



Appendix A

Ambient PM2.5 Data Analysis



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Appendix A: Ambient PM2.5 Data Analysis

The concentration of ambient PM2.5 at any given location in the San Joaquin Valley (Valley) is a function of meteorology, the natural environment, atmospheric chemistry, and PM2.5 emissions from regulated and unregulated sources. The San Joaquin Valley Air Pollution Control District (District), the California Air Resources Board (ARB), and other agencies¹ monitor PM2.5 concentrations throughout the Valley, as detailed in the 2011 Air Monitoring Network Plan,² using filter-based monitoring (starting in 1999) and real-time concentration monitoring (starting in 2002). The U.S. Environmental Protection Agency (EPA) serves as the official repository of ambient PM2.5 data and analysis.³

The District uses the collected data to show air quality improvement through the standardized design value calculations, using EPA protocols to document basin-wide improvement and attainment of the National Ambient Air Quality Standards (NAAQS). As shown in this appendix, the design value data show steady, long-term air quality improvement that will lead to the attainment of the 2006 PM2.5 NAAQS.

The District also uses the data to evaluate the impact of changing daily, quarterly, and annual PM2.5 concentrations on public health. These trend analyses provide the District with critical information about how to develop control measures and incentive programs that provide the most impact to public health improvements.

This appendix provides the technical details used to evaluate and analyze the District's PM2.5 concentration data as summarized in Chapters 3 and 4 of the *2012 PM2.5 Plan*. It also shows the multiple factors that affect ambient PM2.5 concentrations in the Valley (e.g. meteorology, exceptional events) and the evidence for air quality improvement through District regulatory actions, including the District's highly successful Rule 4901 (Wood Burning Fireplaces and Wood Burning Heaters).

A.1 PM2.5 CONCENTRATIONS—MEASUREMENT AND INFLUENCES

The District, ARB, and other agencies manage an extensive air monitoring network throughout the Valley. The information obtained from the PM2.5 monitors within this network provide the District with necessary information for demonstrating attainment of the NAAQS and valuable information for protecting public health throughout the year. The monitoring network captures the spatial, seasonal, daily, weekly, and annual variations in PM2.5 concentrations throughout the Valley that result from changing meteorology, the occurrence of exceptional events (e.g. high winds and wild fires), and PM2.5 emissions from regulated and unregulated sources.

¹ Other agencies include the Tachi Yokut Tribe and the National Park Service.

² San Joaquin Valley Air Pollution Control District [SJVAPCD]. (2011). *2011 Air Monitoring Network Plan*. Fresno, CA: June 30, 2011 submittal to EPA. Available at http://www.valleyair.org/aqinfo/Docs/2011/1_2011AirMonitoringNetworkPlanandAppendixA_Final2.pdf

³ U.S. Environmental Protection Agency: Technology Transfer Network (TTN), Air Quality System (AQS): AQS Web Application. (2010). Available at <http://www.epa.gov/ttn/airs/airsaqs/aqsweb/>

A.1.1 PM2.5 Monitor Types

The District and ARB use three types of PM2.5 monitors in the Valley:

- Filter-based Federal Reference Method (FRM) monitors, defined as the standard for data collection;
- Real-time beta-attenuation method (BAM) monitors designated as federal equivalent method (FEM) monitors, and hereafter referred to as BAM/FEM monitors;
- Ordinary BAMs, not designated FEM, and hereafter referred to as BAM; and
- Filter-based speciation monitors, similar to FRM monitors.

Only FRM and BAM/FEM monitors produce data that is suitable for comparison with the NAAQS, and are therefore used for design value calculations. Real-time monitors (BAM/FEM and BAM) produce hourly measurements that the District uses every day to produce daily air quality forecasts, wood burning declarations, public health notifications, and Real-time Air Advisory Network (RAAN) notifications for schools.

The filter-based speciation monitors operate similarly to the standard FRM monitors; however, because of the specific analysis requirements for the different PM2.5 species (e.g. metals, silicon, chlorine, organics) multiple filter media are required, hence a multi-filter collection system. The evaluation and analysis of multiple PM2.5 species is critical to the development of an effective attainment strategy.

A.1.2 Meteorological Influences on PM2.5 Concentrations

Particulates in the atmosphere are dispersed by horizontal and vertical mixing within an air mass. Wind flow (horizontal mixing) and temperature instability (decreasing temperature with height leading to vertical mixing) provides the strongest mechanisms for dispersing pollutants. Wind speed can greatly influence the pollutant concentrations by horizontally mixing and dispersing pollutants over a large area. Generally, the higher the wind speed the lower the PM2.5 concentrations; however, in some cases, excessive winds may cause elevated PM2.5 levels as high winds entrain PM10 as well as PM2.5.

Vertical mixing of the air mass can result from atmospheric instability. A temperature inversion, or increasing temperature with increasing height, can shut down the vertical mixing of an air mass, thus creating a situation in which pollutants are trapped near the surface. Prolonged periods of high pressure and stable conditions with low-wind speeds can cause stagnant conditions that trap pollutants near the surface. PM2.5 concentrations increase during these poor dispersion periods. During low-pressure events, unstable conditions and stronger wind speeds occur. PM2.5 concentrations can decrease or increase depending on the strength and characteristics of the low pressure system.

Hemispheric weather patterns affect Valley meteorology and PM_{2.5} concentrations. As an example, during the 2011–12 wood-burning season (November 2011 through February 2012), the Valley experienced a strong stagnation episode from December 2011 to January 2012 that resulted in many days above the PM_{2.5} 24-hour NAAQS of 35 µg/m³. Unusual climate conditions caused by the La Niña weather pattern resulted in historically dry and poor air quality conditions in the San Joaquin Valley and throughout the state of California. During this event the District issued an unprecedented number of wood-burning prohibitions.

A La Niña is caused by a buildup of cooler-than-normal subsurface waters in the tropical Pacific. Eastward-moving atmospheric and oceanic waves help bring the cold water to the surface resulting in drier-than-normal precipitation and stagnant weather conditions not only in the Valley, but throughout most of California. December 2011 tied December 1989 (another strong La Niña year) as the driest December on record for the Valley. For the Valley, unusually cold overnight temperatures and warm air aloft during the 2011–2012 wood-burning season created strong surface-based temperature inversions (ranging from 500 feet to 2,500 feet) that trapped particulate pollution within a very small volume of air. Because of the La Niña weather pattern, the Valley experienced four times as many days at or below freezing during the 2011–2012 winter season compared to the previous winter. Combined with clear skies and afternoon sunlight, secondary particulate aerosol formation occurred, contributing to higher PM_{2.5} levels.

Such extreme, prolonged poor dispersion conditions have not occurred since the 1999–2000 and 2000–2001 La Niña years. Figures A-1 and A-2 show the PM_{2.5} concentration comparison between the three La Niña years for the Fresno-First and Bakersfield-California air monitoring sites, respectively.⁴ The 1999–2000 and 2000–2001 PM_{2.5} concentrations reflect filter-based data, whereas, 2011–2012 PM_{2.5} (preliminary) concentrations reflect measurements from real-time monitors. The duration of the PM_{2.5} events were similar amongst the three seasons, however PM_{2.5} concentrations were lower during the 2011–2012 season. This reduction in PM_{2.5} concentrations under very similar stagnant weather patterns suggests that efforts related to District Rule 4901 (Wood Burning Fireplaces and Wood Burning Heaters) and other controls that have been implemented have resulted in a reduction in winter-time emissions.

⁴ Note: In 2012, the Fresno-First site was moved from the cross streets of First and Shields to First and Garland. The data from both Fresno site locations are shown together in Figure A-1.

Figure A-1 Stagnation Episodes Comparison at Fresno-First

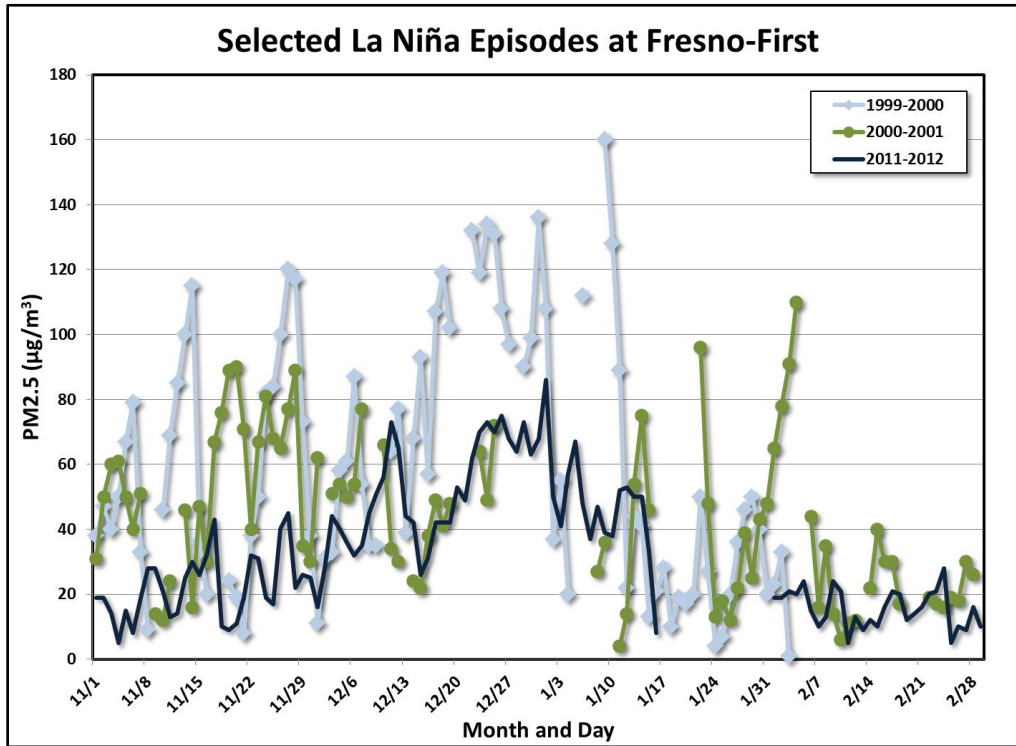
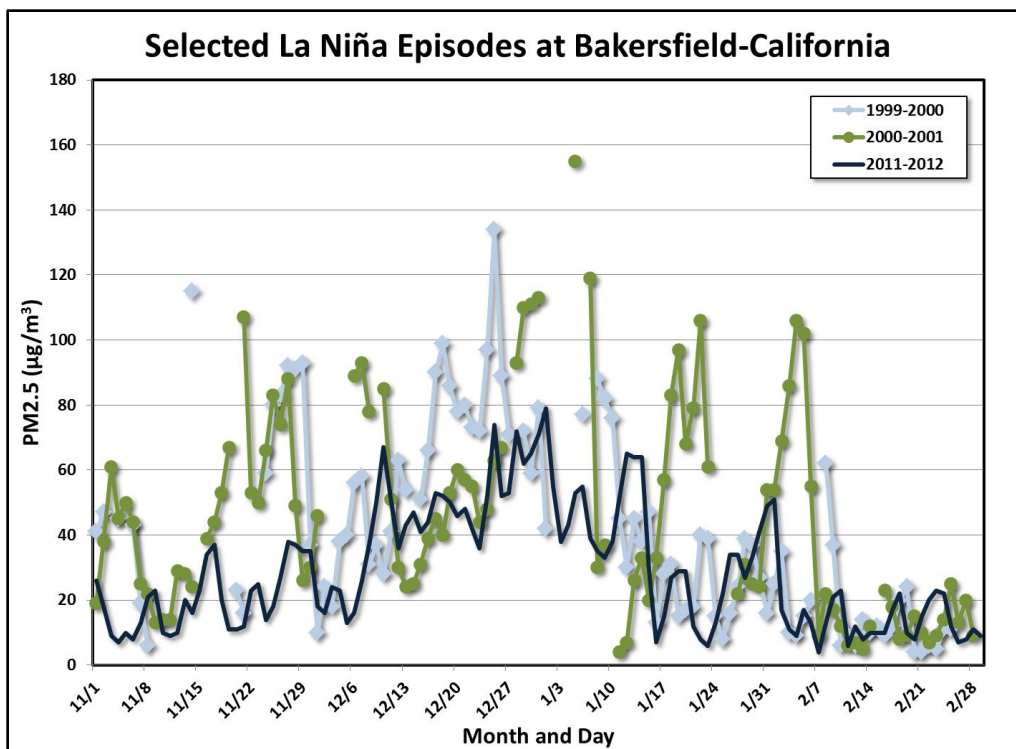


Figure A-2 Stagnation Episodes Comparison at Bakersfield-California



A.1.3 Exceptional Events Influences on PM_{2.5} Concentrations

In addition to local, regional, and hemispheric weather patterns, Valley PM_{2.5} concentrations are also affected by exceptional events such as wildfires, high winds events, and fireworks. These unforeseen events (with the exception of fireworks), can result in PM_{2.5} concentration peaks or even extended high-concentration episodes (in the case of summertime wildfires).

