2017
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
CV	Coefficient of variation
FEM	Federal equivalent method
FRM	Federal reference method
FRV	Flow rate verification
MQO	Measurement quality objective
PEP	Performance Evaluation Program
PM	Particulate matter
POC	Parameter occurrence code
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
TSP	Total suspended particulates
TEOM	Tapered element oscillating microbalance
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 four 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 the U.S. Environmental Protection Agency's (EPA) 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. Where appropriate, comparisons to other PQAOs in California and the national average[2] are also made. The other PQAOs in California include: Bay Area Air Quality Management District (BAAQMD), San Diego County Air Pollution Control District (SDCAPCD), and South Coast Air Quality Management District (SCAQMD). It is important to note that this assessment is solely based on data available in 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 to that of 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 difference between the instrument response and 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 verifications performed by site operators. Total $PM_{2.5}$ bias for a PQAO is also assessed through the Performance Evaluation Program run by EPA.

[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}.

Accuracy for both gaseous instruments and PM samplers is further verified by the 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 2017 from both gaseous instruments and PM samplers are summarized below.

Gaseous Instruments

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

- Ninety-five percent of the gaseous instruments operating under CARB's PQAO achieved the ambient data capture rate of at least 75 percent in 2017. Most also achieved CARB's goal of at least 85 percent data capture.

- Ninety-seven percent of the gaseous instruments operating under CARB's PQAO reported at least 75 percent of the required QC checks submitted to AQS.

- CFR precision and bias/accuracy criteria (from one-point QC checks) were met at the PQAO level.

- 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.

PM Samplers

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

- Ninety-five percent of the particulate samplers operating under CARB's PQAO achieved the ambient data capture rate of at least 75 percent in 2017. Most also achieved CARB's goal of at least 85 percent capture.

- As indicated in CARB's *Annual Network Plan Covering Operations in 25 California Air Districts, June 2018,*[4] CARB's PQAO met the minimum 15 percent collocation requirement. This is an improvement compared to previous years, when one or more methods did not meet the requirement.

- For the five PM_{10} and sixteen $PM_{2.5}$ pairs of collocated samplers that were present within CARB's PQAO, all except three reported at least 75 percent of the required precision data in 2017.

- 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 three methods involving sequential samplers with very sharp cut cyclone) for which data are available. (See Table B3 for more details.)

- All PM_{10} samplers and most $PM_{2.5}$ 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 EPA, shows results consistent with the accuracy results that were evaluated via flow rate verification and audits.

[4]http://www.arb.ca.gov/aqd/amnr/amnr2018.pdf

Recommendations – PM Program

- In terms of precision, CV values among collocated $PM_{2.5}$ samplers remain high in 2017 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. In 2017, staff expanded the empirical analysis to include the evaluation of more years of data and further broke down the analysis by identifying 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.

- 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.

In an effort to compare 2017 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 2 areas that monitored gases only, and both achieved all MQOs for gases.
- Among 19 areas that monitored gases and PM without collocation, 10 met all MQOs, 3 did not meet the MQOs for gases only, and 4 did not meet MQOs for PM, and 2 did not meet for both gases and PM.
- Among 9 areas that monitored gases and PM with collocation, none achieved all MQOs.

Several monitoring sites within the CARB's PQAO had operational issues (machine malfunction, power failures, etc.), leading to the MQOs not being achieved in some geographic areas. Our evaluation of the issues indicates no systemic problems exist with the instruments or samplers; we will continue monitoring and documenting any issues that may arise.

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 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 2017 ambient data in AQS for CARB's PQAO have been certified and are considered suitable for comparison to federal standards.

In addition, data producers are encouraged to review their monitoring networks to ensure that AQS 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 and QA Results (Both Gas and PM) for Local Districts Within CARB's PQAO

Geographic Area*	All Gaseous Inst. Achieved ≥ 75% Data Capture Rates?	All Gaseous Inst. Reported ≥ 75% QC Checks?	All Gaseous Inst. Attained CFR Precision Criteria?	All Gaseous Inst. Attained CFR Bias Criteria?	All Gaseous Inst. Audited?	All Audited Inst. Met CARB Perf. Audit Criteria?	All PM Samplers Achieved ≥ 75% Data Capture Rates?	At Least 75% of Precision Data Reported from Collocated Sites?	Collocated Sites Achieved CFR Precision Criteria?	FRV Data Reported for All PM?	All PM Samplers Audited?	All Audited Samplers Met Flow Rate Audit Criteria?
Amador County	✓	✓	✓	✓	✓	✓	N/A	N/A	N/A	N/A	N/A	N/A
Antelope Valley	✓	✓	✓	✓	✓	✓	✓	N/A	N/A	✓	✓	✓
Butte County	✓	✓	✓	✓	✓	✓	✓	N/A	N/A	✓	✓	X**
Calaveras County	✓	✓	✓	✓	✓	✓	X**	N/A	N/A	✓	✓	✓
Colusa County	✓	✓	✓	✓	✓	✓	✓	N/A	N/A	✓	✓	✓
Eastern Kern	✓	✓	✓	✓	✓	✓	X	N/A	N/A	✓	✓	✓
El Dorado County	X**	X**	✓	✓	X**	✓	✓	N/A	N/A	✓	✓	X**
Feather River	X**	X**	✓	✓	✓	✓	✓	N/A	N/A	✓	✓	✓
Glenn County	✓	✓	✓	✓	✓	✓	✓	N/A	N/A	✓	✓	✓
Great Basin	X	✓	✓	✓	✓	X	✓	X	X	✓	✓	✓

Table ES-1 (cont'd). Composite Table of Ambient and QA Results (Both Gas and PM) for Local Districts Within CARB's PQAO

Geographic Area*	All Gaseous Inst. Achieved ≥ 75% Data Capture Rates?	All Gaseous Inst. Reported ≥ 75% QC Checks?	All Gaseous Inst. Attained CFR Precision Criteria?	All Gaseous Inst. Attained CFR Bias Criteria?	All Gaseous Inst. Audited?	All Audited Inst. Met CARB Perf. Audit Criteria?	All PM Samplers Achieved ≥ 75% Data Capture Rates?	At Least 75% of Precision Data Reported from Collocated Sites?	Collocated Sites Achieved CFR Precision Criteria?	FRV Data Reported for All PM?	All PM Samplers Audited?	All Audited Samplers Met Flow Rate Audit Criteria?
Imperial County	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X**
Lake County	✓	✓	✓	✓	✓	✓	✓	N/A	N/A	✓	✓	✓
Mariposa County	✓	✓	✓	✓	✓	✓	✓	N/A	N/A	✓	✓	✓
Mendocino County	✓	✓	✓	✓	✓	✓	✓	N/A	N/A	✓	✓	✓
Mojave Desert	X**	✓	✓	✓	✓	X**	✓	✓	X	✓	✓	✓
Monterey Bay	✓	✓	✓	✓	✓	✓	✓	✓	X	✓	✓	✓
North Coast	✓	✓	✓	✓	✓	✓	X	N/A	N/A	X	✓	✓
Northern Sierra	✓	✓	✓	✓	✓	✓	X	X	✓	X	✓	X
Northern Sonoma County	✓	✓	✓	✓	✓	✓	✓	N/A	N/A	✓	✓	✓
Placer County	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	✓	✓

Table ES-1 (cont'd). Composite Table of Ambient and QA Results (Both Gas and PM) for Local Districts Within CARB's PQAO

Geographic Area*	All Gaseous Inst. Achieved ≥ 75% Data Capture Rates?	All Gaseous Inst. Reported ≥ 75% QC Checks?	All Gaseous Inst. Attained CFR Precision Criteria?	All Gaseous Inst. Attained CFR Bias Criteria?	All Gaseous Inst. Audited?	All Audited Inst. Met CARB Perf. Audit Criteria?	All PM Samplers Achieved ≥ 75% Data Capture Rates?	At Least 75% of Precision Data Reported from Collocated Sites?	Collocated Sites Achieved CFR Precision Criteria?	FRV Data Reported for All PM?	All PM Samplers Audited?	All Audited Samplers Met Flow Rate Audit Criteria?
Sacramento Metropolitan	X	X	X	X	X	X	✓	✓	X	✓	✓	X
San Joaquin Valley	✓	✓	✓	✓	✓	X**	X	X	X	X**	✓	✓
San Luis Obispo County	✓	✓	✓	✓	✓	✓	✓	N/A	N/A	✓	✓	✓
Santa Barbara County	✓	✓	✓	✓	✓	X**	✓	N/A	N/A	✓	✓	✓
Shasta County	✓	X	✓	✓	✓	✓	✓	N/A	N/A	✓	✓	✓
Siskiyou County	X	✓	✓	✓	✓	X	✓	N/A	N/A	✓	✓	✓
Tehama County	X**	X**	✓	✓	✓	X**	✓	N/A	N/A	✓	✓	X
Tuolumne County	✓	✓	✓	✓	✓	✓	N/A	N/A	N/A	N/A	N/A	N/A
Ventura County	✓	✓	✓	✓	✓	✓	✓	✓	X	✓	✓	✓
Yolo-Solano	✓	✓	✓	✓	✓	X**	✓	N/A	N/A	✓	✓	✓

* Geographic Area: regional extent covered by an air district. Sites within a given district may be operated by the district, CARB, or both.
X** Impacted site operated by CARB.
FRV: flow rate verification.
✓: Met criteria. X: Did not meet criteria.
N/A = Not applicable

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 (EPA) has defined CARB as the Primary Quality Assurance Organization (PQAO) for all of California with the exception of the Bay Area Air Quality Management District (BAAQMD), the South Coast Air Quality Management District (SCAQMD), and the San Diego County Air Pollution Control District (SDCAPCD). In addition, the National Park Service (NPS) is its own PQAO at the national level; this report will not discuss NPS as a PQAO.

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.[5]

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.")

[5] 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.

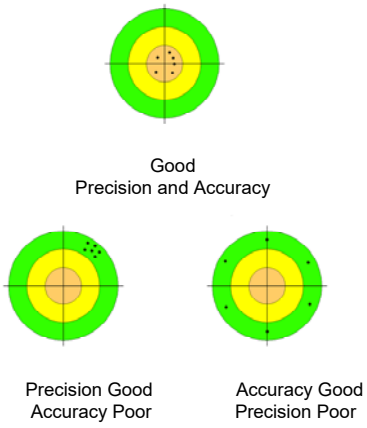
II. QUALITY ASSURANCE

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.[6] In this report, the two terms are used interchangeably.

[6] http://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

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.[7]

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 could also be flagged if monitoring agencies determine and 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.

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

The 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 six-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 six-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 http://www.arb.ca.gov/qaweb.

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 with an assessment of the quality behind the data. Statistical results presented in this report reflect the current information in AQS, with the exception of 2017 data, which is also updated to reflect corrections of data quality issues noted in Appendix B. These minor changes to 2017 data are not reflected in AQS since the data have already been certified and changing the data would require recertification. Data for 2015 and 2016 directly reflect the current information in AQS, and as such, they will reflect changes that occurred to past data since the 2016 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 2015 or 2016 data that differ from those published in the 2016 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[8] is met

[8] 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).

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 10 gaseous instruments did not report at least 75% of the required ambient data. When subjected to CARB's goal of 85%, an additional 8 instruments[9] would not meet this goal.

Table A1. Ambient Gaseous Pollutant Data Capture Results

Pollutant	PQAO	Year	# of Instruments	# of Instruments Reporting ≥ 75% Ambient Data Capture	% of Instruments Reporting ≥ 75% Ambient Data
CO	CARB	2017	25	24	96
		2016	25	24	96
		2015	31	28	90
	BAAQMD	2017	15	15	100
		2016	15	15	100
		2015	14	14	100
	SCAQMD	2017	27	27	100
		2016	27	27	100
		2015	27	26	96
	SDCAPCD	2017	2	2	100
		2016	4	4	100
		2015	4	4	100
	NATIONAL	2017	266	256	96
		2016	261	246	94
		2015	261	251	96

[9] Eight gaseous instruments that do not meet CARB's goal of 85% data capture rates are at Colusa, El Centro, Santa Maria, Davis-UCD, White Mountain Research, Maricopa, Vandenberg AFB, and Anderson.

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

Pollutant	PQAO	Year	# of Instruments	# of Instruments Reporting ≥ 75% Ambient Data Capture	% of Instruments Reporting ≥ 75% Ambient Data
NO_2	CARB	2017	52	50	96
		2016	53	52	98
		2015	53	51	96
	BAAQMD	2017	18	17	94
		2016	18	18	100
		2015	17	16	94
	SCAQMD	2017	27	27	100
		2016	27	27	100
		2015	27	27	100
	SDCAPCD	2017	7	7	100
		2016	9	9	100
		2015	9	9	100
	NATIONAL	2017	412	390	95
		2016	396	375	95
		2015	398	382	96
O_3	CARB	2017	106	101	95
		2016	105	103	98
		2015	107	106	99
	BAAQMD	2017	20	20	100
		2016	20	20	100
		2015	19	19	100
	SCAQMD	2017	29	29	100
		2016	29	29	100
		2015	29	29	100
	SDCAPCD	2017	7	7	100
		2016	9	9	100
		2015	9	9	100
	NATIONAL	2017	1138	1115	98
		2016	1015	989	97
		2015	1027	992	97

