CALIFORNIA AIR RESOURCES BOARD

2023
Annual Data Quality Report

California Air Resources Board's
Primary Quality Assurance Organization

Monitoring and Laboratory Division
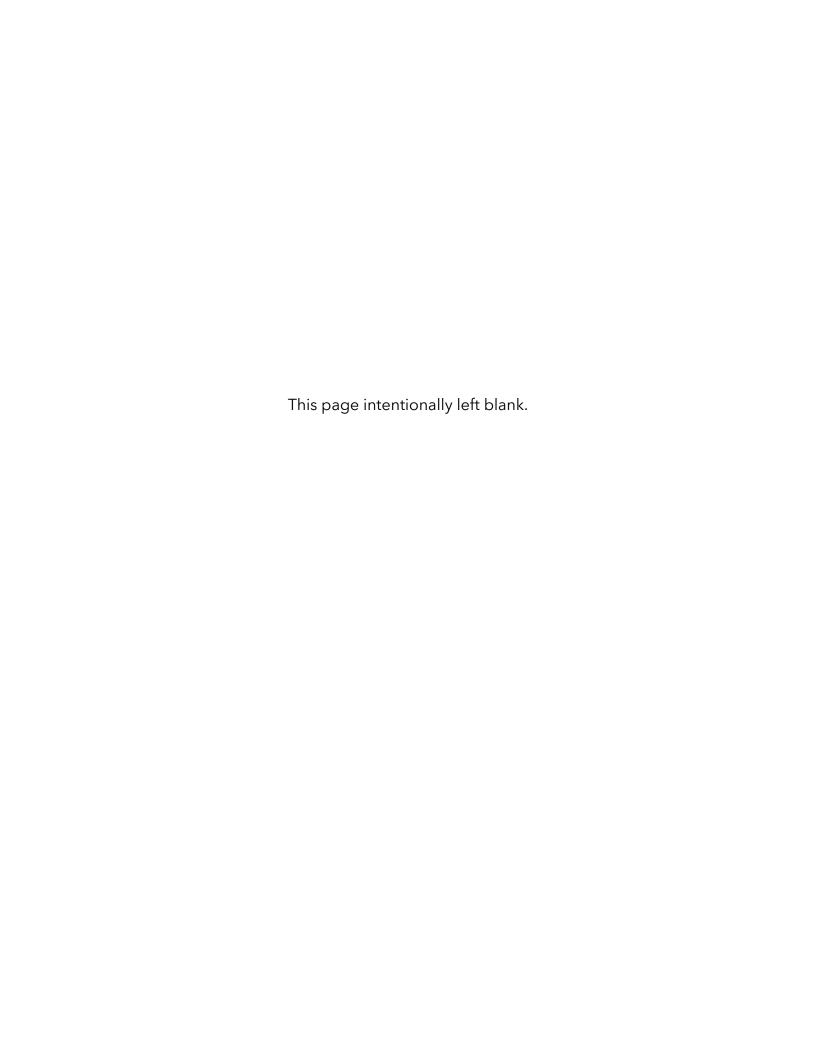
Quality Management Branch

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Acronyms

1-pt QC Check	One-Point Quality Control Check
AMP	Air Monitoring Performance
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
Low-Vol	Low Volume
mm	Millimeter
MO	Monitoring Organization
MQO	Measurement Quality Objective
m/s	Meters per Second
NA	Not Applicable
NDA	No Certified Data Available
NO_2	Nitrogen Dioxide
OS	Operating System
O_3	Ozone
PE	Performance Evaluation
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

Acronyms (cont.)

ppb	Parts per Billion
ppm	Parts per Million
PQAO	Primary Quality Assurance Organization
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
SLAMS	State and Local Air Monitoring Stations
SO_2	Sulfur Dioxide
SPM	Special Purpose Monitors
TEOM	Tapered Element Oscillating Microbalance
U.S. EPA	United States Environmental Protection Agency
$\mu g/m^3$	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)[1]. The specific MQOs reviewed in this report include:

- Ambient data capture rate, which is the amount of ambient data reported.
- Precision, which is the degree of mutual agreement among individual measurements of the same property.
- Bias, which is the systematic or persistent distortion of a measurement process which causes a shift in one direction.
- The amount of precision and bias data collected and reported.

The criteria by which the assessments are made are mostly dictated in Appendix A of 40 CFR Part 58 ([1]) and United States Environmental Protection Agency (U.S. EPA) guidance ([3]) and are provided in Appendices A-C of this report. Details on the gaseous instruments and particulate matter (PM) samplers that did not meet certain criteria are provided in Appendices D-E of this report.

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 within California. 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.[2] This assessment is solely based on certified data available in U.S. EPA's Air Quality System (AQS)[3].

The gaseous criteria pollutants (gaseous pollutants) assessed include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). The ambient data capture rate represents the percentage of ambient data collected and

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[1] MQOs identify the quality control samples and the acceptance criteria for those samples that will allow one to quantify the data quality indicators ([3]).

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

[3] AQS is U.S. EPA's repository for ambient air quality data collected by U.S. EPA, and state, local, and tribal air pollution control agencies. AQS also provides detailed information about each monitoring site including its geographic location, operator, data quality assurance/quality control information, and meteorological data.

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 respective monitoring organizations to confirm an instrument's ability to respond to a known concentration of gas. Precision represents the degree of variability among the 1-pt QC checks (i.e., how close they are to each other). These checks are also used to assess bias for each instrument by comparing how far the instrument's response is from the true value of a reference gas of known concentration.

The PM assessed include PM with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) and PM with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$). Precision for most PM samplers is assessed by collocated sampling in which two identical or equivalent samplers are operated side-by-side.[4] Bias for PM samplers is assessed by using the routine flow rate verifications (FRV) performed by respective monitoring organizations. During an FRV, flow rate from a PM sampler is compared against the flow rate from a reference standard. Total $PM_{2.5}$ bias for a PQAO is also assessed through the Performance Evaluation Program (PEP) audit administered by U.S. EPA.

Bias for both gaseous instruments and PM samplers is further verified by CARB's performance evaluation audits (CARB's PE audit). CARB's PE audits include through-the-probe audits on gaseous instruments and flow rate audits on PM samplers ([2]). The ambient data capture rate and the accompanying precision and bias data for 2023 from both gaseous instruments and PM samplers are summarized below, followed with recommendations.

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 meet all MQOs set by U.S. EPA or the data producers themselves. The 2023 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 bias 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 may be used with the knowledge of the quality behind it.

All data in this report come from AQS. Data producers are encouraged to review their monitoring networks to ensure data correctly reflects the number of operational sites and instruments/samplers operating. This review would also ensure all required ambient, precision, and bias data collected are continually reported to AQS in a timely manner (within 90 days of the end of each quarter) ([1]).

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[4] Collocated sampling is required for all PM samplers, except continuous PM_{10}.

Gaseous Instruments

Conclusions and recommendations pertaining to gaseous instruments and associated MQOs are highlighted below.

Conclusions

- Ambient data capture rate criteria of at least 75 percent were met by 97 percent of the gaseous instruments operating within CARB's PQAO in 2023.
- More than 99 percent of the gaseous instruments operating within CARB's PQAO in 2023 reported at least 75 percent of the required 1-pt QC checks. Additionally, more than 99 percent met the 2016 revised critical criteria[5] for individual 1-pt QC checks for percent, absolute difference, and prescribed range, set by U.S. EPA ([3])([4]).
- CARB's PQAO met the CFR criteria for precision and bias based on 1-pt QC checks ([1]).
- Data from CARB's PE audits indicate that 99 percent of all instruments met the audit criteria for CARB's PQAO. This is consistent with bias information obtained from 1-pt QC checks.

Recommendations

- Overall, MQOs associated with the gaseous instruments showed an improvement compared to 2022, continuing the trend observed over the past two years for CARB's PQAO. However, 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.

Particulate Matter Samplers

Conclusions and recommendations pertaining to PM samplers and associated MQOs are highlighted below.

Conclusions

- Ambient data capture rate criteria of at least 75 percent were met by 98 percent of the PM samplers operating within CARB's PQAO in 2023.
- CARB's PQAO continued to meet the minimum 15 percent collocation requirement in the network of primary PM samplers, as indicated in CARB's Annual Network Plan ([5]).

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[5] U.S. EPA describes "critical" criteria as criteria deemed to maintaining the integrity of a sample or group of samples ([3]).

- CARB's PQAO met precision completeness criteria of at least 75 percent for collocated PM samplers. The CFR precision criteria of 10 percent upper bound for CARB's PQAO was not met for PM_{10} and for 50 percent of the methods for $PM_{2.5}$. This is an improvement compared to 2022 data. U.S. EPA is aware of the systemic issue of PM imprecision (in California and nationwide).
- CARB's PQAO reported 100 percent for PM_{10} (Hi-Vol), more than 99 percent for $_{10}$ (Low-Vol), and more than 95 percent for $PM_{2.5}$ of the required FRVs performed. The results at the PQAO level indicate that the PM network exhibited low bias in 2023.
- CARB's PE audit data indicate that CARB's PQAO met audit criteria for flow rate audits. This is consistent with bias information from the routine FRV data, and an improvement compared to 2022 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 low bias, consistent with results determined by FRVs and CARB's PE audits for flow rate.

Recommendations

- In terms of precision, CV values among collocated $PM_{2.5}$ samplers within CARB's PQAO remain high for 50 percent of the methods in 2023. 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 adopted new statistics for calculating CV in its *Reconsideration of the National Ambient Air Quality Standards for Particulate Matter* ([19](#)) in March 2024. CARB should continue exploring the potential causes behind low $PM_{2.5}$ precision among some of the collocated $PM_{2.5}$ samplers within CARB's PQAO.
- There were instances of PM_{10} and/or $PM_{2.5}$ samplers not meeting the MQOs (e.g., ambient data capture rate, CV precision, 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.

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 ([6](#)). CARB and local air pollution control agencies operate ambient monitoring sites 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) within California. 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, responsible for a set of sites that monitors the same pollutants and for which data quality assessments can logically be pooled. Each criteria pollutant sampler/monitor at a monitoring site in the State and Local Air Monitoring Station (SLAMS) Network must be associated with one, and only one, PQAO.[6]

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 (gaseous pollutants) and particulate matter (PM) are compared to measurement quality objectives (MQO)[7].

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[6] 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 subject to Appendix A of 40 CFR Part 58 ([1](#)).

[7] MQOs identify the quality control samples and the acceptance criteria for those samples that will allow one to quantify the data quality indicators ([3](#)).

Where appropriate, comparisons to the nationwide average[8] and other PQAOs are also made.

II. Quality Assurance

Quality assurance (QA) 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. 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.

Quality assessment is a set of external and internal, 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 perform 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 QA 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 bias. 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 a shift in one direction ([1]). 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." 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) or the standard deviation of the differences in measurements, 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

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

rate verifications (FRV). The criteria for achieving precision and bias are mostly dictated in Appendix A of 40 CFR Part 58 (1) and U.S. EPA guidance (3) and are provided in Appendices A-C of this report. Available tools for assessing precision and bias are summarized in Appendix B of this report, while details on instances 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 (8).

Bias for both gaseous instruments and PM samplers is further verified by CARB's performance evaluation audits (CARB's PE audit). CARB's PE audits include through-the-probe audits on gaseous instruments and flow rate audits on PM samplers (2). Appendix C of this report lists CARB's PE audit criteria, which were developed to closely match the National Performance Audit Program (9).

This report also assesses the amount of ambient air quality data produced by the instruments or samplers, consistent with assessing precision and bias. Ambient data capture rate is compiled as a percentage of the ambient data collected, depending on the sampling frequency of each respective instrument or sampler, over the total amount of data possible.

An Air Quality Data Action (AQDA) is a key tool used by the Quality Management Branch of CARB's Monitoring and Laboratory Division to identify, document, and correct issues which would adversely affect the quality of the ambient data generated by the samplers. An AQDA is initiated by the Quality Management Branch upon a failed audit. After an AQDA has been issued, an investigation into the causes of the failure will determine an outcome on the possibly affected data. The data in question can be affected in two ways: released or invalidated. Data that are released meet compliance criteria and can be used in all aspects of decision making. In some instances, data are flagged with qualifier codes as they are released. 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. The number of AQDAs issued and closed within CARB's PQAO is provided in Appendix E of this report.

Outside the AQDA process, data could be flagged with quality assurance qualifiers or 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 is another key tool used to identify, document, and correct issues that impact, or potentially impact, data quality, completeness, storage, or reporting (10). 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. The number of CANs issued and closed within CARB's PQAO is provided in Appendix E of this report.

CARB's Quality Assurance Program is outlined in a five-volume Quality Assurance Manual ([11]), which guides the operation of the quality assurance programs used by CARB, monitoring organizations, and private industry in California.

There are more than 250 (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 site audited by the Quality Management Branch is available online ([2]).

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 ambient data capture rate) is discussed first, followed by an assessment of the quality behind the data. Statistical results for 2023[9] and the previous two years (2021 and 2022) reflect certified data available in U.S. EPA's Air Quality System (AQS)[10] as of July 2024. Additionally, the 2021 and 2022 Annual Data Quality Reports ([7]) may not reflect current information in AQS due to potential data uploads to AQS occurring after these reports were published. The monitoring organization responsible for the correction may recertify the data already submitted through a data certification process, depending on the nature of the data correction.

A. Gaseous Pollutants

The gaseous pollutants assessed in this report are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2).

Ambient Data Capture Rate

Ambient data capture rate, as described in this report, is derived from the AQS Air Monitoring Performance (AMP) 430 Data Completeness Report. The calculated number in AMP 430 represents the average of the monthly ambient data capture rates for the calendar year and may not always be indicative of whether the

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[9] Statistical results for 2023 exclude 2023 data which were manually adjusted, as described in Appendix E, Table E-11 of this report.

