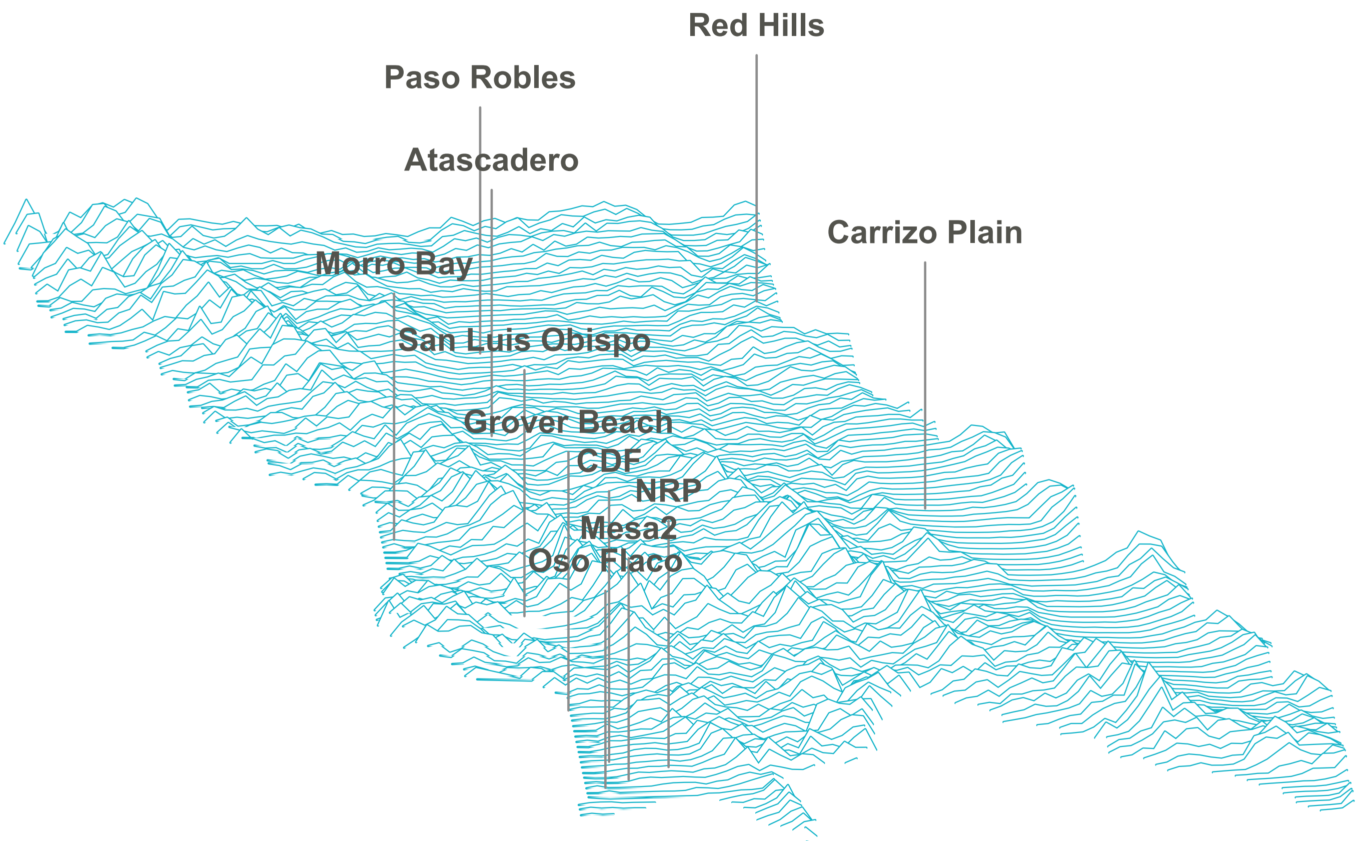
ANNUAL AIR QUALITY REPORT 2018



SLO COUNTY apcd

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<u>2018 Annual Air Quality Report</u>
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Executive Summary

Air quality in San Luis Obispo County generally improved from 2017 to 2018:

- **Ozone** trends show either continued improvement or leveling off; no sites saw higher levels (Figures 7 & 8). Ozone standards were exceeded on 6 days in 2018, with all of these occurring during wildfire events.
- **PM_{10}** on the Nipomo Mesa also improved (Figures 9 – 11), with the fewest exceedances of the state standard ever recorded at CDF. As discussed in Appendix A, we attribute some of this improvement to mitigation measures deployed on the Oceano Dunes State Vehicular Recreation Area (ODSVRA).
- **$PM_{2.5}$** annual averages decreased at most sites (Figure 12), including those on the Nipomo Mesa, despite wildfire-related exceedances of the federal $PM_{2.5}$ standard on 2 days (Table 4).
- One exception to the general improvement in air quality was **PM_{10} in Paso Robles**. Construction adjacent to the monitoring station caused a jump in PM_{10} levels, and 2018 saw the most exceedances of the state standard ever at this location (Figure 9).

Smoke from wildfires had major impacts on air quality in 2018. The District issued press releases on July 30th and August 6th, 7th, 17th, 20th, and 24th warning the public of elevated ozone and/or particulate levels related to wildfires. All exceedances of the ozone standards occurred between August 3rd and 9th, when several large wildfires were burning in California. These include the Mendocino Complex (or Ranch) Fire near Clear Lake, which started on July 27th and burned into November (at more the 450,000 acres, it was the largest wildfire ever recorded in the state); the Holy Fire in Orange and Riverside Counties, which started on August 6th and burned over 23,000 acres before full containment on September 13th; and the Turkey Fire in Monterey County, which burned 2,225 acres on August 6th.

August 23rd and 24th saw the highest $PM_{2.5}$ levels of the year at CDF, Mesa2, San Luis Obispo, and Atascadero (Table 4). All exceedances of the $PM_{2.5}$ standard were recorded on these days, as were some of the year's highest PM_{10} averages at San Luis Obispo and Oso Flaco. These were likely related to the Mendocino Complex and Holy Fires, as well as the Front Fire, which burned just over 1,000 acres near the San Luis Obispo–Santa Barbara County border from August 19th to August 29th.

The Camp Fire in Butte County started on November 8th and burned over 150,000 acres before being fully contained on November 25th. This fire contributed to elevated particulate levels across the county, including many of the year's highest PM_{10} and $PM_{2.5}$ averages at Atascadero, Paso Robles, and San Luis Obispo, and Mesa2 (Table 4).

South County air quality continues to be impacted by dust blown from the ODSVRA. While the federal PM_{10} standard was not exceeded anywhere in 2018, the more stringent state standard was exceeded on 47 days on the Nipomo Mesa, and most of these exceedances were due to windblown dust. In addition, the Rule 1001 performance standard was violated 40 times. This is an improvement over the previous year, when the state standard was exceeded 97 times at CDF and Rule 1001 was violated 66 times.

There were no exceedances of the standards for nitrogen dioxide or sulfur dioxide at any stations this year.

This report contains three appendices. Appendix A presents an analysis of the effect of the ODSVRA mitigations on downwind PM_{10} concentrations. Using the methodology proposed in the 2017 Annual Air

Quality Report, it is estimated that the 2018 mitigations reduced PM_{10} levels at CDF by 22.4% (95% CI: 7.4 – 34.9%). Appendix B reports the results of crystalline silica sampling conducted 2019 at CDF. None of the 26 samples exceeded the Occupational Safety and Health Administration (OSHA) 8-hour workplace health-based standard for respirable crystalline silica. An estimate of the 2018 annual average silica concentration does not exceed the California chronic Reference Exposure Level (REL). Finally, Appendix C presents an "infographic" summarizing the main points from this annual report.

The air quality database for San Luis Obispo County is a public record and is available from the District office in various forms, including comprehensive records of all hourly or other sample values acquired anywhere in the county. Data summaries are published in Annual Air Quality Reports, like this one. Summary data appear weekly in the Saturday edition of The Tribune, a local newspaper. Ambient monitoring data is added to separate archives maintained by EPA and CARB. Summary data from San Luis Obispo County can be found in EPA and CARB publications and on the world wide web at the following websites:

www.slocleanair.org
APCD website
www.arb.ca.gov
CARB website
www.epa.gov
US EPA website
www.airnow.gov
Air Quality Index site

Air Quality Monitoring and Data

Air quality in San Luis Obispo County was measured by a network of 11 permanent ambient air monitoring stations in 2018; their locations are depicted in Figure 1. The San Luis Obispo County Air Pollution Control District (District) owned and operated seven permanent stations: Nipomo Regional Park (NRP), Grover Beach, Morro Bay, Atascadero, Red Hills, Carrizo Plain, and the CDF fire station on the Nipomo Mesa. The California Air Resources Board (CARB) operated stations in San Luis Obispo and Paso Robles. Two stations are owned by third parties but operated by the District: Mesa2, located on the Nipomo Mesa and owned by the Phillips 66 refinery, and Oso Flaco, located within the ODSVRA and owned by the California Department of Parks and Recreation. See Table 2 for a summary of the pollutants monitored at each station.

The District prepares an *Ambient Air Monitoring Network Plan* every year. This document is an evaluation of the network of air pollution monitoring stations in the county. The annual review is required by 40 CFR 58.10 and helps ensure continued consistency with the monitoring objectives defined in federal regulations. Each report is a directory of existing and proposed monitors in the county network and serves as a progress report on the recommendations and issues raised in earlier network reviews. They are available online at http://www.slocleanair.org/airquality/monitoringstations.php.

Air quality monitoring is subject to rigorous federal and state quality assurance and quality control requirements, and equipment and data are audited periodically to ensure data validity. Gaseous pollutant levels are measured every few seconds and averaged to yield hourly values. Particulate matter ($PM_{2.5}$ and PM_{10}) is sampled hourly. All monitoring instruments are Environmental Protection Agency (EPA)-approved Federal Equivalent Methods (FEMs) or Federal Reference Methods (FRMs).

The 2018 data reviewed in this report were extracted from the EPA's Air Quality System (AQS) database. Prior to being uploaded to AQS, all data were thoroughly reviewed and validated by the collecting agency (i.e., CARB for data from Paso Robles and San Luis Obispo and the District for all other sites). The raw data and computer code used to compile the statistics and generate the graphs in this report are available online at https://github.com/sloapcdkt/2018aqrptR.

Figure 1: Map of Monitoring Stations in San Luis Obispo County

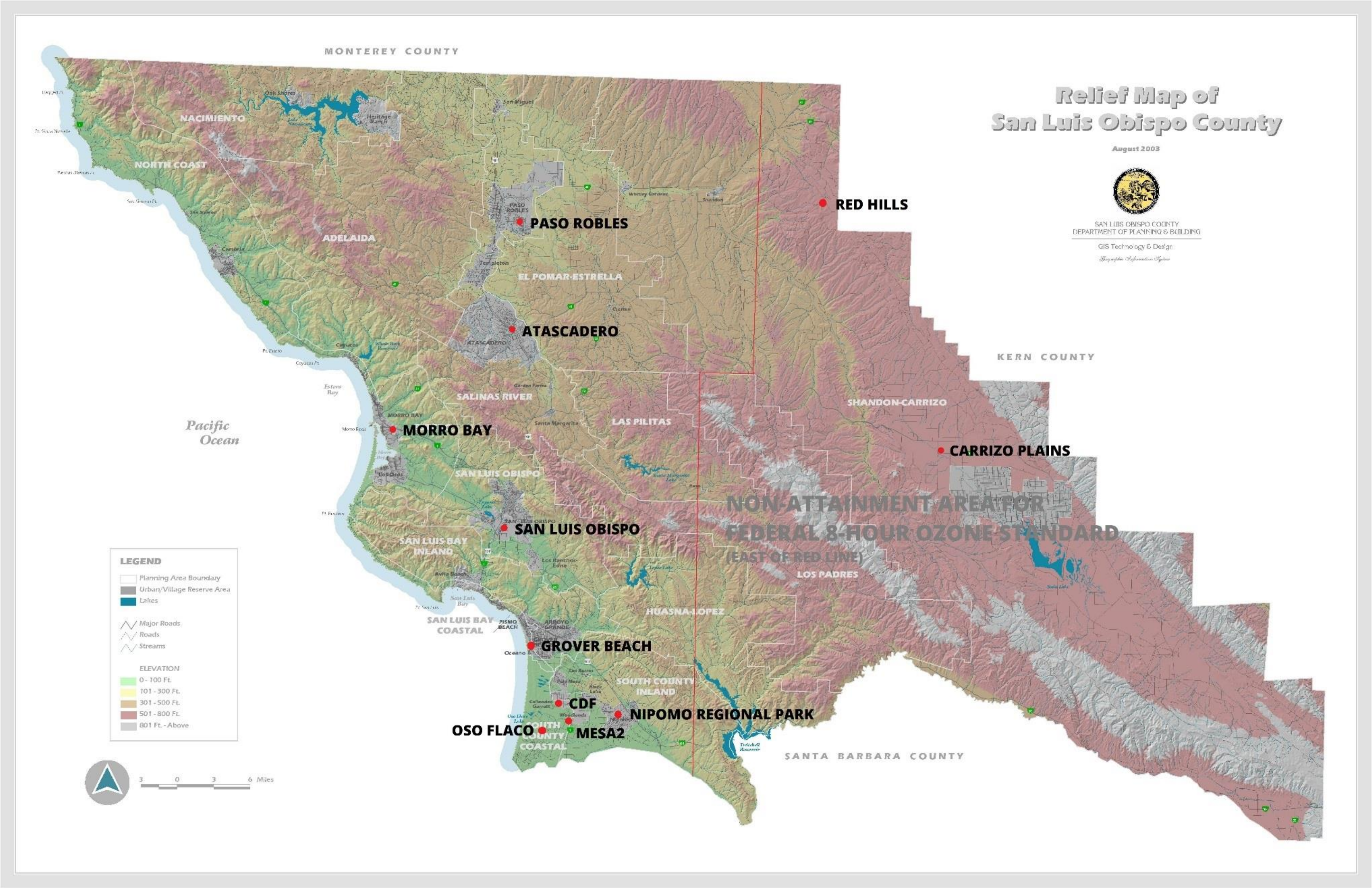

Table 1: Ambient Air Quality Parameters Monitored in San Luis Obispo County in 2018

