows impacts above the thresholds at about half the sites.

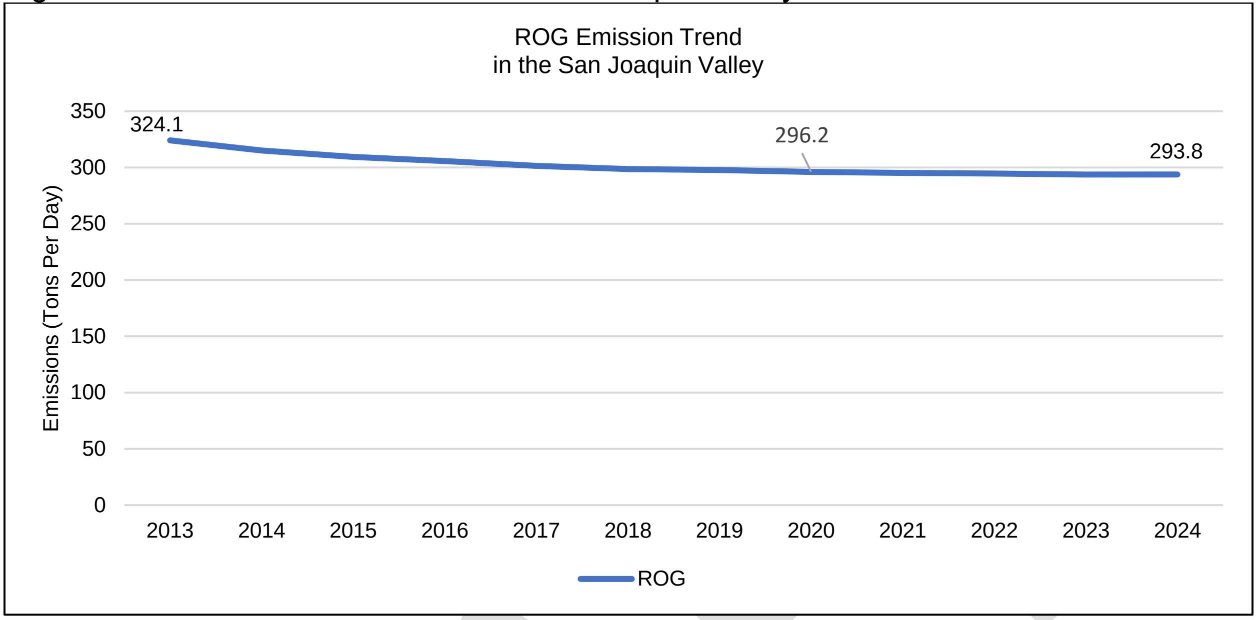
Consideration of Additional Information

To supplement modeling analysis, U.S. EPA guidance also allows an air agency to consider additional information. Accordingly, CARB evaluated the trend of ROG emissions in the Valley to support the sensitivity-based analysis and conducted future year sensitivity modeling.

Emissions Trend

CARB has an extensive suite of measures in place to reduce ROG emissions, particularly in the area of regulating consumer products. In addition, the District has numerous rules that provide ROG emissions reductions in the Valley. CARB's ROG inventory indicates that these existing controls reduce emissions by approximately 30 tons, or nine percent, between 2013 and 2024, as shown in Figure 5. Thus, the role ROG plays in $PM_{2.5}$ formation may differ in the base and future years, and the sensitivity-based analysis performed for 2013 is not representative into the future.

Figure 5. ROG emission trend in the San Joaquin Valley between 2013 and 2024



Source: CEPAM Inventory version 1.05

Future Year Modeling

Even though the estimated air quality impact of reducing ROG emissions in the base year by 30 percent is under U.S. EPA's recommended thresholds at all but two Valley monitors for the 24-hour standard, and falls below the recommended annual threshold at all sites, CARB staff repeated the sensitivity-based analysis of ROG for the future attainment years of 2020 and 2024 for completeness.[36] Staff used an air quality model to estimate the $PM_{2.5}$ design value for the annual and 24-hour standards in 2020 and 2024 at each Valley monitor. Then, CARB staff applied a 30 percent reduction to ROG emissions and used the air quality model to estimate the $PM_{2.5}$ design values in 2020 and 2024, shown in Tables 11 and 12 respectively. The difference between the two design values represents the modeled impact on $PM_{2.5}$ levels of a 30 percent reduction in ROG emissions in each attainment year.

