South Coast AQMD

APPENDIX VI

Precursor Demonstration

Table of Contents

Introduction

Fine particulate matter (PM2.5) is composed of particles that are both directly emitted, such as soot and dust, or formed as a result of secondary reactions between atmospheric chemicals. The United States Environmental Protection Agency (U.S. EPA) identifies four gaseous species as precursors of PM2.5 due to their participation in reactions resulting in secondary PM2.5 formation: oxides of nitrogen (NOx), oxides of sulfur (SOx), volatile organic compounds (VOCs), and ammonia (NH3).

As a part of the EPA's PM2.5 State Implementation (SIP) Requirements Rule (PM2.5 Rule)[1], these four precursor pollutants are subject to PM2.5 SIP planning requirements. The PM2.5 Precursor Demonstration Guidance [2] (Guidance) permits air agencies to "submit an optional precursor demonstration designed to show that for a specific PM2.5 nonattainment area, emissions of a particular precursor from sources within the nonattainment area do not or would not contribute significantly to PM2.5 levels that exceed" the national ambient air quality standards (NAAQS). 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."

The following contains demonstrations that two PM2.5 precursors, SOx and VOCs do not contribute significantly to ambient PM2.5 levels that exceed the 2012 annual PM2.5 standard in the South Coast Air Basin (Basin) and therefore, South Coast Air Quality Management District (AQMD) is requesting for exclusion from certain control requirements specified in the Clean Air Act (Act). The other two precursors, NOx and NH3, are significant precursors to annual PM2.5 in the Basin and are consequently not included in this demonstration.

The contents of the demonstration are as follows: 1) An overview of EPA guidelines surrounding the PM2.5 precursor demonstration is provided, and it includes the introduction of modeling methods, the calculation of the PM2.5 design value, 2) and an overview of the concentration- and sensitivity-based analyses which serve as the basis of the precursor demonstration. 2) The methodology behind the calculation of contribution thresholds, originally outlined by the U.S. EPA, is described. Following this methodology, the calculations of a confidence interval and contribution threshold specific to the Basin are outlined. And the alternative contribution threshold calculated for the Basin is discussed. 3) The results of precursor demonstration relative to the alternative contribution threshold is presented. Furthermore, the concentration- and sensitivity-based analyses are discussed.

[1] PM25 NAAQS Final SIP Requirements Rule July 2016 | US EPA. Available at: https://www.epa.gov/pm-pollution/pm25-naaqs-final-sip-requirements-rule-july-2016

[2] PM2.5 Precursor Demonstration Guidance, May 2019. Available at: https://www.epa.gov/sites/default/files/2019-05/documents/transmittal_memo_and_pm25_precursor_demo_guidance_5_30_19.pdf

U.S. EPA PM2.5 Precursor Demonstration Guidance

The Guidance, finalized by the U.S. EPA in May 2019, is available to "assist air agencies who may wish to submit PM2.5 precursor demonstrations." The Guidance provides recommendations or guidelines, as authorized under the Act, "that will be useful to air agencies in developing the precursor demonstrations by which the U.S. EPA can ultimately determine whether sources of a particular precursor contribute significantly to PM2.5 levels that exceed the standard in a particular nonattainment area." The recommendations encompass methods for modeling the essential analysis and establishing thresholds for assessing how a precursor affects PM2.5 levels.

Following the Guidance, the following precursor demonstration analyzes "the relationship between precursor emissions and the formation of secondary PM2.5 components" using an air quality model and take into consideration additional relevant factors. The following features two PM2.5 precursors: VOCs and SOx emissions in the South Coast Air Basin. The Guidance outlines a process for conducting the precursor demonstration, which comprises an initial analysis based on concentration, followed by a sensitivity analysis, and the addition of supporting information that complements the sensitivity-based analysis.

The purpose of the precursor demonstration is to determine the presence or absence of significance corresponding to the contribution of a given PM2.5 precursor to PM2.5 levels. The U.S. EPA defines significance in terms of a contribution threshold, a mathematically determined cutoff derived using an approach similar to that used for the Significant Impact Level (SIL) developed in the Prevention of Significant Deterioration (PSD) memorandum.[3] Discussions of significance and the development of SILs are based on an understanding of the inherent variability of regional air quality arising from changes in meteorological conditions. Consequently, in the context of PM2.5 precursors, when observing changes in air quality, small changes – defined as those lower than the SIL – are considered insignificant, as their contributions are lower than the day-to-day variability in air quality in a given region.

The Guidance recommends using a contribution threshold based on nationwide data, as well as the statistical methodology behind its calculation. However, it specifically states that "if the estimated air quality impact is greater than or equal to the recommended contribution threshold, this fact would not necessarily preclude approval of the precursor demonstration". The U.S. EPA allows air agencies to submit additional information regarding other pertinent factors they deem relevant for assessing whether the contribution of emissions of a particular precursor to levels that exceed the NAQQS is "significant" or not. The significance of a precursor's contribution is to be determined "based on the facts and circumstances of the area".

[3] PM2.5 Precursor Demonstration Guidance, May 2019. Available at: https://www.epa.gov/sites/default/files/2019-05/documents/transmittal_memo_and_pm25_precursor_demo_guidance_5_30_19.pdf

The emissions inventory, air quality modeling system and design values (DV) employed for this precursor demonstration are identical to those used in the rest of the PM2.5 plan. While a brief description of emissions inventory and modeling configuration are provided in this section, details are available in Chapters 3 and 5 of the PM2.5 plan and Appendices I and II.

Emissions Inventory and Air Quality Modeling

The emissions inventory consists of stationary sources and mobile sources. Stationary sources are divided into two major subcategories: point sources and area sources. Point sources are permitted facilities with one or more emission sources at an identified location (e.g., power plants, refineries, and industrial processes factories) and subject to Annual Emission Report (AER) program[4]. These facilities generally have annual emissions of 4 tons or more of either VOCs, NOx, SOx, or PM, or annual emissions of over 100 tons of CO. Facilities are required to report their emissions of criteria pollutants and selected air toxics pursuant to Rule 301 to the South Coast AQMD on an annual basis, subject to audit, if any of these thresholds are exceeded. The 2018 annual reported emissions are used to update the stationary source inventory.

Area sources consist of many small emission sources (e.g., residential water heaters, architectural coatings, consumer products, and permitted sources that are smaller than the above thresholds) which are distributed across the basin and are not required to individually report their emissions. CARB and the South Coast AQMD jointly develop emission estimates for approximately 400 area source categories. Emissions from these sources are estimated using the latest activity information and representative emission factors if available. Activity data are usually obtained from survey data or scientific reports, e.g., U.S. Energy Information Administration (EIA) reports for fuel consumption other than natural gas fuel, natural gas consumption data from Southern California Gas Company (SoCalGas), and solvent, sealant and architectural coatings sales reports required under the South Coast AQMD Rules 314, 1113 and 1168. Some activity data, such as population, housing, and vehicle miles travelled (VMT), as well as a large portion for area sources are from SCAG. Emission factors are based on rule compliance factors, source tests, manufacturer's product or technical specification data, default factors (mostly from AP-42, the U.S. EPA's published emission factor compilation), or weighted emission factors derived from point source facilities' annual emissions reports. Additionally, emissions over a given area may be calculated using socioeconomic data, such as population, number of households, or employment in different industry sectors.

Mobile sources consist of two subcategories: on-road sources and off-road sources. On-road vehicle emissions were calculated with CARB's EMFAC2021 model and travel activity data provided by SCAG from their adopted 2020 RTP/SCS. EMFAC2021 calculates exhaust and evaporative emission rates by vehicle type for different vehicle speeds and environmental conditions. Temperature and humidity profiles are used to produce monthly, annual, and episodic inventories. Emission rate data in EMFAC2021 is collected from various sources, such as individual vehicles in a laboratory setting, tunnel studies, and certification

[4] https://www.aqmd.gov/home/rules-compliance/compliance/annual-emission-reporting

data. The EMFAC2021 model incorporates recently adopted regulations, such as Advanced Clean Trucks (ACT),[5] and Heavy-Duty Low NOx Omnibus Regulations. EMFAC2021 does not incorporate Heavy-Duty Inspection and Maintenance (I/M) Regulation, because this regulation was approved after the development of EMFAC2021. However, the effect of Heavy Duty I/M is incorporated in this plan as an external adjustment to EMFAC2021 emissions.