[10] AQS is U.S. EPA's repository for ambient air quality data collected by U.S. EPA, and state, local, and tribal air pollution control agencies. AQS also provides detailed information about each monitoring site including its geographic location, operator, data quality assurance/quality control information, and meteorological data.

75 percent regulatory completeness requirement[11] is met for a particular pollutant, considering the operational period in the year. This report focuses on a minimum ambient data capture rate of 75 percent uploaded to AQS.

Table 1 presents the percentage of instruments that reported at least 75 percent of the possible ambient data capture rate for each gaseous pollutant for each of the four PQAOs this report focuses on and the nationwide average. Ninety-seven percent of the instruments within CARB's PQAO reported at least 75 percent of the required ambient data in 2023. Details on CARB's PQAO instruments not reporting at least 75 percent ambient data capture rate are provided in Appendices D-E of this report. Information for years 2021 and 2022 is only provided for historical perspective.

Table 1.   Gaseous Instruments – Ambient Data Capture Rate Results (2021-2023)

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments Reporting ≥ 75% Ambient Data Capture Rate	Percent of Instruments Reporting ≥ 75% Ambient Data Capture Rate
CO	CARB	2023	13	12	92
		2022	13	11	85
		2021	19	13	68
	Bay Area AQMD	2023*	NDA	NDA	NDA
		2022	14	14	100
		2021	16	16	100
	South Coast AQMD	2023	21	21	100
		2022	23	23	100
		2021	25	24	96
	San Diego County APCD	2023	3	3	100
		2022	2	2	100
		2021	2	2	100
	Nationwide	2023*	238	217	91
		2022	243	226	93
		2021	258	238	92

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[11] 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). Detailed information on the calculations for meeting the regulatory completeness requirement, including specific consideration of seasons and exceptional events, are outside the scope of this report.

Table 1.   Gaseous Instruments – Ambient Data Capture Rate Results (2021-2023) (cont.)

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments Reporting ≥ 75% Ambient Data Capture Rate	Percent of Instruments Reporting ≥ 75% Ambient Data Capture Rate
NO₂	CARB	2023	39	38	97
		2022	40	37	93
		2021	42	37	88
	Bay Area AQMD	2023*	NDA	NDA	NDA
		2022	16	16	100
		2021	18	18	100
	South Coast AQMD	2023	27	27	100
		2022	28	28	100
		2021	29	29	100
	San Diego County APCD	2023	9	9	100
		2022	8	8	100
		2021	16	16	100
	Nationwide	2023*	436	421	97
		2022	441	416	94
		2021	459	432	94
O₃	CARB	2023	99	96	97
		2022	98	96	98
		2021	99	95	96
	Bay Area AQMD	2023*	NDA	NDA	NDA
		2022	18	18	100
		2021	20	20	100
	South Coast AQMD	2023	24	24	100
		2022	27	27	100
		2021	29	29	100
	San Diego County APCD	2023	7	7	100
		2022	7	7	100
		2021	7	7	100
	Nationwide	2023*	1,176	1,146	97
		2022	1,180	1,152	98
		2021	1,188	1,163	98

Table 1.   Gaseous Instruments – Ambient Data Capture Rate Results (2021-2023) (cont.)

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments Reporting ≥ 75% Ambient Data Capture Rate	Percent of Instruments Reporting ≥ 75% Ambient Data Capture Rate
SO$_2$	CARB	2023	7	7	100
		2022	7	5	71
		2021	9	9	100
	Bay Area AQMD	2023*	NDA	NDA	NDA
		2022	9	9	100
		2021	9	9	100
	South Coast AQMD	2023	4	4	100
		2022	4	4	100
		2021	5	5	100
	San Diego County APCD	2023	1	0	0
		2022	1	1	100
		2021	1	1	100
	Nationwide	2023*	361	355	98
		2022	378	363	96
		2021	400	387	97

- Source: AQS, AMP 430 Data Completeness Report, run July 2024.
- NDA means no certified data available in AQS.
- *Bay Area AQMD's PQAO 2023 data are not reflected in this report (for PQAO and nationwide), as certified data were not available in AQS (Source: AMP 256 Data Quality Indicator Report, run July 2024).

Precision and Bias

The 1-pt QC checks are performed by respective monitoring organizations to confirm an 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 Appendix A of 40 CFR Part 58 ([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 O$_3$, 10 percent for CO and SO$_2$, or 15 percent for NO$_2$.

The 1-pt QC checks are also used to estimate the bias inherent in the sampling system associated with each instrument. Appendix A of 40 CFR Part 58 ([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 O_3, ±10 percent for CO and SO_2, and ±15 percent for NO_2. 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 ([8]).

CFR requires 1-pt QC checks be performed at least once every 14 days 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 Appendix A of 40 CFR Part 58 ([1]) and the QA handbook ([12]). Bias estimates are further verified via CARB's PE audits; details are in the Bias Assessment via Performance Audits section of this report.

Table 2 shows that CARB's PQAO (as well as most other California PQAOs) met precision and bias criteria in 2023 for gaseous pollutants required by CFR (CO, NO_2, O_3, and SO_2). Information for years 2021 and 2022 is provided for a historical perspective only. In general, 2023 precision data and 2023 bias data are consistent with those in the previous two years, and 98 percent of the required number of 1-pt QC checks for gaseous instruments was met for CARB's PQAO. Table 2 also includes the number of gaseous instruments with at least 75 percent of the required 1-pt QC check data reported for 2023. Details on CARB's PQAO instruments not meeting precision and bias criteria are provided in Appendices D-E of this report, where applicable.

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 sites each year.

Table 2.   Gaseous Instruments – Precision and Bias Results (2021-2023)

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments with ≥ 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	2023	13	12	4.16	Yes	±3.37	Yes
		2022	14	12	3.96	Yes	±3.06	Yes
		2021	19	15	4.64	Yes	±3.58	Yes
	Bay Area AQMD	2023*	NDA	NDA	NDA	NDA	NDA	NDA
		2022**	14	1	12.67	No	±5.55	Yes
		2021	16	1	4.00	Yes	±3.26	Yes
	South Coast AQMD	2023	21	21	3.76	Yes	±2.64	Yes
		2022	23	23	3.41	Yes	±2.45	Yes
		2021	25	25	3.52	Yes	±2.28	Yes
	San Diego County APCD	2023	3	3	1.82	Yes	±1.79	Yes
		2022	2	2	2.11	Yes	±1.79	Yes
		2021	2	2	2.41	Yes	±1.89	Yes
	Nationwide	2023*	243	213	3.65	Yes	±3.51	Yes
		2022	250	213	4.00	Yes	±3.75	Yes
		2021	263	227	3.88	Yes	±3.72	Yes
NO$_2$	CARB	2023	40	40	6.00	Yes	±5.11	Yes
		2022	41	38	5.65	Yes	±4.98	Yes
		2021	43	41	5.17	Yes	±4.03	Yes
	Bay Area AQMD	2023*	NDA	NDA	NDA	NDA	NDA	NDA
		2022	16	15	2.44	Yes	±2.01	Yes
		2021	18	18	2.29	Yes	±1.85	Yes
	South Coast AQMD	2023	27	27	3.44	Yes	±3.12	Yes
		2022	28	28	3.54	Yes	+3.49	Yes
		2021	29	29	4.23	Yes	±3.45	Yes
	San Diego County APCD	2023	9	9	1.77	Yes	+2.15	Yes
		2022	8	8	2.28	Yes	+2.65	Yes
		2021	13	13	3.03	Yes	+3.64	Yes
	Nationwide	2023*	449	414	3.99	Yes	±4.38	Yes
		2022	450	402	4.03	Yes	±4.40	Yes
		2021	461	425	4.10	Yes	±4.33	Yes

Table 2.   Gaseous Instruments – Precision and Bias Results (2021-2023) (cont.)

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments with ≥ 75% of Required 1-pt QC Checks	Upper Bound of CV (Precision)	CFR Criteria for Precision Met?	Bias	CFR Criteria for Bias Met?
O₃	CARB	2023	99	98	2.52	Yes	±1.93	Yes
		2022	98	95	2.59	Yes	±1.95	Yes
		2021	99	96	2.57	Yes	±1.98	Yes
	Bay Area AQMD	2023*	NDA	NDA	NDA	NDA	NDA	NDA
		2022	18	18	1.84	Yes	±1.49	Yes
		2021	20	20	1.84	Yes	±1.45	Yes
	South Coast AQMD	2023	24	24	2.00	Yes	±1.59	Yes
		2022	27	27	1.86	Yes	±1.35	Yes
		2021	29	29	2.08	Yes	±1.61	Yes
	San Diego County APCD	2023	7	7	1.64	Yes	±1.45	Yes
		2022	7	7	1.18	Yes	-1.65	Yes
		2021	8	8	1.87	Yes	±1.54	Yes
	Nationwide	2023*	1,189	1,161	2.04	Yes	±2.08	Yes
		2022	1,189	1,161	3.94	Yes	±2.67	Yes
		2021	1,193	1,173	2.11	Yes	±2.08	Yes
SO₂	CARB	2023	7	7	3.56	Yes	±2.74	Yes
		2022	7	5	2.85	Yes	±2.74	Yes
		2021	9	8	3.65	Yes	±3.22	Yes
	Bay Area AQMD	2023*	NDA	NDA	NDA	NDA	NDA	NDA
		2022	9	9	4.27	Yes	±1.80	Yes
		2021	9	2	2.34	Yes	±1.83	Yes
	South Coast AQMD	2023	4	4	2.37	Yes	±1.91	Yes
		2022	4	4	3.33	Yes	±2.99	Yes
		2021	5	5	3.39	Yes	±2.56	Yes
	San Diego County APCD	2023	1	1	2.73	Yes	-8.14	Yes
		2022	1	1	3.52	Yes	-6.53	Yes
		2021	1	1	3.29	Yes	-11.65	No
	Nationwide	2023*	369	350	3.17	Yes	±3.30	Yes
		2022	384	358	2.99	Yes	±3.16	Yes
		2021	400	359	2.94	Yes	±3.07	Yes

- Source: AQS, AMP 256 Data Quality Indicator Report, run July 2024.
- NDA means no certified data available in AQS.
- Upper bound of CV (precision) is estimated by the upper confidence limit of the standard deviation of differences measured by 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 CV and bias are provided in Appendix A of this report.
- 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).

Table 2. **Gaseous Instruments – Precision and Bias Results (2021-2023) (cont.)**

- *Bay Area AQMD's PQAO 2023 data are not reflected in this report (for PQAO and nationwide), as certified data were not available in AQS (Source: AMP 256 Data Quality Indicator Report, run July 2024).
- **Bay Area AQMD's PQAO faced issues procuring the appropriate gas cylinders due to manufacturer supply delays. After installing the appropriate gas cylinders at the end of 2022, 1-pt QC checks met critical criteria.

Assessment of Individual 1-pt QC Checks

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 critical criteria. Table 3 presents results on individual 1-pt QC checks at the PQAO level. Overall, more than 99 percent of 1-pt QC checks performed for CARB's PQAO in 2023 meet the critical criteria. 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 performed within the prescribed ranges: 0.005 parts per million (ppm) to 0.08 ppm for NO_2, O_3, and SO_2; and 0.5 ppm to 5.0 ppm for CO. Table 4 provides individual 1-pt QC checks performed within the prescribed range for each PQAO and showcases the overall good reporting from most PQAOs. Details on CARB's PQAO instruments not meeting these criteria are provided in Appendices D-E of this report.

All monitoring organizations are reminded that the updates to AQS regarding 1-pt QC check requirements became effective on January 1, 2019. U.S. EPA also provided additional guidance and notification through webpages and newsletters ([4](14)).

Table 3.   Gaseous Instruments – 1-pt QC Checks Individual Assessment (2023)

Pollutant	PQAO	Number of Instruments	Number of 1-pt QC Checks Performed	Number of 1-pt QC Checks Meeting Critical Criteria	Percent of 1-pt QC Checks Meeting Critical Criteria (%)
CO	CARB	13	1,769	1,761	99.5
	Bay Area AQMD*	NDA	NDA	NDA	NDA
	South Coast AQMD	19	7,201	7,173	99.6
	San Diego County APCD	3	644	644	100.0
NO$_2$	CARB	40	9,055	9,052	99.9
	Bay Area AQMD*	NDA	NDA	NDA	NDA
	South Coast AQMD	25	9,539	9,539	100.0
	San Diego County APCD	9	2,488	2,488	100.0
O$_3$	CARB	99	19,691	19,691	100.0
	Bay Area AQMD*	NDA	NDA	NDA	NDA
	South Coast AQMD	24	8,430	8,430	100.0
	San Diego County APCD	7	2,103	2,103	100.0
SO$_2$	CARB	7	1,414	1,414	100.0
	Bay Area AQMD*	NDA	NDA	NDA	NDA
	South Coast AQMD	4	1,450	1,450	100.0
	San Diego County APCD	1	208	208	100.0

- Source: AQS, AMP 504 EXTRACT QA Data text file and AMP 251 AQ Raw Assessment Report, run July 2024.
- NDA means no certified data available in AQS.
- Criteria for assessing individual 1-pt QC checks are provided in Appendix A of this report.
- *Bay Area AQMD's PQAO 2023 data are not reflected in this report, as certified data were not available in AQS (Source: AMP 256 Data Quality Indicator Report, run July 2024).