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[36] CARB did not conduct sensitivity analysis for the 2025 attainment year for the 2012 annual $PM_{2.5}$ standard due to the close proximity of the attainment years for the 2012 and 2006 standards. Precursor sensitivities in 2025 are assumed to be very similar to those modeled in 2024.

Table 11. Future Year 2020 $PM_{2.5}$ – 30 Percent ROG Reduction

	Annual			24-Hour		
Site	**2020 Baseline DV**	**2020 DV with 30% ROG Reduction**	**Difference**	**2020 Baseline DV**	**2020 DV with 30% ROG Reduction**	**Difference**
Bakersfield-Planz	14.58	14.55	0.03	41.2	40.9	0.3
Madera	14.15	14.12	0.03	38.9	38.6	0.2
Hanford	13.30	13.35	-0.50	43.7	43.7	0.0
Visalia	13.51	13.47	0.04	42.8	42.2	0.6
Clovis	13.43	13.37	0.06	41.1	40.9	0.3
Bakersfield-California	13.48	13.47	0.01	47.6	47.5	0.1
Fresno-Garland	12.42	12.37	0.05	44.3	44.0	0.3
Turlock	12.47	12.46	0.01	37.8	37.7	0.1
Fresno-HW	11.86	11.80	0.06	45.6	45.2	0.4
Stockton	11.43	11.42	0.01	33.5	33.4	0.1
Merced-S Coffee	10.86	10.86	0.00	30.0	29.9	0.0
Modesto	10.97	10.96	0.01	35.8	35.7	0.1
Merced-M	9.34	9.33	0.01	32.9	32.9	0.0
Manteca	8.67	8.66	0.01	30.1	30.0	0.1
Tranquility	6.40	6.41	-0.01	21.5	21.6	-0.1

Table 12. Future Year 2024 $PM_{2.5}$ – 30 Percent ROG Reduction

	Annual			24-Hour		
Site	**2024 Baseline DV**	**2024 DV with 30% ROG Reduction**	**Difference**	**2024 Baseline DV**	**2024 DV with 30% ROG Reduction**	**Difference**
Bakersfield-Planz	12.03	11.92	-0.01	30.0	30.0	-0.2
Madera	11.98	11.99	-0.01	30.2	30.3	-0.1
Hanford	10.52	10.59	-0.07	30.1	30.5	-0.4
Visalia	11.09	11.1	-0.01	30.2	30.4	-0.3
Clovis	11.37	11.34	0.03	30.7	30.7	0.0
Bakersfield-California	11.01	10.91	-0.01	33.3	33.5	-0.4
Fresno-Garland	10.43	10.41	0.02	32.8	32.9	-0.1
Turlock	11.14	11.16	-0.02	30.2	30.3	-0.1
Fresno-HW	10.02	9.99	0.03	35.1	35.2	0.0
Stockton	10.66	10.67	-0.01	28.6	28.6	-0.1
Merced-S Coffee	9.65	9.67	-0.02	24.2	24.3	-0.1
Modesto	9.97	9.98	-0.01	29.1	29.2	-0.1
Merced-M	8.61	8.61	0.00	27.4	27.8	-0.1
Manteca	7.97	7.98	-0.01	25.8	25.8	0.0
Tranquility	5.54	5.55	-0.01	16.2	16.3	-0.1

In both 2020 and 2024, the modeled air quality impact of reducing ROG emissions by 30 percent falls under U.S. EPA's recommended thresholds at all sites.

