



2021 Annual Data Quality Report

California Air Resources Board's Primary Quality Assurance Organization

Monitoring and Laboratory Division
Quality Management Branch

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Acronyms

1-pt QC Check	One-Point Quality Control Check
AI	Insufficient Data
AN	Machine Malfunction
APCD	Air Pollution Control District
AQDA	Air Quality Data Action
AQMD	Air Quality Management District
AQS	Air Quality System
ARD	Air Resources District
BAM	Beta Attenuation Method
CAN	Corrective Action Notification
CARB	California Air Resources Board
CFR	Code of Federal Regulations
CL	Confidence Level
CO	Carbon Monoxide
CV	Coefficient of Variation
FEM	Federal Equivalent Method
FRM	Federal Reference Method
FRV	Flow Rate Verification
Hi-Vol	High Volume
ID	Industrial Monitor

Acronyms (cont.)

Low-Vol	Low Volume
mm	Millimeter
MO	Monitoring Organization
MQO	Measurement Quality Objective
m/s	Meters per second
NA	Not Applicable
NDA	No Data Available
NO ₂	Nitrogen Dioxide
OS	Operating System
O ₃	Ozone
Pb	Lead
PEP	Performance Evaluation Program
PM	Particulate Matter
PM _{2.5}	Particulate Matter with Aerodynamic Diameter ≤ 2.5 Micrometer
PM ₁₀	Particulate Matter with Aerodynamic Diameter ≤ 10 Micrometer
POC	Parameter Occurrence Code
ppb	Parts per Billion
ppm	Parts per Million
PQAO	Primary Quality Assurance Organization

Acronyms (cont.)

QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
SLAMS	State and Local Air Monitoring Station Network
SO ₂	Sulfur Dioxide
SPM	Special Purpose Monitors
STP	Standard Temperature Pressure
TEOM	Tapered Element Oscillating Microbalance
U.S. EPA	United States Environmental Protection Agency
µg/m ³	Microgram per Cubic Meter
VSCC	Very Sharp Cut Cyclone

Executive Summary

The Code of Federal Regulations (CFR) defines the California Air Resources Board (CARB) as one of seven Primary Quality Assurance Organizations (PQAO) in California responsible for monitoring air pollutants and assessing data quality. The purpose of this report is to provide ambient air quality data producers and users with a centralized review of the data quality within CARB's PQAO with respect to criteria defined by measurement quality objectives (MQO).

The MQOs reviewed include data capture (amount of ambient data reported), precision (the degree of mutual agreement among individual measurements of the same property), bias/accuracy (the degree of agreement between an observed value and an accepted known or reference value), and the amount of precision and bias/accuracy data collected and reported. The criteria by which the assessments are made are mostly dictated in CFR (1) and are listed in Appendices A-C of this report. Appendices D-E of this report provides details on the gaseous instruments/particulate matter (PM) samplers that did not meet certain criteria. The United States Environmental Protection Agency (U.S. EPA) has designated CARB, the Bay Area Air Quality Management District (Bay Area AQMD), South Coast Air Quality Management District (South Coast AQMD), San Diego County Air Pollution Control District (San Diego County APCD), National Park Service, Morongo Band of Mission Indians, and Pechanga Band of Luiseño Indians as their own PQAOs. This report focuses on four PQAOs (CARB, Bay Area AQMD, South Coast AQMD, and San Diego County APCD) which encompass most of the geographic area and population in the State. Where appropriate, results for CARB's PQAO are compared to results for these three other PQAOs and the nationwide average.¹ This assessment is solely based on data available in U.S. EPA's Air Quality System (AQS).

The gaseous criteria pollutants assessed include carbon monoxide (CO), nitrogen dioxide (NO₂), ozone (O₃), and sulfur dioxide (SO₂). The ambient data capture rate represents the percentage of ambient data collected and uploaded to AQS compared to the total amount of data possible. For gaseous pollutants, one-point quality control checks (1-pt QC check) are performed by the monitoring organizations to confirm the instrument's ability to respond to a known concentration of gas. Precision represents the degree of variability among the 1-pt QC checks. These checks are also used to assess bias/accuracy for each instrument by comparing the instrument response to a reference gas.

Precision for most PM (PM₁₀ and PM_{2.5}) samplers is assessed by collocated sampling where two identical or equivalent samplers are operated side-by-side.² Bias for PM samplers is assessed by using the routine flow rate verifications performed by site

¹ Nationwide average includes State, county, monitoring organization, National Park Service, and tribal sites, including those in California.

² Collocated sampling is required for all PM samplers, except continuous PM₁₀.

operators. Total PM_{2.5} bias for a PQAO is also assessed through the Performance Evaluation Program (PEP) audit administered by U.S. EPA.

Accuracy for both gaseous instruments and PM samplers is further verified by CARB's through-the-probe performance audits (CARB's performance audit) on gaseous instruments and flow rate audits on PM samplers (2). The ambient data capture rate and the accompanying precision and accuracy data for 2021 from both gaseous instruments and PM samplers are summarized below, followed with recommendations.³

The statistics provided in this report are intended as assessment tools for the data producers and users to identify areas where program improvements can be made to achieve all MQOs set by U.S. EPA or the data producers themselves. The 2021 ambient data in AQS for CARB's PQAO have been certified and are considered suitable for comparison to federal standards. Although CFR criteria for precision and accuracy are generally applied and evaluated at the PQAO level, assessments at the monitoring organization or site level may differ and can be important as well. When certain CFR criteria are not met, it does not necessarily mean that the corresponding air quality data cannot be used, but rather, the data could be used with the knowledge of the quality behind it.

As all data in this report come from AQS, data producers are encouraged to review their monitoring networks to ensure data accurately reflects the number of operational sites and instruments/samplers operating and all required ambient, precision, and accuracy data collected are continually reported to AQS in a timely manner (within 90 days of the end of each quarter, per CFR).

Gaseous Instruments

Key findings and recommendations pertaining to gaseous instruments are highlighted below.

Findings

- Ninety-one percent of the gaseous instruments operating within CARB's PQAO achieved the ambient data capture rate of at least 75 percent in 2021, with 86 percent also achieving CARB's goal of at least 85 percent data capture.
- Ninety-four percent of the gaseous instruments operating within CARB's PQAO reported at least 75 percent of the required 1-pt QC checks submitted to AQS. Additionally, most met the revised critical criteria (for percent and absolute difference) for individual 1-pt QC checks, set by U.S. EPA (3)(4).
- All California's PQAOs met annual CFR precision and bias/accuracy criteria (from 1-pt QC checks)

³ CARB continued limited audit operations and PM laboratory support in early parts of 2021, due the COVID-19 pandemic and following 2020 guidance on priorities from U.S. EPA and Governor Newsom's regional stay-at-home order.

- Data from CARB’s performance audits of O₃ instruments indicate that on average, except for a few instruments, CARB’s PQAO met the audit criteria. This is consistent with bias information obtained from 1-pt QC checks.

Recommendations

- Although MQOs associated with the gaseous instruments were met at the PQAO level, there were a few instances where instruments did not meet the MQO (e.g., ambient data capture rate, submittal of required 1-pt QC checks, etc.). Monitoring organizations should investigate why these objectives were not met for each instrument in their respective jurisdictions and develop corrective actions, if appropriate, to meet them in subsequent years.

PM Samplers

Key findings and recommendations pertaining to PM samplers are highlighted below.

Findings

- Ninety-two percent of the PM samplers operating within CARB’s PQAO achieved the ambient data capture rate of at least 75 percent in 2021, with 90 percent also achieving CARB’s goal of at least 85 percent data capture.
- As indicated in CARB’s Annual Network Plan (5), CARB’s PQAO continued meeting the minimum 15 percent collocation requirement.
- While precision completeness was met at the PQAO level, the CFR criteria of 10 percent coefficient of variation (CV) upper bound was not met for PM₁₀ or any method of PM_{2.5} for CARB, which is not an improvement compared to the previous year.
- Most PM₁₀ and PM_{2.5} samplers reported flow rate verification data to AQS, and the results indicate that the PM network exhibited low bias.
- The audit accuracy data indicates that CARB’s PQAO met CARB criteria for flow rate audits. This is consistent with bias information from the routine flow rate verification data.
- Total PM_{2.5} bias for CARB’s PQAO via PEP audits administered by U.S. EPA and based on limited mass samples, shows high bias, inconsistent with results determined by flow rate verification and flow rate audits. This high estimate for total bias may be due to the low number of valid samples collected in 2021 for CARB’s PQAO.

Recommendations

- In terms of precision, CV values among collocated PM_{2.5} samplers within CARB’s PQAO remain high in 2021. CARB explored potential causes behind low PM_{2.5} precision among some collocated PM_{2.5} samplers; however, no definitive source of the issue was identified. U.S. EPA is aware of the systemic issue of PM imprecision (in California and nationwide). The agency, in an attempt to remedy PM_{2.5} precision, proposed new statistics in its *Reconsideration of the National*

Ambient Air Quality Standards for Particulate Matter (19); public comments on the proposal were due March 28, 2023.

- There were instances of PM₁₀ and/or PM_{2.5} samplers not meeting the MQOs (e.g., ambient data capture rate, flow rate verifications, etc.). Monitoring organizations should investigate why these objectives were not met for each sampler in their respective jurisdictions and develop corrective actions, if appropriate, to meet them in subsequent years. An overall evaluation indicates that some PM-related issues within CARB's PQAO were due to resource constraints imposed by COVID-19 related restrictions. Overall, California's monitoring network as a whole performed exceptionally well despite the limitations during the COVID-19 pandemic in the first two quarters of 2021, as described in Appendix F of this report.

I. Introduction

The California Air Resources Board (CARB) is the governmental agency delegated under State law with the authority and responsibility for collecting ambient air quality data as directed by the federal Clean Air Act of 1977 and Clean Air Act Amendments of 1990 (7). CARB and local air pollution control agencies operate ambient monitoring stations throughout the State. As stated in the Code of Federal Regulations (CFR), the United States Environmental Protection Agency (U.S. EPA) has designated CARB, the Bay Area Air Quality Management District (Bay Area AQMD), South Coast Air Quality Management District (South Coast AQMD), San Diego County Air Pollution Control District (San Diego County APCD), National Park Service, Morongo Band of Mission Indians, and Pechanga Band of Luiseño Indians as their own Primary Quality Assurance Organizations (PQAO). This report focuses on the four PQAOs (CARB, Bay Area AQMD, South Coast AQMD, and San Diego County APCD) which encompass most of the geographic area and population in the State.

A PQAO is a monitoring organization, or a coordinated aggregation of such organizations that is responsible for a set of stations that monitors the same pollutants and for which data quality assessments can logically be pooled. Each criteria pollutant sampler/monitor at a monitoring station in the State and Local Air Monitoring Station (SLAMS) Network must be associated with one, and only one, PQAO.⁴

Factors defining a PQAO include:

- Operation by a common team of field operators according to a common set of procedures.
- Use of a common quality assurance project plan or standard operating procedures.
- Common calibration facilities and standards.
- Oversight by a common quality assurance organization.
- Support by a common management, laboratory, or headquarters.

The purpose of this report is to provide ambient air quality data producers and users with a centralized review of the data quality within CARB's PQAO. Specifically, data from instruments measuring gaseous criteria pollutants and particulate matter (PM) are compared to measurement quality objectives (MQO). Where appropriate, comparisons to the nationwide average⁵ and other PQAOs are also made.

⁴ Samplers may also be identified as Special Purpose Monitors (SPM) or industrial monitors. There are a limited number of SPM and industrial monitors in California. The statistics provided in this report are predominantly the result of SLAMS monitors but also include a small number of SPM and industrial monitors.

⁵ Nationwide average includes State, county, monitoring organization, National Park Service, and tribal sites, including those in California.

II. Quality Assurance

Quality assurance is an integrated system of management activities that involves planning, implementing, assessing, and assuring data quality through a process, item, or service that meets users' needs for quality, completeness, and representativeness. Known data quality enables users to make judgments about compliance with air quality standards, air quality trends, and health effects based on sound data with a known level of confidence.

Quality assurance is composed of two main activities: quality control (QC) and quality assessment (QA). QC is composed of a set of internal tasks performed routinely at the instrument level that ensures accurate and precise measured ambient air quality data. QC tasks address sample collection, handling, analysis, and reporting. Examples include calibrations, routine service checks, chain-of-custody documentation, duplicate analyses, development and maintenance of standard operating procedures, and routine preparation of QC reports.

QA is a set of external, quantitative tasks that provide certainty that the QC system is satisfactory and that the stated quantitative programmatic objectives for air quality data are met. Staff independent of data generators performs these external tasks, which include conducting regular performance audits, on-site system audits, inter-laboratory comparisons, and periodic evaluations of internal QC data.

The objective of quality assurance is to provide accurate and precise data, minimize data loss due to malfunctions, and to assess the validity of the air monitoring data to provide representative and comparable data of known precision and accuracy.

Precision is a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. It is a random component of error and is estimated by various techniques using some derivation of the standard deviation.

Bias is the systematic or persistent distortion of a measurement process which causes error in one direction. It is determined by estimating the positive and negative deviation from the true value as a percentage of the true value. When a certain bias is detected, the measurement process is said to be "inaccurate." The term "bias" is used to describe accuracy in CFR (1). In this report, the two terms are used interchangeably.

Precision is based on one-point quality control checks (1-pt QC check) for gaseous instruments and paired measurements from collocated samplers for PM. For precision, the statistic is the upper bound of the coefficient of variation (CV), which reflects the highest estimate of the variability in the instrument's measurements. The 1-pt QC checks for gaseous instruments are also used to estimate bias. For PM, bias can be estimated from flow rate verifications; however, only flow rate verifications from continuous PM₁₀ samplers are required to be uploaded to U.S. EPA's Air Quality System (AQS). Available tools for assessing precision and bias are summarized in Appendices A-C of this report, while details on cases where the criteria for precision or bias are not met can be found in Appendix E. Detailed descriptions of CV and the bias

estimator, including the formula behind each calculation, can be found in U.S. EPA guidance for the use of precision and bias data (11).

Accuracy of the instruments is further validated or assessed by CARB's through-the-probe performance audit (CARB performance audit) for gaseous pollutants or via the semi-annual flow rate audits for PM (2). Appendix C of this report lists CARB's audit performance criteria, which were developed to closely match the National Performance Audit Program (8).

Consistent with the goals of assessing precision and accuracy of the instruments and samplers, this report also assesses the amount of ambient air quality data produced by the instruments or samplers. Depending on the sampling frequency of each respective instrument or sampler, data capture is compiled as a percentage of the ambient data collected over the total amount of data possible.

Air Quality Data Actions (AQDA) are key tools used by the Quality Management Branch of CARB's Monitoring and Laboratory Division to identify and correct issues which would adversely affect the quality of the ambient data generated by the samplers. An AQDA is initiated by CARB auditors upon a failed audit. After an AQDA has been issued, an investigation into the causes of the failure will determine an outcome on the affected data. The data in question can be affected in three ways: released, corrected, or invalidated. Data that are released meet compliance criteria and can be used in all aspects of decision making. In some cases, data are flagged with qualifier codes as they are released. Corrected data pertains to when a calculated correction value is applied, rendering the data as meeting the established control criteria. Invalidated data are considered not for record, meaning the data set will not be utilized in any designation, enforcement, or regulatory decisions. As such, null codes are associated with invalidated data. Outside the AQDA process, data could also be flagged if monitoring organizations determine, and U.S. EPA concurs, the collected data were influenced by an exceptional or natural event. Additionally, there are informational flags that do not impact the usage of the data.

The implementation of a comprehensive corrective action system throughout CARB's PQAO is an essential component for improving data quality and facilitating continuous process improvement. The Corrective Action Notification (CAN) process documents issues that impact, or potentially impact, data quality, completeness, storage, or reporting (9). The goal of the CAN process is to investigate, correct, and reduce the recurrence of these issues. As such, the CAN process will identify issues not addressed by AQDAs, improve data quality, and help ensure compliance with State, federal, and local requirements.

CARB's Quality Assurance Program is outlined in a five-volume Quality Assurance Manual (10), which guides the operation of the quality assurance programs used by CARB, monitoring organizations, and private industry in California.

There are more than 220 (SLAMS and SPM) air monitoring sites among the four California PQAOs operating in 15 separate air basins in California. Within CARB's PQAO, there are 22 monitoring organizations operating sites under CARB's guidance.

Information about each air monitoring station audited by the Quality Management Branch is available online (2). As of 2020, CARB no longer audits gaseous instruments outside of its PQAO.

III. Data Quality – Statistical Summary Results

The results are presented for two groups of pollutants: gaseous and PM. For each group, the amount of ambient data collected (or captured) is discussed first, followed by an assessment of the quality behind the data. Statistical results presented in this report reflect the information in AQS as of November 2022, with the exception of 2021 data, which is also updated to reflect corrections of data quality issues noted in Appendix E of this report. Depending on the severity of the issues, a monitoring organization responsible for a correction might want to recertify the data already submitted through the formal process each year, along with proper justification for recertification. Often, these issues do not result in any regulatory impact, so they do not warrant the need for data recertification. Data for 2019 and 2020 directly reflect the current information in AQS, and as such, will reflect changes that occurred to past data since the 2020 Annual Data Quality Report (6) was prepared. For example, “begin” and “end” dates for monitors may have been corrected, and parameter or method codes may have been updated to reflect the correct status of monitors in AQS. These changes may result in 2019 or 2020 data that differ from those published in the 2020 Annual Data Quality Report.

A. Gaseous Pollutants

The gaseous criteria pollutants assessed in this report are carbon monoxide (CO), nitrogen dioxide (NO₂), ozone (O₃), and sulfur dioxide (SO₂).

Ambient Data Capture

Ambient data capture, as described in this report, is derived from the AQS completeness report AMP 430. The calculated number in AMP 430 represents the average of the monthly data capture rates for the calendar year and may not always be indicative of whether the 75 percent regulatory completeness requirement⁶ is met for a particular pollutant, considering the operational period in the year. While this report focuses on the federal requirement of a minimum data capture rate of 75 percent, CARB’s goal is to have at least 85 percent of the data in AQS.

Table 1 presents the percentage of instruments that reported at least 75 percent of the possible ambient data for each gaseous pollutant for each of the four PQAOs this report focuses on and the nationwide average. Many instruments within CARB’s

⁶ Ambient data from a given instrument or sampler must be at least 75 percent complete in a calendar year to be included in making regulatory decisions, e.g., attainment of National Ambient Air Quality Standards. California also defines data “completeness” using 75 percent. However, unlike the federal definition, California factors in the high season of the pollutant in the completeness criteria (e.g., only high O₃ months are considered for O₃ standard).

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PQAO reported at least 75 percent of the required ambient data in 2021, with some sites not achieving this objective due to resource constraints imposed by COVID-19 related restrictions. Details on CARB’s PQAO instruments not reporting ≥ 75 percent ambient data are provided in Appendices D-E of this report and details pertaining to COVID-19 related restrictions are provided in Appendix F. Information for years 2019 and 2020 is only provided for historical perspective.

Table 1. 2019-2021 Ambient Gaseous Pollutant Data Capture Results

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments Reporting $\geq 75\%$ Ambient Data Capture	Percent of Instruments Reporting $\geq 75\%$ Ambient Data Capture
CO	CARB	2021	19	13	68
		2020	18	18	100
		2019	18	17	94
	Bay Area AQMD	2021	16	16	100
		2020	16	16	100
		2019	16	16	100
	South Coast AQMD	2021	25	24	96
		2020	25	24	96
		2019	26	26	100
	San Diego County APCD	2021	2	2	100
		2020	2	2	100
		2019	2	2	100
Nationwide	2021	212	196	92	
	2020	207	199	96	
	2019	221	213	96	
NO ₂	CARB	2021	42	37	88
		2020	40	40	100
		2019	43	41	95
	Bay Area AQMD	2021	18	18	100
		2020	18	18	100
		2019	18	18	100
	South Coast AQMD	2021	29	29	100
		2020	29	29	100
		2019	28	28	100
	San Diego County APCD	2021	16	16	100
		2020	9	9	100
		2019	8	8	100
Nationwide	2021	385	366	95	
	2020	369	361	98	
	2019	369	354	96	

Table 1. 2019-2021 Ambient Gaseous Pollutant Data Capture Results (cont.)