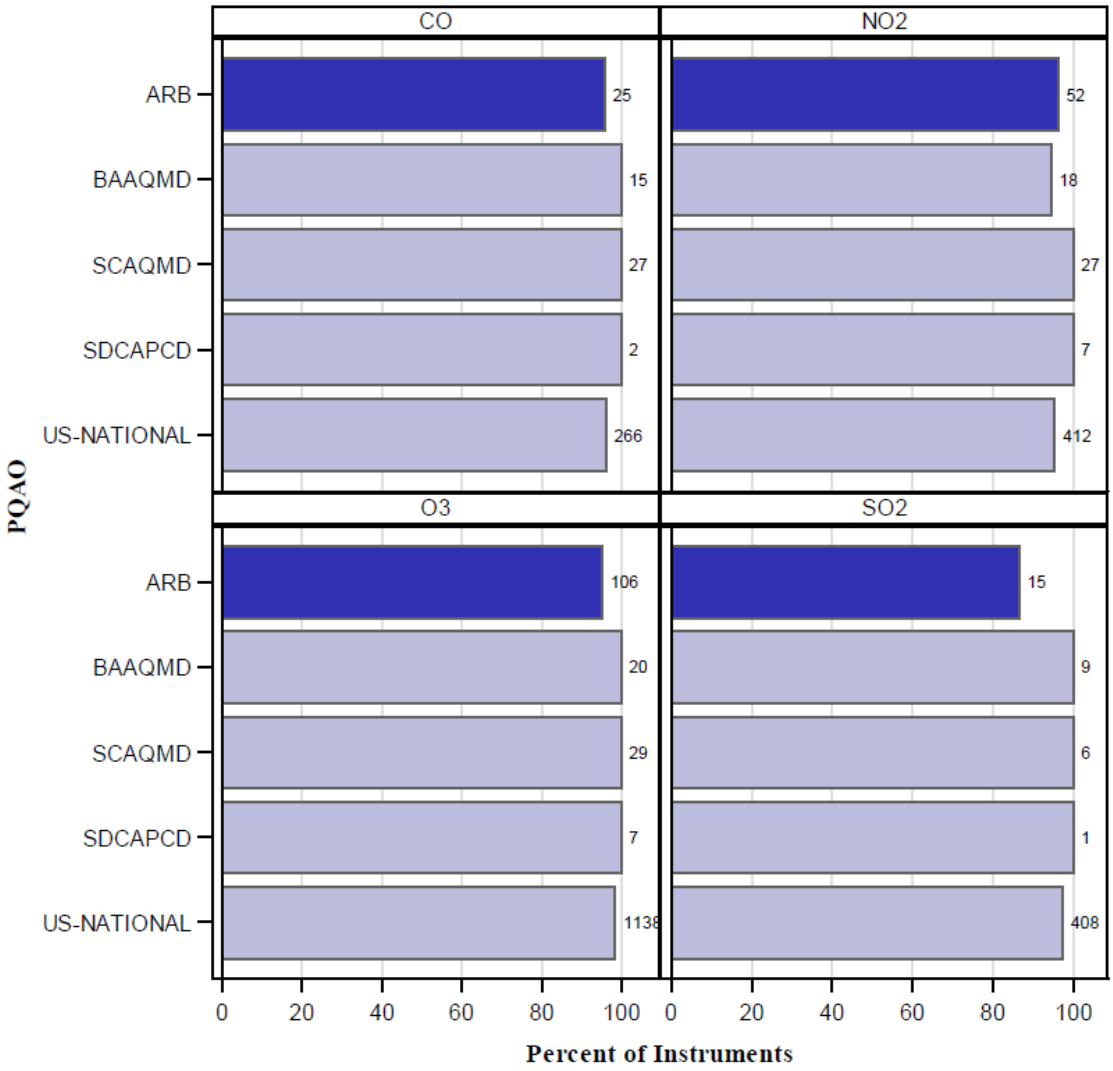
Table A1 (cont'd). Ambient Gaseous Pollutant Data Capture Results

Pollutant	PQAO	Year	# of Instruments	# of Instruments Reporting ≥ 75% Ambient Data Capture	% of Instruments Reporting ≥ 75% Ambient Data
SO_2	CARB	2017	15	13	87
		2016	15	15	100
		2015	15	15	100
	BAAQMD	2017	9	9	100
		2016	9	9	100
		2015	9	9	100
	SCAQMD	2017	6	6	100
		2016	6	6	100
		2015	6	5	83
	SDCAPCD	2017	1	1	100
		2016	2	2	100
		2015	1	1	100
	NATIONAL	2017	408	395	97
		2016	344	338	98
		2015	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 July 2018, 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 2017, including changes to past data since the 2016 Annual Data Quality Report. Therefore, results for 2016 and 2015 might differ from those in the 2016 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 July 2018, except as noted in Appendix B.

Table A2. 2017 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)	# of Instruments	# 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	B	2	2	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	4	3	75
	San Joaquin Valley Unified APCD	B	5	5	100
	Santa Barbara County APCD	B	6	6	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	2	100
	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	7	5	71
	San Joaquin Valley Unified APCD	B	17	17	100
	San Luis Obispo County APCD	D	2	2	100
	Santa Barbara County APCD	B	11	11	100
	Ventura County APCD	D	2	2	100
	Yolo-Solano AQMD	C	1	1	100
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	D	1	1	100
	El Dorado County AQMD	C	3	2	67
	Feather River AQMD	C	2	1	50
	Glenn County APCD	C	1	1	100
	Great Basin APCD	D	1	1	100
	Imperial County APCD	B	4	4	100
	Lake County APCD	D	2	2	100
	Mariposa County APCD	C	1	1	100

Table A2 (cont'd). 2017 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)	# of Instruments	# of Instruments Reporting ≥ 75% Ambient Data	% of Instruments Reporting ≥ 75% Ambient Data
O_3	Mendocino County AQMD	D	1	1	100
	Mojave Desert AQMD	B	6	5	83
	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	7	7	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	C	3	3	100
	Siskiyou County APCD	D	1	0	0
	Tehama County APCD	B	2	1	50
	Tuolumne County APCD	C	1	1	100
	Ventura County APCD	D	5	5	100
	Yolo-Solano AQMD	B	3	3	100
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	0	0
	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 July 2018, 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.[10] A detailed description of the bias estimator, including the formulae behind the calculations, can be found in Appendix C of this report.

Bias estimates are further verified via the through-the-probe performance audits. CARB acceptance criteria for performance audits for 2017 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, 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 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 2017, as shown in Table A3. Information for years 2014 and 2015 are provided for a historical perspective. Three-year averages for each PQAO are also included. In general, 2017 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 precision data reported for 2017.

[10]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.

Table A3. 2015-2017 Gaseous Pollutant Instrument Precision and Bias Results

Pollutant	PQAO	Year	# of Instruments	# of Instruments with ≥ 75% of Required Q/C checks	Upper Bound of Coefficient of Variation	CFR Criteria for Precision Met?	Bias	CFR Criteria for Bias Met?
CO	CARB	2017	25	25	4.71	Yes	± 2.67	Yes
		2016	25	24	3.59	Yes	± 2.91	Yes
		2015	31	29	4.27	Yes	± 2.85	Yes
		Avg			4.24	Yes	± 2.77	Yes
	BAAQMD	2017	15	15	1.72	Yes	± 1.41	Yes
		2016	15	15	1.55	Yes	+ 1.35	Yes
		2015	14	14	1.44	Yes	+ 1.37	Yes
		Avg			1.58	Yes	± 1.36	Yes
	SCAQMD	2017	27	27	3.26	Yes	± 2.68	Yes
		2016	27	27	3.22	Yes	± 2.62	Yes
		2015	27	26	3.45	Yes	± 2.73	Yes
		Avg			3.27	Yes	± 2.62	Yes
	SDCAPCD	2017	2	2	4.40	Yes	± 3.87	Yes
		2016	4	4	3.23	Yes	- 4.30	Yes
		2015	4	4	3.97	Yes	± 3.39	Yes
		Avg			3.96	Yes	± 3.72	Yes
	NATIONAL	2017	266	250	3.73	Yes	± 3.62	Yes
		2016	282	273	3.97	Yes	± 3.99	Yes
		2015	282	268	3.43	Yes	± 3.50	Yes
NO_2	CARB	2017	52	50	5.61	Yes	± 4.03	Yes
		2016	53	52	5.04	Yes	± 3.82	Yes
		2015	53	51	5.18	Yes	± 4.16	Yes
		Avg			5.31	Yes	± 3.96	Yes
	BAAQMD	2017	18	17	2.00	Yes	± 1.45	Yes
		2016	18	18	1.64	Yes	± 1.24	Yes
		2015	18	17	1.66	Yes	± 1.28	Yes
		Avg			1.77	Yes	± 1.31	Yes
	SCAQMD	2017	27	27	5.67	Yes	± 4.69	Yes
		2016	27	27	5.25	Yes	± 4.40	Yes
		2015	27	27	5.36	Yes	± 4.55	Yes
		Avg			5.35	Yes	± 4.46	Yes

Table A3 (cont'd). 2015-2017 Gaseous Pollutant Instrument Precision and Bias Results

Pollutant	PQAO	Year	# of Instruments	# of Instruments with ≥ 75% of Required Q/C checks	Upper Bound of Coefficient of Variation	CFR Criteria for Precision Met?	Bias	CFR Criteria for Bias Met?
NO_2	SDCAPCD	2017	7	7	4.87	Yes	± 4.20	Yes
		2016	9	9	3.45	Yes	- 4.16	Yes
		2015	10	10	2.99	Yes	- 4.22	Yes
		Avg			3.77	Yes	- 4.09	Yes
	NATIONAL	2017	412	391	4.51	Yes	± 4.42	Yes
		2016	417	394	4.25	Yes	± 4.32	Yes
		2015	418	394	4.61	Yes	± 4.28	Yes
O_3	CARB	2017	106	102	2.95	Yes	± 2.12	Yes
		2016	105	105	2.83	Yes	± 2.09	Yes
		2015	107	106	2.86	Yes	± 2.17	Yes
		Avg			2.87	Yes	± 2.11	Yes
	BAAQMD	2017	20	20	1.63	Yes	± 1.29	Yes
		2016	20	20	1.47	Yes	± 1.16	Yes
		2015	19	19	1.71	Yes	± 1.39	Yes
		Avg			1.59	Yes	± 1.26	Yes
	SCAQMD	2017	29	29	2.54	Yes	± 2.11	Yes
		2016	29	29	2.33	Yes	± 1.84	Yes
		2015	29	29	2.54	Yes	± 2.03	Yes
		Avg			2.45	Yes	± 1.96	Yes
	SDCAPCD	2017	7	7	1.94	Yes	± 1.49	Yes
		2016	9	9	2.36	Yes	± 1.74	Yes
		2015	9	7	1.78	Yes	± 1.36	Yes
		Avg			2.04	Yes	± 1.48	Yes
	NATIONAL	2017	1138	1079	2.07	Yes	± 1.98	Yes
		2016	1139	1095	2.11	Yes	±2.13	Yes
		2015	1130	1060	2.06	Yes	± 2.10	Yes
SO_2	CARB	2017	15	15	5.50	Yes	± 3.41	Yes
		2016	15	14	4.31	Yes	± 2.97	Yes
		2015	15	14	5.33	Yes	± 3.37	Yes
		Avg			5.12	Yes	± 3.17	Yes
	BAAQMD	2017	9	9	1.93	Yes	± 1.47	Yes
		2016	9	9	1.99	Yes	± 1.57	Yes
		2015	9	9	1.77	Yes	± 1.48	Yes
		Avg			1.91	Yes	± 1.48	Yes

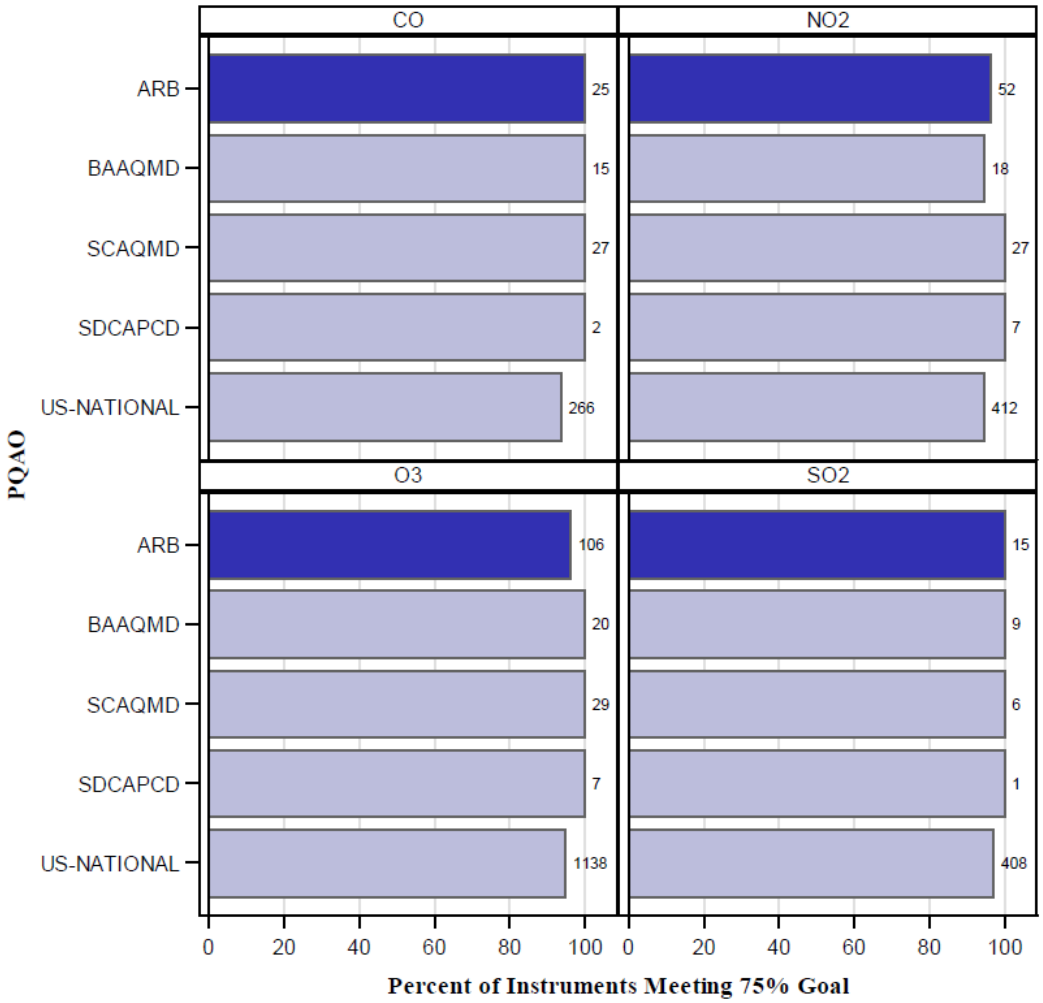
Table A3 (cont'd). 2015-2017 Gaseous Pollutant Instrument Precision and Bias Results

Pollutant	PQAO	Year	# of Instruments	# of Instruments with ≥ 75% of Required Q/C checks	Upper Bound of Coefficient of Variation	CFR Criteria for Precision Met?	Bias	CFR Criteria for Bias Met?
SO_2	SCAQMD	2017	6	6	3.81	Yes	± 3.13	Yes
		2016	6	6	3.82	Yes	± 3.21	Yes
		2015	6	6	3.92	Yes	- 5.46	Yes
		Avg			4.32	Yes	± 3.83	Yes
	SDCAPCD	2017	1	1	2.69	Yes	- 5.99	Yes
		2016	2	2	2.45	Yes	- 4.67	Yes
		2015	1	1	2.64	Yes	- 3.04	Yes
		Avg			2.78	Yes	- 4.33	Yes
	NATIONAL	2017	408	370	3.16	Yes	± 3.26	Yes
		2016	384	356	3.14	Yes	± 3.35	Yes
		2015	371	381	2.83	Yes	± 3.05	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 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 July 13, 2017.
- National average includes state, county, district, National Park Service, and tribal sites, including those in California; Note: discrepancies may exist in # 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 2016 Annual Data Quality Report. Therefore, results for 2016 and 2015 might differ from those in the 2016 DQ report.

