2018
Annual Data Quality Report

Monitoring and Laboratory Division
Quality Management Branch

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Annual Data Quality Report

California Air Resources Board's
Primary Quality Assurance Organization

Prepared by:

Quality Management Branch
Monitoring and Laboratory Division
California Air Resources Board

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Acronyms and Abbreviations

APCD	Air pollution control district
AQDA	Air quality data action
AQMD	Air quality management district
AQS	Air Quality System
ARD	Air resources district
BAAQMD	Bay Area Air Quality Management District
BAM	Beta attenuation method
CAN	Corrective action notification
CARB	California Air Resources Board
CFR	Code of Federal Regulations
CO	Carbon monoxide
CV	Coefficient of variation
FEM	Federal equivalent method
FRM	Federal reference method
FRV	Flow rate verification
MQO	Measurement quality objective
NO_2	Nitrogen dioxide
NPS	National Park Service
O_3	Ozone
Pb	Lead
PEP	Performance Evaluation Program
PM	Particulate matter
$PM_{2.5}$	Particulate matter with aerodynamic diameter ≤2.5 µm
PM_{10}	Particulate matter with aerodynamic diameter ≤10 µm
POC	Parameter occurrence code

ppb	Parts per billion
ppm	Parts per million
PQAO	Primary quality assurance organization
QC	Quality control
QMB	Quality Management Branch
SCAQMD	South Coast Air Quality Management District
SDCAPCD	San Diego County Air Pollution Control District
SLAMS	State and Local Air Monitoring Station Network
SO_2	Sulfur dioxide
SPM	Special Purpose Monitors
TSP	Total suspended particulates
TEOM	Tapered element oscillating microbalance
U.S. EPA	U.S. Environmental Protection Agency
VSCC	Very sharp cut cyclone

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Appendices

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Executive Summary

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

The MQOs reviewed include data capture (amount of ambient data reported), precision (the degree of mutual agreement among individual measurements of the same property), bias/accuracy (the degree of agreement between an observed value and an accepted known or reference value), and the amount of precision and bias/accuracy data collected and reported. The criteria by which the assessments are made are mostly dictated in CFR[1] and are listed in Appendix A of this report. Appendix B provides details on the instruments/samplers that did not meet certain criteria. The U.S. Environmental Protection Agency (U.S. EPA) has designated CARB, the Bay Area Air Quality Management District (BAAQMD), South Coast Air Quality Management District (SCAQMD), San Diego County Air Pollution Control District (SDCAPCD), National Park Service (NPS), Morongo Band of Mission Indians, and Pechanga Band of Luiseño Indians as their own PQAOs. Where appropriate, comparisons of results to BAAQMD, SCAQMD, and SDCAPCD and the national average[2] are made. It is important to note that this assessment is solely based on data available in U.S. EPA's Air Quality System (AQS). PQAOs may have collected certain precision and/or bias/accuracy data that was not uploaded to AQS; in some cases, that particular data was not federally required to be uploaded.

The gaseous criteria pollutants assessed include: carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). The ambient data capture rate represents the percentage of ambient data collected and uploaded to AQS compared to the total amount of data possible. For gaseous pollutants, one-point quality control (QC) precision checks (mostly automated) are performed by the monitoring organizations to confirm the instrument's ability to respond to a known concentration of gas. Precision represents the degree of variability among the one-point checks. The one-point checks are also used to assess bias/accuracy for each instrument. This is done by comparing the instrument response to a reference gas.

Precision for most particulate matter (PM_{10} and $PM_{2.5}$) samplers is assessed via collocated sampling whereby two identical or equivalent samplers are operated side-by-side.[3] Bias for PM samplers is assessed by using the routine flow rate

[1] Title 40 CFR Appendix A to Part 58.
[2] National average includes state, county, district, National Park Service, and tribal sites, including those in California.
[3] Collocated sampling is required for all PM samplers, except continuous PM_{10}

verifications performed by site operators. Total $PM_{2.5}$ bias for a PQAO is also assessed through the Performance Evaluation Program (PEP) run by U.S. EPA.

Accuracy for both gaseous instruments and PM samplers is further verified by CARB's performance evaluation audit program using through-the-probe audit techniques on gaseous instruments and checking flow rates on particulate samplers. The ambient data capture rate and the accompanying precision and accuracy data for 2018 from both gaseous instruments and PM samplers are summarized below.

Gaseous Instruments

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

- Ninety-eight percent of the gaseous instruments operating under CARB's PQAO achieved the ambient data capture rate of at least 75 percent in 2018. Ninety-five percent of the gaseous instruments also achieved CARB's goal of at least 85 percent data capture.
- Ninety-nine percent of the gaseous instruments operating under CARB's PQAO reported at least 75 percent of the required QC checks submitted to AQS. Most met the revised critical criteria (on percent and absolute difference) for individual QC checks, set by U.S. EPA,[4,5] starting in March 2017.
- CFR precision and bias/accuracy criteria (from one-point QC checks) were met at the PQAO level on an annual basis.
- Performance audit data indicate that, except for a few instruments, CARB's PQAO met the audit criteria. This finding is consistent with the bias information obtained from the one-point QC checks.

<u>Recommendation – Gaseous Program</u>

- Although MQOs associated with the gaseous instruments were met at the PQAO level, there were a few instances of analyzers not meeting the MQO (e.g., ambient data capture rate, submittal of required QC checks, etc.). Monitoring agencies should investigate why these objectives were not met for each analyzer in their respective jurisdictions and develop corrective actions, if appropriate, to meet them in subsequent years.
- Upon examination of the data quality issues within CARB's PQAO in 2018, several gaseous instruments that did not pass the annual performance audits were operated by CARB. We investigated the audit and calibration equipment as well as other possible sources of error. Our evaluation of the issues indicates

[4]https://www3.epa.gov/ttn/amtic/files/ambient/pm25/qa/APP_D%20validation%20template%20version%2003_2017_for%20AMTIC%20Rev_1.pdf
[5]https://www3.epa.gov/ttn/amtic/files/ambient/pm25/qa/Changes%20to%20Validation%20Templates%202013%20to%202017.pdf

no systemic problems exist with the instruments and that those particular instruments did not fail audits in 2019. We will continue monitoring and documenting any issues that may arise.

PM Samplers

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

- Ninety-eight percent of the particulate samplers operating under CARB's PQAO achieved the ambient data capture rate of at least 75 percent in 2018. Ninety-three percent of the particulate samplers also achieved CARB's goal of at least 85 percent data capture.
- As indicated in CARB's *Annual Network Plan Covering Operations in 25 California Air Districts, July 2019,*[6] CARB's PQAO continued meeting the minimum 15 percent collocation requirement.
- For the five PM_{10} and fifteen $PM_{2.5}$ pairs of collocated samplers that were present within CARB's PQAO, all except two reported at least 75 percent of the required precision data in 2018.
- For PM_{10}, with the exception of one geographic area, the precision criteria was met in CARB's PQAO (as well as other California PQAOs).
- For $PM_{2.5}$, CARB's PQAO did not meet the precision criteria at the PQAO level for all methods of collection (except for one method involving sequential samplers with very sharp cut cyclone). (See Table B3 for more details.)
- Almost all PM_{10} and $PM_{2.5}$ samplers reported flow rate verification data to AQS, and the results indicate that the PM network exhibited low bias.
- The audit accuracy data indicates that CARB's PQAO met CARB criteria for flow rate audits. This finding is consistent with the bias information from the routine flow rate verification data.
- Total $PM_{2.5}$ bias for CARB's PQAO, via the Performance Evaluation Program conducted by U.S. EPA, shows results consistent with the bias results that were evaluated via flow rate verification and audits.

<u>Recommendations – PM Program</u>

- In terms of precision, coefficient of variation (CV) values among collocated $PM_{2.5}$ samplers remain high in 2018 within CARB's PQAO and generally on a national basis. 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 vs federal equivalent methods. While no definitive source of imprecision has been

[6] http://www.arb.ca.gov/aqd/amnr/amnr2019.pdf

identified, staff has begun a discussion with monitoring agencies to closely examine operational practices in order to help the PQAO achieve the precision criteria for PM.

- There were instances of samplers not meeting the MQOs (e.g., ambient data capture rate, submittal of required collocated measurements, etc). Monitoring agencies 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.

Summary of Results

In an effort to compare 2018 data quality results across geographic areas within California, Table ES-1 presents results for both gases and PM in one composite table. To make a fair comparison, we divided the geographic areas into three categories according to monitoring activities: 1) gas only; 2) gas and PM without collocation; and 3) gas and PM with collocation. Below are some key observations for CARB's PQAO from Table ES-1:

- There are two areas that monitored gases only, and both achieved all MQOs.
- Among 19 areas that monitored gases and PM without collocation, 9 met all MQOs, 5 did not meet the MQOs for gases only, 4 did not meet MQOs for PM, and 1 did not meet for both gases and PM.
- Among nine areas that monitored gases and PM with collocation, one achieved all MQOs.

The statistics reported herein are intended as assessment tools for the data producers and users to identify areas where program improvements can be made to achieve all MQOs set by U.S. EPA or the data producers themselves. Although CFR criteria for precision and accuracy are generally applied and evaluated at the PQAO level, assessments at the district or site level may differ and can be important as well. However, it is important to note that when certain CFR criteria are not met, it does not necessarily mean that the corresponding air quality data should not be used, but rather, the data should be used with the knowledge of the quality behind it. The 2018 ambient data in AQS for CARB's PQAO have been certified and are considered suitable for comparison to federal standards.

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

Table ES-1. Composite Table of Ambient Data and Quality Assurance Results (Both Gas and PM) for Local Districts Within CARB's PQAO

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

*Geographic Area: region covered by an air district. Sites within air district may be operated by district, CARB, or both.

✓ Met criteria N/A Not Applicable X Did not meet criteria X** Impacted site operated by CARB

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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. CARB and local air pollution control agencies operate ambient monitoring stations throughout the State. As stated in the Code of Federal Regulations (CFR), the U.S. Environmental Protection Agency (U.S. EPA) has designated CARB, the Bay Area Air Quality Management District (BAAQMD), South Coast Air Quality Management District (SCAQMD), San Diego County Air Pollution Control District (SDCAPCD), National Park Service (NPS), Morongo Band of Mission Indians, and Pechanga Band of Luiseño Indians as their own PQAOs. This report will focus on four PQAOs: CARB, BAAQMD, SCAQMD, and SDCAPCD.

A PQAO is a local air district, or a coordinated aggregation of such organizations that is responsible for a set of stations that monitors the same pollutants and for which data quality assessments can logically be pooled. Each criteria pollutant sampler/monitor at a monitoring station in the State and Local Air Monitoring Station (SLAMS) Network must be associated with one, and only one, PQAO.[7]

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 criteria gaseous and particulate pollutants are compared to measurement quality objectives (MQO). Where appropriate, comparisons to the national average and other PQAOs in California are also made. (The national average includes agencies defined as "state," "county," "district," "National Park Service," or "tribal.")

[7] Samplers may also be identified as Special Purpose Monitors (SPM) or Industrial (ID) monitors. There are a limited number of SPM and ID monitors in California. The statistics reported in this report are predominantly the result of SLAMS monitors but also include a small number of SPM and ID monitors as well.

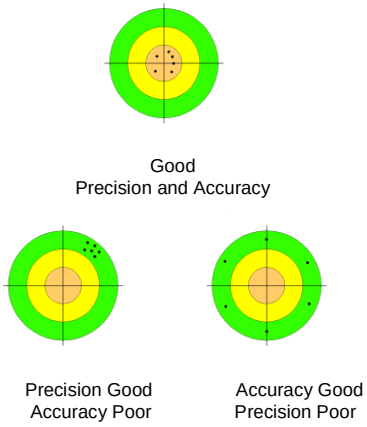
II. QUALITY ASSURANCE

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

Quality assurance is composed of two main activities: quality control (QC) and quality assessment. 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, quantitative tasks that provide certainty that the QC system is satisfactory and that the stated quantitative programmatic objectives for air quality data are met. Staff independent of data generators performs these external tasks, which include conducting regular performance audits, on-site system audits, inter-laboratory comparisons, and periodic evaluations of internal QC data.

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



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

Bias is the systematic or persistent distortion of a measurement process which causes error in one direction. It is determined by estimating the positive and negative deviation from the true value as a percentage of the true value. When a certain bias is detected, the measurement process is said to be "inaccurate." The term "bias" is

used to describe accuracy in CFR.[8] In this report, the two terms are used interchangeably.

Precision is based on one-point QC checks for gaseous instruments and paired measurements from collocated samplers for particulate matter (PM). For precision, the statistic is the upper bound of the coefficient of variation (CV), which reflects the highest estimate of the variability in the instrument's measurements. One-point QC checks for gaseous instruments are also used to estimate bias. For PM, bias can be estimated from flow rate verifications; however, only flow rate verifications from continuous PM_{10} analyzers are required to be uploaded to AQS. Available tools for assessing precision and bias are summarized in Appendix A of this report (while details on cases where the criteria for precision or bias are not met can be found in Appendix B). Detailed descriptions of the CV and the bias estimator, including the formulae behind the calculations, can be found in Appendix C of this report.

Accuracy of the instruments is further validated or assessed by the through-the-probe performance audits conducted via the CARB annual performance evaluation program for gaseous pollutants or via the semi-annual flow rate audits for PM. Appendix A lists CARB's audit performance criteria, which were developed to closely match the National Performance Audit Program.[9]

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

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

[8] https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=1&SID=cd262bfedc5072c4808c47832bf484bb&ty=HTML&h=L&n=40y6.0.1.1.6&r=PART%20-%2040:6.0.1.1.6.7.1.3.34#ap40.6.58.0000_0nbspnbspnbsp.a

[9] http://www3.epa.gov/ttn/amtic/npepqa.html

could also be flagged if monitoring agencies determine and U.S. EPA concurs that the collected data were influenced by an exceptional or natural event. Additionally, there are informational flags that do not impact the usage of the data.

The implementation of a comprehensive corrective action system throughout CARB's PQAO is an essential component for improving data quality and facilitating continuous process improvement.

The Corrective Action Notification (CAN) process documents issues that impact, or potentially impact, data quality, completeness, storage, or reporting. The goal of the CAN process is to investigate, correct, and reduce the recurrence of these issues. As such, the CAN process will identify issues not addressed by AQDAs, improve data quality, and help ensure compliance with state, federal, and local requirements.

CARB's Quality Assurance Program is outlined in a five-volume Quality Assurance Manual, which guides the operation of the quality assurance programs used by CARB, local air districts, and private industry in California. The five-volume Quality Assurance Manual is available at http://www.arb.ca.gov/aaqm/qa/qa-manual/qa-manual.htm.

There are more than 250 air monitoring sites among the four California PQAOs operating in 15 separate air basins in California. Within CARB's PQAO, there are 21 local air districts operating sites under CARB's guidance. Information about each air monitoring station audited by QMB is available at https://ww3.arb.ca.gov/qaweb/siteinfo.php.

III. DATA QUALITY - STATISTICAL SUMMARY RESULTS

The results are presented for two groups of pollutants: gases and particulate matter. For each group, the amount of ambient data collected (or captured) is discussed first, followed by an assessment of the quality behind the data. Statistical results presented in this report reflect the current information in AQS, with the exception of 2018 data, which is also updated to reflect corrections of data quality issues noted in Appendix B. These minor changes to 2018 data are not reflected in AQS since the data have already been certified and changing the data would require recertification. Data for 2016 and 2017 directly reflect the current information in AQS, and as such, they will reflect changes that occurred to past data since the 2017 Annual Data Quality Report was prepared. For example, "begin" and "end" dates for monitors may have been corrected, and parameter or method codes may have been updated to reflect the correct status of monitors in AQS. These changes may result in 2016 or 2017 data that differ from those published in the 2017 report.

A. Gaseous Criteria Pollutants

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

Ambient Data Capture: Data capture, as described in this report, is derived from the AQS completeness report AMP 430. The calculated number in AMP 430 represents the average of the monthly data capture rates for the calendar year and may not always be indicative of whether the 75 percent regulatory completeness requirement[10] is met for a particular pollutant, considering the operational period in the year. Note that while this report focuses on the federal requirement of a minimum data capture rate of 75 percent, CARB's goal is to have at least 85 percent of the data in AQS.

Table A1 and Figure A1 present the percentage of instruments that reported at least 75 percent of the possible ambient data for each gaseous pollutant for each PQAO. Table A2 displays similar information for CARB and each local air district operating within CARB's PQAO. Monitoring sites within each geographic area may be operated by the district, CARB, or both. As shown in the tables, a small number of instruments within CARB's PQAO reported a data capture rate of less than 75 percent. In fact, only three gaseous instruments did not report at least 75% of the required ambient data.

Table A1. Ambient Gaseous Pollutant Data Capture Results

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments Reporting ≥ 75% Ambient Data Capture	% of Instruments Reporting ≥ 75% Ambient Data
CO	CARB	2018	22	22	100
		2017	25	24	96
		2016	25	24	96
	BAAQMD	2018	17	17	100
		2017	15	15	100
		2016	15	15	100
	SCAQMD	2018	26	25	96
		2017	27	27	100
		2016	27	27	100
	SDCAPCD	2018	2	2	100
		2017	2	2	100
		2016	4	3	75
	NATIONAL	2018	255	245	96
		2017	261	246	94
		2016	261	251	96

[10] 40 CFR Part 50 states that the ambient data from a given instrument or sampler, in a calendar year, must be at least 75% complete to be included in making regulatory decisions, such as determinations of attainment of the ambient air quality standards. The State of California defines data "completeness" in a similar way, also using 75% as part of its criteria. However, unlike the federal definition, the State requirement factors in the high season of the pollutant in the completeness criteria (e.g., only months within the high ozone season are considered for ozone standard).

Table A1 (cont'd). Ambient Gaseous Pollutant Data Capture Results

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments Reporting ≥ 75% Ambient Data Capture	% of Instruments Reporting ≥ 75% Ambient Data
NO_2	CARB	2018	49	48	98
		2017	52	50	96
		2016	53	52	98
	BAAQMD	2018	19	19	100
		2017	18	17	94
		2016	18	18	100
	SCAQMD	2018	26	25	96
		2017	27	27	100
		2016	27	27	100
	SDCAPCD	2018	7	7	100
		2017	7	7	100
		2016	9	9	100
	NATIONAL	2018	416	395	95
		2017	396	375	95
		2016	398	382	96
O_3	CARB	2018	104	103	99
		2017	106	101	95
		2016	105	103	98
	BAAQMD	2018	21	21	100
		2017	20	20	100
		2016	20	20	100
	SCAQMD	2018	28	28	100
		2017	29	29	100
		2016	29	29	100
	SDCAPCD	2018	6	6	100
		2017	7	7	100
		2016	9	9	100
	NATIONAL	2018	1126	1105	98
		2017	1015	989	97
		2016	1027	992	97

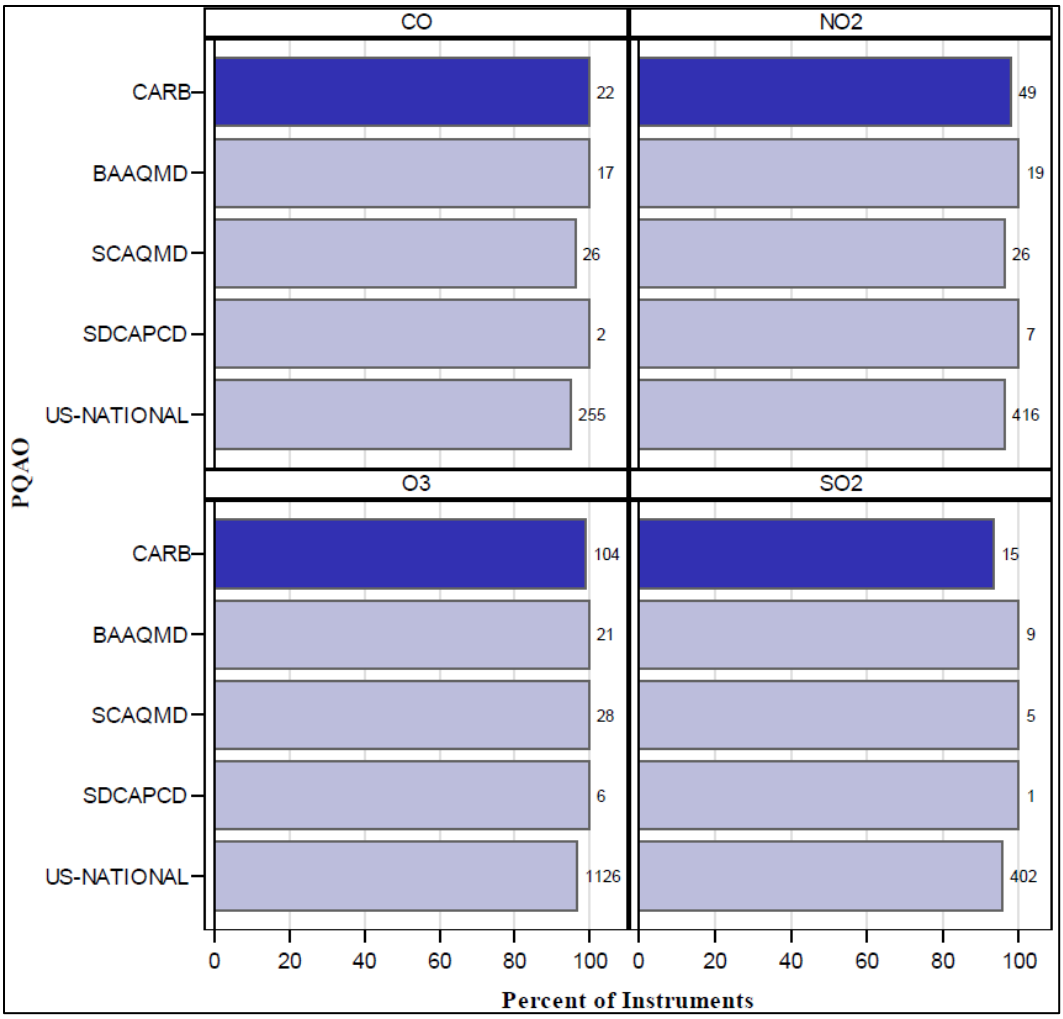
Table A1 (cont'd). Ambient Gaseous Pollutant Data Capture Results

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments Reporting ≥ 75% Ambient Data Capture	% of Instruments Reporting ≥ 75% Ambient Data
SO_2	CARB	2018	15	14	93
		2017	15	13	87
		2016	15	15	100
	BAAQMD	2018	9	9	100
		2017	9	9	100
		2016	9	9	100
	SCAQMD	2018	5	5	100
		2017	6	6	100
		2016	6	6	100
	SDCAPCD	2018	1	1	100
		2017	1	1	100
		2016	2	2	100
	NATIONAL	2018	402	390	97
		2017	344	338	98
		2016	328	321	98

- Further details on instruments not reporting ≥ 75% ambient data can be viewed in Appendix B.
- Source: Air Quality System, AMP 430 Data Completeness Report, run October 2019, except as noted in Appendix B.
- National average includes state, county, district, National Park Service, and tribal sites, including those in California.
- Results reflect current information in AQS from October 2019, including changes to past data since the 2017 Annual Data Quality Report. Therefore, results for 2017 and 2016 might differ from those in the 2017 DQ report.