Emissions from off-road vehicle categories are primarily based on estimated activity levels and emission factors using a suite of category-specific models or the OFFROAD2007 model where a new model was not available. Separate models have been developed for estimating emissions from different categories of off-road mobile sources. The emissions presented here are consistent with the off-road emissions developed for the 2022 AQMP, except for a small change in construction equipment emissions. After the development of the 2022 AQMP, an error was discovered in the emission allocations for in-use emissions from off-road construction equipment in Riverside County. This error only affected future year emissions and is now corrected.

The emissions obtained from the above were used as inputs to calculate pollutant concentrations. Pollutant concentrations were calculated using the U.S. EPA-supported Community Multiscale Air Quality (CMAQ) (version 5.3.3) model, with chemistry input from the Statewide Air Pollution Research Center (SAPRC) 07 chemistry and the Weather Research and Forecasting (WRF) (version 4.4.2) model supplying meteorology data. The modeling platform tracks primary pollutants directly emitted that includes precursors of ozone and particulate matter (PM2.5) and the formation of secondary pollutants like ozone and particles formed from the chemical reactions that occur in the atmosphere. The PM2.5 simulations spanned an entire year, from January to December, using meteorological conditions from 2018. The simulations were conducted over an area with a western boundary over 100 miles west of the Ports of Los Angeles and Long Beach. The eastern boundary extends slightly beyond the Colorado River while the northern and southern boundaries of the domain extend to the San Joaquin Valley and the Northern portions of Mexico, respectively. CMAQ was simulated with a 4-kilometer grid resolution.

PM2.5 concentrations were simulated with CMAQ for the base 2018 and the attainment year, 2030.The modeling setup for 2030 remains consistent with the attainment scenario outlined in Chapter 5, with the exception of increased ammonia and NOx emissions by 9 and 4 tons per day, respectively. These adjustments were made to rectify technical errors identified in earlier emissions scenarios. This simulation is referred as 2030 Reference Scenario in this Appendix. These adjustments are not anticipated to alter the precursor sensitivities discussed in this Appendix. Figure VI-1 provides the PM precursors as well as direct emitted PM2.5 emission over the South Coast Air Basin in 2018 and in the attainment year, 2030. For reference, the 2023 baseline (business-as-usual) emission inventory is also provided in the plot.

Future growth projections were based on demographic growth forecasts for various socioeconomic categories (e.g., population, housing, employment by industry) developed by SCAG for their 2020 RTP/SCS. Industry growth factors for 2030 were also provided by SCAG. Table VI-1 summarizes key socioeconomic parameters used in emissions inventory development.

TABLE VI-1
BASELINE DEMOGRAPHIC FORECASTS

Category	2018	2030	2030 % Growth from 2018
Population (Millions)	16.7	18.0	7.9
Housing Units (Millions)	5.3	6.0	11.7
Total Employment (Millions)	7.7	8.3	7.3
Daily VMT (Millions)	388	395	1.8

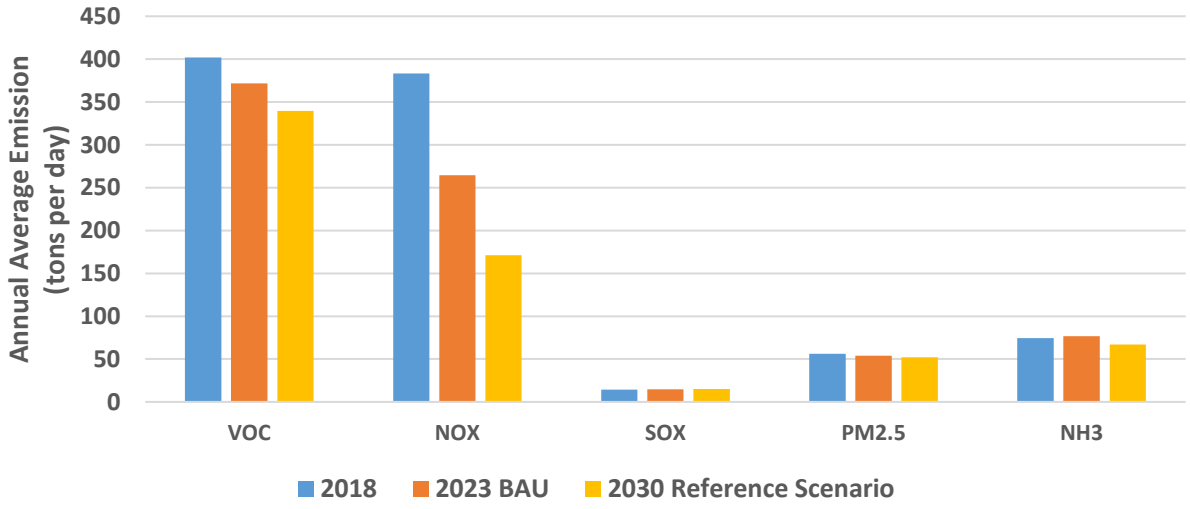

FIGURE VI-1
SOUTH COAST AIR BASIN TOTAL VOC, NOX, SOX, PM2.5, AND NH3 EMISSIONS IN 2018, 2023 BASELINE (BAU), AND 2030 REFERENCE SCENARIO

The air quality modeling platform utilized in this precursor demonstration is the same modeling platform used for the PM2.5 plan. This modeling platform underwent comprehensive model evaluation against available meteorological and air quality measurements at monitoring sites. The WRF model effectively captures synoptic flows, daily land-sea breezes, and mountain-valley circulations. Crucial meteorological parameters for air quality modeling, such as ground temperature, relative humidity, and wind speed, closely align with observed data. The CMAQ model simulates seasonal variations and diurnal changes in PM mass across the basin adequately, albeit with underestimations in the San Fernando region and overestimations in the Foothills and Urban source regions. Additionally, the CMAQ model generally

reproduces the spatial distribution of PM species, exhibiting higher levels of nitrate and organic matter for receptors in urban areas compared to inland stations. Refer to Appendix II of this Plan for further details on model performance evaluation.

Design Values

The PM2.5 annual DV for a specific year is determined by averaging the annual PM2.5 concentrations over a three-year period that includes the given year and the two preceding years. However, U.S. EPA guidance on modeling the attainment demonstration[1] recommends using a 5-year weighted DV centered on the base year selected for the attainment demonstration as the modeling Base Design Value (DVB). This 5-year weighted average approach recommended by EPA is to reduce year-to-year variability compared to a single 3-year DV. In the context of this plan, the DVB for each monitoring station is calculated as the average of the DVs for 2018 through 2020 (denoted as DV 2018, DV 2019, and DV 2020 in Figure VI-2). This calculation covers a 5-year period from 2016 through 2020, centered at the base year 2018. Under certain circumstances, the U.S. EPA allows modification of DVB calculation, such as in the case of exceptional events. Figure VI-2 presents the U.S. EPA-recommended DVB calculation on the left. The 2020 DV calculation includes the year 2020, which was marked by several extraordinary events that significantly altered PM2.5 concentrations in the basin. These events include the COVID-19 pandemic and subsequent changes in human activity, and record-setting wildfires. Thus, this precursor demonstration uses a modified DVB for 2018 that excludes the 2020 DV from DVB calculations and replaces it with the average of 2018 and 2019 annual means (Figure VI-2, right). In addition, exceptional events on July 4 and 5 due to Fourth of July fireworks are also excluded.