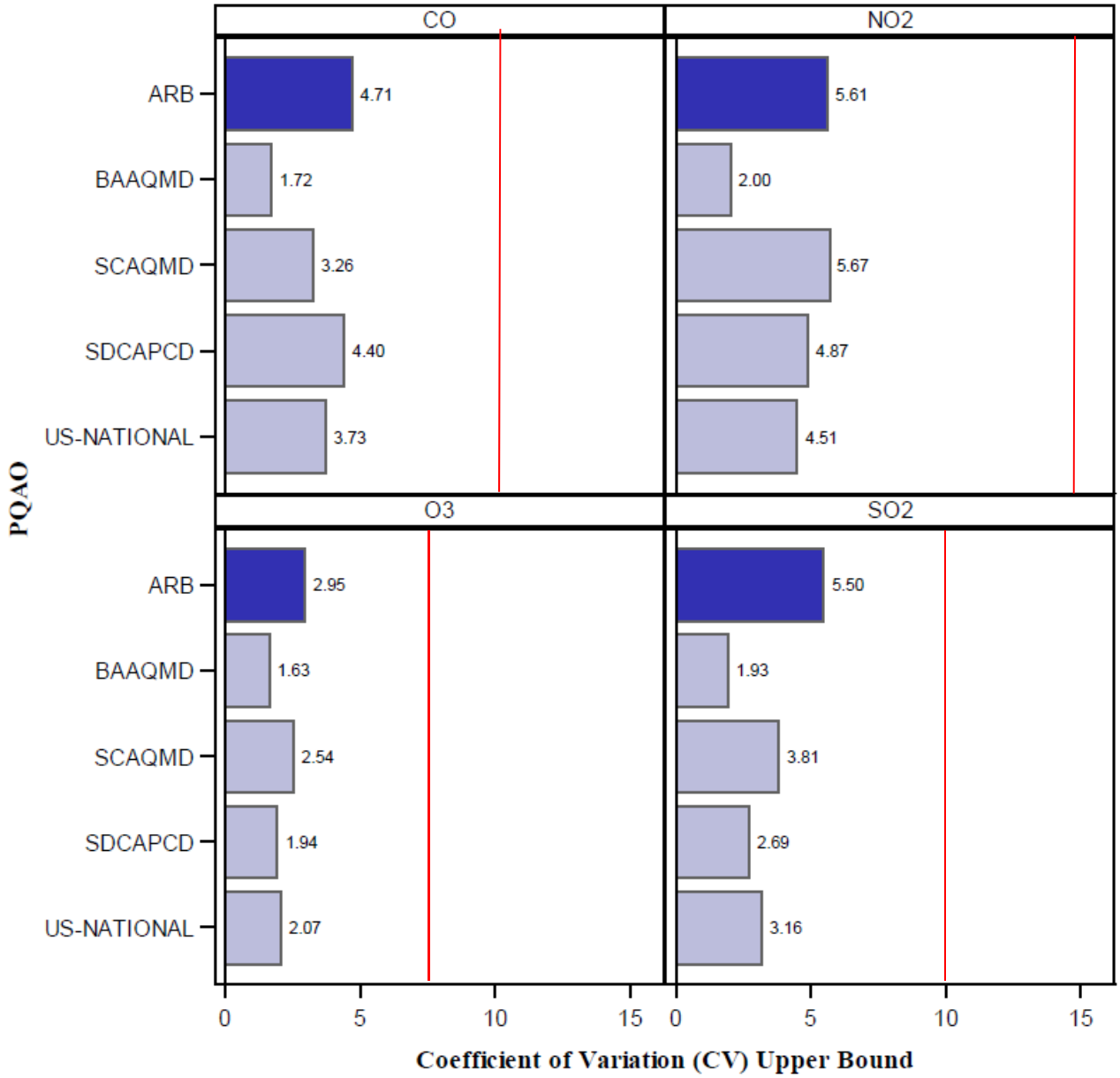
Figure A2. 2017 1-Pt Quality Control Check Completeness – Gaseous Instruments

(Total Instruments in Network Indicated Next to the Bars)



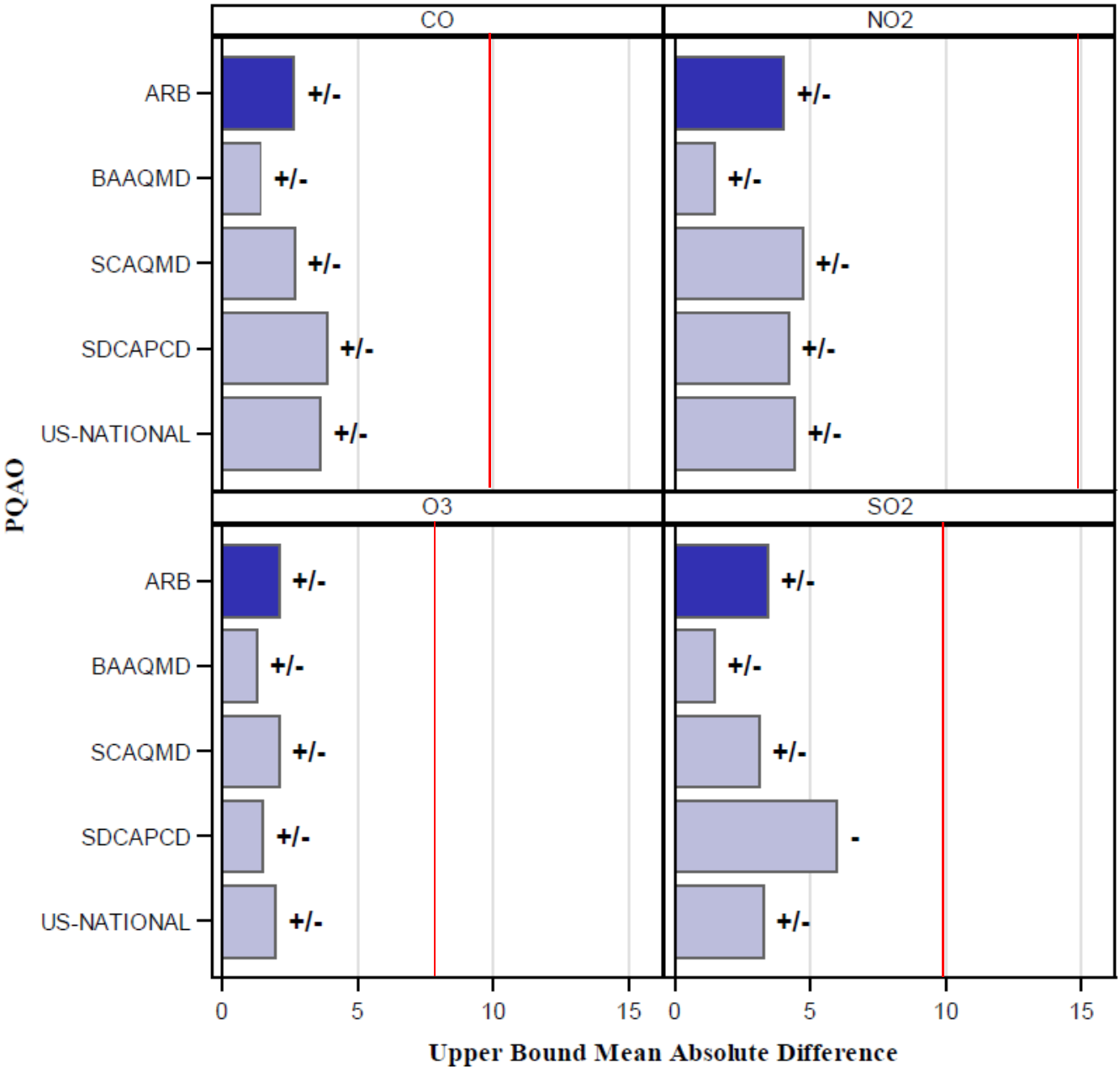
- National average includes state, county, district, National Park Service, and tribal sites, including those in California;
- Source: Air Quality System, AMP 430 Data Completeness Report, run July 2018, except as noted in Appendix B.

Figure A3. 2017 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 July 2018, except as noted in Appendix B.
- The 2017 CFR limit for precision was ± 10% for CO and SO_2, ± 7% for O_3, and ± 15% for NO_2.
- Further details on instruments not meeting these criteria can be viewed in Appendix B.

Figure A4. 2017 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 2018.
- The 2017 CFR limit for bias was ± 10% for CO and SO_2, ± 7% for O_3, and ± 15% for NO_2.
- 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, EPA provides a tool for assessing data quality in terms of three data quality indicators in graphical format.[11] At this link, 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. 2017 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)	# of Instruments	# of Instruments with ≥ 75% of Required QC checks	Upper Bound of Coefficient of Variation
CO	Antelope Valley AQMD	D	1	1	2.97
	Butte County AQMD	C	1	1	2.22
	Great Basin Unified APCD	D	1	1	2.82
	Imperial County APCD	B	2	2	1.57
	Mojave Desert AQMD	D	2	2	2.27
	Monterey Bay ARD	D	1	1	5.89
	North Coast Unified AQMD	D	2	2	2.28
	Sacramento Metropolitan AQMD	D	4	4	7.52
	San Joaquin Valley Unified APCD	B	5	5	3.47
	Santa Barbara County APCD	B	6	6	2.70
NO_2	Antelope Valley AQMD	D	1	1	3.21
	Butte County AQMD	C	1	1	2.79
	Feather River AQMD	C	1	1	4.08
	Imperial County APCD	B	2	2	6.11
	Mojave Desert AQMD	D	3	3	3.84
	Monterey Bay ARD	D	1	1	5.46
	North Coast Unified AQMD	D	2	2	3.00
	Placer County APCD	C	1	1	6.95
	Sacramento Metropolitan AQMD	B	7	5	9.84
	San Joaquin Valley Unified APCD	B	17	17	4.03
	San Luis Obispo County APCD	D	2	2	2.53

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

Table A4 (cont'd). 2017 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)	# of Instruments	# of Instruments with ≥ 75% of Required QC checks	Upper Bound of Coefficient of Variation
NO_2	Santa Barbara County APCD	B	11	11	5.60
	Ventura County APCD	D	2	2	3.41
	Yolo-Solano AQMD	C	1	1	4.94
O_3	Amador County APCD	C	1	1	3.02
	Antelope Valley AQMD	D	1	1	3.33
	Butte County AQMD	C	2	2	2.83
	Calaveras County APCD	C	1	1	3.44
	Colusa County APCD	C	1	1	2.36
	Eastern Kern APCD	D	1	1	3.38
	El Dorado County AQMD	C	3	2	2.13
	Feather River AQMD	C	2	1	1.20
	Glenn County APCD	C	1	1	2.07
	Great Basin Unified APCD	D	1	1	2.74
	Imperial County APCD	B	4	4	2.94
	Lake County APCD	D	2	2	1.00
	Mariposa County APCD	C	1	1	5.69
	Mendocino County AQMD	D	1	1	2.29
	Mojave Desert AQMD	B	6	6	2.87
	Monterey Bay ARD	D	5	5	1.65
	North Coast Unified AQMD	D	2	2	2.28
	Northern Sierra AQMD	B	1	1	1.55
	Northern Sonoma County APCD	D	1	1	1.07
	Placer County APCD	B	5	5	1.70
	Sacramento Metropolitan AQMD	B	7	7	5.49
	San Joaquin Valley Unified APCD	B	23	23	2.21
	San Luis Obispo County APCD	B	7	7	1.51
	Santa Barbara County APCD	B	12	12	2.33
	Shasta County APCD	C	3	2	3.43
	Siskiyou County APCD	D	1	1	5.82
	Tehama County APCD	B	2	1	1.17
	Tuolumne County APCD	C	1	1	2.34
	Ventura County APCD	D	5	5	2.01
	Yolo-Solano AQMD	B	3	3	2.48

Table A4 (cont'd). 2017 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)	# of Instruments	# of Instruments with ≥ 75% of Required QC checks	Upper Bound of Coefficient of Variation
SO_2	Great Basin APCD	D	1	1	5.81
	Imperial County APCD	C	1	1	1.57
	Mojave Desert AQMD	D	2	2	3.50
	North Coast Unified AQMD	D	2	2	4.21
	Sacramento Metropolitan AQMD	D	1	1	15.61
	San Joaquin Valley Unified APCD	C	1	1	8.61
	San Luis Obispo County APCD	B	1	1	1.16
	Santa Barbara County APCD	D	6	6	2.98

- 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 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 July 2018.

An Assessment of Individual 1-Point QC Checks for Gases: In March 2017, EPA revised QA Handbook Volume II, Appendix D, Measurement Quality Objectives and Validation Templates to include 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 and SO_2; < +15.1% (percent difference) or < + 1.5 ppb difference, whichever is greater, for NO_2. Since the revisions did not apply to the entire 12 months in 2017, the following summary is for informational purposes only. Note that while the summary statistics for CARB's PQAO are less than perfect, as a general rule, CARB-operated sites perform more frequent QC checks than required by EPA, and many of the exceedances are often associated with ambient data being affected by issues identified through the AQDA process. A formal assessment for a complete 12-month period will be included in next year's report.

Table A4-1 2017 Gaseous Pollutant 1-Point QC Checks – Individual Assessment

Pollutant	PQAO	Number of Instruments	Number of QC Checks	Number QC Checks Meeting Criteria	Percent of QC Checks Meeting Criteria
CO	CARB	25	3,967	3,956	99.7%
	BAAQMD	15	2,285	2,285	100%
	SCAQMD	27	683	682	99.9%
	SDCAPCD	2	104	104	100%
NO_2	CARB	52	9,162	9,133	99.7%
	BAAQMD	18	2,585	2,585	100%
	SCAQMD	27	683	682	99.9%
	SDCAPCD	7	360	360	100%
O_3	CARB	106	18,761	18,527	98.8%
	BAAQMD	20	2,785	2,785	100%
	SCAQMD	29	735	733	99.7%
	SDCAPCD	7	242	242	100%
SO_2	CARB	15	1,389	1,325	95.4%
	BAAQMD	9	1,369	1,369	100%
	SCAQMD	6	145	145	100%
	SDCAPCD	1	51	49	96.1%

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 2017 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.