With proper documentation and EPA concurrence, data influenced by exceptional events can be excluded from official attainment demonstration calculations. Such documentation is extensive and requires significant District resources.⁵ But since exceptional events are not reasonably preventable or controllable, it is inappropriate to use data influenced by these events without recognition of these circumstances.

EPA generally reviews only those requests that will directly affect an area's attainment status. Although not every event results in a formal submittal to EPA, the District tracks these events and their impact on attainment as part of its ongoing air quality analysis. These ongoing efforts help the District to more accurately characterize ambient PM_{2.5} concentrations and attainment progress.

A.1.3.1 PM_{2.5} Exceptional Event Documentation Submitted to EPA

The District submitted documentation for the July 4 and 5, 2007 fireworks exceptional event and ARB submitted documentation for the summer 2008 wildfires exceptional event. If EPA approves this documentation, data from these events will be excluded from official attainment demonstration calculations.

On July 4th and 5th, 2007, elevated hourly PM_{2.5} concentrations at Fresno-First and Bakersfield-California coincided with fireworks activity. Table A-1 summarizes the effects of removing this data from the annual mean and 24-hour mean concentration calculations. The main effect of removing the data was lowering the PM_{2.5} annual mean values at Fresno-First and Bakersfield-California by 0.4 and 0.2 µg/m³, respectively.

In the summer of 2008, just months after adoption of the *2008 PM_{2.5} Plan*, California experienced a record number of wildfires, burning more than one million acres. The resulting emissions, mostly from outside of the Valley, caused serious public health impacts and unprecedented levels of summertime PM_{2.5} and ozone in the Valley and throughout the state. Valley PM_{2.5} and ozone concentrations were elevated for a number of days during this period.

These exceptional events caused the Valley's PM_{2.5} design values to be higher than normal. Table A-1 also summarizes the effects of removing this data from official attainment demonstration calculations. The prolonged 2008 wildfire event had a

⁵ Treatment of Air Quality Monitoring Data Influenced by Exceptional Events, 72 Fed. Reg. 55, pp. 13560–13581. (2007, March 22). (to be codified in 40 C.F.R. pts. 50 and 51)

noticeable impact, especially for monitoring sites closest to the wildfires in the northern portion of the Valley. The largest difference occurred at the Stockton air monitoring site, where the 24-hour value was 61.6 $\mu\text{g}/\text{m}^3$, with the exceptional event data included, and 48.2 $\mu\text{g}/\text{m}^3$, with that data removed. Excluding days that were impacted by smoke reduces the PM_{2.5} annual mean value by 1.5 $\mu\text{g}/\text{m}^3$.

The EPA has a policy of acting only upon those exceptional event documents that have a direct impact on an area's attainment status. As such, the EPA reviews and makes decisions on the concurrence or non-concurrence of the District's PM₁₀ exceptional event documents, but has not yet made a decision on the submitted PM_{2.5} documents mentioned above since that decision would not change the District's attainment status of the PM_{2.5} NAAQS.

Since the timeframe discussed in the above analysis is outside of the 2009–2011 period, these exceptional events would not affect the 2011 attainment demonstration calculations. However, this analysis is illustrative of how these events can influence such calculations, and possibly whether an area is able to achieve attainment of the PM_{2.5} NAAQS.

Subsequent fireworks and wildland fire use exceptional events have occurred since the 2007 and 2008 documentation that was submitted to EPA. On July 4th, 2010, elevated PM_{2.5} concentrations at Bakersfield-Planz, Fresno-First, and Bakersfield-California coincided with fireworks activity. On September 25–30, 2010, Corcoran and Madera-City experienced smoke impacts and elevated PM_{2.5} levels from a wildland fire in the Sierra Nevadas. Since the District has not submitted official documentation of these events to EPA, the impact on the 24-hour and annual mean PM_{2.5} values are not shown.

Table A-1 2007 and 2008 Exceptional Events Impact on 24-hour and Annual PM_{2.5} Values

Year	Site	Annual Mean Before EE Concurrence	Annual Mean with EPA EE Concurrence	Difference $\mu\text{g}/\text{m}^3$	24-hour Mean Before EE Concurrence	24-hour Mean with EPA EE Concurrence	Difference $\mu\text{g}/\text{m}^3$
2008	Stockton	14.4	12.9	-1.5	61.6	48.2	-13.4
	Modesto	16.0	14.7	-1.3	53.3	49.5	-3.8
	Merced	14.9	13.9	-1.0	51.1	45.2	-5.9
	Clovis	16.0	14.8	-1.2	49.0	49.0	0.0
	Fresno-First	17.4	16.1	-1.3	57.4	54.4	-3.0
	Fresno-Winery	16.5	15.6	-0.9	44.5	44.5	0.0
	Visalia	21.0	19.5	-1.5	62.1	55.5	-6.6
	BAK-CA	21.9	20.0	-1.9	64.5	63.4	-1.1
	BAK-Planz	23.5	22.8	-0.7	72.3	72.3	0.0
2007	Fresno - First	18.8	18.4	-0.4	67.0	66.0	-1.0
	BAK-CA	22.0	21.8	-0.2	73.0	73.0	0.0

A.1.3.2 High-Wind Events Effects on PM2.5 Data

Valley high-wind events can result in significant increases in PM10 concentrations. Geologic particulates are the primary component of PM10 measured during these events. The District routinely submits formal PM10 exceptional event documentation for such events.

The District has observed similarities in hourly increases in PM10 and PM2.5 during certain high-wind events. High-wind events were recorded at the Bakersfield-Planz monitoring site on January 4, 2008 and October 13, 2009, and corresponding PM2.5 measurements were unusually high—100.3 $\mu\text{g}/\text{m}^3$ and 167.7 $\mu\text{g}/\text{m}^3$, respectively. Table A-2 summarizes an example of the impact of the 2008 and 2009 high-wind events on Bakersfield-Planz attainment calculations (design values represent a three-year average of mean 24-hour and annual pollutant concentrations and are discussed fully in Section A.2). The District has not submitted PM2.5 exceptional event documentation for either of these events.

Although not included in Table A-2, another high-wind event occurred on April 11, 2010. The Bakersfield Planz monitor recorded a PM2.5 concentration of 107.8 $\mu\text{g}/\text{m}^3$. Similarly, the District submitted documentation to EPA in regards to a PM10 exceptional event affecting Bakersfield-Planz that occurred on April 11, 2010, but has not submitted PM2.5 documentation

Table A-2 Example of High-Wind Event Influence on Bakersfield–Planz Design Value

Year	High-Wind Events			
	24-hour Design Values ($\mu\text{g}/\text{m}^3$)		Annual Design Values ($\mu\text{g}/\text{m}^3$)	
	Included	Excluded	Included	Excluded
2007*	72.2	72.2	21.8	21.8
2008	72.3	61.0	23.5	22.6
2009	65.5	65.4	22.5	21.4
2007-09 DV	70	66	22.6	21.9
Difference		4		0.7

* - No high-wind events were captured in the 2007 data set.

A.2 ATTAINMENT DEMONSTRATION—DESIGN VALUES

Design values represent the official metric for assessing air quality improvements and attainment of the NAAQS per the Federal Clean Air Act and EPA regulations. Design value calculations are three-year averages that follow EPA protocols for rounding, averaging conventions, data completeness, sampling frequency, data substitutions, and data validity. The results provide consistency and transparency to determine basin-wide attainment for both components of the 2006 PM_{2.5} NAAQS, including the 24-hour PM_{2.5} standard of 35 µg/m³ and the annual PM_{2.5} standard of 15.0 µg/m³. If any monitoring site within the air basin has either a 24-hour or annual PM_{2.5} design value higher than the respective standard, then the entire air basin is designated nonattainment.

Table A-3 provides the generalized descriptions of how the 24-hour average and annual average design values are calculated for PM_{2.5}. EPA provides detailed guidelines and standards for the calculation⁶ and data handling⁷ methodologies.

Table A-3 General PM_{2.5} Design Value Calculation Methods

Averaging Period	Level	Calculation Method
24-hour	35 µg/m ³	<p>Step 1: Determine the 98th percentile value for each year over a consecutive three year period.</p> <p>Step 2: Average the three 98th percentile values.</p> <p>Step 3: Round the resulting value to the nearest 1.0 µg/m³.</p> <p>Step 4: Compare the result to the standard.</p>
Annual	15.0 µg/m ³	<p>Step 1: Calculate the average of each quarter of each year over a three year period.</p> <p>Step 2: Average the four quarters in a calendar year to determine the average for each year.</p> <p>Step 3: Average the three annual values.</p> <p>Step 4: Round the resulting value to the nearest 0.1 µg/m³.</p> <p>Step 5: Compare the result to the standard.</p>

Tables A-4 through A-7 show the trend of the 24-hour average and annual average values for each PM_{2.5} monitoring site in the Valley by year as well as the three-year average design values for these metrics through the year 2011.

Table A-4 shows 24-hour single-year 98th-percentile averages, which are used to generate the three-year average 24-hour design values in Table A-5. Table A-6 shows single-year average PM_{2.5} concentrations, which are used to generate the three-year average annual design values in Table A-7. These data are also shown graphically in Figures A-3.1 through A-3.20 for a number of monitoring sites in the Valley. Monitoring

⁶ Interpretation of the National Ambient Air Quality Standards for PM_{2.5}, 40 C.F.R. Pt. 50 Appendix N (2012).

Available at <http://ecfr.gpoaccess.gov/cgi/t/text/text->

[idx?c=ecfr&sid=9bdb7a34dcb75892aef9ee60b74da642&rgn=div9&view=text&node=40:2.0.1.1.1.0.1.18.15&idno=40](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=9bdb7a34dcb75892aef9ee60b74da642&rgn=div9&view=text&node=40:2.0.1.1.1.0.1.18.15&idno=40)

⁷ Environmental Protection Agency [EPA]: Office of Air Quality Planning and Standards. (1999, April). *Guideline on Data Handling Conventions for the PM NAAQS* (EPA-454/R-99-008). Retrieved from

<http://www.epa.gov/ttn/oarpg/t1/memoranda/pmfinal.pdf>

sites with a brief PM_{2.5} monitoring history do not have line charts displayed. Note that the sites at Manteca, Madera-City, Tranquillity, and Hanford have limited PM_{2.5} data available; therefore, there is no three-year average. Design values for these sites will be able to be calculated in the future as their PM_{2.5} data records continue. The Bakersfield-Golden site was closed in early 2010, and the Corcoran site has been unavailable since the middle of 2011.

Average ambient PM_{2.5} concentrations vary by monitoring site within the Valley. In general, monitoring sites in the northern part of the Valley record the lowest ambient PM_{2.5} concentrations. Currently more Valley air monitoring sites meet the 1997 24-hour average standard of 65 µg/m³ than the annual average standard of 15.0 µg/m³. Although the single-year 98th-percentile and annual average values were higher in 2011 compared to the last few years, the 2009–2011 design values for some of the sites are showing a downward trend, including the peak Valley design value, while others have shown an increase. A downward trend will need to occur for all of the sites in the region as the Valley progresses towards attainment of the federal standard.