2018 Base Design Value (DVB)

DV 2018	DV 2019	DV 2020
2016-2018	2017-2019	2018-2020

$$\text{Average = DVB} = \frac{(DV\ 2018) + (DV\ 2019) + (DV\ 2020)}{3}$$

2018 Base Design Value (DVB)

DV 2018	DV 2019	DV Modified
2016-2018	2017-2019	2018-2019

$$\text{Average = DVB} = \frac{(DV\ 2018) + (DV\ 2019) + (\frac{Avg2018 + Avg2019}{2})}{3}$$

FIGURE VI-2

PM2.5 5-YEAR WEIGHTED AVERAGE FOR 2018 BASE DESIGN VALUE

Precursor Demonstration Methods

EPA's Guidance allows for two types of analyses to be used as a part of a precursor demonstration:

1. The **concentration-based** analysis is the initial required step in the precursor demonstration. The goal of the concentration-based analysis is to analyze the contribution of SOx and VOC to overall PM2.5 DVs, through the use of ambient data and, optionally, air quality modeling. The following demonstration estimates the contribution of precursors to overall PM2.5 DVs based on speciated measurements during the period of 2017-2019. This approach is consistent with the speciation used in the attainment demonstration in the Draft PM Plan. The contribution of individual precursor was evaluated with a concentration-based analysis using ambient data to determine whether precursor emissions contribute to total annual PM2.5 concentrations.

2. The **sensitivity-based analysis** is an optional analysis that may be necessary should the concentration-based analysis fail to demonstrate that a precursor does not significantly contribute to PM2.5 DVs. In contrast to the concentration-based analysis, which reports the direct contributions of precursors to PM2.5 DVs, the sensitivity-based analysis reports the changes in PM2.5 DVs in response to a decrease in precursor emissions. If reductions scenarios show that a pre-specified percentage drop in precursor concentrations results in a change in DV that is less than the contribution threshold, then the contribution of these reductions can be deemed non-significant. The U.S. EPA recommends multiple percentage emissions reductions sensitivities in the range of 30-70 percent precursor reductions, with a strict recommendation of keeping percent reductions above 30 percent. In light of U.S. EPA's recommendations, we conducted a sensitivity analysis of SOx and VOC emissions, testing reductions of 30 and 50 percent. Emission reductions are applied to all anthropogenic emissions throughout the Basin, including emissions over water up to 100 nautical miles from the shore.

This demonstration follows the EPA-approved methodology previous employed in the San Joaquin Valley SIP revision.[5] The sensitivity-based analysis is focused on the future year 2030 DVs. To estimate future PM2.5 DVs, the U.S. EPA recommends the use of relative response factors (RRF). In this approach, future year concentration predictions require two elements: base year (2018) DVs and RRFs. The RRF is simply a ratio of the future year predicted air quality to the simulated air quality in the base year, representing the model predicted change in air quality in response to predicted emissions changes. For the annual PM2.5 attainment demonstration, base year and future modeled concentrations are calculated as a quarterly average of a 3-by-3 grid centered at each station for each specific component. The ratio of base to future year quarterly mean concentrations for each component is the RRF for that component. Future year DVs were calculated using species- and site-specific RRFs by the corresponding quarterly DVs. The total future

[5] Precursor demonstration for the 1997 Annual PM2.5 Standard for the San Joaquin Valley, available at: https://ww2.valleyair.org/media/3cme1oo5/chapter-4-precursor-demonstration.pdf. U.S. EPA proposed the approval of the precursor demonstration (88 FR 45276)

quarterly values at each site are then calculated by adding all the individual components and the blank and the four quarterly average concentrations are then averaged at each site to determine the future annual DVs.

The Guidance allows air agencies to conduct precursor demonstration modeling to illustrate that precursor emissions do not significantly contribute to PM2.5 concentrations in nonattainment areas, "either in a base year or a future year". Following the precursor demonstration included in the San Joaquin Valley SIP revision for the 1997 annual PM2.5 standard[6], this demonstration conducted a sensitivity analysis using projected emissions for 2030, the future attainment year. The projected emissions for 2030 encompass measures from the 2022 AQMP/SIP that can be implemented by 2030, as detailed in the attainment control strategy presented in Chapter 4 of this Plan. Using 2030 as the reference year for the precursor demonstration is justified because emission levels for PM2.5 precursors in 2030 are closer to the emission levels in 2023, the conditions during the development of this Plan, than to the emission levels in 2018 (as shown in Figure VI-1). Although 2023 is closer to 2018 than to 2030, emission inventories indicate that between 2018 and 2023, the South Coast Air Basin experienced a sharper yearly decline in PM2.5 precursor emissions compared to the period from 2023 to 2030. The average NOx emission decrease rate is 24 tons per year during the years 2018 to 2023, compared with 13 tons per year during 2023 to 2030. The reduction in PM2.5 precursor emissions is primarily driven by cleaner vehicles and equipment, resulting in corresponding declines in NOx emissions, which are already in place and will continue to decrease with defined stationary and mobile control measures included in the 2022 AQMP/SIP and CARB's 2022 State SIP Strategies[7] and this Plan. In addition, with the expected rapid change of baseline NOx emissions over the basin in coming years, the atmospheric chemistry conditions in modeling base year 2018 may not be representative at the 2030 attainment year nor in the future beyond that. Model response in the 2030 attainment year provides a more realistic assessment of the potential impact of PM precursors controls than transient current conditions.

The sensitivity-based analysis is based on the sensitivity of PM2.5 DVs to reductions of 30-50 percent in the PM2.5 precursor emissions. The results of the sensitivity-based analyses for SOx and VOC emission reductions are discussed in following sections.

[6] *Ibid*.

[7] 2022 State Strategy for the State Implementation Plan, available at: https://ww2.arb.ca.gov/sites/default/files/2022-08/2022_State_SIP_Strategy.pdf.

Development of Contribution Threshold for Annual PM2.5 in South Coast Air Basin

This section describes the calculation of a contribution threshold that is specific to the South Coast Air Basin. Past Federal Reference Method (FRM) 24-hour PM2.5 data are first used to calculate a bootstrapped confidence interval for DVs and then this confidence interval is used to calculate the contribution threshold using only observations from monitors within the Basin.

Calculation of Bootstrapped Confidence Interval

The FRM 24-hour PM2.5 data (with likely exceptional events removed) are used to calculate the confidence interval in the region. DV periods each include three consecutive years (with exceptions[8]) and labeled with the last year of the three-year period. The DV periods used in this analysis are: 2017, 2018, 2019, 2020, 2019, 2021, and 2022. The data from each single year are grouped by quarter (i.e., Jan-Mar as Q1, Apr-Jun as Q2, Jul-Sep as Q3, and Oct-Dec as Q4). Bootstrap re-sampling with replacement using the Matlab function "bootstrp" is performed on the individual quarter 20,000 times, following the U.S. EPA recommendation in the Technical Basis for the EPA's Development of the Significant Impact Thresholds for PM2.5 and Ozone[9] (Technical Basis) to ensure the stability of all the cases, and the default seed was chosen to allow the repeatability of resampling results. Each resampling dataset keeps the original data size and is then averaged to obtain the quarterly mean. For example, if Q1 has 80 samples, Q2 has 86 samples, Q3 has 91 samples and Q4 has 85 samples, then for Q1, 20,000 new sample datasets, Q1(1), Q1(2), Q1(3), …, Q1(20,000), each with 80 measurements of PM2.5 are sampled with replacement from the original dataset Q1. A similar process is applied to the other three quarters, resulting in 20,000 datasets of Q2 with 86 samples in each set, 20,000 datasets of Q3 with 91 samples in each set and 20,000 datasets of Q4 with 85 samples in each set. The 20,000 averaged $\overline{Q1}$, $\overline{Q2}$, $\overline{Q3}$, and $\overline{Q4}$ are then calculated respectively and rounded to the hundredth µg/m3 (i.e., two decimal places).

The quarterly means are further averaged to obtain the annual mean. The same calculations are also applied on the other two years in the defined DV period. The DV for the annual PM2.5 NAAQS were then computed as the average of the three annual means and rounded to the tenth µg/m3 (i.e., one decimal place) for the defined DV period. This process is consistent with the annual PM2.5 DV calculation and yields 20,000 resampling DV values. To determine the confidence interval (CI) from these 20,000 DVs, the

[8] Exceptional events include exceedances caused by Independence Days fireworks for all years, 2017 Thomas Fire, 2018 Woolsey Fire, 2018 Camp Fire, 2020 Bobcat and El Dorado Fires, 2020 long range transport of wildfire smoke from Central and Northern California, 2020 Blue Ridge and Silverado Fires, and the 2020 Airport and Bond Fires. To ensure that the contribution threshold is not biased high from exceptional events, these days are removed for the contribution threshold calculation.