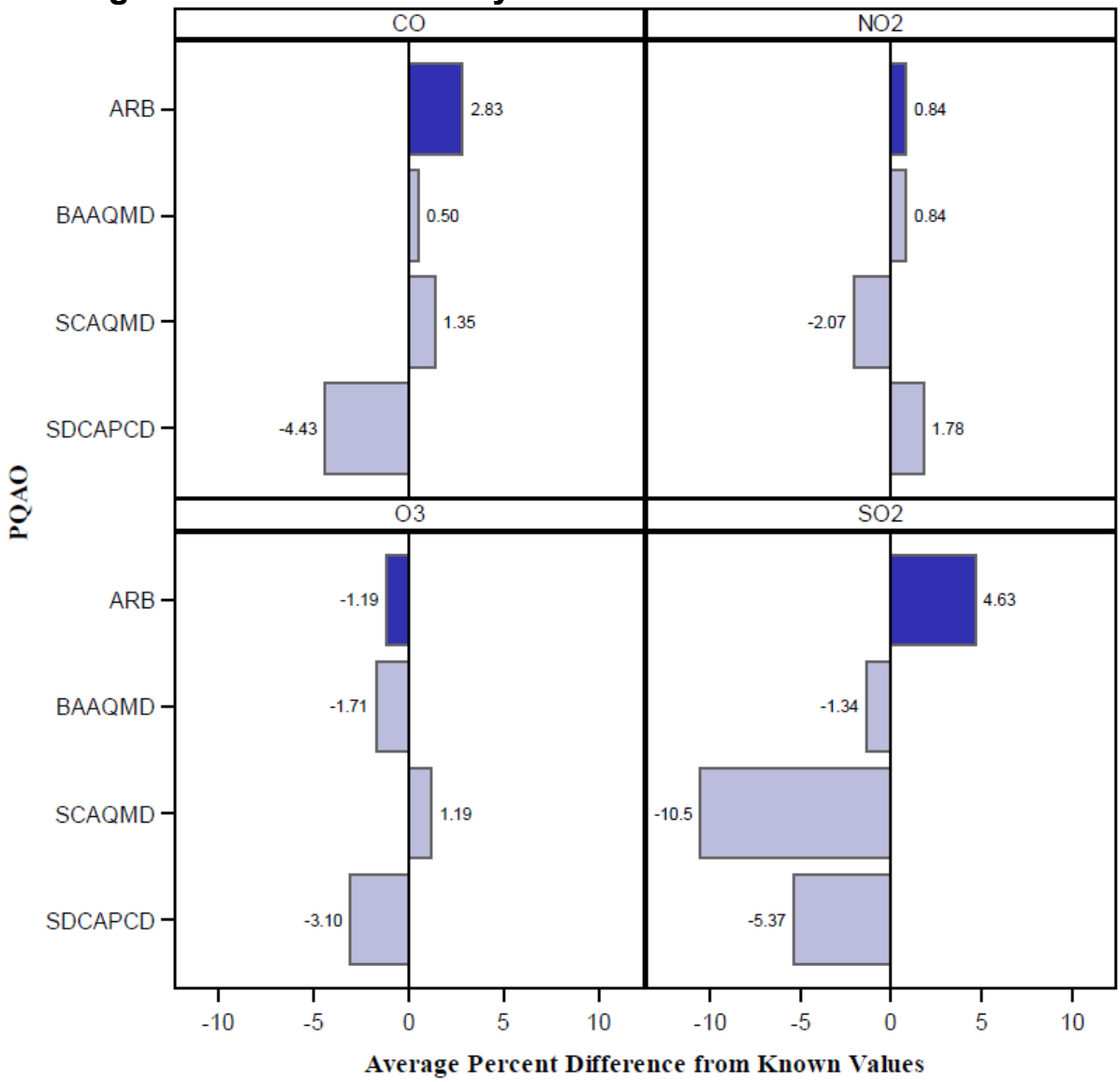
Performance audit results in 2017 corroborate what the QC checks revealed: that CARB's PQAO is providing accurate data for all gaseous pollutants. The average percent differences at the PQAO level were well below the audit criteria (±10 percent for ozone, ±15 percent for other gases) for all gaseous pollutants. This fact is further strengthened by the small number of audits that did not meet CARB performance audit criteria.

Table A5. 2017 Results for Performance Audits of Gaseous Pollutant Instruments

Pollutant	PQAO	# of Instruments	# of Instruments Audited	# of Audits Not Meeting CARB Criteria	Average Percent Difference
CO	CARB	25	25	1	2.83
	BAAQMD	15	15	0	0.50
	SCAQMD	27	27	1	1.35
	SDCAPCD	2	2	1	-4.43
NO_2	CARB	52	51	1	0.84
	BAAQMD	18	17	0	0.84
	SCAQMD	27	27	1	-2.07
	SDCAPCD	7	7	1	1.78
O_3	CARB	106	105	4	-1.19
	BAAQMD	20	20	1	-1.71
	SCAQMD	29	29	1	1.19
	SDCAPCD	7	7	1	-3.10
SO_2	CARB	15	15	2	4.63
	BAAQMD	9	9	0	-1.34
	SCAQMD	6	6	1	-10.55
	SDCAPCD	1	1	0	-5.37

- The CARB performance audit criteria for 2017 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 July 2018.

Figure A5. 2017 Accuracy via Audits – Gaseous Instruments



- AMP 256 Data Quality Indicator Report, run July 2018.
- The CARB performance audit criteria for 2017 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. 2017 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	Average Percent Difference
CO	Antelope Valley AQMD	D	1	1	3.51
	Butte County AQMD	C	1	1	2.92
	Great Basin APCD	D	1	1	6.72
	Imperial County APCD	B	2	2	0.97
	Mojave Desert AQMD	D	2	2	-1.38
	Monterey Bay ARD	D	1	1	-4.98
	North Coast Unified AQMD	D	2	2	6.25
	Sacramento Metropolitan AQMD	D	4	4	1.84
	San Joaquin Valley Unified APCD	B	5	5	5.14
	Santa Barbara County APCD	B	6	6	2.77
NO_2	Antelope Valley AQMD	D	1	1	-0.42
	Butte County AQMD	C	1	1	5.01
	Feather River AQMD	C	1	1	-1.76
	Imperial County APCD	B	2	2	-1.96
	Mojave Desert AQMD	D	3	3	-0.90
	Monterey Bay ARD	D	1	1	2.59
	North Coast Unified AQMD	D	2	2	7.10
	Placer County APCD	C	1	1	-0.34
	Sacramento Metropolitan AQMD	B	7	6	-7.05
	San Joaquin Valley Unified APCD	B	17	17	0.92
	San Luis Obispo County APCD	D	2	2	-1.83
	Santa Barbara County APCD	B	11	11	0.83
	Ventura County APCD	D	2	2	-2.53
	Yolo-Solano AQMD	C	1	1	-11.45
O_3	Amador County APCD	C	1	1	-8.34
	Antelope Valley AQMD	D	1	1	-3.60
	Butte County AQMD	C	2	2	-6.00
	Calaveras County APCD	C	1	1	-1.84
	Colusa County APCD	C	1	1	-1.97
	Eastern Kern APCD	D	1	1	-4.11
	El Dorado County AQMD	C	3	2	-5.52
	Feather River AQMD	C	2	2	1.51
	Glenn County APCD	C	1	1	-1.31
	Great Basin APCD	D	1	1	4.58
	Imperial County APCD	B	4	4	-4.32
	Lake County APCD	D	2	2	-2.03
	Mariposa County APCD	C	1	1	-6.89

Table A6 (cont'd). 2017 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	Average Percent Difference
O_3	Mendocino County AQMD	D	1	1	-3.35
	Mojave Desert AQMD	B	6	6	-3.74
	Monterey Bay ARD	D	5	5	1.75
	North Coast Unified AQMD	D	2	2	1.42
	Northern Sierra AQMD	B	1	1	4.50
	Northern Sonoma County APCD	D	1	1	0.46
	Placer County APCD	B	5	5	-2.19
	Sacramento Metropolitan AQMD	B	7	7	-1.45
	San Joaquin Valley Unified APCD	B	23	23	-1.14
	San Luis Obispo County APCD	B	7	7	-1.05
	Santa Barbara County APCD	B	12	12	-0.43
	Shasta County AQMD	C	3	3	-7.73
	Siskiyou County APCD	D	1	1	8.14
	Tehama County APCD	B	2	2	1.55
	Tuolumne County APCD	C	1	1	8.13
	Ventura County APCD	D	5	5	0.58
	Yolo-Solano AQMD	B	3	3	-2.88
SO_2	Great Basin APCD	D	1	1	0.00
	Imperial County APCD	C	1	1	-2.21
	Mojave Desert AQMD	D	2	2	3.32
	North Coast Unified AQMD	D	2	2	8.49
	Sacramento Metropolitan AQMD	D	1	1	0.00
	San Joaquin Valley Unified APCD	C	1	1	16.10*
	San Luis Obispo County APCD	B	1	1	5.52
	Santa Barbara County APCD	D	6	6	1.89

- The CARB performance audit criteria for 2017 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 2018.

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[12] 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 2017. In fact, only ten PM samplers reported less than 75% ambient data in 2017. When subjected to CARB's goal of 85%, an additional five samplers[13] did not meet this goal.

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 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

[12] 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.

[13] PM samplers at Eureka-Humbodt, Truckee, Paso Robles, Santa Maria, and Lompoc do not meet CARB's goal of 85% data capture.

data is required to be in AQS. Several of the collocated sampler pairs within the CARB's PQAO experienced operational issues during parts of 2017; hence, about 92 percent achieved the data capture rates.

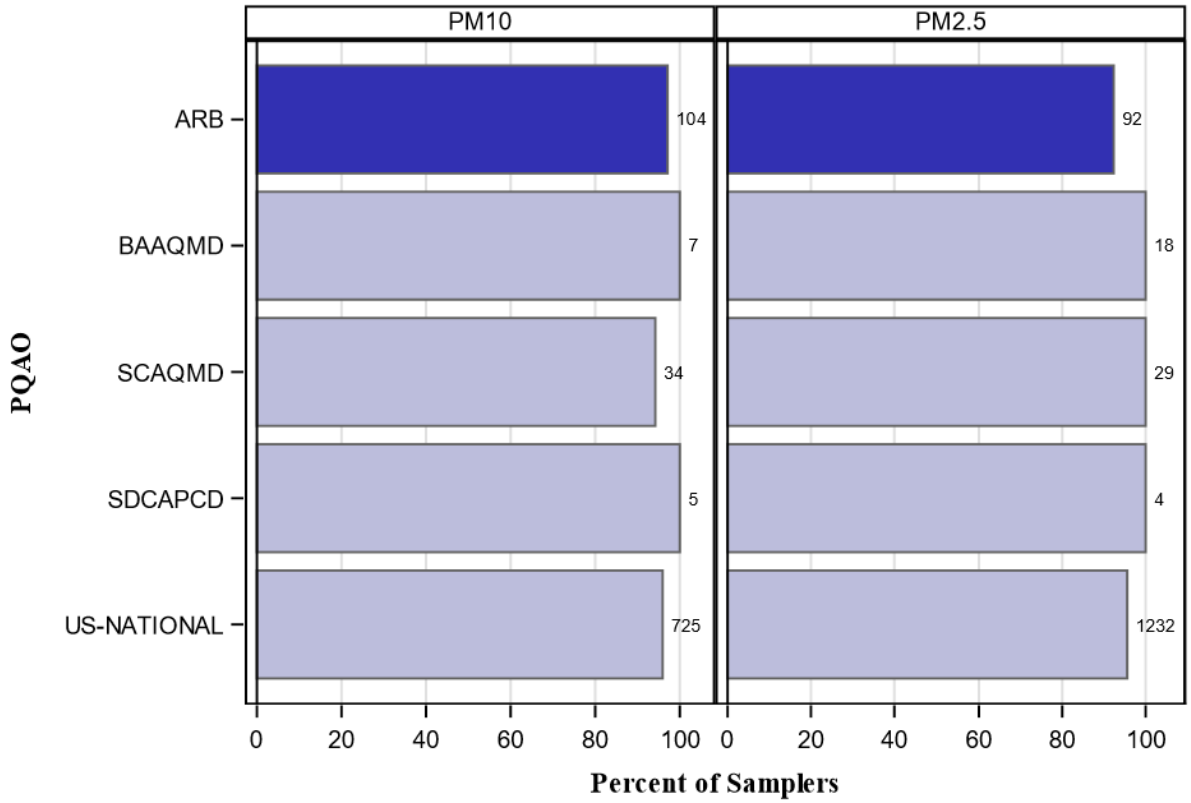
Table B1. 2017 Ambient PM Data Capture Results

Pollutant	PQAO	Year	# of Samplers	# of Samplers Reporting ≥ 75% Data Capture	% of Samplers Reporting ≥ 75% Data Capture
PM_{10}	CARB	2017	104	101	97
		2016	103	102	99
		2015	111	105	95
	BAAQMD	2017	7	7	100
		2016	9	9	100
		2015	8	8	100
	SCAQMD	2017	34	32	94
		2016	34	33	97
		2015	33	32	97
	SDCAPCD	2017	5	5	100
		2016	7	7	100
		2015	7	7	100
	NATIONAL	2017	725	695	96
		2016	747	708	95
		2015	768	736	96
$PM_{2.5}$	CARB	2017	92	85	92*
		2016	86	83	97
		2015	88	80	91
	BAAQMD	2017	18	18	100
		2016	19	19	100
		2015	18	18	100
	SCAQMD	2017	29	29	100
		2016	25	25	100
		2015	23	23	100
	SDCAPCD	2017	4	4	100
		2016	6	6	100
		2015	6	6	100
	NATIONAL	2017	1232	1178	96
		2016	1136	1082	95
		2015	1108	1048	95

- *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 2018, except as noted in Appendix B.
- Results reflect current information in AQS, including changes to past data since the 2016 Annual Data Quality Report. Therefore, results for 2016 and 2015 might differ from those in the 2016 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 July 2018, 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 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. 2017 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)	# of Samplers	# 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	0	0*
	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	18	18	100
	Imperial County APCD	D	5	5	100
	Lake County APCD	D	4	4	100
	Mariposa County APCD	C	1	1	100
	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	0	0*
	Northern Sonoma County APCD	D	3	3	100
	Placer County APCD	C	1	1	100
	Sacramento Metropolitan AQMD	B	7	7	100
	San Joaquin Valley Unified APCD	B	22	21	96*
	San Luis Obispo County APCD	D	7	7	100
	Santa Barbara County APCD	B	7	7	100
	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	0	0*
	Colusa County APCD	C	1	1	100
	Eastern Kern APCD	D	2	1	50*
	Feather River AQMD	C	1	1	100
	Great Basin Unified APCD	D	4	4	100
	Imperial County APCD	D	4	4	100
	Lake County APCD	D	2	2	100
	Mendocino County AQMD	D	2	2	100
	Mojave Desert AQMD	D	2	2	100
	Monterey Bay ARD	D	7	7	100
	North Coast Unified AQMD	D	4	2	50*
	Northern Sierra AQMD	D	6	4	67*

Table B2 (cont'd). 2017 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)	# of Samplers	# of Samplers Reporting ≥ 75% Data	% of Samplers Reporting ≥ 75% Data
$PM_{2.5}$	Placer County APCD	B	3	3	100
	Sacramento Metropolitan AQMD	B	7	7	100
	San Joaquin Valley Unified APCD	B	26	25	96*
	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	1	1	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 July 2018, 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, June 2018.*[14] As indicated there, CARB has met the 15 percent minimum collocation requirement in 2017 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 2017, lead 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 2015 and 2016 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:

- For the five PM_{10} and sixteen $PM_{2.5}$ pairs of collocated samplers that were present within CARB's PQAO, all except three reported at least 75 percent of the required precision data in 2017.
- 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 methods 143, 145, and 204 – sequential samplers with VSCC) for which data are available. CV values have remained about the same from 2016 to 2017.

[14] http://www.arb.ca.gov/aqd/amnr/amnr2018.pdf
[15] In 2017, there are two lead samplers in CARB's PQAO: Fresno-Garland and Calexico-Ethel. Neither has a collocated sampler.