Table 4. **Gaseous Instruments – 1-pt QC Checks Individual Assessment on Prescribed Range (2023)**

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	13	1,769	1,740	98.4
	Bay Area AQMD*	NDA	NDA	NDA	NDA
	South Coast AQMD	19	7,201	7,123	98.9
	San Diego County APCD	3	644	642	99.7
NO$_2$	CARB	40	9,055	8,969	99.1
	Bay Area AQMD*	NDA	NDA	NDA	NDA
	South Coast AQMD	25	9,539	9,445	99.0
	San Diego County APCD	9	2,488	2,468	99.2
O$_3$	CARB	99	19,691	19,595	99.5
	Bay Area AQMD*	NDA	NDA	NDA	NDA
	South Coast AQMD	24	8,430	8,362	99.2
	San Diego County APCD	7	2,103	2,096	99.7
SO$_2$	CARB	7	1,414	1,409	99.6
	Bay Area AQMD*	NDA	NDA	NDA	NDA
	South Coast AQMD	4	1,450	1,435	99.0
	San Diego County APCD	1	208	206	99.0

- Source: AQS, AMP 504 EXTRACT QA Data text file and AMP 251 AQ Raw Assessment Report, run July 2024.
- Prescribed ranges are provided in Appendix A of this report.
- NDA means no certified data available in AQS.
- *Bay Area AQMD's PQAO 2023 data are not reflected in this report, as certified data were not available in AQS (Source: AMP 256 Data Quality Indicator Report, run July 2024).

Bias Assessment via Performance Audits

To further assess bias estimates from 1-pt QC checks, Appendix A of 40 CFR Part 58 ([1](#)) requires that independent performance audits be conducted, and the percent differences be evaluated against pre-determined criteria. Bias is estimated 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. Lower and upper confidence limits represent the range of all audit results across each PQAO. CARB's objective is to conduct CARB's PE audits for all sites within its PQAO annually, utilizing CARB's PE audit criteria ([2](#)). Other PQAOs are responsible for performing their own audits and may utilize different audit criteria.

Table 5 summarizes the 2023 performance audit results for gaseous instruments. The average percent differences at the PQAO level were well below the audit criteria for all gaseous pollutants. CARB's PE audit criteria are: ±10 percent for O_3 (with warning at ±7 percent) and ±15 percent for CO, NO_2, and SO_2 (with warning at ±10 percent) for each audit point ([3](#)). CARB's PE audit results show that, in general, all audited gaseous instruments within CARB's PQAO met CARB's PE audit criteria for bias.

CARB's PE audit results of gaseous instruments in 2023 corroborate what the 1-pt QC checks revealed: that CARB's PQAO is providing data of low bias for all gaseous pollutants. This is further strengthened since 99 percent of the audited instruments met CARB's PE audit criteria.

A complete listing of CARB's PE audit criteria is provided in Appendix C of this report. Details on CARB's PQAO instruments not meeting CARB's PE audit criteria are provided in Appendices D-E of this report. CARB's PE audits are only conducted for CARB's PQAO, and therefore only CARB's PQAO is subject to the AQDA process.

Table 5. Gaseous Instruments – Performance Audits Results (2023)

Pollutant	PQAO	Number of Instruments	Number of Instruments Audited	Number of Audits Not Meeting Criteria	Average Percent Difference** (%)	Confidence Limit	
						Lower	Upper
CO	CARB*	13	13	1	-5.35	-7.02	8.92
	Bay Area AQMD***	NDA	NDA	NDA	NDA	NDA	NDA
	South Coast AQMD	21	21	1	-16.14	-8.01	6.58
	San Diego County APCD	3	3	1	-0.13	-2.21	4.69
NO$_2$	CARB*	40	38	0	2.51	-9.02	14.27
	Bay Area AQMD***	NDA	NDA	NDA	NDA	NDA	NDA
	South Coast AQMD	27	27	0	-3.56	-4.80	8.55
	San Diego County APCD	9	9	1	4.00	-1.62	5.18
O$_3$	CARB*	98	98	1	-1.73	-4.89	4.94
	Bay Area AQMD***	NDA	NDA	NDA	NDA	NDA	NDA
	South Coast AQMD	24	24	1	-1.39	-4.07	3.70
	San Diego County APCD	7	7	1	1.72	-3.87	2.41
SO$_2$	CARB*	7	7	0	0.04	-6.24	7.38
	Bay Area AQMD***	NDA	NDA	NDA	NDA	NDA	NDA
	South Coast AQMD	4	4	1	-3.81	-4.27	4.79
	San Diego County APCD	1	1	1	-12.22	-12.85	-2.84

- Source: AQS, AMP 256 Data Quality Indicator Report, run July 2024.
- NDA means no certified data available in AQS.
- *CARB's PE audit criteria are provided in Appendix C of this report (3). Since the two lowest audit points for trace CO and trace SO$_2$ are U.S. EPA audit levels 1 and 2, and the lowest audit point for O$_3$ is U.S. EPA audit level 2, they were not subject to the AQDA process and were excluded from this analysis.
- **Bias is estimated 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 performance audits.
- ***Bay Area AQMD's PQAO 2023 data are not reflected in this report, as certified data were not available in AQS (Source: AMP 256 Data Quality Indicator Report, run July 2024).

B. Particulate Matter

The PM assessed in this report are PM with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) and PM with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$).

PM monitoring is performed using both manual and continuous type samplers. Manual samplers are operated on a daily, one-in-three-day, one-in-six-day, or one-in-twelve-day sampling schedule for PM_{10}, and a similar schedule for $PM_{2.5}$. Continuous samplers report hourly values.

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

Ambient Data Capture Rate

Ambient data capture rate, as described in this report, is derived from the AQS AMP 430 Data Completeness Report. The calculated number in AMP 430 represents the average of the monthly ambient data capture rates for the calendar year and may not always be indicative of whether the 75 percent regulatory completeness requirement[12] is met for a particular pollutant. This report focuses on a minimum ambient data capture rate of 75 percent uploaded to AQS.

Table 6 presents the percentage of samplers that reported an ambient data capture rate of at least 75 percent for each of the four PQAOs this report focuses on and the nationwide average. Ninety-eight percent of the samplers within CARB's PQAO reported at least 75 percent of the required ambient data in 2023. Details on CARB's PQAO samplers not meeting criteria are provided in Appendices D-E of this report. Information for years 2021 and 2022 is only provided for historical perspective.

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[12] 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). Detailed information on the calculations for meeting the regulatory completeness requirement, including specific consideration of seasons and exceptional events, are outside the scope of this report.

Table 6.   **PM Samplers – Ambient Data Capture Rate Results (2021-2023)**

Pollutant	PQAO	Year	Number of Samplers	Number of Samplers Reporting ≥ 75% Ambient Data Capture Rate	% of Samplers Reporting ≥ 75% Ambient Data Capture Rate
PM_{10}	CARB	2023	89	88	99
		2022	93	91	98
		2021	98	95	97
	Bay Area AQMD	2023*	NDA	NDA	NDA
		2022	6	6	100
		2021	7	7	100
	South Coast AQMD	2023	26	26	100
		2022	32	32	100
		2021	33	32	97
	San Diego County APCD	2023	14	14	100
		2022	9	9	100
		2021	4	4	100
	Nationwide	2023*	661	639	97
		2022	626	611	98
		2021	659	636	97
$PM_{2.5}$	CARB	2023	89	87	98
		2022	91	86	95
		2021	94	79	84
	Bay Area AQMD	2023*	NDA	NDA	NDA
		2022	19	19	100
		2021	21	21	100
	South Coast AQMD	2023	26	26	100
		2022	36	34	94
		2021	33	33	100
	San Diego County APCD	2023	21	16	76
		2022	17	17	100
		2021	8	8	100
	Nationwide	2023*	1,838	1,475	80
		2022	1,745	1,660	95
		2021	1,693	1,591	94

- Source: AQS, AMP 430 Data Completeness Report, run July 2024.
- NDA means no certified data available in AQS.
- *Bay Area AQMD's PQAO 2023 data are not reflected in this report (for PQAO or nationwide), as certified data were not available in AQS (Source: AMP 256 Data Quality Indicator Report, run July 2024).

Precision and Bias

PM is subject to 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 PM_{10} 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 PM_{10} and both manual and continuous $PM_{2.5}$ sampling. Each PQAO is required to have 15 percent of its primary monitors collocated to represent its monitoring network ([1]). From each pair of collocated samplers, a minimum of 75 percent of ambient data is required to be in AQS. CARB's Annual Network Plan ([5]) includes a discussion of collocated sampling and indicates CARB's PQAO continues to meet the 15 percent minimum collocation requirement ([1]) in 2023 for the network of primary PM samplers.

Precision of the data is based on the 90 percent confidence limit of 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: PM_{10} (Hi-Vol): 15 microgram per cubic meter ($\mu g/m^3$); PM_{10} (Low-Vol): 3 $\mu g/m^3$; and $PM_{2.5}$: 3 $\mu g/m^3$. 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. Appendix A of 40 CFR Part 58 ([1]) requires that this upper bound of CV not exceed 10 percent for both PM_{10} and $PM_{2.5}$ at the PQAO level. A detailed description of CV, including the formula for calculating it, can be found in U.S. EPA guidance for the use of precision and bias data ([11]). Table 7 shows the number of sites with collocated precision data reported in respective years.

Bias of all PM samplers is assessed using monthly FRVs 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.

Bias is further assessed via the semi-annual flow rate audit by comparing the instrument's flow rate to a certified orifice (e.g., PM_{10} 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 PE audit criteria, based on the average percent difference during a semi-annual flow rate audit, were ±7 percent for PM_{10} high volume (Hi-Vol) and ±4 percent for PM_{10} low volume (Low-Vol) and $PM_{2.5}$.

Precision Results

For the reported collocated sites, Appendix A of 40 CFR Part 58 ([1]) requires that 30 paired observations per year (equivalent to 1-in-12 days) be collected from each site with collocated PM 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 2021 and 2022 is provided for historical perspectives. Precision completeness of at least 75 percent for collocated PM samplers was met for CARB's PQAO. The CFR precision criteria of 10 percent CV upper bound for CARB's PQAO was not met for PM_{10} or for 50 percent of the methods for $PM_{2.5}$. This is an improvement compared to 2022 data. U.S. EPA is aware of the systemic issue of PM imprecision (in California and nationwide). Details on CARB's PQAO samplers not meeting these criteria are provided in Appendices D-E of this report.

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) versus 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 to help the PQAO meet 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 adopted new statistics for calculating CV in its *Reconsideration of the National Ambient Air Quality Standards for Particulate Matter* ([19]) in March 2024.

Table 7.   PM Samplers – Precision Results Based on Available Collocated Samplers (2021-2023)

Pollutant	PQAO	Year	Measurement Method	Pairs of Collocated Samplers Reported	Percent Precision Completeness (%)	Upper Bound of CV (Precision)	CFR Criteria for Precision Met?
PM_{10}	CARB	2023	All	3*	100	**23.57***	No
		2022	All	4	100	20.31	No
		2021	All	4	100	19.20	No
	Bay Area AQMD	2023**	NDA	NDA	NDA	NDA	NDA
		2022	All	1	100	3.02	Yes
		2021	All	1	100	9.05	Yes
	South Coast AQMD	2023	All	3	100	5.12	Yes
		2022	All	3	100	12.57	No
		2021	All	3	100	8.53	Yes
	San Diego County APCD	2023	All	2	100	3.05	Yes
		2022	All	1	100	3.93	Yes
		2021	All	1	100	2.67	Yes
	Nationwide	2023**	All	70*	97	9.52*	Yes
		2022	All	68	99	10.66	No
		2021	All	72	98	10.08	No

Table 7. **PM Samplers – Precision Results Based on Available Collocated Samplers (2021-2023) (cont.)**

Pollutant	PQAO	Year	Measurement Method	Pairs of Collocated Samplers Reported	Percent Precision Completeness (%)	Upper Bound of CV (Precision)	CFR Criteria for Precision Met?
PM$_{2.5}$	CARB	2023	143	1	100	1.54	Yes
		2022	143	NDA	NDA	NDA	NDA
		2021	143	NDA	NDA	NDA	NDA
		2023	145	2	93	7.00	Yes
		2022	145	3	73	26.25	No
		2021	145	4	78	24.77	No
		2023	170	8	100	**14.33**	No
		2022	170	7	100	15.32	No
		2021	170	9	100	15.67	No
		2023	181	1	100	**12.45**	No
		2022	181	1	100	17.38	No
		2021	181	1	100	11.42	No
		2023	209	1	100	**12.45**	No
		2022	209	1	100	26.84	No
		2021	209	NDA	NDA	NDA	NDA
		2023	238	1	100	8.32	Yes
		2022	238	1	100	14.27	No
		2021	238	1	100	12.97	No
	Bay Area AQMD	2023**	NDA	NDA	NDA	NDA	NDA
		2022	170	3	100	10.41	No
		2021	170	3	100	9.66	Yes
	South Coast AQMD	2023	143	NDA	NDA	NDA	NDA
		2022	143	1	100	6.19	Yes
		2021	143	1	100	2.14	Yes
		2023	145	3	100	4.02	Yes
		2022	145	3	100	5.11	Yes
		2021	145	3	100	4.65	Yes
		2023	170	1	96	**11.63**	No
		2022	170	2	100	14.47	No
		2021	170	NDA	NDA	NDA	NDA
		2023	183	NDA	NDA	NDA	NDA
		2022	183	1	100	14.57	No
		2021	183	NDA	NDA	NDA	NDA
		2023	209	1	83	**10.25**	No
		2022	209	1	100	12.12	No
		2021	209	NDA	NDA	NDA	NDA

Table 7. **PM Samplers – Precision Results Based on Available Collocated Samplers (2021-2023) (cont.)**

Pollutant	PQAO	Year	Measurement Method	Number Pairs of Collocated Samplers Reported	Percent Precision Completeness (%)	Upper Bound of CV (Precision)	CFR Criteria for Precision Met?
PM$_{2.5}$	San Diego County APCD	2023	238	1	100	**11.83**	No
		2022	238	1	100	11.52	No
		2021	238	NDA	NDA	NDA	NDA
		2023	545	1	100	3.81	Yes
		2022	545	1	100	4.69	Yes
		2021	545	1	100	3.03	Yes
	Nationwide	2023	143	5	60	**10.05**	No
		2022	143	5	81	11.59	No
		2021	143	6	94	6.72	Yes
		2023	145	80	97	8.44	Yes
		2022	145	82	97	8.65	Yes
		2021	145	87	97	9.60	Yes
		2023	155	NDA	NDA	NDA	NDA
		2022	155	NDA	NDA	NDA	NDA
		2021	155	1	73	11.49	No
		2023**	170	42	99	**16.26**	No
		2022	170	39	100	17.60	No
		2021	170	39	99	15.79	No
		2023	181	3	100	**11.12**	No
		2022	181	3	100	18.52	No
		2021	181	3	100	12.56	No
		2023	183	4	97	**14.46**	No
		2022	183	5	99	15.20	No
		2021	183	4	98	17.72	No
		2023	209	27	96	**12.54**	No
		2022	209	21	99	14.15	No
		2021	209	19	97	11.00	No
		2023	238	30	99	**13.44**	No
		2022	238	28	100	14.56	No
		2021	238	25	100	12.38	No
		2023	545	5	100	7.35	Yes
		2022	545	5	100	7.00	Yes
		2021	545	5	100	7.93	Yes

- Source: AQS, AMP 256 Data Quality Indicator Report, run July 2024.
- NDA means no certified data available in AQS; *bold* text indicates CV greater than 10% in 2023; underlined text indicates CV greater than 10% in 2021 or 2022.