[9] Technical Basis for the EPA's Development of the Significant Impact Thresholds for PM2.5 and Ozone. April 2018. Available at: https://www.epa.gov/sites/default/files/2018-04/documents/ozone_pm2.5_sils_technical_document_final_4-17-18.pdf

DV are ranked from low to high. According to the Technical Basis, "*the lower bound for the 50 percent CI is the 5000th ranked DV, and the upper bound for the 50 percent CI is the 15,000th ranked DV. That is, the CI are determined simply by ranking the resulting distribution of DVs and the (1-q) percent CI for the mean is the bounds of the center of the data that contains q percentage of the results (i.e., the lower bound is the (q/2) percentile and the upper bound is the (1-q/2) percentile).*" We used the MATLAB function "prctile" to determine the 50 percent CI for the threshold contribution calculation.

Calculation of Contribution Threshold

Based on the definition of contribution threshold, (i.e., the SIL defined in the Technical Basis), "the median variability from the 50 percent CI from the entire US ambient monitoring network is used to calculate SIL values" and then "a representative value can be multiplied by the level of that NAAQS to obtain a value in concentration units" where "variability" and "representative value" both refer to the relative variability. Relative variability is defined as "the difference between the bounds of the bootstrapped CI and the actual design value for a single monitoring site, divided by the actual design value for the site". To develop the contribution threshold for the Basin, CI values from all 17 sites (see Table VI-6) with regulatory monitoring data in the Basin are used. For each DV period, 17 relative variabilities for 17 FRM sites can be obtained, and median value of relative variabilities is chosen to avoid the interference of extreme values in the calculation. The contribution threshold values for the Basin are calculated using three approaches:

1. Take the average of the median relative variability in the three most recent DV periods as recommended by the U.S. EPA, i.e., 2018-2020, 2019-2021 and 2020-2022 for most sites and 2017-2019, 2018-2020, and 2019-2021 for the four sites containing PM2.5 monitors that were temporarily or permanently discontinued in 2022.
2. Take the average of the median relative variability for the DV periods used in the 2018 base year, i.e., 2016-2018, 2017-2019, and 2018-2019 in the Basin. Note that in this approach, the 2018-2019 DV period only includes two years due to the unrepresentative and anomalous emissions in 2020.
3. Take the average of all the DV periods from 2015 to 2022.

The mean values from these three methods are multiplied by the annual PM2.5 NAAQS (12.0 µg/m^3) to obtain a value in concentration units (i.e., µg/m^3 for PM2.5), respectively.

Results

Figure VI-3 shows that the annual median relative variability for all the sites in the Basin are consistently higher than the national relative variability (1.66 percent), which is likely due to the large range (difference between highest and lowest concentration) of PM2.5 variation in the Basin. For example, the observed ranges at the Compton and Long Beach-Route 710 Near Road sites – both situated near a major roadways – both exceed 100 µg/m^3 (Table VI-2), which may be due to various factors including emissions, meteorological conditions and terrain characteristics in the area. It is also noted that the relative variability for the Big Bear site is much higher with a mean value of 6.9 percent compared with other sites,

but it decreases to 5.3 percent for the DV period of 2020-2022. The sampling frequency at Big Bear was one in 6-day sampling until 2021 and changed to everyday sampling in 2022 (Table VI-3). The Technical Basis shows the relationship between the sampling frequency and relative variability, suggesting that a low sampling frequency usually leads to high variability. Based on the analysis, the variability pattern at Big Bear may be related to its sampling frequency. The decreasing variability from 4.2 percent to 2.3 percent is also found at the Compton site, corresponding to the change of sampling frequency from one-in-three-day to everyday sampling in 2019.

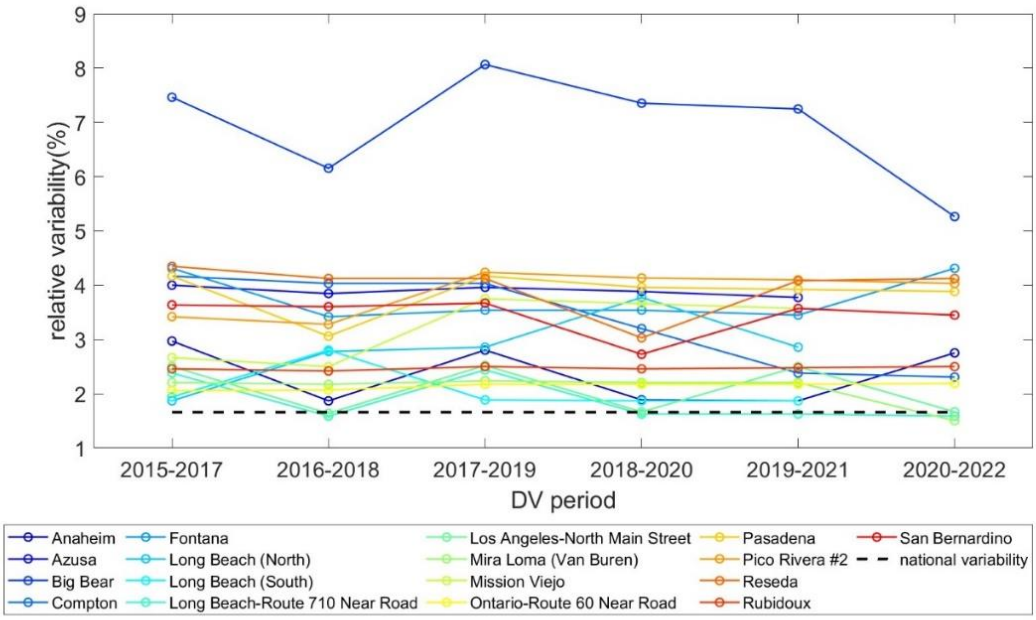

FIGURE VI-3

ANNUAL RELATIVE VARIABILITY FOR ALL THE 17 SITES IN THE JURISDICTION AS WELL AS THE NATIONAL VARIABILITY (1.66 PERCENT) REPORTED IN THE TECHNICAL BASIS

TABLE VI-2

STATISTICAL OVERVIEW OF OBSERVATION FOR 17 SITES (NOT BOOTSTRAPPING RESULTS) IN THE BASIN

Station	Count	Mean	Standard Error	Standard Deviation	Variance	Min	Max	Range
Anaheim	2819	10.5	0.1	6.2	37.9	1.2	63.1	61.9
Azusa	832	10.3	0.2	6.2	38.6	0.7	61.9	61.2
Big Bear	743	7.5	0.2	5.0	25.4	0.3	39.4	39.1
Compton	1824	12.5	0.2	7.5	56.8	1.5	102.1	100.6
Fontana	922	11.4	0.2	6.4	41.4	0.1	55.1	55.0
Long Beach (North)	1778	10.7	0.1	6.2	37.9	1.9	79.6	77.7
Long Beach (South)	2505	10.6	0.1	6.1	37.8	1.1	77.3	76.2
Long Beach-Route 710 Near Road	2868	12.4	0.1	6.7	44.6	1.7	103.8	102.1
Los Angeles-North Main Street	2840	12.0	0.1	6.5	42.6	1.7	61.4	59.7
Mira Loma (Van Buren)	2830	13.4	0.1	7.9	61.6	0.1	86.0	85.9
Mission Viejo	1037	8.4	0.1	4.5	20.1	0.5	38.9	38.4
Ontario-Route 60 Near Road	2856	13.9	0.1	6.8	46.3	0.2	65.4	65.2
Pasadena	953	9.8	0.2	5.6	31.4	1.3	63.6	62.3
Pico Rivera #2	937	11.9	0.2	6.6	43.8	0.1	66.0	65.9
Reseda	916	9.5	0.2	5.4	29.1	0.6	55.5	54.9
Rubidoux	2875	12.0	0.1	6.9	47.9	1.2	82.0	80.8
San Bernardino	903	11.2	0.2	6.1	37.5	1.2	57.9	56.7