Table B3. 2015-2017 Precision Results Based on Available Collocated PM Samplers

Pollutant	PQAO	Year	Method Code	# Pairs of Collocated Samplers Reported	% Precision Completeness	Upper Bound of Coefficient of Variation	CFR Criteria for Precision Met?
PM_{10}	CARB	2017	ALL	5	100	***17.76***	No
		2016	ALL	4	100	11.04	No
		2015	ALL	4	100	11.52	No
		Avg			100	13.38	No
	BAAQMD	2017	ALL	1	100	4.86	Yes
		2016	ALL	2	100	6.79	Yes
		2015	ALL	1	100	15.62	No
		Avg			100	9.34	Yes
	SCAQMD	2017	ALL	3	100	9.22	Yes
		2016	ALL	3	100	6.65	Yes
		2015	ALL	3	100	10.11	No
		Avg			100	8.34	Yes
	SDCAPCD	2017	ALL	1	100	3.64	Yes
		2016	ALL	1	100	2.84	Yes
		2015	ALL	1	100	2.53	Yes
		Avg			100	3.00	Yes
	NATIONAL	2017	ALL	112	97	9.20	Yes
		2016	ALL	126	96	9.69	Yes
		2015	ALL	129	98	9.24	Yes
$PM_{2.5}$	CARB	2017	143	1	100	9.96	Yes
		2016	143	1	96	20.02	No
		2015	143	1	46	4.08	Yes
		2017	145	5	76	7.11	Yes
		2016	145	5	92	6.43	Yes
		2015	145	5	74	17.56	No
		2017	170	7	100	***15.54***	No
		2016	170	7	100	22.37	No
		2015	170	6	100	18.00	No
		2017	181	1	100	***16.66***	No
		2016	181	1	100	15.95	No
		2015	181	1	100	17.34	No
		2017	204	1	100	8.72	Yes
		2016	204	NDA	NDA	NDA	NDA
		2015	204	NDA	NDA	NDA	NDA
		2017	238	1	40	***37.19***	No
		2016	238	NDA	NDA	NDA	NDA
		2015	238	NDA	NDA	NDA	NDA

Table B3 (cont'd). 2015-2017 Precision Results Based on Available Collocated PM Samplers

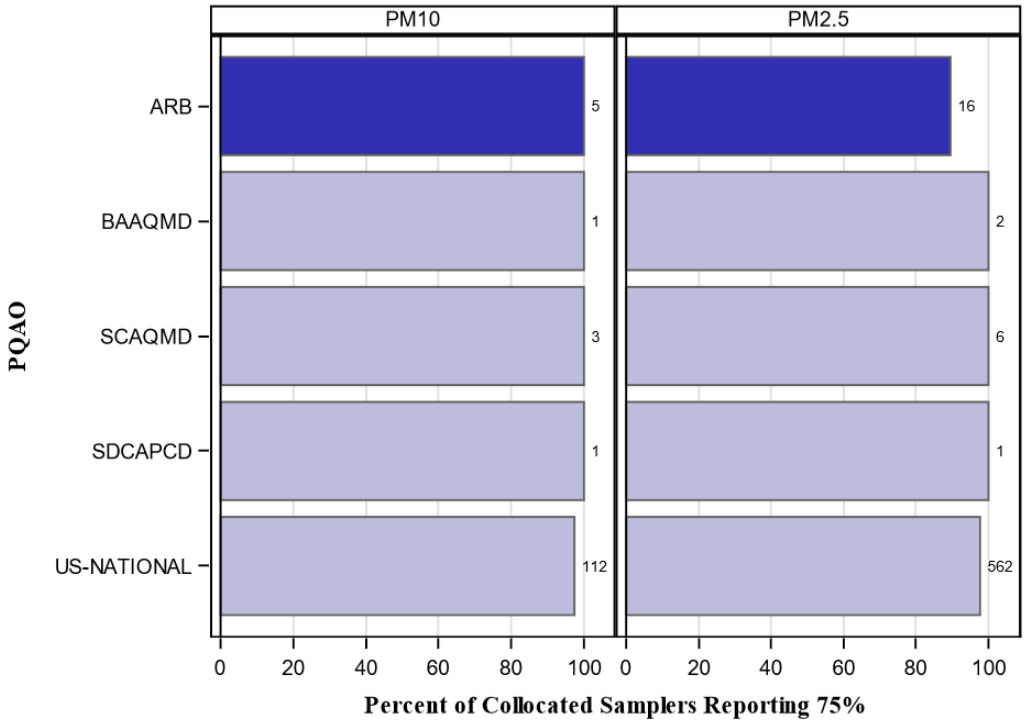
Pollutant	PQAO	Year	Method Code	# Pairs of Collocated Samplers Reported	% Precision Completeness	Upper Bound of Coefficient of Variation	CFR Criteria for Precision Met?
$PM_{2.5}$	BAAQMD	2017	170	2	100	***14.18***	No
		2016	170	2	100	20.84	No
		2015	170	2	100	16.36	No
	SCAQMD	2017	143	1	100	2.81	Yes
		2016	143	NDA	NDA	NDA	NDA
		2015	143	NDA	NDA	NDA	NDA
		2017	145	3	100	4.67	Yes
		2016	145	3	100	7.47	Yes
		2015	145	3	100	10.07	No
		2017	155	2	100	4.73	Yes
		2016	155	NDA	NDA	NDA	NDA
		2015	155	NDA	NDA	NDA	NDA
	SDCAPCD	2017	145	1	100	3.77	Yes
		2016	145	1	100	4.11	Yes
		2015	145	1	100	7.93	Yes
	NATIONAL	2017	117	1	100	3.72	Yes
		2016	117	2	91	5.97	Yes
		2015	117	3	100	16.93	No
		2017	118	9	69	***14.38***	No
		2016	118	48	82	8.03	Yes
		2015	118	61	100	8.14	No
		2017	120	NDA	NDA	NDA	NDA
		2016	120	3	83	7.83	Yes
		2015	120	7	72	14.50	No
		2017	143	11	96	8.78	Yes
		2016	143	11	99	11.08	No
		2015	143	11	88	10.69	No
		2017	145	124	97	9.55	Yes
		2016	145	113	94	9.41	Yes
		2015	145	85	96	8.72	Yes

Table B3 (cont'd). 2015-2017 Precision Results Based on Available Collocated PM Samplers

Pollutant	PQAO	Year	Method Code	# Pairs of Collocated Samplers Reported	% Precision Completeness	Upper Bound of Coefficient of Variation	CFR Criteria for Precision Met?
$PM_{2.5}$	NATIONAL	2017	170	51	99	***22.14***	No
		2016	170	45	99	19.35	No
		2015	170	45	100	18.66	No
		2017	181	5	100	***13.28***	No
		2016	181	4	100	14.23	No
		2015	181	3	100	18.53	No
		2017	204	2	100	***11.89***	No
		2016	204	1	100	15.12	No
		2015	204	1	100	12.34	No
		2017	238	3	79	***23.33***	No
		2016	238	NDA	NDA	NDA	NDA
		2015	238	NDA	NDA	NDA	NDA

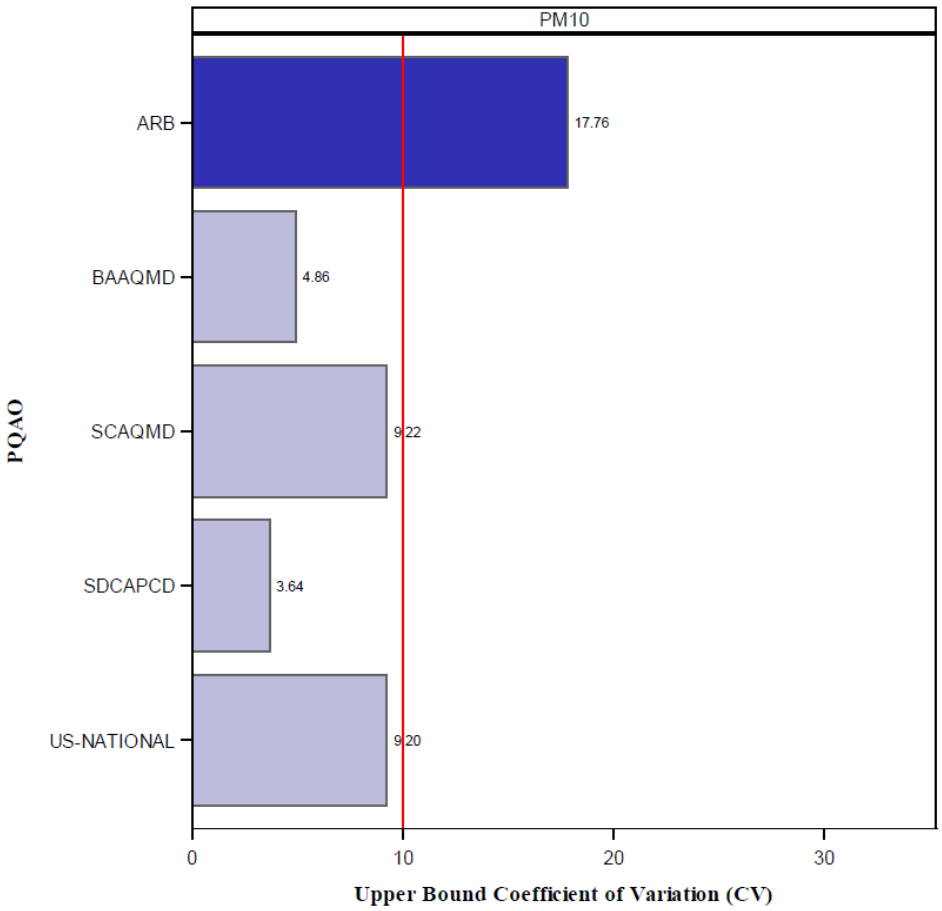
- CFR Limit is a coefficient of variation of ≤ 10% for PM. Percent precision completeness is based on data collected from collocated samples. Further details on samplers not meeting these criteria can be found in Appendix B.
- Method 117 = R & P Model 2000 PM2.5 Sampler w/WINS; Method 118= R & P Model 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 2017 while underlined font indicates CV greater than 10% in 2016 or 2015.
- 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 July 2018.
- 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 2016 Annual Data Quality Report. Therefore, results for 2016 and 2015 might differ from those in the 2016 DQ report.

Figure B2. 2017 Precision Completeness - PM



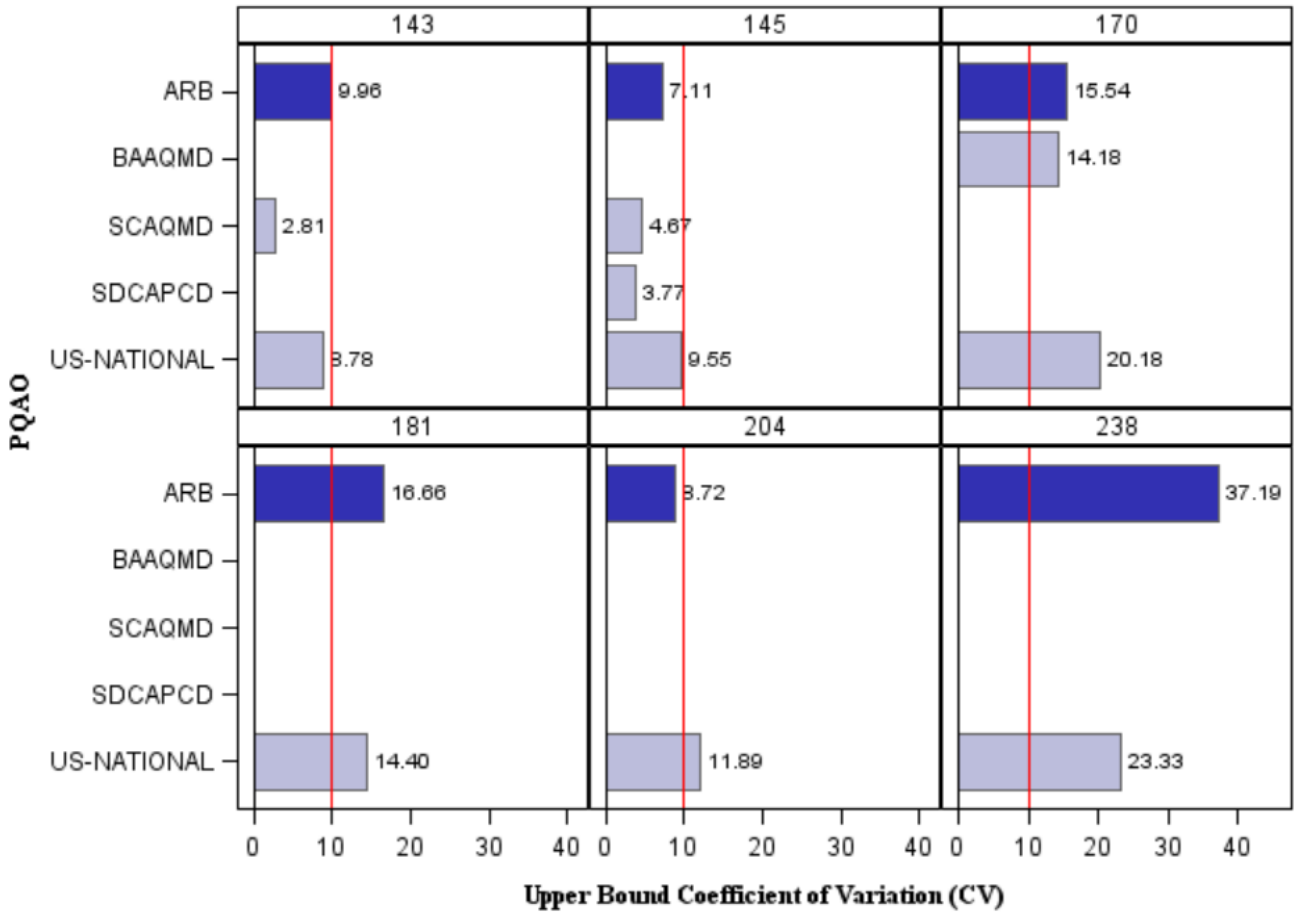
- National average includes state, county, district, National Park Service, and tribal sites, including those in California.
- Source: Air Quality System, AMP 430 Data Completeness Report, run July 2018, except as noted in Appendix B.

Figure B3. 2017 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 July 2018. 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.

Figure B4. 2017 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: Air Quality System, AMP 256 Data Quality Indicator Report, run July 2018, 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 July 2018, 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.

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, Northern Sierra, and San Joaquin Valley) 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: Imperial County APCD, Northern Sierra AQMD, Placer County APCD, and San Joaquin Valley Unified APCD. In all instances, method 145 played a role in the collocations. Note the same number of collocated locations achieved the CV limit for $PM_{2.5}$ in 2016.

It is noteworthy that the high CV problem exists at the national level as well as within the CARB PQAO. In 2017, 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. In 2017, staff expanded the empirical analysis to include the evaluation of more years of data and further broke down the analysis by identifying 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.