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments Reporting $\geq 75\%$ Ambient Data Capture	Percent of Instruments Reporting $\geq 75\%$ Ambient Data Capture
O ₃	CARB	2021	99	95	96
		2020	100	95	95
		2019	100	92	92
	Bay Area AQMD	2021	20	20	100
		2020	20	20	100
		2019	20	19	95
	South Coast AQMD	2021	29	29	100
		2020	29	29	100
		2019	28	28	100
	San Diego County APCD	2021	7	7	100
		2020	7	7	100
		2019	7	7	100
Nationwide	2021	946	932	99	
	2020	927	910	98	
	2019	952	910	96	
SO ₂	CARB	2021	9	9	100
		2020	9	9	100
		2019	10	10	100
	Bay Area AQMD	2021	9	9	100
		2020	9	9	100
		2019	9	9	100
	South Coast AQMD	2021	5	5	100
		2020	4	4	100
		2019	5	5	100
	San Diego County APCD	2021	1	1	100
		2020	1	1	100
		2019	1	1	100
Nationwide	2021	312	302	97	
	2020	317	312	98	
	2019	329	320	97	

- Source: AQS, AMP 430 Data Completeness Report, run November 2022.
- Details on CARB's PQAO instruments not reporting $\geq 75\%$ ambient data are provided in Appendices D-E of this report.
- Nationwide average includes State, county, monitoring organization, National Park Service, and tribal sites, including those in California.
- Results reflect information in AQS from November 2022, including changes to past data since the 2020 Annual Data Quality Report (6). Therefore, results for 2019 and 2020 might differ from those in the 2020 Annual Data Quality Report.

Precision and Bias

The 1-pt QC checks are performed by monitoring organizations to confirm the instrument's ability to respond to a known concentration of gaseous pollutant. The degree of variability in each of these measurements is computed as the precision of that instrument's measurements. For precision, the statistic defined in CFR (1) is the CV upper bound, an upper confidence limit of the standard deviation of the differences between the instrument's response and the known concentrations, which reflects the highest tolerable variability in the data. This CV upper bound is not to exceed 7 percent for O₃, 10 percent for CO and SO₂, or 15 percent for NO₂.

The 1-pt QC checks are also used to estimate the bias inherent in the sampling system associated with each instrument. CFR (1) outlines how bias is calculated based on 1-pt QC checks for gaseous pollutants. The bias estimator is the upper bound on the mean absolute value of the percent differences between the instrument's response and the true value of a known gaseous concentration. A sign (positive or negative) is applied when the 25th and 75th percentiles are of the same sign. In other words, when at least 75 percent of the differences are all positive or negative, the bias estimate has a sign. Otherwise, the bias is denoted with "±." For bias, the CFR criteria are: ±7 percent for O₃, ±10 percent for CO and SO₂, and ±15 percent for NO₂. A detailed description of the bias estimator, including the formula behind its calculation, can be found in U.S. EPA guidance for the use of precision and bias data (11).

CFR requires 1-pt QC checks be performed at least once every two weeks on each automated instrument, which translates to a minimum of 26 checks per year for an instrument operating year-round. During data certification, U.S. EPA flags instruments that do not have at least 75 percent of the required 1-pt QC checks in AQS; thus, 75 percent is the criterion used in Table 2. A complete listing of all MQOs set forth by U.S. EPA can be found in CFR (1) and the QA handbook (12). Bias estimates are further verified via CARB's performance audits; details are in the Accuracy Validation via CARB's Performance Audits section of this report.

Table 2 shows CARB's PQAQO (as well as other California PQAQOs) met the precision and bias criteria in 2021 for gaseous pollutants required by CFR (CO, NO₂, O₃, and SO₂). Information for years 2019 and 2020 are provided for a historical perspective only. In general, 2021 precision data are consistent with those in the previous two years and the required number of 1-pt QC checks was achieved at most sites. Table 2 also includes the number of gaseous instruments with at least 75 percent of the required 1-pt QC check data reported for 2021.

In order to provide decision makers with data of known quality, U.S. EPA provides a web-based tool for assessing data quality in terms of three data quality indicators in graphical format. Graphs from a U.S. EPA precision and bias report (13) provide detailed information on precision (CV), bias, and the number of 1-pt QC checks performed at each monitoring station in a given year.

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Table 2. 2019-2021 Gaseous Instrument Precision and Bias Results

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments with $\geq 75\%$ of Required 1-pt QC Checks	Upper Bound of CV (Precision)	CFR Criteria for Precision Met?	Bias	CFR Criteria for Bias Met?
CO	CARB	2021	19	15	4.64	Yes	± 3.58	Yes
		2020	18	17	8.96	Yes	± 4.48	Yes
		2019	18	12	4.00	Yes	± 3.19	Yes
	Bay Area AQMD	2021	16	1	4.00	Yes	± 3.25	Yes
		2020	16	1	3.30	Yes	± 3.55	Yes
		2019	16	1	3.02	Yes	+3.64	Yes
	South Coast AQMD	2021	25	25	3.52	Yes	± 2.27	Yes
		2020	25	25	3.70	Yes	± 2.49	Yes
		2019	26	26	3.44	Yes	± 2.44	Yes
	San Diego County APCD	2021	2	2	2.41	Yes	± 1.89	Yes
		2020	2	2	2.87	Yes	± 2.34	Yes
		2019	2	2	2.90	Yes	± 2.59	Yes
Nationwide	2021	237	204	3.93	Yes	± 3.79	Yes	
	2020	221	194	3.82	Yes	± 3.71	Yes	
	2019	244	189	4.22	Yes	± 3.89	Yes	
NO ₂	CARB	2021	42	41	5.17	Yes	± 4.03	Yes
		2020	40	40	5.14	Yes	± 3.94	Yes
		2019	43	42	4.97	Yes	± 4.03	Yes
	Bay Area AQMD	2021	18	18	2.29	Yes	± 1.84	Yes
		2020	18	17	2.21	Yes	± 1.79	Yes
		2019	18	NDA	NDA	NDA	NDA	NDA
	South Coast AQMD	2021	29	29	4.23	Yes	± 3.44	Yes
		2020	29	29	4.68	Yes	± 3.74	Yes
		2019	28	28	5.64	Yes	± 4.04	Yes
	San Diego County APCD	2021	16	13	3.03	Yes	+3.64	Yes
		2020	9	9	4.18	Yes	± 3.22	Yes
		2019	8	8	4.52	Yes	± 3.48	Yes
Nationwide	2021	426	406	4.09	Yes	± 4.30	Yes	
	2020	417	397	4.17	Yes	± 4.34	Yes	
	2019	421	359	4.38	Yes	± 4.53	Yes	

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Table 2. 2019-2021 Gaseous Instrument Precision and Bias Results (cont.)

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments with $\geq 75\%$ of Required 1-pt QC Checks	Upper Bound of CV (Precision)	CFR Criteria for Precision Met?	Bias	CFR Criteria for Bias Met?
O ₃	CARB	2021	99	97	2.57	Yes	± 1.98	Yes
		2020	100	99	2.68	Yes	± 2.06	Yes
		2019	100	95	2.80	Yes	± 2.20	Yes
	Bay Area AQMD	2021	20	20	1.84	Yes	± 1.45	Yes
		2020	20	20	1.47	Yes	± 1.17	Yes
		2019	20	NDA	NDA	NDA	NDA	Yes
	South Coast AQMD	2021	29	29	1.68	Yes	± 1.31	Yes
		2020	29	29	2.22	Yes	± 1.68	Yes
		2019	28	28	2.18	Yes	± 1.98	Yes
	San Diego County APCD	2021	7	7	1.87	Yes	± 1.53	Yes
		2020	7	7	1.77	Yes	± 1.56	Yes
		2019	7	7	1.94	Yes	± 1.73	Yes
	Nationwide	2021	1,097	1,078	2.11	Yes	± 2.08	Yes
		2020	1,095	1,068	2.18	Yes	± 2.08	Yes
		2019	1,105	1,030	2.15	Yes	± 2.06	Yes
SO ₂	CARB	2021	9	8	3.65	Yes	± 3.22	Yes
		2020	9	9	3.50	Yes	± 2.52	Yes
		2019	10	10	3.10	Yes	± 2.81	Yes
	Bay Area AQMD	2021	9	2	2.34	Yes	± 1.82	Yes
		2020	9	1	2.02	Yes	+2.05	Yes
		2019	9	1	1.81	Yes	+2.12	Yes
	South Coast AQMD	2021	5	5	3.39	Yes	± 2.55	Yes
		2020	4	4	2.96	Yes	± 2.39	Yes
		2019	5	5	5.37	Yes	± 2.62	Yes
	San Diego County APCD	2021	1	1	3.29	Yes	-11.65	No
		2020	1	1	2.08	Yes	-7.83	Yes
		2019	1	1	2.44	Yes	-8.16	Yes
	Nationwide	2021	355	330	2.86	Yes	± 3.02	Yes
		2020	369	346	3.28	Yes	± 3.16	Yes
		2019	382	353	3.08	Yes	± 3.18	Yes

Table 2. 2019-2021 Gaseous Instrument Precision and Bias Results (cont.)

- Source: AQS, AMP 256 Data Quality Indicator Report, run November 2022.
- NDA means no data available in AQS.
- For Bay Area AQMD, some 2019 and 2020 1-pt QC checks performed outside of prescribed range indicated that data were of acceptable quality such that Bay Area AQMD certification was accepted by U.S. EPA. The 1-pt QC check levels were adjusted to meet the prescribed range for O₃ and NO₂ in mid- to late-2020 and for CO and SO₂ in mid-2021.
- Upper bound of CV (precision) is estimated by the upper confidence limit of the standard deviation of differences measured by 1-pt QC checks; CFR limits for CV: 7% for O₃, 15% for NO₂, 10% for CO and SO₂. Bias is estimated as the upper bound on the mean absolute value of the percent differences measured by 1-pt QC checks; CFR limits for bias: ±7% for O₃, ±15% for NO₂, ±10% for CO and SO₂.
- Details on CARB's PQAO instruments not meeting these criteria are provided in Appendices D-E of this report.
- Nationwide average includes State, county, monitoring organization, National Park Service, and tribal sites, including those in California. Discrepancies may exist in the Number of Instruments listed in Table 1 compared to Table 2 of this report due to different report sources (AMP 256 and AMP 430).
- Results reflect information in AQS, including changes to past data since the 2020 Annual Data Quality Report (6). Therefore, results for 2019 and 2020 might differ from those in the 2020 Annual Data Quality Report.

Assessment of Individual 1-pt QC Checks for Gaseous Pollutants

In March 2018, U.S. EPA revised QA Handbook Volume II, Appendix D, Measurement Quality Objectives and Validation Templates with updated criteria for assessing individual 1-pt QC checks. Many monitoring organization-operated sites perform more frequent 1-pt QC checks than required by U.S. EPA. Some exceedances are associated with ambient data being affected by issues identified through the AQDA process, separate from the individual 1-pt QC checks not meeting the criteria. Table 3 presents results on individual 1-pt QC checks at the PQAO level. Overall, 99.9 percent of 1-pt QC checks performed for CARB's PQAO in 2021 meet the criteria.

Table 3. 2021 1-pt QC Checks – Individual Assessment

Pollutant	PQAO	Number of Instruments	Number of 1-pt QC Checks Performed	Number of 1-pt QC Checks Meeting Criteria	Percent of 1-pt QC Checks Meeting Criteria (%)
CO	CARB	19	1,864	1,821	97.7
	Bay Area AQMD	16	2,041	2,039	99.9
	South Coast AQMD	25	8,750	8,671	99.1
	San Diego County APCD	2	593	593	100.0
NO ₂	CARB	42	9,019	9,018	99.9
	Bay Area AQMD	18	2,606	2,606	100.0
	South Coast AQMD	29	10,399	10,399	100.0
	San Diego County APCD	16	2,590	2,590	100.0
O ₃	CARB	99	19,503	19,503	100.0
	Bay Area AQMD	20	2,943	2,943	100.0
	South Coast AQMD	29	10,396	10,396	100.0
	San Diego County APCD	7	2,053	2,053	100.0
SO ₂	CARB	9	1,369	1,369	100.0
	Bay Area AQMD	9	1,325	1,325	100.0
	South Coast AQMD	5	1,707	1,705	99.9
	San Diego County APCD	1	296	296	100.0

- Source: AQS, AMP 251 QA Raw Assessment Report, run November 2022.
- Criteria for assessing individual 1-pt QC checks are as follows CO: < ±10.1 percent difference; NO₂: < ±15.1 percent difference or < ±1.5 ppb difference, whichever is greater; O₃: < ±7.1 percent difference or < ±1.5 ppb difference, whichever is greater; SO₂: < ±10.1 percent difference or < ±1.5 ppb difference, whichever is greater. Details on CARB's PQAO instruments not meeting these criteria are provided in Appendices D-E of this report.

Individual 1-pt QC checks are to be conducted within the prescribed ranges: 0.005 parts per million (ppm) to 0.08 ppm for NO₂, O₃, and SO₂; and 0.5 to 5.0 ppm for CO. Table 4 provides individual 1-pt QC checks conducted within the prescribed range for each PQAO and showcases the overall good reporting from all PQAOs. All monitoring organizations are reminded that the updates to AQS regarding 1-pt QC check requirements became effective on January 1, 2020. U.S. EPA also provided additional guidance and notification through webpages and newsletters (4)(14).

Table 4. 2021 1-pt QC Checks – Individual Assessment on Prescribed Range

Pollutant	PQAO	Number of Instruments	Number of 1-pt QC Checks Performed	Number of 1-pt QC Checks within Prescribed Range	Percent of 1-pt QC Checks within Prescribed Range (%)
CO	CARB	19	1,864	1,808	97.0
	Bay Area AQMD	16	2,041	156	7.6
	South Coast AQMD	25	8,750	8,725	99.7
	San Diego County APCD	2	593	593	100.0
NO ₂	CARB	42	9,019	9,014	99.9
	Bay Area AQMD	18	2,606	2,606	100.0
	South Coast AQMD	29	10,399	10,357	99.6
	San Diego County APCD	16	2,590	2,585	99.8
O ₃	CARB	99	19,503	19,455	99.8
	Bay Area AQMD	20	2,943	2,943	100.0
	South Coast AQMD	29	10,396	10,362	99.7
	San Diego County APCD	7	2,053	2,053	100.0
SO ₂	CARB	9	1,369	1,369	100.0
	Bay Area AQMD	9	1,325	772	58.3
	South Coast AQMD	5	1,707	1,697	99.4
	San Diego County APCD	1	296	296	100.0

- Source: AQS, AMP 251 QA Raw Assessment Report, run November 2022.
- Prescribed ranges: 0.005 ppm to 0.08 ppm for NO₂, O₃, and SO₂; and 0.5 to 5.0 ppm for CO. The 1-pt QC check gaseous concentration selected within the prescribed range should be related to the monitoring objectives for the monitor. If monitoring at an NCore site or for trace level monitoring, the 1-pt QC check concentration should be selected to represent the mean or median concentrations at the site. If the mean or median concentrations at trace gas sites are below the method detection limit of the instrument the monitoring organization can select the lowest concentration in the prescribed range that can be practically achieved. If the mean or median concentrations at trace gas sites are above the prescribed range the monitoring organization can select the highest concentration in the prescribed range.
- Bay Area AQMD 1-pt QC checks: some 2019 and 2020 1-pt QC checks performed outside of prescribed range indicated that the data were of acceptable quality such that Bay Area AQMD certification was accepted by U.S. EPA. The 1-pt QC check levels were adjusted to meet the prescribed range for NO₂ and O₃ in mid- to late-2020 and for CO and SO₂ in mid-2021.

Accuracy Validation via CARB's Performance Audits

To further validate bias estimates from QC checks, CFR (1) requires that independent performance audits be conducted and the average percent differences be evaluated against pre-determined criteria. Following Governor Newsom's regional stay-at-home order in December 2020, CARB focused on PM flow rate audits and a few O₃ audits during the first two quarters of 2021, before expanding to full operations for gaseous pollutants for the remainder of the year. See communication between CARB and U.S. EPA regarding limited operations due to COVID-19 restrictions in Appendix F of this report.

Table 5 summarizes the 2021 performance audit results for gaseous instruments. CARB's acceptance criteria for performance audits are: ± 10 percent for O₃ (with warning at ± 7 percent) and ± 15 percent for CO, NO₂, and SO₂ (with warning at ± 10 percent) for each audit point. CARB's objective is to audit all sites within its PQAO annually (2). PQAOs not part of CARB's PQAO are responsible for performing audits as part of an annual evaluation. Accuracy is represented as an average percent difference, which is the arithmetic mean of the combined differences from the known value of all the individual audit points over the range considered in the audits. Audit results show that, in general, all audited gaseous instruments met CARB criteria for bias at the PQAO level. A complete listing of CARB's performance audit criteria can be found in Appendix C of this report.

CARB's performance audit results of O₃ instruments and available data of other gaseous instruments in 2021 corroborate what the 1-pt QC checks revealed: that CARB's PQAO is providing accurate data for all gaseous pollutants. The average percent differences at the PQAO level were well below the audit criteria for all gaseous pollutants (± 10 percent for O₃, ± 15 percent for other gases). This is further strengthened by the small number of audited instruments that did not meet CARB's performance audit criteria. Lower and upper confidence limits represent the range of all audit results across each PQAO.

Table 5. 2021 Results for Performance Audits of Gaseous Instruments

Pollutant	PQAO	Number of Instruments	Number of Instruments Audited	Number of Audits Not Meeting CARB Criteria	Average Percent Difference* (%)	Confidence Limit	
						Lower	Upper
CO	CARB	19	15	4	-4.36	-8.69	9.09
	Bay Area AQMD	16	16	0	1.78	-6.43	8.10
	South Coast AQMD	25	24	1	4.27	-7.42	6.22
	San Diego County APCD	2	2	1	-0.18	-5.07	4.01
NO ₂	CARB	42	35	3	-4.20	-9.11	10.96
	Bay Area AQMD	18	18	0	-0.54	-4.08	4.71
	South Coast AQMD	29	29	1	-1.00	-7.21	9.21
	San Diego County APCD	16	10	1	-0.45	-2.64	9.01
O ₃	CARB	99	96	7	-2.72	-5.09	4.92
	Bay Area AQMD	20	20	0	-1.97	-3.69	3.40
	South Coast AQMD	29	29	1	2.62	-4.11	3.96
	San Diego County APCD	7	7	1	0.34	-3.90	3.27
SO ₂	CARB	9	6	1	3.62	-6.29	7.68
	Bay Area AQMD	9	9	0	-0.42	-4.80	4.09
	South Coast AQMD	5	5	1	1.43	-6.64	6.35
	San Diego County APCD	1	1	1	-6.07	-17.46	-5.24

- Source: AQS, AMP 256 Data Quality Indicator Report, run November 2022.
- Details on CARB's PQAO instruments not meeting these criteria are provided in Appendices D-E of this report. Only audits conducted by CARB were subject to the AQDA process.
- For 2021, CARB focused on PM flow rate audits only during the first two quarters of 2021 before expanding to full operations for gaseous pollutants for the remainder of the year. See communication between CARB and U.S. EPA regarding limited operations due to COVID-19 restrictions in Appendix F of this report.
- *Average percent difference is the arithmetic mean of the combined differences from the known value of all the individual audit points over the range considered in the audits.
- CARB's performance audit criteria for 2021 were: ± 10 percent for O₃ and ± 15 percent for CO, NO₂, and SO₂ for each audit point, with additional absolute differences in U.S. EPA lowest 2 audit levels (see Appendix C of this report for details). Since the two lowest audit points for trace CO and trace SO₂ are U.S. EPA audit levels 1 and 2, and the lowest audit point for O₃ is U.S. EPA audit level 2, they were not subject to the AQDA process and were excluded from this analysis.

B. Particulate Matter

PM monitoring is conducted using both manual and continuous type samplers. Manual samplers are operated on a daily, one-in-six-day, or one-in-three-day sampling schedule for PM₁₀, and a similar schedule for PM_{2.5}. Continuous samplers report hourly values.

Similar to the discussion of gaseous pollutants, ambient data capture is discussed first, followed with an assessment of the quality of the data captured.

Ambient Data Capture

Data capture, as described in this report, is derived from the AQS completeness report AMP 430. The calculated number in AMP 430 represents the average of the monthly data capture rates for the calendar year and may not always be indicative of whether the 75 percent regulatory completeness requirement⁷ is met for a particular pollutant. While this report discusses the data capture rate of at least 75 percent, CARB's goal is to have at least 85 percent of the data in AQS.