Table A-4 Single Year 24-hour Average PM_{2.5} 98th Percentile Values (µg/m³)

SJV Monitoring Site	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Stockton	79.0	55.0	58.0	50.0	41.0	36.0	44.0	42.0	48.0	61.6	40.4	29.7	44.8
Manteca													38.9
Modesto	100.0	71.0	69.0	69.0	47.0	45.0	55.0	52.0	57.4	53.9	54.5	37.3	54.7
Turlock											53.1	43.5	57.4
Merced-Coffee												39.9	47.4
Merced-M	91.9	60.0	49.3	55.1	44.2	43.0	48.3	43.8	52.7	54.0	45.2	35.5	35.4
Madera-City													59.1
Fresno-1st	120.0	90.0	75.0	75.0	56.0	52.0	71.0	51.0	67.0	57.4	55.8	48.8	69.5
Fresno-Winery		64.8	61.5	71.9	49.7	49.4	71.2	55.0	57.4	44.5	48.2	37.0	59.6
Clovis	59.2	72.5	71.5	53.2	48.1	52.4	63.0	51.3	60.9	49.0	49.0	44.3	68.5
Tranquillity												27.7	27.5
Corcoran	53.0	55.1	89.5	65.1	42.2	49.4	74.5	50.1	57.9	47.9	53.4	46.8	
Hanford													64.6
Visalia	114.0	103.0	96.0	70.0	47.0	54.0	65.0	50.0	59.7	62.1	53.9	36.3	50.7
Bakersfield-Golden	95.3	93.9	95.9	80.4	51.9	53.9	74.9	64.4	67.7	60.8	68.6		
Bakersfield-California	97.4	92.7	94.9	73.0	48.3	61.5	63.2	60.5	73.0	64.5	66.7	53.3	65.5
Bakersfield-Planz		76.5	90.6	66.8	47.5	47.6	66.4	64.7	72.2	72.3	65.5	56.2	43.2

Table A-5 24-hour Average PM_{2.5} Design Values (Three-Year Averages, µg/m³)

SJV Monitoring Site	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011
Stockton	64	54	50	42	40	41	45	51	50	44	38
Manteca											^
Modesto	80	70	62	54	49	51	55	54	55	49	49
Turlock									53	48	51
Merced-Coffee											44**
Merced-M	67	55	50	47	45	45	48	50	51	45	39
Madera-City											^
Fresno-1st	95	80	69	61	60	58	63	58	60	54	58
Fresno-Winery	63	66	61	57	57	59	61	52	50	43	48
Clovis	68	66	58	51	55	56	58	54	53	47	54
Tranquillity											28**
Corcoran	66	70	66	52	55	58	61	52	53	49	
Hanford											^
Visalia	104	90	71	57	55	56	58	57	59	51	47
Bakersfield-Golden	95	90	76	62	60	64	69	64	66		
Bakersfield-California	95	87	72	61	58	62	66	66	68	62	62
Bakersfield-Planz	84	78	68	54	54	60	68	70	70	65	55

Notes for Tables A-2 and A-3

- Empty cell: No data or insufficient data
- Asterisk (*): Values do not meet completeness criteria
- Double asterisk (**): Value based on 2-year average of 2010-2011, 2009 had minimal sampling
- ^: Site does not have enough data to calculate a 3-year average, see text for details.

Table A-6 Single Year Annual Mean PM_{2.5} Concentrations (µg/m³)

SJV Monitoring Site	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Stockton	19.7	15.5	13.9	16.7	13.6	13.2	12.5	13.1	12.9	14.4	11.3	10.6	11.3
Manteca													10.7
Modesto	24.9	18.7	15.6	18.7	14.5	13.6	13.9	14.8	15.0	16.0	13.0	12.1	14.7
Turlock											16.1	12.7 ^{^^}	17.1
Merced-Coffee												16.3	15.6
Merced-M	22.6	16.7	14.5*	18.7	15.7	15.2	14.1	14.8	15.2	14.9*	13.6	11.2	10.4
Madera-City													20.4
Fresno-1st	27.6	24.5	19.8	21.5	17.8	16.3	16.7	16.8	18.8	17.4	15.1	13.0	15.5
Fresno-Winery		18.4	18.6	21.3	17.8	17.0	16.9	17.6	16.8	16.5	14.6	13.4	15.4
Clovis	19.8	16.3	18.0	16.2	18.5*	16.4	16.3	16.4	16.4	16.2	18.3	14.7	17.9
Tranquillity												8.8	8.2
Corcoran	14.3*	16.4	19.2	21.5	16.2	17.4	17.5	16.9	18.4	15.8	17.7	17.9	
Hanford													18.0
Visalia	27.6	23.9	22.5	23.2	18.2	17.0	18.8	18.8	20.4	19.8	16.0	13.6	16.1
Bakersfield-Golden	26.2	22.6	21.8	24.1	19.6	18.2	19.1	18.6	19.9	17.9	20.0		
Bakersfield-California	23.8	22.5	21.2	22.7	17.1	18.9	18.0	18.7	22.0	21.9	19.0	14.2	16.2
Bakersfield-Planz		20.3	20.8	23.5	17.8	17.4	19.8	19.3	21.8	23.5	22.5	17.6	14.5

Table A-7 Annual PM_{2.5} Design Values (Three-Year Averages, µg/m³)

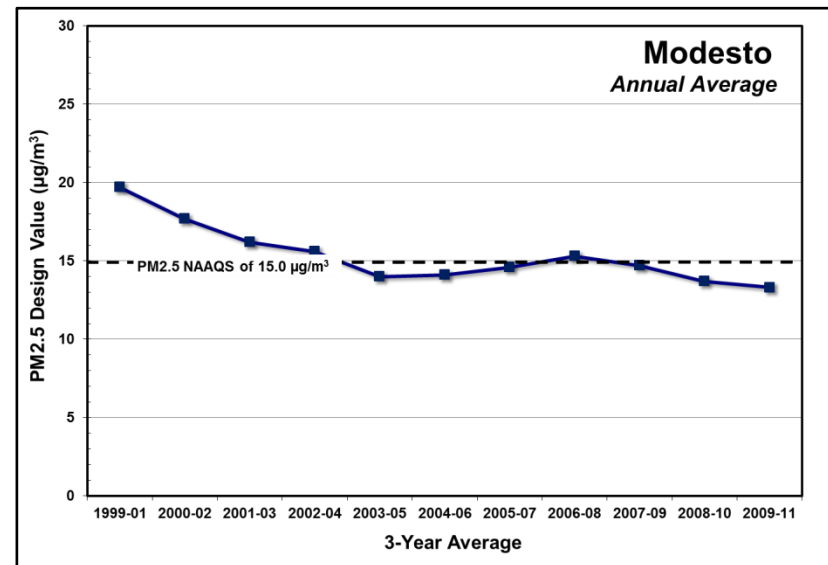
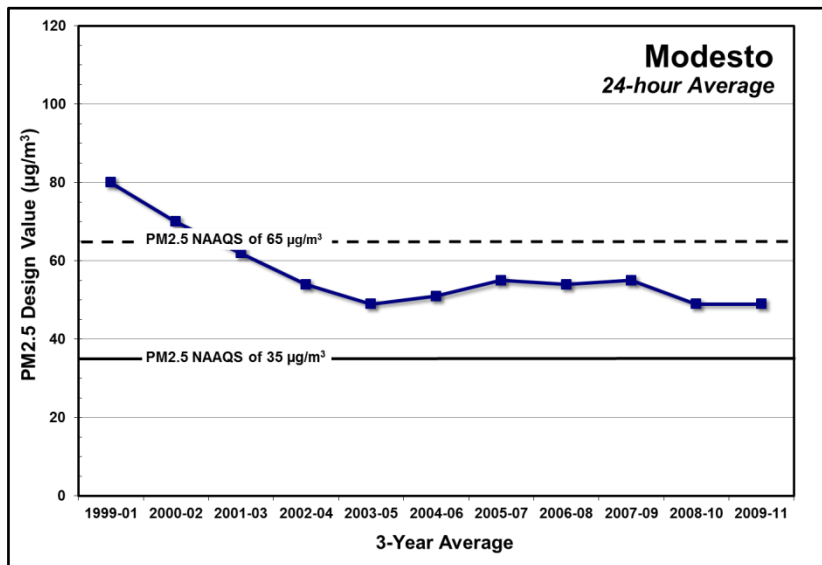
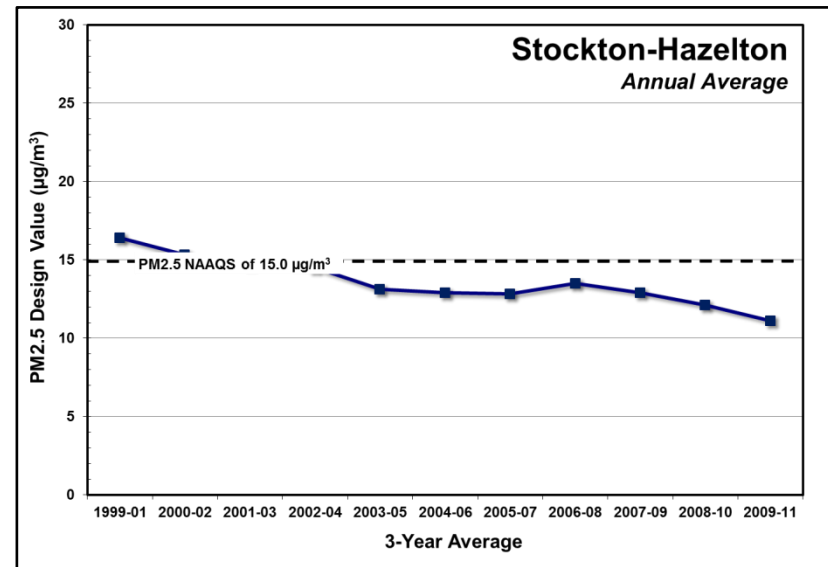
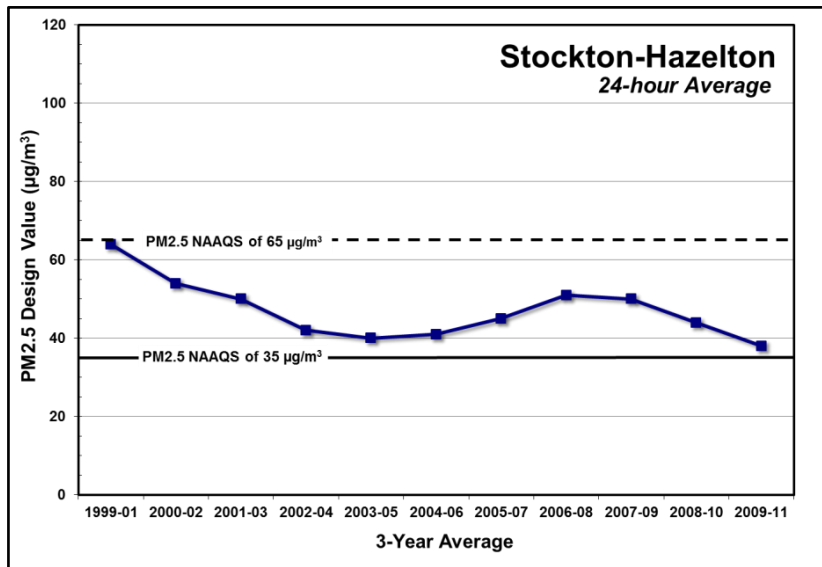
SJV Monitoring Site	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011
Stockton	16.4	15.3	14.7	14.5	13.1	12.9	12.8	13.5	12.9	12.1	11.1
Manteca											^
Modesto	19.7	17.7	16.2	15.6	14.0	14.1	14.6	15.3	14.7	13.7	13.3
Turlock											15.3 ^{^^}
Merced-Coffee											16.0 ^{**}
Merced-M	17.9	16.6	16.3	16.5	15.0	14.7	14.7	15.0	14.6	13.2	11.7
Madera-City											^
Fresno-1st	24.0	21.9	19.7	18.6	16.9	16.6	17.4	17.7	17.1	15.2	14.5
Fresno-Winery	18.5	19.4	19.2	18.7	17.2	17.2	17.1	17.0	16.0	14.8	14.5
Clovis	18.0	16.8	17.6	17.0	17.1	16.4	16.4	16.3	17.0	16.4	17.0
Tranquillity											8.5 ^{**}
Corcoran		19.0	19.0	18.4	17.0	17.2	17.6	17.0	17.3	17.1	
Hanford											^
Visalia	24.7	23.2	21.3	19.5	18.0	18.2	19.3	19.7	18.8	16.5	15.2
Bakersfield-Golden	23.6	22.8	21.8	20.6	19.0	18.6	19.2	18.8	19.3		
Bakersfield-California	22.5	22.1	20.3	19.6	18.0	18.5	19.6	20.9	21.0	18.4	16.5
Bakersfield-Planz		21.5	20.7	19.6	18.4	18.9	20.3	21.5	22.6	21.2	18.2