Figure A1. Percent of Gaseous Instruments Meeting Seventy-Five Percent Ambient Data Capture Rate

(Total Instruments in Network Indicated Next to the Bars)



- National average includes state, county, district, National Park Service, and tribal sites, including those in California.
- Source: Air Quality System, AMP 430 Data Completeness Report, run October 2019, except as noted in Appendix B.

Table A2. 2018 Ambient Gaseous Pollutant Data Capture Results for Local Air Districts Within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Instruments	Number of Instruments Reporting ≥ 75% Ambient Data	% of Instruments Reporting ≥ 75% Ambient Data
CO	Antelope Valley AQMD	D	1	1	100
	Butte County AQMD	C	1	1	100
	Great Basin APCD	D	1	1	100
	Imperial County APCD	C	1	1	100
	Mojave Desert AQMD	D	2	2	100
	Monterey Bay ARD	D	1	1	100
	North Coast Unified AQMD	D	2	2	100
	Sacramento Metropolitan AQMD	D	3	3	100
	San Joaquin Valley Unified APCD	B	5	5	100
	Santa Barbara County APCD	B	5	5	100
NO_2	Antelope Valley AQMD	D	1	1	100
	Butte County AQMD	C	1	1	100
	Feather River AQMD	C	1	1	100
	Imperial County APCD	B	2	1	50
	Mojave Desert AQMD	D	3	3	100
	Monterey Bay ARD	D	1	1	100
	North Coast Unified AQMD	D	2	2	100
	Placer County APCD	C	1	1	100
	Sacramento Metropolitan AQMD	B	5	5	100
	San Joaquin Valley Unified APCD	B	17	17	100
	San Luis Obispo County APCD	D	2	2	100
	Santa Barbara County APCD	B	10	10	100
	Ventura County APCD	D	2	2	100
	Yolo-Solano AQMD	C	1	1	100

Table A2 (cont'd). 2018 Ambient Gaseous Pollutant Data Capture Results for Local Air Districts Within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Instruments	Number of Instruments Reporting ≥ 75% Ambient Data	% of Instruments Reporting ≥ 75% Ambient Data
O_3	Amador County APCD	C	1	1	100
	Antelope Valley AQMD	D	1	1	100
	Butte County AQMD	C	2	2	100
	Calaveras County APCD	C	1	1	100
	Colusa County APCD	C	1	1	100
	Eastern Kern APCD	C	1	1	100
	El Dorado County AQMD	C	3	3	100
	Feather River AQMD	C	2	2	100
	Glenn County APCD	C	1	0	0
	Great Basin APCD	D	1	1	100
	Imperial County APCD	B	4	4	100
	Lake County APCD	D	1	1	100
	Mariposa County APCD	C	1	1	100
	Mendocino County AQMD	D	1	1	100
	Mojave Desert AQMD	B	6	6	100
	Monterey Bay ARD	D	5	5	100
	North Coast Unified AQMD	D	2	2	100
	Northern Sierra AQMD	B	1	1	100
	Northern Sonoma County APCD	D	1	1	100
	Placer County APCD	B	5	5	100
	Sacramento Metropolitan AQMD	B	6	6	100
	San Joaquin Valley Unified APCD	B	23	23	100
	San Luis Obispo County APCD	B	7	7	100
	Santa Barbara County APCD	B	12	12	100
	Shasta County AQMD	D	3	3	100
	Siskiyou County APCD	D	1	1	100
	Tehama County APCD	B	2	2	100
	Tuolumne County APCD	C	1	1	100
	Ventura County APCD	D	5	5	100
	Yolo-Solano AQMD	B	3	3	100

Table A2 (cont'd). 2018 Ambient Gaseous Pollutant Data Capture Results for Local Air Districts Within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Instruments	Number of Instruments Reporting ≥ 75% Ambient Data	% of Instruments Reporting ≥ 75% Ambient Data
SO_2	Great Basin Unified APCD	D	1	0	0
	Imperial County APCD	C	1	1	100
	Mojave Desert AQMD	D	2	2	100
	North Coast Unified AQMD	D	2	2	100
	Sacramento Metropolitan AQMD	D	1	1	100
	San Joaquin Valley Unified APCD	C	1	1	100
	San Luis Obispo County APCD	B	1	1	100
	Santa Barbara County APCD	D	6	6	100

- Further details on instruments not reporting ≥ 75% ambient data can be viewed in Appendix B.
- Source: Air Quality System, AMP 430 Data Completeness Report, run October 2019, except as noted in Appendix B.

Precision and Bias: One-point QC checks (mostly automated) are performed by the monitoring organizations to confirm the instrument's ability to respond to a known concentration of gas. 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 Title 40, CFR Part 58 Appendix A, is the upper bound of the coefficient of variation (CV), 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, and 15 percent for NO_2.

These one-point QC checks are also used to estimate the bias inherent in the sampling system associated with each instrument. Appendix A to Part 58 outlines how bias is calculated based on one-point 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 the gas concentration. A sign (positive/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.[11] A detailed description of the bias estimator, including the formulae behind the calculations, can be found in Appendix C of this report.

[11]The MQO goal for NO_2 was established in guidance in 2006 as 10% and was updated in 2014 to 15%. The goal of 15% was established in regulation in 2010. Prior to 2010, there was no goal in regulation.

Bias estimates are further verified via the through-the-probe performance audits. CARB acceptance criteria for performance audits were: ±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. CARB's policy is to audit 100 percent of local air districts' sites within its PQAO each year and audit non-CARB PQAO monitoring sites at least once every five years. Non-CARB PQAOs perform some audits on their own as part of the annual performance evaluation program.

CFR requires that the one-point QC checks be performed at least once every two weeks on each automated instrument, which translates to a minimum of 26 checks per year for an instrument that operates year-round. During data certification, U.S. EPA flags instruments that do not have at least 75 percent of the required QC checks in AQS; thus, 75 percent is the criterion used in Table A3 and Figure A2. CV upper bound and bias are displayed in Figures A3 and A4. A complete listing of all MQOs set forth by U.S. EPA under Title 40 CFR and the Quality Assurance (QA) Handbook Volume II can be found in Appendix A of this report.

For gaseous pollutants required by 40 CFR (CO, NO_2, O_3, and SO_2), CARB's PQAO (as well as other California PQAOs) met the precision and bias criteria in 2018, as shown in Table A3. Information for years 2016 and 2017 are provided for a historical perspective. Three-year averages for each PQAO are also included. In general, 2018 precision data are consistent with those in the previous two years. In addition, the required number of QC checks was achieved at most stations. Table A3 and Figure A2 include the number of instruments with at least 75 percent of the required QC data reported for 2018.

Table A3. 2016-2018 Gaseous Pollutant Instrument Precision and Bias Results

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments with ≥ 75% of Required Q/C checks	Upper Bound of Coeff of Variation	CFR Criteria for Precision Met?	Bias	CFR Criteria for Bias Met?
CO	CARB	2018	22	22	4.08	Yes	± 2.76	Yes
		2017	25	25	4.88	Yes	± 2.56	Yes
		2016	25	24	3.64	Yes	± 2.71	Yes
		Avg			4.22	Yes	± 2.63	Yes
	BAAQMD	2018	17	17	1.90	Yes	± 1.48	Yes
		2017	15	15	1.72	Yes	± 1.41	Yes
		2016	15	15	1.55	Yes	+ 1.35	Yes
		Avg			1.72	Yes	± 1.40	Yes
	SCAQMD	2018	27	26	4.67	Yes	± 3.16	Yes
		2017	27	27	3.26	Yes	± 2.68	Yes
		2016	27	27	3.22	Yes	± 2.62	Yes
		Avg			4.50	Yes	± 3.08	Yes
	SDCAPCD	2018	2	2	3.90	Yes	± 3.56	Yes
		2017	2	2	4.40	Yes	± 3.87	Yes
		2016	4	4	3.23	Yes	- 4.30	Yes
		Avg			3.82	Yes	- 3.83	Yes
	NATIONAL	2018	255	242	3.82	Yes	± 3.66	Yes
		2017	265	249	3.72	Yes	± 3.61	Yes
		2016	277	270	4.00	Yes	± 4.00	Yes
NO_2	CARB	2018	49	48	4.00	Yes	± 4.07	Yes
		2017	52	50	5.61	Yes	± 4.03	Yes
		2016	53	51	5.04	Yes	± 3.82	Yes
		Avg			5.28	Yes	± 3.95	Yes
	BAAQMD	2018	19	19	1.94	Yes	± 1.46	Yes
		2017	18	17	2.00	Yes	± 1.45	Yes
		2016	18	18	1.64	Yes	± 1.24	Yes
		Avg			1.86	Yes	± 1.37	Yes
	SCAQMD	2018	26	26	6.06	Yes	± 4.48	Yes
		2017	27	27	5.67	Yes	± 4.69	Yes
		2016	27	27	5.25	Yes	± 4.40	Yes
		Avg			5.96	Yes	± 4.47	Yes

Table A3 (cont'd). 2016-2018 Gaseous Pollutant Instrument Precision and Bias Results

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments with ≥ 75% of Required Q/C checks	Upper Bound of Coeff of Variation	CFR Criteria for Precision Met?	Bias	CFR Criteria for Bias Met?
NO_2	SDCAPCD	2018	7	7	3.98	Yes	- 4.51	Yes
		2017	7	7	4.87	Yes	± 4.20	Yes
		2016	9	9	3.45	Yes	- 4.16	Yes
		Avg			4.06	Yes	± 4.18	Yes
	NATIONAL	2018	417	401	4.63	Yes	± 4.55	Yes
		2017	412	391	4.49	Yes	± 4.41	Yes
		2016	417	392	4.25	Yes	± 4.32	Yes
O_3	CARB	2018	104	104	2.62	Yes	± 1.99	Yes
		2017	107	103	2.93	Yes	± 2.11	Yes
		2016	105	105	2.77	Yes	± 2.08	Yes
		Avg			2.77	Yes	± 1.95	Yes
	BAAQMD	2018	21	21	1.50	Yes	± 1.18	Yes
		2017	20	20	1.63	Yes	± 1.29	Yes
		2016	20	20	1.47	Yes	± 1.16	Yes
		Avg			1.19	Yes	± 1.19	Yes
	SCAQMD	2018	29	29	2.54	Yes	± 2.11	Yes
		2017	29	29	2.33	Yes	± 1.84	Yes
		2016	29	29	2.54	Yes	± 2.03	Yes
		Avg			2.45	Yes	± 1.96	Yes
	SDCAPCD	2018	6	6	2.20	Yes	± 1.89	Yes
		2017	7	7	1.94	Yes	± 1.49	Yes
		2016	9	9	2.36	Yes	± 1.74	Yes
		Avg			2.18	Yes	± 1.65	Yes
	NATIONAL	2018	1126	1104	2.34	Yes	± 2.15	Yes
		2017	1136	1078	2.07	Yes	± 1.98	Yes
		2016	1137	1094	2.11	Yes	±2.13	Yes

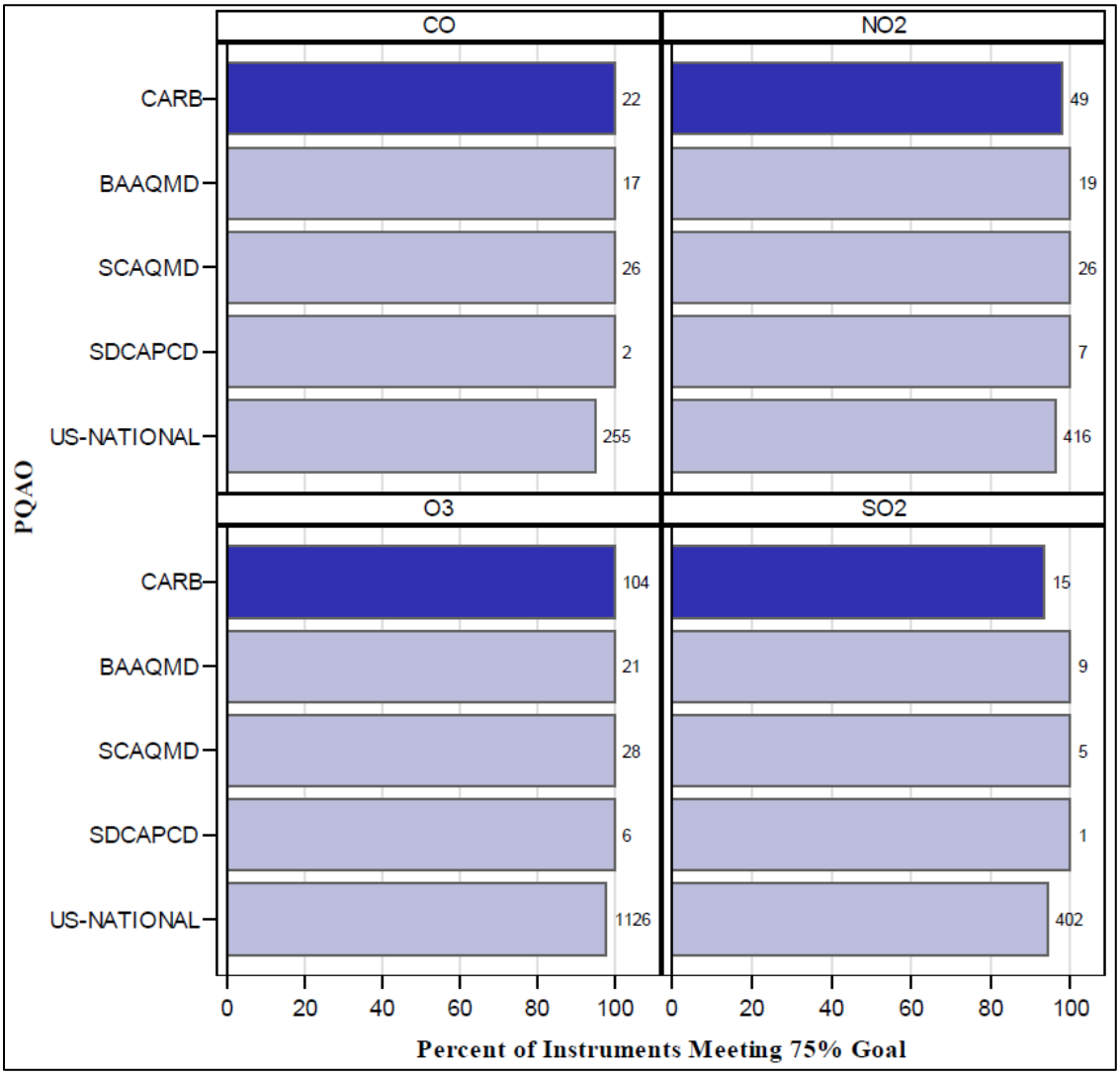
Table A3 (cont'd). 2016-2018 Gaseous Pollutant Instrument Precision and Bias Results

Pollutant	PQAO	Year	Number of Instruments	Number of Instruments with ≥ 75% of Required Q/C checks	Upper Bound of Coeff of Variation	CFR Criteria for Precision Met?	Bias	CFR Criteria for Bias Met?
SO_2	CARB	2018	15	14	3.48	Yes	± 2.68	Yes
		2017	15	15	5.50	Yes	± 3.41	Yes
		2016	15	14	4.31	Yes	± 2.97	Yes
		Avg			4.45	Yes	± 2.95	Yes
	BAAQMD	2018	9	9	1.95	Yes	± 1.57	Yes
		2017	9	9	1.93	Yes	± 1.47	Yes
		2016	9	9	1.99	Yes	± 1.57	Yes
		Avg			1.93	Yes	± 1.51	Yes
	SCAQMD	2018	5	5	5.89	Yes	± 3.59	Yes
		2017	6	6	3.81	Yes	± 3.13	Yes
		2016	6	6	3.82	Yes	± 3.21	Yes
		Avg			5.62	Yes	± 3.49	Yes
	SDCAPCD	2018	1	1	3.74	Yes	- 9.17	Yes
		2017	1	1	2.69	Yes	- 5.99	Yes
		2016	2	2	2.45	Yes	- 4.67	Yes
		Avg			3.40	Yes	- 6.43	Yes
	NATIONAL	2018	402	379	3.21	Yes	± 3.33	Yes
		2017	407	393	3.16	Yes	± 3.27	Yes
		2016	383	368	3.14	Yes	± 3.36	Yes

- CFR limits for precision (CV): 7% for O_3, 15% for NO_2, 10% for CO and SO_2; for bias: ± 7% for O_3, ± 15% for NO_2, ± 10% for CO and SO_2. Both are based on QC checks required to be performed every two weeks, and U.S. EPA AMP 600 report flags instruments that do not have at least 75% of the required QC checks.
- Further details on instruments not meeting these criteria can be viewed in Appendix B.
- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run October, 2019.
- National average includes state, county, district, National Park Service, and tribal sites, including those in California; Note: discrepancies may exist in Number of instruments listed in Table A3 compared to Table A1 due to different report sources, AMP256 and AMP430.
- Results reflect current information in AQS, including changes to past data since the 2017 Annual Data Quality Report. Therefore, results for 2017 and 2016 might differ from those in the 2017 DQ report.