Table 6 presents the percentage of samplers that reported an ambient data capture rate of at least 75 percent for each PQAQ. As can be seen in this table, some PM samplers within CARB's PQAQ failed to report at least a 75 percent data capture rate for the indicated ambient PM data. Following Governor Newsom's regional stay-at-home order in December 2020, CARB continued limited laboratory support of only three selected sites critical for State Implementation Plan determinations into the first quarter of 2021. See communication between CARB and U.S. EPA regarding limited operations due to COVID-19 restrictions in Appendix F of this report. These reduced laboratory operations affected some of the data capture results for filter-based PM_{2.5}.

⁷ The ambient data from a given instrument or sampler must be at least 75 percent complete in a calendar year to be included in making regulatory decisions (e.g., attainment of National Ambient Air Quality Standards) (3). California also defines data "completeness" using 75 percent. However, unlike the federal definition, California factors in the high season of the pollutant in the completeness criteria (e.g., only high O₃ months are considered for O₃ standard).

Table 6. 2019-2021 Ambient PM Data Capture Results

Pollutant	PQAO	Year	Number of Samplers	Number of Samplers Reporting \geq 75% Data Capture	% of Samplers Reporting \geq 75% Data Capture
PM ₁₀	CARB	2021	97	94	97
		2020	98	95	97
		2019	100	99	99
	Bay Area AQMD	2021	7	7	100
		2020	8	8	100
		2019	8	8	100
	South Coast AQMD	2021	33	32	97
		2020	34	9	26
		2019	34	33	97
	San Diego County APCD	2021	4	4	100
		2020	4	4	100
		2019	4	4	100
Nationwide	2021	497	478	96	
	2020	507	458	90	
	2019	539	523	97	
PM _{2.5}	CARB	2021	95	82*	86
		2020	102	97	95
		2019	92	91	99
	Bay Area AQMD	2021	20	20	100
		2020	20	19	95
		2019	20	20	100
	South Coast AQMD	2021	32	32	100
		2020	33	33	100
		2019	31	31	100
	San Diego County APCD	2021	6	6	100
		2020	6	6	100
		2019	5	5	100
Nationwide	2021	1,105	1,051	95	
	2020	1,121	1,023	91	
	2019	1,159	1,129	97	

- Source: AQS, AMP 430 Data Completeness Report, run November 2022.
- Details on CARB's PQAO samplers not reporting \geq 75% ambient data are provided in Appendices D-E of this report.
- Results reflect information in AQS, including changes to past data since the 2020 Annual Data Quality Report (6). Therefore, results for 2019 and 2020 might differ from those in the 2020 Annual Data Quality Report.
- Nationwide average includes State, county, monitoring organization, National Park Service, and tribal sites, including those in California.
- *Low count resulted from limited laboratory support of PM filters due to COVID-19 restrictions. Details related to COVID-19 restrictions are provided in Appendix F of this report.

Precision and Bias

PM is subject to formal MQOs in federal and State regulations. Appendix A of this report lists the MQOs stated in CFR and U.S. EPA guidance (3). For all methods of collecting PM₁₀ and PM_{2.5}, CFR specifies using the upper bound of CV to assess precision. This CV upper bound is not to exceed 10 percent. Collocated sampling is required to assess precision for manual PM₁₀ and both manual and continuous PM_{2.5} sampling. Each PQAO is required to have a certain number of collocated sites to represent its monitoring network. From each pair of collocated samplers, a minimum of 75 percent of ambient data is required to be in AQS.

For continuous PM₁₀ samplers, bias is assessed using the monthly flow rate verifications and comparing the absolute bias upper bound against CFR criterion of ± 4 percent difference. Detailed calculations are explained in U.S. EPA guidance for the use of precision and bias data (11). Total bias for each PQAO is also assessed through PEP audits administered by U.S. EPA.

The accuracy of all PM samplers is assessed via the semi-annual flow rate audit by comparing the instrument's flow rate to a certified orifice (e.g., PM₁₀ and total suspended particulates), or a calibrated mass flow meter (e.g., tapered element oscillating microbalance (TEOM), PM_{2.5}, and beta attenuation method (BAM) samplers) that is certified against a National Institute of Standards and Technology traceable flow device or calibrator. As listed in Appendix C of this report, CARB's 2021 performance audit criteria, based on the average percent difference during a semi-annual flow rate audit, were ± 7 percent for PM₁₀ high volume (Hi-Vol), and ± 4 percent for PM₁₀ low volume (Low-Vol) and PM_{2.5}.

Precision of the data is based on the standard deviation of the percent differences of the mass concentrations of the two identical or equivalent collocated samplers. At low concentrations, precision based on the measurements of collocated samplers may be relatively poor. For this reason, collocated measurement pairs are selected for use in the precision calculations only when both measurements are equal to or above the following limits: PM₁₀ (Hi-Vol): 15 microgram per cubic meter ($\mu\text{g}/\text{m}^3$); PM₁₀ (Low-Vol): 3 $\mu\text{g}/\text{m}^3$; and PM_{2.5}: 3 $\mu\text{g}/\text{m}^3$. The collocated pairs of data that meet these limits are then used to calculate the upper bound of CV as an estimate of precision at each site. CFR requires that this upper bound of CV not exceed 10 percent for both PM₁₀ and PM_{2.5} at the PQAO level. A detailed description of CV, including formula for calculating it, can be found in U.S. EPA guidance for the use of precision and bias data (11).

A discussion of collocated sampling for both PM₁₀ and PM_{2.5} can be found in CARB's Annual Network Plan (5). As indicated there, CARB's PQAO continued meeting the 15 percent minimum collocation requirement in 2021 for both PM₁₀ and PM_{2.5}. Table 7

shows the number of sites with collocated precision data reported in respective years. Lead (Pb) is not discussed in this report due to limited data⁸ for CARB’s PQAO in 2021.

Precision Results

For the reported collocated sites, CFR (1) requires that 30 paired observations per year (equivalent to 1-in-12 days) be collected from each site with collocated samplers operating the entire year. Table 7 displays precision percent completeness (measured as a percent of the collected samples over the required number of observations) in addition to the CV upper bound. Information for years 2019 and 2020 are provided for historical perspectives. While precision completeness was met at the PQAO level, the CFR criteria of 10 percent CV upper bound was not met for PM₁₀ or any method of PM_{2.5} for CARB, which is not an improvement compared to the previous year.

Table 7. 2019-2021 Precision Results Based on Available Collocated PM Samplers

Pollutant	PQAO	Year	Method Code	Number Pairs of Collocated Samplers Reported	Percent Precision Completeness (%)	Upper Bound of CV (Precision)	CFR Criteria for Precision Met?
PM ₁₀	CARB	2021	All	4	100	20.06	No
		2020	All	5	100	<u>20.02</u>	No
		2019	All	5	100	<u>19.02</u>	No
	Bay Area AQMD	2021	All	1	100	9.05	Yes
		2020	All	1	100	3.91	Yes
		2019	All	1	100	3.97	Yes
	South Coast AQMD	2021	All	3	100	8.53	Yes
		2020	All	3	100	5.50	Yes
		2019	All	3	100	9.45	Yes
	San Diego County APCD	2021	All	1	100	2.67	Yes
		2020	All	1	100	3.10	Yes
		2019	All	1	100	5.09	Yes
	Nationwide	2021	All	70	98	9.65	Yes
		2020	All	75	98	8.76	Yes
		2019	All	84	97	<u>10.43</u>	No

⁸ There is one Pb monitor in CARB’s PQAO, located at the Sacramento-Del Paso Manor. However, CARB is not required to collocate for Pb at NCore sites because Pb collocation for NCore sites is addressed by U.S. EPA nationwide.

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Table 7. 2019-2021 Precision Results Based on Available Collocated PM Samplers (cont.)

Pollutant	PQAO	Year	Method Code	Number Pairs of Collocated Samplers Reported	Percent Precision Completeness (%)	Upper Bound of CV (Precision)	CFR Criteria for Precision Met?	
PM _{2.5}	CARB	2021	143	NDA	NDA	NDA	NDA	
		2020	143	1	82	3.05	Yes	
		2019	143	1	100	3.23	Yes	
		2021	145	3	68	27.78	No	
		2020	145	4	92	4.83	Yes	
		2019	145	4	87	8.27	Yes	
		2021	170	5	100	12.66	No	
		2020	170	7	100	11.09	No	
		2019	170	7	100	<u>12.03</u>	No	
		2021	181	1	100	11.42	No	
		2020	181	1	100	<u>10.68</u>	No	
		2019	181	1	100	<u>11.07</u>	No	
		2021	204	NDA	NDA	NDA	NDA	NDA
		2020	204	NDA	NDA	NDA	NDA	NDA
		2019	204	2	100	<u>14.53</u>	No	
		2021	209	1	70	14.43	No	
		2020	209	1	100	7.88	Yes	
		2019	209	1	13	<u>16.06</u>	No	
		2021	238	1	100	10.98	No	
	2020	238	1	100	<u>25.53</u>	No		
	2019	238	1	100	<u>13.99</u>	No		
	2021	170	3	100	10.37	No		
	2020	170	3	100	<u>10.43</u>	No		
	2019	170	3	100	<u>12.84</u>	No		
	South Coast AQMD	2021	143	1	100	2.14	Yes	
		2020	143	1	100	2.26	Yes	
		2019	143	1	100	3.09	Yes	
		2021	145	3	100	4.65	Yes	
		2020	145	3	100	6.09	Yes	
		2019	145	3	100	5.40	Yes	
		2021	155	NDA	NDA	NDA	NDA	NDA
		2020	155	1	20	1.83	Yes	
		2019	155	1	100	4.48	Yes	
	San Diego County APCD	2021	145	NDA	NDA	NDA	NDA	NDA
		2020	145	NDA	NDA	NDA	NDA	NDA
		2019	145	1	100	2.98	Yes	
2021		545	1	100	3.03	Yes		
2020		545	1	100	2.86	Yes		
2019		545	1	70	7.92	Yes		

Table 7. 2019-2021 Precision Results Based on Available Collocated PM Samplers (cont.)

Pollutant	PQAO	Year	Method Code	Number Pairs of Collocated Samplers Reported	Percent Precision Completeness (%)	Upper Bound of CV (Precision)	CFR Criteria for Precision Met?	
PM _{2.5}	Nationwide	2021	117	1	100	8.10	Yes	
		2020	117	1	100	<u>17.93</u>	No	
		2019	117	1	100	3.83	Yes	
		2021	143	6	94	6.72	Yes	
		2020	143	8	89	7.94	Yes	
		2019	143	9	94	6.21	Yes	
		2021	145	86	97	9.76	Yes	
		2020	145	92	95	9.31	Yes	
		2019	145	99	96	7.88	Yes	
		2021	170	49	98	17.54	No	
		2020	170	55	98	<u>16.82</u>	No	
		2019	170	60	97	<u>15.00</u>	No	
		2021	181	3	100	13.54	No	
		2020	181	3	100	<u>17.59</u>	No	
		2019	181	3	100	<u>10.33</u>	No	
		2021	204	NDA	NDA	NDA	NDA	NDA
		2020	204	2	100	<u>28.51</u>	No	
		2019	204	4	100	<u>14.94</u>	No	
		2021	238	21	94	11.41	No	
		2020	238	18	93	<u>10.47</u>	No	
2019	238	16	89	<u>10.61</u>	No			
2021	545	28	100	12.41	No			
2020	545	21	98	<u>12.95</u>	No			
2019	545	16	87	<u>13.46</u>	No			

- Source: AQS, AMP 256 Data Quality Indicator Report, run November 2022.
- NDA means no data available in AQS; **bold italicized** text indicates CV greater than 10% in 2021; underlined text indicates CV greater than 10% in 2019 or 2020.
- Results reflect information in AQS, including changes to past data since the 2020 Annual Data Quality Report (6). Therefore, results for 2019 and 2020 might differ from those in the 2020 Annual Data Quality Report.
- Nationwide average includes State, county, monitoring organization, National Park Service, and tribal sites, including those in California.
- Upper bound of CV (precision) is estimated by the upper confidence limit of the standard deviation of the percent differences of mass concentrations of the two collocated samplers collected on the same day; CFR criteria for CV: ≤ 10% for PM. Details on CARB's PQAO samplers not meeting these criteria are provided in Appendices D-E of this report.
- Method 117 = R & P Model 2000 PM_{2.5} Sampler with WINS; Method 118 = R & P Model 2025 PM_{2.5} Sequential with WINS; Method 120 = Andersen RAAS2.5-300 PM_{2.5} SEQ with WINS; Method 143 = R & P Model 2000 PM_{2.5} Sampler with VSCC; Method 145 = R & P Model 2025 PM_{2.5} Sequential Air Sampler with VSCC; Method 155 = Thermo RAAS2.5-300 with VSCC; Method 170 = Met One BAM-1020 Mass Monitor with VSCC; Method 181 = Thermo TEOM 1400a FDMS, Method 204 =Teledyne Model 602 Beta plus with VSCC, Method 209 =Met One BAM-1022 Real Time Beta Attenuation Mass Monitor, Method 238 =T640X Mass Monitor, Method 545 =Met One E-SEQ-FRM with VSCC.

Notably, the high CV is also encountered nationwide, not just within CARB's PQAO. CARB has continued exploring the potential causes behind low PM_{2.5} precision among some of the collocated PM_{2.5} samplers within CARB's PQAO. The empirical analysis includes the evaluation of multiple years of data and a breakdown of results based on monitors that use federal reference (FRM) vs federal equivalent (FEM) methods. While no definitive source of the issue has been identified as a key contributing factor to the imprecision, monitoring organizations are encouraged to closely examine operational practices in order to help the PQAO achieve the precision criteria for PM. During technical system audits, operational practices or other factors that may influence the low precision are often examined.

U.S. EPA is aware of the systemic issue of PM imprecision (in California and nationwide). The agency, in an attempt to remedy PM_{2.5} precision, proposed new statistics in its *Reconsideration of the National Ambient Air Quality Standards for Particulate Matter* ([19](#)); public comments on the proposal were due March 28, 2023.

Bias Results via Monthly Flow Rate Verifications

Bias results via the monthly flow rate verifications for all PM samplers in 2021 are shown in Table 8. Most of CARB's PM₁₀ and PM_{2.5} samplers reported flow rate verification (FRV) data to AQS in 2021, as well as 2020. In summary, the bias criteria of ± 7 percent for PM₁₀ and ± 4 percent for PM_{2.5} were met in each PQAO for which data are available.

Table 8. 2019-2021 PM₁₀ and PM_{2.5} Bias Results Based on Flow Rate Verifications

Pollutant	PQAO	Year	Type	Number of Samplers in Network	Number of Required Flow Rate Verifications	Number of Reported Flow Rate Verifications	Average Percent Difference* (%)	Bias	CFR Criteria for Bias Met?
PM ₁₀	CARB	2021	Hi-Vol	17	121	217	0.55	3.29	Yes
		2020		21	137	259	0.14	3.90	Yes
		2019		20	142	229	0.40	3.79	Yes
	Bay Area AQMD	2021		6	21	0**	NDA	NDA	NDA
		2020		7	24	0**	NDA	NDA	NDA
		2019		7	28	0**	NDA	NDA	NDA
	South Coast AQMD	2021		24	93	287	-0.11	3.72	Yes
		2020		25	98	235	-0.43	3.20	Yes
		2019		24	96	277	-0.66	3.25	Yes
	San Diego County APCD	2021		NDA	NDA	NDA	NDA	NDA	NDA
		2020		NDA	NDA	NDA	NDA	NDA	NDA
		2019		3	12	46	0.98	±2.48	Yes
	CARB	2021	Low-Vol	80	913	1,458	0.00	1.03	Yes
		2020		77	923	1,426	-0.03	1.05	Yes
		2019		80	924	1,377	-0.26	1.12	Yes
	Bay Area AQMD	2021		1	12	0**	NDA	NDA	NDA
		2020		1	12	0**	NDA	NDA	NDA
		2019		1	12	0**	NDA	NDA	NDA
	South Coast AQMD	2021		9	96	126	0.13	1.53	Yes
		2020		9	108	150	-0.02	±1.39	Yes
		2019		10	111	185	0.26	±4.08	Yes
	San Diego County APCD	2021		4	48	52	0.01	0.89	Yes
		2020		4	48	57	0.23	0.94	Yes
		2019		1	12	14	-0.42	±1.28	Yes

Table 8. 2019-2021 PM₁₀ and PM_{2.5} Bias Results Based on Flow Rate Verifications (cont.)

Pollutant	PQAO	Year	Type	Number of Samplers in Network	Number of Required Flow Rate Verifications	Number of Reported Flow Rate Verifications	Average Percent Difference* (%)	Bias	CFR Criteria for Bias Met?
PM _{2.5}	CARB	2021	All	95	1,037	1,768	0.05	1.05	Yes
		2020		102	1,069	1,733	0.01	0.94	Yes
		2019		92	1,078	1,710	-0.15	0.99	Yes
	Bay Area AQMD	2021		20	229	0**	NDA	NDA	NDA
		2020		20	240	0**	NDA	NDA	NDA
		2019		20	238	0**	NDA	NDA	NDA
	South Coast AQMD	2021		32	384	425	0.42	1.71	Yes
		2020		33	385	421	-0.74	1.55	Yes
		2019		31	372	412	-0.40	1.60	Yes
	San Diego County APCD	2021		6	72	78	-0.09	1.22	Yes
		2020		6	72	81	-0.06	1.08	Yes
		2019		5	55	58	-0.35	1.12	Yes

- Source: AQS, AMP 256 Data Quality Indicator Report, run November 2022.
- NDA means no data available in AQS.
- Results reflect information in AQS, including changes to past data since the 2020 Annual Data Quality Report (6). Therefore, results for 2019 and 2020 might differ from those in the 2020 Annual Data Quality Report.
- CFR criteria for PM₁₀ bias: $\pm 7\%$ (of standard) except for dichotomous samplers, which are subject to $\pm 4\%$, same as criteria for PM_{2.5}.
- Details on CARB's PQAO samplers not uploading the required flow rate data are provided in Appendices D-E of this report.
- *Average percent difference is the arithmetic mean of the differences between the sampler's flow rate and the flow rate of the standard used during the flow rate verifications.
- **According to Bay Area AQMD, FRV were performed and were within the acceptable criteria, but they were not uploaded to AQS due to a lack of resources.

Accuracy Validation via CARB's Flow Rate Audits

Since an accurate measurement of PM is dependent upon the flow rate, CARB and other PQAOs are required to conduct semi-annual flow rate audits on all PM samplers at each site. Such audits are to be conducted five to seven months apart on each sampler in a given calendar year. In addition, as explained earlier, PQAOs are also required to submit the continuous PM₁₀ monthly flow rate verifications to AQS; in this case, bias estimates based on flow rate verifications are further verified using the semi-annual flow rate audit data.

All PM monitors, with a few exceptions, received a semi-annual assessment. Unfortunately, not all PM assessments met the criteria of being conducted five to seven months apart.

Table 9 summarizes the 2021 flow rate audit results for PM samplers. The number of samplers as well as those that met the required number of audits in 2021 are displayed. Two audits are required if a sampler operates more than seven months; one audit if less than seven months but more than three months; and zero if less than three months. The average percent difference between the sampler flow rates and the audit flow rates represent the arithmetic mean of the combined differences from the certified value of all the individual audit points for each sampler. Lower and upper confidence limits represent the range of the audit results across each PQAO. A complete listing of CARB's performance audit criteria can be found in Appendix C of this report.

CARB conducts the semi-annual flow rate audits for most samplers operating within CARB's PQAO. In addition, certain monitoring organizations within CARB's PQAO were allowed to conduct their own audits in 2021, per established roles and responsibility agreements ([15](#)). For example, Great Basin Unified APCD conducts one of the semi-annual flow rate audits for the sites operating within its jurisdiction. PQAOs not part of CARB's PQAOs are responsible for performing their own audits as part of an annual evaluation. Following Governor Newsom's regional stay-at-home order in December 2020, CARB continued limited laboratory support of only three selected sites critical for State Implementation Plan determinations into the first quarter of 2021. See communication between CARB and U.S. EPA regarding limited operations due to COVID-19 restrictions in Appendix F of this report.

Overall, the results of the audited samplers indicate that the PM samplers in the network were operating within CARB's and U.S. EPA's flow rate audit criteria. Flow rate audit results agree with bias estimates based on the flow rate verifications within CARB's PQAO, further validating that the PM samplers were operating accurately.