Table 7.   **PM Samplers – Precision Results Based on Available Collocated Samplers (2021-2023) (cont.)**

- 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 are provided in Appendix A of this report.
- 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 183 = Thermo Scientific 5014i or FH62C14-DHS w/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.
- *CARB's PQAO 2023 data reflects a collocated continuous PM_{10} sampler that was reported to AQS but was not required. CFR does not require collocation reporting to AQS for continuous PM_{10} samplers ([1]).
- **Bay Area AQMD's PQAO 2023 data are not reflected in this report (for PQAO and nationwide), as certified data were not available in AQS (Source: AMP 256 Data Quality Indicator Report, run July 2024).

Bias Results via Monthly Flow Rate Verifications

Bias results via the monthly FRVs for all PM samplers in 2023 are shown in Table 8. CARB's PQAO reported 100 percent for PM_{10} (Hi-Vol), more than 99 percent for PM_{10} (Low-Vol), and more than 95 percent for $PM_{2.5}$ of the required FRVs performed. In summary, the bias criteria of ±7 percent for PM_{10} (Hi-Vol), ±4 percent for PM_{10} (Low-Vol), and ±4 percent for $PM_{2.5}$ were met in each PQAO for which data are available. Details on CARB's PQAO PM samplers not uploading the required flow rate data are provided in Appendices D-E of this report.

Table 8.   **PM Samplers – Bias Results Based on FRVs (2021-2023)**

Pollutant (Collection Method)	PQAO	Year	Number of Samplers	Number of Required FRVs	Percent Required FRVs Performed (%)	Average Percent Difference** (%)	Bias***	CFR Criteria for Bias Met?
PM_{10} (Hi-Vol)	CARB	2023	8	29	100.0	2.45	3.93	Yes
		2022	14	41	100.0	1.55	3.29	Yes
		2021	18	121	100.0	0.55	3.29	Yes
	Bay Area AQMD*	2023	NDA	NDA	NDA	NDA	NDA	NDA
		2022	5	20	NDA	NDA	NDA	NDA
		2021	6	21	NDA	NDA	NDA	NDA
	South Coast AQMD	2023	9	27	100.0	0.49	4.17	Yes
		2022	19	61	100.0	0.13	3.39	Yes
		2021	24	93	100.0	-0.11	3.72	Yes
	San Diego County APCD	2023	NDA	NDA	NDA	NDA	NDA	NDA
		2022	NDA	NDA	NDA	NDA	NDA	NDA
		2021	NDA	NDA	NDA	NDA	NDA	NDA

Table 8.   PM Samplers – Bias Results Based on FRVs (2021-2023) (cont.)

Pollutant (Collection Method)	PQAO	Year	Number of Samplers	Number of Required FRVs	Percent Required FRVs Performed (%)	Average Percent Difference** (%)	Bias***	CFR Criteria for Bias Met?
PM₁₀ (Low-Vol)	CARB	2023	81	955	99.1	-0.10	1.00	Yes
		2022	82	951	97.4	0.06	1.08	Yes
		2021	82	937	97.7	0.01	1.04	Yes
	Bay Area AQMD*	2023	NDA	NDA	NDA	NDA	NDA	NDA
		2022	1	12	NDA	NDA	NDA	NDA
		2021	1	12	NDA	NDA	NDA	NDA
	South Coast AQMD	2023	18	154	100.0	-0.26	2.07	Yes
		2022	14	146	99.4	0.40	1.35	Yes
		2021	9	108	100.0	0.12	1.44	Yes
	San Diego County APCD	2023	9	81	100.0	0.07	1.41	Yes
		2022	9	71	95.6	0.33	1.35	Yes
		2021	4	48	100.0	0.01	0.89	Yes
PM₂.₅ (All)	CARB	2023	94	1,046	95.3	-0.15	±0.88	Yes
		2022	93	1,028	95.2	0.07	±1.00	Yes
		2021	93	1,033	93.7	0.05	±1.05	Yes
	Bay Area AQMD*	2023	NDA	NDA	NDA	NDA	NDA	NDA
		2022	19	228	5.7	0.33	±0.55	Yes
		2021	21	241	4.8	-0.15	±0.64	Yes
	South Coast AQMD	2023	26	312	99.7	-0.29	±1.16	Yes
		2022	39	334	99.3	0.38	±1.28	Yes
		2021	33	396	100.0	0.42	±1.69	Yes
	San Diego County APCD	2023	11	95	80.8	0.25	±1.34	Yes
		2022	17	118	66.3	0.25	±1.34	Yes
		2021	8	88	100.0	0.03	±1.20	Yes

- Source: AQS, AMP 256 Data Quality Indicator Report, run July 2024.
- NDA means no certified data available in AQS.
- CFR criteria for PM₁₀ bias: ±7% (of standard) for hi-vol and ±4% (of standard) for low-vol; CFR criteria for PM₂.₅ bias: ±4% (of standard).
- *Bay Area AQMD's PQAO 2023 data are not reflected in this report, as certified data were not available in AQS (Source: AMP 256 Data Quality Indicator Report, run July 2024). Bay Area AQMD's PQAO stores FRV data in its internal database and is developing a mechanism for uploading the data in AQS; data available for review upon request.
- **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 all FRVs performed.
- ***For PM₁₀ FRV, bias is an average of absolute bias values across samplers with no assigned sign (+, -, or ±).

Bias Assessment via CARB's Flow Rate Audits

CARB's PQAO and other PQAOs are required to conduct semi-annual flow rate audits on all PM samplers at each site, since an accurate measurement of PM is dependent upon the flow rate. Such audits should ideally be conducted five to seven months apart on each sampler in a given calendar year ([1]). In addition, as explained earlier, PQAOs are also required to submit FRVs (at least once every month) to AQS ([1]); in this case, bias estimates based on FRVs are further verified using the semi-annual flow rate audit data. All PM monitors, with a few exceptions, received the required semi-annual flow rate audits.

Table 9 summarizes the 2023 flow rate audit results for PM samplers. The number of samplers as well as those that met the required number of audits in 2023 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 ([20]). Bias is estimated as an average percent difference between the sampler flow rates and the audit flow rates, which represents 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 PE audit criteria is provided in Appendix C of this report. Other PQAOs may utilize different audit criteria.

CARB conducts semi-annual flow rate audits for most samplers operating within CARB's PQAO. In addition, certain monitoring organizations within CARB's PQAO could conduct their own audits in 2023, 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. Other PQAOs are responsible for performing their own audits.

Results of the audited PM samplers indicate that the 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 FRVs within CARB's PQAO. Details on CARB's PQAO samplers not meeting these criteria are provided in Appendices D-E of this report.

Table 9.   PM Samplers – Flow Rate Audits Results (2023)

Pollutant (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
PM₁₀ (Hi-Vol)	CARB	8	8	0	1.08	0.20	1.96
	Bay Area AQMD***	NDA	NDA	NDA	NDA	NDA	NDA
	South Coast AQMD	9	8	0	1.38	0.15	2.61
	San Diego County APCD	0	NDA	NDA	NDA	NDA	NDA
PM₁₀ (Low-Vol)**	CARB	81	80	1	-0.07	-0.28	0.15
	Bay Area AQMD***	NDA	NDA	NDA	NDA	NDA	NDA
	South Coast AQMD	18	18	0	1.45	0.93	1.96
	San Diego County APCD	9	7	0	0.52	-0.05	1.08
PM₂.₅ (All)	CARB	90	89	1	-0.08	-0.26	0.10
	Bay Area AQMD***	NDA	NDA	NDA	NDA	NDA	NDA
	South Coast AQMD	26	25	0	1.39	1.04	1.75
	San Diego County APCD	21	16	1	-0.40	-0.99	0.37

- Source: AQS, AMP 256 Data Quality Indicator Report, run July 2024.
- NDA means no certified 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.
- Sites could be audited multiple times in a quarter (by different entities or due to re-audits).
- CARB's flow rate audit criteria are provided in Appendix A of this report.
- *Bias is estimated as an average percent difference, which 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.
- ***Bay Area AQMD's PQAO 2023 data are not reflected in this report, as certified data were not available in AQS (Source: AMP 256 Data Quality Indicator Report, run July 2024).

Network Bias Results via PEP Audits

As noted earlier, PM₂.₅ 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 conducted annually within each PQAO and each method designation (for every designated FRM and FEM sampler within a PQAO) must be evaluated. Furthermore, each FRM and FEM sampler is subject to a PEP audit at least once every six years. For PQAOs with less than five monitoring sites, five valid PEP audits are required; for PQAOs with more than five monitoring sites, eight valid PEP audits are required. A PEP audit is valid when both the sampler and PEP audit concentrations are above 3 μg/m^3.

Results from 2023 PEP audits for all PQAOs are presented in Table 10, with results from the previous two years presented to assess trends. Results from 2023 indicate that the PM$_{2.5}$ network for CARB's PQAO has low total bias, consistent with results determined through FRV and flow rate audits. U.S. EPA has lowered the threshold from 3 μg/m^3 to 2 μg/m^3 in its *Reconsideration of the National Ambient Air Quality Standards for Particulate Matter* ([19](#)) in March 2024; which should help increase the number of valid samples and improve the bias estimate based on PEP audits in the future.

Table 10.   PM Samplers – Total Bias Results via PEP Audits (2021-2023)

Pollutant	PQAO	Year	Number of Samplers	Number of Audits Required	Number of Audits Collected	Percent Complete (%)	Bias
PM$_{2.5}$	CARB	2023	72	8	4	50	-2.56
		2022	71	8	6	75	5.39
		2021	74	8	5	63	12.83
	Bay Area AQMD	2023*	NDA	NDA	NDA	NDA	NDA
		2022	15	8	5	63	-17.73
		2021	17	8	6	75	-3.21
	South Coast AQMD	2023	15	8	7	88	-0.91
		2022	20	8	9	100	-3.79
		2021	19	8	8	100	7.15
	San Diego County APCD	2023	9	8	2	25	6.94
		2022	8	8	6	75	-8.17
		2021	5	5	6	100	-9.3

- Source: AQS, AMP 256 Data Quality Indicator Report, run July 2024.
- NDA means no certified data available in AQS.
- Number of samplers refers to monitors designated as "primary" in AQS.
- PEP audit criteria are provided in Appendix A of this report.
- *Bay Area AQMD's PQAO 2023 data are not reflected in this report, as certified data were not available in AQS (Source: AMP 256 Data Quality Indicator Report, run July 2024).

C. Summary of Results for Monitoring Organizations within CARB's PQAO

Table 11 summarizes the 2023 data quality results for gaseous pollutants and PM across different geographic areas[13] within CARB's PQAO. To make an assessment, the 30 geographic areas were divided into four categories according to monitoring activities, as shown below. Notable observations from the assessment of these four categories for CARB's PQAO in 2023 include:

Gaseous pollutant monitoring only

- Two geographic areas:
    - Amador County met all MQOs.
    - One did not meet all MQOs.

PM monitoring without collocation only

- One geographic area:
    - Northern Sonoma met all MQOs.

Gaseous pollutant and PM monitoring without collocation

- Seventeen geographic areas:
    - Antelope Valley, Butte County, Calaveras County, Colusa County, Eastern Kern, El Dorado County, Glenn County, Lake County, Mendocino County, North Coast, Placer County, San Luis Obispo, Siskiyou County, and Tehama County met all MQOs.
    - Mariposa County and Yolo-Solano met MQOs for gaseous pollutants only.
    - Santa Barbara County met MQOs for PM only.

Gaseous pollutant and PM monitoring with collocation

- Ten geographic areas:
    - Feather River, Great Basin, Mojave Desert, Monterey Bay, Northern Sierra, Shasta County, and Ventura County met MQOs for gaseous pollutants only.
    - Three did not meet all MQOs for gaseous pollutants and PM.

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[13] 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 of this report for a complete list of geographic areas and associated monitoring organizations.

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 (more details are provided 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.

As indicated earlier in this report, a systemic issue exists with PM precision in California and nationwide. Table 12 shows that most collocated samplers reported upper bound CV values exceeding the criterion of 10 percent. Only one geographic area, Sacramento Metropolitan, met the criterion for achieving CV values of less than 10 percent for PM_{10}, while four geographic areas, Great Basin, North Coast, Sacramento Metropolitan, and San Joaquin Valley, met the criterion for $PM_{2.5}$. U.S. EPA adopted new methods for calculating CV in its *Reconsideration of the National Ambient Air Quality Standards for Particulate Matter* ([19](#)) in March 2024.