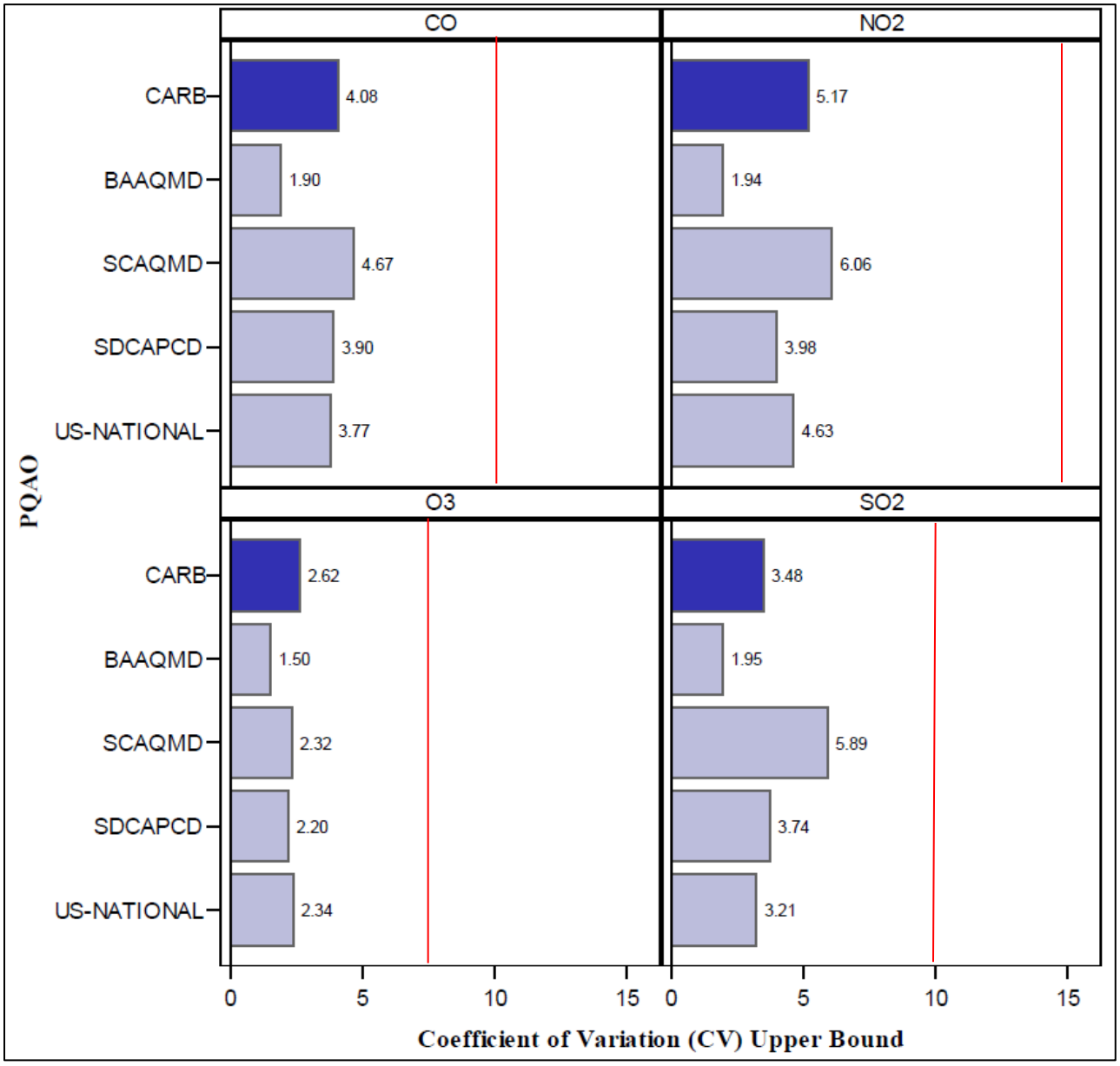
Figure A2. 2018 1-Pt Quality Control Check Completeness – Gaseous Instruments

(Total Instruments in Network Indicated Next to the Bars)



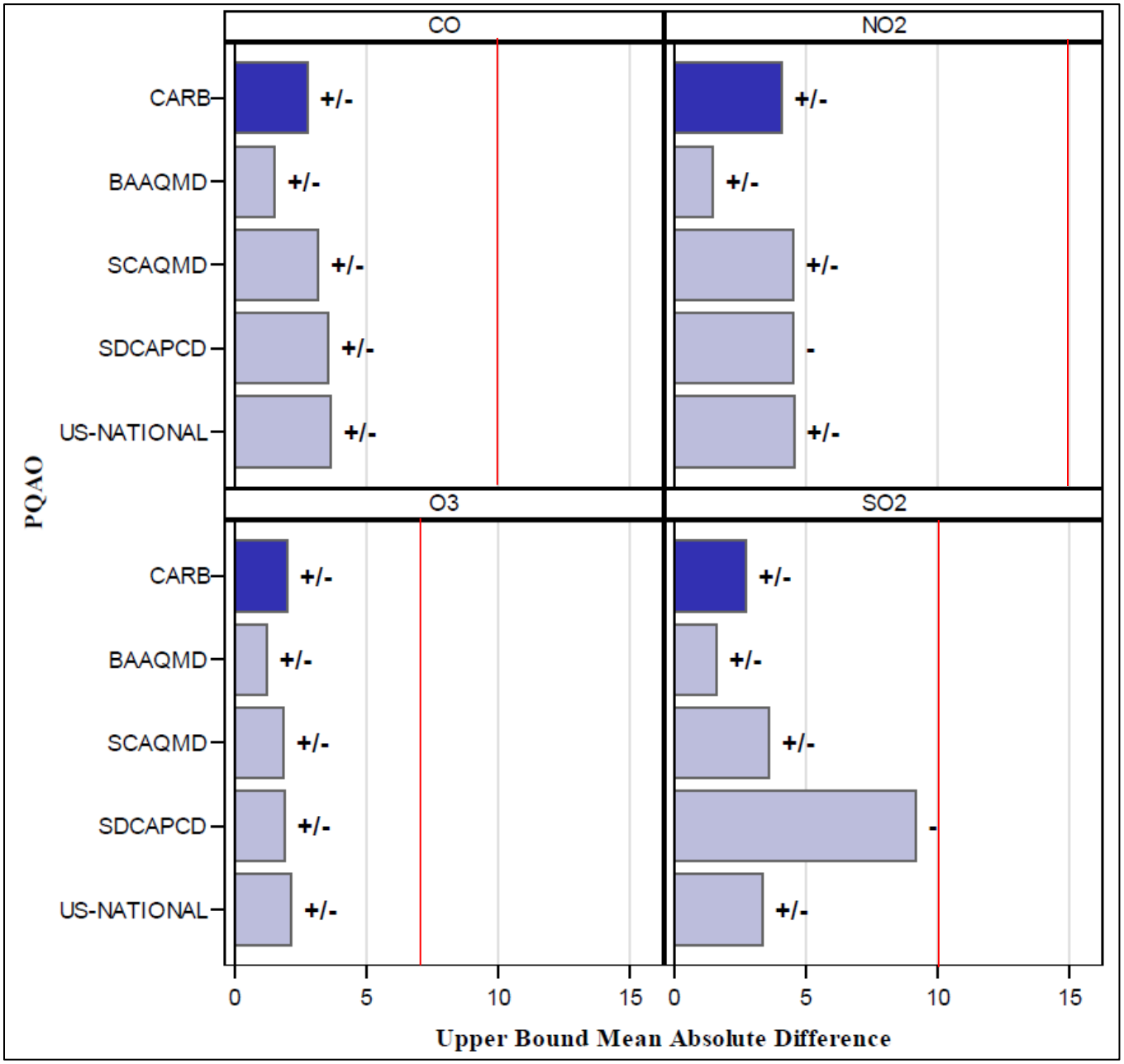
- National average includes state, county, district, National Park Service, and tribal sites, including those in California;
- Source: Air Quality System, AMP 430 Data Completeness Report, run July 2019, except as noted in Appendix B.

Figure A3. 2018 Precision via 1-Pt Quality Control Checks – Gaseous Instruments



- US-National average includes state, county, district, and tribal sites, including those in California; AMP 256 Data Quality Indicator Report, run October 2019, except as noted in Appendix B.
- The 2018 CFR limit for precision was ± 10% for CO and SO_2, ± 7% for O_3, and ± 15% for NO_2 (indicated by red vertical line).
- Further details on instruments not meeting these criteria can be viewed in Appendix B.

Figure A4. 2018 Bias via 1-Pt Quality Control Checks – Gaseous Instruments



- US-National average includes state, county, district, and tribal sites, including those in California; AMP 256 Data Quality Indicator Report, run July 2019.
- The 2018 CFR limit for bias was ± 10% for CO and SO_2, ± 7% for O_3, and ± 15% for NO_2 (indicated by red vertical line).
- Further details on instruments not meeting these criteria can be viewed in Appendix B.

Table A4 displays precision data for each local air district within CARB's PQAO in which sites are operated, with CV averaged across sites within each district. Monitoring sites within these areas may be operated by the district, CARB, or both. As shown in the table, all districts met the CV requirement and had very few instruments with less than 75 percent of required QC data reported.

In order to provide decision makers with data of known quality, U.S. EPA provides a tool for assessing data quality in terms of three data quality indicators in graphical format.[12] At this link, U.S. EPA's graphs provide detailed information on precision (CV), bias, and the number of one-point QC checks performed at each monitoring station in a given year.

Table A4. 2018 Gaseous Pollutant Instrument Precision Results for Local Air Districts Within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Instruments	Number of Instruments with ≥ 75% of Required QC checks	Upper Bound of Coefficient of Variation
CO	Antelope Valley AQMD	D	1	1	2.50
	Butte County AQMD	C	1	1	3.14
	Great Basin Unified APCD	D	1	1	2.22
	Imperial County APCD	C	1	1	3.58
	Mojave Desert AQMD	D	2	2	3.98
	Monterey Bay ARD	D	1	1	2.13
	North Coast Unified AQMD	D	2	2	2.24
	Sacramento Metropolitan AQMD	D	3	3	2.49
	San Joaquin Valley Unified APCD	B	5	5	3.88
	Santa Barbara County APCD	B	5	5	3.71
NO_2	Antelope Valley AQMD	D	1	1	4.08
	Butte County AQMD	C	1	1	5.20
	Feather River AQMD	C	1	1	3.02
	Imperial County APCD	B	2	1	8.41
	Mojave Desert AQMD	D	3	3	4.12
	Monterey Bay ARD	D	1	1	2.19
	North Coast Unified AQMD	D	2	2	3.91
	Placer County APCD	C	1	1	4.54

[12] https://www.epa.gov/outdoor-air-quality-data/single-point-precision-and-bias-report

Table A4 (cont'd). 2018 Gaseous Pollutant Instrument Precision Results for Local Air Districts Within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Instruments	Number of Instruments with ≥ 75% of Required QC checks	Upper Bound of Coefficient of Variation
NO_2	Sacramento Metropolitan AQMD	B	5	5	3.71
	San Joaquin Valley Unified APCD	B	17	17	4.64
	San Luis Obispo County APCD	D	2	2	2.58
	Santa Barbara County APCD	B	10	10	3.72
	Ventura County APCD	D	2	2	2.59
	Yolo-Solano AQMD	C	1	1	5.58
O_3	Amador County APCD	C	1	1	3.77
	Antelope Valley AQMD	D	1	1	3.41
	Butte County AQMD	C	2	2	3.43
	Calaveras County APCD	C	1	1	2.77
	Colusa County APCD	C	1	1	2.54
	Eastern Kern APCD	C	1	1	3.07
	El Dorado County AQMD	C	3	3	2.64
	Feather River AQMD	C	2	2	2.46
	Glenn County APCD	C	1	1	2.57
	Great Basin Unified APCD	D	1	1	1.36
	Imperial County APCD	B	4	4	3.21
	Lake County APCD	D	1	1	0.33
	Mariposa County APCD	C	1	1	2.24
	Mendocino County AQMD	D	1	1	2.62
	Mojave Desert AQMD	B	6	6	2.25
	Monterey Bay ARD	D	5	5	1.69
	North Coast Unified AQMD	D	2	2	2.62
	Northern Sierra AQMD	B	1	1	1.85
	Northern Sonoma County APCD	D	1	1	3.96
	Placer County APCD	B	5	5	1.53
	Sacramento Metropolitan AQMD	B	6	6	2.03
	San Joaquin Valley Unified APCD	B	23	23	2.07
	San Luis Obispo County APCD	B	7	7	1.64

Table A4 (cont'd). 2018 Gaseous Pollutant Instrument Precision Results for Local Air Districts Within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Instruments	Number of Instruments with ≥ 75% of Required QC checks	Upper Bound of Coefficient of Variation
O_3	Santa Barbara County APCD	B	12	12	2.73
	Shasta County APCD	D	3	3	3.71
	Siskiyou County APCD	D	1	1	2.69
	Tehama County APCD	B	2	2	3.79
	Tuolumne County APCD	C	1	1	1.61
	Ventura County APCD	D	5	5	1.68
	Yolo-Solano AQMD	B	3	3	1.67
SO_2	Great Basin APCD	D	1	0	4.03
	Imperial County APCD	C	1	1	1.05
	Mojave Desert AQMD	D	2	2	3.61
	North Coast Unified AQMD	D	2	2	2.99
	Sacramento Metropolitan AQMD	D	1	1	4.76
	San Joaquin Valley Unified APCD	C	1	1	2.77
	San Luis Obispo County APCD	D	1	1	1.05
	Santa Barbara County APCD	D	6	6	2.05

- AQMD – Air Quality Management District
- APCD – Air Pollution Control District
- CFR Limit for precision CV: 7% for O_3, 15% for NO_2, 10% for CO and SO_2, based on QC checks required to be performed every two weeks, and U.S. EPA AMP 600 report flags instruments that do not have at least 75% of the required QC checks.
- Further details on instruments not meeting these criteria can be viewed in Appendix B.
- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run October 2019.

An Assessment of Individual 1-Point QC Checks for Gases: In March 2017, U.S. EPA revised QA Handbook Volume II, Appendix D, Measurement Quality Objectives and Validation Templates with updated criteria for assessing individual 1-point QC checks against the following criteria: < ±7.1% (percent difference) or < ±1.5 ppb difference, whichever is greater, for O_3; < ±10.1% (percent difference) for CO; < ±15.1% (percent difference) or < ±1.5 ppb difference, whichever is greater, for NO_2; and < ±10.1% (percent difference) or < ±1.5 ppb difference, whichever is greater, for SO_2. CARB and some district-operated sites perform more frequent QC checks than required by U.S. EPA. Note that some of the exceedances are associated with ambient data being affected by issues identified through the AQDA process, separate from the individual QC checks not meeting the criteria. Table A4-1 presents results on individual QC checks at the PQAO level. Table A4-2 breaks down CARB statistics by district.

Table A4-1. 2018 Gaseous Pollutant 1-Point QC Checks, by PQAO – Individual Assessment

Pollutant	PQAO	Number of Instruments	Number of QC Checks Performed	Number of QC Checks Meeting Criteria	% of QC Checks Meeting Criteria
CO	CARB	22	3,064	3,040	99.2
	BAAQMD	17	2,352	2,347	99.8
	SCAQMD	24	9,279	9,099	98.1
	SDCAPCD	2	103	103	100.0
NO_2	CARB	49	9,809	9,797	99.9
	BAAQMD	19	2,619	2,619	100.0
	SCAQMD	26	9,367	9,303	99.3
	SDCAPCD	7	358	358	100.0
O_3	CARB	104	19,744	19,654	99.5
	BAAQMD	21	2,794	2,794	100.0
	SCAQMD	28	10,175	10,160	99.9
	SDCAPCD	6	235	235	100.0
SO_2	CARB	15	1,510	1,507	99.8
	BAAQMD	9	1,336	1,335	99.9
	SCAQMD	5	1,824	1,806	99.0
	SDCAPCD	1	51	51	100.0

- Criteria for individual QC checks are: < ±7.1% (percent difference) or < ±1.5 ppb difference, whichever is greater, for O_3; < ±10.1% (percent difference) for CO; < ±15.1% (percent difference) or < ±1.5 ppb difference, whichever is greater, for NO_2; and < ±10.1% (percent difference) or < ±1.5 ppb difference, whichever is greater, SO_2.

Table A4-2. 2018 Gaseous Pollutant 1-Point QC Checks – Individual Assessment for Local Air Districts within CARB's PQAO

Pollutant	Geographic Area	Number of Instruments	Monitoring by (District=D, CARB=C, or Both=B)	Number of QC Checks Performed	Number of QC Checks Meeting Criteria	% of QC Checks Meeting Criteria
CO	Antelope Valley AQMD	1	D	48	48	100.0
	Butte County AQMD	1	C	234	234	100.0
	Great Basin Unified APCD	1	D	49	49	100.0
	Imperial County APCD	1	C	220	216	98.2
	Mojave Desert AQMD	2	D	96	92	95.8
	Monterey Bay Unified APCD	1	D	50	49	98.0
	North Coast Unified AQMD	2	D	211	211	100.0
	Sacramento Metropolitan AQMD	3	D	496	486	98.0
	San Joaquin Valley Unified APCD	5	B	839	837	99.8
	Santa Barbara County APCD	5	B	821	818	99.6
NO_2	Antelope Valley AQMD	1	D	48	48	100.0
	Butte County AQMD	1	C	249	249	100.0
	Feather River AQMD	1	C	256	256	100.0
	Imperial County APCD	2	B	261	258	98.9
	Mojave Desert AQMD	3	D	144	144	100.0
	Monterey Bay Unified APCD	1	D	51	51	100.0
	North Coast Unified AQMD	2	D	204	204	100.0
	Placer County APCD	1	C	251	251	100.0
	Sacramento Metropolitan AQMD	5	B	947	947	100.0
	San Joaquin Valley Unified APCD	17	B	5,067	5,063	99.9
	San Luis Obispo County APCD	2	D	677	677	100.0
	Santa Barbara County APCD	10	B	1,070	1,065	99.5
	Ventura County APCD	2	D	350	350	100.0
	Yolo-Solano AQMD	1	C	234	234	100.0

Table A4-2 (cont'd). 2018 Gaseous Pollutant 1-Point QC Checks – Individual Assessment for Local Air Districts within CARB's PQAO

Pollutant	Geographic Area	Number of Instruments	Monitoring by (District=D, CARB=C, or Both=B)	Number of QC Checks Performed	Number of QC Checks Meeting Criteria	% of QC Checks Meeting Criteria
O_3	Amador County APCD	1	C	359	356	99.2
	Antelope Valley AQMD	1	D	48	48	100.0
	Butte County AQMD	2	C	538	538	100.0
	Calaveras County APCD	1	C	312	312	100.0
	Colusa County APCD	1	C	337	337	100.0
	Eastern Kern APCD	1	C	313	313	100.0
	El Dorado County AQMD	3	C	741	740	99.9
	Feather River AQMD	2	C	432	432	100.0
	Glenn County APCD	1	C	288	288	100.0
	Great Basin Unified APCD	1	D	50	50	100.0
	Imperial County APCD	4	B	313	310	99.0
	Lake County APCD	1	D	50	50	100.0
	Mariposa County APCD	1	C	194	194	100.0
	Mendocino County AQMD	1	D	34	34	100.0
	Mojave Desert AQMD	6	B	598	597	99.8
	Monterey Bay Unified APCD	5	D	259	259	100.0
	North Coast Unified AQMD	2	D	207	205	99.0
	Northern Sierra AQMD	1	D	32	32	100.0
	Northern Sonoma County APCD	1	D	41	41	100.0
	Placer County APCD	5	B	345	345	100.0
	Sacramento Metropolitan AQMD	6	B	1,168	1,164	99.7
	San Joaquin Valley Unified APCD	23	B	7,013	7,000	99.8
	San Luis Obispo County APCD	7	D	2,502	2,486	99.4
	Santa Barbara County APCD	12	D	1,600	1,588	99.3
	Shasta County AQMD	3	D	136	112	82.4
	Siskiyou County APCD	1	D	26	26	100.0
	Tehama County APCD	2	B	223	212	95.1
	Tuolumne County APCD	1	C	348	348	100.0
	Ventura County APCD	5	D	889	889	100.0
	Yolo-Solano AQMD	3	B	348	348	100.0

Table A4-2 (cont'd). 2018 Gaseous Pollutant 1-Point QC Checks – Individual Assessment for Local Air Districts within CARB's PQAO

Pollutant	Geographic Area	Number of Instruments	Monitoring by (District=D, CARB=C, or Both=B)	Number of QC Checks Performed	Number of QC Checks Meeting Criteria	% of QC Checks Meeting Criteria
SO_2	Great Basin Unified APCD	1	D	40	39	97.5
	Imperial County APCD	1	C	207	206	99.5
	Mojave Desert AQMD	2	D	94	94	100.0
	North Coast Unified AQMD	2	D	213	213	100.0
	Sacramento Metropolitan AQMD	1	D	113	112	99.1
	San Joaquin Valley Unified APCD	1	C	65	65	100.0
	San Luis Obispo County APCD	1	D	363	363	100.0
	Santa Barbara County APCD	6	D	415	415	100.0

Criteria for individual QC checks are: < ±7.1% (percent difference) or < ±1.5 ppb difference, whichever is greater, for O_3; < ±10.1% (percent difference) for CO; < ±15.1% (percent difference) or < ±1.5 ppb difference, whichever is greater, for NO_2; and < ±10.1% (percent difference) or < ±1.5 ppb difference, whichever is greater, SO_2.

As part of the new requirements set in 2016, individual QC checks are to be conducted within the prescribed ranges: 0.005 to 0.08 ppm for O_3, NO_2, and SO_2; 0.5 to 5 ppm for CO. Starting in January 2019, AQS will flag QC checks that fall out of the prescribed range. For informational purposes, QC checks conducted within the prescribed range for each PQAO are presented in Table A4-3.