TABLE VI-3
NUMBER OF CREDIBLE SAMPLES (EXCLUDING LIKELY EXCEPTIONAL EVENTS) FOR EACH STATION FROM 2015 TO 2022

Station	2015	2016	2017	2018	2019	2020	2021	2022
Anaheim	295	349	364	363	364	355	364	365
Azusa	119	122	115	120	120	116	120	0
Big Bear	58	55	49	54	46	58	59	364
Compton	111	115	119	117	303	353	349	357
Fontana	113	110	118	110	114	117	120	120
Long Beach (North)	338	356	348	344	156	117	119	0
Long Beach (South)	347	350	363	362	362	357	364	0
Long Beach-Route 710 Near Road	336	361	362	359	365	356	365	364
Los Angeles-North Main Street	342	357	358	346	360	353	363	361
Mira Loma (Van Buren)	343	352	358	351	356	353	352	365
Mission Viejo	115	117	113	107	110	119	356	0
Ontario-Route 60 Near Road	338	361	357	358	364	356	362	360
Pasadena	118	119	121	121	118	117	119	120
Pico Rivera #2	117	120	118	114	118	114	122	114
Reseda	113	113	109	106	118	116	120	121
Rubidoux	341	357	364	364	364	357	364	364
San Bernardino	110	113	116	114	97	115	120	118

Figure VI-4 shows the contribution threshold for each DV period, i.e., the median variability × 12.0 µg/m^3, from 2015 to 2022. A linear regression is applied to the annual values. The coefficient of determination (R^2) of 0.62 and negative slope of -0.02 (not shown here) suggest that the annual variability exhibits a decreasing trend from 2015 to 2022 with relatively high confidence, similar to the national variation reported in the Technical Basis, which is also attributed to the change in sampling frequency. Note that this linear regression should not be used to extrapolate the contribution threshold beyond 2022 as there is no way to predict any future changes in sampling schedules, which could heavily influence the future slope.

The calculated contribution threshold is 0.3 µg/m^3 for the most recent three DV periods (Approach 1), 0.4 µg/m^3 for the 2018 base year (Approach 2) and 0.4 µg/m^3 for all the three-year DV periods from 2015 to

2022 (Approach 3). A contribution threshold of 0.4 µg/m^3 (Approach 2) is recommended for the PM2.5 precursor demonstration as the project is also based on the same DV periods.

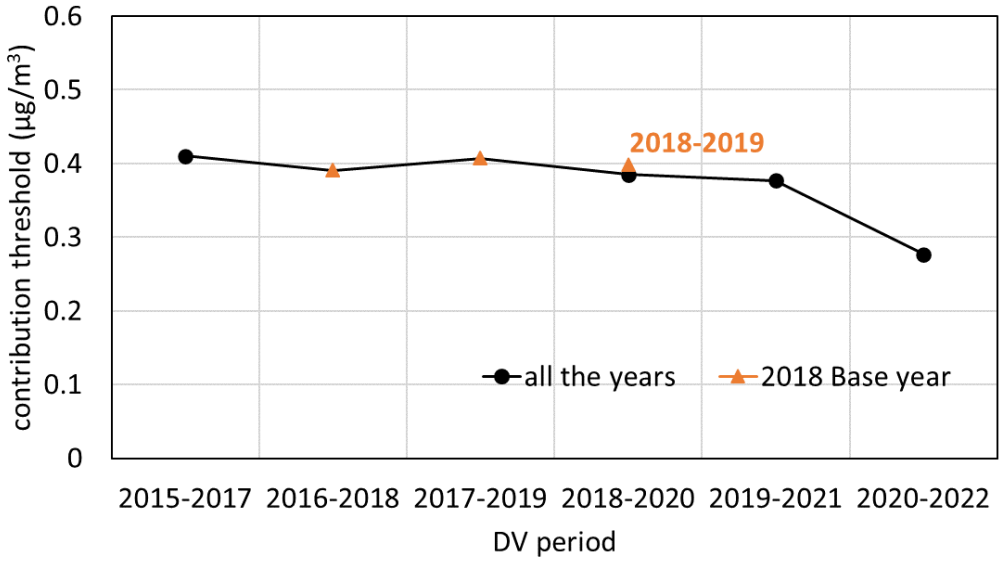

FIGURE VI-4
ANNUAL VARIATION OF THE CONTRIBUTION THRESHOLD (µG/M^3) FOR THE BASIN (17 SITES INCLUDED) FROM 2015 TO 2022. THE PERIODS INCLUDED IN THE 2018 BASE YEAR DESIGN VALUE (I.E., 2016-2018, 2017-2019 AND 2018-2019) ARE MARKED AS ORANGE TRIANGLES

Precursor Demonstration Results

Concentration-based Analysis

The contribution of individual precursor was evaluated with a concentration-based analysis using ambient data to determine whether precursor emissions contribute to total annual PM2.5 concentrations. Each precursor's impact on total PM2.5 mass is compared to contribution thresholds. As previously noted, the primary use of contribution thresholds is to generate a threshold that matches "the inherent variability in the measured atmospheric conditions." This demonstration defines the alternative contribution threshold for the South Coast Air Basin as 0.4 µg/m^3. This is driven from the data collected during 2016 to 2019, the same period used to estimate the weighted design values for the base year 2018, as described previous section.

Table VI-4 shows the speciation fractions of sulfate and organic carbon based on speciation measurements collected between 2017 and 2019. The chemical components are measured at four stations: Anaheim,

Central Los Angeles, Riverside and Fontana. Speciation for other stations is interpolated using inverse distance squared weighting. Table VI-5 shows speciated DVs for the base year 2018. The DVs are based on a modified 5-year weighted average from 2016 to 2019 (described in previous section), with speciation data based on measurements and interpolation from 2017 to 2019. Speciated values exceed the Guidance recommended contribution threshold of 0.4 μg/m^3. On the rightmost column of Table VI-5, VOC contributions to SOA formation were estimated by multiplying the contribution of organic carbon by 2/3.

TABLE VI-4

SPECIATION FRACTIONS FOR SULFATE AND ORGANIC CARBON FROM MEASUREMENTS DURING THE PERIOD 2017-2019. BASE YEAR DESIGN VALUES ARE IDENTICAL TO THOSE PRESENTED IN CHAPTER 5 OF THIS PLAN

Site	Sulfate	Organic Carbon	Base Year Design Value
Anaheim	10.2%	38.0%	10.54
Azusa	11.1%	37.1%	10.13
Big Bear	9.0%	34.9%	6.34
Central Los Angeles	10.7%	40.2%	11.96
Compton	9.9%	39.1%	12.25
Fontana	9.8%	33.9%	11.35
Long Beach Near Road	9.9%	38.8%	12.28
Long Beach	10.1%	38.3%	10.53
Mira Loma	9.3%	35.4%	13.52
Mission Viejo	10.4%	36.2%	7.95
Ontario Near Road	9.6%	34.9%	13.98
Pasadena	11.0%	39.3%	9.68
Pico Rivera	10.2%	38.6%	11.87
Reseda	10.7%	38.6%	9.73
Riverside	9.6%	36.9%	12.13
South Long Beach	9.9%	38.2%	10.57
San Bernardino	9.9%	35.5%	10.88

TABLE VI-5

DESIGN VALUES SHOWING CONTRIBUTION OF SOX (CENTER COLUMN) AND VOCS (RIGHT COLUMN) TO PM2.5 MASS DESIGN VALUE, BY SITE

Site	SOx contribution to PM2.5 design value (µg/m^3)	VOC contribution to PM2.5 design value (µg/m^3)
Anaheim	1.1	2.7
Azusa	1.1	2.5
Big Bear	0.6	1.5
Central Los Angeles	1.3	3.2
Compton	1.2	3.2
Fontana	1.1	2.6
Long Beach Near Road	1.2	3.2
Long Beach	1.1	2.7
Mira Loma	1.3	3.2
Mission Viejo	0.8	1.9
Ontario Near Road	1.3	3.3
Pasadena	1.1	2.5
Pico Rivera	1.2	3.1
Reseda	1.0	2.5
Riverside	1.2	3.0
South Long Beach	1.1	2.7
San Bernardino	1.1	2.6

This concentration-based analysis, however, does not accurately capture the impact of reductions of precursor emissions on PM2.5 levels. Since the concentration-based analysis shows the precursors contribute to total PM2.5 mass in amounts over U.S. EPA's recommended thresholds, a sensitivity-based analysis is conducted to demonstrate that reductions of SOx and VOCs would not significantly contribute to PM2.5 concentrations, and consequently, that SOx and VOC can be excluded from SIP planning requirements.