Notes for Tables A-4 and A-5

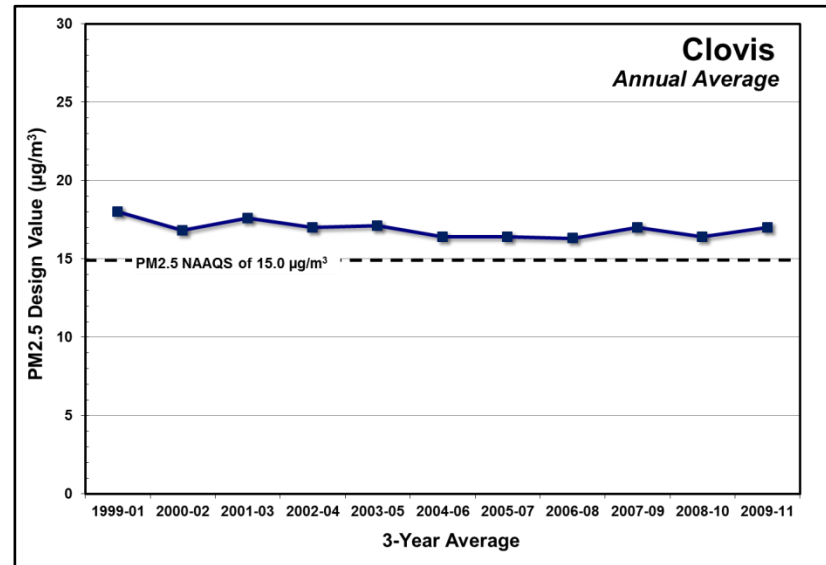
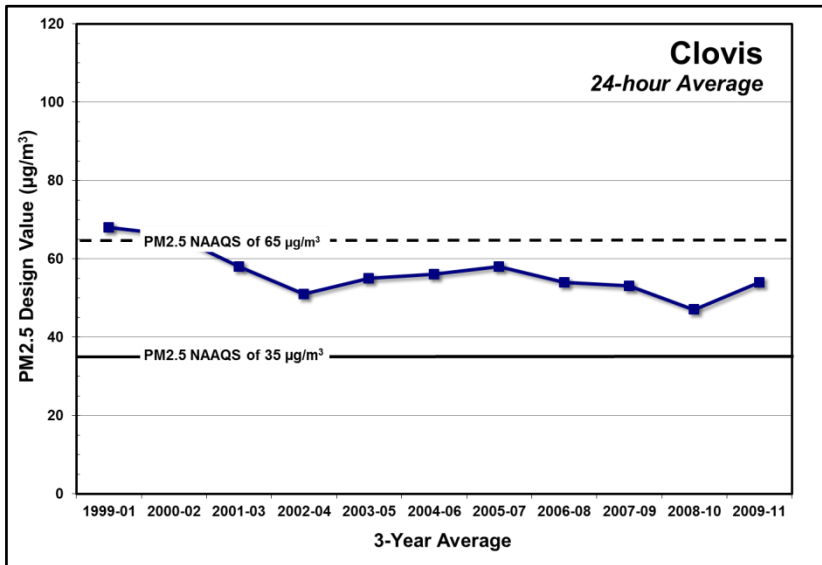
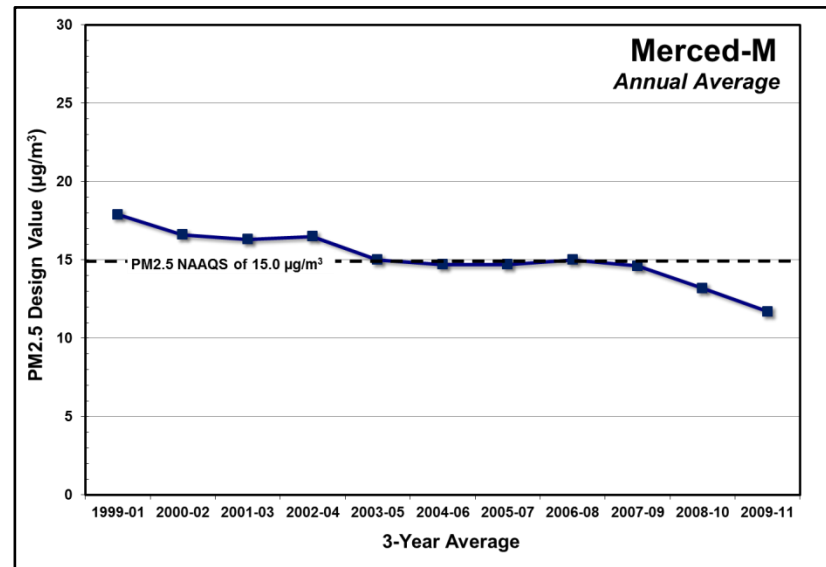
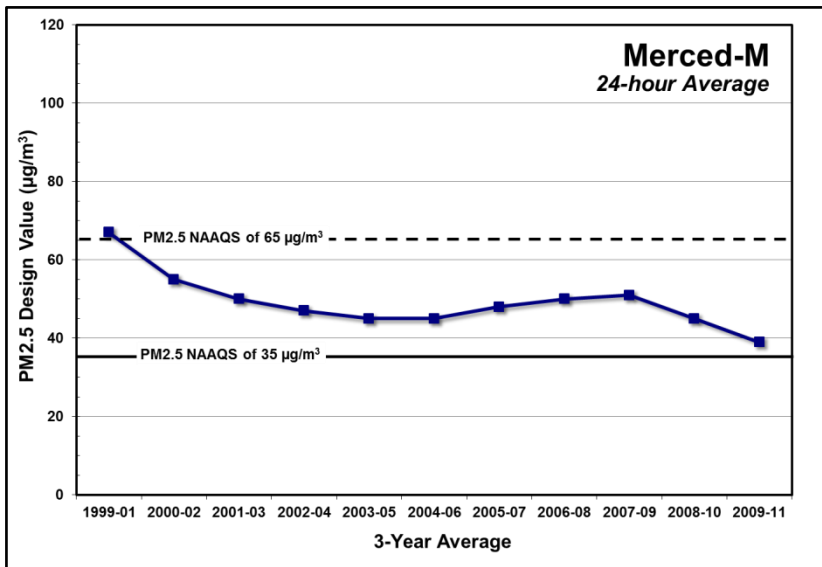
- Empty cell: No data or insufficient data
- Asterisk (*): Values do not meet completeness criteria
- Double asterisk (**): Value based on 2-year average of 2010-2011, 2009 had minimal sampling

- ^: Site does not have enough data to calculate a 3-year average, see text for details.
- ^^: Data incomplete in 2010, however high PM_{2.5} season was still captured.

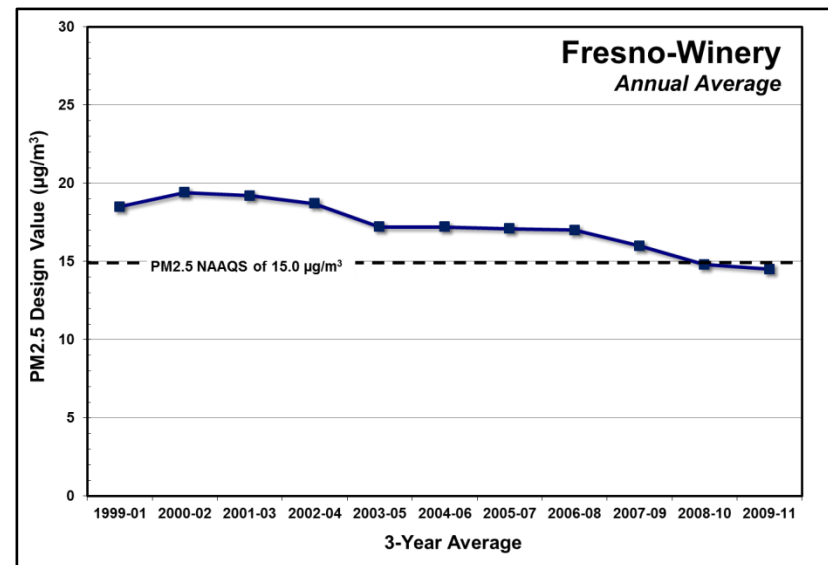
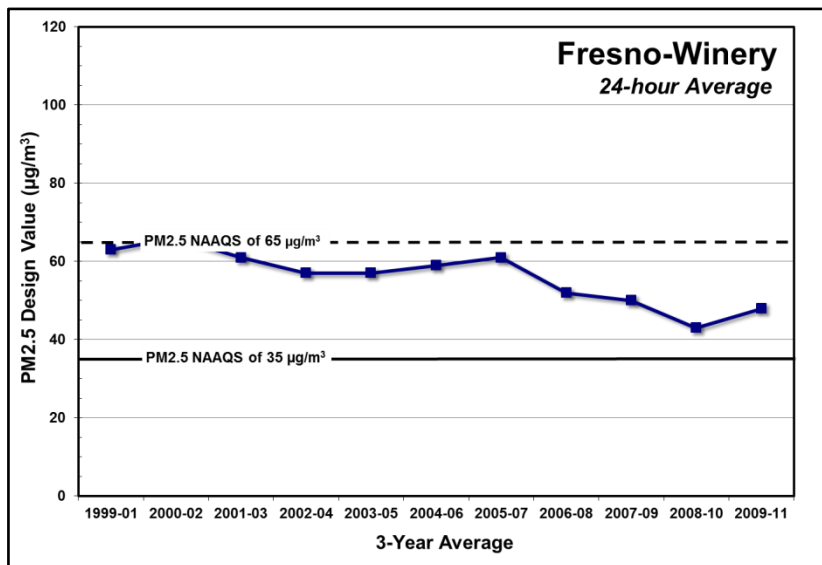
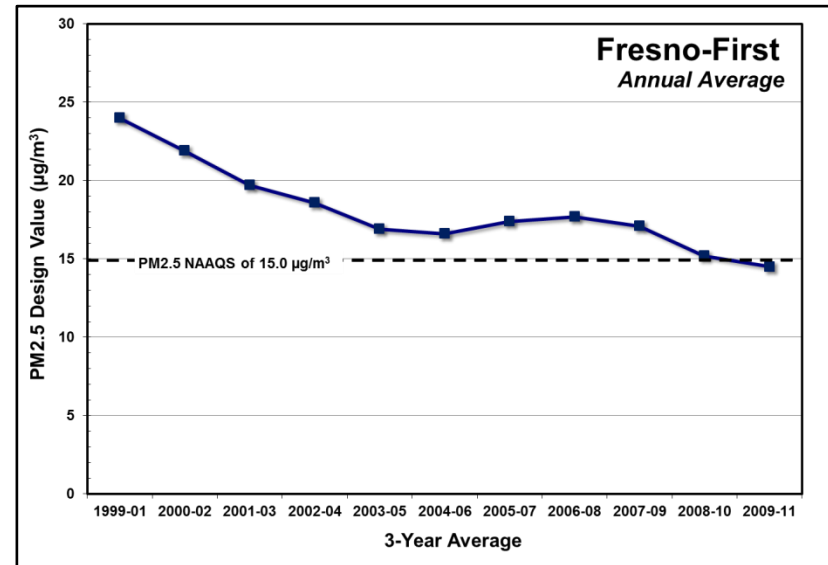
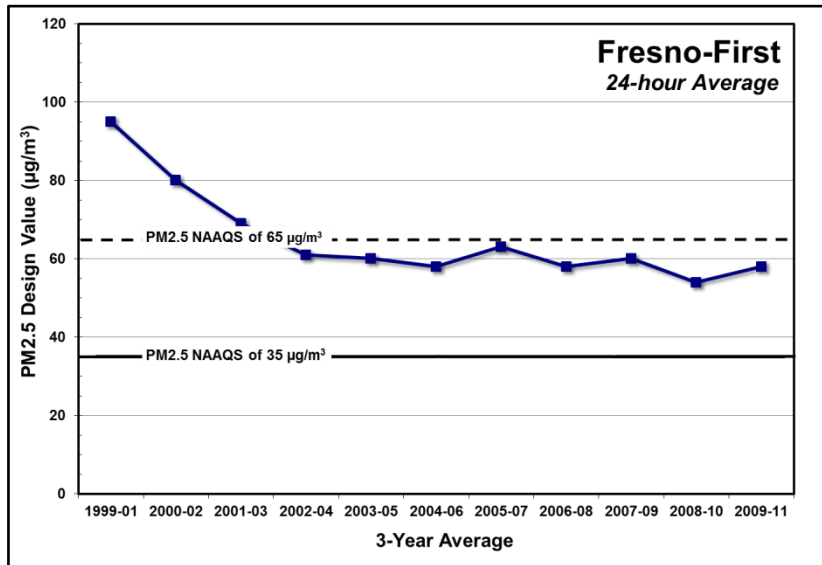
Figures A-3.1 through A-3.4 24-hour and Annual Design Value Trends at Stockton-Hazelton and Modesto