	O_3	NO	NO_2	NO_x	SO_2	PM_{10}	$PM_{2.5}$	WS	WD	ATM
APCD Permanent Stations										
Atascadero	X	X	X	X		X	X	X	X	X
Morro Bay	X							X	X	
Nipomo Regional Park	X	X	X	X		X		X	X	X
Red Hills	X							X	X	X
Carrizo Plain	X							X	X	X
CDF						X	X	X	X	
Grover Beach								X	X	
CARB Stations										
San Luis Obispo	X					X	X	X	X	X
Paso Robles	X					X		X	X	X
Operated by APCD										
Mesa2					X	X	X	X	X	X
Oso Flaco						X		X	X	X

Abbreviations and Chemical Formulas:

NO	Nitric Oxide	SO_2	Sulfur Dioxide	PM_{10}	Particulates < 10 microns	WS	Wind Speed
NO_2	Nitrogen Dioxide	O_3	Ozone	$PM_{2.5}$	Particulates < 2.5 microns	WD	Wind Direction
NO_x	Oxides of Nitrogen					ATM	Ambient Temp

Ambient Air Pollutants Of Local Concern

Ozone

Ozone (O_3) is a gas that is naturally found near the earth's surface at low concentrations, typically 10 to 40 parts per billion (ppb). It is also a principle component of photochemical smog, produced when precursor pollutants such as volatile organic compounds and nitrogen oxides react under the influence of sunlight. Ozone precursors are emitted by many human activities, but industrial processes and motor vehicles are primary sources. The chemistry of atmospheric ozone is complex, and in the absence of sunlight, ozone is destroyed by reaction with the same precursor molecules that fuel its formation during the day. As a result, ozone concentrations typically increase as sunlight intensity increases, peaking midday or in the afternoon and gradually declining from there, typically reaching their lowest levels in the early morning hours and just before sunrise, as shown in Figure 2, below.

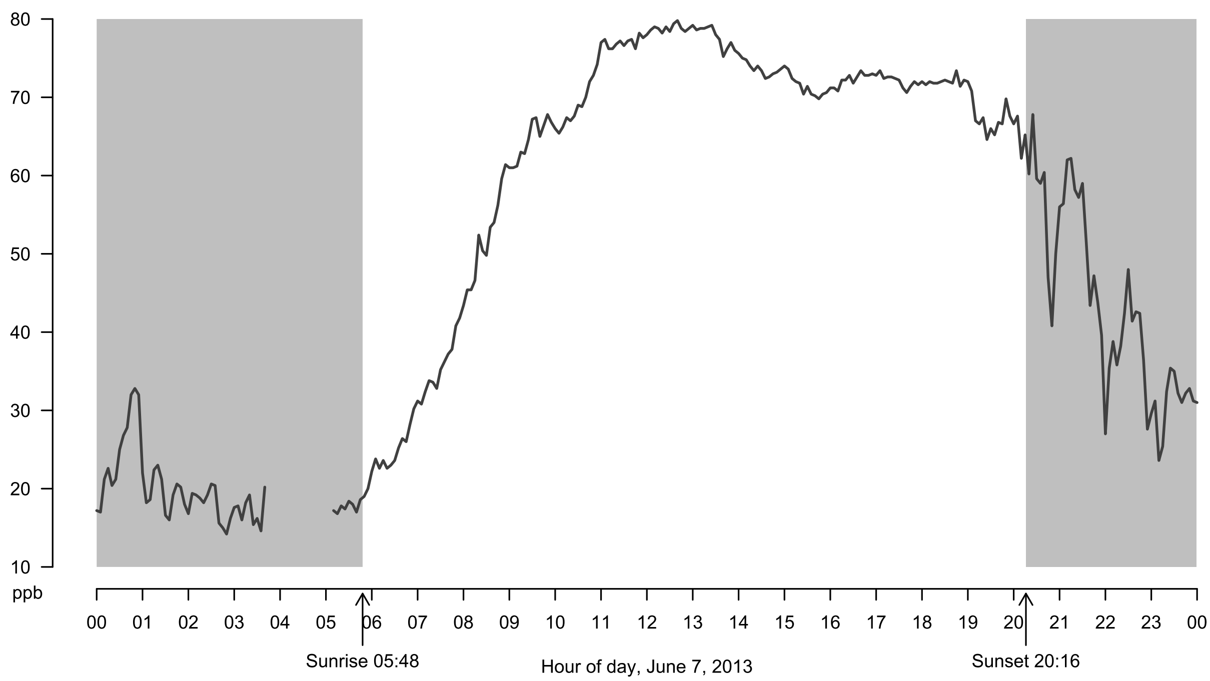

Figure 2: Example of Diurnal Ozone Pattern from Carrizo Plain

As a pollutant, ozone is a strong oxidant gas that attacks plant and animal tissues. It can cause impaired breathing and reduced lung capacity, especially among children, athletes and persons with compromised respiratory systems; it can also cause significant crop and forest damage. Ozone is a pollutant of particular concern in California where geography, climate, and emissions from industrial and commercial sources and millions of vehicles contribute to frequent violations of health-based air quality standards.

While ground level ozone is harmful to plants and animals and is considered a pollutant, upper level (stratospheric) ozone occurs naturally and protects the earth from harmful ultra-violet energy from the sun.

Particulate Matter

Ambient air quality standards have been established for two classes of particulate matter: PM_{10} (respirable particulate matter less than 10 microns in aerodynamic diameter), and $PM_{2.5}$ (fine particulate matter 2.5 microns or less in aerodynamic diameter). Both consist of many different types of particles that vary in their composition and toxicity. $PM_{2.5}$ tends to be a greater health risk since these particles can get lodged deep in the lungs or enter the blood stream, causing both short and long-term damage. Sources of particulate pollution include diesel exhaust; mineral extraction and production; combustion products from industry and motor vehicles; smoke from open burning; paved and unpaved roads; condensation of gaseous pollutants into liquid or solid particles; and windblown dust from soils disturbed by demolition and construction, agricultural operations, off-road vehicle recreation, and other activities.

In addition to its harmful health effects, particulate matter can also greatly reduce visibility.

Nitrogen Dioxide, Sulfur Dioxide, and Carbon Monoxide

Nitrogen dioxide (NO_2) is the brownish-colored component of smog. NO_2 irritates the eyes, nose and throat and can damage lung tissue. Sulfur dioxide (SO_2) is a colorless gas with health effects similar to NO_2. Both pollutants are generated by fossil fuel combustion from mobile sources such as vehicles, ships, and aircraft and at stationary sources such as industry facilities, homes, and businesses. SO_2 is also emitted by petroleum production and refining operations. These pollutants can create aerosols, which may fall as acid rain causing damage to crops, forests, and lakes. They can also exacerbate asthma and harm the human respiratory system.

Carbon monoxide (CO) is a colorless and odorless gas that can interfere with the ability of red blood cells to transport oxygen. Exposure to CO can cause headaches, fatigue, and even death. CO results from fuel combustion of all types, but motor vehicles are by far the chief contributor of CO in outdoor air.

State and National Ambient Air Quality Standards

California Air Resources Board and the U.S. EPA have adopted ambient air quality standards for six common air pollutants of primary public health concern: ozone, particulate matter (PM_{10} and $PM_{2.5}$), nitrogen dioxide, sulfur dioxide, carbon monoxide, and lead.[1] These are called “criteria pollutants” because the standards establish permissible airborne pollutant levels based on criteria developed after careful review of all medical and scientific studies of the effects of each pollutant on public health and welfare.

The National Ambient Air Quality Standards (NAAQS; see Table 2) are used by EPA to designate a region as either “attainment” or “nonattainment” for each criteria pollutant. A nonattainment designation can trigger additional regulations aimed at reducing pollution levels and bringing the region into attainment. For most pollutants, the NAAQS allow a standard to be exceeded a certain number of times each calendar year without resulting in a nonattainment designation. Additionally, exceedances caused by exceptional events (see below) may be excluded from attainment/nonattainment determinations at the discretion of the EPA.

In May 2012, the EPA designated the eastern portion of San Luis Obispo County as marginally nonattainment for the 8-hour ozone standard. This was based on data from enhanced monitoring over the previous decade that revealed previously unrecognized high ozone levels in that region; the western portion of the county retained its attainment status. (See Figure 1 for the boundary between the attainment and nonattainment areas.) In October 2015, the ozone standard was lowered from 75 to 70 ppb, and in April 2018, the EPA designated the eastern portion of the county as a marginal non-attainment zone for the new standard. The county is currently designated as attaining all other NAAQS.

The California Ambient Air Quality Standards are generally more restrictive (i.e. lower) than the NAAQS, and typically are specified as not to be exceeded. Thus, a single exceedance is a violation of the applicable standard and triggers a nonattainment designation. As a result, San Luis Obispo County is designated as a nonattainment area for the state one-hour and 8-hour ozone standards, as well as the state 24-hour and annual PM_{10} standards. The county is designated as attaining the state annual $PM_{2.5}$ standard.

State and federal standards for NO_2 have never been exceeded here. The state standard for SO_2 was exceeded periodically on the Nipomo Mesa until 1993. Equipment and processes at the facilities responsible for the emissions were upgraded as a result, and the state SO_2 standard has not been exceeded since that time. The federal SO_2 standard has only been exceeded once, in 2013, when maintenance activities at these facilities resulted in emissions exceeding the 1-hour standard of 75 ppb. (This standard was established in 2011.) State CO standards have not been exceeded in the county since 1975. The county has never been required to conduct lead monitoring.

Exceptional Events

Exceptional events are unusual or naturally occurring events that can affect air quality but are not reasonably controllable or preventable and are unlikely to reoccur at a particular location. Examples include wildfires and tornadoes. Air quality monitoring data influenced by exceptional events can sometimes be excluded from regulatory determinations related to violations of the NAAQS, if recommended by the APCD and CARB and approved by the EPA. The APCD has not submitted any exceptional event documentation for 2018 and does not expect any data compiled in this report to be excluded from future attainment determinations.

[1] In addition to these six pollutants, California also has standards for hydrogen sulfide, sulfate, vinyl chloride, and visibility reducing particles.

Table 2: Ambient Air Quality Standards for 2018 and Attainment Status*

__A standard exceedance__ occurs when a measured pollutant concentration exceeds (or in some cases, equals) the applicable standard prescribed by state or federal agencies. It does not necessarily constitute a violation.

__A standard violation__ may occur following a single or cumulative series of standard exceedances. Criteria constituting a violation are unique for each pollutant.

__A nonattainment designation__ occurs when a state or federal agency formally declares an area in violation of a standard. Typically, CARB performs designations annually. Several years often pass between EPA designations.

	Averaging Time	California Standard†	National Standard†
Ozone (O_3)	8 Hours	**70 ppb**	**70 ppb**
	1 Hour	**90 ppb**	
Respirable Particulate Matter (PM_{10})	24 Hours	**50 μg/m³**	150 μg/m³
	1 Year‡	**20 μg/m³**	
Fine Particulate Matter ($PM_{2.5}$)	24 Hours		35 μg/m³
	1 Year‡	12 μg/m³	12 μg/m³
Carbon Monoxide (CO)	8 Hours	9.0 ppm	9 ppm
	1 Hours	20 ppm	35 ppm
Nitrogen Dioxide (NO_2)	1 Year‡	30 ppb	53 ppb
	1 Hour	180 ppb	100 ppb
Sulfur Dioxide (SO_2)	3 Hours		500 ppb (secondary)
	1 Hour	250 ppb	75 ppb (primary)
Lead (Pb)	3 Month		0.15 μg/m³
	30 Day	1.5 μg/m³	

* San Luis Obispo County (in whole or in part) is designated as nonattainment for the standards in **boldface print** as of November 2019.

† For clarity, the ozone, SO_2, and NO_2 standards are expressed in parts per billion (ppb), however most of these standards were promulgated in parts per million (ppm). When comparing to the national PM_{10} and $PM_{2.5}$ standards, federal regulations state that measurements shall be rounded to the nearest 10 μg/m³ and 1μg/m³, respectively. Thus, for PM_{10}, 24-hour averages between 150 and 154 μg/m³ are not considered exceedances of the standard, even though they are greater (or equal to) 150 μg/m³.

‡ This standard is calculated as a weighted annual arithmetic mean.

Ozone and Gaseous Pollutant Summary

Exceedances of the 8-hour state and federal standard (both 70 ppb) occurred on 6 different days in 2018, with 5 days exceeding the standard at Red Hills, 3 at Carrizo Plain, and 2 at Paso Robles. The state 1-hour standard (90 ppb) was exceeded only once this year: August 7th at Carrizo Plain. The old standard (75 ppb; in effect through 2015) was exceeded only once in 2018, also August 7th at Carrizo Plain. Standards for nitrogen dioxide and sulfur dioxide were not exceeded this year.