Table 11. **Gaseous Instruments and PM Samplers – Composite Table of Ambient Data and Data Quality Results for Geographic Areas within CARB's PQAO (2023)**

Geographic Area	Gaseous Instruments						PM Samplers					
	Ambient Data Capture Rate	1-pt QC Checks Reported	Precision Criteria Met	Bias Criteria Met	Instruments All Audited	Audited Instruments Met Criteria	Ambient Data Capture Rate	Precision Data Collocated Sites	Collocated Sites Met Criteria	FRV	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	Y	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	Y	Y	NA	NA	Y	Y	Y
Eastern Kern	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
El Dorado County	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Feather River	Y	Y	Y	Y	Y	Y	Y	Y	N†	Y	Y	Y
Glenn County	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Great Basin	Y	Y	Y	Y	Y	Y	N	Y	N	N	N	Y
Imperial County	N	N	Y	Y	Y	Y	N	Y	N†	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	N†	Y	Y
Mendocino County	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Mojave Desert	Y	Y	Y	Y	Y	Y	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	Y	Y	Y	NA	NA	Y	Y	Y
Northern Sierra	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y
Northern Sonoma	NA	NA	NA	NA	NA	NA	Y	NA	NA	Y	Y	Y
Placer County	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Sacramento Metropolitan	N	N	Y	Y	Y	Y	Y	Y	N††	Y	Y	Y
San Joaquin Valley	N	Y	Y	Y	N	Y	Y	Y	N†	N†	Y	Y
San Luis Obispo	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	Y
Santa Barbara County	Y	Y	Y	Y	Y	N	Y	NA	NA	Y	Y	Y
Shasta County	Y	Y	Y	Y	Y	Y	Y	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	N†	NA	NA	NA	NA	NA	NA
Ventura County	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Yolo-Solano	Y	Y	Y	Y	Y	Y	Y	NA	NA	N	Y	Y

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

Table 12.   PM Samplers – Precision Results for Geographic Areas within CARB's PQAO (2023)

Pollutant	Geographic Area	Measurement Method (Primary/ Secondary)	Monitoring By	Percent Precision Completeness (%)	Upper Bound of CV (Precision)
PM$_{10}$	Great Basin	All	MO MO	100 90	**21.24*** **12.15**
	Sacramento Metropolitan	All	MO	100	5.44
PM$_{2.5}$	Feather River	170/170	CARB	100	**10.24**
	Great Basin	181/145 238/145	MO MO	100 100	**12.45** 8.32
	Imperial County	170/143	CARB	93	**12.78**
	Mojave Desert	170/170	MO	100	**13.69**
	Monterey Bay	170/143	MO	100	**17.41**
	North Coast	143/143	MO	100	1.54
	Sacramento Metropolitan	145/145 170/143 170/170	MO CARB MO	97 97 100	3.55 **10.60** **17.59**
	San Joaquin Valley	170/145 145/145	CARB CARB	100 90	**14.33** 8.02
	Shasta County	209/143	MO	100	**12.45**
	Ventura County	170/170	MO	100	**14.59**

- Source: AQS, AMP 256 Data Quality Indicator Report, run July 2024.
- 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 are provided in Appendix A of this report.
- Details on samplers not meeting criteria are provided in Appendices D-E of this report.
- **Bold** text indicates CV greater than 10% in 2023.
- 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 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.
- *Data reflects a collocated continuous PM$_{10}$ sampler that was reported to AQS but was not required. CFR does not require collocation reporting to AQS for continuous PM$_{10}$ samplers ([1]).

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 2023.

A. Gaseous Pollutants

The gaseous pollutants assessed in this report are CO, NO_2, O_3, and SO_2. Conclusions and recommendations pertaining to gaseous instruments and associated MQOs are highlighted below.

Conclusions

- Ambient data capture rate criteria of at least 75 percent were met by 97 percent of the gaseous instruments operating within CARB's PQAO in 2023.
- More than 99 percent of the gaseous instruments operating within CARB's PQAO reported at least 75 percent of the required 1-pt QC checks. Additionally, more than 99 percent met the 2016 revised critical criteria[14] for individual 1-pt QC checks for percent, absolute difference, and prescribed range, set by U.S. EPA ([3])([4]).
- CARB's PQAO met the CFR criteria for precision and bias based on 1-pt QC checks ([1]).
- Data from CARB's PE audits indicate that 99 percent of all instruments met the audit criteria for CARB's PQAO. This confirms the bias estimates based on 1-pt QC checks, which showed that the gaseous network for CARB's PQAO generally exhibits a low bias.

Recommendations

- Overall, MQOs associated with the gaseous instruments showed an improvement compared to 2022, continuing the trend observed over the past two years for CARB's PQAO. However, 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.

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[14] U.S. EPA describes "critical" criteria as criteria deemed to maintaining the integrity of a sample or group of samples ([3]).

B. Particulate Matter

The PM assessed in this report are PM_{10} and $PM_{2.5}$. Conclusions and recommendations pertaining to PM samplers and associated MQOs are highlighted below.

Conclusions

- Ambient data capture rate criteria of at least 75 percent were met by 98 percent of the PM samplers operating within CARB's PQAO in 2023.
- CARB's PQAO continued to meet the minimum 15 percent collocation requirement in the network of primary PM samplers, as indicated in CARB's Annual Network Plan ([5](#)).
- CARB's PQAO met precision completeness criteria of at least 75 percent for collocated PM samplers. The CFR precision criteria of 10 percent CV upper bound for CARB's PQAO was not met for PM_{10} and for 50 percent of the methods for $PM_{2.5}$. This is an improvement compared to 2022 data. U.S. EPA is aware of the systemic issue of PM imprecision (in California and nationwide).
- CARB's PQAO reported 100 percent for PM_{10} (Hi-Vol), more than 99 percent for PM_{10} (Low-Vol), and more than 95 percent for $PM_{2.5}$ of the required FRVs performed. The results at the PQAO level indicate that the PM network exhibited low bias in 2023.
- CARB's PE audit data indicate that CARB's PQAO met audit criteria for flow rate audits. This is consistent with bias information from the routine FRV data, and an improvement compared to 2022 data.
- Total $PM_{2.5}$ bias for CARB's PQAO, via PEP audits administered by U.S. EPA based on limited mass samples, shows low bias, consistent with results determined by FRVs and CARB's PE audits for flow rate.

Recommendations

- In terms of precision, CV values among collocated $PM_{2.5}$ samplers within CARB's PQAO remain high for 50 percent of the methods in 2023. 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 adopted new statistics for calculating CV in its *Reconsideration of the National Ambient Air Quality Standards for Particulate Matter* ([19](#)) in March 2024. CARB should continue exploring the potential causes behind low $PM_{2.5}$ precision among some of the collocated $PM_{2.5}$ samplers within CARB's PQAO.
- There were instances of PM_{10} and/or $PM_{2.5}$ samplers not meeting the MQOs (e.g., ambient data capture rate, CV precision, 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 2023 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 bias 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 MQOs 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 may be used with the knowledge of the quality behind it.

CARB has in place extensive Standard Operating Procedures 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 criteria, including AQDAs and CANs. Deviations from MQOs do not invalidate the data for regulatory decision making. A weight of evidence evaluation based on data quality measurements, in combination with other data information, reports, and similar documentation, can be used to demonstrate compliance with requirements in Appendix A of 40 CFR Part 58 ([1](#)).

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 meet all MQOs set by U.S. EPA or the data producers themselves.

A comprehensive list of all references used in this report is provided in Appendix F.

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 < $\pm$10.1% for bias (< $\pm$10.1% percent difference and 0.5-5.0 ppm for an individual 1-pt QC check) NO_2: 90% CL CV < 15.1% for precision 95% CL < $\pm$15.1% for bias (< $\pm$15.1% (percent difference) or < $\pm$1.5 ppb difference, whichever is greater, and 0.005-0.08 ppm for an individual 1-pt QC check) O_3: 90% CL CV < 7.1% for precision 95% CL < $\pm$7.1% for bias (< $\pm$7.1% (percent difference) or < $\pm$1.5 ppb difference, whichever is greater, and 0.005-0.08 ppm for an individual 1-pt QC check) SO_2: 90% CL CV < 10.1% for precision 95% CL < $\pm$10.1% for bias (< $\pm$10.1% (percent difference) or < $\pm$1.5 ppb difference, whichever is greater, and 0.005-0.08 ppm for an individual 1-pt QC check)
CARB's PE Audits: 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

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

Method and Pollutant	CFR Reference	Coverage (Annual)	Minimum Frequency	MQOs
FRV: 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
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 $\leq$ 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
FRV: 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
FRV: 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 $\leq$ 5 sites 2. 8 valid audits for primary QA orgs, with > 5 sites 3. All samplers in 6 years	Over all 4 quarters	< $\pm$10.1% bias for values > 3.0 µg/m^3

- *The details in this table were informed by U.S. EPA guidance ([3](#)).

Appendix B. Tools for Assessing Precision and Bias

Table B-1.   Tools for Assessing Precision and Bias

Pollutant	Precision		Bias		
	1-pt QC Checks	Collocated Measurements	1-pt QC Checks	FRVs	CARB's PE Audits
Gaseous					
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 Evaluation Audit Criteria

Table C-1.   Gaseous Instruments and PM Samplers – CARB's PE Audit Criteria

Instrument/Sampler	Control Limit	Warning
CO, NO_2, and SO_2	±15%*	±10%
O_3	±10%*	±7%
PM_{10} (Dichotomous, Continuous); PM_{10} (Filter-Based Low-Vol; Lead 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, Lead 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 (Lead 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 audit criteria based on U.S. EPA guidance ([3](#)):
  - For CO: ±0.03 ppm difference or ±15% difference, whichever is greater.
  - For NO_2, O_3, and SO_2: ±1.5 ppb difference or ±15% difference, whichever is greater.
- CARB's PE audit criteria are operational, and exceedances (especially at lower levels) do not automatically invalidate the data.

Table C-2.   Meteorological Sensors – CARB's PE Audit Criteria

Audit Parameters	Control Limit
Ambient Temperature	±0.5 degrees Celsius
Barometric Pressure	±2.25 mm of mercury
Wind Direction	≤ 5.0 degrees 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 m/s and < 5% difference above 5 m/s (not to exceed 2.5 m/s difference)
Wind Speed (starting threshold)	≤ 0.5 m/s

- CARB's PE audits at air monitoring sties do not include an audit for 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 bias 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	Monitoring By
Amador County	Amador County APCD	CARB
Antelope Valley	Antelope Valley AQMD	MO
Butte County	Butte County AQMD	CARB
Calaveras County	Calaveras County APCD	CARB
Colusa County	Colusa County APCD	CARB
Eastern Kern	Eastern Kern APCD	MO; CARB
El Dorado County	El Dorado County AQMD	CARB
Feather River	Feather River AQMD	CARB
Glenn County	Glenn County APCD	CARB
Great Basin	Great Basin Unified APCD	MO
Imperial County	Imperial County APCD	MO; CARB
Lake County	Lake County APCD	MO
Mariposa County	Mariposa County APCD	CARB
Mendocino County	Mendocino County AQMD	MO
Mojave Desert	Mojave Desert AQMD	MO; CARB
Monterey Bay	Monterey Bay ARD	MO
North Coast	North Coast Unified AQMD	MO
Northern Sierra	Northern Sierra AQMD	MO
Northern Sonoma	Northern Sonoma County APCD	MO
Placer County	Placer County APCD	MO; CARB
Sacramento Metropolitan	Sacramento Metropolitan AQMD	MO; CARB
San Joaquin Valley	San Joaquin Valley APCD	MO; CARB
San Luis Obispo	San Luis Obispo County APCD	MO; CARB
Santa Barbara County	Santa Barbara County APCD	MO
Shasta County	Shasta County APCD	MO
Siskiyou County	Siskiyou County APCD	MO
Tehama County	Tehama County APCD	MO; CARB
Tuolumne County	Tuolumne County APCD	CARB
Ventura County	Ventura County APCD	MO
Yolo-Solano	Yolo-Solano AQMD	MO; CARB

Table D-2.   Gaseous Instruments – Ambient Data Capture Rate Results for Geographic Areas within CARB's PQAO (2023)

Geographic Area	Monitoring By	Number of CO Instruments	Number of Instruments Reporting ≥ 75% Ambient Data Capture Rate	Percent of Instruments Reporting ≥ 75% Ambient Data Capture Rate (%)
Butte County	CARB	1	1	100
Great Basin	MO	1	1	100
Imperial County	CARB	1	1	100
Monterey Bay	MO	1	1	100
North Coast	MO	1	1	100
Sacramento Metropolitan	MO	1	0	0
San Joaquin Valley	MO; CARB	6	6	100
Santa Barbara County	MO	1	1	100
Geographic Area	Monitoring By	Number of NO$_2$ Instruments	Number of Instruments Reporting ≥ 75% Ambient Data Capture Rate	Percent of Instruments Reporting ≥ 75% Ambient Data Capture Rate (%)
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	4	80
San Joaquin Valley	MO; CARB	18	18	100
San Luis Obispo	MO	2	2	100
Ventura County	MO	2	2	100
Yolo-Solano	CARB	1	1	100

Table D-2.   Gaseous Instruments – Ambient Data Capture Rate Results for Geographic Areas within CARB's PQAO (2023) (cont.)

Geographic Area	Monitoring By	Number of O₃ Instruments	Number of Instruments Reporting ≥ 75% Ambient Data Capture Rate	Percent of Instruments Reporting ≥ 75% Ambient Data Capture Rate (%)
Amador County	CARB	1	1	100
Antelope Valley	MO	1	1	100
Butte County	CARB	3	3	100
Calaveras County	CARB	1	1	100
Colusa County	CARB	1	1	100
Eastern Kern	CARB	1	1	100
El Dorado County	CARB	3	3	100
Feather River	CARB	2	2	100
Glenn County	CARB	1	1	100
Great Basin	MO	1	1	100
Imperial County	MO; CARB	4	3	75
Lake County	MO	1	1	100
Mariposa County	CARB	1	1	100
Mendocino County	MO	1	1	100
Mojave Desert	MO; CARB	7	7	100
Monterey Bay	MO	5	5	100
North Coast	MO	1	1	100
Northern Sierra	MO	1	1	100
Placer County	MO; CARB	5	5	100
Sacramento Metropolitan	MO; CARB	5	4	80
San Joaquin Valley	MO; CARB	23	22	96
San Luis Obispo	MO; CARB	7	7	100
Santa Barbara County	MO	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 Instruments – Ambient Data Capture Rate Results for Geographic Areas within CARB's PQAO (2023) (cont.)