Table A4-3. 2018 Gaseous Pollutant 1-Point QC Checks – Individual Assessment on Prescribed Range, by PQAO

Pollutant	PQAO	Number of Instruments	Number of QC Checks Performed	Number of QC Checks Within Prescribed Range	% of QC Checks Within Prescribed Range
CO	CARB	22	3,064	2,259	73.7
	BAAQMD	17	2,352	0	0.0
	SCAQMD	24	9,279	8,019	86.4
	SDCAPCD	2	103	52	50.5
NO_2	CARB	49	9,809	9,346	95.3
	BAAQMD	19	2,619	0	0.0
	SCAQMD	26	9,367	9,254	98.8
	SDCAPCD	7	358	358	100.0
O_3	CARB	104	19,744	19,223	97.4
	BAAQMD	21	2,794	0	0.0
	SCAQMD	28	10,175	10,078	99.0
	SDCAPCD	6	235	235	100.0
SO_2	CARB	15	1,510	1,427	94.5
	BAAQMD	9	1,336	157	11.8
	SCAQMD	5	1,824	1,801	98.7
	SDCAPCD	1	51	51	100.0

- Prescribed ranges: 0.005 to 0.08 ppm for O_3, NO_2, and SO_2; 0.5 to 5 ppm for CO.

Accuracy Validation via Performance Audits: To further validate bias estimates from one-point QC checks, CFR requires that independent performance audits be conducted and the average percent differences be evaluated against pre-determined criteria. In addition, auditing results should be assessed as to whether they are in agreement with the one-point QC checks.

Table A5 and Figures A5 summarize the 2018 performance audit results for the gaseous criteria pollutants. Accuracy is represented as an average percent difference. The average percent difference is the arithmetic mean of the combined differences from the known value of all the individual audit points. Audit results show that, in general, all gaseous instruments met CARB criteria for bias at the PQAO level. Table A6 shows similar data for local air districts within CARB's PQAO.

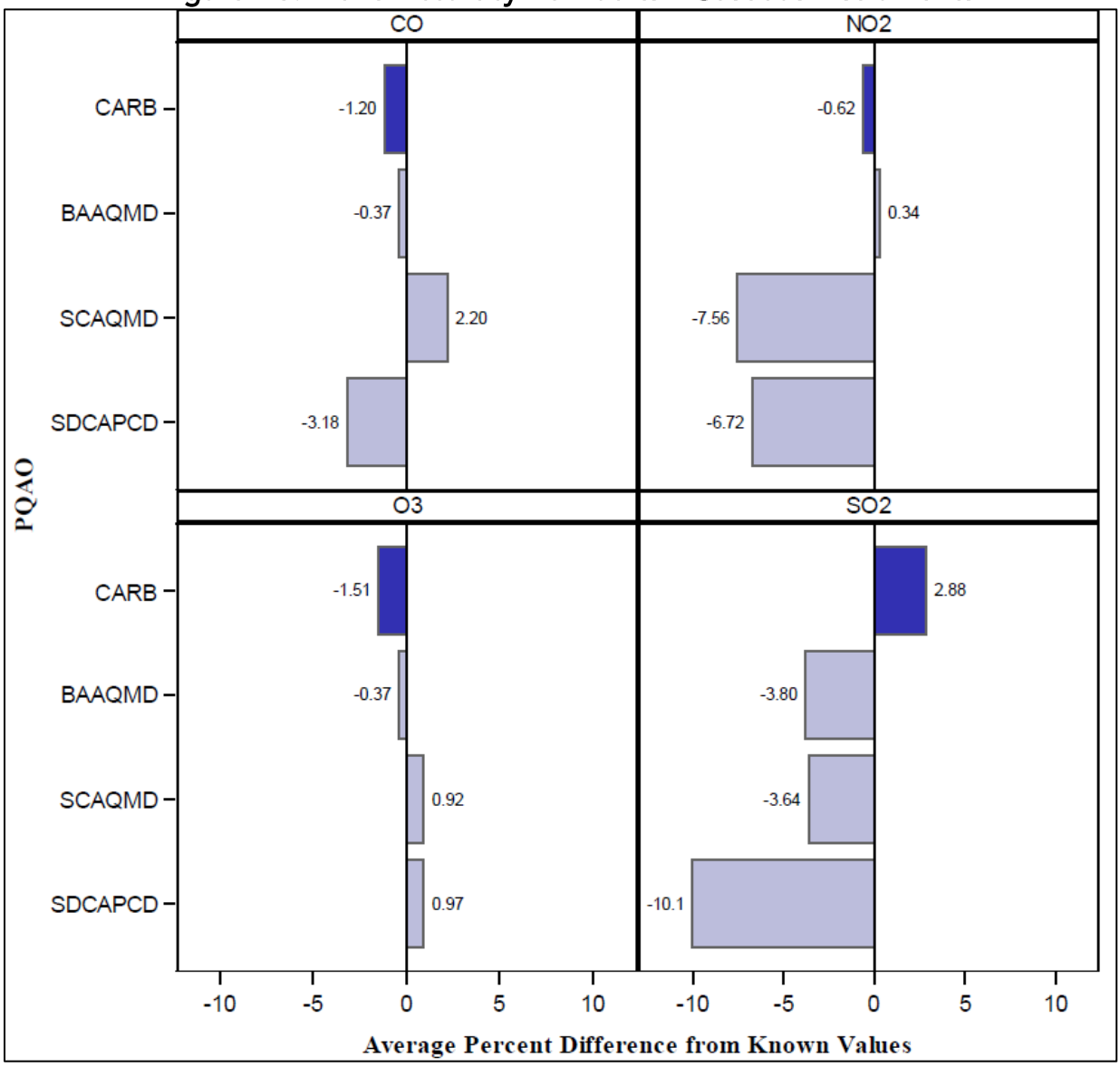
Performance audit results in 2018 corroborate what the QC checks revealed: that CARB's PQAO is providing accurate data for all gaseous pollutants. The average percent differences at the PQAO level were well below the audit criteria (±10 percent for ozone, ±15 percent for other gases) for all gaseous pollutants. This fact is further strengthened by the small number of audits that did not meet CARB performance audit criteria.

Table A5. 2018 Results for Performance Audits of Gaseous Pollutant Instruments

Pollutant	PQAO	Number of Instruments	Number of Instruments Audited	Number of Audits Not Meeting CARB Criteria	Avg % Diff.
CO	CARB	22	22	0	-9.25
	BAAQMD	17	16	0	-0.37
	SCAQMD	26	26	1	2.20
	SDCAPCD	2	2	0	-3.18
NO_2	CARB	49	48	3	-0.62
	BAAQMD	19	18	0	0.34
	SCAQMD	26	26	1	-7.56
	SDCAPCD	7	7	1	-20.47
O_3	CARB	104	103	5	-1.51
	BAAQMD	21	21	0	-0.37
	SCAQMD	28	27	1	0.92
	SDCAPCD	6	6	0	0.97
SO_2	CARB	15	15	0	5.51
	BAAQMD	9	9	0	-3.80
	SCAQMD	5	5	0	-3.64
	SDCAPCD	1	1	1	-10.10

- The CARB performance audit criteria for 2018 were: ±10% for O_3 and ±15% for CO, NO_2, and SO_2 for each audit point. Starting in 2017, lower audit levels were implemented in performance audits but only used for informational purposes (no AQDA). Thus, audit points in 2 lowest levels for trace CO and SO_2, 2 lowest levels for O_3, and 1 lowest level for regular CO and NO_2 were excluded in summarizing the results here in order to provide a more representative performance comparison to the audit levels utilized in past years.
- Further details on instruments not meeting these criteria can be viewed in Appendix B. Only audits conducted by CARB were subjected to the AQDA process.
- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run October 2019.

Figure A5. 2018 Accuracy via Audits – Gaseous Instruments



- AMP 256 Data Quality Indicator Report, run October 2019.
- The CARB performance audit criteria for 2018 were: ±10% for O_3 and ±15% for CO, NO_2, and SO_2 for each audit point. Starting in 2017, lower audit levels were implemented in performance audits but only used for informational purposes (no AQDA). Thus, audit points in 2 lowest levels for trace CO and SO_2, 2 lowest levels for O_3, and 1 lowest level for regular CO and NO_2 were excluded in summarizing the results here in order to provide a more representative performance comparison to the audit levels utilized in past years.
- Only audits conducted by CARB were subjected to the AQDA process.
- Further details on instruments not meeting these criteria can be viewed in Appendix B.

Table A6. 2018 Results for Performance Audits of Gaseous Pollutant Instruments for Local Air Districts within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Instruments	Number of Instruments Audited	Avg % Diff.
CO	Antelope Valley AQMD	D	1	1	-3.96
	Butte County AQMD	C	1	1	-5.02
	Great Basin APCD	D	1	1	-0.51
	Imperial County APCD	B	1	1	-3.72
	Mojave Desert AQMD	D	2	2	-1.98
	Monterey Bay ARD	D	1	1	3.35
	North Coast Unified AQMD	D	2	2	-2.38
	Sacramento Metropolitan AQMD	D	3	3	-0.33
	San Joaquin Valley Unified APCD	B	5	5	1.76
	Santa Barbara County APCD	B	5	5	-1.61
NO_2	Antelope Valley AQMD	D	1	1	-9.00
	Butte County AQMD	C	1	1	-0.92
	Feather River AQMD	C	1	1	-8.50
	Imperial County APCD	B	2	2	-12.97
	Mojave Desert AQMD	D	3	3	-2.17
	Monterey Bay ARD	D	1	1	6.05
	North Coast Unified AQMD	D	2	2	2.40
	Placer County APCD	C	1	1	-8.72
	Sacramento Metropolitan AQMD	B	5	5	-6.14
	San Joaquin Valley Unified APCD	B	17	16	-1.08
	San Luis Obispo County APCD	D	2	2	0.52
	Santa Barbara County APCD	B	10	10	-1.45
	Ventura County APCD	D	2	2	-2.11
	Yolo-Solano AQMD	C	1	1	-10.74
O_3	Amador County APCD	C	1	1	-5.25
	Antelope Valley AQMD	D	1	1	2.37
	Butte County AQMD	C	2	2	-4.49
	Calaveras County APCD	C	1	1	-6.31
	Colusa County APCD	C	1	1	-11.58
	Eastern Kern APCD	C	1	1	-0.06
	El Dorado County AQMD	C	3	2	-2.74
	Feather River AQMD	C	2	2	-0.97
	Glenn County APCD	C	1	1	-13.29
	Great Basin APCD	D	1	1	3.08
	Imperial County APCD	B	4	4	-3.09
	Lake County APCD	D	1	1	-10.42

Table A6 (cont'd). 2018 Results for Performance Audits of Gaseous Pollutant Instruments for Local Air Districts within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Instruments	Number of Instruments Audited	Avg % Diff.
O_3	Mariposa County APCD	C	1	1	-1.11
	Mendocino County AQMD	D	1	1	-4.69
	Mojave Desert AQMD	B	6	6	3.06
	Monterey Bay ARD	D	5	5	-2.20
	North Coast Unified AQMD	D	2	2	1.28
	Northern Sierra AQMD	B	1	1	3.20
	Northern Sonoma County APCD	D	1	1	-1.62
	Placer County APCD	B	5	4	-1.93
	Sacramento Metropolitan AQMD	B	6	6	-1.64
	San Joaquin Valley Unified APCD	B	23	23	-1.68
	San Luis Obispo County APCD	B	7	7	-1.41
	Santa Barbara County APCD	B	12	12	-0.05
	Shasta County AQMD	D	3	3	-5.45
	Siskiyou County APCD	D	1	1	-2.95
	Tehama County APCD	B	2	2	0.41
	Tuolumne County APCD	C	1	1	-0.08
	Ventura County APCD	D	5	5	-0.49
	Yolo-Solano AQMD	B	3	3	-2.92
SO_2	Great Basin APCD	D	1	1	-2.39
	Imperial County APCD	C	1	1	-5.48
	Mojave Desert AQMD	D	2	2	2.71
	North Coast Unified AQMD	D	2	2	0.83
	Sacramento Metropolitan AQMD	D	1	1	1.99
	San Joaquin Valley Unified APCD	C	1	1	10.23
	San Luis Obispo County APCD	B	1	1	3.18
	Santa Barbara County APCD	D	6	6	1.79

- The CARB performance audit criteria for 2018 were: ±10% for O_3 and ±15% for CO, NO_2, and SO_2 for each audit point. Starting in 2017, lower audit levels were implemented in performance audits but only used for informational purposes (no AQDA). Thus, audit points in 2 lowest levels for trace CO and SO_2, 2 lowest levels for O_3, and 1 lowest level for regular CO and NO_2 were excluded in summarizing the results here in order to provide a more representative performance comparison to the audit levels utilized in past years.
- *Further details on instruments not meeting these criteria can be viewed in Appendix B.
- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run July 2019.

B. Particulate Matter

Particulate matter (PM) monitoring is conducted using both manual and continuous type samplers. Manual samplers are operated on a one-in-six-day or one-in-three-day sampling schedule for PM_{10}, and a similar, or more frequent schedule, for $PM_{2.5}$. Continuous samplers report hourly values.

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

Ambient Data Capture: Data capture, as described in this report, is derived from the AQS completeness report AMP 430. The calculated number in AMP 430 represents the average of the monthly data capture rates for the calendar year and may not always be indicative of whether the 75 percent regulatory completeness requirement[13] is met for a particular pollutant. Note that while this report discusses the data capture rate of at least 75 percent, CARB's goal is to have at least 85% of the data in AQS.

Table B1 and Figure B1 present the percentage of samplers that reported an ambient data capture rate of at least 75 percent for each PQAO. Table B2 displays similar information for each local air district within CARB's PQAO in which a PM sampler was operated. As can be seen in these tables, very few PM samplers within CARB's PQAO failed to report at least a 75 percent data capture rate for the indicated ambient PM data. PM ambient data were well captured in 2018. In fact, only four PM samplers reported less than 75% ambient data in 2018.

Precision and Bias: PM is subject to formal measurement quality objectives (MQOs) in federal and State regulations. Appendix A of this report lists the MQOs stated in CFR and U.S. EPA guidance. For all methods of collecting PM_{10} and $PM_{2.5}$, Title 40 CFR Part 58 Appendix A 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 a certain number of collocated sites to represent its monitoring network. From each pair of collocated samplers, a minimum of 75 percent of ambient data is required to be in AQS.

[13] 40 CFR Part 50 states that the ambient data from a given instrument or sampler, in a calendar year, must be at least 75% complete to be included in making regulatory decisions, such as determinations of attainment of the ambient air quality standards. The State of California defines data "completeness" in a similar way, also using 75% as its criteria. However, unlike the federal definition, the State requirement factors in the high season of the pollutant in the completeness criteria.

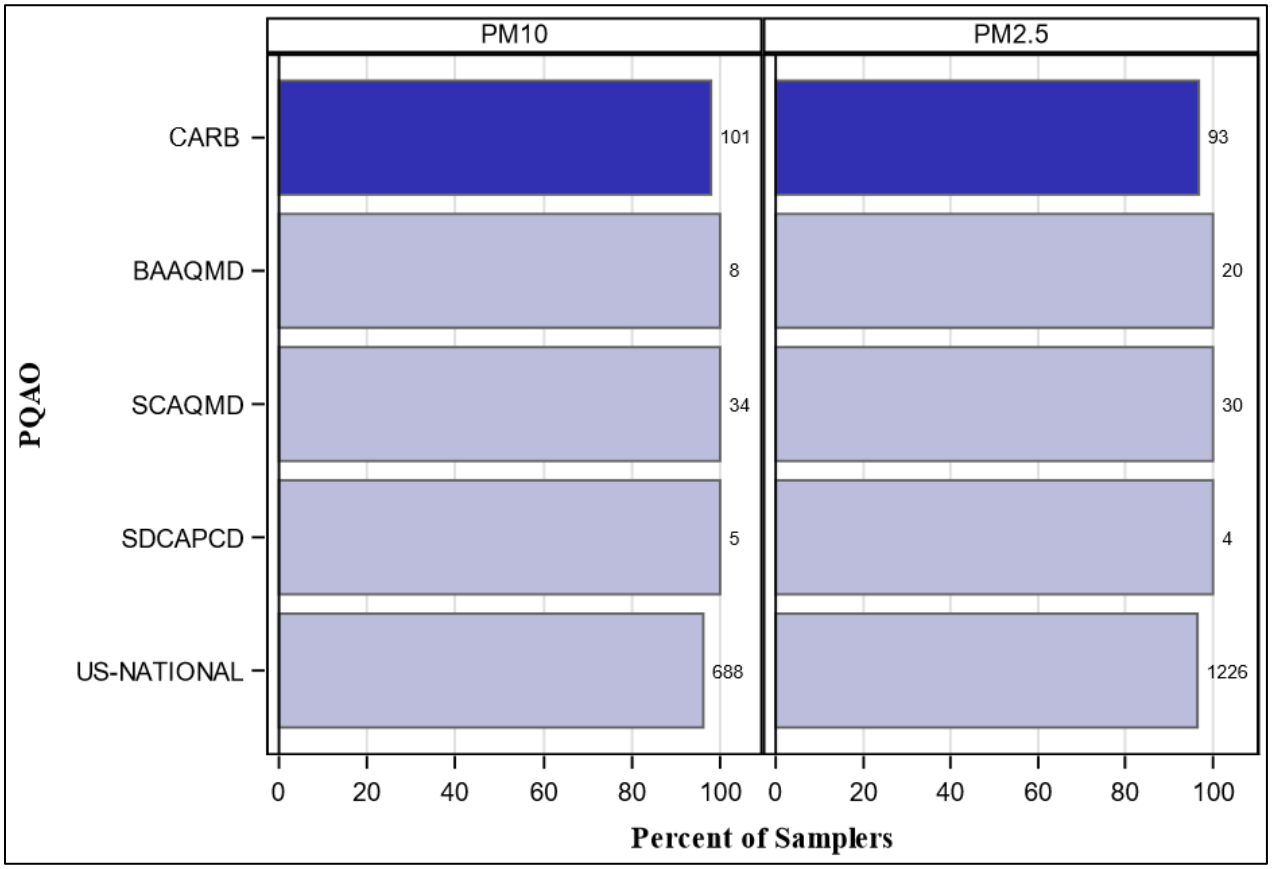
Table B1. 2016-2018 Ambient PM Data Capture Results

Pollutant	PQAO	Year	Number of Samplers	Number of Samplers Reporting ≥ 75% Data Capture	% of Samplers Reporting ≥ 75% Data Capture
PM_{10}	CARB	2018	101	99	98*
		2017	104	101	97
		2016	103	101	98
	BAAQMD	2018	8	8	100
		2017	7	7	100
		2016	9	9	100
	SCAQMD	2018	34	34	100
		2017	34	32	94
		2016	34	33	97
	SDCAPCD	2018	5	5	100
		2017	5	5	100
		2016	7	7	100
	NATIONAL	2018	688	661	96
		2017	713	684	96
		2016	742	703	95
$PM_{2.5}$	CARB	2018	93	91	98*
		2017	86	81	94
		2016	81	78	96
	BAAQMD	2018	20	20	100
		2017	20	20	100
		2016	20	20	100
	SCAQMD	2018	30	30	100
		2017	29	29	100
		2016	25	25	100
	SDCAPCD	2018	4	4	100
		2017	4	4	100
		2016	6	6	100
	NATIONAL	2018	1226	1183	97
		2017	1201	1151	96
		2016	1108	1058	96

- *Further details on samplers not reporting ≥ 75% ambient data can be viewed in Appendix B.
- National average includes state, county, district, National Park Service, and tribal sites, including those in California.
- Source: Air Quality System, AMP 430 Data Completeness Report, run July 2019, except as noted in Appendix B.
- Results reflect current information in AQS, including changes to past data since the 2017 Annual Data Quality Report. Therefore, results for 2017 and 2016 might differ from those in the 2018 DQ report.

Figure B1. Percent of Particulate Samplers Meeting Seventy-Five Percent Ambient Data Capture Rate

(Total Samplers in Network Indicated Next to Bars)



- National average includes state, county, district, National Park Service, and tribal sites, including those in California.
- Source: Air Quality System, AMP 430 Data Completeness Report, run October 2019, except as noted in Appendix B.

For continuous PM_{10} samplers, bias is assessed using the monthly flow rate verifications and comparing the absolute bias upper bound against CFR criterion of ±4 percent difference. Detailed calculations are explained in Appendix C. Total bias for each PQAO is also assessed through the Performance Evaluation Program run by U.S. EPA.