Table 3 lists the highest hourly (and for ozone, 8-hour[2]) values recorded in 2018 for ozone, sulfur dioxide, and nitrogen dioxide at the stations where they are monitored. Concentrations are in parts per billion (ppb). The sample date appears under each pollutant value in the format “month/day.” Values that exceed federal standards are shown in **bold**, and those exceeding state standards are <u>underlined</u>.

Many of the highest observed ozone concentrations (including all exceedances of the 1- and 8-hour standards) occurred in early August, when several large wildfires were burning in California. These include the Mendocino Complex (or Ranch) Fire near Clear Lake, which started on July 27th and burned into November. At more the 450,000 acres, it was the largest wildfire ever recorded in the state. The Holy Fire in Orange and Riverside Counties started on August 6th and burned over 23,000 acres before full containment on September 13th. More locally, the Turkey Fire in Monterey County burned 2,225 acres on August 6th. The District issued Better Breather Alert press releases on July 30th and August 7th which warned of elevated ozone levels related to wildfires.

Table 3: Highest Measurements for Gaseous Pollutants in 2018

Station	O_3 1-hour			O_3 8-hour				SO_2 1-hour			NO_2 1-hour		
	1st	2nd	3rd	1st	2nd	3rd	4th	1st	2nd	3rd	1st	2nd	3rd
Paso Robles	87 08/09	79 08/19	77 08/06	**<u>71</u>** 08/08	**<u>71</u>** 08/09	66 06/22	64 06/02						
Atascadero	77 08/07	75 08/06	74 09/26	69 08/08	63 08/09	61 08/06	60 06/02				38 11/15	35 11/07	33 11/12
Morro Bay	57 04/12	56 02/03	56 04/30	55 04/12	53 08/24	52 04/30	50 11/07						
San Luis Obispo	62 06/02	58 08/08	58 09/20	53 11/11	52 08/24	52 09/20	52 10/19						
Red Hills	81 08/06	81 09/27	78 08/04	**<u>73</u>** 08/03	**<u>73</u>** 08/09	**<u>72</u>** 08/04	**<u>71</u>** 08/06						
Carrizo Plain	<u>92</u> 08/07	81 07/31	80 08/06	**<u>80</u>** 08/07	**<u>75</u>** 08/09	**<u>71</u>** 08/04	70 07/29						
Nipomo Regional Park	63 09/20	62 11/01	58 02/03	55 08/24	53 07/06	53 10/19	53 11/01				25 11/15	23 1/29	22 12/19
Mesa2, Nipomo								2 07/06	2 07/07	1 01/31			

[2] The daily maximum 8-hour averages in Table 3 and Figures 3 and 4 are calculated according to the 2015 revisions to the 8-hr ozone standard specified in 40 CFR 50 Appendix U, Section 3(c). Specifically, “[t]he daily maximum 8-hour average O_3 concentration for a given day is the highest of the 17 consecutive 8-hour averages beginning with the 8-hour period from 7:00 a.m. to 3:00 p.m. and ending with the 8-hour period from 11:00 p.m. to 7:00 a.m. the following day (i.e., the 8-hour averages for 7:00 a.m. to 11:00 p.m.).”

Visual Ozone Summary

Figures 3 and 4 depict the ozone values from each station where it was monitored in 2018. The maximum 8-hour average for each day is shown for each site; exceedances of the 70-ppb standard are shown in red with the day of month printed beside them. The heavy "stair step" line marks the monthly median. The vertical axis extends to the annual maximum; units are ppb.

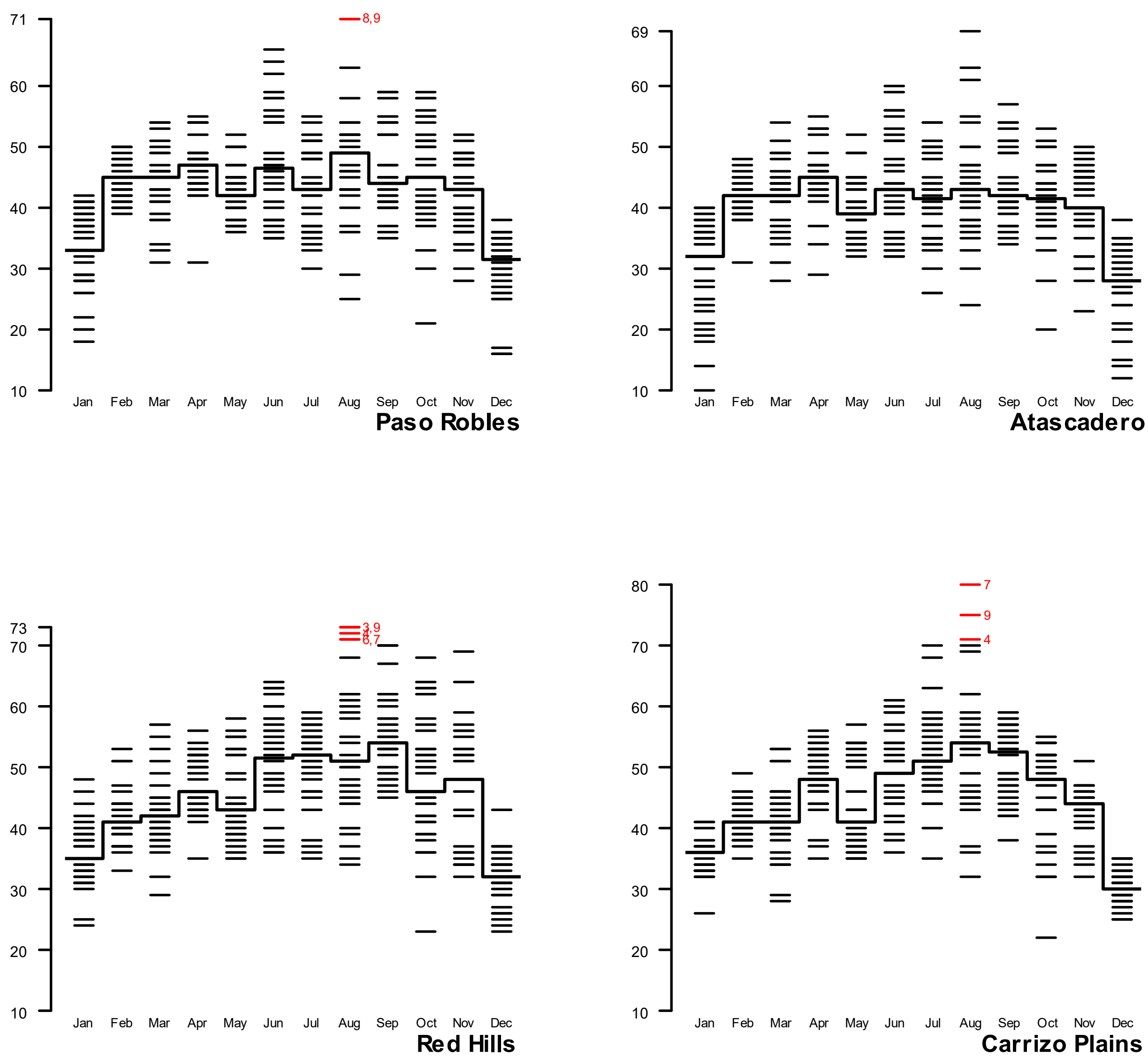

Figure 3: Daily Maximum 8-Hour Average for 2018

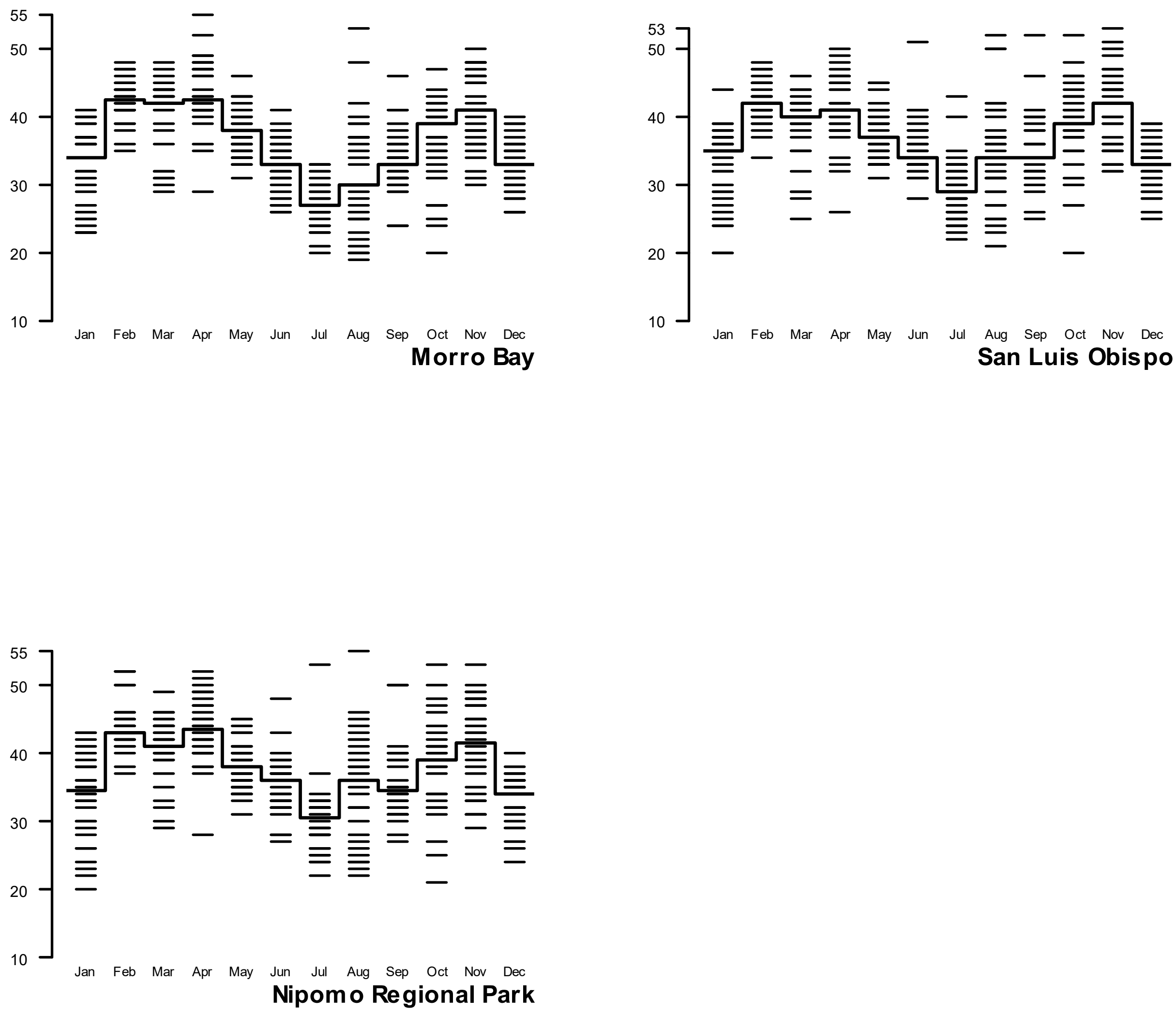

Figure 4: Daily Maximum 8-Hour Average for 2018

Particulate Matter Summary

In 2018, there were no exceedances of the federal 24-hour PM_{10} standard (150 $\mu g/m^3$) anywhere in the county. Exceedances of the California 24-hour PM_{10} standard (50 $\mu g/m^3$) were observed on 74 different days: 47 days at CDF, 39 at Mesa2, 27 at Paso Robles, 17 at NRP, 3 at Atascadero, and 2 at Oso Flaco.[3] This year, CDF, Mesa2, Paso Robles, NRP, and Oso Flaco exceeded the state annual average PM_{10} standard of 20 $\mu g/m^3$.

Local Rule 1001, which is intended to address windblown dust emissions and downwind air quality impacts from the Oceano Dunes State Vehicular Recreation Area (ODSVRA), states that the park operator "shall ensure that if the 24-hour average PM_{10} concentration at the [riding area] Monitor is more than 20% above the 24-hour average PM_{10} concentration at the Control Site Monitor, the 24-hour average PM_{10} concentration at the [riding area] Monitor shall not exceed 55 $\mu g/m^3$."[4] For determining compliance with this standard, the CDF and Oso Flaco monitors have been designated as the riding area and control site monitors, respectively. This year there were 40 days that violated the Rule 1001 standard, as well as 1 possible violation day when the CDF 24-hour average exceeded 55 $\mu g/m^3$ but Oso Flaco was offline.

For $PM_{2.5}$, exceedances of the federal 24-hour standard (35 $\mu g/m^3$) were observed on 2 days: August 23rd at CDF and August 24th at CDF, Mesa2 and San Luis Obipso.[5] The federal and state annual average standards (both 12 $\mu g/m^3$) were not exceeded anywhere in the county this year.

Table 4 lists the highest 24-hour concentrations recorded in 2018 and the dates on which they occurred, as well as the annual means for PM_{10} and $PM_{2.5}$. Concentrations are in $\mu g/m^3$. Values exceeding federal standards are shown in **bold**; those exceeding state standards are <u>underlined</u>.

Windblown dust, wildfires, and construction caused elevated PM_{10} and $PM_{2.5}$ this year. In general, elevated particulate levels at CDF, Mesa2, and Nipomo Regional Park are associated with windblown dust events. This year, the 3 highest 24-hour PM_{10} averages for CDF and Mesa2 and the 2 highest for NRP were all due to windblown dust.