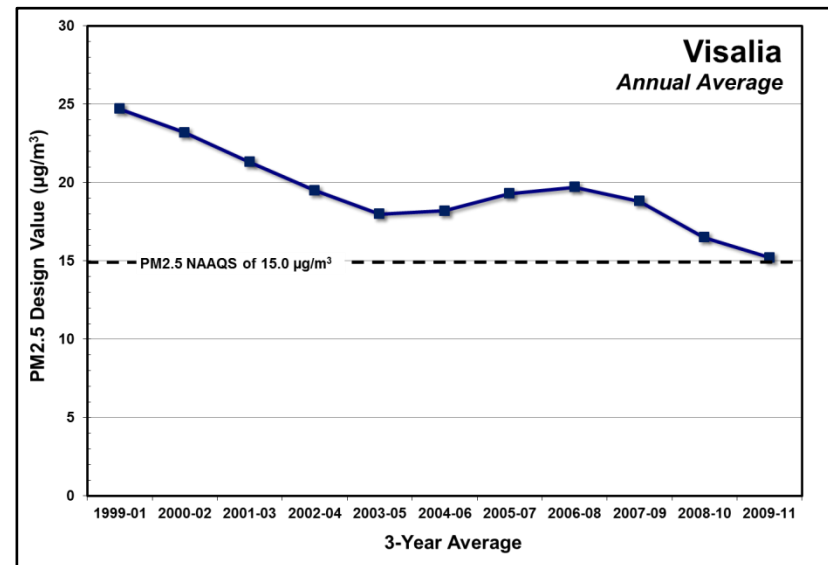
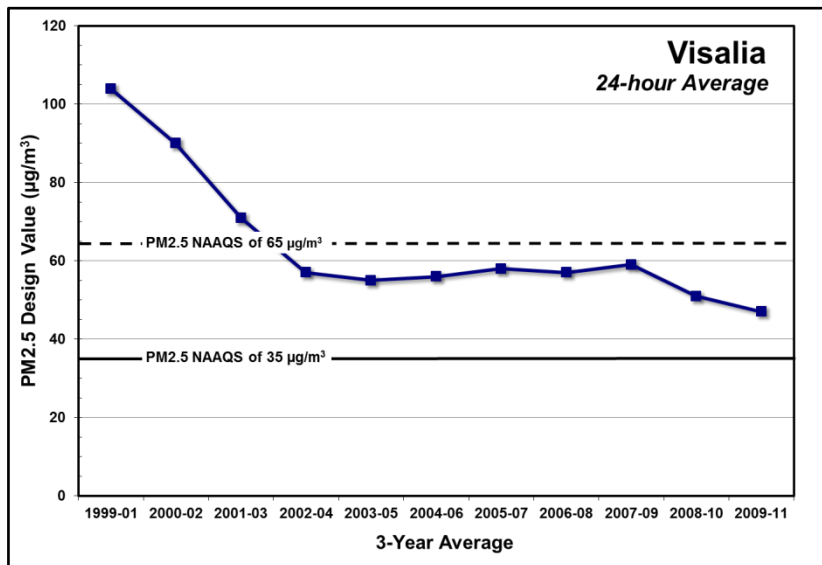
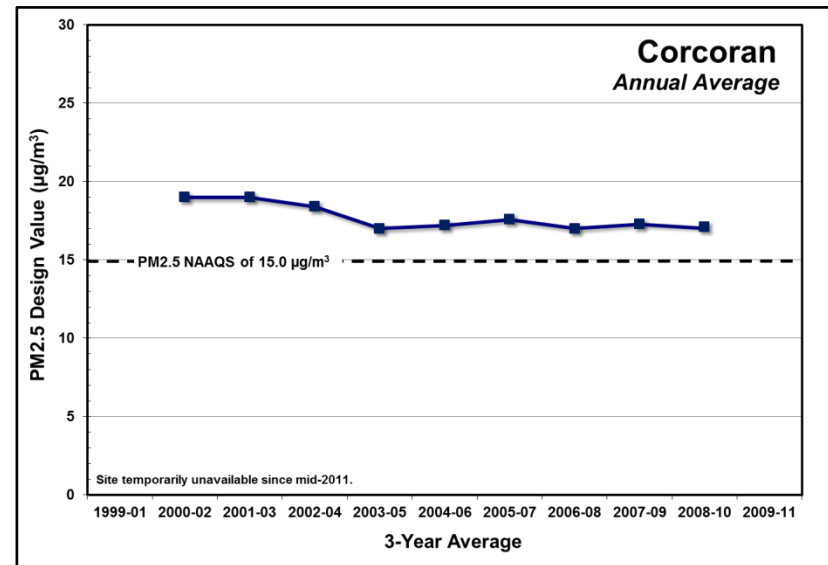
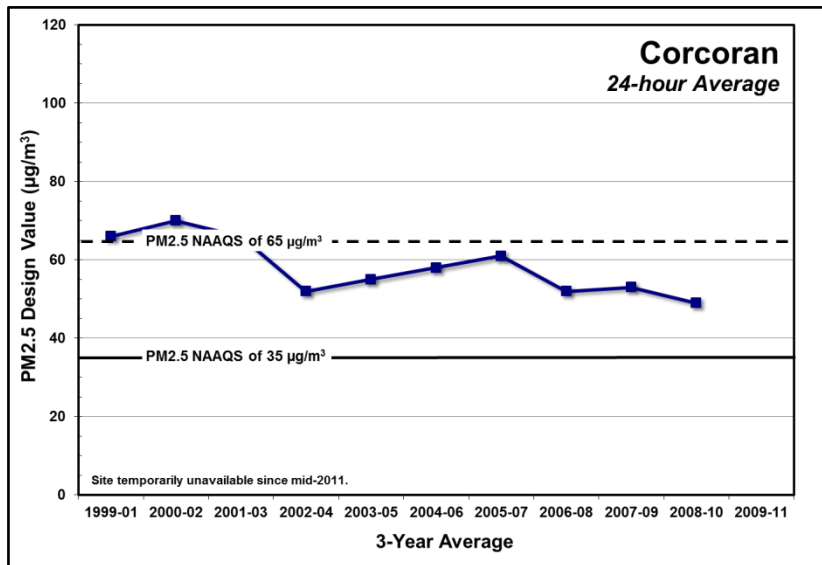
Figures A-3.5 through A-3.8 24-hour and Annual Design Value Trends at Merced-M and Clovis



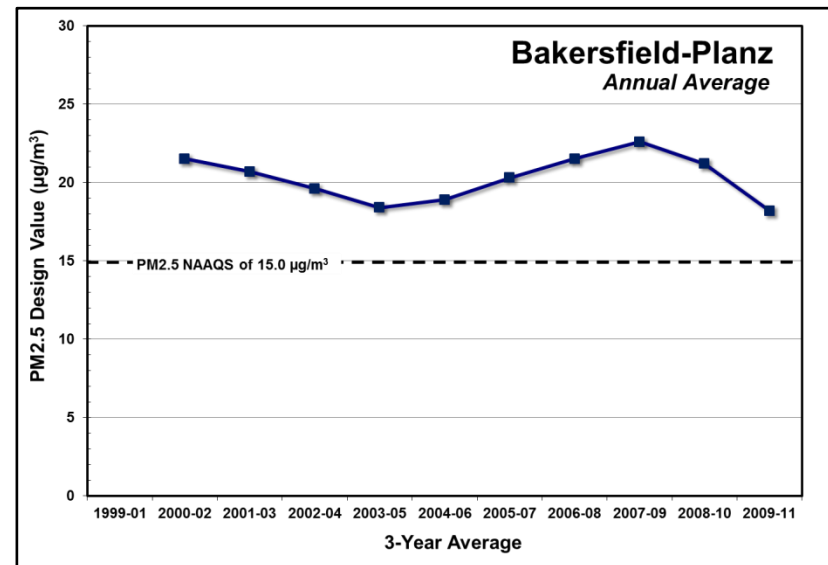
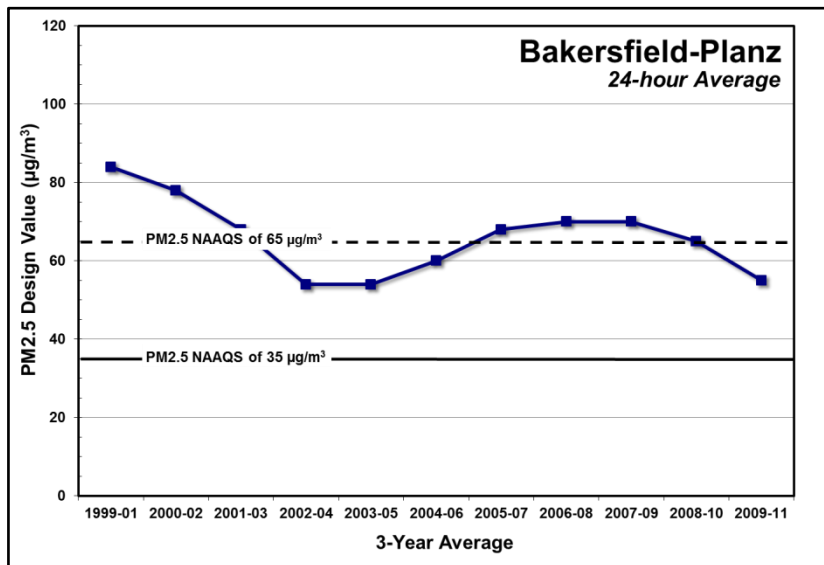
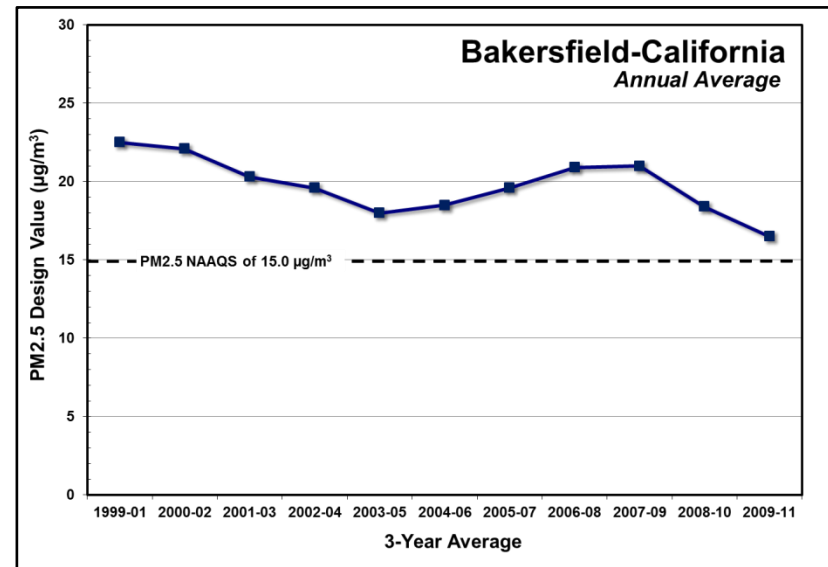
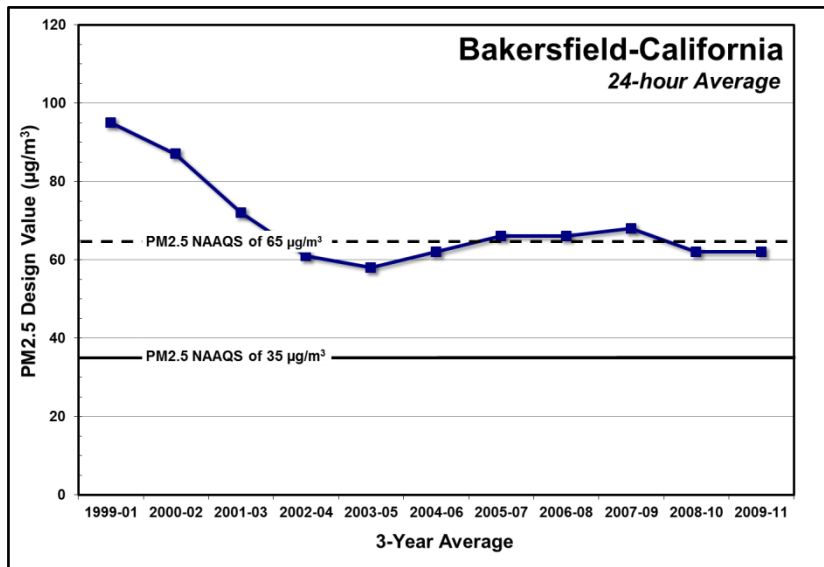
Figures A-3.9 through A-3.12 24-hour and Annual Design Value Trends at Fresno-First and Fresno-Winery