The accuracy of all particulate samplers is assessed via the semi-annual flow rate audit by comparing the instrument's flow rate to a certified orifice (PM_{10} and TSP), or a calibrated mass flow meter (TEOM, $PM_{2.5}$, and BAM samplers) that is certified against a National Institute of Standards and Technology traceable flow device or calibrator. As listed in Appendix A of this report, CARB's 2017 performance criteria, based on the average percent difference during a semi-annual flow rate audit, were ±7 percent for PM_{10} Hi-Vol, and ±4 percent for PM_{10} Low-Vol and $PM_{2.5}$.

Precision of the data is based on the standard deviation of the percent differences of the mass concentrations of the two identical or equivalent collocated samplers. At low concentrations, precision based on the measurements of collocated samplers may be relatively poor. For this reason, collocated measurement pairs are selected for use in the precision calculations only when both measurements are equal to or above the following limits: (1) PM_{10} (Hi-Vol): 15 $\mu g/m^3$; (2) PM_{10} (Lo-Vol): 3 $\mu g/m^3$; and (3) $PM_{2.5}$: 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. Title 40 CFR requires that this upper bound of the CV not exceed 10 percent for both PM_{10} and $PM_{2.5}$ at the PQAO level. A detailed description of CV, including formulae for calculating it, can be found in Appendix C.

Table B2. 2018 Ambient PM Data Capture Results for Local Air Districts Within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Samplers	Number of Samplers Reporting ≥ 75% Data	% of Samplers Reporting ≥ 75% Data
PM_{10}	Antelope Valley AQMD	D	1	1	100
	Butte County AQMD	C	1	1	100
	Calaveras County APCD	C	1	1	100
	Colusa County APCD	C	1	1	100
	Eastern Kern APCD	B	4	4	100
	El Dorado County AQMD	C	1	1	100
	Feather River AQMD	C	1	1	100
	Glenn County APCD	C	1	1	100
	Great Basin Unified APCD	D	19	19	100
	Imperial County APCD	B	5	5	100
	Lake County APCD	D	3	3	100
	Mariposa County APCD	C	1	0	0
	Mendocino County AQMD	D	1	1	100
	Mojave Desert AQMD	D	5	5	100
	Monterey Bay ARD	D	2	2	100
	North Coast Unified AQMD	D	1	1	100
	Northern Sonoma County APCD	D	3	3	100
	Placer County APCD	C	1	1	100
	Sacramento Metropolitan AQMD	B	5	5	100
	San Joaquin Valley Unified APCD	B	21	21	100
	San Luis Obispo County APCD	D	7	7	100
	Santa Barbara County APCD	B	7	6	86*
	Shasta County AQMD	D	3	3	100
	Tehama County APCD	D	1	1	100
	Ventura County APCD	D	2	2	100
	Yolo-Solano AQMD	D	3	3	100
$PM_{2.5}$	Antelope Valley AQMD	D	1	1	100
	Butte County AQMD	C	1	1	100
	Calaveras County APCD	C	1	1	100
	Colusa County APCD	C	1	1	100
	Eastern Kern APCD	B	3	2	67
	Feather River AQMD	C	1	1	100
	Great Basin Unified APCD	D	6	6	100
	Imperial County APCD	B	4	3	75*
	Lake County APCD	D	1	1	100
	Mendocino County AQMD	D	2	2	100

Table B2 (cont'd). 2018 Ambient PM Data Capture Results for Local Air Districts Within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Samplers	Number of Samplers Reporting ≥ 75% Data	% of Samplers Reporting ≥ 75% Data
$PM_{2.5}$	Mojave Desert AQMD	D	2	2	100
	Monterey Bay ARD	D	7	7	100
	North Coast Unified AQMD	D	2	2	100
	Northern Sierra AQMD	D	6	5	83*
	Placer County APCD	B	3	3	100
	Sacramento Metropolitan AQMD	B	7	7	100
	San Joaquin Valley Unified APCD	B	26	26	100
	San Luis Obispo County APCD	D	4	4	100
	Santa Barbara County APCD	B	4	4	100
	Shasta County AQMD	D	1	1	100
	Siskiyou County APCD	D	2	2	100
	Tehama County APCD	D	1	1	100
	Ventura County APCD	D	6	6	100
	Yolo-Solano AQMD	D	1	1	100

- *Further details on samplers not reporting ≥ 75% ambient data can be viewed in Appendix B.
- Source: Air Quality System, AMP 430 Data Completeness Report, run October 2019, except as noted in Appendix B.

A discussion of collocated sampling for both PM_{10} and $PM_{2.5}$ can be found in CARB's *Annual Network Plan Covering Monitoring Operations in 25 California Air Districts, July 2019.*[14] As indicated there, CARB has met the 15 percent minimum collocation requirement in 2018 for both PM_{10} and $PM_{2.5}$. Table B3 shows the number of sites with collocated precision data reported in respective years. Note that due to limited data[15] for CARB's PQAO in 2018, lead (Pb) is not discussed herein.

Precision Results: For the reported collocated sites, CFR requires that 30 paired observations per year be collected from each site with collocated samplers operating the entire year. Table B3 displays precision percent completeness (measured as a percent of the collected samples over the required number of observations and graphed in Figure B2) in addition to the CV upper bound. Information for years 2016 and 2017 are provided for historical perspectives. Three-year PQAO averages are also included. Summary precision info is displayed in Figures B3 and B4. A few highlights include:

[14] http://www.arb.ca.gov/aqd/amnr/amnr2019.pdf

[15] There is one Pb monitor in the CARB PQAO, located at the Sacramento-Del Paso Manor. However, Pb collocation for NCore sites is addressed by U.S. EPA at the national level. Thus, CARB is not required to collocate for lead at the NCore sites.

- For the five PM_{10} and fifteen $PM_{2.5}$ pairs of collocated samplers that were present within CARB's PQAO, all except two reported at least 75 percent of the required precision data in 2018.
- For PM_{10}, with the exception of one geographic area, the CV was below 10 percent in CARB's PQAO (as well as other California PQAOs).
- For $PM_{2.5}$, CARB's PQAO did not meet the 10 percent CV requirement at the PQAO level for all methods of collection (except method 143 – sequential sampler with VSCC). Overall, CV results are similar to the results from previous years.

Table B3. 2016-2018 Precision Results Based on Available Collocated PM Samplers

Pollutant	PQAO	Year	Method Code	Number Pairs of Collocated Samplers Reported	% Precision Completeness	Upper Bound of Coefficient of Variation	CFR Criteria for Precision Met?
PM_{10}	CARB	2018	ALL	5	100	**21.19**	No
		2017	ALL	5	100	17.76	No
		2016	ALL	6	100	11.22	No
		Avg			100	18.01	No
	BAAQMD	2018	ALL	1	100	5.23	Yes
		2017	ALL	1	100	4.86	Yes
		2016	ALL	2	100	6.79	Yes
		Avg			100	5.13	Yes
	SCAQMD	2018	ALL	3	100	9.56	Yes
		2017	ALL	3	100	8.33	Yes
		2016	ALL	2	100	7.65	Yes
		Avg			100	8.48	Yes
	SDCAPCD	2018	ALL	1	100	3.32	Yes
		2017	ALL	1	100	3.64	Yes
		2016	ALL	1	100	2.84	Yes
		Avg			100	3.25	Yes
	NATIONAL	2018	ALL	96	99	9.31	Yes
		2017	ALL	113	98	9.18	Yes
		2016	ALL	125	97	9.66	Yes
$PM_{2.5}$	CARB	2018	143	1	93	3.64	Yes
		2017	143	1	100	9.96	Yes
		2016	143	1	96	20.02	No
		2018	145	4	71	**11.40**	No
		2017	145	4	75	6.03	Yes
		2016	145	4	91	7.11	Yes

Table B3 (cont'd). 2016-2018 Precision Results Based on Available Collocated PM Samplers

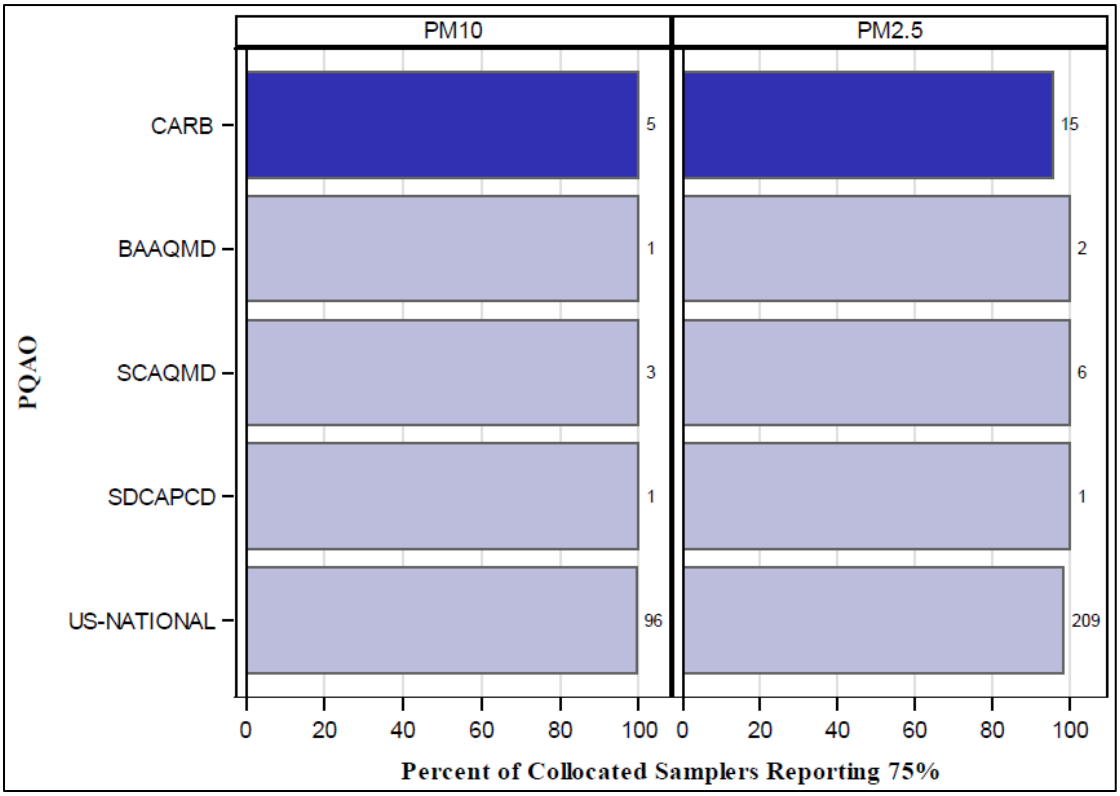
Pollutant	PQAO	Year	Method Code	Number Pairs of Collocated Samplers Reported	% Precision Completeness	Upper Bound of Coefficient of Variation	CFR Criteria for Precision Met?
$PM_{2.5}$	CARB	2018	170	6	100	**17.15**	No
		2017	170	7	100	15.54	No
		2016	170	7	100	22.37	No
		2018	181	1	100	**15.98**	No
		2017	181	1	100	16.66	No
		2016	181	1	100	15.95	No
		2018	204	2	100	**10.27**	No
		2017	204	2	100	8.72	Yes
		2016	204	NDA	NDA	NDA	NDA
		2018	238	1	100	**21.82**	No
		2017	238	1	40	37.19	No
		2016	238	NDA	NDA	NDA	NDA
	BAAQMD	2018	170	2	100	**11.65**	No
		2017	170	2	100	14.18	No
		2016	170	2	100	20.84	No
	SCAQMD	2018	143	1	100	3.24	Yes
		2017	143	1	100	2.81	Yes
		2016	143	3	100	6.88	Yes
		2018	145	3	100	4.67	Yes
		2017	145	3	100	7.47	Yes
		2016	145	2	100	5.09	Yes
		2018	155	2	100	4.73	Yes
		2017	155	1	100	3.24	Yes
		2016	155	NDA	NDA	NDA	NDA
	SDCAPCD	2018	145	1	100	3.66	Yes
		2017	145	1	100	3.77	Yes
		2016	145	1	100	4.11	Yes
	NATIONAL	2018	117	1	100	3.83	Yes
		2017	117	1	100	3.72	Yes
		2016	117	2	91	5.97	Yes
		2018	118	1	88	5.75	Yes
		2017	118	9	69	14.42	No
		2016	118	48	82	8.03	Yes
		2018	120	NDA	NDA	NDA	NDA
		2017	120	NDA	NDA	NDA	NDA
		2016	120	3	83	7.83	Yes
		2018	143	9	98	7.03	Yes
		2017	143	10	95	8.02	Yes
		2016	143	11	99	11.12	No
		2018	145	125	98	9.32	Yes
		2017	145	126	96	9.70	Yes

Table B3 (cont'd). 2016-2018 Precision Results Based on Available Collocated PM Samplers

Pollutant	PQAO	Year	Method Code	Number Pairs of Collocated Samplers Reported	% Precision Completeness	Upper Bound of Coefficient of Variation	CFR Criteria for Precision Met?
$PM_{2.5}$	NATIONAL	2018	145	125	98	9.32	Yes
		2017	145	126	96	9.70	Yes
		2016	145	111	94	9.62	Yes
		2018	170	58	99	**16.54**	No
		2017	170	58	99	20.11	No
		2016	170	53	99	22.28	No
		2018	181	3	100	**11.62**	No
		2017	181	6	100	14.47	No
		2016	181	5	100	13.28	No
		2018	204	7	98	**16.80**	No
		2017	204	6	100	10.98	No
		2016	204	2	100	12.17	No
		2018	238	8	91	**12.34**	No
		2017	238	4	79	23.33	No
		2016	238	NDA	NDA	NDA	NDA

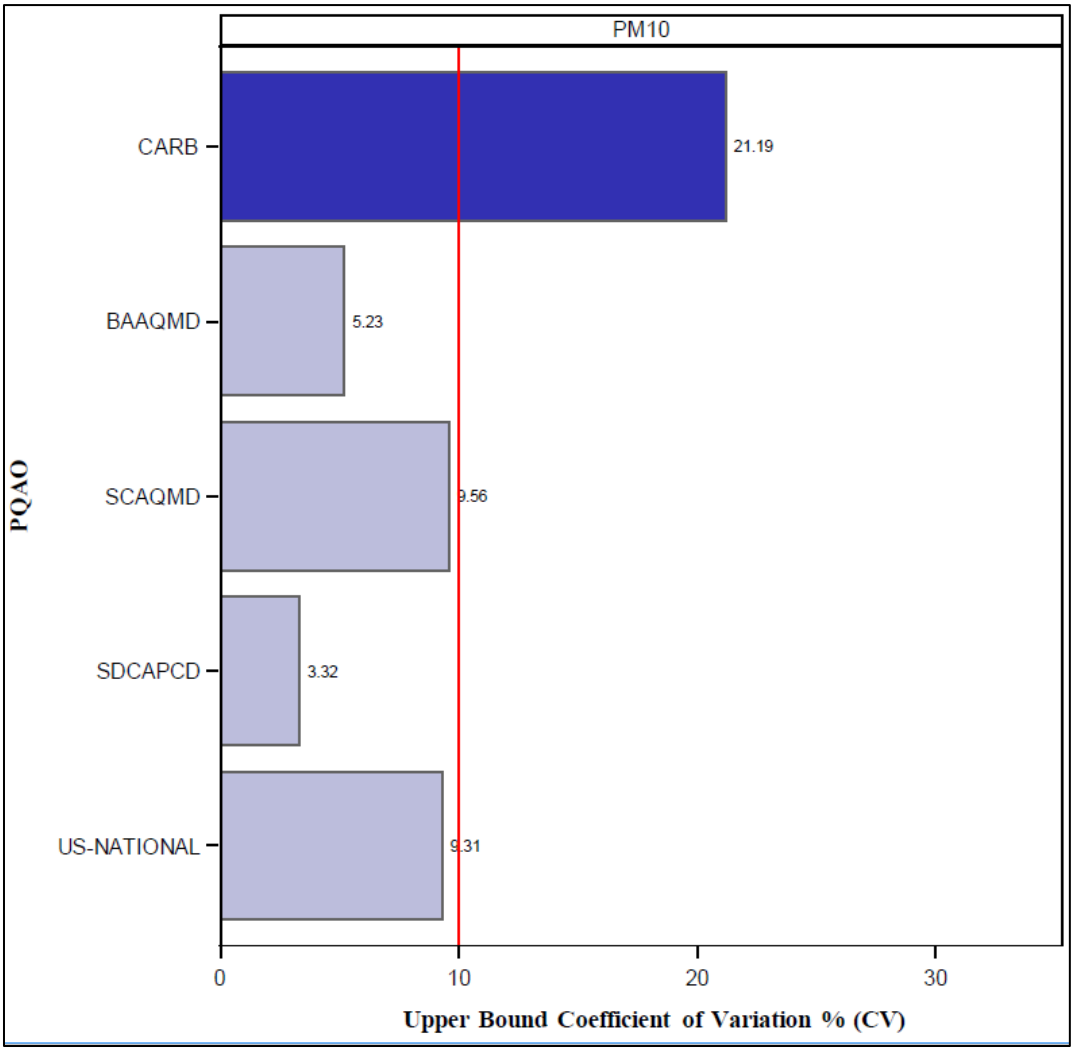
- CFR Limit is a coefficient of variation of ≤ 10% for PM. Percent precision completeness is based on data collected from collocated samples. Further details on samplers not meeting these criteria can be found in Appendix B.
- Method 117 = R & P Model 2000 PM2.5 Sampler w/WINS; Method 118= R & P Model 2025 PM2.5 Sequential w/WINS; Method 120= Andersen RAAS2.5-300 PM2.5 SEQ w/WINS; Method 143= R & P Model 2000 PM2.5 Sampler w/VSCC; Method 145= R & P Model 2025 PM2.5 Sequential Air Sampler w/VSCC; Method 155=Thermo RAAS2.5-300 w/VSCC; Method 170= Met One BAM-1020 Mass Monitor w/VSCC; Method 181=Thermo TEOM 1400a FDMS, Method 204=Teledyne Model 602 Beta plus w/VSCC, Method 238=T640X Mass Monitor.
- ***Bold italicized*** font indicates CV greater than 10% in 2018 while underlined font indicates CV greater than 10% in 2016 or 2017.
- NDA= No collocated data available from AQS, but ambient data were reported to AQS.
- Source: Air Quality System, AMP 256 Data Quality Indicator Report (Collocation Summary), run October 2019.
- National average includes state, county, district, National Park Service, and tribal sites, including those in California.
- Results reflect current information in AQS, including changes to past data since the 2017 Annual Data Quality Report. Therefore, results for 2017 and 2016 might differ from those in the 2017 DQ report.

Figure B2. 2018 Precision Completeness - PM



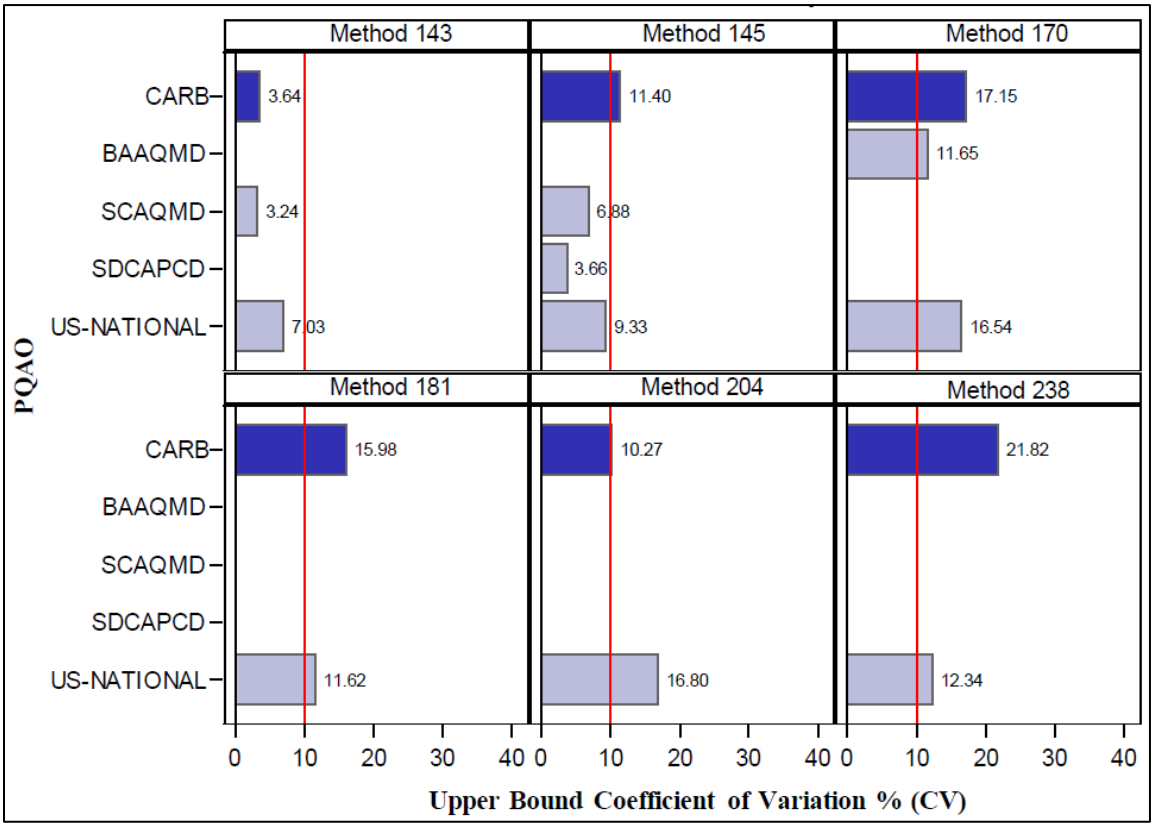
- National average includes state, county, district, National Park Service, and tribal sites, including those in California.
- Source: Air Quality System, AMP 430 Data Completeness Report, run October 2019, except as noted in Appendix B.