Table B4. 2017 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	84	***24.81***
	Sacramento Metro AQMD	All	D	100	3.57
	San Joaquin Valley APCD	All	D C	100 97	2.64 2.68
$PM_{2.5}$	Great Basin Unified APCD	181/145 238/170	D D	100 40	***16.66*** ***37.19***
	Imperial County APCD	145/145	C	87	4.61
	Mojave Desert AQMD	170/170	D	100	***11.25***
	Monterey Bay ARD	170/143	D	100	***15.36***
	Northern Sierra AQMD	145/145	D	50	5.67
	Placer County APCD	143/143	C	100	9.96
	Sacramento Metro AQMD	145/145 170/170	D D	83 100	***11.07*** ***18.45***
	San Joaquin Valley APCD	145/145 145/145 170/145 170/170 170/143 204/145	C C D C C D	80 80 70 100 90 100	***11.55*** 3.27 ***26.61*** ***18.14*** ***10.95*** 8.72
	Ventura County APCD	170/170	D	100	***11.72***

- 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 2017.
- 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 July 2018.

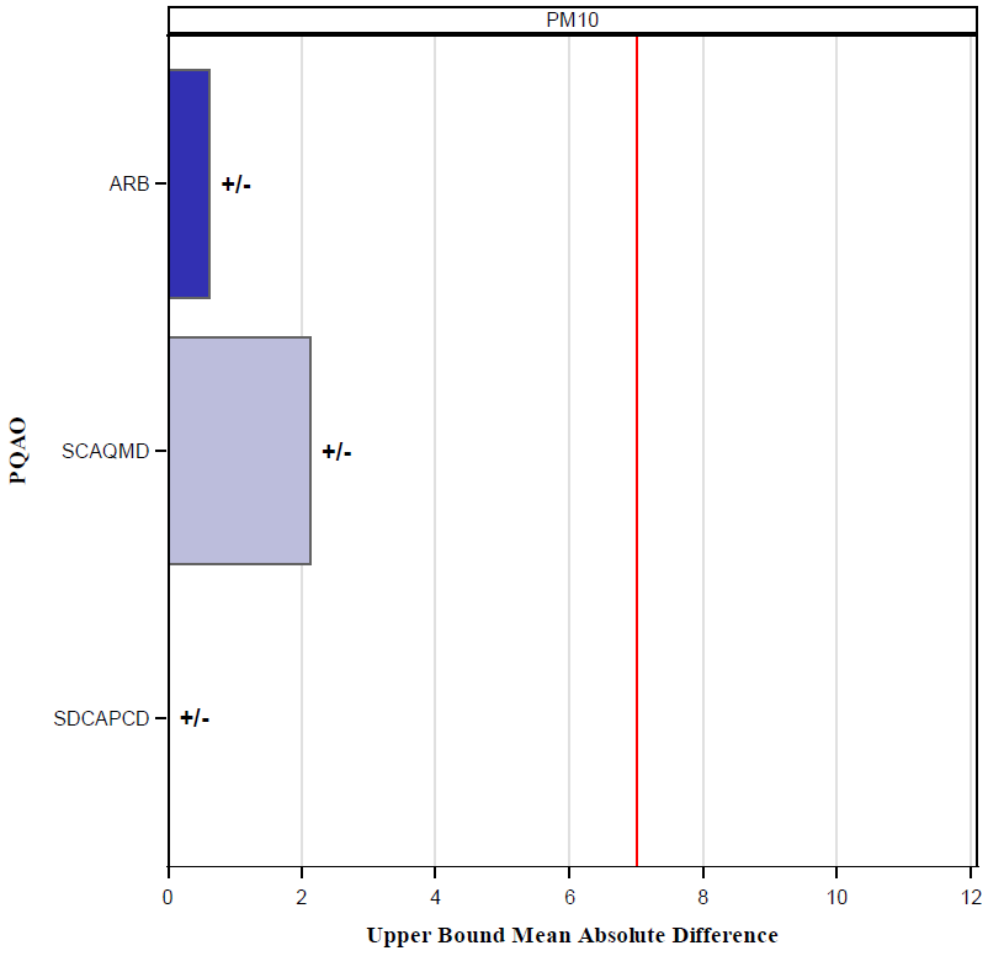
Bias Results via Monthly Flow Rate Verifications: Starting in April 2016, flow rate verification data are required to be in AQS for all PM samplers. 2017 was the first year when this requirement was in effect for the entire 12-month period. Bias results via the monthly flow rate verifications for all samplers in 2017 and for continuous PM_{10} samplers in 2015 and 2016 are shown in Table B5-1. Hence, a 3-year average would not be appropriate. Similar info for $PM_{2.5}$ samplers are shown in Table B5-2. Note that all of CARB's continuous PM_{10} samplers and a high percentage of $PM_{2.5}$ samplers reported FRV data to AQS in 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. Figures B6 and B7 display the summary statistics.

Table B5-1. PM_{10} Bias Results Based on Flow Rate Verifications

Pollutant	PQAO	Year	# of Samplers in Network	# of Samplers Reporting Flow Rates	Average % Difference	Bias (%)	CFR Criteria for Bias Met?
PM_{10}	CARB	2017	104	104	-0.24	± 0.62	Yes
		2016*	66	66	-0.21	± 0.38	Yes
		2015*	72	68	0.23	± 0.13	Yes
		Avg			N/A	N/A	N/A
	SDCAPCD	2017	4	4	0.22	±2.01	Yes
		2016*	2	0	NDA	NDA	NDA
		2015*	1	1	-0.48	± 2.01	Yes
		Avg			N/A	N/A	N/A
	SCAQMD	2017	34	34	0.04	± 3.08	Yes
		2016*	9	9	-0.26	± 1.19	Yes
		2015*	10	10	0.25	± 1.75	Yes
		Avg			N/A	N/A	N/A

- *Flow rate verifications available for continuous PM methods only in 2015 and 2016 in this table.
- NDA=No data available.
- CFR criteria for bias: ±7% (of standard) except for dichotomous samplers, which are subjected to ±4%.
- 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 July 2018.
- Results reflect current information in AQS, including changes to past data since the 2016 Annual Data Quality Report. Therefore, results for 2016 and 2015 might differ from those in the 2016 DQ report.
- Bay Area AQMD had no flow rate verification data for PM_{10} samplers reported in AQS for 2015-2017; data collected can be requested through Bay Area AQMD.

Figure B6. 2017 Bias via Flow Checks – PM_{10}



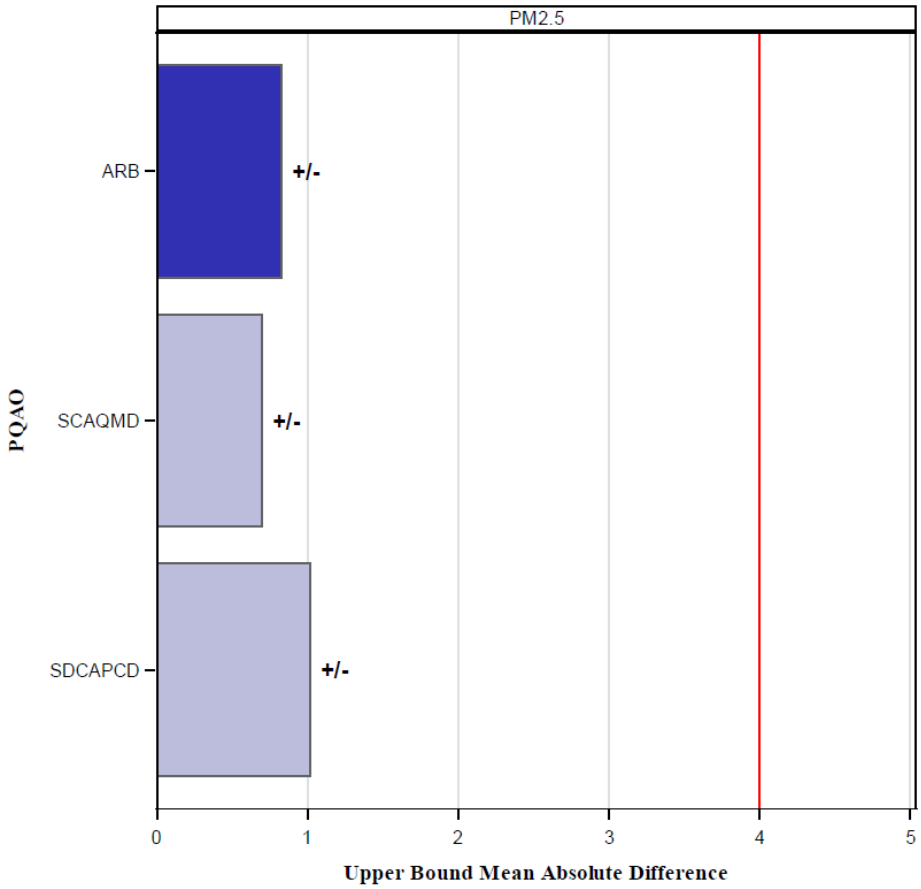
- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run July 2018, except as noted in Appendix B.
- CFR criteria for bias: ±7% (of standard) except for dichotomous samplers, which are subjected to ±4%.
- Specific criteria can be found in Section III and Appendix A.
- Further details on samplers not meeting criteria can be viewed in Appendix B.

Table B5-2. 2017 All (Continuous and Manual) $PM_{2.5}$ Bias Results Based on Flow Rate Verifications

Pollutant	PQAO	Year	# of all Samplers in Network	# of Samplers Reporting Flow Rates	Average % Difference	Bias (%)	CFR Criteria for Bias Met?
$PM_{2.5}$	CARB	2017	92	89*	0.46	± 0.83	Yes
		2016	85	64	-0.07	± 0.83	Yes
		2015	92	33	-0.02	± 0.27	Yes
		Avg	-	-	0.12	0.64	Yes
	SDCAPCD	2017	6	6	0.33	± 1.02	Yes
		2016	6	6	0.67	± 1.38	Yes
		2015	7	7	-0.11	± 1.09	Yes
		Avg	-	-	0.30	1.16	Yes
	SCAQMD	2017	29	29	-0.05	± 0.70	Yes
		2016	23	23	0.14	± 0.84	Yes
		2015	23	23	1.12	± 2.29	Yes
		Avg	-	-	0.40	1.28	Yes

- CFR criteria for bias: ±4% (of standard).
- 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.
- *Further details on samplers not reporting Flow Rates can be viewed in Appendix B.
- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run July 2018.
- Results reflect current information in AQS, including changes to past data since the 2016 Annual Data Quality Report. Therefore, results for 2016 and 2015 might differ from those in the 2016 DQ report.

Figure B7. 2017 Bias via Flow Checks – $PM_{2.5}$



- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run July 2018, except as noted in Appendix B.
- CFR criteria for bias: ±4% (of standard).
- Further details on samplers not meeting criteria can be viewed in Appendix B.

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 B8-B9 summarize the 2017 performance audit results for PM samplers. The numbers of samplers as well as those that met the required number of audits in 2017 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 B8, 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 2017, 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 EPA's flow rate audit criteria. For continuous PM_{10}, flow rate audit results agree with bias estimates based on the flow rate verifications under CARB's PQAO, further validating that the continuous PM_{10} samplers were operating accurately. $PM_{2.5}$ samplers which reported flow rate verifications (as shown in Table B5-2) have similar results, indicating that the PM network operating under CARB's PQAO generally exhibits a high level of accuracy.

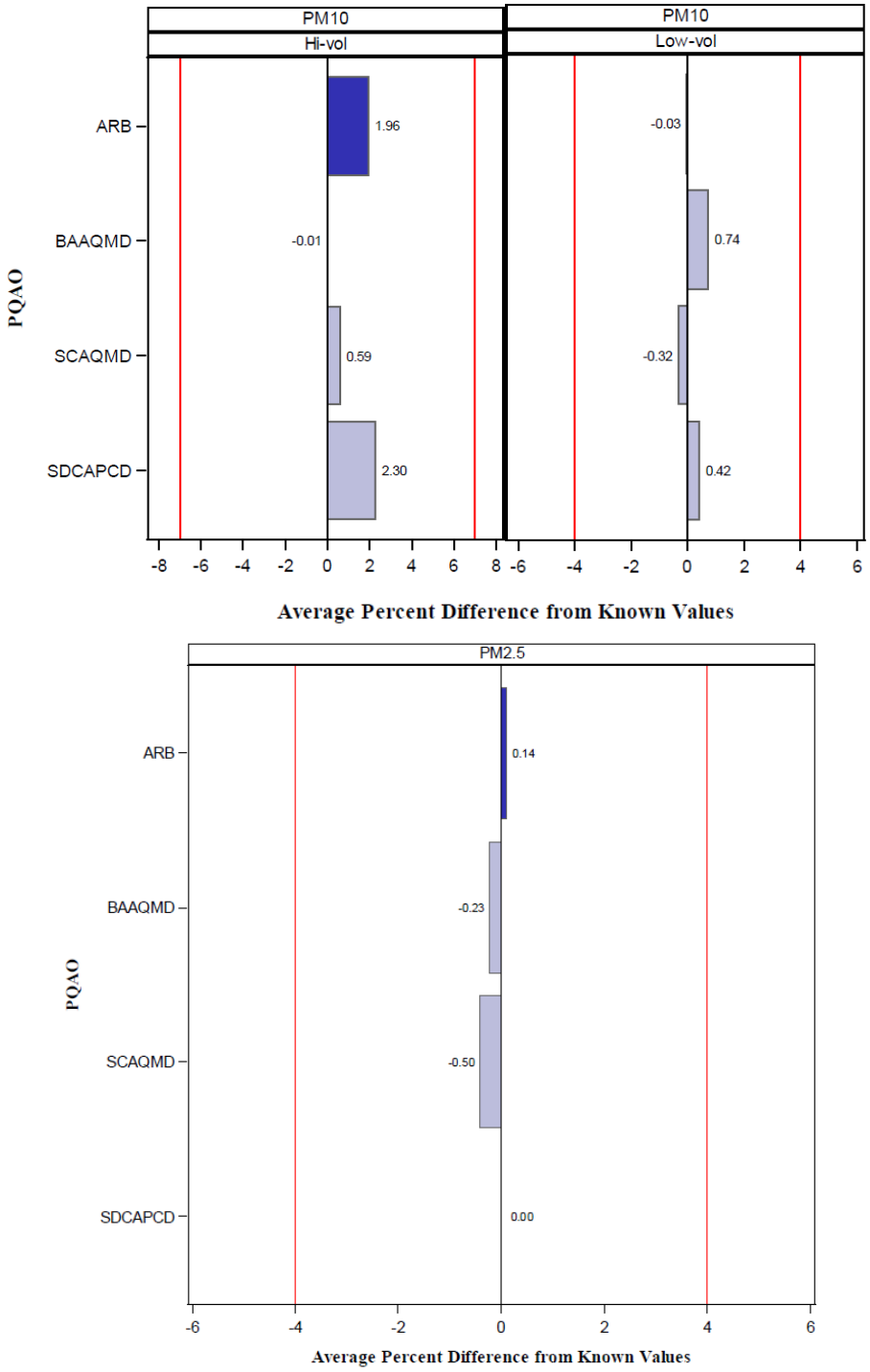
[16] https://arb.ca.gov/aaqm/qa/pqao/repository/rr_docs.htm

Table B6. 2017 Results for Particulate Sampler Performance Audits

Pollutant	Collection Method	PQAO	# of Samplers	# of Audits Required	# of Audits Conducted	# of Samplers Meeting Required Number of Audits	# of Flow Rate Audits Not Meeting CARB Criteria *	Average Percent Difference
PM_{10}	Hi-Vol	CARB	25	48	48	25	0	1.96
		BAAQMD	6	12	24	6	0	-0.01
		SCAQMD	25	50	57	21	1	0.59
		SDCAPCD	4	8	16	4	0	2.30
	Low-Vol**	CARB	79	152	217	79	3	-0.03
		BAAQMD	1	2	4	1	0	0.74
		SCAQMD	9	18	19	8	4	-0.32
		SDCAPCD	1	3	2	2	0	0.42
$PM_{2.5}$	ALL	CARB	92	173	190	92	4	0.14
		BAAQMD	18	36	72	18	0	-0.23
		SCAQMD	29	58	66	25	0	-0.50
		SDCAPCD	4	8	9	4	0	0.00

- *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 include original audits and possible reaudits; hence, #audits conducted can be larger than #audits 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 July 2018, except as noted in Appendix B.