Figures A-3.13 through A-3.16 24-hour and Annual Design Value Trends at Corcoran and Visalia



Figures A-3.17 through A-3.20 24-hour and Annual Design Value Trends at Bakersfield-CA and Bakersfield-Planz



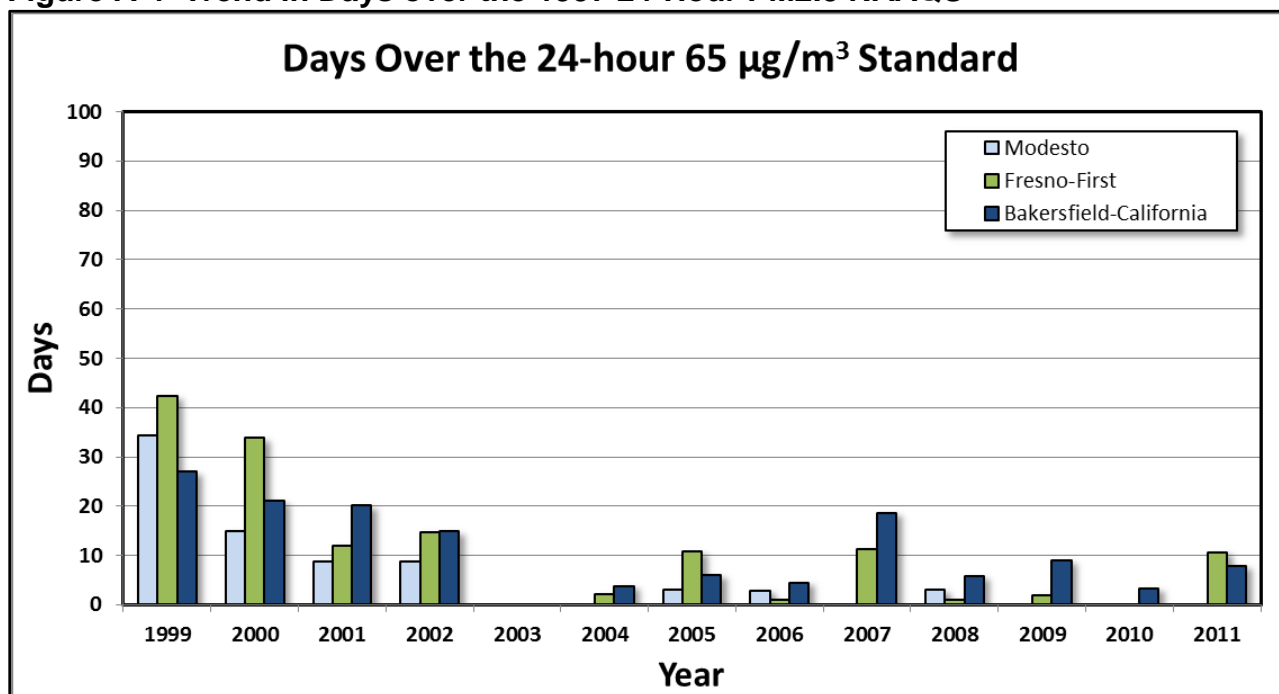
A.3 AMBIENT PM_{2.5} CONCENTRATION DATA TRENDS

Design values summarize data from a monitoring site with just two concentration values representing a three-year time period: an annual average and a value representing 24-hour peaks. These parameters are required for attainment demonstrations, but design values alone do not reveal the hourly, daily, weekly, seasonal, and regional PM_{2.5} effects on public health, nor do they track air quality improvements within such parameters. The District uses data from air monitoring sites to analyze air quality trends to provide a deeper understanding of changes in ambient PM_{2.5} concentrations as they relate to the implementation of District programs and to inform the attainment planning process and Risk-based Strategy.

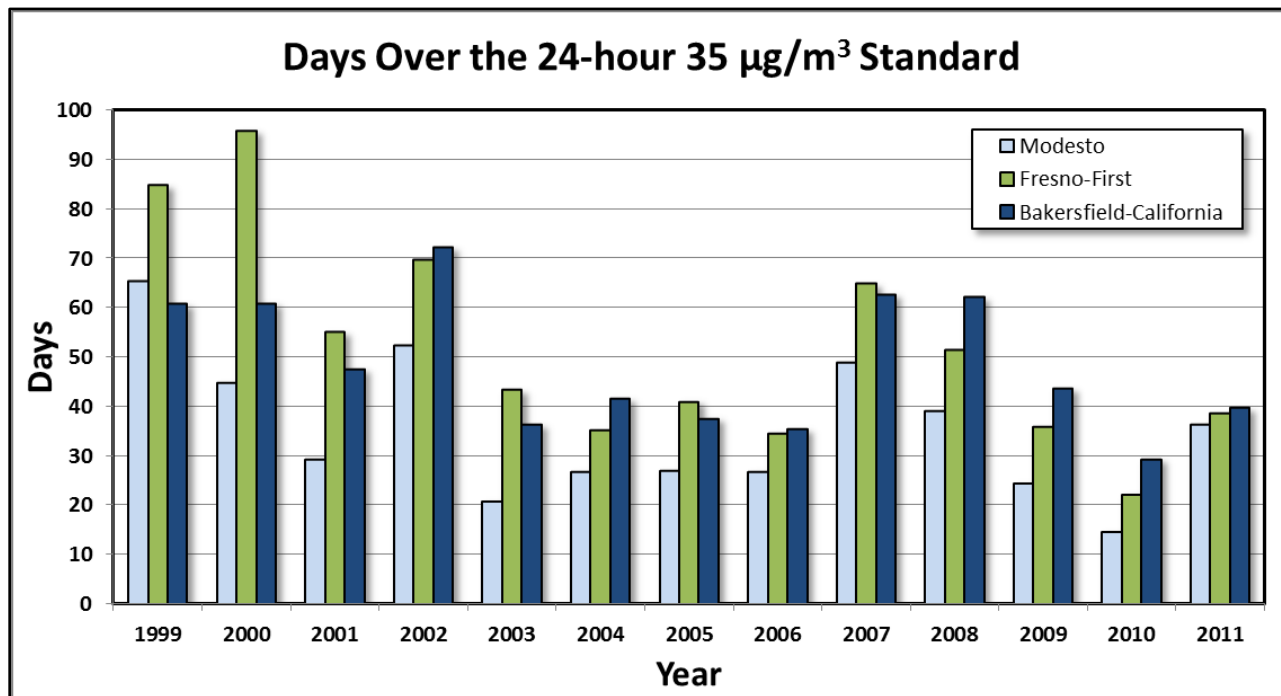
A.3.1 Days Over the 24-Hour PM_{2.5} NAAQS

The number of days over the PM_{2.5} NAAQS is another indicator of air quality progress. Focusing on historical air monitoring sites from the northern, central, and southern portions of the Valley, Figures A-4 and A-5 show the trend of the number of days above both the 1997 and 2006 24-hour PM_{2.5} NAAQS (65 $\mu\text{g}/\text{m}^3$ and 35 $\mu\text{g}/\text{m}^3$, respectively) at the Modesto, Fresno-First, and Bakersfield-California monitoring sites. These counts have been estimated and normalized to account for the varying sampling schedules of the Valley's 1-in-6-day, 1-in-3-day, and daily PM_{2.5} monitors. Design value calculations for the 24-hour NAAQS use the 98th-percentile concentration value from each monitoring site (higher values in the 99th and 100th percentiles are not used to account for extreme outliers). Because of this, a region may experience a limited number of days over the standard, but still be considered in attainment.

Figure A-4 Trend in Days over the 1997 24-Hour PM_{2.5} NAAQS



Note: Years and sites with no data (colored bars) represent zero exceedances.

Figure A-5 Trend in Days over the 2006 24-Hour PM_{2.5} NAAQS

As shown in Figure A-4, the District has experienced a significant drop in the number of exceedances of the 65 $\mu\text{g}/\text{m}^3$ standard. In 1999, approximately 103 exceedances of this standard occurred between the sites of Modesto, Fresno-First, and Bakersfield-California. Comparing this to the 17 exceedances that occurred in 2011, this represents an 83% decrease in the number of violations among these sites.

Figure A-5 shows that significant progress has been made towards the 35 $\mu\text{g}/\text{m}^3$ standard despite the fact that sites recorded 35 to 40 exceedances in 2011. The number of exceedances of the 2006 PM_{2.5} NAAQS has decreased by 46%. The District's emissions reduction strategy, the investment from the regulated industry in control technology, and the public's willingness to make a change for cleaner air have all played key roles in the reduction of concentrations over this time period.

Despite this notable progress, the Valley still experiences many exceedance days over the 2006 24-hour PM_{2.5} NAAQS (35 $\mu\text{g}/\text{m}^3$) during the winter months. During the winter, with unfavorable meteorology, as experienced during the 2011–2012 winter season, the number of exceedances spiked relative to seasons with favorable meteorology under identical regulatory controls. The values for 2011 in Figure A-5 show this resulting spike as compared to the years 2009 and 2010, when meteorology was more favorable. Similar poor dispersion conditions were experienced during the winter of 1999–2000; however, under those similar conditions, the number of exceedances in 2011 was markedly less than the number of exceedances in 1999, which strongly suggest a real reduction in emissions.

A.3.2 Seasonal Trends—First- and Fourth-Quarter Averages

The Valley experiences the highest PM_{2.5} concentrations during the fall and winter months, when residential wood burning is at its highest. The District evaluates ambient concentration trends during this time period (October through March) to document changes and patterns in seasonal PM_{2.5} peak concentrations.

A review of historical 24-hour PM_{2.5} filter data shows a general trend of ambient concentration reductions in both the average concentration and the magnitude of the concentration. Specifically, the District looked at PM_{2.5} filter data from 1999 through 2011, focusing on the first and fourth quarters at six sites in the Valley that tend to have the highest concentrations, including Clovis, Fresno-First, Corcoran, Visalia, Bakersfield-California, and Bakersfield-Planz.

The Bakersfield-California site is typical of the trend in improvement for these six sites: first quarter (January through March) ambient PM_{2.5} concentrations show greater reduction rates than fourth quarter (October through December) measurements. At the Bakersfield-California site the average PM_{2.5} concentration showed a downward trend of 0.74 $\mu\text{g}/\text{m}^3$ per year for the first quarter and 1.15 $\mu\text{g}/\text{m}^3$ per year for the fourth quarter, as shown in Figures A-6 and A-7, respectively.