Geographic Area	Monitoring By	Number of SO$_2$ Instruments	Number of Instruments Reporting ≥ 75% Ambient Data Capture Rate	Percent of Instruments Reporting ≥ 75% Ambient Data Capture Rate (%)
Great Basin	MO	1	1	100
Imperial County	CARB	1	1	100
North Coast	MO	1	1	100
Sacramento Metropolitan	MO	1	1	100
San Joaquin Valley	CARB	1	1	100
San Luis Obispo	MO	1	1	100
Santa Barbara County	MO	1	1	100

Table D-3.   Gaseous Instruments – Precision Results and Bias for Geographic Areas within CARB's PQAO (2023)

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*
Butte County	CARB	1	1	3.41	2.67
Great Basin	MO	1	1	3.09	5.28
Imperial County	CARB	1	1	3.80	5.88
Monterey Bay	MO	1	1	3.11	2.41
North Coast	MO	1	1	4.54	4.24
Sacramento Metropolitan	MO	1	0	3.67	2.80
San Joaquin Valley	MO; CARB	6	6	2.76	3.25
Santa Barbara County	MO	1	1	3.44	3.35
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	2.48	2.26
Butte County	CARB	1	1	3.50	2.98
Feather River	CARB	1	1	3.47	3.08
Imperial County	MO; CARB	2	2	4.03	3.83
Mojave Desert	MO	3	3	3.08	3.25
Monterey Bay	MO	1	1	2.76	2.63

Table D-3.   Gaseous Instruments – Precision Results and Bias for Geographic Areas within CARB's PQAO (2023) (cont.)

Geographic Area	Monitoring By	Number of NO₂ Instruments	Number of Instruments with ≥ 75% of Required 1-pt QC Checks	Upper Bound of CV (Precision)	Bias*
North Coast	MO	1	1	5.00	7.70
Placer County	CARB	1	1	5.57	4.78
Sacramento Metropolitan	MO; CARB	5	5	4.81	5.78
San Joaquin Valley	MO; CARB	18	18	4.71	6.40
San Luis Obispo	MO	2	2	2.26	3.21
Santa Barbara County	MO	1	1	5.71	5.88
Ventura County	MO	2	2	1.70	1.96
Yolo-Solano	CARB	1	1	3.39	2.58
Geographic Area	Monitoring By	Number of O₃ Instruments	Number of Instruments with ≥ 75% of Required 1-pt QC Checks	Upper Bound of CV (Precision)	Bias*
Amador County	CARB	1	1	2.47	3.04
Antelope Valley	MO	1	1	1.72	1.40
Butte County	CARB	3	3	2.00	2.12
Calaveras County	CARB	1	1	2.40	1.72
Colusa County	CARB	1	1	1.16	1.00
Eastern Kern	CARB	1	1	2.03	4.55
El Dorado County	CARB	3	3	4.45	2.72
Feather River	CARB	2	2	2.04	2.45
Glenn County	CARB	1	1	1.58	2.17
Great Basin	MO	1	1	6.27	6.06
Imperial County	MO; CARB	4	3	3.25	2.73
Lake County	MO	1	1	2.01	3.20
Mariposa County	CARB	1	1	2.13	1.66
Mendocino County	MO	1	1	2.00	1.70
Mojave Desert	MO; CARB	7	7	2.28	2.41
Monterey Bay	MO	5	5	2.01	2.26
North Coast	MO	1	1	6.20	4.87
Northern Sierra	MO	1	1	4.88	4.01
Placer County	MO; CARB	5	5	2.09	2.23
Sacramento Metropolitan	MO; CARB	5	5	1.87	2.15
San Joaquin Valley	MO; CARB	23	23	1.82	2.05

Table D-3.   Gaseous Instruments – Precision Results and Bias for Geographic Areas within CARB's PQAO (2023) (cont.)

Geographic Area	Monitoring By	Number of O₃ Instruments	Number of Instruments with ≥ 75% of Required 1-pt QC Checks	Upper Bound of CV (Precision)	Bias*
San Luis Obispo	MO; CARB	7	7	1.68	1.89
Santa Barbara County	MO	8	8	1.92	2.18
Shasta County	MO	3	3	2.64	2.52
Siskiyou County	MO	1	1	2.95	2.67
Tehama County	MO; CARB	2	2	1.49	2.02
Tuolumne County	CARB	1	1	1.49	1.68
Ventura County	MO	5	5	1.37	1.31
Yolo-Solano	MO; CARB	3	3	2.08	2.57
Geographic Area	Monitoring By	Number of SO₂ Instruments	Number of Instruments with ≥ 75% of Required 1-pt QC Checks	Upper Bound of CV (Precision)	Bias*
Great Basin	MO	1	1	3.27	3.91
Imperial County	CARB	1	1	1.18	1.14
North Coast	MO	1	1	5.93	5.90
Sacramento Metropolitan	MO	1	1	2.89	2.61
San Joaquin Valley	CARB	1	1	2.60	5.16
San Luis Obispo	MO	1	1	1.87	1.53
Santa Barbara County	MO	1	1	3.12	3.14

- Source: AQS, AMP 256 Data Quality Indicator Report, run July 2024.
- 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. 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 CV and bias are provided in Appendix A of this report. The AMP 600 report flags instruments that do not have at least 75% of the required 1-pt QC checks.
- *For each geographic area, bias is an average of absolute bias values across individual instruments within each area, with no assigned sign (+, -, or ±).

Table D-4.   Gaseous Instruments – 1-pt QC Checks Individual Assessment for Geographic Areas within CARB's PQAO (2023)

Geographic Area	Monitoring By	Number of Instruments	Number of CO 1-pt QC Checks Performed	Number of CO 1-pt QC Checks Meeting Critical Criteria	Percent of CO 1-pt QC Checks Meeting Critical Criteria (%)
Butte County	CARB	1	239	239	100.0
Great Basin	MO	1	60	58	96.7
Imperial County	CARB	1	140	140	100.0
Monterey Bay	MO	1	48	48	100.0
North Coast	MO	1	32	31	96.9
Sacramento Metropolitan	MO	1	133	133	100.0
San Joaquin Valley	MO; CARB	6	757	752	99.3
Santa Barbara County	MO	1	360	360	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 Critical Criteria	Percent of NO_2 1-pt QC Checks Meeting Critical Criteria (%)
Antelope Valley	MO	1	323	323	100.0
Butte County	CARB	1	243	243	100.0
Feather River	CARB	1	255	255	100.0
Imperial County	MO; CARB	2	277	277	100.0
Mojave Desert	MO	3	148	148	100.0
Monterey Bay	MO	1	52	52	100.0
North Coast	MO	1	118	118	100.0
Placer County	CARB	1	219	219	100.0
Sacramento Metropolitan	MO; CARB	5	860	860	100.0
San Joaquin Valley	MO; CARB	18	5,093	5,090	99.9
San Luis Obispo	MO	2	519	519	100.0
Santa Barbara County	MO	1	351	351	100.0
Ventura County	MO	2	346	346	100.0
Yolo-Solano	CARB	1	251	251	100.0

Table D-4.   Gaseous Instruments – 1-pt QC Checks Individual Assessment for Geographic Areas within CARB's PQAO (2023) (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 Critical Criteria	Percent of O_3 1-pt QC Checks Meeting Critical Criteria (%)
Amador County	CARB	1	328	328	100.0
Antelope Valley	MO	1	342	342	100.0
Butte County	CARB	3	718	718	100.0
Calaveras County	CARB	1	294	294	100.0
Colusa County	CARB	1	357	357	100.0
Eastern Kern	CARB	1	36	36	100.0
El Dorado County	CARB	3	688	688	100.0
Feather River	CARB	2	461	461	100.0
Glenn County	CARB	1	340	340	100.0
Great Basin	MO	1	59	59	100.0
Imperial County	MO; CARB	4	321	321	100.0
Lake County	MO	1	52	52	100.0
Mariposa County	CARB	1	30	30	100.0
Mendocino County	MO	1	51	51	100.0
Mojave Desert	MO; CARB	7	593	593	100.0
Monterey Bay	MO	5	265	265	100.0
North Coast	MO	1	121	121	100.0
Northern Sierra	MO	1	45	45	100.0
Placer County	MO; CARB	5	315	315	100.0
Sacramento Metropolitan	MO; CARB	5	910	910	100.0
San Joaquin Valley	MO; CARB	23	6,851	6,851	100.0
San Luis Obispo	MO	7	1,908	1,908	100.0
Santa Barbara County	MO	8	2,638	2,638	100.0
Shasta County	MO	3	104	104	100.0
Siskiyou County	MO	1	26	26	100.0
Tehama County	MO; CARB	2	266	266	100.0
Tuolumne County	CARB	1	349	349	100.0
Ventura County	MO	5	879	879	100.0
Yolo-Solano	MO; CARB	3	344	344	100.0

Table D-4.   Gaseous Instruments – 1-pt QC Checks Individual Assessment for Geographic Areas within CARB's PQAO (2023) (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 Critical Criteria	Percent of SO$_2$ 1-pt QC Checks Meeting Critical Criteria (%)
Great Basin	MO	1	60	60	100.0
Imperial County	CARB	1	258	258	100.0
North Coast	MO	1	116	116	100.0
Sacramento Metropolitan	MO	1	100	100	100.0
San Joaquin Valley	CARB	1	169	169	100.0
San Luis Obispo	MO	1	350	350	100.0
Santa Barbara County	MO	1	361	361	100.0

- Source: AQS, AMP 251 QA Raw Assessment Report, run July 2024.
- Criteria for individual 1-pt QC checks are provided in Appendix A of this report. Details on CARB's PQAO instruments not meeting these criteria are provided in Appendix E of this report.

Table D-5.   Gaseous Instruments – 1-pt QC Checks Individual Assessment on Prescribed Range for Geographic Areas within CARB's PQAO (2023)

Geographic Area	Monitoring By	Number of Instruments	Number of CO 1-pt QC Checks Performed	Number of CO 1-pt QC Checks Meeting Critical Criteria	Percent of CO 1-pt QC Checks Meeting Critical Criteria (%)
Butte County	CARB	1	239	239	100.0
Great Basin	MO	1	60	60	100.0
Imperial County	CARB	1	140	140	100.0
Monterey Bay	MO	1	48	48	100.0
North Coast	MO	1	32	32	100.0
Sacramento Metropolitan	MO	1	133	127	95.5
San Joaquin Valley	MO; CARB	6	757	757	100.0
Santa Barbara County	MO	1	360	337	93.6

Table D-5.   **Gaseous Instruments – 1-pt QC Checks Individual Assessment on Prescribed Range for Geographic Areas within CARB's PQAO (2023) (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 Critical Criteria	Percent of NO_2 1-pt QC Checks Meeting Critical Criteria (%)
Antelope Valley	MO	1	323	308	95.4
Butte County	CARB	1	243	243	100.0
Feather River	CARB	1	255	255	100.0
Imperial County	MO; CARB	2	277	277	100.0
Mojave Desert	MO	3	148	143	96.6
Monterey Bay	MO	1	52	52	100.0
North Coast	MO	1	118	118	100.0
Placer County	CARB	1	219	219	100.0
Sacramento Metropolitan	MO; CARB	5	860	796	92.6
San Joaquin Valley	MO; CARB	18	5,093	5,093	100.0
San Luis Obispo	MO	2	519	519	100.0
Santa Barbara County	MO	1	351	349	99.4
Ventura County	MO	2	346	346	100.0
Yolo-Solano	CARB	1	251	251	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 Critical Criteria	Percent of O_3 1-pt QC Checks Meeting Critical Criteria (%)
Amador County	CARB	1	328	328	100.0
Antelope Valley	MO	1	342	339	99.1
Butte County	CARB	3	718	718	100.0
Calaveras County	CARB	1	294	294	100.0
Colusa County	CARB	1	357	357	100.0
Eastern Kern	CARB	1	36	36	100.0
El Dorado County	CARB	3	688	688	100.0
Feather River	CARB	2	461	461	100.0
Glenn County	CARB	1	340	340	100.0
Great Basin	MO	1	59	59	100.0
Imperial County	MO; CARB	4	321	321	100.0
Lake County	MO	1	52	52	100.0
Mariposa County	CARB	1	30	30	100.0
Mendocino County	MO	1	51	51	100.0
Mojave Desert	MO; CARB	7	593	593	100.0
Monterey Bay	MO	5	265	265	100.0

Table D-5. Gaseous Instruments – 1-pt QC Checks Individual Assessment on Prescribed Range for Geographic Areas within CARB's PQAO (2023) (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 Critical Criteria	Percent of O_3 1-pt QC Checks Meeting Critical Criteria (%)
North Coast	MO	1	121	121	100.0
Northern Sierra	MO	1	45	45	100.0
Placer County	MO; CARB	5	315	315	100.0
Sacramento Metropolitan	MO; CARB	5	910	893	98.1
San Joaquin Valley	MO; CARB	23	6,851	6,851	100.0
San Luis Obispo	MO	7	1,908	1,900	99.6
Santa Barbara County	MO	8	2,638	2,570	97.4
Shasta County	MO	3	104	104	100.0
Siskiyou County	MO	1	26	26	100.0
Tehama County	MO; CARB	2	266	266	100.0
Tuolumne County	CARB	1	349	349	100.0
Ventura County	MO	5	879	879	100.0
Yolo-Solano	MO; CARB	3	344	344	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 Critical Criteria	Percent of SO_2 1-pt QC Checks Meeting Critical Criteria (%)
Great Basin	MO	1	60	57	95.0
Imperial County	CARB	1	258	258	100.0
North Coast	MO	1	116	116	100.0
Sacramento Metropolitan	MO	1	100	98	98.0
San Joaquin Valley	CARB	1	169	169	100.0
San Luis Obispo	MO	1	350	350	100.0
Santa Barbara County	MO	1	361	361	100.0

- Source: AQS, AMP 251 QA Raw Assessment Report, run July 2024.
- Details on CARB's PQAO instruments not meeting these criteria are provided in Appendix E of this report.