Figure B3. 2018 Precision via Collocated Samplers – PM_{10}



- Precision for manual PM_{10} samplers is based on collocated samples;
- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run October 2019. Further details on samplers not meeting criteria can be viewed in Appendix B.
- National average includes state, county, district, National Park Service, and tribal sites, including those in California.
- Red vertical line indicates CFR limit for CV which is 10% for PM.

Figure B4. 2018 Precision via Collocated Samplers – $PM_{2.5}$



- $PM_{2.5}$ precision criteria are based on collocated measurements; further details on samplers not meeting criteria can be viewed in Appendix B.
  Source: AQS, AMP 256 Data Quality Indicator Report, run October 2019, except as noted in Appendix B.
- National average includes state, county, district, National Park Service, and tribal sites, including those in California; AMP 256 Data Quality Indicator Report, run October 2019, except as noted in Appendix B.
- Method 143= R & P Model 2000 $PM_{2.5}$ Sampler w/VSCC; Method 145= R & P Model 2025 $PM_{2.5}$ Sequential Air Sampler w/VSCC; Method 155=Thermo RAAS2.5-300 w/VSCC; Method 170= Met One BAM-1020 Mass Monitor w/VSCC; Method 181=Thermo TEOM 1400a FDMS, Method 204=Teledyne Model 602 Beta plus w/VSCC, Method 238=T640X Mass Monitor.
- Red vertical line indicates CFR limit for CV which is 10% for PM.

Table B4 breaks down the statistics displayed in Table B3 under CARB's PQAO by local air districts. Monitoring sites within these areas may be operated by the district, CARB, or both. All except three areas (Great Basin, Imperial, and Northern Sierra) reported at least 75 percent of the required precision data. The upper bound CV was met in all districts for PM_{10} with the exception of Great Basin. However, the CV for $PM_{2.5}$ is exceeded at all districts except a few. Sites with $PM_{2.5}$ CV upper bound below 10 percent are in the following districts: Mojave Desert AQMD, Northern Sierra AQMD, Placer County APCD, and Sacramento Metro AQMD. In all instances, identical methods were collocated at the sites that achieved the CV criteria. Note that five collocated locations achieved the CV limit for $PM_{2.5}$ in 2017.

Table B4. 2018 Precision Results for Districts within CARB's PQAO

Pollutant	Geographic Area	Method Code (Primary/ Secondary)	Monitoring by (District=D, CARB=C)	% Precision Completeness	Upper Bound of Coefficient of Variation (CV)
PM_{10}	Great Basin Unified APCD	All	D D	100 87	***15.64*** ***10.01***
	Sacramento Metro AQMD	All	D	100	5.09
	San Joaquin Valley APCD	All	D C	100 90	3.73 3.22
$PM_{2.5}$	Great Basin Unified APCD	181/145 238/145	D D	100 100	***15.98*** ***21.82***
	Imperial County APCD	145/145	C	50	***13.43***
	Mojave Desert AQMD	170/170	D	100	9.11
	Monterey Bay ARD	170/143	D	100	***14.46***
	Northern Sierra AQMD	145/145	D	63	4.11
	Placer County APCD	143/143	C	93	3.64
	Sacramento Metro AQMD	145/145 170/170	D D	80 100	5.37 ***18.15***
	San Joaquin Valley APCD	145/145 170/170 170/143 204/145 204/145	C C C C D	93 100 100 100 97	***19.05*** ***16.06*** ***12.90*** ***10.58*** 9.87
	Ventura County APCD	170/170	D	100	***14.51***

- CFR Limit for CV is 10% for PM. Further details on samplers not meeting these criteria can be viewed in Appendix B.
- ***Bold italicized*** font indicates CV greater than 10% in 2018.
- Method 143= R & P Model 2000 $PM_{2.5}$ Sampler w/VSCC; Method 145= R & P Model 2025 $PM_{2.5}$ Sequential Air Sampler w/VSCC; Method 155=Thermo RAAS2.5-300 w/VSCC; Method 170= Met One BAM-1020 Mass Monitor w/VSCC; Method 181=Thermo TEOM 1400a FDMS, Method 204=Teledyne Model 602 Beta plus w/VSCC, Method 238=T640X Mass Monitor.
- Source: Air Quality System, AMP 256 Data Quality Indicator Report (Collocation Detail Report), run October 2019.

It is noteworthy that the high CV problem exists at the national level as well as within the CARB 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 vs federal equivalent methods. While no definitive source of the issue has been identified as a key contributing factor to the imprecision, monitoring agencies are encouraged to closely examine operational practices in order to help the PQAO achieve the precision criteria for PM.

Bias Results via Monthly Flow Rate Verifications: Starting in April 2016, flow rate verification data are required to be in AQS for all PM samplers. 2017 was the first year when this requirement was in effect for the entire 12-month period; hence, a 3-year average for 2016-2018 would not be appropriate. Bias results via the monthly flow rate verifications for all PM samplers in 2018 and for continuous PM_{10} samplers in 2016 and 2017 are shown in Table B5. Note that almost all of CARB's PM_{10} and $PM_{2.5}$ samplers reported FRV data to AQS in 2018 as well as 2017. In summary, the bias criteria of ± 7 percent for PM_{10} and ± 4 percent for $PM_{2.5}$ were met in each PQAO for which data are available. This finding is consistent across PQAOs with available data in the past three years.

Table B5. 2016-2018 PM_{10} and $PM_{2.5}$ Bias Results Based on Flow Rate Verifications

Pollutant	PQAO	Year	Type	Number of Samplers in Network	Number of Reported Flow Rate Verifications	Number of Required Flow Rate Verifications	Avg % Diff.	Bias (%)	CFR Criteria for Bias Met?
PM_{10}	CARB	2018	Hi-Vol	23	250	144	-0.10	± 4.53	Yes
		2017		25	244	150	-0.51	± 3.44	Yes
		2016		30	149	167	-0.97	± 4.10	Yes
	BAAQMD	2018		7	0	27	N/A	N/A	N/A
		2017		6	0	24	N/A	N/A	N/A
		2016		8	0	26	N/A	N/A	N/A
	SCAQMD	2018		25	227	100	-0.68	± 2.95	Yes
		2017		25	315	100	0.73	± 3.42	Yes
		2016		26	309	99	-0.67	± 2.43	Yes
	SDCAPCD	2018		4	48	16	0.94	± 2.53	Yes
		2017		4	45	16	0.22	± 2.01	Yes
		2016		5	58	19	0.26	± 2.02	Yes
	CARB	2018	Low-Vol	78	1485	939	-0.24	± 1.27	Yes
		2017		80	1416	912	-0.16	± 1.13	Yes
		2016*		75	1408	890	-0.16	± 1.06	Yes
	BAAQMD	2018		1	0	12	N/A	N/A	N/A
		2017		1	0	12	N/A	N/A	N/A
		2016*		1	0	12	N/A	N/A	N/A
	SCAQMD	2018		9	168	108	-0.19	± 2.11	Yes
		2017		9	168	108	0.01	± 2.13	Yes
		2016*		9	162	108	-0.26	± 2.06	Yes
	SDCAPCD	2018		1	0	12	N/A	N/A	N/A
		2017		1	0	12	N/A	N/A	N/A
		2016*		2	0	12	N/A	N/A	N/A

Table B5 (cont'd). 2016-2018 PM_{10} and $PM_{2.5}$ Bias Results Based on Flow Rate Verifications

Pollutant	PQAO	Year	Type	Number of Samplers in Network	Number of Reported Flow Rate Verifications	Number of Required Flow Rate Verifications	Avg % Diff.	Bias (%)	CFR Criteria for Bias Met?
$PM_{2.5}$	CARB	2018	All	93	1687	1093	-0.12	± 1.06	Yes
		2017	All	94	1722	1060	-0.12	± 0.97	Yes
		2016	All	88	1355	1021	-0.08	± 1.08	Yes
	BAAQMD	2018	All	20	0	225	N/A	N/A	Yes
		2017	All	18	0	216	N/A	N/A	Yes
		2016	All	18	0	210	N/A	N/A	Yes
	SCAQMD	2018	All	30	420	352	-0.33	± 1.14	Yes
		2017	All	29	378	335	-0.05	± 1.52	Yes
		2016	All	25	297	296	0.17	± 1.41	Yes
	SDCAPCD	2018	All	4	48	48	-0.30	± 1.15	Yes
		2017	All	4	48	48	0.33	± 1.02	Yes
		2016	All	6	57	57	0.67	± 1.38	Yes

- *Flow rate verifications available for continuous PM methods only in 2016 and 2017 in this table.
- Three-year average not available since 2017 was the first year of full implementation for reporting of FRV data to AQS.
- CFR criteria for PM_{10} bias: ±7% (of standard) except for dichotomous samplers, which are subjected to ±4%, same as criteria for $PM_{2.5}$.
- Further details on samplers not uploading the required flow rate data can be viewed in Appendix B.
- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run October 2019.
- Results reflect current information in AQS, including changes to past data since the 2017 Annual Data Quality Report. Therefore, results for 2017 and 2016 might differ from those in the 2017 DQ report.
- Bay Area AQMD had no flow rate verification data for PM_{10} samplers reported in AQS for 2016-2018; data collected can be requested through Bay Area AQMD.

Accuracy Validation via Performance Audits: Since an accurate measurement of PM is dependent upon the flow rate, CARB and other PQAOs are required to conduct semi-annual flow rate audits on all PM samplers at each site. Such audits are to be conducted five to seven months apart on each sampler in a given calendar year. In addition, as explained earlier, PQAOs are also required to submit the continuous PM_{10} monthly flow rate verifications to AQS; in this case, bias estimates based on flow rate verifications are further verified using the semi-annual flow rate audit data.

Table B6 and Figures B5-B6 summarize the 2018 performance audit results for PM samplers. The numbers of samplers as well as those that met the required number of audits in 2018 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, zero if less than three months.) The average percent difference between the sampler flow rates and the audit flow rates represents the arithmetic mean of the combined differences from the certified value of all the individual audit points for each sampler. Table B7 presents similar data for local air districts within CARB's PQAO. Note that in Figure B6, the percent of PM samplers is defined as the number of samplers meeting the required number of audits divided by the total number of samplers in each PQAO.

CARB conducts the semi-annual flow rate audits for most samplers operating within CARB's PQAO. In addition, certain local districts within CARB's PQAO were allowed to conduct their own audits in 2018, per the agreed-upon "Roles and Responsibilities" documents.[16] For example, Great Basin Unified APCD conducts one of the semi-annual flow rate audits for the sites operating within its jurisdiction. CARB's policy is to audit non-CARB PQAO monitoring sites at least once every five years. Non-CARB PQAOs are responsible for performing their own audits as part of the annual performance evaluation program.

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

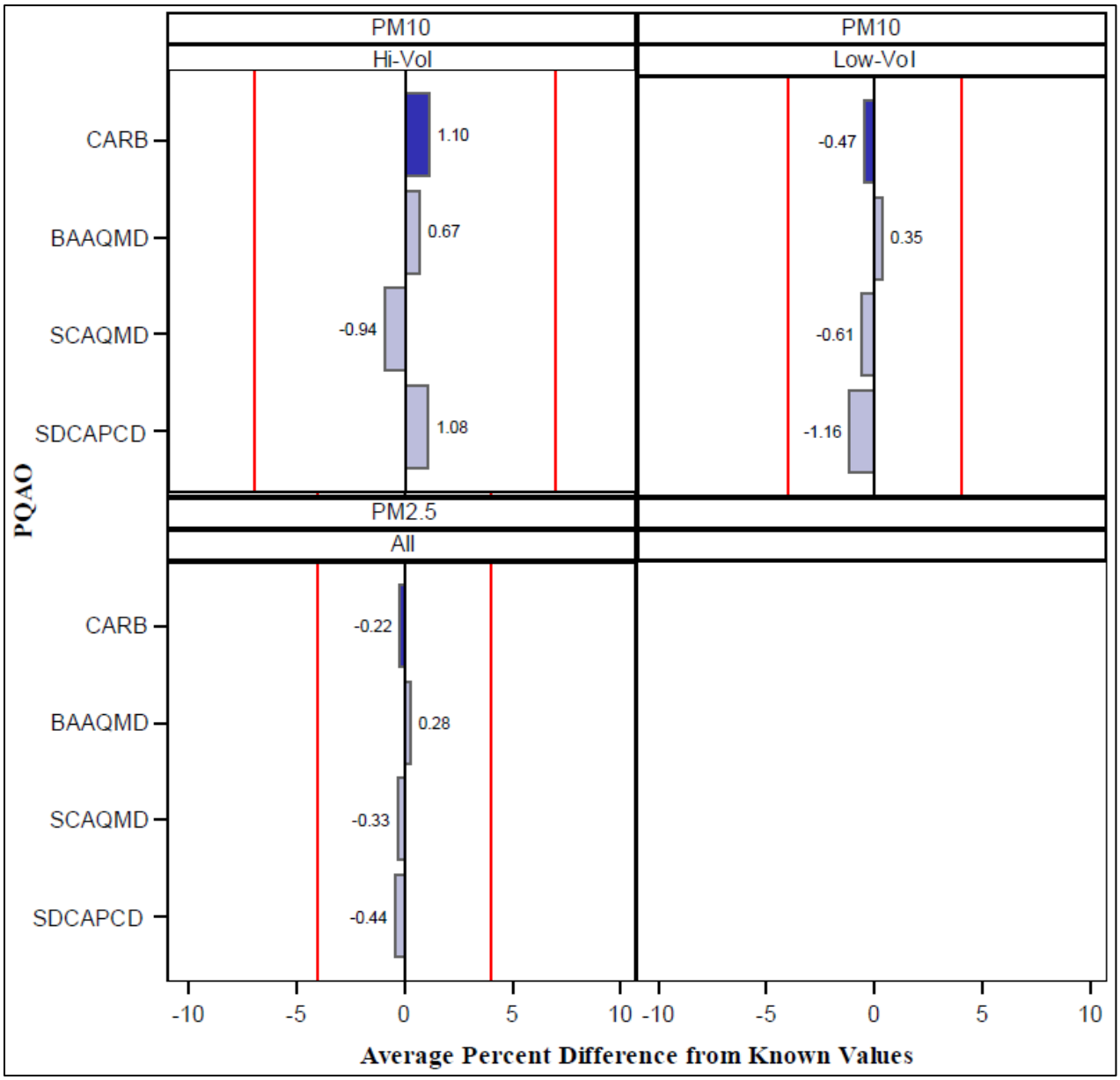
[16] https://arb.ca.gov/aaqm/qa/pqao/repository/rr_docs.htm

Table B6. 2018 Results for Particulate Sampler Performance Audits

Pollutant	Collection Method	PQAO	Number of Samplers	Number of Audits Required	Number of Audits Conducted	Number of Samplers Meeting Required Number of Audits	Number of Flow Rate Audits Not Meeting CARB Criteria *	Avg % Diff.
PM_{10}	Hi-Vol	CARB	23	42	46	23	0	1.10
		BAAQMD	7	14	26	6	0	0.67
		SCAQMD	25	50	56	25	0	-0.94
		SDCAPCD	4	8	10	4	0	1.08
	Low-Vol**	CARB	78	156	193	76	3	-0.47
		BAAQMD	1	2	4	1	0	0.35
		SCAQMD	9	18	19	9	0	-0.61
		SDCAPCD	1	2	3	1	0	-1.16
$PM_{2.5}$	ALL	CARB	93	180	192	92	4	-0.22
		BAAQMD	20	39	71	18	0	0.28
		SCAQMD	30	60	66	29	0	-0.33
		SDCAPCD	4	8	9	4	0	-0.44

- *AQDAs were issued for audits not meeting criteria. Only audits conducted by CARB were subjected to the AQDA process. Only flow failures are included in this table.
- **Count of low-volume (Low-Vol) samplers includes continuous BAM samplers.
- Sites might be audited multiple times in a quarter (by different entities or due to re-audits.)
- CARB's flow rate audit criteria for 2017 were ±7% for PM_{10} Hi-Vol and ±4% for PM_{10} Low-Vol and $PM_{2.5}$. Further details on samplers not meeting these criteria can be found in Appendix B.
- The number of audits required per year: two if sampler is operating for more than seven months, one if less than seven months but more than three months, zero if less than three months.
- The number of audits conducted include original audits and possible reaudits; hence, Number audits conducted can be larger than Numberaudits required.
- Further details on samplers not meeting these criteria can be viewed in Appendix B.
- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run October 2019, except as noted in Appendix B.

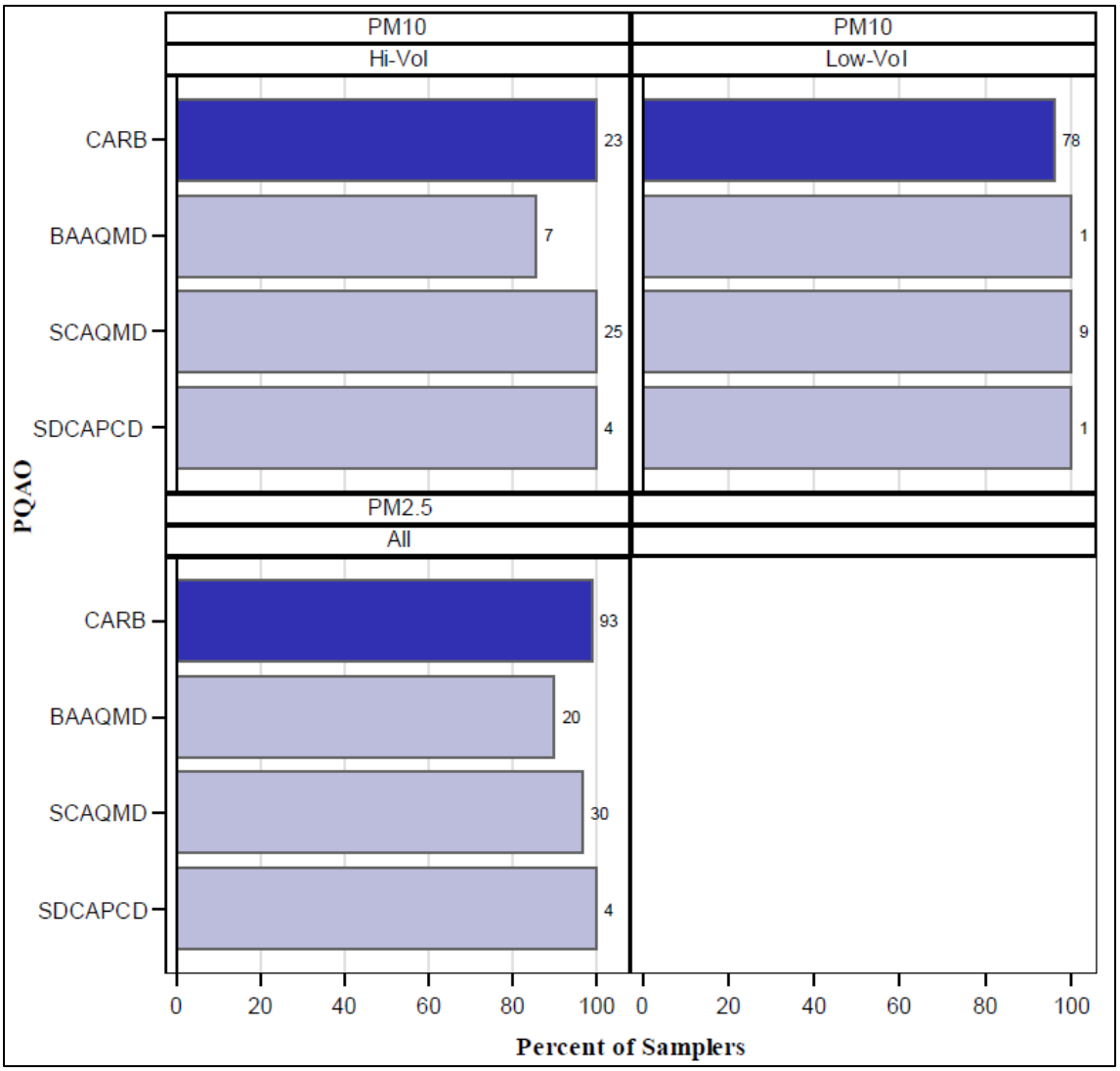
Figure B5. 2018 Accuracy via Audits – PM



- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run October 2019.
- Performance audit criteria for 2018 (red vertical line): ±7% for PM_{10} Hi-Vol and ±4% for PM_{10} Low-Vol and $PM_{2.5}$

Figure B6. Percent of PM Samplers Meeting the Required Number of Performance Audits

(Total Samplers in Network Indicated on Bars)



- The number of audits required per year: two if sampler is operating for more than seven months, one if less than seven months but more than three months, zero if less than three months. Further details on samplers not meeting criteria can be viewed in Appendix B.
- Source: AMP 256 Data Quality Indicator Report, run October 2019, except as noted in Appendix B.