Sensitivity-based Analysis

With regards to the South Coast Air Basin, Table VI-6 lists the monitoring sites in the Basin alongside their baseline 2018 and 2030 DVs. As shown in Table VI-6, five out of 17 sites in the area had DVs over the 12 µg/m^3 annual standard. The Guidance suggests focusing on the sites that fail to reach attainment in the precursor demonstrations. Therefore, this sensitivity-based analyses focus strictly on these five sites.

TABLE VI-6

BASELINE PM2.5 DESIGN VALUES (µG/M^3) FOR YEARS 2018 AND 2030. THE FIVE SITES EXCEEDING 12 µg/m^3 IN 2018 ARE BOLDED

Site	2018 DV (µg/m^3)	2030 Reference Scenario DV (µg/m^3)
Anaheim	10.54	9.70
Azusa	10.13	9.03
Big Bear	6.34	5.60
Los Angeles	11.96	10.76
Compton	**12.25**	**11.08**
Fontana	11.35	9.77
Long Beach Near Road	**12.28**	**11.11**
Long Beach	10.53	9.55
Mira Loma	**13.52**	**11.74**
Mission Viejo	7.95	7.18
Ontario Near Road	**13.98**	**12.11**
Pasadena	9.68	8.75
Pico Rivera	11.87	10.73
Reseda	9.73	8.56
Riverside	**12.13**	**10.60**
South Long Beach	10.57	9.60
San Bernardino	10.88	9.37

Sulfur Dioxide Analysis

SOx are emitted from stationary and mobile combustion sources, predominantly in the form of SO_2. Petroleum refining, ocean going vessels, aircrafts and on-road vehicles are among the largest contributors. Once emitted into the atmosphere, SOx compounds are oxidized into sulfuric acid (H_2SO_4), which then forms ammonium sulfate ($(NH_4)_2SO_4$) after reacting with NH_3. Ammonium sulfate is in particulate form, thus making SOx a particulate matter precursor.

The contribution of SOx to annual PM2.5 was tested by reducing basin-wide SOx emissions in 2030 by 30 and 50 percent. Table VI-7 lists the DVs projected for 2030, as well as modeled PM2.5 DVs under the 30 and 50 percent SOx reduction scenarios. The difference between the 2030 DV and the two design values (shown in parentheses) represents the modeled impact on PM2.5 levels of 30-50 percent reduction in SOx emissions in 2030. This is the value that is compared to the contribution threshold. As shown in Table VI-7, the difference remains below the Guidance recommended contribution threshold of 0.2 µg/m^3.

The precursor demonstration modeling shows disbenefit from SOx controls at some sites for annual PM2.5 DV (e.g. Mira Loma and Riverside). The nonlinear response of PM2.5 mass to SOx emission reductions in specific locations within South Coast Air Basin may be attributed to the competition of

sulfate (SO4) and nitrate (NO3) for available ammonium (NH4) to form particulates of ammonium nitrate (NH4NO3) or ammonium sulfate ($(NH_4)_2SO_4$). Given the one-to-one combination ratio for NH4NO3 compared to the two-to-one ratio for $(NH_4)_2SO_4$, reducing one unit of SOx would reduce one unit of $(NH_4)_2SO_4$, but it free two units of ammonium that could form two units of NH4NO3, resulting in a net increase of PM2.5 mass.[10] The approved precursor demonstration for San Joaquin Valley SIP revision also discusses how the inorganic aerosol thermodynamic equilibrium module ISORROPIA used to model inorganic secondary PM2.5 in the CMAQ model may introduce nonlinearity for SOx reductions.[11]

TABLE VI-7

PM2.5 DESIGN VALUES FROM 2030 BASE CASE, 30 PERCENT, AND 50 PERCENT SOX REDUCTION SCENARIOS

Site	2030 DV	30 percent SOx reduction (difference)	50 percent SOx reduction (difference)	Significant Contribution
Compton	11.08	10.98 (0.10)	10.93 (0.15)	No
Long Beach Near Road	11.11	10.98 (0.13)	10.93 (0.18)	No
Mira Loma	11.74	11.77 (-0.03)	11.75 (-0.01)	No
Ontario Near Road	12.11*	12.07 (0.04)	12.04 (0.07)	No
Riverside	10.60	10.64 (-0.04)	10.62 (-0.02)	No

*This value represents RRF adjusted CMAQ predictions, not the final attainment demonstration

Consideration of Additional Information

To supplement modeling analysis, the Guidance allows agencies to consider additional information. South Coast AQMD has accordingly evaluated trends in SOx emissions to support the sensitivity-based analysis. Estimated SOx emissions (tons/day) by major source between 2018 and 2030, are shown in Figure VI-5. While there are small variations in sources contributing to SOx emissions, overall SOx emissions from the base year to 2030 remain flat. With marginal fluctuations in point source emissions, there is no discernable trend in SOx emissions, and overall, emissions are projected to stay constant.

As SOx requires the presence of NH3 to form secondary PM2.5, we also visualized trends in NH3 emissions across the same time period in Figure VI-6. Like SOx, relative levels of ammonia remain similar through

[10] West, J.J. Ansari, A.S. Pandis, S.N., 1999. Marginal PM2.5: Nonlinear aerosol mass response to sulfate reductions in the eastern United States, Jounrnal of the Air & Waste Management Association, 49, 1415-1424. http://doi.org/10.1080/10473289.1999.10463973.

[11] Precursor demonstration for the 1997 Annual PM2.5 Standard for the San Joaquin Valley, available at: https://ww2.valleyair.org/media/3cme1oo5/chapter-4-precursor-demonstration.pdf. U.S. EPA proposed the approval of the precursor demonstration (88 FR 45276)

the attainment year. The largest contributor to NH3 is the emissions from human and animal perspiration that is not controllable. However, the strategy to attain the 2015 8-hour ozone in 2037 requires economywide transition to zero emission technology, which will result in substantial reductions in all pollutants including NH3. The SOx and NH3 emissions ensure that no significant changes are expected in their contribution to future annual PM2.5 levels, and therefore, SOx is expected to be insignificant to annual PM2.5 in the South Coast Air Basin.