August 23rd and 24th saw the highest 24-hour $PM_{2.5}$ averages of the year at CDF, Mesa2, San Luis Obispo, and Atascadero. These elevated $PM_{2.5}$ concentrations were related to wildfires. The District issued an Air Quality Alert on August 24th, warning of air quality impacts from "a variety of sources, including urban areas and wildfires" and specifically mentioning the Front Fire, which burned just over 1,000 acres near the San Luis Obispo–Santa Barbara County border from August 19 to August 29. The previously mentioned Mendocino Complex and Holy Fires were also burning during this time.

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[3] CARB and EPA apply different conventions to the handling of significant digits. The CARB website (https://www.arb.ca.gov/adam/topfour/topfour1.php) thus counts 55 exceedances of the state PM_{10} standard at CDF, 40 at Mesa2, 26 at Paso Robles, 20 at NRP, 4 at Atascadero, and 5 at Oso Flaco. The database used by the CARB website may also contain erroneous values.

[4] San Luis Obispo County Air Pollution Control District, "RULE 1001 Coastal Dunes Dust Control Requirements," Adopted November 16, 2011, Revised by Court Order CV12-0013, March 7, 2016. Available online at https://ww3.arb.ca.gov/drdb/slo/cur.htm.

[5] In addition to the exceedance noted for San Luis Obispo on August 24th, a value of 35.2 μg/m3 was also recorded on August 23rd; however, this is not considered an exceedance of the standard. While the federal $PM_{2.5}$ standard is nominally 35 $\mu g/m^3$, 40 CFR 50 Appendix N specifies that ambient $PM_{2.5}$ measurements are to be rounded to the nearest 1 $\mu g/m^3$ before being compared to the standard. Therefore, 24-hour $PM_{2.5}$ measurements between 35.0 and 35.4 $\mu g/m^3$ are technically not exceedances of the standard and are not counted as such by the EPA when determining attainment.

The Camp Fire in Butte County started on November 8th and burned over 150,000 acres before being fully contained on November 25th. This fire contributed to elevated particulate levels across the county, including many of the 3 highest daily PM_{10} averages in Atascadero, Paso Robles, and San Luis Obispo, and also the third highest daily $PM_{2.5}$ averages at both San Luis Obispo and Mesa2.

Finally, construction activity in the lot adjacent to the Paso Robles station caused the unusual number of exceedances of the state PM_{10} standard observed these this year. This year 27 days exceeded the standard, while last year there were only 4 days, and none in the 2 prior years. (See Figure 9, later, for a graphical comparison.)

Table 4: PM_{10} and $PM_{2.5}$ Summary for 2018

Station	Highest 24-hour PM_{10}			Annual	Highest 24-hour $PM_{2.5}$			Annual
	1st	2nd	3rd	Average PM_{10} ‡	1st	2nd	3rd	Average $PM_{2.5}$ ‡
Paso Robles	85 06/04	78 11/19	77 11/15	26.0				
Atascadero	54 11/09	52 11/11	51 11/08	19.0	34.1 08/24	27.6 08/23	23.4 01/03	6.5
San Luis Obispo	44 08/24	43 11/17	40 8/23	14.0	**38.4** 08/24	35.2 [5] 08/23	32.0 11/17	5.9
CDF, Arroyo Grande	117 07/06	116 08/31	115 06/10	28.7	**46.8** 08/24	**40.7** 08/23	34.6 08/31	8.8
Nipomo Regional Park	89 07/07	66 06/08	65 06/24	24.3				
Oso Flaco	56 06/10	52 08/24	50 04/08	20.5				
Mesa2, Nipomo	124 06/10	123 08/31	111 08/06	27.3	**38.3** 08/24	33.4 08/23	31.7 11/18	7.6

‡ Weighted arithmetic mean as calculated by an AMP450 AQS report.

Visual $PM_{2.5}$ and PM_{10} Summaries

Figures 5 and 6, below, show the 24-hour $PM_{2.5}$ and PM_{10} values from the stations where these pollutants were measured in 2018. As with the ozone plots in the previous section, these show daily concentrations by month for each site; exceedances of state and federal standards are shown in red with the day of month printed beside them. The heavy "stair step" line marks the monthly median. The vertical axis extends the annual maximum; units are $\mu g/m^3$.

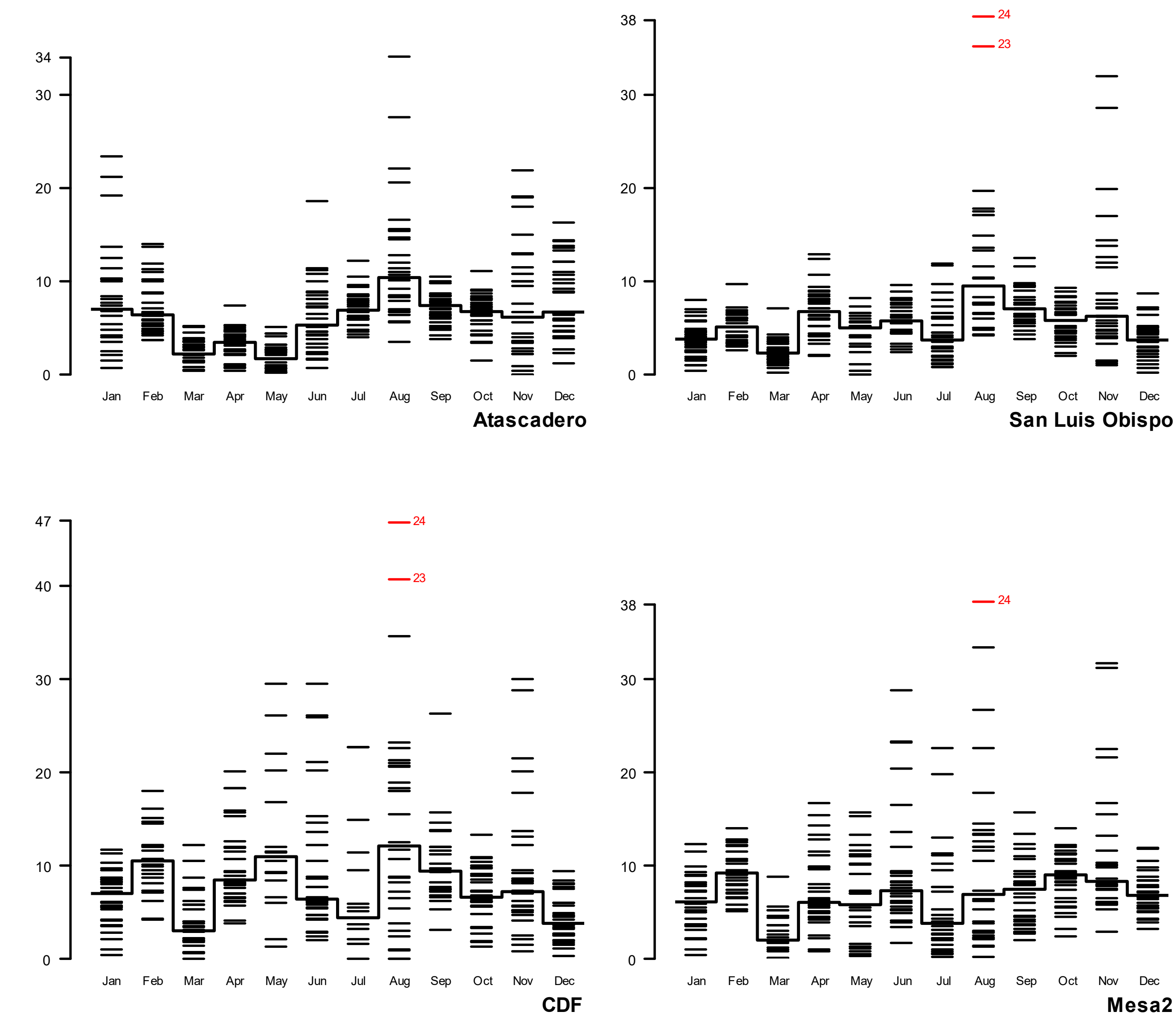

Figure 5: Daily $PM_{2.5}$ Values for 2018

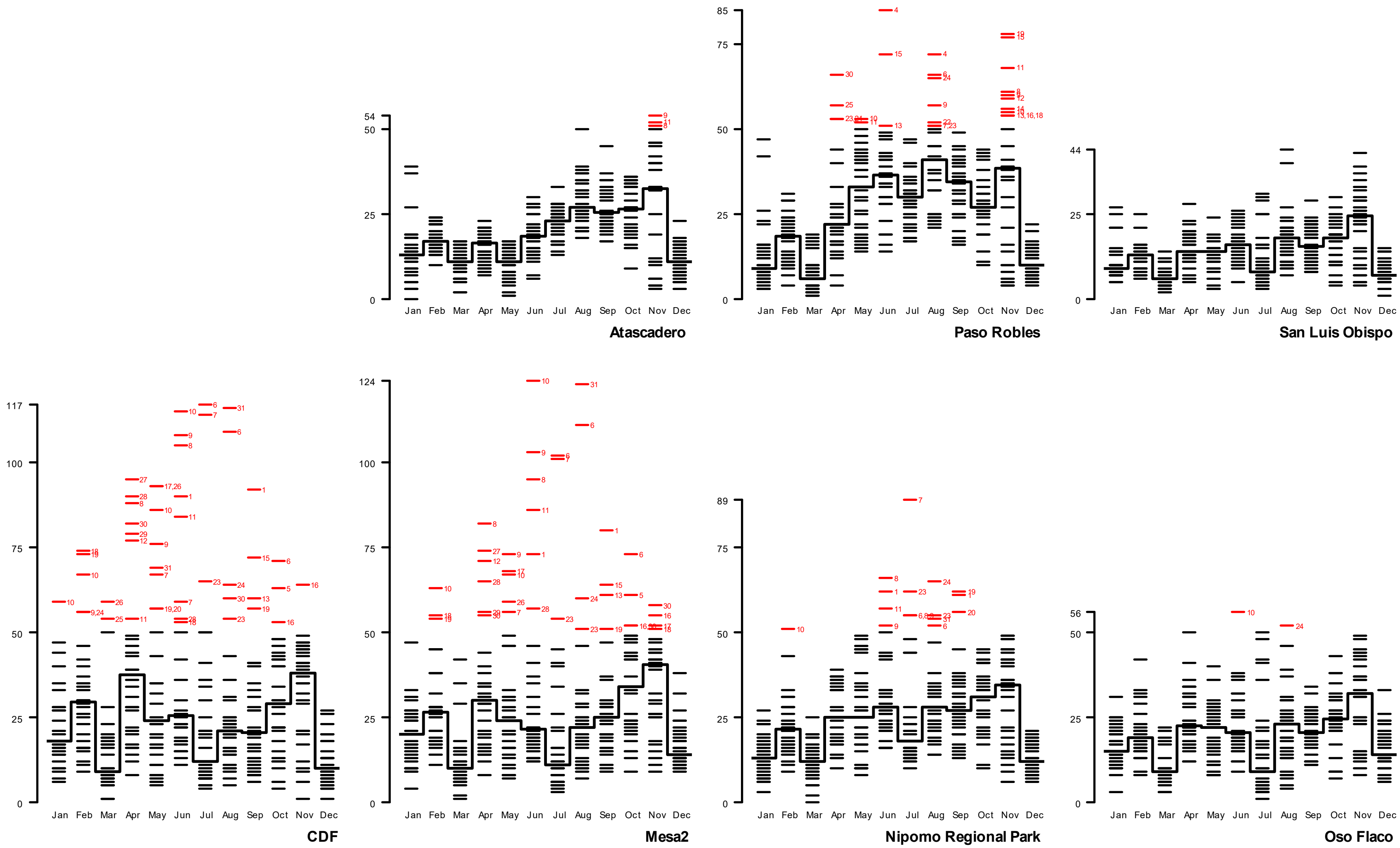

Figure 6: Daily PM_{10} Values for 2018

10-Year Trends

Ozone

Figure 7, below, depicts the total number of hours each year during which the ozone concentration was at or above 65 ppb. This is a useful indicator for trends, even though there are no health standards for single-hour exposure to this level of ozone. Figure 8 shows ozone design values over the same period. Design values are used by EPA to determine whether an area attains a federal standard. For ozone, the design value is calculated by averaging the 4th highest annual 8-hour average over three consecutive years. For example, a 2016 design value is the average of the 4th highest 8-hour averages from 2014, 2015, and 2016. Only design values meeting data completeness requirements are included; the dashed red line indicates the federal 8-hour standard which changed from 75 to 70 ppb in 2015.