Table D-6. Gaseous Instruments – Results for CARB's PE Audits for Geographic Areas within CARB's PQAO (2023)

Geographic Area	Monitoring By	Number of CO Instruments	Number of CO Instruments Audited	Average Percent Difference* (%)
Butte County	CARB	1	1	-48.40**
Great Basin	MO	1	1	-12.46
Imperial County	MO; CARB	1	1	-1.96
Monterey Bay	MO	1	1	2.17
Sacramento Metropolitan	MO	2	2	-8.42
San Joaquin Valley	MO; CARB	6	6	-0.23**
Santa Barbara County	MO	1	1	6.23
Geographic Area	Monitoring By	Number of NO_2 Instruments	Number of NO_2 Instruments Audited	Average Percent Difference* (%)
Antelope Valley	MO	1	1	7.33
Butte County	CARB	1	1	-0.54
Feather River	CARB	1	1	16.50
Imperial County	MO; CARB	2	2	-2.32
Mojave Desert	MO	3	3	-1.02
Monterey Bay	MO	1	1	5.50
North Coast	MO	1	1	-1.00
Placer County	CARB	1	1	3.53
Sacramento Metropolitan	MO; CARB	5	5	4.61
San Joaquin Valley	MO; CARB	18	16	-5.33
San Luis Obispo	MO	2	2	14.87
Santa Barbara County	MO	1	1	-8.93
Ventura County	MO	2	2	-0.07
Yolo-Solano	CARB	1	1	-6.47
Geographic Area	Monitoring By	Number of O_3 Instruments	Number of O_3 Instruments Audited	Average Percent Difference* (%)
Amador County	CARB	1	1	-0.70
Antelope Valley	MO	1	1	1.59
Butte County	CARB	3	3	-4.88
Calaveras County	CARB	1	1	-2.78
Colusa County	CARB	1	1	3.38
El Dorado County	CARB	3	3	2.28
Feather River	CARB	2	2	0.42
Glenn County	CARB	1	1	-2.83**
Great Basin	MO	1	1	-1.31
Imperial County	MO; CARB	4	4	-2.15

Table D-6. Gaseous Instruments – Results for CARB's PE Audits for Geographic Areas within CARB's PQAO (2023) (cont.)

Geographic Area	Monitoring By	Number of O_3 Instruments	Number of O_3 Instruments Audited	Average Percent Difference* (%)
Lake County	MO	1	1	10.09
Mariposa County	CARB	1	1	3.40
Mendocino County	MO	1	1	-2.64
Mojave Desert	MO; CARB	7	7	-0.45
Monterey Bay	MO	5	5	-2.08
North Coast	MO	1	1	-4.68
Northern Sierra	MO	1	1	11.01**
Placer County	MO; CARB	5	5	4.22
Sacramento Metropolitan	MO; CARB	4	4	-2.80
San Joaquin Valley	MO; CARB	23	23	-3.53
San Luis Obispo	MO; CARB	8	8	2.21
Santa Barbara County	MO	8	8	0.73
Shasta County	MO	3	3	10.31
Siskiyou County	MO	1	1	10.62
Tehama County	MO; CARB	2	2	1.43
Tuolumne County	CARB	1	1	14.98
Ventura County	MO	5	5	-2.12
Yolo-Solano	MO; CARB	3	3	-13.62**
Geographic Area	Monitoring By	Number of SO_2 Instruments	Number of SO_2 Instruments Audited	Average Percent Difference* (%)
Great Basin	MO	1	1	-2.02
Imperial County	CARB	1	1	2.66
North Coast	MO	1	1	2.43
Sacramento Metropolitan	MO	1	1	-11.02
San Joaquin Valley	CARB	1	1	19.05**
San Luis Obispo	MO	1	1	-11.29
Santa Barbara County	MO	1	1	6.48

- Source: AQS, AMP 256 Data Quality Indicator Report, run July 2024.
- NDA means no certified data available in AQS.
- Details on CARB's PQAO instruments not meeting these criteria are provided in Appendix E of this report.
- CARB's PE audit criteria are provided in Appendix A of this report and additional absolute differences in U.S. EPA audit levels 1 and 2 are provided in Appendix C of this report. Since the two lowest audit points for trace CO and trace SO_2 are U.S. EPA audit levels 1 and 2, and the lowest audit point for O_3 is U.S. EPA audit level 2, they were not subject to the AQDA process.
- *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.
- **These values were due to trace values and were not subject to the AQDA process.

Table D-7.   PM Samplers – Ambient Data Capture Rate Results for Geographic Areas within CARB's PQAO (2023)

Geographic Area	Monitoring By	Number of PM$_{10}$ Samplers	Number of PM$_{10}$ Samplers Reporting ≥ 75% Ambient Data Capture Rate	Percent of PM$_{10}$ Samplers Reporting ≥ 75% Ambient Data Capture Rate (%)
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	18	17	94
Imperial County	MO; CARB	5	5	100
Lake County	MO	1	1	100
Mariposa County	CARB	1	1	100
Mendocino County	MO	1	1	100
Mojave Desert	MO	6	6	100
Monterey Bay	MO	3	3	100
North Coast	MO	1	1	100
Northern Sonoma	MO	3	3	100
Placer County	CARB	1	1	100
Sacramento Metropolitan	MO; CARB	4	4	100
San Joaquin Valley	MO; CARB	16	16	100
San Luis Obispo	MO	7	7	100
Santa Barbara County	MO	4	4	100
Shasta County	MO	1	1	100
Tehama County	MO	2	2	100
Ventura County	MO	2	2	100
Yolo-Solano	MO	3	3	100

Table D-7.   PM Samplers – Ambient Data Capture Rate Results for Geographic Areas within CARB's PQAO (2023) (cont.)

Geographic Area	Monitoring By	Number of PM$_{2.5}$ Samplers	Number of PM$_{2.5}$ Samplers Reporting ≥ 75% Ambient Data Capture Rate	Percent of PM$_{2.5}$ Samplers Reporting ≥ 75% Ambient Data Capture Rate (%)
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	6	6	100
Imperial County	MO; CARB	4	3	75
Lake County	MO	1	1	100
Mendocino County	MO	2	2	100
Mojave Desert	MO	3	3	100
Monterey Bay	MO	6	6	100
North Coast	MO	2	2	100
Northern Sierra	MO	5	4	80
Placer County	MO; CARB	2	2	100
Sacramento Metropolitan	MO; CARB	9	9	100
San Joaquin Valley	MO; CARB	20	20	100
San Luis Obispo	MO	4	4	100
Santa Barbara County	MO	5	5	100
Shasta County	MO	2	2	100
Siskiyou County	MO	1	1	100
Tehama County	MO	1	1	100
Ventura County	MO	6	6	100
Yolo-Solano	MO	2	2	100

- Source: AQS, AMP 430 Data Completeness Report, run July 2024.
- Details on CARB's PQAO samplers not reporting at least 75% ambient data are provided in Appendix E of this report.

Table D-8.   PM Samplers – Bias Results for FRVs for Geographic Areas within CARB's PQAO (2023)

Geographic Area	Monitoring By	PM$_{10}$ Collection Method	Number of PM$_{10}$ Samplers	Number of PM$_{10}$ FRVs Required	Percent Required PM$_{10}$ FRVs Performed (%)	Average Percent Difference* (%)	Bias**
Antelope Valley	MO	Low-Vol	1	12	100.0	-0.26	0.83
Butte County	CARB	Low-Vol	1	12	100.0	-0.16	2.67
Calaveras County	CARB	Low-Vol	1	12	100.0	-0.49	0.86
Colusa County	CARB	Low-Vol	1	12	100.0	-0.62	1.13
Eastern Kern	MO	Low-Vol	3	25	100.0	-0.44	0.59
El Dorado County	CARB	Low-Vol	1	12	100.0	-0.72	1.06
Feather River	CARB	Low-Vol	1	12	100.0	-0.53	1.09
Glenn County	CARB	Low-Vol	1	12	100.0	-0.23	1.78
Great Basin	MO	Low-Vol	18	216	96.3	0.21	1.09
Imperial County	MO	Low-Vol	5	60	100.0	-0.05	0.67
Lake County	MO	Low-Vol	1	12	100.0	0.15	0.61
Mariposa County	CARB	Low-Vol	1	12	91.7	-0.25	1.87
Mendocino County	MO	Low-Vol	1	12	100.0	-1.08	1.32
Mojave Desert	MO	Low-Vol	6	70	100.0	-0.59	1.52
Monterey Bay	MO	Low-Vol	3	36	100.0	-0.08	0.88
North Coast	MO	Low-Vol	1	12	100.0	0.71	1.40
Northern Sonoma	MO	Low-Vol	3	36	100.0	0.70	1.21
Placer County	CARB	Low-Vol	1	12	100.0	-0.25	0.81
Sacramento Metropolitan	MO; CARB	Hi-Vol	3	12	100.0	1.23	2.01
		Low-Vol	1	12	100.0	-0.90	1.25
San Joaquin Valley	MO; CARB	Low-Vol	16	192	100.0	-0.05	0.89
San Luis Obispo	MO	Low-Vol	7	84	100.0	-0.39	0.97
Santa Barbara County	MO	Low-Vol	4	48	100.0	-0.20	0.46
Shasta County	MO	Hi-Vol	1	4	100.0	3.13	4.76
Tehama County	MO	Hi-Vol	1	1	100.0	4.81	6.14
		Low-Vol	1	8	100.0	0.02	0.33
Ventura County	MO	Low-Vol	2	24	100.0	0.14	0.44
Yolo-Solano	MO	Hi-Vol	3	12	100.0	2.66	4.84

Table D-8. PM Samplers – Bias Results for FRVs for Geographic Areas within CARB's PQAO (2023) (cont.)

Geographic Area	Monitoring By	PM$_{2.5}$ Collection Method	Number of PM$_{2.5}$ Samplers	Number of PM$_{2.5}$ FRVs Required	Percent Required PM$_{2.5}$ FRVs Performed (%)	Average Percent Difference* (%)	Bias**
Antelope Valley	MO	All	1	12	100.0	-0.18	0.57
Butte County	CARB	All	1	12	100.0	-0.43	1.25
Calaveras County	CARB	All	1	12	100.0	-0.20	0.49
Colusa County	CARB	All	1	12	100.0	-1.08	1.45
Eastern Kern	MO	All	2	13	100.0	-0.84	1.45
Feather River	CARB	All	2	24	100.0	-0.42	0.94
Great Basin	MO	All	8	76	100.0	0.08	0.91
Imperial County	MO; CARB	All	4	48	100.0	0.27	1.01
Lake County	MO	All	1	12	100.0	-0.05	0.92
Mendocino County	MO	All	2	24	100.0	-0.35	0.62
Mojave Desert	MO	All	3	34	100.0	-0.75	1.56
Monterey Bay	MO	All	7	84	100.0	-0.18	0.89
North Coast	MO	All	2	13	100.0	-0.49	1.76
Northern Sierra	MO	All	5	49	80.0	-0.07	0.78
Placer County	MO	All	2	24	100.0	0.46	0.82
Sacramento Metropolitan	MO; CARB	All	9	108	100.0	-0.08	0.74
San Joaquin Valley	MO; CARB	All	20	240	98.7	-0.29	0.83
San Luis Obispo	MO	All	4	48	100.0	0.12	0.63
Santa Barbara County	MO	All	5	51	100.0	-0.07	0.74
Shasta County	MO	All	2	24	100.0	-1.70	2.21
Siskiyou County	MO	All	1	12	100.0	0.39	0.73
Tehama County	MO	All	2	11	100.0	-0.32	0.80
Ventura County	MO	All	6	72	100.0	-0.03	0.47
Yolo-Solano	MO	All	2	24	91.7	0.69	1.53

- *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 all FRVs performed.
- **Bias is an average of absolute bias values across samplers with no sign assigned (+, -, or +) due to the absence of sign data by geographic area reported to AQS.

Table D-9.   PM Samplers – Results for Flow Rate Audits for Geographic Areas within CARB's PQAO (2023)

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	-0.15
Butte County	CARB	1	1	0	0.70
Calaveras County	CARB	1	1	0	-0.18
Colusa County	CARB	1	1	0	-0.83
Eastern Kern	MO	3	3	0	-0.58
El Dorado County	CARB	1	1	0	-0.26
Feather River	CARB	1	1	0	-0.06
Glenn County	CARB	1	1	0	-0.17
Great Basin	MO	18	17	1	-0.20
Imperial County	MO	5	5	0	0.73
Lake County	MO	1	1	0	0.54
Mariposa County	CARB	1	1	0	0.98
Mendocino County	MO	1	1	0	0.51
Mojave Desert	MO	6	6	0	0.50
Monterey Bay	MO	3	3	0	-0.17
North Coast	MO	1	1	0	-0.58
Northern Sonoma	MO	3	3	0	0.80
Placer County	MO; CARB	1	1	0	0.55
Sacramento Metropolitan	MO; CARB	4	4	0	0.89
San Joaquin Valley	MO; CARB	16	16	0	-0.42
San Luis Obispo	MO	7	7	0	-0.10
Santa Barbara County	MO	4	4	0	-0.57
Shasta County	MO	1	1	0	1.93
Tehama County	MO	2	2	0	1.52
Ventura County	MO	2	2	0	0.17
Yolo-Solano	MO	3	3	0	-0.26
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	0.24
Butte County	CARB	1	1	0	0.48
Calaveras County	CARB	1	1	0	-0.51
Colusa County	CARB	1	1	0	-1.04
Eastern Kern	MO	2	2	0	-0.12
Feather River	CARB	2	2	0	0.23
Great Basin	MO	6	6	0	-0.56
Imperial County	MO	4	3	1	0.76
Lake County	MO	1	1	0	0.33

Table D-9.   PM Samplers – Results for Flow Rate Audits for Geographic Areas within CARB's PQAO (2023) (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** (%)
Mendocino County	MO	2	2	0	0.57
Mojave Desert	MO	3	3	0	0.60
Monterey Bay	MO	7	7	0	-0.65
North Coast	MO	2	2	0	1.93
Northern Sierra	MO	5	5	0	0.12
Placer County	MO; CARB	2	2	0	0.64
Sacramento Metropolitan	MO; CARB	9	9	0	-0.08
San Joaquin Valley	MO; CARB	19	19	0	-0.52
San Luis Obispo	MO	4	4	0	-0.31
Santa Barbara County	MO	5	5	0	-0.47
Shasta County	MO	2	2	0	-1.45
Siskiyou County	MO	1	1	0	1.00
Tehama County	MO	2	2	0	0.88
Ventura County	MO	6	6	0	0.09
Yolo-Solano	MO	2	2	0	1.74

- Source: AQS, AMP 256 Data Quality Indicator Report, run July 2024.
- CARB's flow rate audit criteria are provided in Appendix A of this report. Only audits conducted by CARB were subject to the AQDA process. Details on CARB's PQAO samplers not meeting these criteria are provided in Appendix E of this report. Only flow failures are included in this table.
- *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.