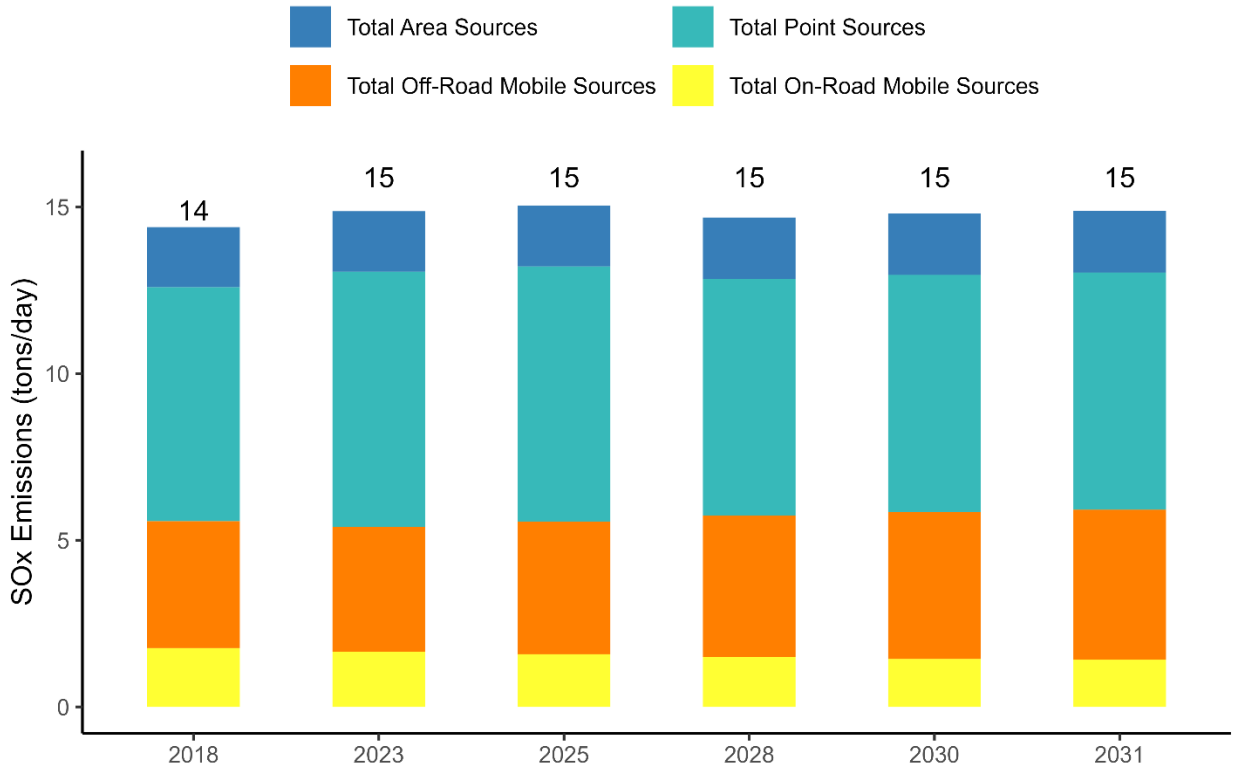

FIGURE VI-5
SOX EMISSION (TONS/DAY) TREND, BY SOURCE, IN THE SOUTH COAST AIR BASIN BETWEEN 2018 AND 2031

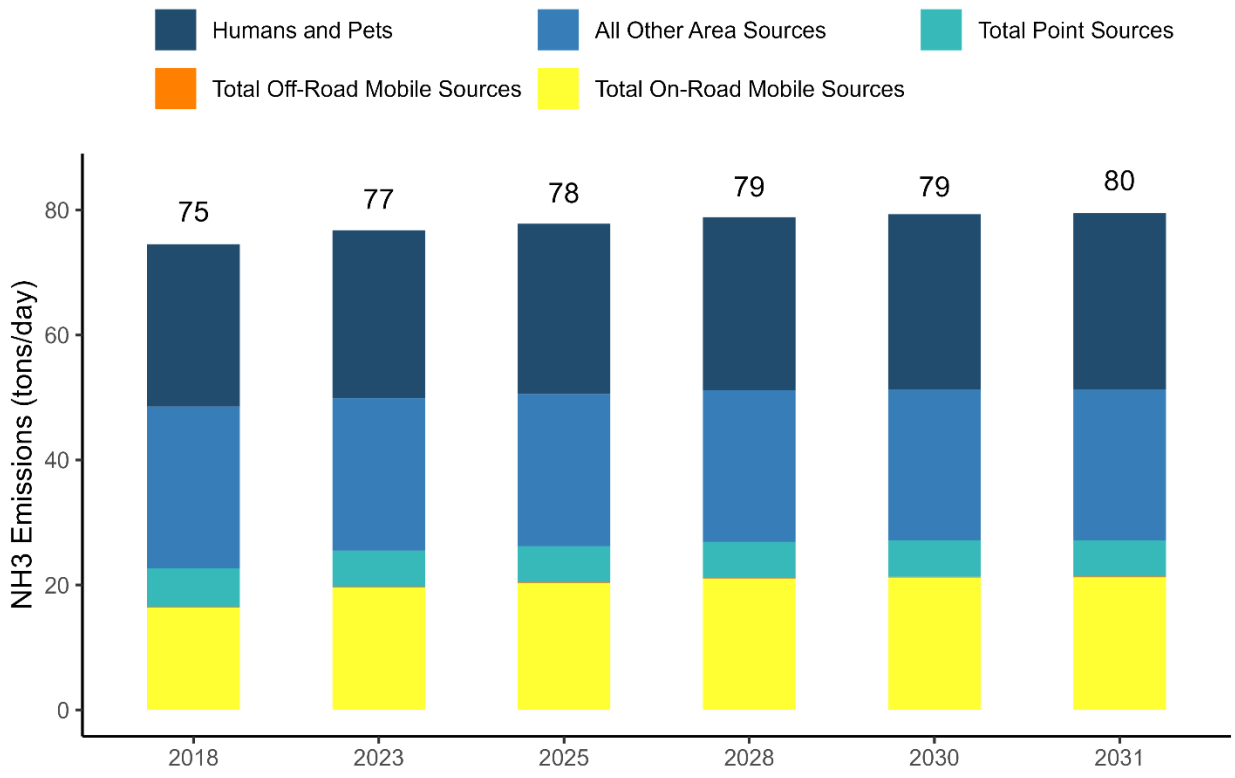

FIGURE VI-6
NH3 EMISSIONS (TONS/DAY) TREND, BY SOURCE, IN THE SOUTH COAST AIR BASIN BETWEEN 2018 AND 2031

Volatile Organic Carbon Analysis

Formation of secondary organic aerosols (SOA) strongly depend on the presence of VOCs, making VOCs a potentially important precursor to PM2.5. VOC contribution to annual PM2.5 is tested by reducing basin-wide VOC emissions in 2030 by 30 and 50 percent. Table VI-8 lists the DVs projected for 2030, as well as modeled PM2.5 DVs under 30 and 50 percent VOC reduction scenarios. The difference between the 2030 DV and the two design values (shown in parentheses) represents the modeled impact on PM2.5 levels of 30-50 percent reduction in VOC emissions in 2030. This is the value that is compared to the contribution threshold. As shown in Table VI-8, the difference remains below the Guidance recommended contribution threshold of 0.2 µg/m^3 for most sites, except for the case of a 50 percent reduction in VOCs at the Long Beach Near Road site, where the contribution to the annual DV is 0.22 µg/m^3. While this value is slightly above the contribution threshold of 0.2 µg/m^3, it is lower than the alternative contribution threshold of 0.4 µg/m^3 that is calculated for the South Coast Air Basin (as described in previous section). Even if the contribution threshold is calculated with more recent observational data, this contribution threshold is 0.3 µg/m^3 (shown in Figure VI-4), which is higher than the VOC contribution at the Long Beach Near Road

site. Furthermore, the Guidance does not definitively state whether a single monitor recording above the contribution threshold implies significance of the precursor.

Similar to the SOx demostration, the CMAQ model shows disbenifit for VOC controls on annual PM2.5 DV at specific locations (e.g. Mira Loma and Riverside) with 30 percent VOC control across the basin. The reduction of VOCs under different NOx conditions may trigger various chemical reaction regimes, thus yielding different responses to PM2.5 formation. Decreasing VOC emissions in NOx-saturated environments reduces oxidant levels, subsequently lowering sulfate and organic aerosols. However, in NOx lean environments, such as the 2030 attainment year utilized in this analysis, VOC reduction can produce negative feedback, leading to an increase in the OH radical concentration and thus accelerated VOC oxidation. Consequently, due to this negative feedback effect, VOC emission reduction becomes less effective in reducing aerosol mass.[12]

TABLE VI-8

PM2. DESIGN VALUES FROM 2030 BASE CASE, 30 PERCENT, AND 50 PERCENT VOC REDUCTION SCENARIO

Site	2030 DV	30 percent VOC reduction (difference)	50 percent VOC reduction (difference)	Significant Contribution
Compton	11.08	10.97 (0.11)	10.89 (0.19)	No
Long Beach Near Road	11.11	10.96 (0.15)	10.89 (0.22)	No (30 precent) Yes (50 percent)
Mira Loma	11.74	11.77 (-0.03)	11.73 (0.01)	No
Ontario Near Road	12.11*	12.08 (0.03)	12.03 (0.08)	No
Riverside	10.60	10.63 (-0.03)	10.60 (0.00)	No

*This value represents RRF adjusted CMAQ predictions, not the final attainment demonstration

Consideration of Additional Information

As shown in Figure VI-7, VOC emissions are projected to decrease between 2018 and 2030, with major reductions from on-road and off-road emissions. The biggest reductions are projected to occur between 2018 and 2023 driven by the reductions in mobile sources. Area sources such as consumer products are tied with population growth. However, regulations on stationary and mobile sources are expected to compensate the growth, leading to overall reductions in total VOC emissions. VOC emissions are projected

[12] Alexandra P. Tsimpidi, Vlassis A. Karydis & Spyros N. Pandis (2008) Response of Fine Particulate Matter to Emission Changes of Oxides of Nitrogen and Anthropogenic Volatile Organic Compounds in the Eastern United States, Journal of the Air & Waste Management Association, 58:11, 1463-1473, DOI: 10.3155/1047-3289.58.11.1463

to decline from 402 tons per day in 2018 to 344 tons per day in 2030. This reduction represents a decrease of 15 percent in VOC emissions. While the contribution of VOCs to annual PM2.5 levels are less than significant, these reductions will further assure improvement of annual PM2.5 levels in the Basin.