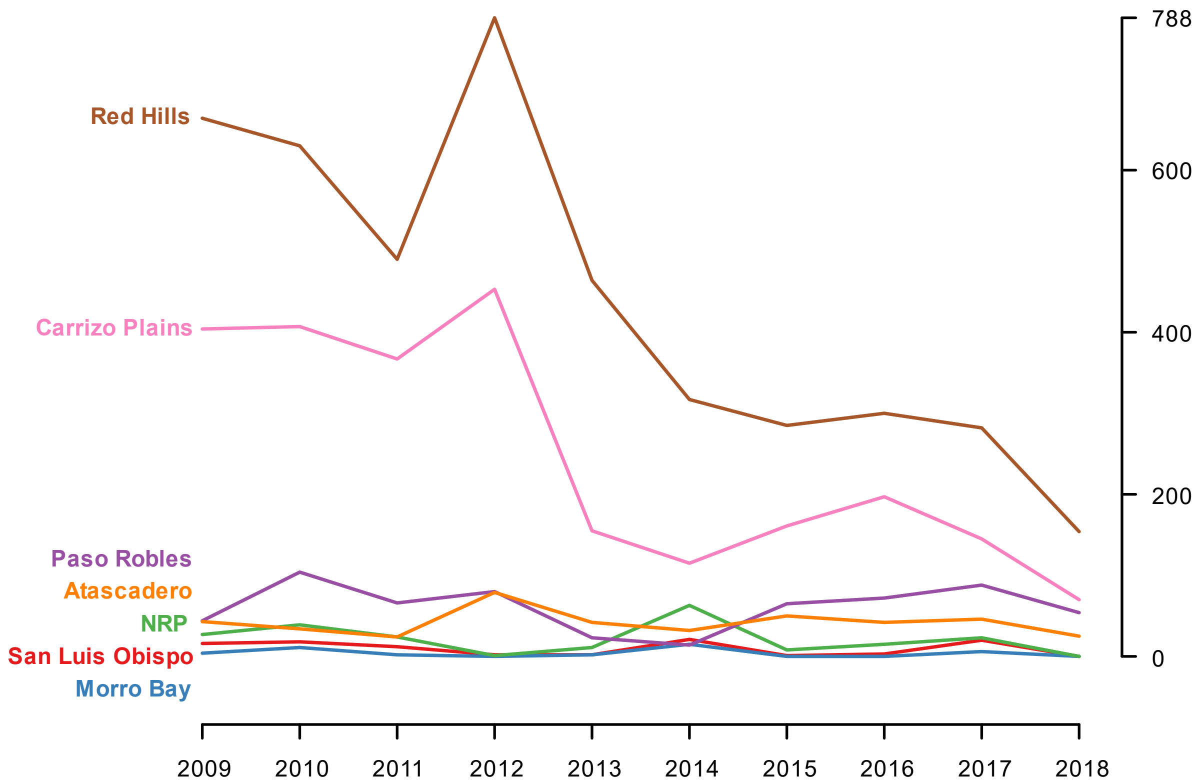

Figure 7: Hours At or Above 65 ppb Ozone, 2009-2018

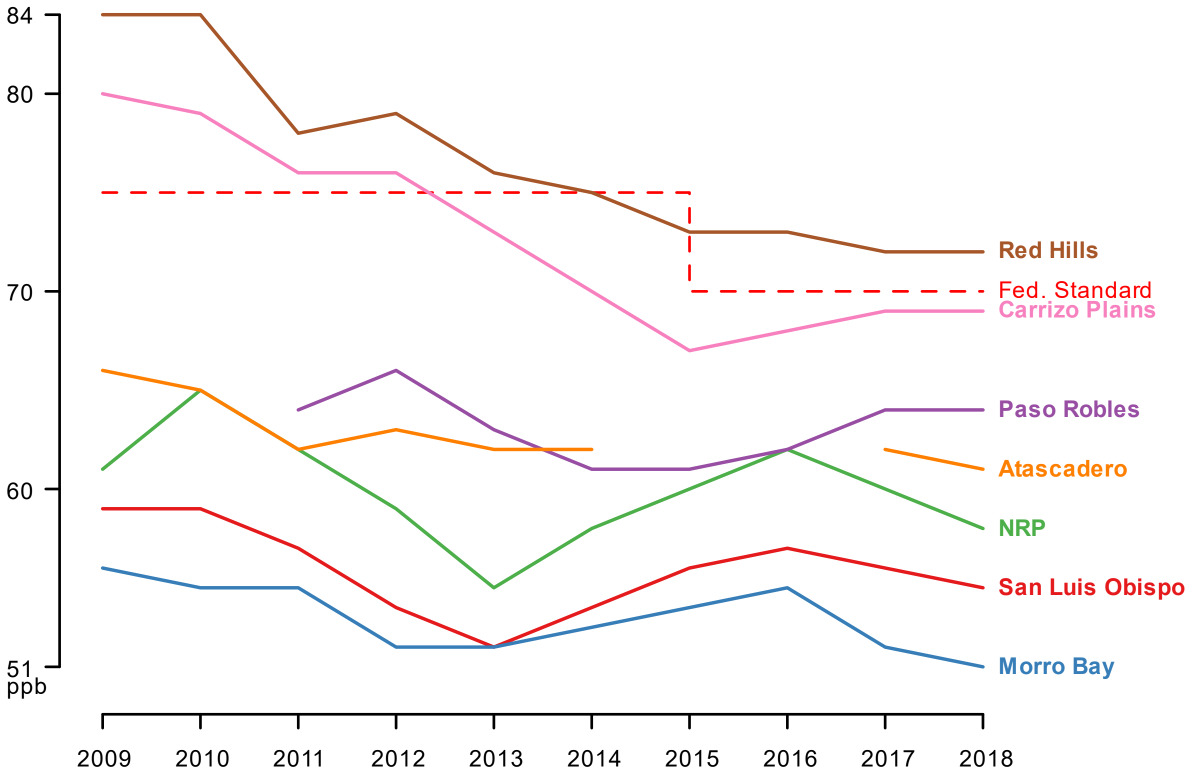

Figure 8: Ozone Design Value Trends, 2009-2018

Particulate Matter

Figure 9 (next page) shows the number of exceedances of the state PM_{10} standard at each site by year. Collection of daily data began in mid–2009 for some sites and later for others, and years missing more than 10% of daily values are omitted. Oso Flaco is omitted because only 2018 meets this data completeness requirement.

Figure 10 plots the total number of hours each year when PM_{10} was at or above 50 $\mu g/m^3$ during the hours when people are most likely to be active (10 am to 4 pm). This metric is intended to illustrate trends in population exposure, even though there are no health standards for single-hour exposure to this level of PM_{10}. Years missing more than 10% of daily values are omitted. Oso Flaco is omitted because only 2018 meets this data completeness requirement.

Figure 11 depicts annual average PM_{10} concentrations over the past 10 years;[6] years with partial data are omitted. The red dashed line marks the state standard for the annual mean (20 $\mu g/m^3$).

Trends in $PM_{2.5}$ annual averages are depicted in Figure 12 for the four sites where it is measured. Data for the past 10 years are shown, and years with partial data are omitted. The red dashed line marks the 12 $\mu g/m^3$ state and federal $PM_{2.5}$ standard for the annual mean.

[6] In general, these are seasonally weighted averages as calculated by AQS. For years when sampling methodology changed or a site was moved, the average depicted is the time-weighted average of the methodologies or locations.