Table 9. 2021 Results for PM Sampler Flow Rate Audits

Collection Method	PQAO	Number of Samplers	Number of Samplers Meeting Required Number of Audits	Number of Flow Rate Audits Not Meeting CARB Criteria*	Average Percent Difference**	Confidence Limit	
						Lower	Upper
PM ₁₀ Hi-Vol	CARB	17	17	2	2.03	-4.29	5.40
	Bay Area AQMD	6	6	0	2.07	NDA	NDA
	South Coast AQMD	24	24	0	1.44	-6.02	5.82
	San Diego County APCD	0	NDA	NDA	NDA	NDA	NDA
PM ₁₀ Low-Vol***	CARB	80	79	0	-0.10	-1.58	1.60
	Bay Area AQMD	1	1	0	-1.30	NDA	NDA
	South Coast AQMD	9	9	0	-1.04	-2.27	2.51
	San Diego County APCD	4	4	0	-0.33	-1.79	1.81
PM _{2.5}	CARB	95	87	5	0.30	-2.38	2.36
	Bay Area AQMD	20	19	0	-0.15	NDA	NDA
	South Coast AQMD	32	30	0	-0.12	-2.93	3.79
	San Diego County APCD	6	6	0	-0.29	-2.30	2.12

- Source: AQS, AMP 256 Data Quality Indicator Report, run November 2022.
- NDA means no data available in AQS.
- Although ambient data collected at some SPM sites are not used for regulatory purposes, SPM sites are audited at the request of the monitoring organization, subject to availability of auditing resources, and results are included in this table.
- *AQDAs were issued for audits not meeting criteria. Only audits conducted by CARB were subject to the AQDA process. Only flow failures are included in this table.
- **Average percent difference is the arithmetic mean of the differences between the sampler's flow rate and the flow rate of the standard used during the flow rate audits.
- ***Count of Low-Vol samplers includes continuous BAM samplers.
- Sites could be audited multiple times in a quarter (by different entities or due to re-audits).
- CARB's flow rate audit criteria for 2021 were $\pm 7\%$ for PM₁₀ Hi-Vol and $\pm 4\%$ for PM₁₀ Low-Vol and PM_{2.5}. Details on CARB's PQAO samplers not meeting these criteria are provided in Appendices D-E of this report.

Network Bias Results via PEP Audits

As noted earlier, PM_{2.5} samplers are subject to a PEP audit to assess “total bias” of the network. In general terms, a PEP audit is a type of audit in which the quantitative data generated in a measurement system are obtained independently and compared with routinely obtained data to evaluate the proficiency of the analyst or laboratory. The goal of a PEP audit is to evaluate total measurement system bias, which includes measurement uncertainties from both field and laboratory activities. PEP audits are performed on the SLAMS monitors annually within each PQAO. For PQAOs with less than five monitoring sites, five valid PEP audits are required; for PQAOs with more than five sites, eight valid audits are required. A PEP audit is valid when both primary monitor and PEP audit concentrations are above 3 µg/m³. Each year, every designated FRM or FEM monitor within a PQAO must: have each method designation evaluated; and have all FRM or FEM samplers subject to a PEP audit at least once every six years, which equates to approximately 15 percent of the sites audited each year. Results from 2021 PEP audits for all PQAOs are presented in Table 10, with results from the previous two years presented to assess trends. Results from 2021 indicate the PM_{2.5} network for CARB’s PQAO has high total bias, inconsistent with results determined via flow rate verification and flow rate audits. This high estimate may be due to the low number of valid samples (five of the required eight audits) and lack of re-audits due to COVID-19 restrictions. U.S. EPA proposed to lower the threshold from 3 µg/m³ to 2 µg/m³ in its *Reconsideration of the National Ambient Air Quality Standards for Particulate Matter* (19); public comments on the proposal were due March 28, 2023. If adopted, this change should help increase the number of valid samples and improve the bias estimate based on PEP audits.

Table 10. 2019-2021 Total Bias Results via PEP Audits

Pollutant	PQAO	Year	Number of Samplers	Number of Audits Required	Number of Audits Collected	Percent Complete (%)	Bias
PM _{2.5}	CARB	2021	75	8	5	63	12.83
		2020	72	8	8	100	-1.20
		2019	70	8	8	100	-6.44
	Bay Area AQMD	2021	17	8	6	75	-3.21
		2020	17	8	9	100	-4.09
		2019	17	8	5	63	0.15
	South Coast AQMD	2021	19	8	8	100	7.15
		2020	19	8	7	88	-5.78
		2019	19	8	7	88	-15.89
	San Diego County APCD	2021	5	5	6	100	-9.30
		2020	5	5	4	80	5.39
		2019	4	5	5	100	1.12

- Source: AQS, AMP 256 Data Quality Indicator Report, run November 2022.
- Number of samplers refers to monitors designated as “primary” in AQS.
- PEP audit criteria: < ±10% for PM_{2.5}.

C. Summary of Results for CARB’s PQAO Monitoring Organizations

Table 11 summarizes the 2021 data quality results for gaseous pollutants and PM across different geographic areas⁹ within CARB’s PQAO. To make an assessment, the 30 geographic areas were divided into four categories according to monitoring activities. Key observations from the assessment of these four categories for CARB’s PQAO in 2021 include:

- Gaseous pollutant monitoring only (two geographic areas):
 - Both Amador County and Tuolumne County achieved all MQOs. This was expected, as CARB’s PQAO did well in the gaseous program overall.
- PM monitoring only (one geographic area):
 - Northern Sonoma met all MQOs (without collocation).
- Gaseous pollutant and PM monitoring without collocation (17 geographic areas):
 - Nine met all MQOs for both gaseous pollutants and PM: Antelope Valley, Calaveras County, Eastern Kern, Glenn County, Lake County, Mariposa County, Mendocino County, Siskiyou County, and Tehama County.
 - Six met MQOs for PM only.
 - Two did not meet all MQOs for gaseous pollutants and PM.
- Gaseous pollutant and PM monitoring with collocation (10 geographic areas):
 - One achieved all MQOs: Ventura County.
 - Four met MQOs for gaseous pollutants only. This was mainly due to data capture or PM precision problems.
 - Five did not meet all MQOs for gaseous pollutants and PM. While there were no persistent problems with PM precision, several problems with gaseous pollutants and PM were observed for Sacramento Metropolitan and San Joaquin Valley.

In Table 11, a “Y” indicates that all monitors within a given geographic area have met the MQOs while an “N” indicates otherwise. In some instances, one instrument or sampler may be responsible for several “N” marks due to instrument/sampler failure (see more details in Appendix E of this report). Note that MQOs were developed to be evaluated at the PQAO level but can be used for informational purposes at the monitoring organization level. The ongoing goal is to identify potential issues behind sites and/or monitoring organizations and remediate in a timely manner so as not to affect CARB’s PQAO as a whole.

⁹ In this report, a geographic area refers to a region covered by a monitoring organization. Sites may be operated by the monitoring organization, CARB, or both. See Appendix D for a complete list of geographic areas and associated monitoring organizations.

Table 11. Composite Table of Ambient Data and Data Quality Results for Geographic Areas within CARB's PQAO

Geographic Area*	Gaseous Instruments						PM Samplers					
	Data Capture Rate	1-pt QC Checks Reported	Precision Criteria Met	Bias Criteria Met	Instruments All Audited	Audited Instruments Met Criteria	Data Capture Rate	Precision Data Collocated Sites	Collocated Sites Met Criteria	Flow Rate Verification	Samplers All Audited	Audited Samplers Met Criteria
Amador County	Y	Y	Y	Y	Y	Y	NA	NA	NA	NA	NA	NA
Antelope Valley	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Butte County	Y	Y	Y	Y	Y	N†	Y	NA	NA	Y	Y	Y
Calaveras County	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Colusa County	Y	Y	Y	Y	Y	N†	Y	NA	NA	Y	Y	Y
Eastern Kern	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
El Dorado County	N†	N†	Y	Y	Y	N†	Y	NA	NA	Y	Y	Y
Feather River	Y	Y	Y	Y	Y	N†	Y	NA	NA	Y	N†	Y
Glenn County	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Great Basin	Y	Y	Y	Y	N	Y	N	Y	N	Y	Y	Y
Imperial County	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y
Lake County	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Mariposa County	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Mendocino County	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Mojave Desert	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y
Monterey Bay	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
North Coast	Y	Y	Y	Y	N	Y	Y	NA	NA	Y	Y	Y
Northern Sierra	Y	N	Y	Y	Y	Y	N	N	N	N	N	N
Northern Sonoma	NA	NA	NA	NA	NA	NA	Y	NA	NA	Y	Y	Y
Placer County	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Sacramento Metropolitan	N	N	Y	Y	Y	N††	N	N	N	N	N††	Y
San Joaquin Valley	N†	N†	Y	Y	N††	N†	N†	N†	N†	Y	N	N†
San Luis Obispo	N†	Y	Y	Y	N	Y	Y	NA	NA	Y	Y	Y
Santa Barbara County	N†	Y	Y	Y	N†	N	Y	NA	NA	Y	Y	Y
Shasta County	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y
Siskiyou County	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Tehama County	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Tuolumne County	Y	Y	Y	Y	Y	Y	NA	NA	NA	NA	NA	NA
Ventura County	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Yolo-Solano	Y	Y	Y	Y	Y	N	N	NA	NA	N	N	N

- Y = met criteria; N = not all sites met criteria; † = impacted site(s) operated by CARB; †† = impacted site(s) operated by both the monitoring organization and CARB; NA = not applicable.
- *For this report, a geographic area refers to a region covered by a monitoring organization. Sites may be operated by the monitoring organization, CARB, or both. See Appendix D for complete list of geographic areas and associated monitoring organizations.

For 2021, following Governor Newsom’s regional stay-at-home order in late December 2020, CARB focused on PM flow rate audits only during the first two quarters before being expanded to full operations for gaseous pollutants in the remainder of the year. In addition, CARB continued limited laboratory support of only three selected sites critical for State Implementation Plan determinations into the first quarter of 2021 and expanded support to all sites during the remaining quarter. See communication between CARB and U.S. EPA regarding limited operations due to COVID-19 restrictions in Appendix F of this report.

As indicated earlier in this report, the problem with PM precision is a systemic issue (in California and nationwide). As shown in Table 12, most collocated samplers reported upper bound CV values exceeding the criterion of 10 percent. Only three locations achieved CV values less than 10 percent, including identical methods collocated in Northern Sierra and Ventura, and BAM 1020 collocated with FRM in San Joaquin Valley. U.S. EPA proposed new methods for calculating CV in its *Reconsideration of the National Ambient Air Quality Standards for Particulate Matter* ([19](#)); public comments on the proposal were due March 28, 2023. If adopted, this change should help remedy this PM precision problem.

Table 12. 2021 Precision Results for Geographic Areas within CARB’s PQAO

Pollutant	Geographic Area	Method Code (Primary/Secondary)	Monitoring By	Percent Precision Completeness (%)	Upper Bound of CV (Precision)
PM ₁₀	Great Basin	All	MO MO	100 96	11.06 21.10
	Sacramento Metropolitan	All	MO	100	5.43
	San Joaquin Valley	All	MO	100	2.55
PM _{2.5}	Great Basin	181/145 238/145	MO MO	100 100	11.42 10.98
	Mojave Desert	170/170	MO	100	11.17
	Monterey Bay	170/143	MO	100	13.75
	Northern Sierra	145/145 170/143	MO MO	67 20	5.30 12.38
	Sacramento Metropolitan	145/145	MO	73	17.39
	San Joaquin Valley	170/145 145/145	CARB CARB	44 67	4.42 50.73
	Shasta County	209/145	MO	70	14.43
	Ventura County	170/170	MO	100	7.69

- Source: AQS, AMP 256 Data Quality Indicator Report, run November 2022.
- Upper bound of CV (precision) is estimated by the upper confidence limit of the standard deviation of the percent differences of mass concentrations of the two collocated samplers collected on the same day; CFR criteria for CV: ≤ 10% for PM.
- Details on samplers not meeting criteria are provided in Appendices D-E of this report.
- ***Bold italicized*** text indicates CV greater than 10% in 2021.
- Method 143 = R & P Model 2000 PM_{2.5} Sampler with VSCC; Method 145 = R & P Model 2025 PM_{2.5} Sequential Air Sampler with VSCC; Method 155 = Thermo RAAS2.5-300 with VSCC; Method 170 = Met One BAM-1020 Mass Monitor with VSCC; Method 181 = Thermo TEOM 1400a FDMS; Method 209 = Met One BAM-1022 Mass Monitor with VSCC; Method 238 = T640X Mass Monitor.

IV. Conclusions and Recommendations

This report provides ambient air quality data producers and users with a centralized review of the data quality within CARB's PQAO with respect to MQOs. In addition, comparisons to other PQAOs in California and the nationwide average are shown where appropriate. Below are some highlights for 2021.

A. Gaseous Pollutants

The gaseous criteria pollutants assessed in this report are: CO, NO₂, O₃, and SO₂.

Conclusions

- Ninety-one percent of the instruments operating within CARB's PQAO achieved the ambient data capture rate of at least 75 percent in 2021. Eighty-six percent also met CARB's goal of at least 85 percent data capture.
- Ninety-four percent of the instruments operating within CARB's PQAO reported at least 75 percent of the required 1-pt QC checks for gaseous pollutants. Individual 1-pt QC checks were assessed according to new critical criteria set in 2018, which were met by most instruments; monitoring organizations have been encouraged to closely monitor the ranges of these checks to ensure they are conducted within prescribed ranges.
- All California PQAOs met the CFR criteria for precision and bias based on 1-pt QC checks.
- CARB's performance audit acceptance criteria were met, on average, at the PQAO level for CARB's PQAO (as well as other PQAOs) with only a small number of instruments not passing performance audit criteria. This validates the bias estimates based on 1-pt QC checks, which showed that the gaseous network generally exhibits a high level of accuracy.

Recommendations

- Although MQOs associated with gaseous instruments were met at the PQAO level, there were a few instances where instruments did not meet the MQO (e.g., ambient data capture rate, submittal of required 1-pt QC checks, etc.). Monitoring organizations should investigate why these objectives were not met for each instrument in their respective jurisdictions and develop corrective actions, if appropriate, to meet them in subsequent years.

B. Particulate Matter

The particulate matter assessed in this report are: PM₁₀ and PM_{2.5}.

Conclusions

- Ninety-two percent of the PM samplers operating within CARB's PQAO achieved the ambient data capture rate of at least 75 percent in 2021. Ninety percent also met CARB's goal of at least 85 percent data capture.
- As indicated in CARB's Annual Network Plan (5), CARB's PQAO continues to meet the minimum collocation requirement.
- While precision completeness was met, the precision criteria of 10 percent CV upper bound was not met by PM₁₀ or any PM_{2.5} method for CARB's PQAO.
- Most PM₁₀ and PM_{2.5} samplers reported flow rate verification data to AQS, and the results indicate that the PM network exhibited low bias.
- Flow rate audit data indicate that CARB's PQAO met CARB criteria. This is consistent with bias information from the routine flow rate verification data.
- Total PM_{2.5} bias for CARB's PQAO, via PEP audits administered by U.S. EPA based on limited mass samples, shows high bias, inconsistent with results determined by flow rate verification and flow rate audits. This high estimate for total bias may be due to the low number of valid samples collected in 2021 for CARB's PQAO.

Recommendations

- In terms of precision, CV values among collocated PM_{2.5} samplers within CARB's PQAO remain high in 2021. CARB explored potential causes behind low PM_{2.5} precision among some collocated PM_{2.5} samplers; however, no definitive source of the issue was identified. U.S. EPA is aware of the systemic issue of PM imprecision (in California and nationwide). The agency, in an attempt to remedy PM_{2.5} precision, proposed new statistics in its *Reconsideration of the National Ambient Air Quality Standards for Particulate Matter* (19); public comments on the proposal were due March 28, 2023.
- There were instances of samplers not meeting the MQOs (e.g., ambient data capture rate, submittal of required collocated measurements, etc.). Monitoring organizations should investigate why these objectives were not met for each sampler in their respective jurisdictions and develop corrective actions, if appropriate, to meet them in subsequent years.

The 2021 ambient data in AQS for CARB's PQAO have been certified and are considered suitable for comparison to federal ambient air quality standards. Although CFR criteria for precision and accuracy are generally applied and evaluated at the PQAO level, assessments at the monitoring organization or site level may differ and can be important as well. Therefore, data producers are strongly encouraged to review the site-level information and assess whether their data quality objectives are met. When certain CFR criteria are not met, it does not necessarily mean that the

corresponding air quality data cannot be used, but rather, the data could be used with the knowledge of the quality behind it.

CARB has in place extensive SOPs and data review protocols through Quality Assurance Project Plans (QAPP) (16)(17) and the Quality Management Plan (QMP) (18) as well as detailed processes to document deviations from critical criteria, including AQDAs and CANs. For objective checks which are found to be outside of the acceptance criteria, a weight of evidence evaluation will be performed as outlined in CFR (1).

40 CFR, Appendix A to Part 58, section 1.2.3: 'Failure to conduct or pass a required check or procedure, or a series of required checks or procedures, does not itself invalidate data for regulatory decision making. Rather, PQAOs and the U.S. EPA shall use the checks and procedures required in this appendix in combination with other data information, reports, and similar documentation that demonstrate overall compliance with Part 58.'

The statistics presented in this report are intended as assessment tools for the data producers to identify areas where program improvements can be made to achieve all MQOs set by U.S. EPA or the data producers themselves.

See Appendix G for a comprehensive list of all references used in this report.

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V. Appendices

Appendix A. U.S. EPA's Measurement Quality Objectives

Table A-1. Ambient Air Monitoring Measurement Quality Objectives*

Method	CFR Reference	Coverage (Annual)	Minimum Frequency	MQOs
1-pt QC Check: CO, NO ₂ , O ₃ , SO ₂	Section 3.2.1	Each instrument	Once every 14 days	CO: 90% Confidence Level (CL) CV < 10.1% for Precision, 95% CL < ±10.1% for Bias (< ±10.1% percent difference) NO ₂ : 90% CL CV < 15.1% for Precision 95% CL < ±15.1% for Bias (< ±15.1% (percent difference) or < ±1.5 ppb difference, whichever is greater) O ₃ : 90% CL CV < 7.1% for Precision 95% CL < ±7.1% for Bias (< ±7.1% (percent difference) or < ±1.5 ppb difference, whichever is greater) SO ₂ : 90% CL CV < 10.1% for Precision 95% CL < ±10.1% for Bias (< ±10.1% (percent difference) or < ±1.5 ppb difference, whichever is greater)
Annual Performance Evaluation: CO, NO ₂ , O ₃ , SO ₂	Section 3.2.2	Each instrument	Once per year	CO, NO ₂ , SO ₃ , < 15.1% for each audit concentration O ₃ : < 10.1% for each audit concentration
National Performance Audit Program: CO, NO ₂ , O ₃ , SO ₂	Section 2.4	20% of sites per year	Once per year	CO, NO ₂ , SO ₃ , < 15.1% for each audit concentration O ₃ : < 10.1% for each audit concentration
Flow Rate Verification: PM ₁₀ , PM _{2.5}	Section 3.2.3	Each sampler	Once every month	PM ₁₀ < 10.1% of standard and design value PM _{2.5} < 4.1% of standard and 5.1% of design value

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Table A-1. Ambient Air Monitoring Measurement Quality Objectives* (cont.)

Method and Pollutant	CFR Reference	Coverage (Annual)	Minimum Frequency	MQOs
Semi-Annual Flow Rate Audit: PM ₁₀ Continuous, PM _{2.5}	Section 3.2.4	Each sampler	Once every 6 months	PM ₁₀ < 10.1% of standard and design value PM _{2.5} < 4.1% of standard and 5.1% of design value
Collocated Sampling: PM _{2.5}	Section 3.2.5	15%	Every 12 days	CV < 10.1% of samples > 3.0 µg/m ³
PM Performance Evaluation Program: PM _{2.5}	Section 3.2.7	1. 5 valid audits for primary QA orgs, with ≤ 5 sites 2. 8 valid audits for primary QA orgs, with > 5 sites 3. All samplers in 6 years	Over all 4 quarters	< 10.1% of samples > 3.0 µg/m ³
Collocated Sampling: PM ₁₀ , PM _{2.5}	Section 3.3.1 and 3.3.5	15%	Every 12 days	CV < 10.1% of PM _{2.5} samples > 3.0 µg/m ³ and of PM ₁₀ samples > 15.0 µg/m ³
Flow Rate Verification: PM ₁₀ (Low-Vol), PM _{2.5}	Section 3.3.2	Each sampler	Once every month	< 4.1% of standard and 5.1% of design value
Flow Rate Verification: PM ₁₀ (Hi-Vol)	Section 3.3.2	Each sampler	Once a quarter	< 10.1% of standard and design value
Semi-Annual Flow Rate Audit: PM ₁₀ (Low-Vol), PM _{2.5}	Section 3.3.3	Each sampler, all locations	Once every 6 months	< 4.1% of standard and 5.1% of design value
Semi-Annual Flow Rate Audit: PM ₁₀ (Hi-Vol)	Section 3.3.3	Each sampler, all locations	Once every 6 months	< 7.1% of standard and 10.1% of design value
Performance Evaluation Program: PM _{2.5}	Section 3.3.7 and 3.3.8	1. 5 valid audits for primary QA orgs, with ≤ 5 sites 2. 8 valid audits for primary QA orgs, with > 5 sites 3. All samplers in 6 years	Over all 4 quarters	< ±10.1% bias for values > 3.0 µg/m ³

*The details from this table can be found in U.S. EPA guidance (3).