Another approach to justify that VOC is not a significant precursor is demonstrating reasonable VOC controls would not advance the attainment date for annual PM2.5. The 2030 baseline design value at Mira Loma is predicted to be 12.5 µg/m³, necessitating an improvement exceeding 0.45 µg/m³ for attainment. However, with only a 0.01 µg/m³ response resulting from a 50 percent VOC reduction, the impact is deemed inconsequential. In addition, achieving a 50 percent emission reductions from consumer products, one of the top three VOC source categories, is not feasible within next six years until 2030, as the development, production at a commercial scale, and distribution of such products require significant time. In the South Coast Air Basin, the top three sources of VOC emissions are Consumer Products (122 tons per day), Light and medium-duty Vehicles (45 tons per day), and Off-Road Equipment (29 tons per day) in 2030. 50 percent VOC reductions in the mobile source categories are infeasible within the next six years as well. in summary, VOC controls are not expected to advance attainment of the annual PM2.5 standard in the Basin.

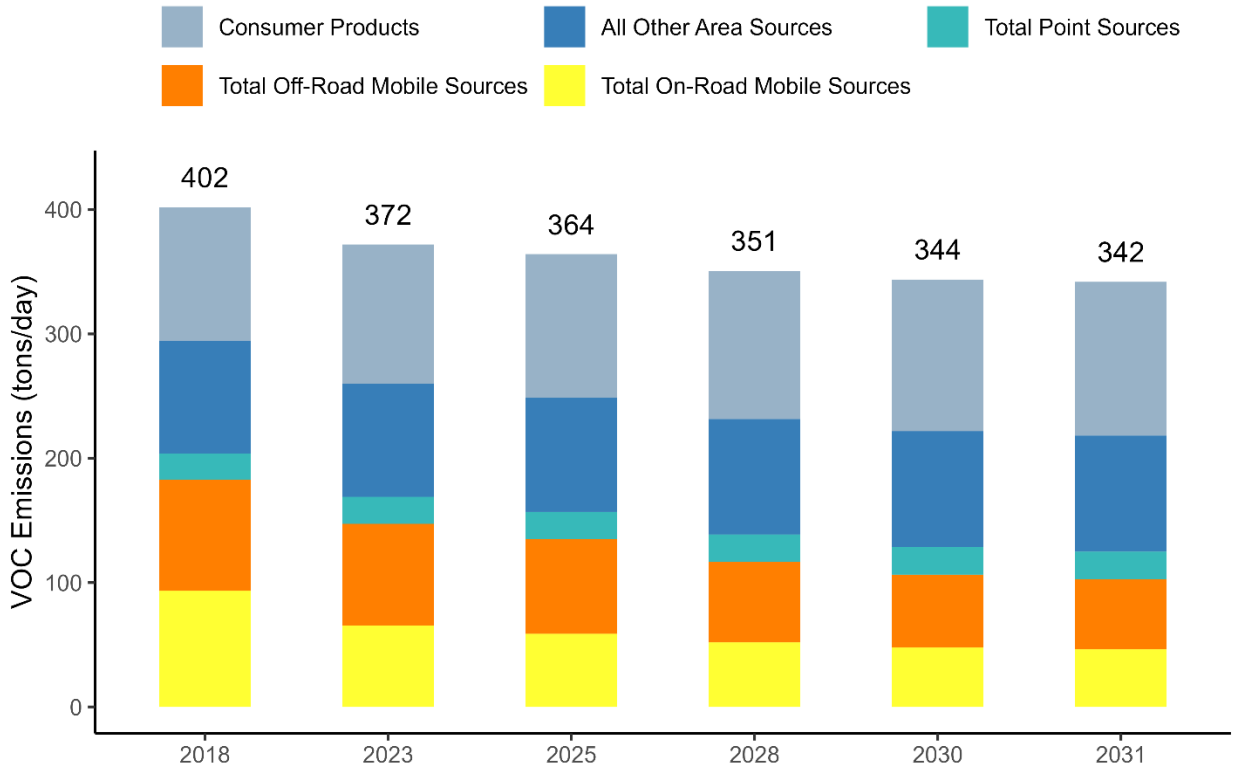

FIGURE VI-7
VOC EMISSION TREND, BY SOURCE, IN THE SOUTH COAST AIR BASIN BETWEEN 2018 AND 2031

Conclusion

This precursor analysis evaluated whether VOC and SOx emissions contribute significantly to annual PM2.5 levels that exceed the 12 µg/m^3 annual NAAQS following the U.S. EPA precursor demonstration guidance. The methodologies related to modeling and design value calculation are identical to those used in the rest of this Plan. In consideration of emission trends spanning between 2018 and 2030, which include existing regulations, adopted control measures and the control strategy in this PM2.5 plan, emissions levels in 2023, the time that this PM2.5 plan was under development, are more closely related to projected emissions in 2030 than to 2018. Emissions in the Basin decrease sharply from 2018 to 2023 and marginally slowed down afterwards. This trend is evident in both VOC and NOx emissions. Consequently, the sensitivity-based analysis included in this precursor demonstration is based on the 2030 emissions, because the chemical regime under the 2030 emissions is expected to be closer to current conditions than to the chemical regime caused by 2018 emissions.

It is noted that the variability in PM2.5 observed nationwide may not represent the conditions in the South Coast Air Basin accurately. The Guidance permits air agencies some discretion to develop precursor demonstrations that differ from the guidance on a case-by-case basis. Thus, this precursor demonstration derived a region-specific contribution threshold, applying the same methodology solely to monitors within the South Coast Air Basin. The contribution threshold specific to the Basin is 0.4 µg/m^3 if derived using the same years (2016 to 2019) utilized for design value this Plan, and it is 0.3 µg/m^3 if derived using more recent data. Thus, the contribution threshold for the Basin is higher than the threshold established nationally. The South Coast Air Basin exhibits distinctive atmospheric conditions owing to its complex terrain and diverse land use, ranging from dense urban clusters to inland residential areas and farmlands, further extending to the Coachella Valley near deserts. Some monitoring sites near coastal areas frequently experience impacts from emissions by ships, while two sites situated near busy major freeways are heavily influenced by on-road mobile sources. This suggests that the adoption of the nationwide contribution threshold may overestimate the significance of PM2.5 precursors in the basin. Calculating a value specific to the basin may better capture the local variability in PM2.5 concentrations.

The contribution of SOx and VOC emissions to PM2.5 concentrations were evaluated using concentration- and sensitivity-based methods. The concentration-based analysis shows that both precursors contribute to PM2.5 concentrations, with an impact that exceeds the contribution threshold. However, the concentration-based analysis does not measure the degree to which PM2.5 DVs would change in response to changes in precursor emissions. Therefore, the analysis was supplemented with a sensitivity-based analysis. The sensitivity analysis estimated changes in 2030 PM2.5 design values using the emissions and air quality modeling platform identical to the one used in the rest of this PM Plan. Precursor sensitivities were tested with 30 and 50 percent reductions of VOCs and SOx emissions to assess consequent changes to annual PM2.5 DVs. The sensitivity-based analysis showed that 30 and 50 percent reductions in SOx and VOC emissions fail to significantly impact annual PM2.5 DVs. Therefore, SOx and VOC are not significant precursors to annual PM2.5 in the South Coast Air Basin.