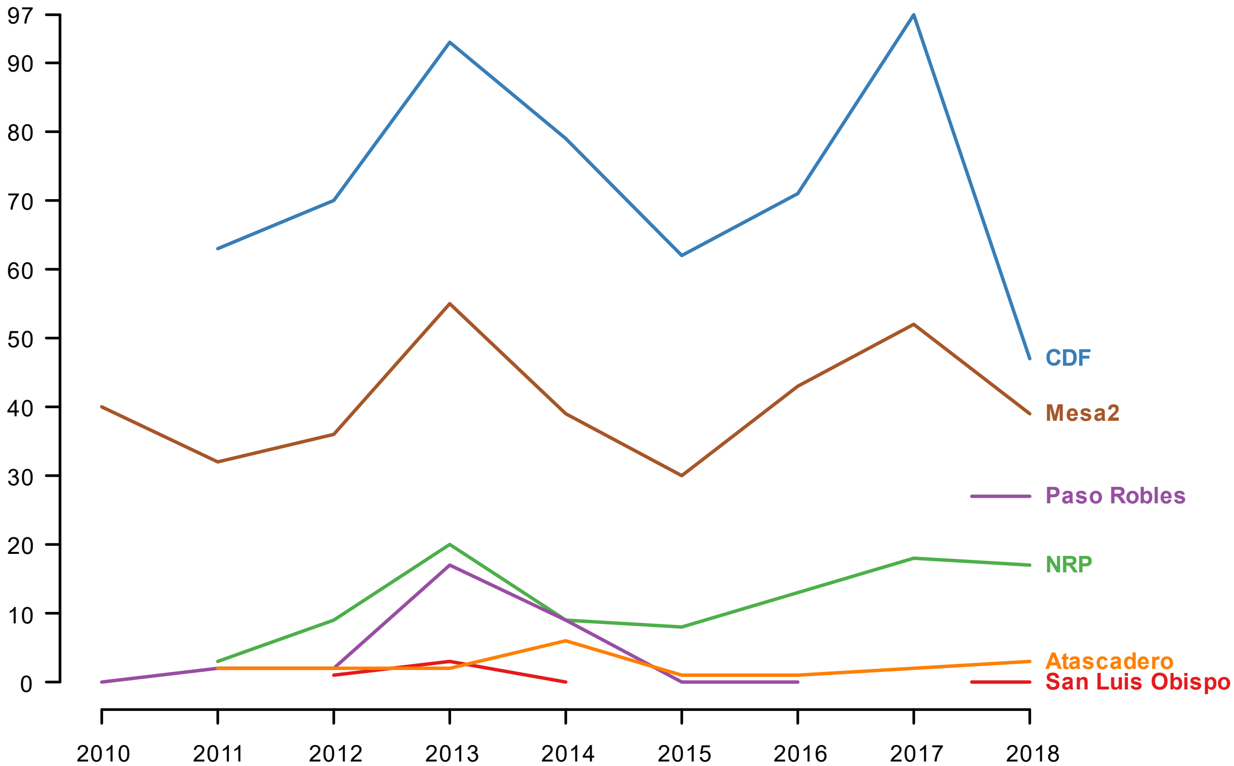

Figure 9: Exceedances of the California 24-hour PM_{10} Standard, 2010–2018

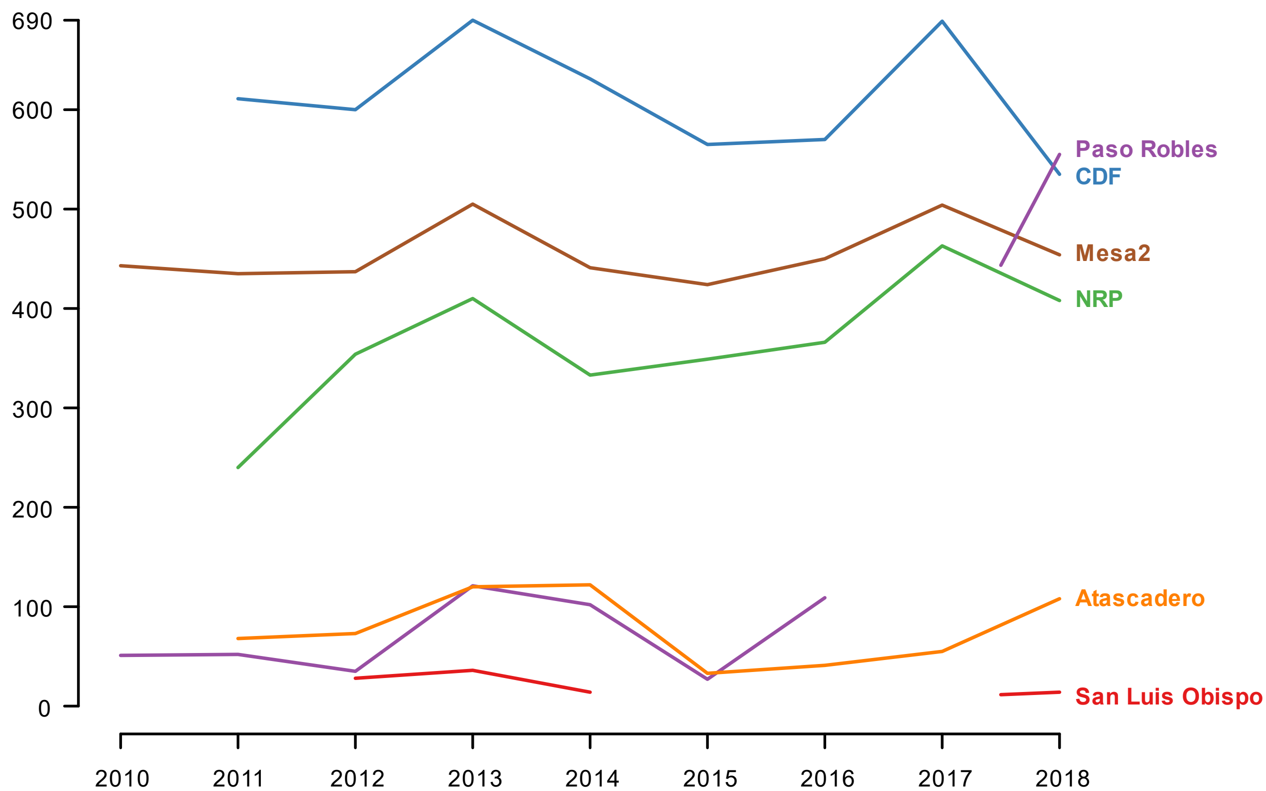

Figure 10: Hours At or Above 50 g/m³ PM_{10}, 2010–2018

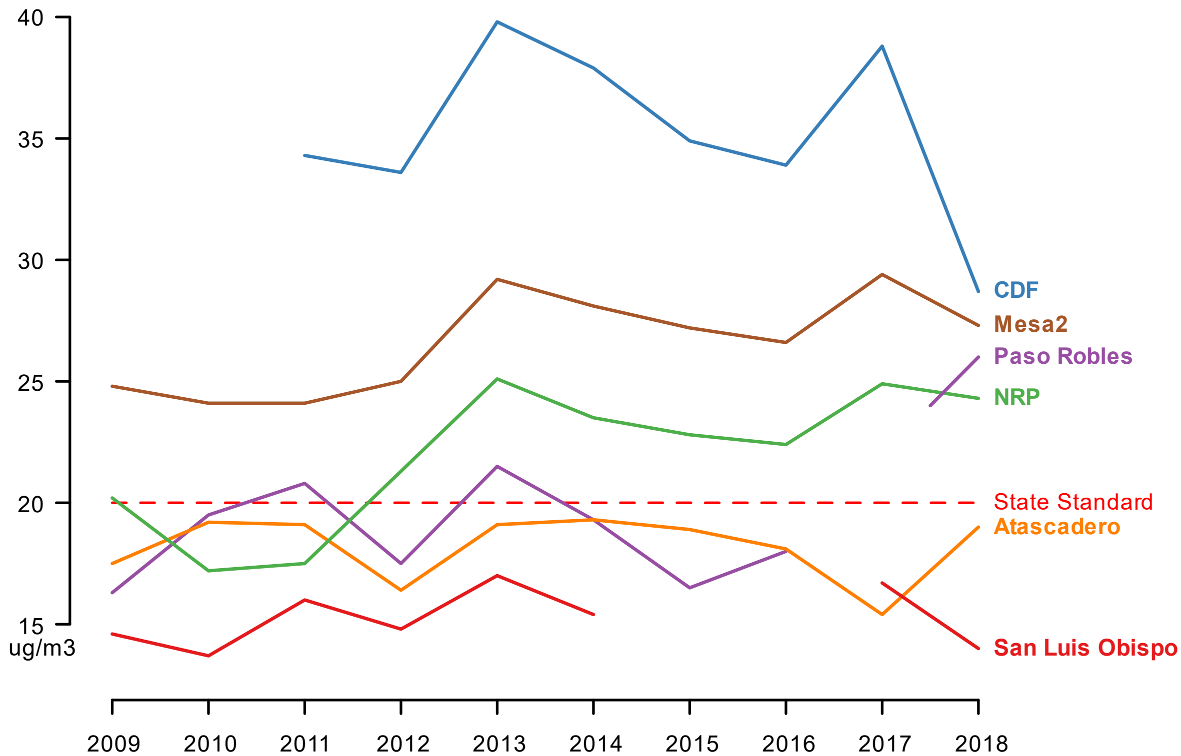

Figure 11: PM_{10} Annual Averages, 2009–2018

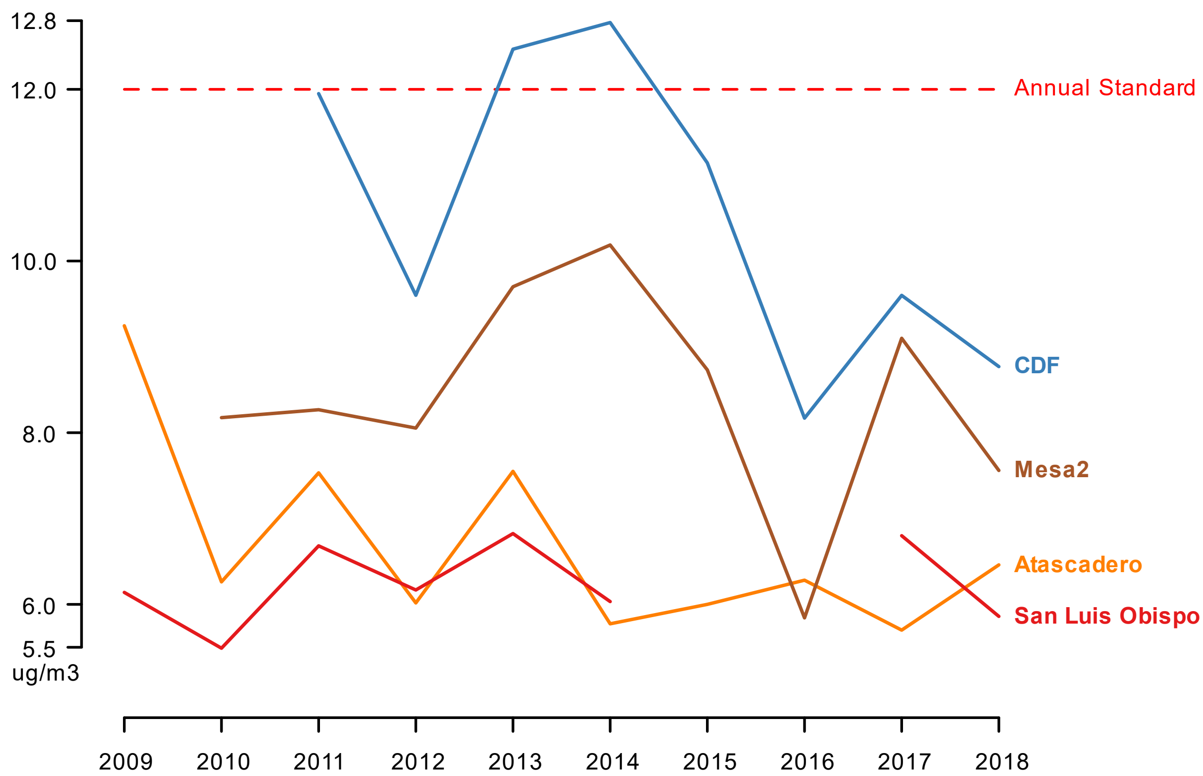

Figure 12: $PM_{2.5}$ Annual Averages, 2009-2018

Appendix A: Assessing the Effectiveness of ODSVRA Mitigations

Introduction

The 2015, 2016, and 2017 Annual Air Quality Reports[7] contained appendices that analyzed recent trends in particulate matter on the Nipomo Mesa. They concluded that the mitigation measures deployed by the ODSVRA operator (California Department of Parks and Recreation) did not detectibly reduce PM_{10} levels at CDF. The 2017 Annual Air Quality Report presented new methodology for assessing mitigation effectiveness. This section applies that methodology to the dataset from 2018.

The District's Preliminary Review Letter for State Parks' Draft Particulate Matter Reduction Plan[8] contains an earlier version of this analysis which used preliminary data. What follows is the final version using fully validated data.

Background and Methodology

From 2011 to 2017, the annual number of exceedances of the state PM_{10} standard at CDF varied from as few as 62 to as many as 97. In 2018, there were 47. It would be naïve to attribute these year-to-year changes solely to changes in the extent of State Parks' mitigation efforts. As discussed in the 2017 Annual Air Quality Report, downwind PM_{10} concentrations are potentially influenced not only by the mitigations, but also by other factors including regional particulate matter events, wildfires, non-ODSRVA sources, and—most importantly—meteorology, in particular, the strength and direction of on-shore winds. It is wind that drives the actual dust emissions, so, all else being equal, windier years are expected to be dustier than less windy years.

Appendix A of the 2017 Annual Air Quality Report proposed a "Difference-in-Differences" approach to disentangling the potential effects of the mitigations from meteorology and other factors. In a nutshell, this method looks at the ratio of PM_{10} concentrations between CDF and Oso Flaco on wind event days, and then asks whether that ratio changes from one year to the next. The crux of the idea is that comparing to Oso Flaco implicitly controls for inter-annual variations in meteorology and other factors. This is because the mitigation measures are upwind of CDF but not Oso Flaco, so changes in the mitigations should affect CDF but not Oso Flaco. Meanwhile, both sites should experience approximately the same trends in meteorology, and they should be similarly influenced by wildfires and regional particulate matter events.

See the 2017 Annual Air Quality Report for a more complete description of the methodology. As noted in the Air Quality Monitoring and Data section of this report, all data and computer code needed to fully reproduce this analysis are available online at https://github.com/sloapcdkt/2018aqrptR.

Results

This method requires PM_{10} data from Oso Flaco and CDF as well as wind data from CDF and the S1 tower located within the ODSVRA. The CDF and Oso Flaco are fully validated, but the S1 data used in this analysis was obtained from State Parks, and its validation status is unknown. It was used as-is.

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[7] San Luis Obispo County Air Pollution Control District, "2015 Annual Air Quality Report," "2016 Annual Air Quality Report," and "2017 Annual Air Quality Report" at https://www.slocleanair.org/library/air-quality-reports.php.

[8] San Luis Obispo County Air Pollution Control District, "SLO County APCD Preliminary Review Letter." Gary E Willey, Air Pollution Control Officer, to Dan Canfield, Acting Deputy Director, OHMVR Division, dated February 25, 2019. Online at https://storage.googleapis.com/slocleanair-org/images/cms/upload/files/Feb%2025%202019%20APCD%20Response%20to%20SP-Feb%201%202019%20PMRP%20%28Signed%29%20%281%29.pdf

The first full year of data from Oso Flaco was 2016, thus the only year-to-year comparisons that are possible are 2016 vs 2017, 2016 vs 2018, and 2017 vs 2018. The 2017 Annual Air Quality Report compared 2016 and 2017 and found no significant difference in the CDF/Oso ratio. This was not surprising, since the ODSVRA mitigations for those years were small (40 and 20 acres, respectively), and the change from year to year was also small (20 acres). As discussed in that report, 2017 was selected as the baseline to compare future years to, since it had the least amount of mitigation and is thus the closest possible scenario to a fully un-mitigated baseline. This analysis thus compares 2018, where there about 93.7 acres of mitigations on the ODSVRA,[9] to 2017, when there were about 20 acres.

The comparison of 2018 to 2017 shows a statistically significant decrease in event-day CDF PM_{10} of 22.4% (95% CI: 7.4 - 34.9%; p-value: 0.0061). In other words, 2018 wind event PM_{10} levels at CDF were 22.4% lower than what they would have been if the 2018 mitigation projects had not been undertaken and instead the 2017 projects remained.

This is visualized in Figure A1, which display boxplots of the CDF/Oso Flaco ratio for 2016 through 2018; the ratios for 2018 are shifted to lower values compared to the earlier years.

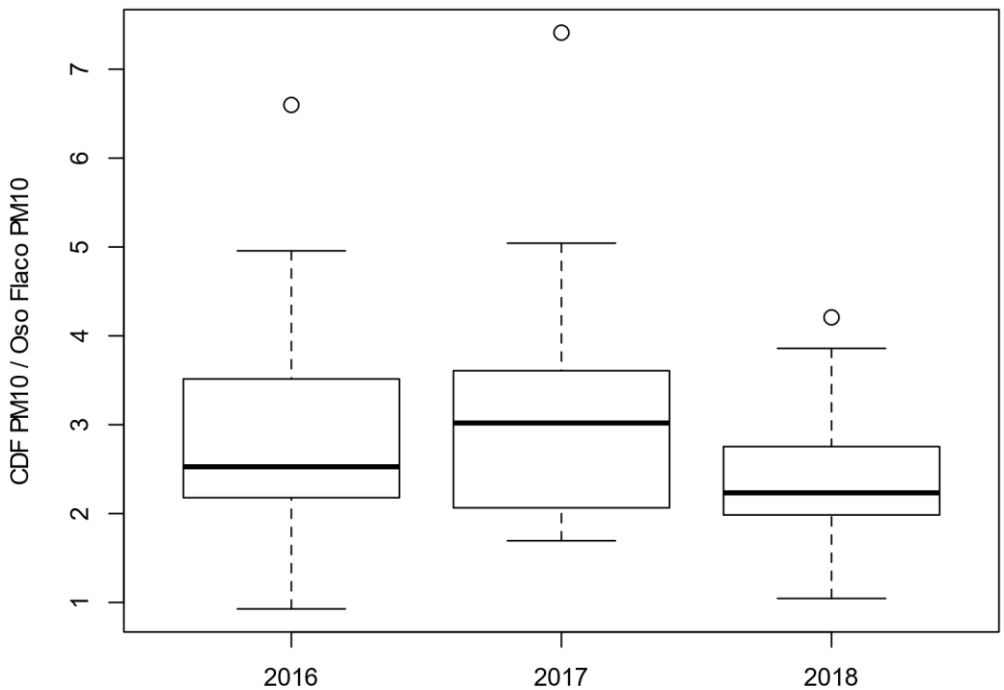

Figure A1: CDF/Oso Flaco PM_{10} Ratio for Wind Event Days

[9] The mitigation acreage is derived from State Parks' Draft Particulate Matter Reduction Plan (June 2019; https://storage.googleapis.com/slocleanair-org/images/cms/upload/files/Draft_PMRP_20190606.pdf), in particular Figure 5-1. This figure shows 48.6 acres of "initial SOA" wind fencing, 36.1 of "initial SOA" straw bales, and 9 acres of "Pre-SOA" wind fencing, which was in place for most of 2018 but subsequently removed. These 93.7 acres were installed over the course of 2018, so the actual mitigation acreage was likely less during wind events that occurred early in the year. Not including in the totals for 2017 or 2018 are 18.4 acres of "Pre-SOA" vegetation projects, installed "During the 2017 planting season (which runs from fall 2017 to winter 2018)".

In principle, the decrease in the ratio could be due to either a decrease in the CDF levels or an increase in Oso Flaco levels. As shown in Table A1, below, the CDF average for 2018 is indeed lower than for 2016 and 2017, and rather than increasing in 2018, the average level for Oso Flaco also decreased. Thus, the decline in the CDF/Oso Flaco ratio can be attributed to declining CDF levels rather than increasing Oso Flaco levels.