Appendix B. Tools for Assessing Precision and Bias/Accuracy

Table B-1. Tools for Assessing Precision and Bias/Accuracy

Pollutant	Precision		Bias/Accuracy		
	1-pt QC Checks	Collocated Measurements	1-pt QC Checks	FRV	Performance Audits
Gaseous Pollutant					
CO, NO ₂ , O ₃ , SO ₂	✓	--	✓	--	annually
Continuous PM					
PM _{2.5}	--	✓	--	monthly	semi-annually
PM ₁₀ ,	--	--	--	monthly	semi-annually
Manual PM					
PM _{2.5}	--	✓	--	monthly	semi-annually
PM ₁₀ (Hi-Vol)	--	✓	--	quarterly	semi-annually
PM ₁₀ (Low-Vol)	--	✓	--	monthly	semi-annually

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Appendix C. CARB's Performance Audit Criteria

Table C-1. Audit Criteria for Gaseous Instruments and PM Samplers

Instrument/Criteria*	Control Limit	Warning
CO, NO ₂ , and SO ₂	±15%	±10%
O ₃	±10%	±7%
PM ₁₀ (Dichot, Continuous); PM ₁₀ (Filter-Based Low-Vol; Pb Low-Vol)	±10%	±7%
PM ₁₀ (Filter-Based Hi-Vol)	±7% of transfer standard ±10% from design flow rate	±5%
PM ₁₀ , PM _{2.5} (Filter-based Low-Vol, PM coarse); PM ₁₀ (Filter-Based Low-Vol, Pb Low-Vol)	±4% of transfer standard ±5% from design flow rate	none
PM _{2.5} (Filter-Based, Continuous)	±4% of transfer standard ±5% from design flow rate	none
Total Suspended Particulates (Pb Hi-Vol)	±7% of transfer standard	±5%
Xontech 920/924 Toxic and Carbonyl Sampler	±10%	±7%

- *Audit levels 1 and 2 are subject to the following acceptance criteria based on U.S. EPA guidance:
 - For CO: ±0.03 ppm difference or ±15% difference, whichever is greater.
 - For NO₂, O₃, and SO₂: ±1.5 ppb difference or ±15% difference, whichever is greater.
- CARB performance audits are operational criteria and exceedances (especially at lower levels) do not automatically invalidate the data.

Table C-2. Audit Criteria for Meteorological Sensors

Audit Criteria	Control Limit
Ambient Temperature	±0.5 degrees Celsius
Barometric Pressure	±2.25 mm of mercury
Wind Direction	≤ 5° combined accuracy and orientation error
Wind Direction (starting threshold)	≤ 0.5 meters per second (m/s)
Wind Speed	±0.25 m/s between 0.5 and 5.0 m/s and < 5% difference above 5.0 m/s (not to exceed 2.5 m/s difference)
Wind Speed (starting threshold)	≤ 0.5 m/s

- CARB does not audit relative humidity, solar radiation, or vertical wind speed.

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Appendix D. Data Quality Tables for Geographic Areas within CARB's PQAO

This appendix further breaks down the results for CARB's PQAO from tables within this report into geographic areas within CARB's PQAO. Monitoring sites within each geographic area may be operated by a monitoring organization (MO), CARB, or both, and this distinction is noted in each table. While MQOs were developed for assessment of precision and accuracy at the PQAO level, information at the monitoring organization level may be used to identify underlying issues, which in turn may be helpful for improving the overall performance of CARB's PQAO. For this report, a geographic area refers to a region covered by a monitoring organization; see Table D-1 for a complete list of geographic areas and associated monitoring organizations.

Table D-1. Geographic Areas and Associated Monitoring Organizations

Geographic Area	Monitoring Organization
Amador County	Amador County APCD
Antelope Valley	Antelope Valley AQMD
Butte County	Butte County AQMD
Calaveras County	Calaveras County APCD
Colusa County	Colusa County APCD
Eastern Kern	Eastern Kern APCD
El Dorado County	El Dorado County AQMD
Feather River	Feather River AQMD
Glenn County	Glenn County APCD
Great Basin	Great Basin Unified APCD
Imperial County	Imperial County APCD
Lake County	Lake County APCD
Mariposa County	Mariposa County APCD
Mendocino County	Mendocino County AQMD
Mojave Desert	Mojave Desert AQMD
Monterey Bay	Monterey Bay ARD
North Coast	North Coast Unified AQMD
Northern Sierra	Northern Sierra AQMD
Northern Sonoma	Northern Sonoma County APCD
Placer County	Placer County APCD
Sacramento Metropolitan	Sacramento Metropolitan AQMD
San Joaquin Valley	San Joaquin Valley APCD
San Luis Obispo	San Luis Obispo County APCD
Santa Barbara County	Santa Barbara County APCD
Shasta County	Shasta County APCD
Siskiyou County	Siskiyou County APCD
Tehama County	Tehama County APCD
Tuolumne County	Tuolumne County APCD
Ventura County	Ventura County APCD
Yolo-Solano	Yolo-Solano AQMD

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Table D-2. Gaseous Pollutants – 2021 Ambient Data Capture Results for Geographic Areas within CARB’s PQAO

Geographic Area	Monitoring By	Number of CO Instruments	Number of Instruments Reporting ≥ 75% Ambient Data	Percent of Instruments Reporting ≥ 75% Ambient Data (%)
Antelope Valley	MO	1	1	100
Butte County	CARB	1	1	100
Great Basin	MO	1	1	100
Imperial County	CARB	1	1	100
Mojave Desert	MO	2	2	100
Monterey Bay	MO	1	1	100
North Coast	MO	1	1	100
Sacramento Metropolitan	MO	2	0	0
San Joaquin Valley	MO; CARB	7	4	57
Santa Barbara County	MO; CARB	2	1	50
Geographic Area	Monitoring By	Number of NO ₂ Instruments	Number of Instruments Reporting ≥ 75% Ambient Data	Percent of Instruments Reporting ≥ 75% Ambient Data (%)
Antelope Valley	MO	1	1	100
Butte County	CARB	1	1	100
Feather River	CARB	1	1	100
Imperial County	MO; CARB	2	2	100
Mojave Desert	MO	3	3	100
Monterey Bay	MO	1	1	100
North Coast	MO	1	1	100
Placer County	CARB	1	1	100
Sacramento Metropolitan	MO; CARB	5	1	20
San Joaquin Valley	MO; CARB	19	19	100
San Luis Obispo County	MO	2	2	100
Santa Barbara County	MO; CARB	2	1	50
Ventura County	MO	2	2	100
Yolo-Solano	CARB	1	1	100

Table D-2. Gaseous Pollutants – 2021 Ambient Data Capture Results for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Number of O ₃ Instruments	Number of Instruments Reporting ≥ 75% Ambient Data	Percent of Instruments Reporting ≥ 75% Ambient Data (%)
Amador County	CARB	1	1	100
Antelope Valley	MO	1	1	100
Butte County	CARB	2	2	100
Calaveras County	CARB	1	1	100
Colusa County	CARB	1	1	100
Eastern Kern	CARB	1	1	100
El Dorado County	CARB	3	2	67
Feather River	CARB	2	2	100
Glenn County	CARB	1	1	100
Great Basin	MO	1	1	100
Imperial County	MO; CARB	4	4	100
Lake County	MO	1	1	100
Mariposa County	CARB	1	1	100
Mendocino County	MO	1	1	100
Mojave Desert	MO; CARB	6	6	100
Monterey Bay	MO	5	5	100
North Coast	MO	1	1	100
Northern Sierra	MO; CARB	1	1	100
Placer County	MO; CARB	5	5	100
Sacramento Metropolitan	MO; CARB	6	4	67
San Joaquin Valley	MO; CARB	24	24	100
San Luis Obispo County	MO; CARB	7	6	86
Santa Barbara County	MO; CARB	8	8	100
Shasta County	MO	3	3	100
Siskiyou County	MO	1	1	100
Tehama County	MO; CARB	2	2	100
Tuolumne County	CARB	1	1	100
Ventura County	MO	5	5	100
Yolo-Solano	MO; CARB	3	3	100

Table D-2. Gaseous Pollutants – 2021 Ambient Data Capture Results for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Number of SO ₂ Instruments	Number of Instruments Reporting ≥ 75% Ambient Data	Percent of Instruments Reporting ≥ 75% Ambient Data (%)
Great Basin	MO	1	1	100
Imperial County	CARB	1	1	100
Mojave Desert	MO	2	2	100
North Coast	MO	1	1	100
Sacramento Metropolitan	MO	1	1	100
San Joaquin Valley	CARB	1	1	100
San Luis Obispo County	MO; CARB	1	1	100
Santa Barbara County	MO	1	1	100

Table D-3. Gaseous Pollutants – 2021 Instrument Precision Results and Bias for Geographic Areas within CARB’s PQAO

Geographic Area	Monitoring By	Number of CO Instruments	Number of Instruments with ≥ 75% of Required 1-pt QC checks	Upper Bound of CV (Precision)	Bias
Antelope Valley	MO	1	1	1.87	±1.63
Butte County	CARB	1	1	6.88	±6.17
Great Basin	MO	1	1	1.91	±2.37
Imperial County	CARB	1	1	2.11	±5.78
Mojave Desert	MO	2	2	4.28	±3.86
Monterey Bay	MO	1	1	5.36	±4.56
North Coast	MO	1	1	2.93	±1.99
Sacramento Metropolitan	MO	2	1	2.81	±2.81
San Joaquin Valley	MO; CARB	7	4	3.73	±3.05
Santa Barbara County	MO	2	2	2.70	±4.60
Geographic Area	Monitoring By	Number of NO ₂ Instruments	Number of Instruments with ≥ 75% of Required 1-pt QC checks	Upper Bound of CV (Precision)	Bias
Antelope Valley	MO	1	1	1.76	±1.46
Butte County	CARB	1	1	3.20	±3.96
Feather River	CARB	1	1	3.08	±2.82
Imperial County	MO; CARB	2	2	3.15	±9.12
Mojave Desert	MO	3	3	3.01	±4.61
Monterey Bay	MO	1	1	5.10	±6.99

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Table D-3. Gaseous Pollutants – 2021 Instrument Precision Results for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Number of NO ₂ Instruments	Number of Instruments with ≥ 75% of Required 1-pt QC checks	Upper Bound of CV (Precision)	Bias
North Coast	MO	1	1	3.58	±3.50
Placer County	CARB	1	1	5.20	±4.64
Sacramento Metropolitan	MO; CARB	5	4	3.32	±3.31
San Joaquin Valley	MO; CARB	19	19	4.14	±4.71
San Luis Obispo County	MO	2	2	2.90	±2.87
Santa Barbara County	MO	2	2	1.39	±8.14
Ventura County	MO	2	2	3.01	±2.53
Yolo-Solano	CARB	1	1	3.29	±1.94
Geographic Area	Monitoring By	Number of O ₃ Instruments	Number of Instruments with ≥ 75% of Required 1-pt QC checks	Upper Bound of CV (Precision)	Bias
Amador County	CARB	1	1	3.10	±3.50
Antelope Valley	MO	1	1	0.87	±4.64
Butte County	CARB	2	2	2.67	±3.31
Calaveras County	CARB	1	1	3.43	±4.71
Colusa County	CARB	1	1	1.92	±2.87
Eastern Kern	CARB	1	1	2.24	±8.14
El Dorado County	CARB	3	2	1.59	±2.53
Feather River	CARB	2	2	1.98	±1.94
Glenn County	CARB	1	1	2.95	±3.50
Great Basin	MO	1	1	4.81	±4.64
Imperial County	MO; CARB	4	4	2.38	±3.31
Lake County	MO	1	1	1.58	±4.71
Mariposa County	CARB	1	1	3.03	±2.87
Mendocino County	MO	1	1	2.93	±8.14
Mojave Desert	MO; CARB	6	6	1.98	±2.53
Monterey Bay	MO	5	5	1.68	±1.94
North Coast	MO	1	1	3.89	±3.50
Northern Sierra	MO; CARB	1	0	2.76	±4.64
Placer County	MO; CARB	5	5	2.08	±3.31
Sacramento Metropolitan	MO; CARB	6	6	2.43	±4.71
San Joaquin Valley	MO; CARB	24	24	1.71	±2.87

Table D-3. Gaseous Pollutants – 2021 Instrument Precision Results for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Number of O ₃ Instruments	Number of Instruments with ≥ 75% of Required 1-pt QC checks	Upper Bound of CV (Precision)	Bias
San Luis Obispo County	MO; CARB	7	7	1.51	±1.90
Santa Barbara County	MO; CARB	8	8	3.73	±2.40
Shasta County	MO	3	3	4.97	±5.70
Siskiyou County	MO	1	1	2.91	±2.62
Tehama County	MO; CARB	2	2	2.14	±1.90
Tuolumne County	CARB	1	1	1.95	±1.60
Ventura County	MO	5	5	1.43	±1.40
Yolo-Solano	MO; CARB	3	3	2.77	±3.37
Geographic Area	Monitoring By	Number of SO ₂ Instruments	Number of Instruments with ≥ 75% of Required 1-pt QC checks	Upper Bound of CV (Precision)	Bias
Great Basin	MO	1	1	1.76	±3.89
Imperial County	CARB	1	1	5.26	±4.87
Mojave Desert	MO	2	2	3.42	±3.67
North Coast	MO	1	1	3.30	±2.46
Sacramento Metropolitan	MO	1	1	2.18	±3.53
San Joaquin Valley	CARB	1	0	4.91	±4.03
San Luis Obispo County	MO	1	1	1.54	±3.26
Santa Barbara County	MO	1	1	1.38	±2.42

- Source: AQS, AMP 256 Data Quality Indicator Report, run November 2022.
- Details on CARB’s PQAO instruments not meeting these criteria are provided in Appendix E of this report.
- Upper bound of CV (precision) is estimated by the upper confidence limit of the standard deviation of differences measured by 1-pt QC checks; CFR limit for CV: 7% for O₃, 15% for NO₂, 10% for CO and SO₂, based on 1-pt QC checks required to be performed every two weeks, and U.S. EPA AMP 600 report flags instruments that do not have at least 75% of the required 1-pt QC checks. Bias is estimated as the upper bound on the mean absolute value of the percent differences measured by 1-pt QC checks; CFR limits for bias: ±7% for O₃, ±15% for NO₂, ±10% for CO and SO₂.

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Table D-4. Gaseous Pollutants – 2021 1-pt QC Checks – Individual Assessment for Geographic Areas within CARB’s PQAO

Geographic Area	Monitoring By	Number of Instruments	Number of CO 1-pt QC Checks Performed	Number of CO 1-pt QC Checks Meeting Criteria	Percent of CO 1-pt QC Checks Meeting Criteria (%)
Antelope Valley	MO	1	57	57	100.0
Butte County	CARB	1	183	174	95.1
Great Basin	MO	1	57	57	100.0
Imperial County	CARB	1	244	244	100.0
Mojave Desert	MO	2	100	99	99.0
Monterey Bay	MO	1	52	52	100.0
North Coast	MO	1	106	105	99.1
Sacramento Metropolitan	MO	2	216	214	99.1
San Joaquin Valley	MO; CARB	7	470	440	93.6
Santa Barbara County	MO	2	379	379	100.0
Geographic Area	Monitoring By	Number of Instruments	Number of NO ₂ 1-pt QC Checks Performed	Number of NO ₂ 1-pt QC Checks Meeting Criteria	Percent of NO ₂ 1-pt QC Checks Meeting Criteria (%)
Antelope Valley	MO	1	54	54	100.0
Butte County	CARB	1	250	250	100.0
Feather River	CARB	1	238	238	100.0
Imperial County	MO; CARB	2	271	271	100.0
Mojave Desert	MO	3	150	150	100.0
Monterey Bay	MO	1	52	52	100.0
North Coast	MO	1	115	115	100.0
Placer County	CARB	1	252	252	100.0
Sacramento Metropolitan	MO; CARB	5	756	756	100.0
San Joaquin Valley	MO; CARB	19	5,248	5,247	99.9
San Luis Obispo County	MO	2	709	709	100.0
Santa Barbara County	MO	2	369	369	100.0
Ventura County	MO	2	338	338	100.0
Yolo-Solano	CARB	1	217	217	100.0

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Table D-4. Gaseous Pollutants – 2021 1-pt QC Checks – Individual Assessment for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Number of Instruments	Number of O ₃ 1-pt QC Checks Performed	Number of O ₃ 1-pt QC Checks Meeting Criteria	Percent of O ₃ 1-pt QC Checks Meeting Criteria (%)
Amador County	CARB	1	359	359	100.0
Antelope Valley	MO	1	55	55	100.0
Butte County	CARB	2	599	599	100.0
Calaveras County	CARB	1	356	356	100.0
Colusa County	CARB	1	325	325	100.0
Eastern Kern	CARB	1	354	354	100.0
El Dorado County	CARB	3	602	602	100.0
Feather River	CARB	2	401	401	100.0
Glenn County	CARB	1	340	340	100.0
Great Basin	MO	1	41	41	100.0
Imperial County	MO; CARB	4	315	315	100.0
Lake County	MO	1	52	52	100.0
Mariposa County	CARB	1	172	172	100.0
Mendocino County	MO	1	50	50	100.0
Mojave Desert	MO; CARB	6	576	576	100.0
Monterey Bay	MO	5	259	259	100.0
North Coast	MO	1	105	105	100.0
Northern Sierra	MO	1	15	15	100.0
Placer County	MO; CARB	5	362	362	100.0
Sacramento Metropolitan	MO; CARB	6	1,095	1,095	100.0
San Joaquin Valley	MO; CARB	24	6,798	6,798	100.0
San Luis Obispo County	MO	6	2,082	2,082	100.0
Santa Barbara County	MO	9	2,198	2,198	100.0
Shasta County	MO	3	119	119	100.0
Siskiyou County	MO	1	27	27	100.0
Tehama County	MO; CARB	2	257	257	100.0
Tuolumne County	CARB	1	362	362	100.0
Ventura County	MO	5	878	878	100.0
Yolo-Solano	MO; CARB	3	349	349	100.0

Table D-4. Gaseous Pollutants – 2021 1-pt QC Checks – Individual Assessment for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Number of Instruments	Number of SO ₂ 1-pt QC Checks Performed	Number of SO ₂ 1-pt QC Checks Meeting Criteria	Percent of SO ₂ 1-pt QC Checks Meeting Criteria (%)
Great Basin	MO	1	57	57	100.0
Imperial County	CARB	1	235	235	100.0
Mojave Desert	MO	2	97	97	100.0
North Coast	MO	1	114	114	100.0
Sacramento Metropolitan	MO	1	114	114	100.0
San Joaquin Valley	CARB	1	35	35	100.0
San Luis Obispo County	MO	1	361	361	100.0
Santa Barbara County	MO	1	356	356	100.0

- Source: AQS, AMP 251 QA Raw Assessment Report, run November 2022.
- Criteria for individual 1-pt QC checks are: < $\pm 7.1\%$ (percent difference) or < ± 1.5 ppb difference, whichever is greater, for O₃; < $\pm 10.1\%$ (percent difference) for CO; < $\pm 15.1\%$ (percent difference) or < ± 1.5 ppb difference, whichever is greater, for NO₂; and < $\pm 10.1\%$ (percent difference) or < ± 1.5 ppb difference, whichever is greater, for SO₂. Details on CARB’s PQAO instruments not meeting these criteria are provided in Appendix E of this report.