Table B7. 2018 Results for Particulate Sampler Flow Rate Audits for Local Air Districts Within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Samplers	Number of Samplers not Audited	Number of Flow Rate Audits Not Meeting CARB Criteria	Avg % Diff.
PM_{10}	Antelope Valley AQMD	D	1	0	0	-0.28
	Butte County AQMD	C	1	0	1*	-1.65
	Calaveras County APCD	C	1	0	0	-0.66
	Colusa County APCD	C	1	0	0	-0.09
	Eastern Kern APCD	D	4	1	0	1.90
	El Dorado County AQMD	C	1	1	1*	-1.73
	Feather River AQMD	C	1	0	0	-0.21
	Glenn County APCD	C	1	0	0	0.30
	Great Basin Unified APCD	D	19	0	0	-0.86
	Imperial County APCD	D	5	0	1*	-0.30
	Lake County APCD	D	3	0	0	-0.57
	Mariposa County APCD	C	1	0	0	0.51
	Mendocino County AQMD	D	1	0	0	-0.46
	Mojave Desert AQMD	D	5	0	0	-0.17
	Monterey Bay ARD	D	2	0	0	0.23
	North Coast Unified AQMD	D	1	0	0	-0.86
	Northern Sonoma County APCD	D	3	0	0	-0.46
	Placer County APCD	B	1	0	0	0.66
	Sacramento Metropolitan AQMD	B	5	0	0	1.54
	San Joaquin Valley Unified APCD	B	21	0	0	0.34
	San Luis Obispo County APCD	D	7	0	0	-0.90
	Santa Barbara County APCD	B	7	1	0	-0.34
	Shasta County AQMD	D	3	0	0	2.25
	Tehama County APCD	D	1	0	0	-0.41
	Ventura County APCD	D	2	0	0	-1.25
	Yolo-Solano AQMD	B	3	0	0	-1.54
$PM_{2.5}$	Antelope Valley AQMD	D	1	0	0	-0.89
	Butte County AQMD	C	1	0	0	-1.15
	Calaveras County APCD	C	1	0	0	-0.67
	Colusa County APCD	C	1	0	0	1.21
	Eastern Kern APCD	D	3	1	0	0.80

Table B7 (cont'd). 2018 Results for Particulate Sampler Flow Rate Audits for Local Air Districts Within CARB's PQAO

Pollutant	Geographic Area	Monitoring by (District=D, CARB=C, or Both=B)	Number of Samplers	Number of Samplers not Audited	Number of Flow Rate Audits Not Meeting CARB Criteria	Avg % Diff.
$PM_{2.5}$	Feather River AQMD	C	1	0	0	-1.15
	Great Basin Unified APCD	D	6	0	0	-0.60
	Imperial County APCD	D	4	0	0	0.53
	Lake County APCD	D	1	0	0	-1.50
	Mendocino County AQMD	D	2	0	0	0.36
	Mojave Desert AQMD	D	2	0	0	0.04
	Monterey Bay ARD	D	7	0	0	0.04
	North Coast Unified AQMD	D	2	0	0	1.80
	Northern Sierra AQMD	D	6	0	0	-0.35
	Placer County APCD	B	3	0	0	-0.34
	Sacramento Metropolitan AQMD	B	7	0	0	-0.57
	San Joaquin Valley Unified APCD	B	26	0	0	-0.10
	San Luis Obispo County APCD	D	4	0	0	-0.24
	Santa Barbara County APCD	B	4	0	0	-0.01
	Shasta County AQMD	D	1	0	0	-0.65
	Siskiyou County APCD	D	2	0	0	-0.46
	Tehama County APCD	D	1	0	0	-2.12
	Ventura County APCD	D	6	0	0	-1.14
	Yolo-Solano AQMD	B	1	0	0	1.27

- *Further details on samplers not being audited or not meeting audit criteria can be viewed in Appendix B.
- CARB's flow rate audit criteria for 2018 were ±7% for PM_{10} Hi-Vol and ±4% for PM_{10} Low-Vol and $PM_{2.5}$. Only audits conducted by CARB were subjected to the AQDA process. Further details on samplers not meeting these criteria can be found in Appendix B. Only flow failures are included in this table.
- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run October 2019, except as noted in Appendix B.

Network Bias Results via PEP Audits: As noted earlier, $PM_{2.5}$ samplers are subjected to the national Performance Evaluation Program (PEP) audit program to assess "total bias" of the network. In general terms, a performance evaluation 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. In the case of the PEP, the goal is to evaluate total measurement system bias, which includes measurement uncertainties from both field and laboratory activities. Performance evaluations are performed on the SLAMS monitors annually within each PQAO. For PQAOs with less than 5 monitoring sites, five valid PEP audits are collected; for PQAOS with more than 5 sites, eight valid audits are required. A PEP audit is valid when both primary monitor and PEP audit concentrations are above 3 ug/m^3. Each year, every designated FRM or FEM monitor within a PQAO must: 1) have each method designation evaluated; and 2) have all FRM or FEM samplers subject to a PEP audit at least once every six years, which equates to approximately 15 percent of the sites audited each year. Results from 2018 PEP audits are presented in Table B8 and Figure B7. In Table B8, results from previous two years and 3-year average are presented to assess trends. CARB's PQAO has low "total" bias in its $PM_{2.5}$ network in 2018 as well as over the 3-year period 2016-2018. Similar information for other PQAOs in California are also presented in Table B8. Since PEP is intended to evaluate the bias at the network level, no breakdown of results by monitor is presented.

Results from 2018 indicate the $PM_{2.5}$ network for CARB's PQAO has very low total bias, consistent with the accuracy results that were evaluated via flow rate verifications and flow rate audits.

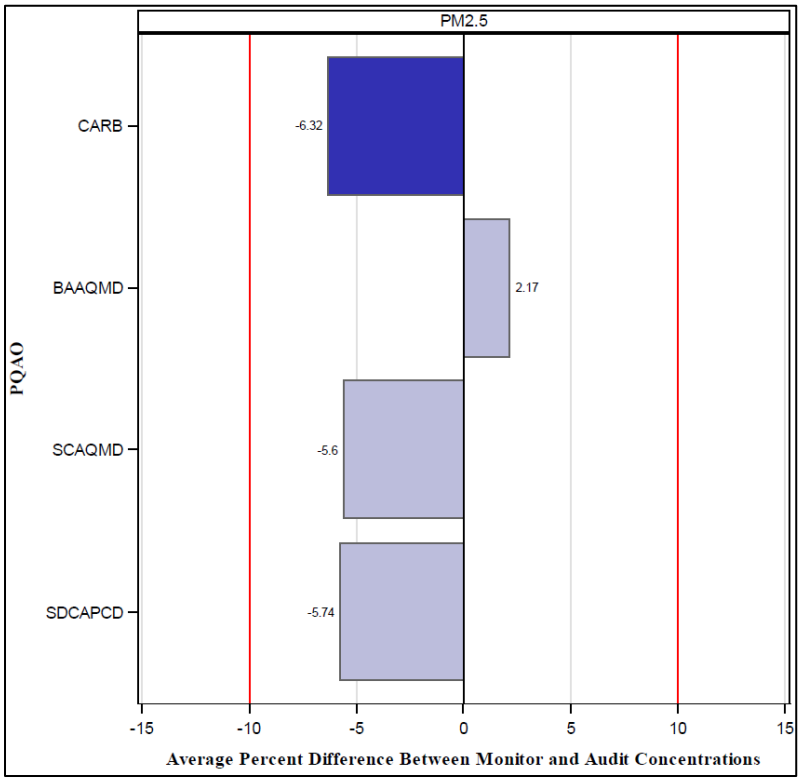
Table B8. CARB's PQAO Bias via PEP Audits

Pollutant	PQAO	Year	Number of Samplers	Number of Audits Required	Number of Audits Collected	% Complete	Bias
$PM_{2.5}$	CARB	2018	73	8	5*	63	-6.32
		2017	72	8	7	88	+12.60
		2016	69	8	14	100	1.37
		SUMMARY					+2.55
	BAAQMD	2018	18	8	8	100	+2.17
		2017	16	8	7	88	+6.37
		2016	16	8	8	100	+8.97
		SUMMARY					+5.83
	SCAQMD	2018	19	8	6	75	-5.60
		2017	19	8	9	100	-2.82
		2016	19	8	9	100	-8.17
		SUMMARY					-5.53
	SDCAPCD	2018	3	5	4	80	-5.74
		2017	3	5	5	100	1.65
		2016	5	5	5	100	-0.01
		SUMMARY					-1.37

*Although 8 audits were conducted, only 5 were considered valid.

- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run October 2019.
- Performance audit criteria: < ±10% for $PM_{2.5}$

Figure B7. Bias via PEP Audits – $PM_{2.5}$



- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run October 2019.
- Performance audit criteria for 2018 (red vertical line): ±10% for $PM_{2.5}$

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 national average are shown where appropriate.

Below are some highlights for 2018.

Gaseous Pollutants (CO, O_3, NO_2, and SO_2)

- Ninety-eight percent of the instruments operating under CARB's PQAO achieved the ambient data capture rate of at least 75 percent in 2018. Ninety-five percent also met CARB's goal of at least 85 percent data capture.
- Ninety-nine percent of the instruments operating within CARB's PQAO reported at least 75 percent of the required one-point QC checks for the gaseous pollutants. 2018 was the first year in which a full year of individual QC checks were assessed according to the new critical criteria, which was met by most instruments; however, monitoring organizations are encouraged to closely

monitor the ranges of these checks to ensure they are conducted within the prescribed ranges.

- All of the California PQAOs met the CFR criteria for precision and bias based on one-point QC checks.
- The performance audit acceptance criteria were met, on average, at the PQAO level for CARB's PQAO (as well as other PQAOs) with only a small number of analyzers not passing performance audit criteria. This validates the bias estimates based on one-point QC checks, which showed that the gaseous network generally exhibits a high level of accuracy.

Particulate Matter (PM_{10} and $PM_{2.5}$)

- Ninety-eight percent of the particulate samplers operating under CARB's PQAO achieved the ambient data capture rate of at least 75 percent in 2018. Ninety-three percent also met CARB's goal of at least 85 percent data capture.
- As indicated in CARB's *Annual Network Plan Covering Operations in 25 California Air Districts, July 2019*, CARB's PQAO met the minimum collocation requirement.
- For the five PM_{10} and fifteen $PM_{2.5}$ pairs of collocated samplers that were present within CARB's PQAO, all except two reported at least 75 percent of the required precision data in 2018.
- For PM_{10}, with the exception of one area, the CV was below 10 percent in CARB's PQAO (as well as other California PQAOs).
- For $PM_{2.5}$, CARB's PQAO did not meet the 10 percent CV requirement at the PQAO level for all methods of collection except method 143 – sequential samplers with VSCC, as shown in Table IV-1. Overall, CV results are similar to the results from previous years.

Table IV-1. 2018 CARB's PQAO Precision Assessment for $PM_{2.5}$

PQAO	Method 143	Method 145	Method 170	Method 181	Method 204	Method 238
CARB	✓	X	X	X	X	X
BAAQMD	-----	-----	X	-----	-----	-----
SCAQMD	✓	✓	-----	-----	-----	-----
SDCAPCD	-----	✓	-----	-----	-----	-----

Dashed marks (----) = method not applicable to PQAO; X = No; and ✓ = Yes. NDA=No data available in AQS.

- Flow rate audit data indicate that CARB's PQAO met CARB criteria. This finding is consistent with the bias information from the routine flow rate verification data.
- PEP audits conducted indicate low total bias for the PM2.5 network, consistent with results via flow rate verification and flow rate audits showing the PM2.5 network is accurate.

In an effort to compare 2018 data quality results across geographic areas within California, results for both gases and PM are summarized in one composite table in the Executive Summary. To make a fair comparison, we divided the geographic areas into three categories according to monitoring activities: 1) gas only; 2) gas and PM without collocation; and 3) gas and PM with collocation. Below are some key observations for CARB's PQAO in 2018:

- There are two areas that monitored gases only, and both achieved all MQOs.
- Among 19 areas that monitored gases and PM without collocation, 9 met all MQOs, 5 did not meet the MQOs for gases only, 4 did not meet MQOs for PM, and 1 did not meet for both gases and PM.
- Among nine areas that monitored gases and PM with collocation, one achieved all MQOs.

In terms of precision, CV values among collocated $PM_{2.5}$ samplers remain high in 2018 within CARB's PQAO and generally on a national basis. 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 vs federal equivalent methods. While no definitive source of imprecision has been identified, staff has begun a discussion with monitoring agencies to closely examine operational practices in order to help the PQAO achieve the precision criteria for PM.

Although CFR criteria for precision and accuracy are generally applied and evaluated at the PQAO level, assessments at the district or site level may differ and can be important as well. Therefore, data producers are strongly encouraged to review the site-level information and assess whether their data quality objectives are met. It is important to note that when certain CFR criteria are not met, it does not necessarily mean that the corresponding air quality data should not be used, but rather, the data should be used with the knowledge of the quality behind it. The 2018 ambient data in AQS for the CARB's PQAO have been certified and are considered suitable for comparison to federal ambient air quality standards.

The statistics presented in this report are intended as assessment tools for the data producers to identify areas where program improvements can be made to achieve all MQOs set by U.S. EPA or the data producers themselves. CARB has implemented a comprehensive corrective action system throughout CARB's PQAO which is expected to serve as an essential component for improving data quality and facilitating continuous process improvement. Specifically, CARB developed the Corrective Action Notification (CAN) process that can be used to document issues that impact or potentially impact data quality, completeness, storage, or reporting. The goal of the CAN process is to investigate, correct, and reduce the recurrence of these issues. As such, the information obtained from this report can be coupled with the CAN process

to identify issues (not already identified by AQDAs), improve data quality, and ensure compliance with State, federal, and local requirements.

A complete listing of all references used in this report can be found in Appendix D.

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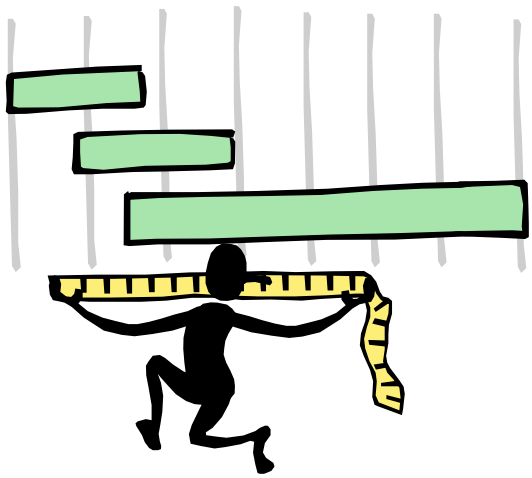
APPENDIX A

U.S. EPA's
MEASUREMENT QUALITY OBJECTIVES

TOOLS FOR ASSESSING PRECISION AND BIAS/ACCURACY

CARB's PERFORMANCE AUDIT CRITERIA



U.S. EPA's Measurement Quality Objectives

Table 1. Ambient Air Monitoring Measurement Quality Samples

(Table A-2 in 40 CFR Part 58 Appendix A; QA Handbook Volume II Appendix D, March 2017)

Method	CFR Reference	Coverage (annual)	Minimum frequency	MQOs
Automated Methods				
One-Point QC: for SO_2, NO_2, O_3, CO	Section 3.2.1	Each analyzer	Once per 2 weeks	**O_3**, 90% CL CV < 7.1% for Precision, 95% CL < ± 7.1% for Bias (< ±7.1% (percent difference) or < ±1.5 ppb difference, whichever is greater) **NO_2**, 90% CL CV < 15.1% for Precision, 95% CL < ± 15.1% for Bias (< ±15.1% (percent difference) or < ±1.5 ppb difference, whichever is greater) **SO_2**, 90% CL CV < 10.1% for Precision, 95% CL < ± 10.1% for Bias (< ±10.1% (percent difference) or < ±1.5 ppb difference, whichever is greater) **CO** 90% CL CV < 10.1% for Precision, 95% CL < ± 10.1% for Bias (< ±10.1% percent difference)
Annual performance evaluation for SO_2, NO_2, O_3, CO	Section 3.2.2	Each analyzer	Once per year	**O_3**, < 10.1 % for each audit concentration **NO_2**, **SO_2**, **CO** < 15.1 % for each audit concentration
National performance audit program for SO_2, NO_2, O_3, CO	Section 2.4	20% of sites per year	Once per year	**O_3**, < 10.1 % for each audit concentration **NO_2**, **SO_2**, **CO** < 15.1 % for each audit concentration
Flow rate verification PM_{10}, $PM_{2.5}$	Section 3.2.3	Each sampler	Once every month	PM_{10} < 10.1% of standard and design value $PM_{2.5}$ < 4.1% of standard and 5.1% of design value
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 twelve days	CV < 10.1% of samples > 3.0 µg/m^3
PM Performance evaluation program $PM_{2.5}$	Section 3.2.7	1. 5 valid audits for primary QA orgs, with ≤ 5 sites 2. 8 valid audits for primary QA orgs, with > 5 sites 3. All samplers in 6 years	Over all 4 quarters	< ± 10.1% bias for values > 3.0 µg/m^3

U.S. EPA's Measurement Quality Objectives (cont'd)

Method	CFR Reference	Coverage (annual)	Minimum frequency	MQOs
		Manual Methods		
Collocated sampling PM_{10}, $PM_{2.5}$	3.3.1 and 3.3.5	15%	Every 12 days	CV < 10.1% of $PM_{2.5}$ samples > 3.0 µg/m^3 and of PM_{10} samples > 15.0 µg/m^3
Flow rate verification PM_{10} (low Vol), $PM_{2.5}$	3.3.2	Each sampler	Once every month	< 4.1% of standard and 5.1% of design value
Flow rate verification PM_{10} (High-Vol)	3.3.2	Each sampler	Once every quarter	< 10.1% of standard and design value
Semi-annual flow rate audit PM_{10} (low Vol), $PM_{2.5}$	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} (High-Vol)	3.3.3	Each sampler, all locations	Once every 6 months	< 7.1% of standard and 10.1% of design value
Performance evaluation program $PM_{2.5}$	3.3.7 and 3.3.8	1. 5 valid audits for primary QA orgs, with ≤ 5 sites 2. 8 valid audits for primary QA orgs, with ≥ 5 sites 3. All samplers in 6 years	Over all 4 quarters	< ± 10.1% bias for values > 3.0 µg/m^3

Tools for Assessing Precision and Bias/Accuracy

Pollutant	Precision			Bias/Accuracy		
	1-Pt QC Checks	Collocated Measurements		1-Pt QC Checks	Flow Rate Verification	Performance Audits
Gaseous						
O_3, CO, NO_2, SO_2	✓			✓		annual
Continuous						
$PM_{2.5}$		✓			monthly	semi-annual
PM_{10}					monthly	semi-annual
Manual						
$PM_{2.5}$		✓			monthly	semi-annual
PM_{10} (high vol)		✓			quarterly	semi-annual
PM_{10} (low vol)		✓			monthly	semi-annual

CARB's Performance Audit Criteria

(2018)

Instrument/Criteria	Control Limit	Warning
Carbon Monoxide, Nitrogen Dioxide, Sulfur Dioxide*	± 15%	± 10%
Ozone*	± 10%	± 7%
PM10 (Dichot, Continuous) PM10 (Filter Based Low Volume, Pb Low Volume)**	± 10%	± 7%
PM10 (Filter Based High Volume)	± 7% of Transfer Standard ± 10% from Design flow rate	± 5%
PM10-2.5 (Filter Based Low Volume, PM coarse) PM10 (Filter Based Low Volume, Pb Low Volume)**	± 4% of Transfer Standard ± 5% from Design flow rate	none
PM2.5 (Filter Based, Continuous)	± 4% of Transfer Standard ± 5% from Design flow rate	none
TSP (Pb High Volume)	± 7% of Transfer Standard	± 5%
Xontech 920/924 Toxic and Carbonyl samplers	± 10%	± 7%

* Audit levels 1 and 2 are subject to the following acceptance criteria based on U.S. EPA guidance:
  - For O3, SO2, and NO2: ± 1.5 ppb difference or ± 15 percent difference, whichever is greater.
  - For CO: ± 0.03 ppm difference or ± 15 percent difference, whichever is greater.