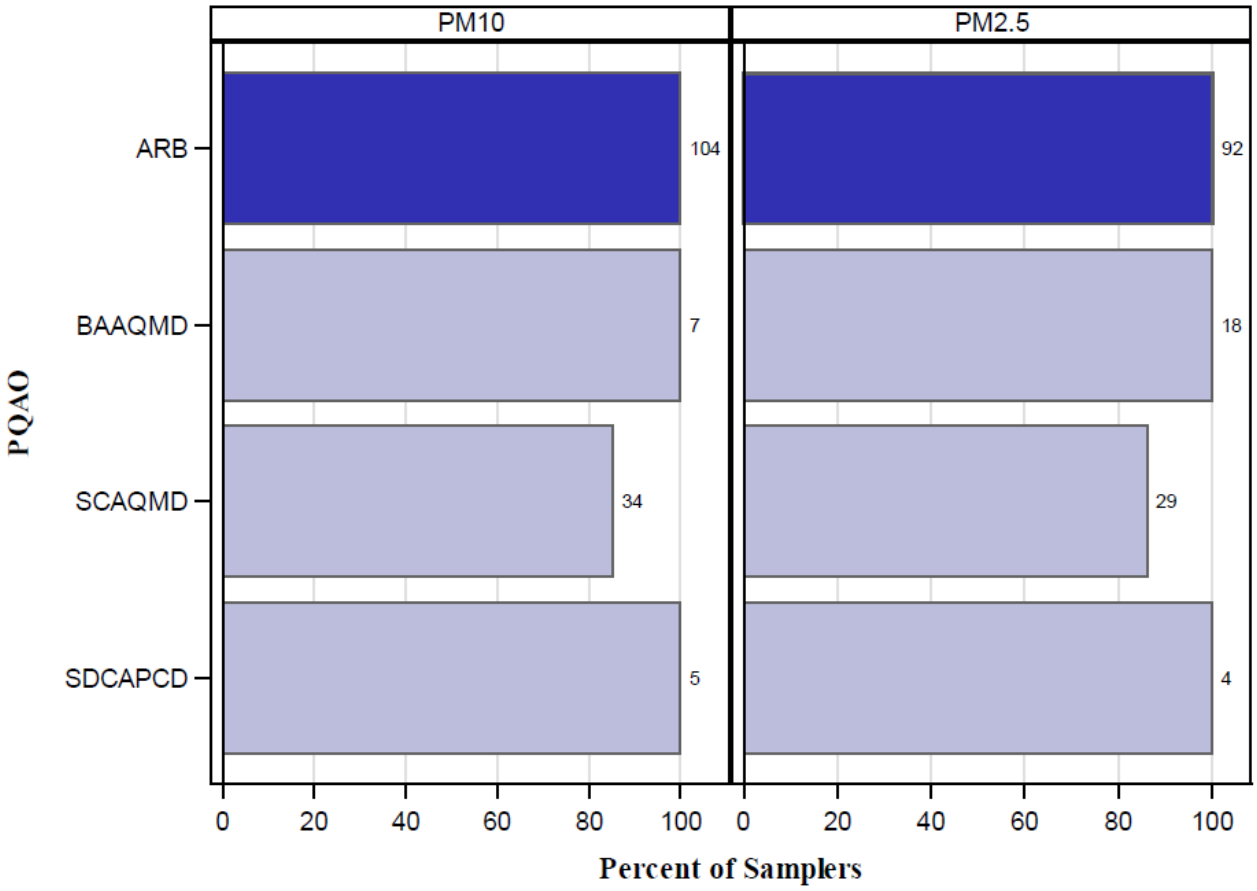
Figure B8. 2017 Accuracy via Audits – PM



- Source: Air Quality System, AMP 256 Data Quality Indicator Report, run July 2018.
- CARB's performance audit criteria for 2017: ±7% for PM_{10} Hi-Vol and ±4% for PM_{10} Low-Vol and $PM_{2.5}$

Figure B9. 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 July 2018, except as noted in Appendix B.

Table B7. 2017 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)	# of Samplers	# of Samplers not Audited	# of Flow Rate Audits Not Meeting CARB Criteria	Average Percent Difference
PM_{10}	Antelope Valley AQMD	D	1	0	0	0.64
	Butte County AQMD	C	1	0	1*	5.72
	Calaveras County APCD	C	1	0	0	-0.59
	Colusa County APCD	C	1	0	0	-1.60
	Eastern Kern APCD	D	4	0	0	2.55
	El Dorado County AQMD	C	1	0	1*	-0.50
	Feather River AQMD	C	1	0	0	0.09
	Glenn County APCD	C	1	0	0	-0.56
	Great Basin Unified APCD	D	18	0	0	-0.92
	Imperial County APCD	D	5	0	1*	0.43
	Lake County APCD	D	4	0	0	-0.14
	Mariposa County APCD	C	1	0	0	0.36
	Mendocino County AQMD	D	1	0	0	0.30
	Mojave Desert AQMD	D	5	0	0	0.29
	Monterey Bay ARD	D	2	0	0	0.33
	North Coast Unified AQMD	D	1	0	0	-0.56
	Northern Sonoma County APCD	D	3	0	0	0.27
	Placer County APCD	B	1	0	0	0.79
	Sacramento Metropolitan AQMD	B	7	0	0	0.12
	San Joaquin Valley Unified APCD	B	22	0	0	1.19
	San Luis Obispo County APCD	D	7	0	0	0.03
	Santa Barbara County APCD	B	7	0	0	0.37
	Shasta County AQMD	D	3	0	0	3.30
	Tehama County APCD	D	1	0	0	2.41
	Ventura County APCD	D	2	0	0	-0.19
	Yolo-Solano AQMD	B	3	0	0	1.72
$PM_{2.5}$	Antelope Valley AQMD	D	1	0	0	0.32
	Butte County AQMD	C	1	0	0	0.51
	Calaveras County APCD	C	1	0	0	0.64
	Colusa County APCD	C	1	0	0	0.48
	Eastern Kern APCD	D	2	0	0	0.86
	Feather River AQMD	C	1	0	0	0.18
	Great Basin Unified APCD	D	4	0	0	-0.59

Table B7 (cont'd). 2017 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)	# of Samplers	# of Samplers not Audited	# of Flow Rate Audits Not Meeting CARB Criteria	Average Percent Difference
$PM_{2.5}$	Imperial County APCD	D	4	0	0	0.71
	Lake County APCD	D	2	0	0	0.24
	Mendocino County AQMD	D	2	0	0	-0.13
	Mojave Desert AQMD	D	2	0	0	0.87
	Monterey Bay ARD	D	7	0	0	0.35
	North Coast Unified AQMD	D	4	0	0	0.53
	Northern Sierra AQMD	D	6	0	1*	-1.56
	Placer County APCD	B	3	0	0	0.33
	Sacramento Metropolitan AQMD	B	7	0	2*	0.11
	San Joaquin Valley Unified APCD	B	26	0	0	0.15
	San Luis Obispo County APCD	D	4	0	0	0.30
	Santa Barbara County APCD	B	4	0	0	0.24
	Shasta County AQMD	D	1	0	0	-0.57
	Siskiyou County APCD	D	1	0	0	-0.95
	Tehama County APCD	D	1	0	1*	3.34
	Ventura County APCD	D	6	0	0	0.08
	Yolo-Solano AQMD	B	1	0	0	0.33

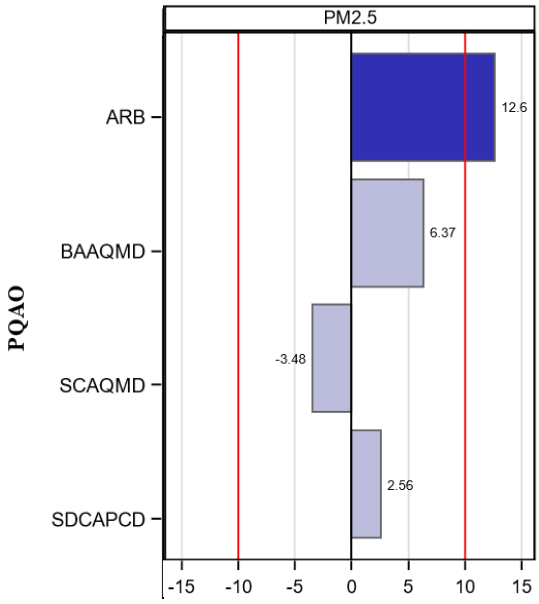
- *Further details on samplers not being audited or not meeting audit criteria can be viewed in Appendix B.
- CARB's flow rate audit criteria for 2017 were ±7% for PM_{10} Hi-Vol and ±4% for PM_{10} Low-Vol and $PM_{2.5}$. Only audits conducted by CARB were subjected to the AQDA process. Further details 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 July 2018, 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 PE 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 2017 PEP audits are presented in Table B5-3 and Figure B7-1. In Table B5-3, results from previous two years and 3-year average are presented to assess trends. CARB's PQAO is estimated to have low "total" bias in its $PM_{2.5}$ network in 2017 as well as over the 3 year period 2015-2017. Similar information for other PQAOs in California are also presented in Table B5-3. Since PEP is intended to evaluate the bias at the network level, no breakdown of results by monitor is presented.

Table B5-3. PQAO Bias via PEP Audits

Pollutant	PQAO	Year	# of Samplers	# of Audits Required	# of Audits Collected	Percent Complete	Bias
$PM_{2.5}$	CARB	2017	72	8	7	88	+12.60
		2016	69	8	14	100	+10.12
		2015	67	8	11	100	-0.75
		SUMMARY					+7.32
	BAAQMD	2017	16	8	7	88	+6.37
		2016	16	8	8	100	+8.97
		2015	15	8	7	88	+18.57
		SUMMARY					+11.30
	SCAQMD	2017	19	8	7	88	-3.48
		2016	19	8	9	100	-8.17
		2015	19	8	6	75	-5.64
		SUMMARY					-5.76
	SDCAPCD	2017	3	5	4	80	+2.56
		2016	5	5	5	100	-0.01
		2015	5	5	5	100	+6.62
		SUMMARY					+3.06

Figure B7-1. PQAO Bias via PEP Audits – $PM_{2.5}$



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 2017.

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

- Ninety-five percent of the instruments operating under CARB's PQAO achieved the ambient data capture rate of at least 75 percent in 2017. Most also met CARB's goal of at least 85 percent data capture.
- Ninety-seven 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.
- 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-five percent of the particulate samplers operating under CARB's PQAO achieved the ambient data capture rate of at least 75 percent in 2017. Most 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, June 2018*, CARB's PQAO met the minimum collocation requirement.
- For the five PM_{10} and sixteen $PM_{2.5}$ pairs of collocated samplers that were present within CARB's PQAO, all except three reported at least 75 percent of the required precision data in 2017.
- 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 PM2.5, CARB's PQAO did not meet the 10 percent CV requirement at the PQAO level for all methods of collection (except methods 143, 145, and 204 – sequential samplers with VSCC – as shown in Table IV-1) for which data are available. CV values have remained about the same from 2016 to 2017.

Table IV-1. 2017 Precision Assessment for $PM_{2.5}$

PQAO	Method 143	Method 145	Method 170	Method 181	Method 204	Method 238
CARB	✓	✓	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 that can be ascertained from the routine flow rate verification data available in AQS and for $PM_{2.5}$.

In an effort to compare 2017 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 2017:

- There are 2 areas that monitored gases only, and both achieved all MQOs for gases.
- Among 19 areas that monitored gases and PM without collocation, 10 met all MQOs, 3 did not meet the MQOs for gases only, 4 did not meet MQOs for PM, and 2 did not meet for both gases and PM.
- Among 9 areas that monitored gases and PM with collocation, none achieved all MQOs.

Several monitoring sites within the CARB's PQAO had operational issues (machine malfunction, power failures, etc.), leading to the MQOs not being achieved in some geographic areas. Our evaluation of the issues indicates no systemic problems exist with the instruments or samplers; we will continue monitoring and documenting any issues that may arise.

In terms of precision, CV values among collocated $PM_{2.5}$ samplers remain high in 2017 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. In 2017, staff expanded the empirical analysis to include the evaluation of more years of data and further broke down the analysis by identifying 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.