Figure A-6 1st Quarter Average Trend at Bakersfield-California

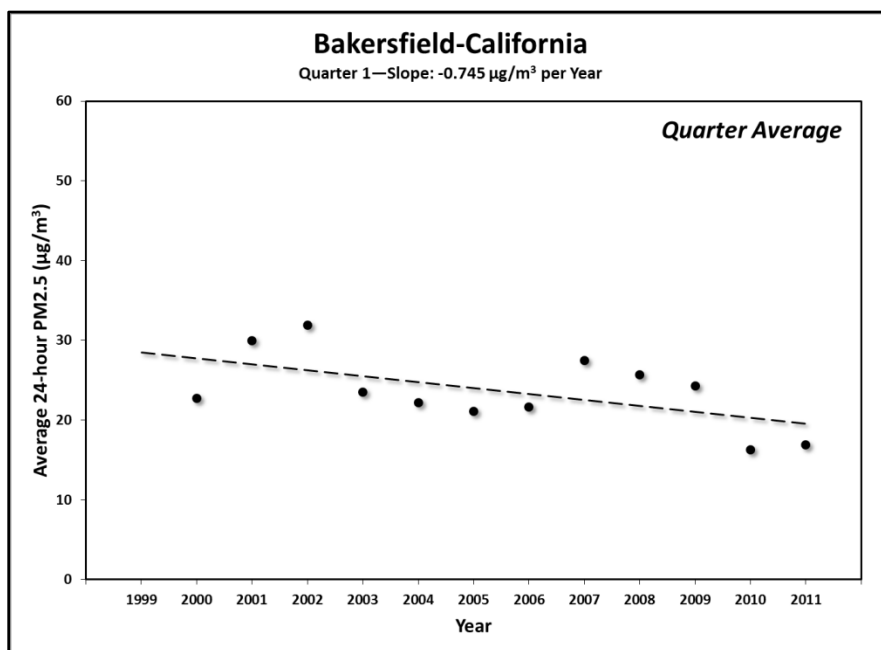
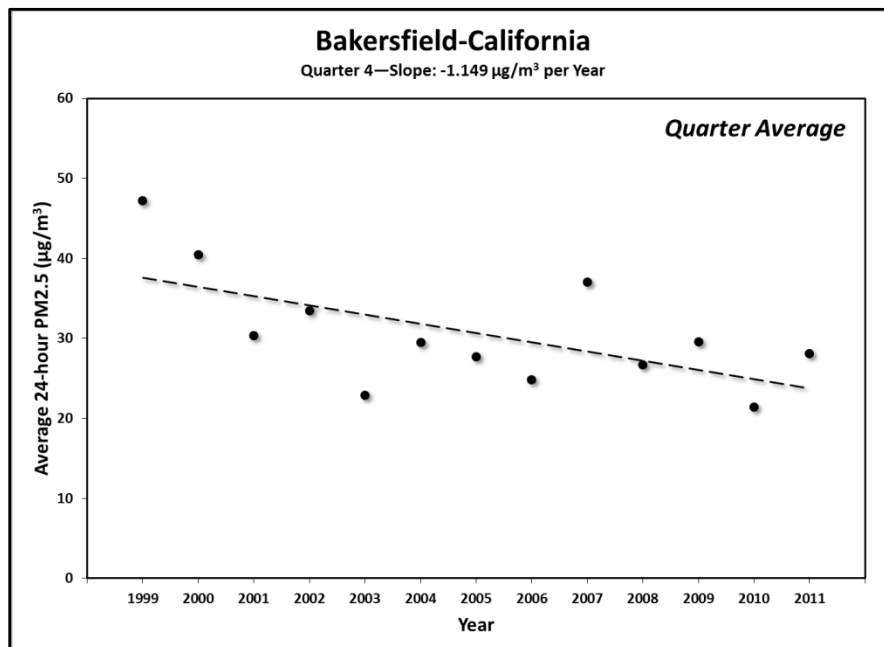


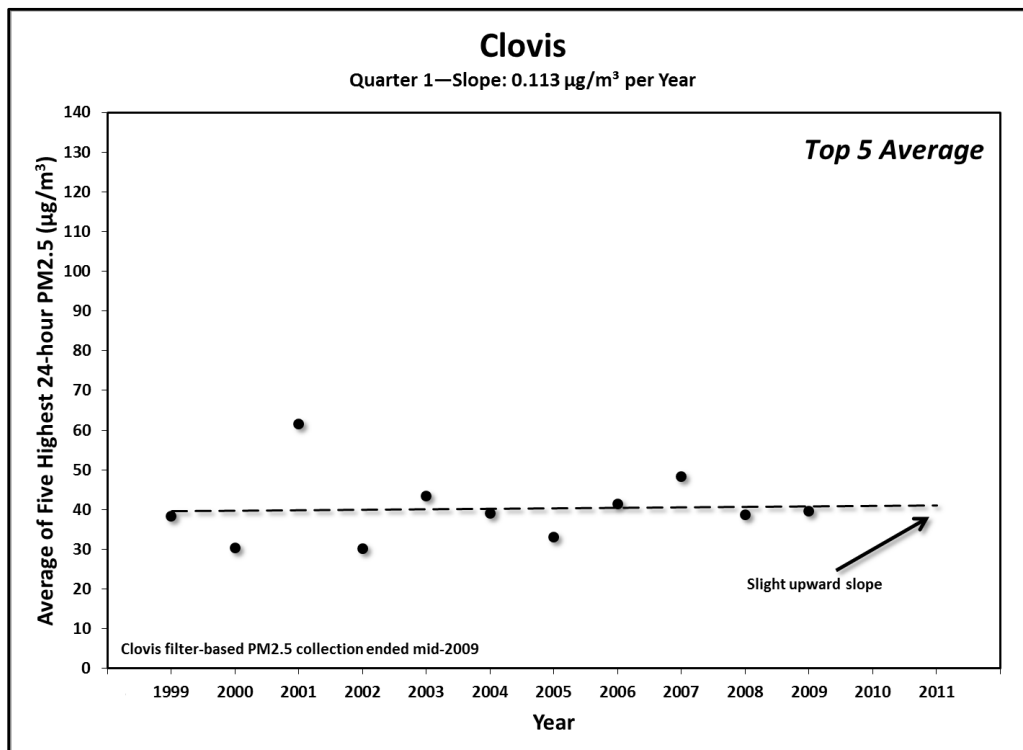
Figure A-7 4th Quarter Average Trend at Bakersfield-California



Using the same data, but focusing only on the five worst days of each quarter, the District was able to determine that not only are the average concentrations decreasing in each quarter, but the severity of the worst days (highest concentrations) are decreasing at a more rapid rate. Using the five worst days from the Visalia air monitoring site data (Figures A-9.13 through A-9.16), over the same time period as above, shows a 3.30 µg/m³ per year reduction rate for the first quarter compared to a 1.22 µg/m³ per year reduction rate for the same quarter when considering the average of all the first-quarter data. This data gives indication that the severity of PM_{2.5} episodes is decreasing over time, and supports the effectiveness of District wood-burning controls, controls that reduce public exposure to extremely high concentrations of PM_{2.5}.

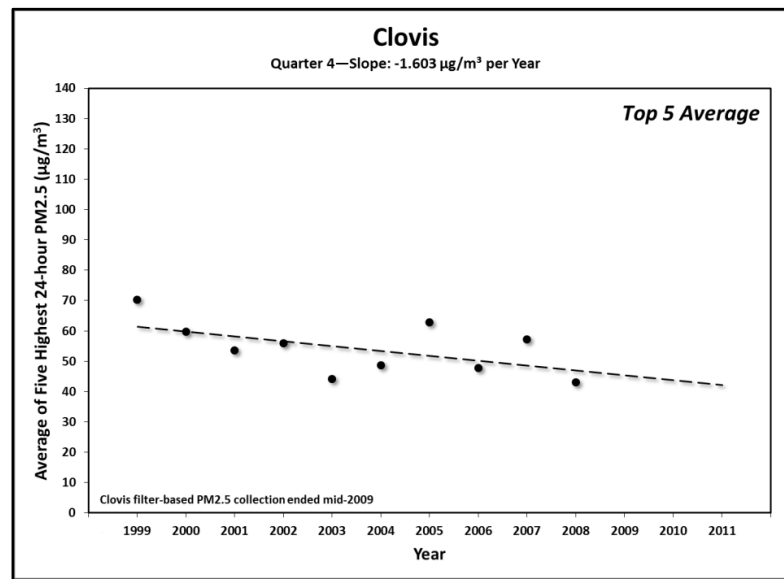
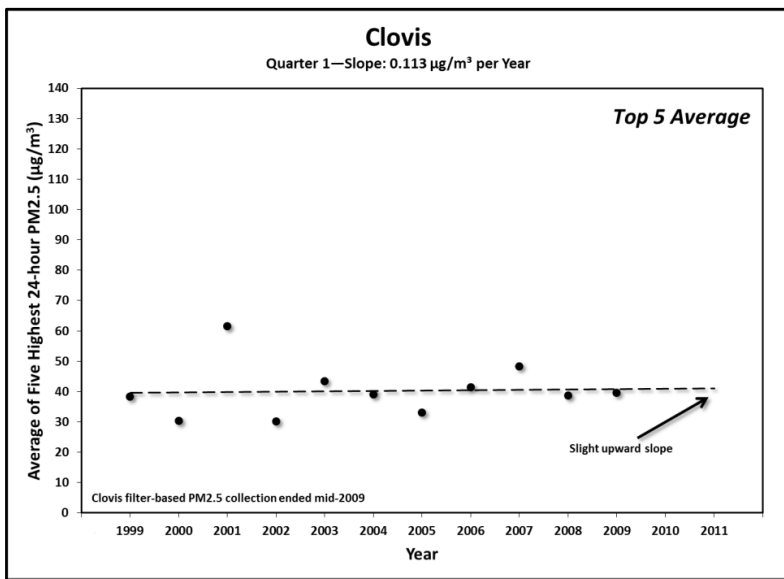
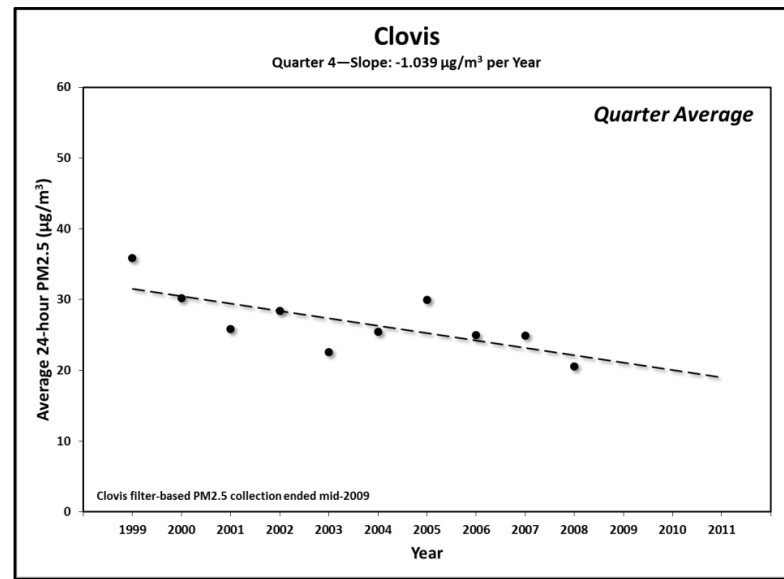
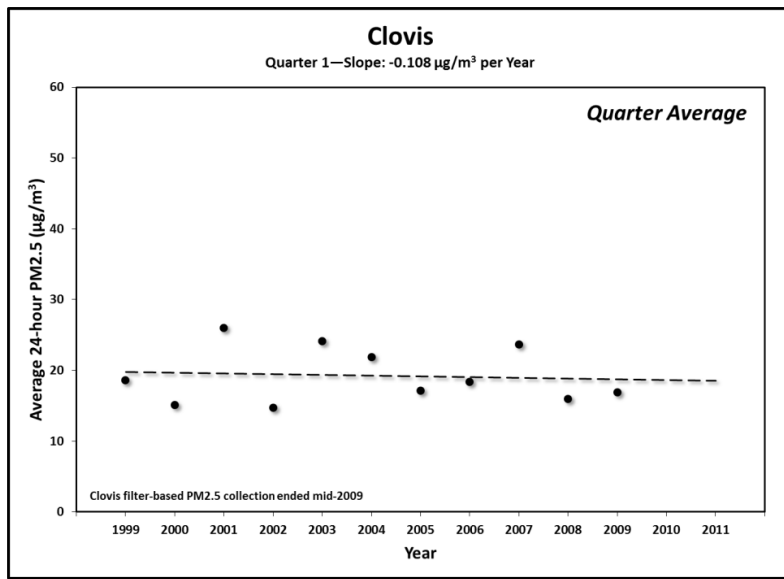
While most Valley air monitoring sites showed a similar pattern of peak reductions as with the Visalia site, evaluation of the Clovis site did not show the same pattern. As shown in Figure A-8, evaluation of the five worst days indicates a slight increase in the peak ambient concentration. However, such an increase may reflect random variation in the data and does not conclusively indicate an overall increase in the average PM_{2.5} concentration. While this anomaly occurs in the first-quarter data for the Clovis site, the fourth-quarter data is consistent with the overall decreasing trend in ambient PM_{2.5} concentrations.