Table D-5. Gaseous Pollutants – 2021 1-pt QC Checks – Individual Assessment on Prescribed Range for Geographic Areas within CARB’s PQAO

Geographic Area	Monitoring By	Number of Instruments	Number of CO 1-pt QC Checks Performed	Number of CO 1-pt QC Checks Meeting Criteria	Percent of CO 1-pt QC Checks Meeting Criteria (%)
Antelope Valley	MO	1	57	57	100.0
Butte County	CARB	1	183	183	100.0
Great Basin	MO	1	57	57	100.0
Imperial County	CARB	1	244	244	100.0
Mojave Desert	MO	2	100	100	100.0
Monterey Bay	MO	1	52	52	100.0
North Coast	MO	1	106	106	100.0
Sacramento Metropolitan	MO	2	216	216	100.0
San Joaquin Valley	MO; CARB	7	470	438	93.2
Santa Barbara County	MO	2	379	355	93.7

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Table D-5. Gaseous Pollutants – 2021 1-pt QC Checks – Individual Assessment on Prescribed Range for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Number of Instruments	Number of NO ₂ 1-pt QC Checks Performed	Number of NO ₂ 1-pt QC Checks Meeting Criteria	Percent of NO ₂ 1-pt QC Checks Meeting Criteria (%)
Antelope Valley	MO	1	54	54	100.0
Butte County	CARB	1	250	250	100.0
Feather River	CARB	1	238	238	100.0
Imperial County	MO; CARB	2	271	271	100.0
Mojave Desert	MO	3	150	150	100.0
Monterey Bay	MO	1	52	52	100.0
North Coast	MO	1	115	115	100.0
Placer County	CARB	1	252	252	100.0
Sacramento Metropolitan	MO; CARB	5	756	752	99.5
San Joaquin Valley	MO; CARB	19	5248	5248	100.0
San Luis Obispo County	MO	2	709	709	100.0
Santa Barbara County	MO	2	369	368	99.7
Ventura County	MO	2	338	338	100.0
Yolo-Solano	CARB	1	217	217	100.0
Geographic Area	Monitoring By	Number of Instruments	Number of O ₃ 1-pt QC Checks Performed	Number of O ₃ 1-pt QC Checks Meeting Criteria	Percent of O ₃ 1-pt QC Checks Meeting Criteria (%)
Amador County	CARB	1	359	359	100.0
Antelope Valley	MO	1	55	55	100.0
Butte County	CARB	2	599	599	100.0
Calaveras County	CARB	1	356	356	100.0
Colusa County	CARB	1	325	325	100.0
Eastern Kern	CARB	1	354	354	100.0
El Dorado County	CARB	3	602	602	100.0
Feather River	CARB	2	401	401	100.0
Glenn County	CARB	1	340	340	100.0
Great Basin	MO	1	41	41	100.0
Imperial County	MO; CARB	4	315	315	100.0
Lake County	MO	1	52	52	100.0
Mariposa County	CARB	1	172	172	100.0
Mendocino County	MO	1	50	50	100.0
Mojave Desert	MO; CARB	6	576	576	100.0
Monterey Bay	MO	5	259	259	100.0

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Table D-5. Gaseous Pollutants – 2021 1-pt QC Checks – Individual Assessment on Prescribed Range for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Number of Instruments	Number of O ₃ 1-pt QC Checks Performed	Number of O ₃ 1-pt QC Checks Meeting Criteria	Percent of O ₃ 1-pt QC Checks Meeting Criteria (%)
North Coast	MO	1	105	105	100.0
Northern Sierra	MO	1	15	15	100.0
Northern Sonoma County	MO	1	NDA	NDA	NDA
Placer County	MO; CARB	5	362	362	100.0
Sacramento Metropolitan	MO; CARB	6	1,095	1,058	96.6
San Joaquin Valley	MO; CARB	24	6,798	6,798	100.0
San Luis Obispo County	MO	7	2,082	2,082	100.0
Santa Barbara County	MO	9	2,198	2,187	99.5
Shasta County	MO	3	119	119	100.0
Siskiyou County	MO	1	27	27	100.0
Tehama County	MO; CARB	2	257	257	100.0
Tuolumne County	CARB	1	362	362	100.0
Ventura County	MO	5	878	878	100.0
Yolo-Solano	MO; CARB	3	349	349	100.0
Geographic Area	Monitoring By	Number of Instruments	Number of SO ₂ 1-pt QC Checks Performed	Number of SO ₂ 1-pt QC Checks Meeting Criteria	Percent of SO ₂ 1-pt QC Checks Meeting Criteria (%)
Great Basin	MO	1	57	57	100.0
Imperial County	CARB	1	235	235	100.0
Mojave Desert	MO	2	97	97	100.0
North Coast	MO	1	114	114	100.0
Sacramento Metropolitan	MO	1	114	114	100.0
San Joaquin Valley	CARB	1	35	35	100.0
San Luis Obispo County	MO	1	361	361	100.0
Santa Barbara County	MO	1	356	356	100.0

- Source: AQS, AMP 251 QA Raw Assessment Report, run November 2022.
- Details on CARB’s PQAO instruments not meeting these criteria are provided in Appendix E of this report.

Table D-6. Gaseous Pollutants – 2021 Results for Performance Audits of Gaseous Pollutant Instruments for Geographic Areas within CARB’s PQAO

Geographic Area	Monitoring By	Number of CO Instruments	Number of CO Instruments Audited	Average Percent Difference* (%)
Antelope Valley	MO	1	1	-3.86
Butte County	CARB	1	1	NDA
Great Basin	MO	1	0	NDA
Imperial County	MO; CARB	1	1	-1.05
Mojave Desert	MO	2	2	-8.19
Monterey Bay	MO	1	1	-7.46
North Coast	MO	1	0	NDA
Sacramento Metropolitan	MO	2	2	-5.78
San Joaquin Valley	MO; CARB	7	6	-1.88
Santa Barbara County	MO	2	1	NDA
Geographic Area	Monitoring By	Number of NO ₂ Instruments	Number of NO ₂ Instruments Audited	Average Percent Difference* (%)
Antelope Valley	MO	1	1	0.00
Butte County	CARB	1	1	-5.06
Feather River	CARB	1	1	-6.61
Imperial County	MO; CARB	2	2	-4.71
Mojave Desert	MO	3	3	0.16
Monterey Bay	MO	1	1	-7.60
North Coast	MO	1	0	NDA
Placer County	CARB	1	1	-11.40
Sacramento Metropolitan	MO; CARB	5	5	-5.66
San Joaquin Valley	MO; CARB	19	14	0.29
San Luis Obispo County	MO	2	2	-6.93
Santa Barbara County	MO; CARB	2	1	-4.18
Ventura County	MO	2	2	-2.13
Yolo-Solano	CARB	1	1	-7.63
Geographic Area	Monitoring By	Number of O ₃ Instruments	Number of O ₃ Instruments Audited	Average Percent Difference* (%)
Amador County	CARB	1	1	-2.13
Antelope Valley	MO	1	1	3.17
Butte County	CARB	2	2	-7.53
Calaveras County	CARB	1	1	1.33
Colusa County	CARB	1	1	-11.75
Eastern Kern	CARB	1	1	-4.49
El Dorado County	CARB	3	3	-7.36
Feather River	CARB	2	2	-8.17
Glenn County	CARB	1	1	-10.45
Great Basin	MO	1	1	-5.64
Imperial County	MO; CARB	4	4	-3.89
Glenn County	CARB	1	1	-10.45

Table D-6. Gaseous Pollutants – 2021 Results for Performance Audits of Gaseous Pollutant Instruments for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Number of O ₃ Instruments	Number of O ₃ Instruments Audited	Average Percent Difference* (%)
Great Basin	MO	1	1	-5.64
Imperial County	MO; CARB	4	4	-3.89
Lake County	MO	1	1	-7.01
Mariposa County	CARB	1	1	-0.74
Mendocino County	MO	1	1	-6.96
Mojave Desert	MO; CARB	6	6	1.04
Monterey Bay	MO	5	5	-1.26
North Coast	MO	1	1	-8.17
Northern Sierra	MO; CARB	1	1	-1.03
Placer County	MO; CARB	5	5	0.73
Sacramento Metropolitan	MO; CARB	6	6	-2.61
San Joaquin Valley	MO; CARB	24	23	-4.12
San Luis Obispo County	MO; CARB	7	6	-2.89
Santa Barbara County	MO; CARB	8	7	-2.98
Shasta County	MO	3	3	-6.65
Siskiyou County	MO	1	1	-4.45
Tehama County	MO; CARB	2	2	-3.88
Tuolumne County	CARB	1	1	-3.67
Ventura County	MO	5	5	-0.96
Yolo-Solano	MO; CARB	3	3	-10.36
Geographic Area	Monitoring By	Number of SO ₂ Instruments	Number of SO ₂ Instruments Audited	Average Percent Difference* (%)
Great Basin	MO	1	0	NDA
Imperial County	CARB	1	1	-9.58
Mojave Desert	MO	2	2	10.05
North Coast	MO	1	0	NDA
Sacramento Metropolitan	MO	1	1	-9.71
San Joaquin Valley	CARB	1	1	13.72
San Luis Obispo County	MO; CARB	1	0	NDA
Santa Barbara County	MO	1	1	-0.68

- Source: AQS, AMP 256 Data Quality Indicator Report, run November 2022.
- Details on CARB’s PQAO instruments not meeting these criteria are provided in Appendix E of this report.
- NDA means no data available in AQS. For 2021, CARB focused on PM flow rate audits only during the first two quarters of 2021 before expanding to full operations for gaseous pollutants for the remainder of the year. See communication between CARB and U.S. EPA regarding limited operations due to COVID-19 restrictions in Appendix F of this report.
- *Average percent difference is the arithmetic mean of the combined differences from the known value of all the individual audit points over the range considered in the audits.
- CARB’s performance audit criteria for 2021 were: $\pm 10\%$ for O₃ and $\pm 15\%$ for CO, NO₂, and SO₂ for each audit point, with additional absolute differences in U.S. EPA audit levels 1 and 2 (see Appendix C of this report for details). Since the two lowest audit points for trace CO and trace SO₂ are U.S. EPA audit levels 1 and 2, and the lowest audit point for O₃ is U.S. EPA audit level 2, they were not subject to the AQDA process and were excluded from this analysis.

Table D-7. PM Samplers – 2021 Ambient PM Data Capture Results for Geographic Areas within CARB’s PQAO

Geographic Area	Monitoring By	Number of PM ₁₀ Samplers	Number of PM ₁₀ Samplers Reporting ≥ 75% Data	Percent of PM ₁₀ Samplers Reporting ≥ 75% Data (%)
Antelope Valley	MO	1	1	100
Butte County	CARB	1	1	100
Calaveras County	CARB	1	1	100
Colusa County	CARB	1	1	100
Eastern Kern	MO; CARB	3	3	100
El Dorado County	CARB	1	1	100
Feather River	CARB	1	1	100
Glenn County	CARB	1	1	100
Great Basin	MO	19	17	89
Imperial County	MO; CARB	5	4	80
Lake County	MO	3	3	100
Mariposa County	CARB	1	1	100
Mendocino County	MO	1	1	100
Mojave Desert	MO	5	5	100
Monterey Bay	MO	3	3	100
North Coast	MO	1	1	100
Northern Sonoma County	MO	3	3	100
Placer County	CARB	1	1	100
Sacramento Metropolitan	MO; CARB	5	5	100
San Joaquin Valley	MO; CARB	20	20	100
San Luis Obispo County	MO	8	8	100
Santa Barbara County	MO; CARB	4	4	100
Shasta County	MO	2	2	100
Tehama County	MO	1	1	100
Ventura County	MO	2	2	100
Yolo-Solano	MO	3	3	100

Table D-7. PM Samplers – 2021 Ambient PM Data Capture Results for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Number of PM ₁₀ Samplers	Number of PM _{2.5} Samplers Reporting ≥ 75% Data	Percent of PM _{2.5} Samplers Reporting ≥ 75% Data (%)
Antelope Valley	MO	1	1	100
Butte County	CARB	1	1	100
Calaveras County	CARB	1	1	100
Colusa County	CARB	1	1	100
Eastern Kern	MO; CARB	2	2	100
Feather River	CARB	2	2	100
Great Basin	MO	7	5	71
Imperial County	MO; CARB	6	6	100
Lake County	MO	1	1	100
Mendocino County	MO	3	3	100
Mojave Desert	MO	2	2	100
Monterey Bay	MO	7	7	100
North Coast	MO	1	1	100
Northern Sierra	MO	6	2	33
Placer County	MO; CARB	2	2	100
Sacramento Metropolitan	MO; CARB	9	6	67
San Joaquin Valley	MO; CARB	22	19	86
San Luis Obispo County	MO	5	5	100
Santa Barbara County	MO; CARB	4	4	100
Shasta County	MO	2	1	50
Siskiyou County	MO	1	1	100
Tehama County	MO	1	1	100
Ventura County	MO	6	6	100
Yolo-Solano	MO	2	1	50

- Source: AQS, AMP 430 Data Completeness Report, run November 2022.
- Details on CARB’s PQAO samplers not reporting ≥ 75% ambient data are provided in Appendix E of this report.

Table D-8. PM Samplers – 2021 Results for PM Flow Rate Verifications for Geographic Areas within CARB’s PQAO

Geographic Area	Monitoring By	Type	Number of PM ₁₀ Samplers	Number of PM ₁₀ FRVs Required	Number of PM ₁₀ FRVs Performed	Average Percent Difference* (%)	Bias
Antelope Valley	MO	Low-Vol	1	12	12	0.30	1.57
Butte County	CARB	Low-Vol	1	12	12	0.05	1.31
Calaveras County	CARB	Low-Vol	1	12	12	-0.51	1.22
Colusa County	CARB	Low-Vol	1	12	12	-0.07	0.81
Eastern Kern	MO	Low-Vol	3	36	60	-0.17	0.75
El Dorado County	CARB	Low-Vol	1	12	12	-0.59	1.18
Feather River	CARB	Low-Vol	1	12	12	1.71	2.25
Glenn County	CARB	Low-Vol	1	12	12	0.71	1.05
Great Basin	MO	Low-Vol	19	221	380	0.05	1.07
Imperial County	MO	Low-Vol	5	60	110	0.55	1.22
Lake County	MO	Low-Vol	3	36	39	-0.02	1.12
Mariposa County	CARB	Low-Vol	1	12	12	-0.82	1.32
Mendocino County	MO	Low-Vol	1	12	15	-0.82	1.34
Mojave Desert	MO	Low-Vol	5	60	57	-0.23	1.33
Monterey Bay	MO	Low-Vol	3	34	144	-0.71	1.04
North Coast	MO	Low-Vol	1	12	21	0.14	0.71
Northern Sonoma County	MO	Low-Vol	3	36	36	0.21	1.01
Placer County	MO; CARB	Low-Vol	1	12	12	-0.66	1.55
Sacramento Metropolitan	MO; CARB	Hi-Vol	4	16	41	1.47	2.53
		Low-Vol	1	12	12	0.05	0.72
San Joaquin Valley	MO; CARB	Hi-Vol	7	82	142	-0.57	3.11
		Low-Vol	13	141	192	0.12	0.85
San Luis Obispo County	MO	Low-Vol	8	84	153	-0.14	0.71
Santa Barbara County	MO; CARB	Low-Vol	4	37	72	-0.03	1.19
Shasta County	MO	Hi-Vol	2	7	13	2.07	4.52
Tehama County	MO	Hi-Vol	1	4	9	1.31	2.12
Ventura County	MO	Low-Vol	2	24	59	0.01	0.53
Yolo-Solano	MO; CARB	Hi-Vol	3	12	12	0.67	4.32

Table D-8. PM Samplers – 2021 Results for PM Flow Rate Verifications for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Type	Number of PM _{2.5} Samplers	Number of PM _{2.5} FRVs Required	Number of PM _{2.5} FRVs Performed	Average Percent Difference* (%)	Bias
Antelope Valley	MO	All	1	12	12	1.35	1.83
Butte County	CARB	All	1	12	12	0.41	1.68
Calaveras County	CARB	All	1	12	12	0.13	0.71
Colusa County	CARB	All	1	12	12	0.20	0.89
Eastern Kern	MO	All	2	24	37	-1.09	1.32
Feather River	CARB	All	2	21	21	1.23	1.78
Great Basin	MO	All	7	84	102	0.05	0.93
Imperial County	MO; CARB	All	6	44	65	0.46	1.14
Lake County	MO	All	1	12	13	0.01	0.81
Mendocino County	MO	All	3	24	38	-0.06	1.15
Mojave Desert	MO	All	2	24	24	0.19	1.51
Monterey Bay	MO	All	7	84	328	-0.36	0.75
North Coast	MO	All	1	12	24	0.69	0.90
Northern Sierra	MO	All	6	68	59	-0.19	1.38
Placer County	MO	All	2	24	38	0.22	0.72
Sacramento Metropolitan	MO; CARB	All	9	105	157	-0.03	1.34
San Joaquin Valley	MO; CARB	All	22	240	343	0.02	0.83
San Luis Obispo County	MO	All	5	48	95	-0.05	0.59
Santa Barbara County	MO	All	4	37	72	-0.12	1.15
Shasta County	MO	All	2	24	25	0.76	4.07
Siskiyou County	MO	All	1	12	25	0.95	1.12
Tehama County	MO	All	1	12	37	0.00	0.32
Ventura County	MO	All	6	72	202	-0.04	0.55
Yolo-Solano	MO	All	2	18	15	-0.08	0.70

- *Average percent difference is the arithmetic mean of the differences between the sampler’s flow rate and the flow rate of the standard used during the flow rate verifications.

Table D-9. PM Samplers – 2021 Results for PM Sampler Flow Rate Audits for Geographic Areas within CARB’s PQAO

Geographic Area	Monitoring By	Number of PM ₁₀ Samplers	Number of PM ₁₀ Samplers Audited*	Number of PM ₁₀ Flow Rate Audits Not Meeting CARB Criteria*	Average Percent Difference** (%)
Antelope Valley	MO	1	1	0	0.38
Butte County	CARB	1	1	0	0.69
Calaveras County	CARB	1	1	0	-0.12
Colusa County	CARB	1	1	0	0.52
Eastern Kern	MO	3	3	0	-0.64
El Dorado County	CARB	1	1	0	-1.18
Feather River	CARB	1	1	0	1.64
Glenn County	CARB	1	1	0	2.61
Great Basin	MO	19	19	0	-0.34
Imperial County	MO	5	4	0	0.39
Lake County	MO	3	3	0	-0.34
Mariposa County	CARB	1	1	0	-0.30
Mendocino County	MO	1	1	0	-1.55
Mojave Desert	MO	5	5	0	-0.30
Monterey Bay	MO	3	3	0	0.04
North Coast	MO	1	1	0	-1.27
Northern Sonoma County	MO	3	3	0	0.15
Placer County	MO; CARB	1	1	0	0.00
Sacramento Metropolitan	MO; CARB	5	5	0	1.73
San Joaquin Valley	MO; CARB	20	20	0	0.42
San Luis Obispo County	MO	8	8	0	-0.23
Santa Barbara County	MO; CARB	4	4	0	-0.01
Shasta County	MO	2	2	0	3.88
Tehama County	MO	1	1	0	1.28
Ventura County	MO	2	2	0	-0.45
Yolo-Solano	MO; CARB	3	3	2	3.49
Geographic Area	Monitoring By	Number of PM _{2.5} Samplers	Number of PM _{2.5} Samplers Audited*	Number of PM _{2.5} Flow Rate Audits Not Meeting CARB Criteria*	Average Percent Difference** (%)
Antelope Valley	MO	1	1	0	0.02
Butte County	CARB	1	1	0	1.03
Calaveras County	CARB	1	1	0	0.94
Colusa County	CARB	1	1	0	0.78
Eastern Kern	MO	2	2	0	-1.36
Feather River	CARB	2	1	0	1.48
Great Basin	MO	7	7	0	-0.29
Imperial County	MO	6	6	0	0.64
Lake County	MO	1	1	0	-0.42
Mendocino County	MO	3	3	0	-0.44

Table D-9. PM Samplers – 2021 Results for PM Sampler Flow Rate Audits for Geographic Areas within CARB’s PQAO (cont.)