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 2017 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 EPA or the data producers themselves. CARB has recently 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

EPA's
MEASUREMENT QUALITY OBJECTIVES

TOOLS FOR ASSESSING PRECISION AND BIAS/ACCURACY

CARB's PERFORMANCE AUDIT CRITERIA

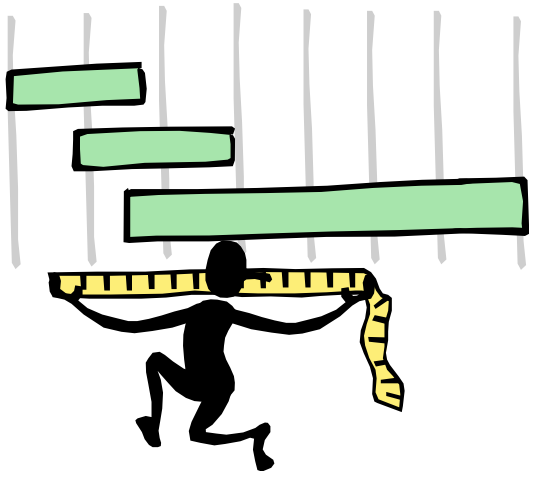

Table 1. Ambient Air Monitoring Measurement Quality Samples

(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 **NO_2** 90% CL CV < 15.1% for Precision, 95% CL < ± 15.1% for Bias **SO_2 and CO** 90% CL CV < 10.1% for Precision, 95% CL < ± 10.1% for Bias
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
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 (2017)

CARB's Control and Warning Limits

Limits		Instrument
Control	Warning	
±10 %	±7 %	Ozone
±15 %	±10 %	Carbon Monoxide, Nitrogen Dioxide, Sulfur Dioxide
±15 %	±10 %	Total Suspended Particulate (TSP) Samplers, including Lead.
±10 %	±7 %	Dichotomous (Dichot), Tapered Element Oscillating Microbalance (TEOM), Beta Attenuated Monitors (BAM)
±7 % (Flow) ±10 % (Design)	None None	PM_{10} Hi-Vol
±4 % (Flow) ±5 % (Design)	None None	PM_{10} Low-Vol, $PM_{2.5}$

Acceptance Criteria For Meteorological (MET) Sensors

Limits	Sensor
±1.0° Celsius (±0.5°C PAMS only)	Ambient Temperature
±2.25mm of Mercury (Hg)	Barometric Pressure
less than or equal to 5° combined accuracy and orientation error	Wind Direction
less than or equal to 0.5m/s	Wind Direction Starting Threshold
±0.25m/s between 0.5 and 5m/s and less than 5 % difference above 5m/s	Horizontal Wind Speed
less than or equal to 0.5m/s	Horizontal Wind Speed Starting Threshold

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

APPENDIX B

CARB's PQAO
DATA QUALITY ISSUES

Background

This appendix contains a listing of 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**
06-067-0015-1	Bercut	Sac Metro AQMD	Sac Metro AQMD	CO	67% (Exceeded shelter temperature; required data invalidation & A/C upgrade)
06-067-0002-1	North Highlands-Blackfoot Way	Sac Metro AQMD	Sac Metro AQMD	NO_2	3% (Analyzer malfunctioned and was turned off for remainder of the year)
06-067-0015-1	Bercut	Sac Metro AQMD	Sac Metro AQMD	NO_2	47% (Exceeded shelter temperature required data invalidation & A/C upgrade)
06-017-0012-1	Echo Summit	El Dorado County AQMD	CARB	O_3	70% (did not operate for part of the season)
06-065-9003-1	Blythe	Mojave Desert AQMD	CARB	O_3	43% (Failed QA Audit AQDA 8366 resulted in data from Jan 1st - July 11th 2017 being invalidated.)
06-093-2001-1	Yreka	Siskiyou County APCD	Siskiyou County APCD	O_3	41% (AQDA issued 8382 data invalidated from March to September)
06-101-0004-1	Sutter Buttes (seasonal)	Feather River AQMD	CARB	O_3	23% (Data from 5 June 2017 QA Audit to end of 2017 O3 season invalidated)
06-103-0004-1	Tuscan Buttes (seasonal)	Tehama County APCD	CARB	O_3	60% (Failed QA Audit AQDA 8374 resulted in data from April 3rd - June 22nd 2017 invalidated)
06-027-0002-1	White Mountain Research Station	Great Basin Unified APCD	Great Basin Unified APCD	SO_2	61% (AQDA issued 8387 required data to be invalidated)
06-067-0006-1	Del Paso Manor	Sac Metro AQMD	Sac Metro AQMD	SO_2	61% (The analyzer malfunctioned in January and October 2017. The analyzer was replaced in November 2017)

Gases - Precision/Bias 1-Point Checks <75% Reported					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-067-0002-1	North Highlands-Blackfoot Way	Sac Metro AQMD	Sac Metro AQMD	NO_2	12% (The analyzer malfunctioned during most of year, and the 1-pt QC checks could not be conducted)
06-067-0015-1	Bercut	Sac Metro AQMD	Sac Metro AQMD	NO_2	62% (Exceeded shelter temperature required 1-pt data invalidation & A/C upgrade)
06-017-0012-1	Echo Summit	El Dorado County AQMD	CARB	O_3	73% (not operation for part of the ozone season)
06-089-0007-1	Anderson North Street	Shasta County AQMD	Shasta County AQMD	O_3	73% (AQDA 8381 led ozone data to be invalidated)
06-101-0004-1	Sutter Buttes (seasonal)	Feather River AQMD	CARB	O_3	33% (Data from 5 June to end of 2017 data invalidated)
06-103-0004-1	Tuscan Buttes (seasonal)	Tehama County APCD	CARB	O_3	67% (AQDA 8374 resulted in data from April 3rd - June 22nd 2017 invalidated)
Gases – Precision/Accuracy/Bias Criteria Exceeded					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-067-0002-1	North Highlands-Blackfoot Way	Sac Metro AQMD	Sac Metro AQMD	CO	20.93 (exceeds 10% of CV criteria; 1 large difference due to calibrator issue)
06-067-0006-1	Del Paso Manor	Sac Metro AQMD	Sac Metro AQMD	SO_2	15.61 precision/11.49 bias (exceeds 10% CV criteria; excessive drift in Sep led to replacement in Oct)
06-067-0006-1	Del Paso Manor	Sac Metro AQMD	Sac Metro AQMD	NO_2	18.01 (exceeds 15% CV criteria; calibrator issues; ambient data associated with analyzer issues invalidated)
06-067-0015-1	Bercut	Sac Metro AQMD	Sac Metro AQMD	NO_2	18.55 (exceeds 15% CV criteria; two 100% differences in April)
06-067-0002-1	North Highlands-Blackfoot Way	Sac Metro AQMD	Sac Metro AQMD	O_3	7.36 (exceeds 7% CV criteria, mostly due to calibrator)
06-067-0006-1	Sacramento Del Paso	Sac Metro AQMD	Sac Metro AQMD	O_3	10.01 (exceeds 7% CV criteria; one 90.9% difference occurred due to pump failure)

Gases – Audit Criteria or Critical Criteria Not Met					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-067-0006-1	Sacramento Del Paso	Sac Metro AQMD	Sac Metro AQMD	NO_2	Low converter efficiency (AQDA #8358)
06-083-1008-3	Santa Maria - South Broadway	Santa Barbara County APCD	CARB	CO	As-is failure (AQDA #8392)
06-019-0011-3	Fresno - Garland	San Joaquin Valley APCD	CARB	SO_2	As-is failure (AQDA #8393)
06-027-0002-1	White Mountain Research Center	Great Basin Unified APCD	Great Basin Unified APCD	SO_2	As-is failure (AQDA #8387)
06-113-0004-1	UC Davis Campus	Yolo-Solano AQMD	CARB	NO_2	As-is failure (AQDA #8388)
06-061-1004-1	Colfax City Hall	Placer County APCD	Placer County APCD	O_3	As-is failure (AQDA #8375)
06-065-9003-1	Blythe Murphy Street	Mojave Desert AQMD	CARB	O_3	As-is failure (AQDA #8366)
06-093-2001-1	Yreka	Siskiyou County APCD	Siskiyou County APCD	O_3	As-is failure (AQDA #8382)
06-103-0004-1	Tuscan Buttes (seasonal)	Tehama County APCD	CARB	O_3	As-is failure (AQDA #8374)
Gases – Audits not Performed					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-067-0002-1	North Highlands-Blackfoot Way	SAC Metro AQMD	SAC Metro AQMD	NO_2	No audit performed; instrument malfunction
06-017-0012-1	Echo Summit	El Dorado County AQMD	CARB	O_3	Had electrical issues; not audited
PM - Ambient Data Completeness <75% Reported					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-009-0001-3	San Andreas-Gold Strike Road	Calaveras County APCD	CARB	PM_{10}	62% (Data between March 1st to June 27th invalidated due to failure of semi-annual calibration)

PM - Ambient Data Completeness <75% Reported					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-023-1004-1	Eureka - Jacobs	North Coast Unified AQMD	North Coast Unified AQMD	PM_{10}	47% (Completeness not met GRIMM had operation issues throughout year)
06-029-0232-3	Oildale	San Joaquin Valley Unified APCD	CARB	PM_{10}	64% (Monitor did not operate entire year. HI-Vol SSI was replaced w/ a BAM in July)
06-009-0001-3	San Andreas-Gold Strike Road	Calaveras County APCD	CARB	$PM_{2.5}$	64% (Data between March 1st to June 27th invalidated due to failure of semi-annual calibration)
06-039-2010-1	Madera City	San Joaquin Valley Unified APCD	San Joaquin Valley Unified APCD	$PM_{2.5}$	73% (Multiple Machine Malfunction throughout the year)
06-063-1010-1	Portola - Gulling	Northern Sierra AQMD	Northern Sierra AQMD	$PM_{2.5}$	61% (AQDA issued 8385 data invalidated 9/15-12/19)
06-015-0006-1	Crescent City	North Coast Unified AQMD	North Coast Unified AQMD	$PM_{2.5}$	74% (GRIMM sampler had operation issues (which led to a loss of data in few months)
06-023-1005-1	Eureka - Humboldt Hill	North Coast Unified AQMD	North Coast Unified AQMD	$PM_{2.5}$	65% (GRIMM sampler had operation issues (which led to a loss of data in few months)
06-029-0015-1	Ridgecrest	Eastern Kern APCD	Eastern Kern APCD	$PM_{2.5}$	74% (Power failure, machine malfunction, and filter damage)
06-057-0005-3	Grass Valley	Northern Sierra AQMD	Northern Sierra AQMD	$PM_{2.5}$	73% (Closed for shelter upgrade operated only November and December)
PM Precision (Collocated) Data < 75% Reported					
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	$PM_{2.5}$	40% precision data uploaded
06-063-1010-1	Portola-Gulling	Northern Sierra AQMD	Northern Sierra AQMD	$PM_{2.5}$	50% precision data uploaded

PM Precision (Collocated) Data < 75% Reported					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-039-2010-3	Madera City	San Joaquin Valley Unified APCD	San Joaquin Valley Unified APCD	$PM_{2.5}$	70% 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 = 27.04*
06-027-1003-6	Keeler-Cerro Gordo Road	Great Basin Unified APCD	Great Basin Unified APCD	PM_{10}	CV = 22.57*
06-019-0011-1	Fresno Garland	San Joaquin Valley Unified APCD	CARB	$PM_{2.5}$	CV = 11.55
06-027-0002-1	White Mountain Research Station	Great Basin Unified APCD	Great Basin Unified APCD	$PM_{2.5}$	CV = 37.19*
06-027-1003-3	Keeler-Cerro Gordo Road	Great Basin Unified APCD	Great Basin Unified APCD	$PM_{2.5}$	CV = 16.66*
06-039-2010-3	Madera City	San Joaquin Valley Unified APCD	San Joaquin Valley Unified APCD	$PM_{2.5}$	CV = 26.61
06-053-1003-3	Salinas-#3	Monterey Bay ARD	Monterey Bay ARD	$PM_{2.5}$	CV = 15.36
06-067-0006-1	Del Paso Manor	Sac Metro AQMD	Sac Metro AQMD	$PM_{2.5}$	CV = 11.07
06-067-0012-3	Folsom-Natoma Street	Sac Metro AQMD	Sac Metro AQMD	$PM_{2.5}$	CV = 18.45
06-071-0306-1	Victorville-14306 Park Avenue	Mojave Desert AQMD	Mojave Desert AQMD	$PM_{2.5}$	CV = 11.25
06-077-1002-3	Stockton-Hazelton Street	San Joaquin Valley Unified APCD	CARB	$PM_{2.5}$	CV = 18.14

*High CV to be expected from a low count of paired concentrations above 3 ug/m^3.

PM Precision Criteria (CV limit of 10%) Not Met					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-099-0005-3	Modesto-14th Street	San Joaquin Valley Unified APCD	CARB	$PM_{2.5}$	CV = 10.95
06-111-2002-3	Simi Valley	Ventura County APCD	Ventura County APCD	$PM_{2.5}$	CV = 11.72
PM – Audit Criteria or Critical Criteria Not Met					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-007-0008-3	Chico-East Ave	Butte County AQMD	CARB	PM_{10}	Flow failure (AQDA #8384)
06-017-0011-5	South Lake Tahoe	El Dorado County AQMD	CARB	PM_{10}	Flow failure (AQDA #8369)
06-025-0005-3	Calexico	Imperial County APCD	CARB	PM_{10}	Flow failure (AQDA #8365)
06-063-0010-1	Portola-Gulling St	Northern Sierra AQMD	Northern Sierra AQMD	$PM_{2.5}$	Flow failure (AQDA #8385)
06-067-0006-3	Del Paso Manor	Sac Metro AQMD	Sac Metro AQMD	$PM_{2.5}$	Flow failure (AQDA #8390)
06-067-0010-1	Sacramento T St	Sac Metro AQMD	CARB	$PM_{2.5}$	Flow failure (AQDA #8370)
06-103-0007-3	Red Bluff	Tehama County APCD	Tehama County APCD	$PM_{2.5}$	Flow failure (AQDA #8383)
PM – Flow Rate Verification (FRV)					
Site ID	**Site Name**	**Geographic Area**	**Monitoring Agency**	**Pollutant**	**Issue/Comment**
06-019-0011-2	Fresno Garland	San Joaquin Valley Unified APCD	CARB	$PM_{2.5}$	FRV data not uploaded to AQS
06-023-1005-1	Eureka - Humboldt Hill	North Coast Unified AQMD	North Coast Unified AQMD	$PM_{2.5}$	FRV not performed; GRIMM related
06-057-0005-3	Grass Valley	Northern Sierra AQMD	Northern Sierra AQMD	$PM_{2.5}$	FRV data not uploaded to AQS

Air Quality Data Action (AQDA) and Corrective Action Notification(CAN) Issued by CARB		
Pollutant	**#AQDAs**	**#CANs**
CO	2	1
NO_2	1	0
O_3	10	5
PM_{10}	5 (3 due to flow failures)	7
$PM_{2.5}$	7 (4 due to flow failures)	11
SO_2	2	2

Manual Adjustments to Information Output from AQS

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
06-083-0011-3	Santa Barbara National Guard	Santa Barbara County APCD	CARB	CO	Sample removed; no audit performed due to being a trace audit which was going to be performed in the fall. However instrument closed in June.
06-101-0004-3	Sutter Buttes (seasonal)	Feather River AQMD	CARB	CO	Special purpose monitor; no audit performed
06-015-0006-1	Crescent City	North Coast Unified AQMD	North Coast Unified AQMD	$PM_{2.5}$	Issue with sampler on second audit; GRIMM related
06-023-1005-1	Eureka - Humboldt Hill	North Coast Unified AQMD	North Coast Unified AQMD	$PM_{2.5}$	Flow Rate Audit incomplete; GRIMM related

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APPENDIX C

DETAILED CALCULATIONS OF STATISTICS USED TO ASSESS PRECISION AND ACCURACY

The materials in this Appendix were adapted from 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

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

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

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

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

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

and the quantity AS is the standard deviation of the absolute value of the d_i's (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

$$\text{Upper Probability Limit} = m + 1.96 \cdot S$$

Equation 17

$$\text{Lower Probability Limit} = m - 1.96 \cdot S$$

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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5. US EPA, *Quality Assurance Handbook for Air Pollution Measurement Systems*. Vol. IV, *Meteorological Measurements Version 2.0 (Final)*, EPA-454/B-08-002, 2008.

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