For completeness, CARB staff repeated this analysis, applying instead the recommended upper bound of a 70 percent reduction to ROG emissions in 2020 and 2024, as shown in Tables 13 and 14.

Table 13. Future Year 2020 PM$_{2.5}$ – 70 Percent ROG Reduction

	Annual			**24-Hour**		
Site	**2020 Baseline DV**	**2020 DV with 70% ROG Reduction**	**Difference**	**2020 Baseline DV**	**2020 DV with 70% ROG Reduction**	**Difference**
Bakersfield-Planz	14.58	14.51	0.07	41.2	40.3	1.0
Madera	14.15	14.09	0.06	38.9	38.3	0.6
Hanford	13.30	13.40	-0.10	43.7	43.5	0.2
Visalia	13.51	13.40	0.11	42.8	41.3	1.5
Clovis	13.43	13.27	0.16	41.1	40.4	0.7
Bakersfield-California	13.48	13.44	0.04	47.6	47.2	0.5
Fresno-Garland	12.42	12.29	0.13	44.3	43.5	0.8
Turlock	12.47	12.43	0.04	37.8	37.5	0.2
Fresno-HW	11.86	11.71	0.15	45.6	44.6	1.0
Stockton	11.43	11.41	0.02	33.5	33.2	0.3
Merced-S Coffee	10.86	10.85	0.01	30.0	29.8	0.1
Modesto	10.97	10.95	0.02	35.8	35.6	0.2
Merced-M	9.34	9.30	0.04	32.9	32.9	0.1
Manteca	8.67	8.64	0.03	30.1	29.8	0.3
Tranquility	6.40	6.41	-0.01	21.5	21.7	-0.2

In 2020, the modeled air quality impact of reducing ROG emissions by 70 percent falls under U.S. EPA's recommended annual threshold at all sites, and under the recommended 24-hour threshold at all sites but one.

Table 14. Future Year 2024 PM$_{2.5}$ – 70 Percent ROG Reduction

	Annual			**24-Hour**		
Site	**2024 Baseline DV**	**2024 DV with 70% ROG Reduction**	**Difference**	**2024 Baseline DV**	**2024 DV with 70% ROG Reduction**	**Difference**
Bakersfield-Planz	12.03	11.94	-0.03	30.0	30.3	-0.5
Madera	11.98	12.01	-0.03	30.2	30.4	-0.3
Hanford	10.52	10.70	-0.18	30.1	31.1	-1.0
Visalia	11.09	11.11	-0.02	30.2	30.7	-0.5
Clovis	11.37	11.29	0.08	30.7	30.7	0.0
Bakersfield-California	11.01	10.94	-0.04	33.3	34.0	-0.9
Fresno-Garland	10.43	10.37	0.06	32.8	33.0	-0.2
Turlock	11.14	11.19	-0.05	30.2	30.5	-0.3
Fresno-HW	10.02	9.95	0.07	35.1	35.2	-0.1
Stockton	10.66	10.67	-0.01	28.6	28.7	-0.1
Merced-S Coffee	9.65	9.69	-0.04	24.2	24.5	-0.3
Modesto	9.97	9.99	-0.02	29.1	29.3	-0.2
Merced-M	8.61	8.60	0.01	27.4	27.7	-0.3
Manteca	7.97	7.98	-0.01	25.8	25.9	-0.1
Tranquility	5.54	5.57	-0.03	16.2	16.6	-0.4

In 2024, the modeled air quality impact of reducing ROG emissions by 70 percent falls under U.S. EPA's recommended thresholds at all sites.

Conclusion

CARB has followed U.S. EPA guidance to evaluate whether ROG contributes significantly to $PM_{2.5}$ levels that exceed the NAAQS. Using sensitivity-based analysis in the base and future years, CARB determined that emissions of ROG do not contribute significantly to $PM_{2.5}$ levels that exceed the 1997, 2006, or 2012 NAAQS in the area. Therefore, CARB has excluded ROG from control requirements in the SIP.