* Annual Performance Evaluations are operational criteria, and exceedances (especially at lower levels) do not automatically invalidate the data.

Criteria for Meteorological (MET) Sensors

Ambient Temperature	± 0.5° Celsius
Barometric Pressure	± 2.25 mm of Mercury (mmHg)
Wind Direction	≤ 5° combined accuracy and orientation error
Wind Direction (starting threshold)	≤ 0.5 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

Note: CARB does not audit relative humidity, solar radiation, and vertical wind speed.

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APPENDIX B

CARB's PQAO
DATA QUALITY ISSUES

Background

This appendix contains a listing of instruments/samplers that did not meet a particular measurement quality objective (MQO). These data are provided for informational purposes only, as most MQOs are assessed at the PQAO level.

Gases - Ambient Data Completeness <75% Reported					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-025-1003-1	El Centro	Imperial County APCD	Imperial County APCD	NO_2	46% (AQDA #8394 required data to be invalidated)
06-021-0003-1	Willows-Colusa	Glenn County APCD	CARB	O3	68% (AQDA #8405 required data to be invalidated)
06-027-0002-1	White Mountain Research Station	Great Basin Unified APCD	Great Basin Unified APCD	SO_2	66% (AQDA #8387 required data to be invalidated)
Gases - Precision/Bias 1-Point Checks <75% Reported					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-025-1003-1	El Centro	Imperial County APCD	Imperial County APCD	NO_2	54% (AQDA #8394 required data to be invalidated)
06-027-0002-1	White Mountain Research Station	Great Basin Unified APCD	Great Basin Unified APCD	SO_2	73% (AQDA #8387 required data to be invalidated)
Gases – Precision/Bias Criteria Exceeded					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-089-0007-1	Anderson-North Street	Shasta County AQMD	Shasta County AQMD	O_3	Bias=7.57 (exceeded +/-7% criteria)
06-011-1002-1	Colusa-Sunrise	Colusa County APCD	CARB	O_3	Bias=10.13 (exceeded +/-7% criteria)
06-021-0003-1	Willows-Colusa	Glenn County APCD	CARB	O_3	Bias=12.23 (exceeded +/-7% criteria)
Gases – Audit Criteria or Critical Criteria Not Met					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-025-1003-1	El Centro	Imperial County APCD	Imperial County APCD	NO_2	Audit criteria exceeded (AQDA #8394)
06-103-0007-1	Red Bluff	Tehama County APCD	Tehama County APCD	O_3	Audit criteria exceeded (AQDA #8396)

Gases – Audit Criteria or Critical Criteria Not Met					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-083-1008-1	Santa Maria-South Broadway	Santa Barbara County APCD	CARB	NO_2	Low converter efficiency (AQDA #8402)
06-021-0003-1	Willows-Colusa	Glenn County APCD	CARB	O_3	Audit criteria exceeded (AQDA #8405)
06-011-1002-1	Colusa-Sunrise	Colusa County APCD	CARB	O_3	Audit criteria exceeded (AQDA #8408)
06-061-0006-1	Roseville-N. Sunrise	Placer County APCD	CARB	O_3	Audit criteria exceeded (AQDA #8409)
06-007-0008-1	Chico East Ave	Butte County APCD	CARB	O_3	Audit criteria exceeded (AQDA #8412)
06-029-0007-1	Edison	San Joaquin Valley APCD	CARB	NO_2	Audit criteria exceeded & low converter efficiency (AQDA #8414)

Gases – Audits not Performed					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-019-2016-1	Fresno-Foundry Park	San Joaquin Valley Unified APCD	San Joaquin Valley Unified APCD	NO_2	Direct NO2 is not compatible with current audit techniques
06-061-2003-1	Lincoln-2885 Moore	Placer County APCD	Placer County APCD	O_3	Started November 1, 2018, so no annual performance audit could be scheduled

PM - Ambient Data Completeness <75% Reported					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-043-1001-3	Yosemite Village	Mariposa County APCD	CARB	PM_{10}	62% downtime during Q1 2018 due to NPS staffing issues. Site impacted by Ferguson Fire.

PM - Ambient Data Completeness <75% Reported					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-083-4003-3	Vandenberg-Air Force Base	Santa Barbara County APCD	Santa Barbara County APCD	PM_{10}	69% (not-operational for two months due to instrument malfunctions)
06-025-0005-2	Calexico-Ethel	Imperial County APCD	CARB	$PM_{2.5}$	52% (Monitor experienced malfunctions throughout the year)
06-063-1010-2	Portola-Gulling	Northern Sierra AQMD	Northern Sierra AQMD	$PM_{2.5}$	71% (Samples were invalidated due to temperature exceedance during transport)
06-029-0015-1	Ridgecrest-CA Ave	Eastern Kern APCD	Eastern Kern APCD	$PM_{2.5}$	56% (operational Jan-Mar; site relocated to Ridgecrest-Ward)
PM Precision (Collocated) Data < 75% Reported					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-025-0005-2	Calexico-Ethel	Imperial County APCD	CARB	$PM_{2.5}$	50% of precision data uploaded
06-063-1010-1	Portola-Gulling	Northern Sierra AQMD	Northern Sierra AQMD	$PM_{2.5}$	63% of precision data uploaded
PM Precision Criteria (CV Limit of 10%) Not Met					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-027-0002-1	White Mountain Research Station	Great Basin Unified APCD	Great Basin Unified APCD	PM_{10}	CV = 15.64
06-027-1003-6	Keeler-Cerro Gordo Road	Great Basin Unified APCD	Great Basin Unified APCD	PM_{10}	CV = 10.01
06-019-5001-1	Clovis N-Villa Ave	San Joaquin Valley Unified APCD	San Joaquin Valley Unified APCD	$PM_{2.5}$	CV = 10.58
06-025-0005-1	Calexico-Ethel	Imperial County APCD	CARB	$PM_{2.5}$	CV = 13.42
06-027-0002-1	White Mountain Research Station	Great Basin Unified APCD	Great Basin Unified APCD	$PM_{2.5}$	CV = 21.82
06-027-1003-3	Keeler-Cerro Gordo Road	Great Basin Unified APCD	Great Basin Unified APCD	$PM_{2.5}$	CV = 15.98
06-029-0014-1	Bakersfield-5558 California Ave	San Joaquin Valley Unified APCD	CARB	$PM_{2.5}$	CV = 19.05

PM Precision Criteria (CV Limit of 10%) Not Met					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-053-1003-3	Salinas-#3	Monterey Bay ARD	Monterey Bay ARD	$PM_{2.5}$	CV = 14.46
06-067-0012-3	Folsom-Natoma Street	Sac Metro AQMD	Sac Metro AQMD	$PM_{2.5}$	CV = 18.15
06-077-1002-3	Stockton-Hazelton Street	San Joaquin Valley Unified APCD	CARB	$PM_{2.5}$	CV = 16.06
06-099-0005-3	Modesto-14th Street	San Joaquin Valley Unified APCD	CARB	$PM_{2.5}$	CV = 12.90
06-111-2002-3	Simi Valley	Ventura County APCD	Ventura County APCD	$PM_{2.5}$	CV = 14.51
PM – Audit Criteria or Critical Criteria Not Met					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-101-0003-3	Yuba City	Feather River AQMD	CARB	PM_{10}	Flow failure (AQDA #8397)
06-083-4003-3	Vandenberg Air Force Base	Santa Barbara County APCD	Santa Barbara County APCD	PM_{10}	As-is failure (AQDA #8400)
06-079-0005-2	Paso Robles	San Luis Obispo APCD	CARB	PM_{10}	Missing flow rate verification (AQDA #8406)
06-057-1001-3	Truckee	Northern Sierra AQMD	Northern Sierra AQMD	$PM_{2.5}$	Missing flow rate verification (AQDA #8403)
06-099-0006-3	Turlock-S Minaret St	San Joaquin Valley Unified APCD	San Joaquin Valley Unified APCD	$PM_{2.5}$	Missing flow rate verification (AQDA #8407)
06-025-0005-2	Calexico-Ethel	Imperial County APCD	CARB	$PM_{2.5}$	External leak test failure (AQDA #8411)
06-029-2009-3	Lebec	San Joaquin Valley Unified APCD	San Joaquin Valley Unified APCD	$PM_{2.5}$	Flow failure (AQDA #8413)

PM – Audits not Performed					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-029-0018-1	Ridgecrest-Ward Ave	Eastern Kern APCD	Eastern Kern APCD	PM_{10}	Only one audit performed due to site relocation
06-083-4003-3	Vandenberg Air Force Base	Santa Barbara County APCD	Santa Barbara County APCD	PM_{10}	Only one audit performed (site not-operational Aug-Oct)
06-029-0018-1	Ridgecrest-Ward Ave	Eastern Kern APCD	Eastern Kern APCD	$PM_{2.5}$	Only one audit performed due to site relocation

Air Quality Data Action (AQDA) and Corrective Action Notification(CAN) Issued by CARB	
Pollutant	**#AQDAs**
CO	0
NO_2	3
O_3	5
PM_{10}	3 (1 due to flow failures)
$PM_{2.5}$	6 (1 due to flow failures)
SO_2	1

Manual Adjustments to Information Output from AQS					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-017-0011	South Lake Tahoe	Placer County APCD	CARB	PM10	Replace N with Y to reflect that 2 audits were performed on June13 and Nov 17 (although they were not 5 to 7 months apart)

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APPENDIX C

DETAILED CALCULATIONS OF STATISTICS USED TO ASSESS PRECISION AND ACCURACY

The materials in this Appendix were adapted from U.S. EPA's "Guideline on the Meaning and the Use of Precision and Bias Data Required by 40 CFR Part 58 to Appendix A".

Data Quality Indicators Calculated for Each Measured Pollutant

Pollutant	*Gaseous Assessments (Precision or Bias)*	*One-Point Flow Rate Bias Estimate*	*$PM_{2.5}$ Bias*	*Semi-Annual Flow Rate Audits*	*Precision Estimate from Collocated Samples*	*Lead Bias*
O_3	Precision Estimate/ Bias Estimate					
SO_2	Precision Estimate/ Bias Estimate					
NO_2	Precision Estimate/ Bias Estimate					
CO	Precision Estimate/ Bias Estimate					
$PM_{2.5}$		One-Point Flow Rate	Bias Estimate, including PEP	Semi-Annual Flow Rate	Precision Estimate	
PM_{10}		One-Point Flow Rate		Semi-Annual Flow Rate	Precision Estimate	
Lead						Precision Estimate/ Bias Estimate

D.1 Gaseous Precision and Bias Assessments

Applies to: CO, O_3, NO_2, SO_2

40 CFR Part 58 Appendix A References:

- ***4.1.1 Percent Difference***
- ***4.1.2 Precision Estimate***
- ***4.1.3 Bias Estimate***
- ***4.1.3.1 Assigning a sign (positive / negative) to the bias estimate.***
- ***4.1.3.2 Calculate the 25th and 75th percentiles of the percent differences for each site.***

Precision and bias estimates are based on 1-point Q/C checks. Then, bias estimates are validated using the annual performance evaluations (audits).

Percent Difference

Equations from this section come from *40 CFR Pt. 58, App. A, Section 4, "Calculations for Data Quality Assessment"*. For each single point check, calculate the percent difference, d_i, as follows:

Equation 1

$$d_i = \frac{meas - audit}{audit} \cdot 100$$

where *meas* is the concentration indicated by the monitoring organization's instrument and *audit* is the audit concentration of the standard used in the QC check being measured or the audit instrument being used in the Annual Performance Evaluation.

Precision Estimate

The precision estimate is used to assess the one-point QC checks for gaseous pollutants described in section 3.2.1 of CFR Part 58, Appendix A. The precision estimator is the coefficient of variation upper bound and is calculated using Equation 2 as follows:

Equation 2

$$CV = \sqrt{\frac{n \cdot \sum_{i=1}^{n} d_i^2 - \left(\sum_{i=1}^{n} d_i\right)^2}{n(n-1)}} \cdot \sqrt{\frac{n-1}{\chi^2_{0.1,n-1}}}$$

where $\chi^2_{0.1,n-1}$ is the 10th percentile of a chi-squared distribution with *n-1* degrees of freedom.

Bias Estimate

The bias estimate is calculated using the one point QC checks for SO_2, NO_2, O_3, or CO described in CFR, section 3.2.1. The bias estimator is an upper bound on the mean absolute value of the percent differences as described in Equation 3 as follows:

Equation 3

$$|bias| = AB + t_{0.95,n-1} \cdot \frac{AS}{\sqrt{n}}$$

where n is the number of single point checks being aggregated; $t_{0.95,n-1}$ is the 95th quantile of a t-distribution with n-1 degrees of freedom; the quantity AB is the mean of the absolute values of the d_i's (calculated by Equation 1) and is expressed as Equation 4 as follows:

Equation 4

$$AB = \frac{1}{n} \cdot \sum_{i=1}^{n} |d_i|$$

and the quantity AS is the standard deviation of the absolute value of the d_i's and is calculated using Equation 5 as follows:

Equation 5

$$AS = \sqrt{\frac{n \cdot \sum_{i=1}^{n} |d_i|^2 - \left(\sum_{i=1}^{n} |d_i|\right)^2}{n(n-1)}}$$

Since the bias statistic as calculated in Equation 3 of this Appendix uses absolute values, it does not have a tendency (negative or positive bias) associated with it. A sign will be designated by rank ordering the percent differences (d_i's) of the QC check samples from a given site for a particular assessment interval. Calculate the 25th and 75th percentiles of the percent differences for each site. The absolute bias upper bound should be flagged as positive if both percentiles are positive and negative if both percentiles are negative. The absolute bias upper bound would not be flagged if the 25th and 75th percentiles are of different signs (i.e., straddling zero).

D.2 Precision Estimates from Collocated Samples

Applies to: $PM_{2.5}$, PM_{10}

40 CFR Part 58 Appendix A References:

- ***4.2.1 Precision Estimate from Collocated Samplers***
- ***4.3.1 Precision Estimate($PM_{2.5}$)***

Precision is estimated for manual instrumentation via duplicate measurements from collocated samplers at a minimum concentration (see table below for minimum concentration levels).

Minimum Concentration Levels for Particulate Matter Precision Assessments

Pollutant	Minimum Concentration Level (in µg/m^3)
$PM_{2.5}$	3
Lo-Vol PM_{10}	3
Hi-Vol PM_{10}	15

Precision is aggregated at the primary quality assurance organization (PQAO) level quarterly, annually, and at the 3-year level. For each collocated data pair, the relative percent difference, d_i, is calculated by Equation 6.

Equation 6

$$d_i = \frac{X_i - Y_i}{(X_i + Y_i)/2} \cdot 100$$

where X_i is the concentration of the primary sampler and Y_i is the concentration value from the audit sampler.

The precision upper bound statistic, CV_{ub}, is a standard deviation on d_i with a 90 percent upper confidence limit (Equation 7).

Equation 7

$$CV\_ub = \sqrt{\frac{n \cdot \sum_{i=1}^{n} d_i^{\,2} - \left(\sum_{i=1}^{n} d_i\right)^2}{2n(n-1)}} \cdot \sqrt{\frac{n-1}{\chi^2_{0.1,n-1}}}$$

where, n is the number of valid data pairs being aggregated, and $\chi^2_{0.1,n-1}$ is the 10th percentile of a chi-squared distribution with n-1 degrees of freedom. The factor of 2 in the denominator adjusts for the fact that each d_i is calculated from two values with error.

D.3 $PM_{2.5}$ Bias Assessment

Applies to: $PM_{2.5}$

40 CFR Part 58 Appendix A Reference:

- ***4.3.2 Bias Estimate ($PM_{2.5}$)***

The bias estimate is calculated using the Performance Evaluation Program (PEP) audits described in CFR, section 4.1.3 of Part 58, Appendix A. The bias estimator is based on upper and lower probability limits on the mean percent differences (Equation 1). The mean percent difference, *D*, is calculated by Equation 8 below.

Equation 8

$$D = \frac{1}{n_j} \cdot \sum_{i=1}^{n_j} d_i$$

Confidence intervals can be constructed for these average bias estimates in Equation 12 of this document using equations 9 and 10 below:

Equation 9

$$\text{Upper 90\% Confidence Interval} = D + t_{0.95,df} \cdot \frac{s_d}{\sqrt{n_j}}$$

Equation 10

$$\text{Lower 90\% Confidence Interval} = D - t_{0.95,df} \cdot \frac{s_d}{\sqrt{n_j}}$$

Where, $t_{0.95,df}$ is the 95th quantile of a t-distribution with degrees of freedom df=n_j-1 and s_d is an estimate of the variability of the average bias and is calculated using Equation 11 below:

Equation 11

$$s_d = \sqrt{\frac{\sum_{i=1}^{n_j} (d_i - D)^2}{n_j - 1}}$$

D.4 One-Point Flow Rate Bias Estimate

Applies to: PM_{10}, $PM_{2.5}$

40 CFR Part 58 Appendix A References:

- ***4.2.2 Bias Estimate Using One-Point Flow Rate Verifications (PM_{10})***

The bias estimate is calculated using the collocated audits previously described. The bias estimator is an upper bound on the mean absolute value of the percent differences (Equation 1), as described in Equation 12 as follows:

Equation 12

$$AB = \frac{1}{n} \cdot \sum_{i=1}^{n} |d_i|$$

where n is the number of flow audits being aggregated; $t_{0.95,n-1}$ is the 95th quantile of a t-distribution with n-1 degrees of freedom; the quantity AB is the mean of the absolute values of the d_i's (calculated by Equation 13) and is expressed as Equation 4 as follows:

Equation 13

$$AS = \sqrt{\frac{n \cdot \sum_{i=1}^{n} |d_i|^2 - \left(\sum_{i=1}^{n} |d_i|\right)^2}{n(n-1)}}$$

and the quantity AS is the standard deviation of the absolute value of the d_i's (Equation 4) and is calculated using Equation 14 as follows:

Equation 14

$$AS = \sqrt{\frac{n \cdot \sum_{i=1}^{n} |d_i|^2 - \left(\sum_{i=1}^{n} |d_i|\right)^2}{n(n-1)}}$$

Since the bias statistic uses absolute values, it does not have a sign direction (negative

or positive bias) associated with it. A sign will be designated by rank ordering the percent differences of the QC check samples from a given site for a particular assessment interval. Calculate the 25th and 75th percentiles of the percent differences for each site. The absolute bias upper bound should be flagged as positive if both percentiles are positive and negative if both percentiles are negative. The absolute bias upper bound would not be flagged if the 25th and 75th percentiles are of different signs (i.e., straddling zero).

D.5 Semi-Annual Flow Rate Audits

Applies to: PM_{10}, TSP, $PM_{2.5}$, $PM_{10-2.5}$

40 CFR Part 58 Appendix A References:

- ***4.2.3 Assessment Semi-Annual Flow Rate Audits***
- ***4.2.4 Percent Differences***

The flow rate audits are used to assess the results obtained from the one-point flow rate verifications and to provide an estimate of flow rate acceptability. For each flow rate audit, calculate the percent difference in volume using equation 15 of this Appendix where meas is the value indicated by the sampler's volume measurement and audit is the actual volume indicated by the auditing flow meter.

Equation 15

$$d_i = \frac{meas - audit}{audit} \cdot 100$$

To quantify this annually at the site level and at the 3-year primary quality assurance organization level, probability limits are calculated from the percent differences using equations 16 and 17 of this document where m is the mean described in equation 8 of this document and k is the total number of one-point flow rate verifications for the year

Equation 16

Upper Probability Limit = m +1.96 S

Equation 17

Lower Probability Limit = m – 1.96 S

where, m is the mean (equation 18):

Equation 18

$$m = \frac{1}{k} \cdot \sum_{i=1}^{k} d_i$$

where, k is the total number of one point QC checks for the interval being evaluated and S is the standard deviation of the percent differences (equation 19) as follows:

Equation 19

$$S = \sqrt{\frac{k \cdot \sum_{i=1}^{k} d_i^2 - \left(\sum_{i=1}^{k} d_i \right)^2}{k(k-1)}}$$

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APPENDIX D

REFERENCES

References

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