Table A1: Average PM_{10} Concentration on Wind Event Days

Site	2016	2017	2018
CDF	74.6	82.9	62.7
Oso Flaco	29.1	29.6	28.3

Appendix B: 2019 Ambient Crystalline Silica Monitoring

Introduction

Inhaling very small particles of crystalline silica is known to cause lung cancer, silicosis, chronic obstructive pulmonary disease (COPD), and kidney disease, and may also be associated with autoimmune disorders and other adverse health effects.[10] To protect workers from these effects, the Occupational Safety and Health Administration (OSHA) has set a workplace standard for respirable crystalline silica of 50 $\mu g/m^3$ averaged over 8-hours.[11] To assess risks to the general public, the California Office of Environmental Health Hazard Assessment (OEHHA) has derived a chronic reference exposure level (REL) of 3 $\mu g/m^3$.[12] A REL is a non-enforceable health benchmark, and exposures to levels less than the REL are believed to be safe. As this is a *chronic* REL exposure, it assumes exposure over a lifetime. Brief exposures to levels above the REL are not necessarily a health risk; on the other hand, an annual average concentration exceeding the REL may indicate a health risk.

Beach sand typically has a high quartz content, and quartz is a form of crystalline silica. *Respirable* crystalline silica particles are at least 100 times smaller than ordinary beach sand, but since the particulate matter impacting the Nipomo Mesa on windy days is derived from ODSVRA sand, it is reasonable to wonder whether crystalline silica is present in this dust. To address these concerns, the District collected 8 samples for respirable crystalline silica analysis in 2017 and 2018. As discussed in the 2017 Annual Air Quality Report,[7] none of these samples, nor an additional sample collected by State Parks in 2018, exceeded the OSHA 8-hour standard. A statistical analysis of that data suggested that the probability of a future exceedance is negligible.

While these findings were reassuring, the District had doubts about the performance of the sampling method in windy conditions. As discussed in the 2017 Report, there is evidence that in high winds the method has a negative bias (i.e., it underestimates silica concentrations). Therefore, more samples were collected in 2019 using an alternative method which has been shown to sample PM_{10}-sized particles efficiently, even in windy conditions. This method and the results are discussed below.

General Considerations

- **Regulatory Framework**. The OSHA standard applies only to workplaces—it is not an ambient air quality standard. Furthermore, it is enforced by OSHA; the APCD has no authority to act on exceedances of this workplace standard.
- **Appropriateness of the OSHA Standard**. The OSHA standard was developed for the workplace, and thus incorporates assumptions that may not be adequate to protect the health of the general population.
- **OEHHA chronic REL**. As noted above, OEHHA has derived a chronic REL for respirable crystalline silica of 3 $\mu g/m^3$. A REL is a non-enforceable health benchmark, and long-term exposures to levels less than the REL are believed to be safe. Occasional 8- or 24-hour air samples exceeding this level

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[10] Centers for Disease Control and Prevention, National Institute for Occupational Health and Safety, "CDC – Silica, General Publications – NIOSH Workplace Safety & Health Topics." https://www.cdc.gov/niosh/topics/silica/default.html.
[11] U.S. Department of Labor, Occupational Safety and Health Administration, "Safety and Health Topics / Silica, Crystalline." https://www.osha.gov/dsg/topics/silicacrystalline/.
[12] Office of Environmental Health Hazard Assessment (2000), "Determination of Noncancer Chronic Reference Exposure Levels. Appendix D3." https://oehha.ca.gov/media/downloads/crnr/appendixd3final.pdf.

are not necessarily an indication of a health risk; on the other hand, an annual or multi-year average concentration that exceeds the REL may indicate a health risk.

- **Particle Size Fraction.** Both the OSHA standard and the OEHHA REL are based on *respirable* crystalline silica, which has a specific definition: roughly, the subset of crystalline silica particles less than 4 microns in aerodynamic diameter, i.e. PM_4. It is not appropriate to directly compare the crystalline silica content of PM_{10} sample to the OSHA standard or OEHHA REL because such a sample would not be a "respirable" sample.[13]

Methodology

The method used by the District and State Parks for silica sampling in 2017 and 2018 is known to be biased in windy conditions; therefore, as noted in the 2017 Annual Air Quality Report, "it is likely that our silica samples underestimate the actual levels." In contrast, EPA-approved sampling methods for PM_{10} and $PM_{2.5}$ have been demonstrated to yield unbiased samples even in high cross winds. The District therefore used an EPA-approved filter-based PM_{10} sampler for collecting samples for silica analysis in 2019. Since a PM_{10} sampler was used, the samples do not meet the "respirable" definition and cannot be compared directly to the OSHA standard or OEHHA REL; therefore *we refer to our silica samples as "PM_{10}-silica" samples to stress the fact that they represent a PM_{10}-size fraction, rather than a respirable fraction.*

All samples were collected using a Rupprecht & Pataschnick Partisol-FRM Model 2000-H sampler (EPA Method ID: RFPS-1298-126 / RFPS-0694-098), operated at 16.7 L/min for 24 hours (midnight to midnight) using 47 mm PVC filter media. When used to collect samples for comparison to the PM_{10} NAAQS, Teflon filter media is required; however, the analytical method for crystalline silica requires the use of PVC filters. This was the only modification made to the EPA-approved PM_{10} sampling method. All samples were collected at the CDF site, the air monitoring station on the Nipomo Mesa which typically records the highest PM_{10} concentrations.

The District contracted with SGS Forensic Laboratories (Hayward, California; previously called Forensic Analytical Laboratories) for silica analysis. The District provided the SGS with empty Partisol filter cassettes, which SGS loaded with PVC filter media, pre-weighed, and returned. After sampling, exposed filter cassettes were shipped to SGS for gravimetric analysis of total dust (NIOSH method 500/600, modified) and crystalline silica analysis by Fourier Transform Infrared Spectroscopy (NIOSH method 7603). For the silica analysis, quartz, cristobalite, and tridymite were analyzed and reported separately. (Cristobalite and tridymite are other silica minerals; they are sometimes encountered in air samplers from mining and industrial worksites.) The reporting limit for total dust varied from 3 to 5 $\mu g/m^3$. The reporting limits for each silica component as well as for total silica were all 0.42 $\mu g/m^3$.

Results

Table B1, below, presents the results of the 26 samples collected in 2019. "PM_{10}-Silica" and "Total Dust" refer to the results of the PVC filter analysis by SGS. No cristobalite or tridymite was detected in any sample; in each sample all of the reported total silica content is quartz. The other columns refer to the results from the District's permanent particulate matter monitors at CDF—these data should be considered preliminary and unofficial, as the District has not fully completed its validation and review of

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[13] International Organization for Standardization (1995), "ISO 7708:1995. Air quality — Particle size fraction definitions for health-related sampling." https://www.iso.org/obp/ui/#iso:std:iso:7708:ed-1:v1:en. The ISO/ACGIH/CEN convention definition of "respirable" is actually an equation for a sigmoid shaped curve plotting the fraction of particles sampled versus particle size. Particles of exactly 4 microns are sampled at 50%, with larger fractions of smaller particles sampled, and smaller fractions of large particles sampled. Particles greater than 10 microns are essentially not sampled at all. Also see page 521 of reference 12 for further discussion.

data from 2019. “PM_{10} Standard Conditions” refers to PM_{10} concentrations corrected to standard temperature and pressure, and “PM_{10} Local Conditions” refers to PM_{10} reported in “local conditions,” i.e. uncorrected to standard conditions. State and federal regulations specify that PM_{10} concentrations must be corrected to standard conditions when comparing to the PM_{10} standards, and all PM_{10} concentrations discussed earlier in this report (including those in Table 4 and in various figures) have this correction. The PM_{10}-silica and total dust values reported by SGS are in local conditions, which is why “PM_{10} Local Conditions” data is included in the table. All concentrations are 24-hour averages. “ND” stands for “Not Detected”.

These results are plotted in Figures B1 and B2 on the following pages. Figure B1 plots the total dust results from the PVC filter analysis (second column in Table B1) against the PM_{10} Local Conditions values from the District’s collocated permanent monitor (forth column in Table B1). The dashed line marks the 1:1 line.

PM_{10}-Silica (third column in Table B1) is plotted against PM_{10} Standard Conditions (fifth column) in Figure B2. The solid line marks best-fit linear regression line.

Table B1: Crystalline Silica Results

Date	Total Dust	PM_{10}-Silica	PM_{10} Local Conditions	PM_{10} Standard Conditions	$PM_{2.5}$
	24-hour averages; all concentrations in µg/m³				
4/9/2019	110	11	104	100	20
4/11/2019	91	8.1	87	83	19
4/13/2019	35	1.3	26	25	3
4/20/2019	39	3	32	31	5
5/14/2019	16	0.49	12	11	2
5/16/2019	20	ND	14	13	1
5/19/2019	17	ND	12	12	1
5/22/2019	59	3.9	53	52	11
5/28/2019	54	11	99	96	17
5/30/2019	19	0.47	15	15	2
6/6/2019	25	ND	21	20	4
6/14/2019	14	0.63	7	7	1
6/27/2019	62	6.3	60	58	11
7/1/2019	89	9.5	88	86	19
7/3/2019	65	5.8	62	60	13
7/11/2019	11	ND	6	6	2
7/15/2019	93	8.9	85	84	18
7/29/2019	40	2.2	40	39	11
8/2/2019	15	1.2	15	15	3
8/10/2019	28	3.5	29	28	5
8/20/2019	40	4.0	39	38	8
8/22/2019	18	ND	16	15	4
9/8/2019	100	12	106	104	24
9/10/2019	52	4.8	51	50	12
9/18/2019	41	2.4	42	41	9
9/28/2019	45	2.1	42	41	10

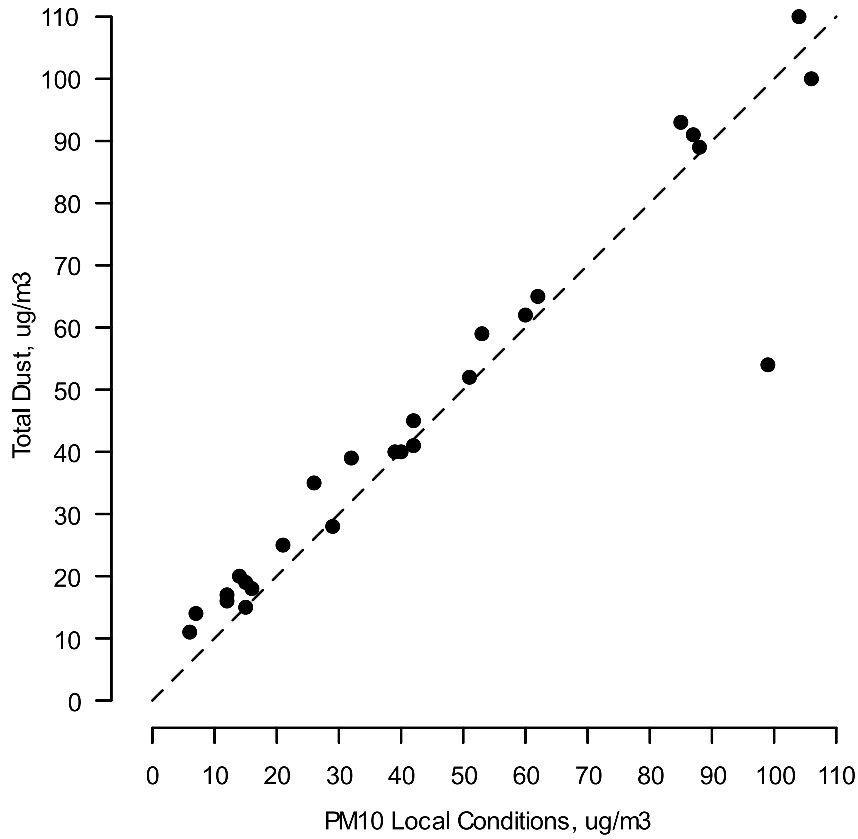


Figure B1: Total Dust (Filter Samples) vs 24-hour PM_{10} Averages from the District's Permanent Monitor

Discussion

Total Dust

The "total dust" results from the filter analysis should be close to the PM_{10} Local Conditions values from the District's collocated permanent monitor, since the filters were collected using an EPA-approved PM_{10} sampler. As shown in Figure B1, below, they are: Except for one outlier, all points lie close to the 1:1 line. (For this comparison, "Local Conditions" values are used rather than "Standard Conditions", since the total dust results are reported in local conditions. Thus, any difference between the total dust results and PM_{10} values are not simply artifacts of converting the PM_{10} concentrations from local to standard conditions.) The correlation coefficient, *r*, between total dust and PM_{10} is 0.95.