Geographic Area	Monitoring By	Number of PM _{2.5} Samplers	Number of PM _{2.5} Samplers Audited*	Number of PM _{2.5} Flow Rate Audits Not Meeting CARB Criteria*	Average Percent Difference** (%)
Mojave Desert	MO	2	2	0	-0.04
Monterey Bay	MO	7	7	0	0.30
North Coast	MO	1	1	0	3.35
Northern Sierra	MO	6	4	2	-0.81
Placer County	MO; CARB	2	2	2	0.38
Sacramento Metropolitan	MO; CARB	9	6	0	0.21
San Joaquin Valley	MO; CARB	22	21	1	1.28
San Luis Obispo County	MO	5	5	0	-0.72
Santa Barbara County	MO; CARB	4	4	0	-0.44
Shasta County	MO	2	2	0	0.00
Siskiyou County	MO	1	1	0	0.82
Tehama County	MO	1	1	0	-0.09
Ventura County	MO	6	6	0	-0.07
Yolo-Solano	MO; CARB	2	1	0	-0.62

- Source: AQS, AMP 256 Data Quality Indicator Report, run November 2022.
- *Details on CARB’s PQAO samplers not being audited or not meeting audit criteria are provided in Appendix E of this report.
- **Average percent difference is the arithmetic mean of the differences between the sampler’s flow rate and the flow rate of the standard used during the flow rate audits.
- CARB’s flow rate audit criteria for 2021 were $\pm 7\%$ for PM₁₀ Hi-Vol and $\pm 4\%$ for PM₁₀ Low-Vol and PM_{2.5}. Only audits conducted by CARB were subject to the AQDA process. Details on CARB’s PQAO samplers not meeting these criteria can be found in Appendix E of this report. Only flow failures are included in this table.

Appendix E. CARB's PQAO Data Quality Issues

This appendix contains a listing of gaseous instruments and PM samplers which did not meet a particular MQO. These data are provided for informational purposes only, as most MQOs are assessed at the PQAO level.

Due to the COVID-19 pandemic and following 2020 guidance on priorities from U.S. EPA and Governor Newsom's regional stay-at-home order, CARB continued limited audit operations and PM laboratory support in early parts of 2021. Furthermore, CARB focused on PM flow rate audits and a few O₃ audits during the first two quarters of 2021, before expanding to full operations for gaseous pollutants for the remainder of the year. See communication between CARB and U.S. EPA regarding limited operations due to COVID-19 restrictions in Appendix F of this report.

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Table E-1. Gaseous Instruments – Ambient Data Completeness < 75% Reported

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	(% Data Reported) Issue/Comment
06-067-0006-42101-1	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	CO 42101	(52%) Instrument malfunctioned in July and was out for maintenance/routine repairs (BA) late July-December.
06-067-0015-42101-1	Bercut Drive	Sacramento Metropolitan	Sacramento Metropolitan AQMD	CO 42101	(72%) Maintenance/routine repairs (BA) early October-December.
06-077-1002-42101-3	Stockton – Hazelton Street	San Joaquin Valley	CARB	CO 42101	(71%) Multiple machine malfunctions (AN) during year. Monitor was shutdown/relocated in November.
06-077-1003-42101-3	Stockton – University Park	San Joaquin Valley	CARB	CO 42101	(42%) Monitor began operating November 5. November data nulled with machine malfunctions (AN).
06-099-0005-42101-3	Modesto – 14 th Street	San Joaquin Valley	CARB	CO 42101	(52%) Data capture rate low due to instrumentation issues with new instrument (OS).
06-083-1008-42101-3	Santa Maria – 906 S Broadway	Santa Barbara County	CARB	CO 42101	(51%) U.S. EPA approved shutdown of site and monitors. Monitor shut down on February 28. Data reported from January-February 1.
06-067-0006-42602-1	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	NO ₂ 42602	(1%) Staff determined an invalid calibration affected data. Data invalidated and rest of data followed the proper data validation process.
06-067-0012-42602-1	Folsom – Natoma Street	Sacramento Metropolitan	Sacramento Metropolitan AQMD	NO ₂ 42602	(73%) Instrument drifted beyond acceptable QC limits in October. Invalid data flagged with a null data qualifier code. Maintenance/routine repairs (BA) for mid-August, and mid-October to mid-December.
06-067-0015-42602-1	Sacramento – Bercut Drive	Sacramento Metropolitan	Sacramento Metropolitan AQMD	NO ₂ 42602	(55%) Instrument drifted beyond acceptable QC limits starting July 2022. Maintenance/routine repairs (BA) for early August-December.
06-067-0011-42602-1	Elk Grove – Bruceville Road	Sacramento Metropolitan	Sacramento Metropolitan AQMD	NO ₂ 42602	(66%) Maintenance/routine repairs (BA) for April, September, and late October-December.

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Table E-1. Gaseous Instruments – Ambient Data Completeness < 75% Reported (cont.)

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	(% Data Reported) Issue/Comment
06-083-1008-42602-1	Santa Maria – 906 S Broadway	Santa Barbara County	CARB	NO ₂ 42602	(51%) U.S. EPA approved shutdown of site and monitors starting February 28. Data reported from January-February 1.
06-017-0012-44201-1	Echo Summit	El Dorado County	CARB	O ₃ 44201	(45%) Monitor impacted by Dixie Fire damage. Power to site was not available, no data from April to mid-May and September-October.
06-067-0006-44201-1	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	O ₃ 44201	(46%) Staff determined an invalid calibration affected data. Data after June 23 remains valid after proper validation process.
06-067-0002-44201-1	Sacramento – North Highlands	Sacramento Metropolitan	Sacramento Metropolitan AQMD	O ₃ 44201	(0%) Staff determined the calibration may not be valid. The entire year of data invalidated.
06-079-2006-44201-1	San Luis Obispo – 3220 South Higuera St	San Luis Obispo County	CARB	O ₃ 44201	(45%) Monitor shut down in early January. Half of data reported with machine malfunction (AN).

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Table E-2. Gaseous Instruments – Precision/Bias 1-pt QC Checks < 75% Reported

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	(% 1-pt QC Checks Reported) Issue/Comment
06-067-0006-42101-1	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	CO 42101	(69%) Affected data was invalidated. Maintenance/ routine repairs (BA) for late July-December. No QC checks performed from mid-September-December.
06-067-0015-42602-1	Sacramento – Bercut Drive	Sacramento Metropolitan	Sacramento Metropolitan AQMD	NO ₂ 42602	(58%) Instrument drifted beyond acceptable QC limits starting in July 2022. Maintenance/ routine repairs (BA) for early August-December; no QC checks conducted.
06-019-0011-42101-3	Fresno – Garland	San Joaquin Valley	CARB	CO 42101	(0%) QC collected. Reported QC checks for this site were <500 ppb. AQS does not provide credit for CO QC checks below 500 ppb. Per CFR, QC checks for trace gas monitors should be conducted at or near routine concentrations measured by the monitors. Mean CO concentrations for this monitor is 349 ppb. 32 QC checks done for the year, missing November and December (see 251 reports).
06-077-1003-42101-3	Stockton – University Park	San Joaquin Valley	CARB	CO 42101	(50%) Monitor began operating November 5. All other QA/QC checks were performed. 16 QC checks conducted in December.
06-099-0005-42101-3	Modesto – 14th Street	San Joaquin Valley	CARB	CO 42101	(69%) Data capture rate low due to instrumentation issues with new instrument (OS). All other QA/QC checks performed.

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Table E-2. Gaseous Instruments – Precision/Bias 1-pt QC Checks < 75% Reported (cont.)

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	(% 1-pt QC Checks Reported) Issue/Comment
06-017-0012-44201-1	Echo Summit	El Dorado County	CARB	O ₃ 44201	(47%) Monitor impacted by Dixie Fire damage. Power to site was not available for a large portion of the O ₃ season. No QC checks performed in April or May, or in September and October.
06-057-0005-44201-1	Grass Valley – Litton Building	Northern Sierra	Northern Sierra AQMD	O ₃ 44201	(42%) No QC checks conducted July-December due to complications with Zero Air Generator.
06-019-0011-42401-3	Fresno – Garland	San Joaquin Valley	CARB	SO ₂ 42401	(73%) No QC checks were conducted in October to December due deviation from a CFR/Critical Criteria Requirement.

Table E-3. Gaseous Instruments – Audits Not Performed

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	Issue/Comment
06-027-0002-42101-1	White Mountain Research Center	Great Basin	Great Basin Unified APCD	CO 42101	CARB was unable to perform audit for this instrument due to COVID-19 restrictions.
06-023-1004-42101-1	Eureka-Jacobs	North Coast	North Coast Unified AQMD	CO 42101	CARB was unable to perform audit for this instrument due to COVID-19 restrictions.
06-077-1003-42101-3	Stockton – University Park	San Joaquin Valley	CARB	CO 42101	Monitor became operational November 5. CARB could not schedule audit before the end of the year.
06-083-1008-42101-3	Santa Maria – 906 S Broadway	Santa Barbara County	CARB	CO 42101	CARB could not perform audit before site closure. U.S. EPA approved a shutdown of this site and monitor operations February 28.

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Table E-3. Gaseous Instruments – Audits Not Performed (cont.)

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	Issue/Comment
06-023-1004-42602-1	Eureka-Jacobs	North Coast	North Coast Unified AQMD	NO ₂ 42602	CARB was unable to perform audit for this instrument due to COVID-19 restrictions.
06-019-2016-42602-1	Fresno – Foundry Park	San Joaquin Valley	San Joaquin Valley APCD	NO ₂ 42602	Direct-read NO ₂ is not compatible with current audit techniques.
06-029-0007-42602-1	Edison	San Joaquin Valley	CARB	NO ₂ 42602	NO ₂ audit was not performed due to audit equipment malfunction.
06-029-2019-42602-1	Bakersfield – Westwind	San Joaquin Valley	San Joaquin Valley APCD	NO ₂ 42602	Direct-read NO ₂ is not compatible with current audit techniques.
06-029-6001-42602-1	Shafter – Walker Street	San Joaquin Valley	CARB	NO ₂ 42602	NO ₂ audit was not performed due to audit equipment malfunction.
06-077-1003-42602-1	Stockton – University Park	San Joaquin Valley	CARB	NO ₂ 42602	CARB could not schedule audit before the end of the year. Monitor became operational November.
06-083-1008-42602-1	Santa Maria – 906 S Broadway	Santa Barbara County	CARB	NO ₂ 42602	CARB could not perform audit before site closure. U.S. EPA approved shutdown of this site and monitor operations February 28.
06-077-1003-44201-1	Stockton – University Park	San Joaquin Valley	CARB	O ₃ 44201	CARB could not schedule audit before the end of the year. Monitor became operational November.
06-079-2006-44201-1	San Luis Obispo – 3220 South Higuera St	San Luis Obispo County	San Luis Obispo County APCD	O ₃ 44201	CARB unable to audit this close to beginning of year. Monitor was shut down early January due to site closure. Data considered valid.
06-083-1008-44201-1	Santa Maria – 906 S Broadway	Santa Barbara County	CARB	O ₃ 44201	CARB unable to audit this close to beginning of year. Monitor was shut down late February due to site closure.

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Table E-3. Gaseous Instruments – Audits Not Performed (cont.)

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	Issue/Comment
06-027-0002-42401-1	White Mountain Research Center	Great Basin	Great Basin Unified APCD	SO ₂ 42401	CARB was unable to perform audit for this instrument due to COVID-19 restrictions.
06-023-1004-42602-1	Eureka-Jacobs	North Coast	North Coast Unified AQMD	SO ₂ 42401	CARB was unable to perform audit for this instrument due to COVID-19 restrictions.
06-079-2004-42401-1	Nipomo – Guadalupe Road	San Luis Obispo County	San Luis Obispo County APCD	SO ₂ 42401	Site was inaccessible to audit van; only PM sampler was accessible by foot and audited.

Table E-4. Gaseous Instruments – Audit Criteria or Critical Criteria Not Met

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	Issue/Comment
06-007-0008-42101-3	Chico – East Avenue	Butte County	CARB	CO 42101	AQDA #8464 issued for non-operational CO instrument at the time of audit.
06-071-0306-42101-1	Victorville – 14306 Park Avenue	Mojave Desert	Mojave Desert AQMD	CO 42101	AQDA #8466 issued for CO instrument that exceeded CARB and U.S. EPA criteria during the audit.
06-067-0006-42101-1	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	CO 42101	AQDA #8457 issued for non-operational CO instrument at the time of audit.
06-083-2004-42101-1	Lompoc – S H Street	Santa Barbara County	Santa Barbara County APCD	CO 42101	AQDA #8471 issued for non-operational CO instrument at the time of audit.
06-067-0002-42602-1	North Highlands – Blackfoot Way	Sacramento Metropolitan	Sacramento Metropolitan AQMD	NO ₂ 42602	AQDA #8456 issued for non-operational NO ₂ instrument at the time of audit.
06-067-0015-42602-1	Sacramento – Bercut Drive	Sacramento Metropolitan	Sacramento Metropolitan AQMD	NO ₂ 42602	AQDA #8452 issued for non-operational NO ₂ instrument at the time of audit.
06-077-1002-42602-1	Stockton – Hazelton	San Joaquin Valley	CARB	NO ₂ 42602	AQDA #8463 issued for NO ₂ instrument operating outside the critical criteria for converter efficiency at the time of audit.

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Table E-4. Gaseous Instruments – Audit Criteria or Critical Criteria Not Met (cont.)

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	Issue/Comment
06-071-0306-42401-1	Victorville – 14306 Park Avenue	Mojave Desert	Mojave Desert AQMD	SO ₂ 42401	AQDA #8467 issued for the SO ₂ instrument that exceeded CARB and U.S. EPA criteria during the audit.
06-007-0007-44201-1	Paradise – Airport	Butte County	CARB	O ₃ 44201	AQDA# 8451 issued for O ₃ instrument that exceeded the criteria difference for audit points 3, 4, and 5 during the audit.
06-011-1002-44201-1	Colusa – Sunrise Blvd	Colusa County	CARB	O ₃ 44201	AQDA #8455 issued for O ₃ instrument that failed all audit levels during the audit.
06-007-0020-44201-1	Cool	El Dorado County	CARB	O ₃ 44201	AQDA# 8450 issued for O ₃ instrument that exceeded audit criteria difference for audit points 3, 4, and 5 during the audit.
06-101-0004-44201-1	Sutter Buttes	Feather River	CARB	O ₃ 44201	AQDA# 8454 issued for O ₃ instrument that failed at audit levels 1, 2, 4, and 5 during the audit.
06-077-1002-44201-1	Stockton – Hazelton	San Joaquin Valley	CARB	O ₃ 44201	AQDA# 8459 issued for O ₃ instrument that exceeded the criteria differences for audit points 1-5 during the audit.
06-067-0010-44201-1	Sacramento – T Street	Sacramento Metropolitan	CARB	O ₃ 44201	AQDA# 8465 issued for O ₃ instrument that exceeded the criteria differences for lower 3 audit points during the audit.
06-113-1003-44201-1	Woodland – Gibson Road	Yolo-Solano	Yolo-Solano AQMD	O ₃ 44201	AQDA# 8453 issued for O ₃ instrument that exceeded the criteria differences for audit points 1-5 during the audit.

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Table E-5. PM Samplers – Ambient Data Completeness <75% Reported

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	(% Reported) Issue/Comment
06-051-0001-81102-6	Mammoth Lakes	Great Basin	Great Basin Unified APCD	PM ₁₀ 81102	(29%) Machine malfunction (AN) throughout the year; March to mid-July, and September-December.
06-051-0005-81102-4	Lee Vining	Great Basin	Great Basin Unified APCD	PM ₁₀ 81102	(56%) Machine malfunction (AN) throughout the year; February-June, July, and November.
06-025-0007-81102-3	Brawley	Imperial County	Imperial County APCD	PM ₁₀ 81102	(72%) Machine malfunction (AN) June-September.
06-051-0001-88101-6	Mammoth Lakes	Great Basin	Great Basin Unified APCD	PM _{2.5} 88101	(29%) Machine malfunction (AN) throughout the year; March to mid-July, and September-December.
06-051-0005-88101-4	Lee Vining	Great Basin	Great Basin Unified APCD	PM _{2.5} 88101	(56%) Machine malfunction (AN) throughout the year; late February-July, and November.
06-057-0005-88101-1	Grass Valley – Litton Building	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	(17%) No filters collected January-March and August-December. Many filters flagged due to insufficient data (AI) from April-July.
06-057-1001-88101-1	Truckee – Fire Station	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	(55%) No filters collected January-March, and some missing in July and September.
06-063-1006-88101-1	Quincy	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	(40%) Monitor down January-March, and November-December. October filter data null coded for poor quality assurance (AS).
06-063-1006-88101-2	Quincy	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	(70%) No filters collected October-December.
06-067-0006-88101-1	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	PM _{2.5} 88101	(74%) CARB's PM _{2.5} laboratory for mass analysis was closed Q1 due to COVID-19. No data reported for Q1; Sacramento Metropolitan AQMD installed PM _{2.5} FEM BAMs as a substitute for any data lost.

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Table E-5. PM Samplers – Ambient Data Completeness <75% Reported (cont.)

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	(% Reported) Issue/Comment
06-067-0006-88101-2	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	PM _{2.5} 88101	(73%) CARB's PM _{2.5} laboratory for mass analysis was closed Q1 due to COVID-19. No data reported for Q1; Sacramento Metropolitan AQMD installed PM _{2.5} FEM BAMs as a substitute for any data lost.
06-019-0011-88101-2	Fresno – Garland	San Joaquin Valley	CARB	PM _{2.5} 88101	(62%) No filters collected from January-March and mid-October to mid-November due to COVID-19 restrictions.
06-029-0014-88101-2	Bakersfield – 5558 California Avenue	San Joaquin Valley	CARB	PM _{2.5} 88101	(67%) Multiple filters flagged for not meeting temperature specifications or not collected due to COVID-19 restrictions.
06-077-1002-88101-4	Stockton – Hazelton Street	San Joaquin Valley	CARB	PM _{2.5} 88101	(37%) Monitor switched from 88101-4 (BAM PM _{2.5}) to 81102-5; also, data reported in January for 2 weeks (BAM PM ₁₀ STP) effective February 1. All required QA/QC performed on monitor during January.
06-089-0004-88101-1	Redding – Health Dept Roof	Shasta County	Shasta County AQMD	PM _{2.5} 88101	(58%) Shasta County AQMD was able to access the monitors in 2021 during COVID-19. However, PM _{2.5} filters were not available from CARB during Q1 and no samples were run during Q1.
06-113-1003-88101-1	Woodland – Gibson Road	Yolo-Solano	Yolo-Solano AQMD	PM _{2.5} 88101	(72%) Due to the COVID-19, CARB had limited staff to perform the weighing of filters. Yolo-Solano AQMD shut down the filter-based FRM PM _{2.5} monitor at this site due to a lack of filters from January-March.

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Table E-6. PM Samplers – Collocated Data Completeness <75% Reported

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	(% Reported) Issue/Comment
06-057-0005-88101-1	Grass Valley – Litton Building	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	(20%) Collocated data collected. Due to quarantine requirements in 2021 and staff turnover.
06-067-0006-88101-1	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	PM _{2.5} 88101	(73%) CARB's PM _{2.5} laboratory for mass analysis was closed Q1 due to COVID-19. No data reported for Q1; PM _{2.5} FEM BAM used as a substitute for data lost.
06-029-0014-88101-1	Bakersfield – 5558 California Avenue	San Joaquin Valley	CARB	PM _{2.5} 88101	(67%) Collocated data collected. Partially due to COVID-19 restrictions and subsequent operational issues.

Table E-7. PM Samplers – Precision Criteria (CV Limit of 10%) Not Met

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	Issue/Comment
06-027-0002-81102-1	White Mountain Research Center	Great Basin	Great Basin Unified APCD	PM ₁₀ 81102	CV = 11.06
06-027-1003-88101-6	Keeler – Cerro Gordo Road	Great Basin	Great Basin Unified APCD	PM _{2.5} 88101	CV = 21.10
06-027-0002-88101-1	White Mountain Research Center	Great Basin	Great Basin Unified APCD	PM _{2.5} 88101	CV = 10.98
06-027-1003-88101-3	Keeler – Cerro Gordo Road	Great Basin	Great Basin Unified APCD	PM _{2.5} 88101	CV = 11.42
06-071-0306-88101-1	Victorville – 14306 Park Avenue	Mojave Desert	Mojave Desert AQMD	PM _{2.5} 88101	CV = 11.17
06-053-1003-88101-1	Salinas	Monterey Bay	Monterey Bay ARD	PM _{2.5} 88101	CV = 13.75
06-057-0005-88101-1	Grass Valley – Litton Building	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	CV = 12.38
06-067-0006-88101-1	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	PM _{2.5} 88101	CV = 17.39
06-029-0014-88101-1	Bakersfield – California Avenue	San Joaquin Valley	CARB	PM _{2.5} 88101	CV = 50.73
06-089-0004-88101-1	Redding – Health Dept Roof	Shasta County	Shasta County AQMD	PM _{2.5} 88101	CV = 14.43

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Table E-8. PM Samplers – Flow Rate Verification

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	(% Flow Rate Checks Collected) Issue/Comment
06-057-0005-88101-1	Grass Valley – Litton Building	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	(75%)
06-063-1006-88101-1	Quincy	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	(75%) Monitor was down January-March and November-December. October filter data was null coded due to poor quality assurance (AS).
06-063-1010-88101-1	Portola – Gulling Street	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	(83%)
06-063-1010-88101-2	Portola – Gulling Street	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	(83%)
06-067-0006-88101-1	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	PM _{2.5} 88101	(75%) Due to COVID-19, CARB's laboratory for PM _{2.5} mass analysis was closed Q1. Flow rate checks were performed Q2-Q4.
06-067-0006-88101-2	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	PM _{2.5} 88101	(75%) Due to COVID-19, CARB's laboratory for PM _{2.5} mass analysis was closed Q1. Flow rate checks were performed Q2-Q4.
06-113-1003-88101-1	Woodland – Gibson Road	Yolo-Solano	Yolo-Solano AQMD	PM _{2.5} 88101	(75%) Due to COVID-19, CARB had limited staff to perform the weighing of filters. Yolo-Solano AQMD shut down the filter-based FRM PM _{2.5} monitor in Woodland due to a lack of filters from January-March.