Appendix E. CARB's PQAO Data Quality Anomalies

This appendix includes a listing of gaseous instruments and PM samplers which did not meet a particular MQO. Instances where an MQO was not met would be considered a data anomaly. The data anomalies provided in this appendix are for informational purposes only, as most MQOs are assessed at the PQAO level.

Table E-1. Gaseous Instruments – Ambient Data Completeness < 75% Reported for Geographic Areas within CARB's PQAO (2023)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant	(% Data Reported) Comment
06-067-0015-42101-1	Sacramento-Bercut Drive	Sacramento Metropolitan	MO	CO	(19%) Data null coded (AS) poor quality assurance results from mid-February - mid-October. A calibration issue was identified with the instrument.
06-067-0012-42602-1	Folsom-Natoma Street	Sacramento Metropolitan	MO	NO_2	(53%) Data null coded (BA) maintenance/routine repairs from mid-May - September.
06-025-4004-44201-1	Niland-English Road	Imperial County	MO	O_3	(53%) Data null coded (AN) machine malfunction from early August - December.
06-067-5003-44201-1	Sloughhouse	Sacramento Metropolitan	MO	O_3	(51%) Data null coded (AS) poor quality assurance results from early July - December. An installation issue with the station calibrator was identified with the instrument.
06-031-1004-44201-1	Hanford-S Irwin Street	San Joaquin Valley	MO	O_3	(64%) Data null coded (AS) poor quality assurance results from mid-March - June. A discrepancy in reporting data to AQS in a timely manner was identified.

Table E-2.   Gaseous Instruments – Precision/Bias 1-pt QC Checks < 75% Reported for Geographic Areas within CARB's PQAO (2023)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant	(% 1-pt QC Checks Reported) Comment
06-067-0015-42101-1	Bercut Drive	Sacramento Metropolitan	MO	CO	(65%) Data null coded (AS) poor quality assurance results from mid-February - mid-October. A calibration issue was identified with the instrument. No 1-pt QC checks performed in January.
06-025-4004-44201-1	Niland-English Road	Imperial County	MO	O_3	(62%) Data null coded (AN) machine malfunction from early August - December. No 1-pt QC checks performed from mid-August - December.

Table E-3.   Gaseous Instruments – CARB's PE Audits Not Conducted for Geographic Areas within CARB's PQAO (2023)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant	Comment
06-019-2016-42602-1	Fresno-Foundry Park	San Joaquin Valley	MO	NO_2	No audit conducted. Direct-read NO_2 is not compatible with current audit techniques.
06-029-2019-42602-1	Bakersfield-Westwind	San Joaquin Valley	MO	NO_2	No audit conducted. Direct-read NO_2 is not compatible with current audit techniques.

Table E-4.   Gaseous Instruments – Audits Criteria Not Met for Geographic Areas within CARB's PQAO (2023)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant	Comment
06-083-2004-42101-1	Lompoc-S H Street	Santa Barbara County	MO	CO	Instrument exceeded CARB and U.S. EPA audit criteria. AQDA #8494 issued.
06-109-0005-44201-1	Sonora-Barretta Street	Tuolumne	CARB	O_3	Instrument exceeded CARB and U.S. EPA audit criteria. AQDA #8488 issued.

Table E-5. PM Samplers – Ambient Data Completeness < 75% Reported for Geographic Areas within CARB's PQAO (2023)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant)	(% Reported) Comment
06-051-0011-81102-3	Mono Lake-North Shore	Great Basin	MO	PM$_{10}$	(21%) Data null coded (AV) power failure multiple times throughout the year. The site experienced a solar system failure from January - March and August - December, and operated periodically from April - July.
06-025-1003-88101-3	El Centro-9th Street	Imperial County	MO	PM$_{2.5}$	(71%) Data null coded (AN) machine malfunction from early March - mid-June.
06-063-1010-88101-2	Portola Gulling Street	Northern Sierra	MO	PM$_{2.5}$	(31%) Data null coded (AQ) collection error for some data in January. Sampler was shut down in early February.

Table E-6. PM Samplers – Collocated Data Completeness < 75% Reported for Geographic Areas within CARB's PQAO (2023)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant	Comment
All PM samplers met collocated data completeness criteria of ≥ 75%, as required. There are no anomalies to include in this table.					

Table E-7.   PM Samplers – Precision Criteria (CV Limit of 10%) Not Met for Geographic Areas within CARB's PQAO (2023)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant	Comment
06-027-0002-81102-1	White Mountain	Great Basin	MO	PM_{10}	CV = 21.24 Collocated site with both FEM and FRM samplers.*
06-027-1003-81102-6	Keeler-Cerro Gordo Road	Great Basin	MO	PM_{10}	CV = 12.15 Collocated site with FRM samplers showing differences in sampling frequency.
06-025-0005-88101-3	Calexico-Ethel Street	Imperial County	CARB	$PM_{2.5}$	CV = 12.78
06-019-0011-88101-3	Fresno-Garland	San Joaquin Valley	CARB	$PM_{2.5}$	CV = 14.33
06-067-0010-88101-3	Sacramento-T Street	Sacramento Metropolitan	CARB	$PM_{2.5}$	CV = 10.60
06-101-0003-88101-3	Yuba City-Almond Street	Feather River	CARB	$PM_{2.5}$	CV = 10.24
06-027-1003-88101-3	Keeler-Cerro Gordo Road	Great Basin	MO	$PM_{2.5}$	CV = 12.45 Collocated site with both FEM and FRM samplers.*
06-071-0306-88101-1	Victorville-14306 Park Avenue	Mojave Desert	MO	$PM_{2.5}$	CV = 13.69
06-053-1003-88101-3	Salinas-#3	Monterey Bay	MO	$PM_{2.5}$	CV = 17.41
06-067-0012-88101-3	Folsom-Natoma Street	Sacramento Metropolitan	MO	$PM_{2.5}$	CV = 17.59
06-089-0004-88101-3	Redding-Health Dept Roof	Shasta County	MO	$PM_{2.5}$	CV = 12.45 Sampler non-operational for several hours one day in August.
06-111-2002-88101-3	Simi Valley-Cochran Street	Ventura County	MO	$PM_{2.5}$	CV = 14.59

- *U.S. EPA is aware of the systemic issue of PM imprecision (in California and nationwide). The agency adopted new statistics for calculating CV in its *Reconsideration of the National Ambient Air Quality Standards for Particulate Matter* ([19]) in March 2024.

Table E-8. PM Samplers – FRVs for Geographic Areas within CARB's PQAO (2023)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant	(% Required FRVs Performed) Comment
06-051-0011-81102-3	Mono Lake-North Shore	Great Basin	MO	PM$_{10}$	(33%) Insufficient FRVs performed. The site experienced a solar system failure from January - March and August - December, and operated periodically from April - July.
06-043-1001-81102-3	Yosemite-Visitor Center	Mariposa County	CARB	PM$_{10}$	(92%) No FRVs performed in January. Sampler non-operational for several days in January.
06-019-0011-88101-3	Fresno-Garland	San Joaquin Valley	CARB	PM$_{2.5}$	(75%) No FRVs reported in AQS from April - June. FRVs performed from April - June are not reflected in this report, as certified data were not available in AQS.
06-063-1010-88101-1	Portola Gulling Street	Northern Sierra	MO	PM$_{2.5}$	(0%) No FRVs performed from January - early February. Sampler was shut down in early February.
06-113-1003-88101-3	Woodland-Gibson Road	Yolo-Solano	MO	PM$_{2.5}$	(83%) No FRVs performed from May - June. Mechanical issues with sampler identified and sampler sent to manufacturer for repair.

Table E-9. PM Samplers – Flow Rate Audits Not Conducted for Geographic Areas within CARB's PQAO (2023)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant	Comment
06-051-0011-81102-3	Mono Lake-North Shore	Great Basin	MO	PM$_{10}$	One audit conducted. First audit was conducted. Sampler non-operational at the time of the second audit.
06-025-1003-88101-3	El Centro-9th Street	Imperial County	MO	PM$_{2.5}$	One audit conducted. Sampler non-operational at the time of the first audit. AQDA #8490 issued. Second audit was conducted.

Table E-10. PM Samplers – Audit Criteria Not Met for Geographic Areas within CARB's PQAO (2023)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant	Comment
All PM samplers met audit criteria, as required. There are no anomalies to include in this table.					

Table E-11. Gaseous Instruments and PM Samplers – Manual Adjustments* to Information Outputs from AQS for Geographic Areas within CARB's PQAO (2023)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant	Comment
06-023-1004-42101-1	Eureka-Jacobs	North Coast	MO	CO	No audit conducted. SPM sites are only audited at the request of the monitoring organization/availability of auditor.
06-067-0006-42101-1	Sacramento-Del Paso Manor	Sacramento Metropolitan	MO	CO	No audit conducted. Instrument non-operational at the time of the audits.
06-029-0019-44201-1	Mojave-CA 58 Business	Eastern Kern	CARB	O_3	No audit conducted. Instrument operational for less than two months prior to shut down (mid-February). U.S. EPA guidance ([20]) states no audit is required if a sampler operates less than three months.
06-079-3001-44201-1	Morro Bay	San Luis Obispo County	MO	O_3	No audit conducted. This instrument was relocated to the Morro Bay Kings Ave. site and audit was conducted in July.
06-027-0002-88101-21	White Mountain	Great Basin	MO	$PM_{2.5}$	(50%) Ambient data collected. U.S. EPA created a Parameter Occurrence Code (POC) placeholder to capture $PM_{2.5}$ data in AQS until a Network Data Alignment ([21]) was completed and a new POC was created. Once completed, ambient data completeness criteria were met (97%) as reported for the new POC.
06-051-0005-88101-24	Lee Vining	Great Basin	MO	$PM_{2.5}$	(58%) Ambient data collected. U.S. EPA created a POC placeholder to capture $PM_{2.5}$ data in AQS until a Network Data Alignment ([21]) was completed and a new POC was created. Once completed, ambient data completeness criteria were met (99%) as reported for the new POC.
06-023-1004-88101-1	Eureka-Jacobs	North Coast	MO	$PM_{2.5}$	(10%) Collocated data collected. Sampler collocation began in December. Collocated data completeness for December was met (100%).

Table E-11. Gaseous Instruments and PM Samplers – Manual Adjustments* to Information Outputs from AQS for Geographic Areas within CARB's PQAO (2023) (cont.)

Site ID	Site Name	Geographic Area	Monitoring By	Pollutant	Comment
06-027-0002-88101-21	White Mountain	Great Basin	MO	$PM_{2.5}$	(0%) No FRVs performed. U.S. EPA created a POC placeholder to capture $PM_{2.5}$ data in AQS until a Network Data Alignment ([21]) was completed and a new POC was created. Once completed, FRV critical criteria were met (100%) as reported for the new POC.
06-051-0005-88101-24	Lee Vining	Great Basin	MO	$PM_{2.5}$	(0%) No FRVs performed. U.S. EPA created a POC placeholder to capture $PM_{2.5}$ data in AQS until a Network Data Alignment ([21]) was completed and a new POC was created. Once completed, FRV critical criteria were met (100%) as reported for the new POC.
06-027-0002-88101-21	White Mountain	Great Basin	MO	$PM_{2.5}$	No PM audit conducted. U.S. EPA created a POC placeholder to capture $PM_{2.5}$ data in AQS until a Network Data Alignment ([21]) was completed and a new POC was created. Once completed, PM audit criteria were met as reported for the new POC.
06-051-0005-88101-24	Lee Vining	Great Basin	MO	$PM_{2.5}$	No PM audit conducted. U.S. EPA created a POC placeholder to capture $PM_{2.5}$ data in AQS until a Network Data Alignment ([21]) was completed and a new POC was created. Once completed, PM audit criteria were met as reported for the new POC.

- *Based on information available and as summarized in this table, data are manually adjusted when information outputs from AQS are not considered to be anomalies.

Table E-12. Gaseous Pollutants and PM – Summary of AQDAs and CANs Issued and Closed for Geographic Areas within CARB's PQAO (2023)

Pollutant	AQDAs Issued	AQDAs Closed*	CANs Issued	CANs Closed*
CO	2	2	7	2
NO_2	2	2	10	5
O_3	4	3	13	6
SO_2	0	0	2	0
PM_{10}	0	0	13	7
$PM_{2.5}$	3	3	10	7

- *The number of AQDAs and CANs closed in 2023 may include resolutions for AQDAs and CANs issued in previous years.

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Appendix F. References

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