The statistic that EPA uses for assessing precision between a pair of collocated particulate samplers is the upper 90% confidence limit for the coefficient of variation (CV_{ub}). For collocated filter-based PM_{10} monitors, the data quality objective is a CV_{ub} of less than 10%.[14] Historically, monitoring organizations have

[14] 40 CFR 58 Appendix A

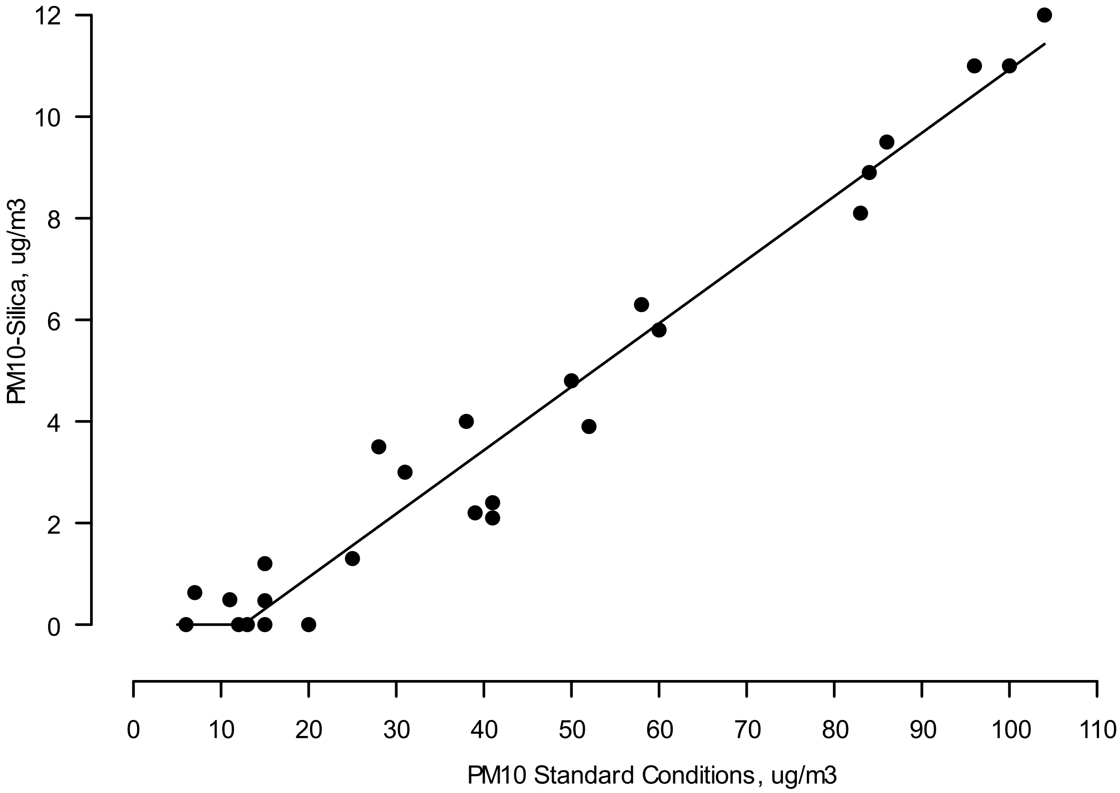


Figure B2: PM_{10}-Silica (Filter Samples)
vs 24-hour PM_{10} Averages from the District's Permanent Monitor

struggled to meet this target—most recently, the 5 pairs of collocated PM_{10} monitors in CARB's network had an average CV_{ub} of 17.76%, while the national average CV_{ub} was 9.20%.[15] The CV_{ub} between our total dust results and the values from the District's collocated permanent monitor is 20.37%. While this is above the data quality objective, it is comparable to the result from the CARB network. Furthermore, unlike the CARB CV_{ub} value, our comparison is between two different sample collection methods, one of which has been slightly modified from the official EPA method as noted above. These results give us confidence in the efficiency of the sampling method.

OSHA Silica 8-hour Standard

None of the 26 24-hour samples from 2019 exceeded the OSHA 8-hour standard of 50 $\mu g/m^3$. The highest observed 24-hour PM_{10}-silica concentration was 12 $\mu g/m^3$; if all the silica in this sample had been collected during the 8 hours of the wind event, then the 8-hour PM_{10}-silica average would have been 36 $\mu g/m^3$,[16] which is still below the OSHA standard. Note also that these samples do not meet the "respirable" definition. They were collected with a PM_{10} sampler, so the amount of *respirable* crystalline silica in each

[15] California Air Resources Board, Quality Management Branch (2018). "2017 Annual Data Quality Report". https://ww2.arb.ca.gov/sites/default/files/2018-12/2017%20Data%20Quality%20Report.pdf

[16] Calculated as $\frac{24\ hrs}{8\ hrs} \times 12\ \mu g/m^3 = 36\ \mu g/m^3$.

sample must be less than the reported silica value, since "respirable" corresponds to PM_4, which is a subset of PM_{10}.

OEHHA Chronic REL

To assess the risk associated with chronic exposure to crystalline silica, we compared estimates of long-term PM_{10}-silica averages to the OEHHA chronic REL of 3 $\mu g/m^3$. While PM_{10}-silica measurements are available only for 26 days in 2019, PM_{10} measurements are available for nearly every day from 2011 through 2018. As shown in Figure B2, there appears to be a consistent relationship between PM_{10}-silica and total PM_{10}. This suggests a strategy of first modeling the PM_{10}-silica vs total PM_{10} relationship, then using the model to estimate daily PM_{10}-silica values for each day from 2011 to 2018. Finally, long-term PM_{10}-silica averages can be estimated from the daily values and then compared to the chronic REL.

The relationship between PM_{10}-silica and total PM_{10} was modeled using censored linear (i.e., Tobit) regression to accommodate the fact that PM_{10}-silica values cannot be negative, while simultaneously allowing the possibility of a threshold effect, i.e. the possibility that silica concentrations are zero (or undetectable) when PM_{10} is low, and then increase linearly above a certain threshold PM_{10} concentration. The relationship was modeled as:

$$PM_{10}\text{-silica} = \begin{cases} 0 & \text{if } PM_{10} \leq 12.5\ \mu g/m^3 \\ 0.125(0.006) \times PM_{10} - 1.57(0.32) & \text{if } PM_{10} > 12.5\ \mu g/m^3 \end{cases}$$

where the values in parentheses are the standard errors of the coefficients and PM_{10} is PM_{10} Standard Conditions. This model has a McFadden pseudo-r^2 of 0.57 and a residual standard error of 0.82 $\mu g/m^3$. It can be interpreted as follows: If the 24-hour PM_{10} value is below 12.5 $\mu g/m^3$, the estimated PM_{10}-silica value is 0 $\mu g/m^3$; above the 12.5 $\mu g/m^3$ threshold, the estimated silica value is 12.5% of the PM_{10} value in excess of the threshold. This relationship is visualized by the dark line in Figure B2.

To calculate annual and multi-year averages, 24-hour PM_{10}-silica concentrations were estimated using this model for each day in the averaging period, and the resulting daily PM_{10}-silica values where then rolled up into long-term averages to compare against the REL. Confidence intervals were calculated by a resampling procedure; they represent the uncertainty associated with the PM_{10}-silica vs total PM_{10} relationship. Table B2, below, summarizes the results.

Table B2: Estimated PM_{10}-Silica Annual Averages

Year(s)	Estimated PM_{10}-Silica Annual Average ($\mu g/m^3$)	95% Confidence Interval ($\mu g/m^3$)
2018	2.17	1.87 – 2.48
2017	3.39	3.06 – 3.72
2016	2.74	2.41 – 3.08
2015	2.81	2.44 – 3.17
2014	3.19	2.82 – 3.55
2013	3.47	3.14 – 3.80
2012	2.73	2.44 – 3.05
2011	2.78	2.43 – 3.13
2011 – 2018	2.91	2.57 – 3.24

As shown in Table B2, the estimated PM_{10}-silica annual average for 2018 was 2.17 $\mu g/m^3$ (95% CI: 1.87–2.48), which is well below the OEHHA chronic REL of 3 $\mu g/m^3$. The multi-year average is also below the REL, albeit only barely at 2.91 $\mu g/m^3$; this average includes all years for which complete PM_{10} data is available at CDF (2011 – 2018). In 2013, 2014, and 2017 the estimated PM_{10}-silica annual averages exceed the REL, and most of the 95% confidence intervals extend above the REL.

The estimates in Table B2 almost certainly overestimate the long-term *respirable* crystalline silica averages. This is because, as previously noted, a "respirable" sample is defined, roughly, as a sample of airborne particles with diameters less than 4 microns. The silica samples collected by the District were PM_{10} samples, with a PM_{10} sample defined, roughly, as a sample of airborne particles with diameters less than 10 microns. Thus, "respirable" is a subset of PM_{10}, and by definition there is less mass in the respirable fraction than in the PM_{10} fraction.

The particle size distribution (PSD) of the silica component of the dust is unknown; for our samples we only know what fraction (by mass) of PM_{10}-sized particles are silica. In theory it is possible that the silica PSD is heavily skewed toward finer particles, and most of the measured silica mass is in the respirable size range. If this were the case, then the amount of respirable crystalline silica in the air might be very close to our PM_{10}-silica measurements. However, this is unlikely: Recent academic studies of dust from the Oceano Dunes found that the silica particles were mostly coarse, with diameters much greater than 10 microns.[17,18] Thus, the silica PSD is likely heavily skewed toward larger particles, with the PM_{10}-silica mass much greater than the respirable silica mass.

Another source of bias in the Table B2 estimates is the influence of non-ODSVRA sources of PM_{10}. While windblown dust from the ODSVRA is the predominant PM_{10} source influencing CDF, elevated PM_{10} can also be caused by wildfires, regional PM_{10} events, and other infrequent sources. PM_{10} from these non-ODSVRA sources would be expected to have no silica content, yet in calculating the Table B2 estimates, all days were treated as though they were purely windblown dust events. Thus, the estimated annual and multi-year averages likely overestimate the true PM_{10}-silica concentrations.

Conclusion

In 2019, 26 24-hour PM_{10}-silica samples were collected at CDF. No samples exceeded the OSHA 8-hr standard for respirable silica, even if it is assumed that for each 24-hour sample all of the silica mass was collected over just 8 hours. A consistent relationship was observed between PM_{10}-silica and total PM_{10}, which can be summarized by the following: If the 24-hour PM_{10} value is below 12.5 $\mu g/m^3$, the estimated PM_{10}-silica value is 0 $\mu g/m^3$; above the 12.5 $\mu g/m^3$ threshold, the estimated silica value is 12.5% of the PM_{10} value in excess of the threshold. Using this relationship, long-term (annual and multi-year) PM_{10}-silica averages were estimated. The estimates of annual PM_{10}-silica average for 2018 and the 2011 – 2018 multi-year average were below the OEHHA chronic REL for respirable silica of 3 $\mu g/m^3$. Long-term averages for *respirable* crystalline silica could not be estimated from the data, but they are most likely much lower than those calculated for PM_{10}-silica; therefore, **chronic risk from respirable crystalline silica is likely to be negligible**.

Finally, these results can be understood in the context of two recently published academic studies. Huang (2019)[17] found that compared to other West Coast beaches, the sand at Oceano has "substantial clay-

[17] Huang, Y., Kok, J. F., Martin, R. L., Swet, N., Katra, I., Gill, T. E., Reynolds, R. L., and Freire, L. S.: Fine dust emissions from active sands at coastal Oceano Dunes, California, Atmos. Chem. Phys., 19, 2947–2964, https://doi.org/10.5194/acp-19-2947-2019, 2019.

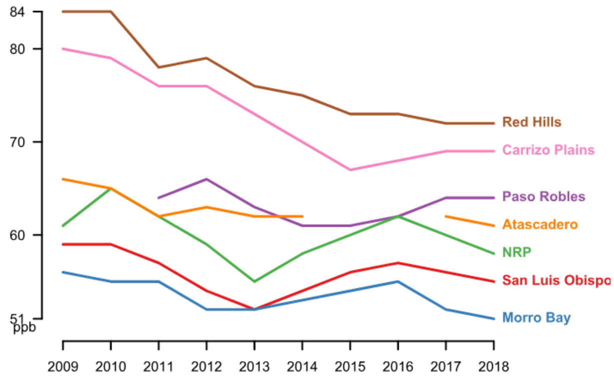
[18] Swet, N., Elperin, T., Kok, J. F., Martin, R. L., Yizhaq, H., and Katra, I.: Can active sands generate dust particles by wind-induced processes?, Earth Planet. Sci. Lett., 506, 371–380, https://doi.org/10.1016/j.epsl.2018.11.013, 2019.

mineral coatings” and a relatively high content of feldspar minerals. The prevalence of feldspars in ODSVRA sand is likely due to the influence of the nearby Santa Maria river transporting feldspar-rich particles eroded from inland sources. Feldspar is softer than quartz, and more easily broken down when saltation occurs. In wind tunnel experiments, Swet (2019)[18] found that dust emitted from ODSVRA sand contains a combination of clays, feldspars, and quartz particles, but the diameters of the quartz particles are mostly in the range of 30-40 micron. This suggests that saltation derived PM_{10} should have significant proportions of feldspar particles and relatively low proportion of quartz particles, which is consistent with the results of the silica sampling noted above.

Appendix C: Infographic Summarizing 2018 Air Quality

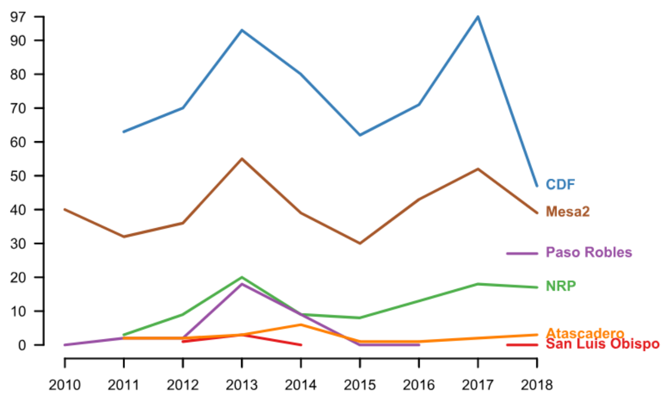
OZONE TRENDS

Compared to previous years, ozone pollution decreased at most of the monitoring stations in SLO County; however, it remained relatively similar in the eastern county and Paso Robles stations.



PARTICULATE MATTER TRENDS

2018 saw improvements in particulate matter trends at most sites, including those on the Nipomo Mesa, where the CDF station recorded the fewest exceedances of the state standard ever. Nonetheless, particulate pollution remains high in that region and SLO County APCD staff, our governing board, and the hearing board continue to work with all stakeholders to solve the dust issue.



Find out more about your local air quality by signing up to receive text notifications with our AirAware program!

SLOCleanAir.org/air-quality-alerts

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