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Table E-9. PM Samplers – Flow Rate Audits Not Performed

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	Issue/Comment
06-025-0007-81102-3	Brawley	Imperial County	Imperial County APCD	PM ₁₀ 81102	One audit performed. BAM with manufacturer for repairs at the time of second audit and could not be audited.
06-101-0003-88101-4	Yuba City – Almond Street	Feather River	CARB	PM _{2.5} 88101	One audit performed. Additional BAM installed April. Auditors not notified until their arrival at the site August 24. CARB implementing processes for improving communications related to network changes.
06-057-0005-88101-1	Grass Valley – Litton Building	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	One audit performed March 3. Second audit due on or after August but could not be performed as sampler not operational after August 13 due to leak check failure and parts unavailability.
06-063-1006-88101-1	Quincy	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	One audit performed. Sampler not operating due to COVID-19 operational constraints (resumed operation in April).
06-067-0006-88101-1	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	PM _{2.5} 88101	One audit performed. Sampler not operating due to COVID-19 operational constraints.
06-067-0006-88101-2	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	PM _{2.5} 88101	One audit performed. Sampler not operating due to COVID-19 operational constraints.
06-067-0010-88101-2	Sacramento – T Street	Sacramento Metropolitan	CARB	PM _{2.5} 88101	One audit performed. Sampler not operating due to COVID-19 operational constraints (resumed operation April; audit performed August).
06-019-2016-88101-3	Fresno – Foundry Park	San Joaquin Valley	San Joaquin Valley APCD	PM _{2.5} 88101	One audit performed. Sampler added January 1, 2020. Auditors notified December 7, 2021. Audit performed December 12, 2021. CARB implementing processes for improving communications related to network changes.
06-113-1003-88101-1	Woodland – Gibson Road	Yolo-Solano	Yolo-Solano AQMD	PM _{2.5} 88101	One audit performed. During CARB PM _{2.5} laboratory shutdown, Yolo-Solano AQMD used BAM2.5 instead of R&P 2025 for PM _{2.5} monitoring. R&P resumed operation in April and was audited July 28.

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Table E-10. PM Samplers – Audit Criteria or Critical Criteria Not Met

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	Issue/Comment
06-095-3001-81102-1	Vacaville – Merchant St	Yolo-Solano	Yolo-Solano AQMD	PM ₁₀ 81102	AQDA #8447 issued during audit because the PM ₁₀ Hi-Vol motor had failed during the instrument's last run.
06-113-1003-81102-1	Woodland	Yolo-Solano	Yolo-Solano AQMD	PM ₁₀ 81102	AQDA #8448 issued during audit because the PM ₁₀ Hi-Vol motor had failed during the instrument's last run.
06-057-0005-88101-1	Grass Valley – Litton Building	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	AQDA #8462 was issued for a PM _{2.5} sampler that was found to be non-operational due to a parts malfunction at the time of the August 30 audit.
06-063-1010-88101-4	Portola – Gulling Street	Northern Sierra	Northern Sierra AQMD	PM _{2.5} 88101	AQDA #8446 was issued for inaccurate pressure reading resulting in a failed flow audit exceeding the limit. The operator then re-calibrated the pressure sensor. A re-audit was performed, and both pressure and flow passed. This sampler was last calibrated on October 28, 2020.
06-061-1004-88101-3	Tahoe City – 221 Fairway Drive	Placer County	Placer County APCD	PM _{2.5} 88101	During the audit on August 27, it was noted that required flow and leak verifications on the BAM2.5 had not been conducted in May. Flow rate and leak checks are required at least once every 30 days.
06-061-0004-88101-3	Colfax – City Hall	Placer County	Placer County APCD	PM _{2.5} 88101	During the audit on August 26, it was noted that required flow and leak verifications on the BAM2.5 had not been conducted in May. Flow rate and leak checks are required at least once every 30 days.
06-029-0016-88101-1	Bakersfield – Airport	San Joaquin Valley	CARB	PM _{2.5} 88101	AQDA #8449 was issued for a sampler that failed flow rate and leak checks at the time of April 28 audit.

Table E-11. Gaseous Instruments and PM Samplers – Manual Adjustments to Information Output from AQS

Site ID	Site Name	Geographic Area	Monitoring Organization	Pollutant	Issue/Comment
06-007-0008-42101-3	Chico – East Avenue	Butte County	CARB	CO 42101	Audit attempted. Instrument non-operational at the time of audit. AQDA #8464 issued.
06-067-0006-42101-1	Sacramento – Del Paso Manor	Sacramento Metropolitan	Sacramento Metropolitan AQMD	CO 42101	Audit attempted. Instrument non-operational at the time of the audit. AQDA #8457 issued.
06-083-2004-42101-1	Lompoc – S H Street	Santa Barbara County	Santa Barbara County APCD	CO 42101	Audit attempted. Instrument non-operational at the time of audit. AQDA #8471 issued.
06-067-0002-42602-1	North Highlands – Blackfoot Way	Sacramento Metropolitan	Sacramento Metropolitan AQMD	NO ₂ 42602	Audit attempted. Instrument non-operational at the time of audit. AQDA #8456 issued.
06-067-0015-42602-1	Sacramento – Bercut Drive	Sacramento Metropolitan	Sacramento Metropolitan AQMD	NO ₂ 42602	Audit attempted. Instrument non-operational at the time of audit. AQDA #8452 issued.
06-079-9001-81102-1	Oso-Flaco	San Luis Obispo County	San Luis Obispo County APCD	PM ₁₀ 81102	One audit performed. SPM sites are only audited at the request of the monitoring organization/availability of auditor.

Table E-12. Gaseous Pollutants and PM – Summary of AQDAs and CANs Issued by CARB

Pollutant	Number of AQDAs Issued	Number of CANs Issued
CO	4	1
NO ₂	3	1
O ₃	7	17
SO ₂	1	1
PM ₁₀	2	6
PM _{2.5}	5	13

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Appendix F. Communication between CARB and U.S. EPA Regarding Limited Operations from 2020-2021 Due to COVID-19 Pandemic Restrictions

This appendix contains correspondence between U.S. EPA and CARB regarding limited operations due to COVID-19 restrictions.



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

March 30, 2020

To: EPA Regional Office Air Monitoring Leads

From: Richard A. Wayland, Director *Richard A. Wayland*
Air Quality Assessment Division

Subject: EPA Input on Ambient Air Monitoring Priorities in the Absence of Monitoring Agency Priorities During COVID-19 Response

In response to questions from state, local, and tribal agencies concerning monitoring priorities during COVID-19, we are providing input to consider when balancing mission-essential functions of ambient air monitoring with local orders and the health and safety of employees.

While EPA considers all ambient air monitoring programs mission essential, we recognize the tremendous strain of the COVID-19 response. Therefore, where necessary, we propose that monitoring agencies set priorities based on health risk from air pollution in local communities where monitoring is conducted. In the absence of local priorities for maintaining monitoring sites, we offer a prioritized list of activities, noting that this does not necessarily take into consideration the unique nature of air quality in a particular area.

Highest Priority to continue operating to the extent possible:

- Ozone and PM_{2.5} automated measurements.
- PM_{2.5} Federal Reference Method (FRM) measurements identified as primary monitors or used as quality assurance (QA) monitors.
- Any other National Ambient Air Quality Standards (NAAQS) measurements (manual or automated) of high priority in that area.
 - This includes any monitor near or above the NAAQS or in an area seeking a clean data finding if recent years are below the level of the NAAQS.
 - This is most likely to include certain Pb and SO₂ monitors (e.g., an SO₂ monitor near an operating source).
- All other NAAQS gases (i.e., CO, NO₂, SO₂) that have automated quality control (QC) checks and continuous PM₁₀ that can continue operation with little operator support.
- Air toxics measurements in communities known to have high risk or the potential for high risk from air toxics exposure.

High Priority to continue, if staff resources are available:

- All other NAAQS monitoring. This includes gas monitoring where automated checks are not available.
- National Air Toxics Trends Stations (NATTS) and all other air toxics measurements in communities not specifically considered to have high risk issues as referenced in highest priority above.

Supporting Measurements to continue, if staff resources are available in addition to above:

- Chemical Speciation Network (CSN).
- IMPROVE Protocol Sites.

Seasonal and Additional Measurements. Although still essential monitoring, we understand that agencies may need some relief. While these measurements are useful and required, it is less important to always have a complete data record every year for them:

- Photochemical Assessment Monitoring Stations (PAMS) measurements.
- NO_y.
- Other air toxics monitoring that is not in a community, not near a source, or not a NATTS station.

We encourage you to share these key points with your monitoring agencies and reassure them that we will continue to collect and respond to their questions and work closely with them during the COVID-19 response. We greatly appreciate your continued leadership and input. If you have specific questions, please reach out to Kristen Benedict and others in the OAQPS Ambient Air Monitoring Group.



Gavin Newsom, Governor
Jared Blumenfeld, CalEPA Secretary
Liane M. Randolph, Chair

January 22, 2021

Ms. Meredith Kurpius
Assistant Director, EPA Region 9, Air and Radiation Division
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San Francisco, California 94105
kurpius.meredith@epa.gov

Dear Ms. Kurpius:

As you are aware, the California Air Resources Board's (CARB) Monitoring and Laboratory Division (MLD) is responsible for the operation and maintenance of ambient air quality and greenhouse gas monitoring networks, including related quality assurance, laboratory analysis, and community air monitoring programs. The purpose of this letter is to document the actions taken during 2020 to maintain those operations.

In March 2020, Governor Newsom issued a statewide stay-at-home order to protect the health and well-being of all Californians, and to establish consistency across the state in order to slow the spread of COVID-19. This state order directed all individuals living in the State of California to stay home or at their place of residence except as needed to maintain continuity of operations of the federal critical infrastructure sectors. In response to this order, CARB reduced its field and laboratory work to maintaining the State's ozone and PM_{2.5} monitoring programs. The continuation of these mission essential programs except where prohibited by state directives followed the United States Environmental Protection Agency (U.S. EPA) guidance memos issued on March 18, 2020 and March 30, 2020. Those memos highlighted that during an emergency or Continuity of Operations Plan (COOP), ambient air monitoring programs are a mission essential function and should continue unless state, local, or tribal directives prohibit their operation. The memos also noted the tremendous strain of the COVID-19 response, and where necessary, proposed that agencies set monitoring priorities based on health risk from air pollution in local communities.

In December 2020, in response to a surge in the level of community spread of COVID-19, Governor Newsom issued a regional stay-at-home order for regions with less than 15 percent intensive care unit availability. In response to this order, all State offices were directed to close for three weeks starting on Monday, December 7, 2020, which was extended to at least January 15, 2021. Those directives have since been extended until further notice. MLD received limited exceptions to this direction for purposes of maintaining critical air monitoring and laboratory functions, as well as on-site management.

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Since March, CARB has continually worked to balance mission-essential functions of ambient air monitoring with current state and local orders and the health and safety of employees. As recommended in the U.S. EPA's March 18th, 2020 memo, CARB continued to operate the air monitoring networks to the best of our ability, while considering employee health and safety. Following the guidance of the prioritized list of activities provided in the March 30, 2020 memo from U.S. EPA, MLD continues to review and adjust operational activities as the situation and directives evolve. MLD continued non-field related activities such as planning, data analyses, report writing, and engagement with stakeholders through work from home protocols. The information below details the operational changes made by CARB in response to the March 2020 statewide stay-at-home order, as well as the recent regional stay-at-home order and resulting directive to close all State buildings.

Laboratory:

Due to the statewide stay-at-home order in March 2020, CARB's Northern Laboratory Branch (NLB) reduced its on-site laboratory operations and transitioned to working remotely whenever feasible. Program operations were suspended for the PM2.5 speciation, Toxics, Pesticides, GHG, Consumer Products, and Composite Wood programs. Only the PM2.5 and PM10 mass weighing programs continued as they were considered of highest priority and therefore allowed to continue despite COVID-19 directives. In July, NLB noticed an increase in PM2.5 samples arriving at the laboratory warm (> 4 °C). In most cases, this increase was attributed to unforeseen shipping delays resulting from delivery business services being affected by COVID-19. To reduce the number of invalid samples, staff implemented new field shipping procedures. Site operators were asked to return PM2.5 samples using next day air rather than ground shipping to ensure samples were received in a timely manner.

Because of the March stay-at-home orders, NLB developed a three phase plan to return-to-work. Phase I maintained PM2.5 and PM10 FRM programs including media shipping, sample receiving and log-in, sample analysis, and data reporting. All other programs were suspended with staff intermittently on-site to maintain instruments with the goal of protecting analytical assets (e.g., monitoring or replacing compressed gas cylinders, performing analytical standard checks, etc.). Phase I also included pick-up and delivery of work products for review or approval, and checking on laboratory health and safety requirements. Phase II built upon Phase I with the additional goals of clearing backlogs for all samples received in early 2020 and preparing instruments for future analysis (e.g., method detection limit verifications, control checks, media preparation, etc.). Phase III included all the above with the goal of resuming full work capacity to meet Federal, State, and client requirements. All plan phases required strict adherence to safety guidelines and established shift schedules to ensure staff wellbeing. At the start of December 2020, NLB was working on the transition from Phase II to Phase III.

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In early December 2020, the new regional stay-at-home order and the resulting closure of all State offices, required CARB to further suspend all laboratory support (media shipment, sample receipt and log-in, analysis, and data reporting) with the exception of three sites for the PM2.5 program: Bakersfield – California, Bakersfield – Southeast (Planz), and Portola. These sites were deemed critical by the planning team due to upcoming SIP determinations. Notification was sent to air monitoring site operators, their management, and other agencies via NLB's Laboratory Information Management System distribution list, as well as with the CAPCOA air monitoring committee. Upon receiving this notification, several air monitoring agencies inquired about the process to retrieve samples that were already collected, but pending laboratory analysis. Considering the amount of time required to meet this request, CARB agreed to weigh all PM2.5 samples collected through the December 7, 2020 stay-at-home order. Districts were asked to immediately return any filters that had not yet been shipped to CARB for weighing. Recognizing that continuous instruments could be operated and collect data without reliance on NLB, CARB worked closely with all Districts to transition sites with filter based (FRM) samplers to continuous (FEM) monitors. This effort is further described below.

Going forward, support for the three selected sites will continue until the order is lifted, including shipment of filter media for future scheduled sampling dates, sample receipt and log-in, analysis, and data reporting. Media will not be shipped to any other PM2.5 sites or PM10 sites for future scheduled sampling dates while the current orders are in place. Currently, staff are again intermittently on-site to maintain instruments to protect analytical assets on set schedules. Once the order is lifted, staff will begin the process of pre-weighing and shipping filter media to all PM2.5 and PM10 sites, which will take approximately 2 to 3 weeks, and implementing Phase III of our return to operations plan.

Ambient Air Monitoring:

When the statewide stay-at-home order was issued in March 2020, CARB's Air Quality Surveillance Branch (AQSB) reduced select field operations. Field staff continued site visits and maintained monitoring site operations for ozone and PM. Site visits and monitoring site operations for all other continuous monitoring (NOx, CO, and SO2) were suspended, but equipment for these criteria pollutants remained operational and continued to report data. PM filters from FRM samplers continued to be collected and sent to the laboratory for analysis. Sample collection for toxics were suspended including VOC and GHG canisters, SASS filters (Ions, XRF metals, Wood Smoke, EC/OC, and PM2.5), and Xontech 924 filters (ICP-MS metals, carbonyls, Cr6+). The Chemical Speciation Network program continued with sample collection at Bakersfield and Fresno. District calibrations were temporarily suspended, but resumed beginning in October and all calibrations for calendar year 2020 were completed.

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In response to the regional stay-at-home order issued in early December 2020, AQSB field staff modified the PM2.5 network to minimize the effects of reduced laboratory functions on collection of PM2.5 ambient data. With the exception of the Bakersfield-California, Bakersfield-Planz, and Portola sites, all PM2.5 FRM filter collection was discontinued and all non-FEM samplers were converted to FEM in early December. The Bakersfield-California, Bakersfield-Planz, and Portola sites continue to collect PM2.5 FRM filter data. CARB also worked with the Districts to replace all but two FRM PM2.5 monitors with FEM monitors to avoid data loss as much as possible. Those conversions were all completed by mid-December.

Quality Assurance:

Beginning in March, audits for the monitoring network continued with an abbreviated function. Following the guidance on priorities from the March 30, 2020 U.S. EPA memo, only the ozone and PM audits were conducted for the CARB PQAO. This permitted the audits to be performed by a single CARB staff person while adhering to the prescribed safety measures. All ozone monitors received an annual assessment and all PM monitors, with a few exceptions, received both semi-annual assessments. The exceptions occurred for a few PM audits for Lake County APCD and Sacramento AQMD, where monitors received only one semi-annual assessment as result of the recent regional stay-at-home order. Due to COVID-19 scheduling challenges, it was not possible for all PM assessments to meet the criteria of being five to seven months apart. Further, audits during this period were not completed for the CO, NO2, and SO2 gaseous monitors in order to reduce field exposures in accordance with State and regional directives.

Standards Laboratory:

Since March 2020, CARB's Standards Laboratory remained operational with the following changes:

- Prioritized ozone standards and PM2.5 equipment certifications per the directives provided in the March 30, 2020 U.S. EPA memo.
- Required clients to justify why their equipment was essential prior to providing service.
- Staggered scheduling of staff in the laboratory to perform essential certifications while adhering to the prescribed safety measures.
- Enacted strict scheduling of client equipment pick-up and drop-off to minimize contact.

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It should be noted that the CARB Standards Laboratory had the only ozone Standards Reference Photometer operating in the U.S. during the first four months of the pandemic (April through July) and continued to provide services to its typical clients (California and several other western states). In response to the December regional stay-at-home order and the recent extension, the Standards Laboratory has suspended all certification services until further notice. Customers who currently have equipment in the laboratory or who are on the upcoming service schedule were contacted to coordinate pick up of equipment or to reschedule service. When the current orders are lifted, the Standards Laboratory will resume operations to support critical air monitoring activities.

All operations have been implemented while following personnel health and safety requirements and in accordance with the recommendations from the Centers for Disease Control and Prevention, California Environmental Protection Agency, CARB, and local public health department guidelines to ensure the safety of its employees, as well as being in line with the two U.S. EPA March 2020 memos.

The changes made to CARB MLD operations in response to the dynamic situation at hand have been made thoughtfully and deliberately to comply with the Governor's orders; to keep our employees and their families safe, keep California communities safe by reducing our on-site presence and reduce the risks to communities that are experiencing low ICU bed availability, and to support the mission essential function of operating the ambient air monitoring programs to the best of our ability. CARB has been able to keep its highest priority programs, ozone and PM2.5, up and running as suggested by the March 2020 memos. When further restrictions were required in December, CARB quickly substituted its FRM filter based samplers to continuous monitors, thereby allowing the ongoing collection of these important data. We anticipate further discussions regarding data quality and certification and will work with Region IX and our CARB colleagues to address any concerns. We also expect to have further discussions regarding monitoring operations in 2021 and what that may look like as we continue to make adjustments to ensure the safety of both CARB and District staff.

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If you have any questions or wish to discuss further, please contact me at (916) 322-0960 or via email at Michael.miguel@arb.ca.gov.

Sincerely,

Mike Miguel

Michael Miguel, Assistant Division Chief
Monitoring Laboratory Division
California Air Resources Board

cc: Edie Chang, Deputy Executive Officer
California Air Resources Board

Michael Benjamin, Chief
Air Quality Planning and Support Division

Catherine Dunwoody, Chief
Monitoring and Laboratory Division

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Appendix G. References

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