Figure A-8 1st Quarter Average Trend at Clovis

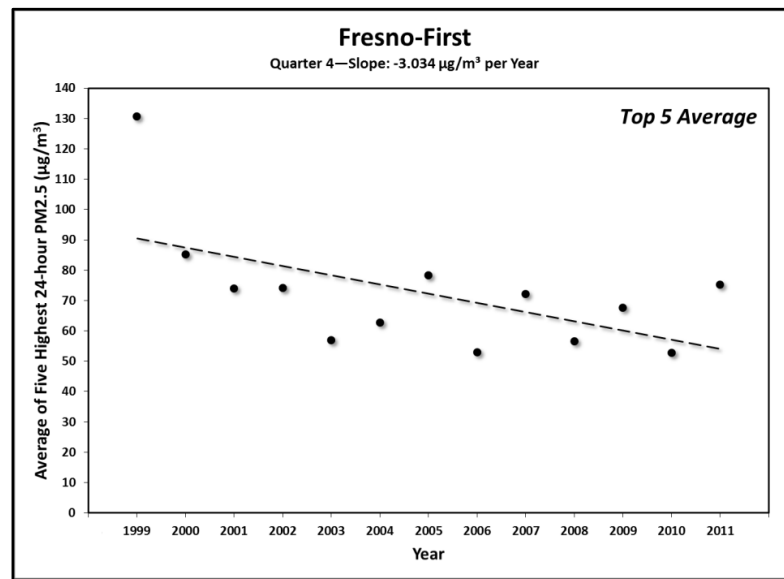
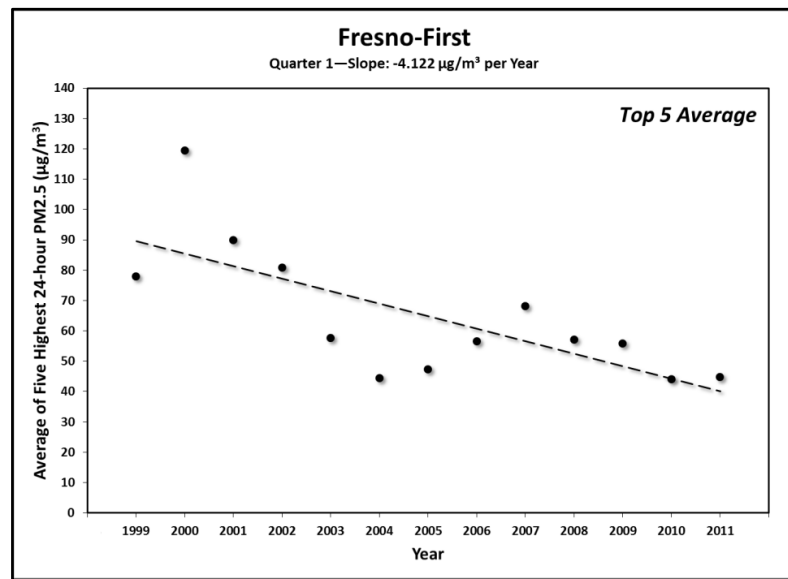
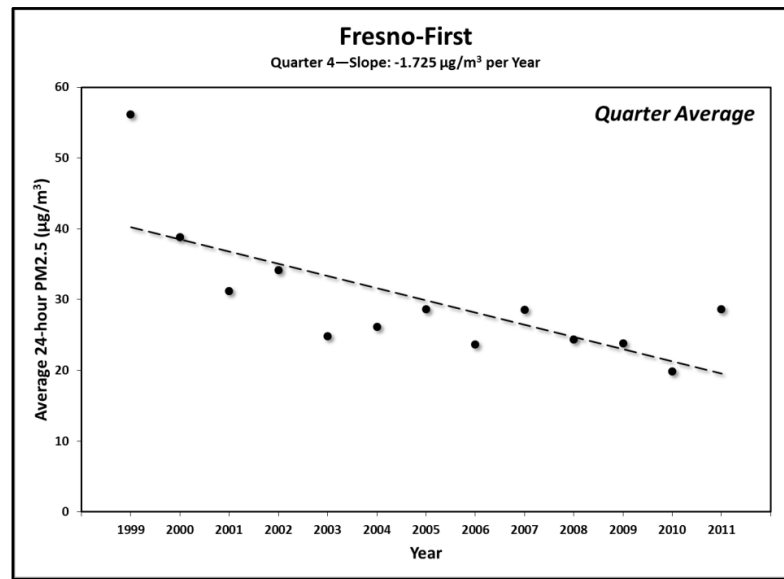
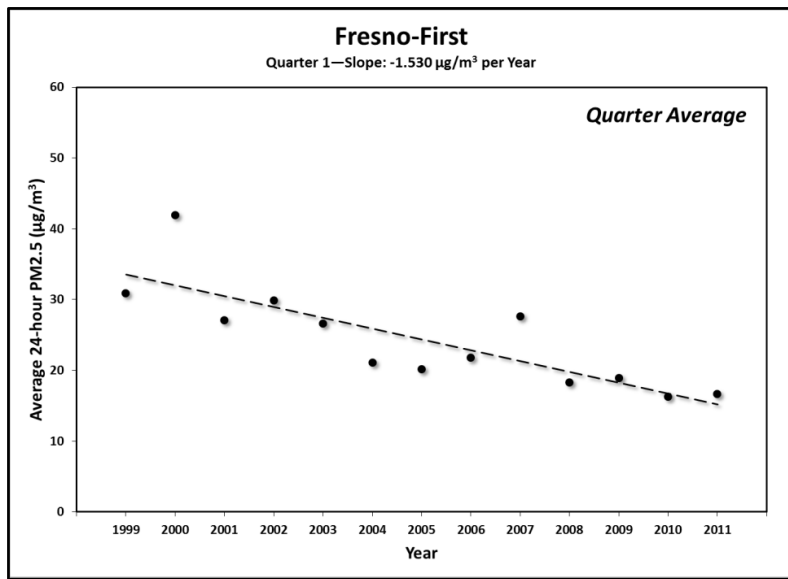


The following graphs, Figures A-9.1 through A-9.24, show the first- and fourth-quarter 24-hour PM_{2.5} averages, along with the average of the top five values within each of these quarters for the six monitoring sites included in this analysis.

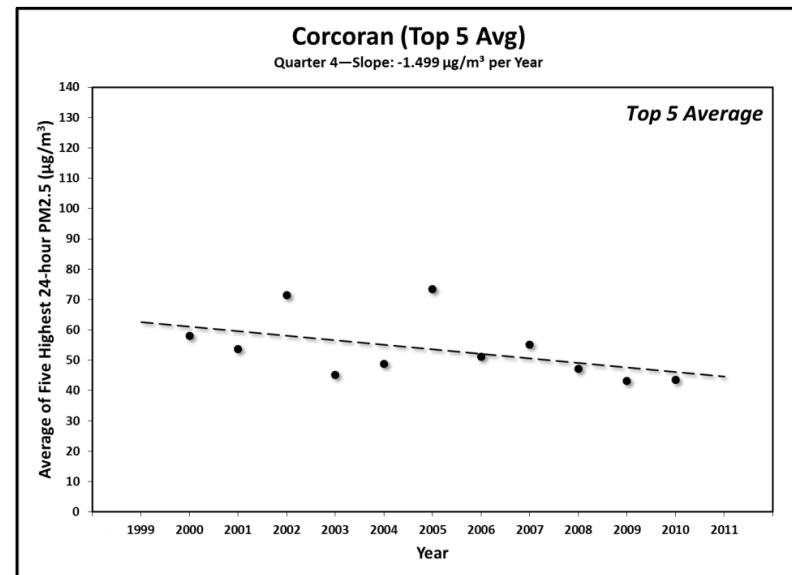
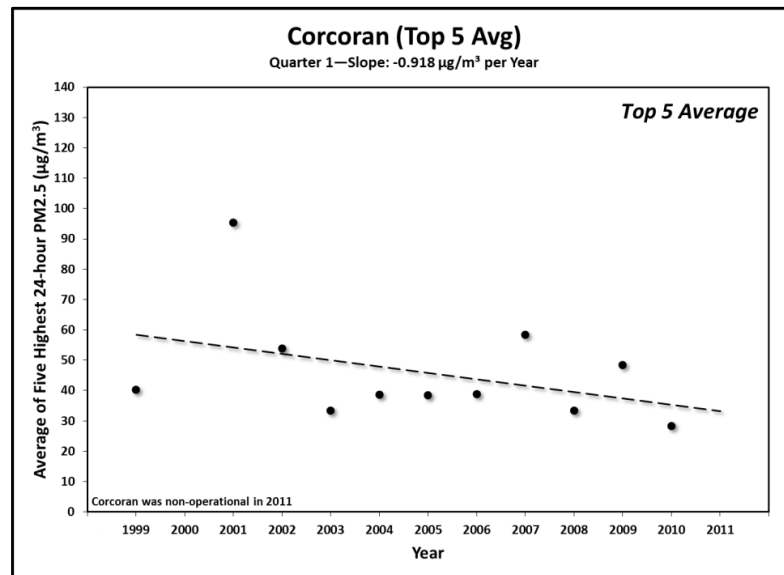
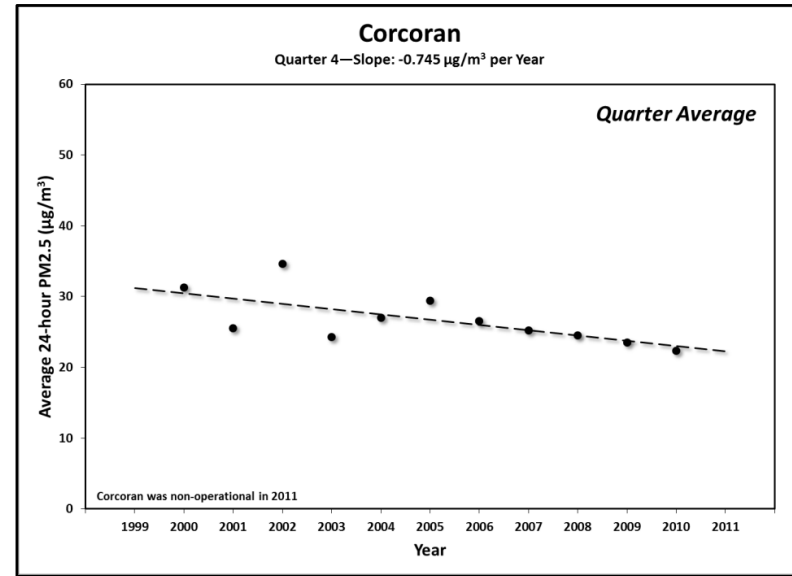
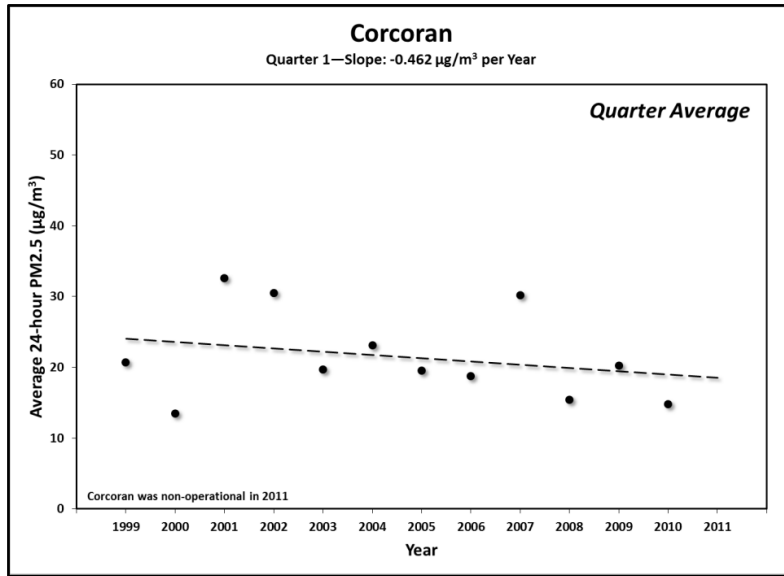
Figures A-9.1 through A-9.4 1st and 4th Quarter PM2.5 Average Trends at Clovis



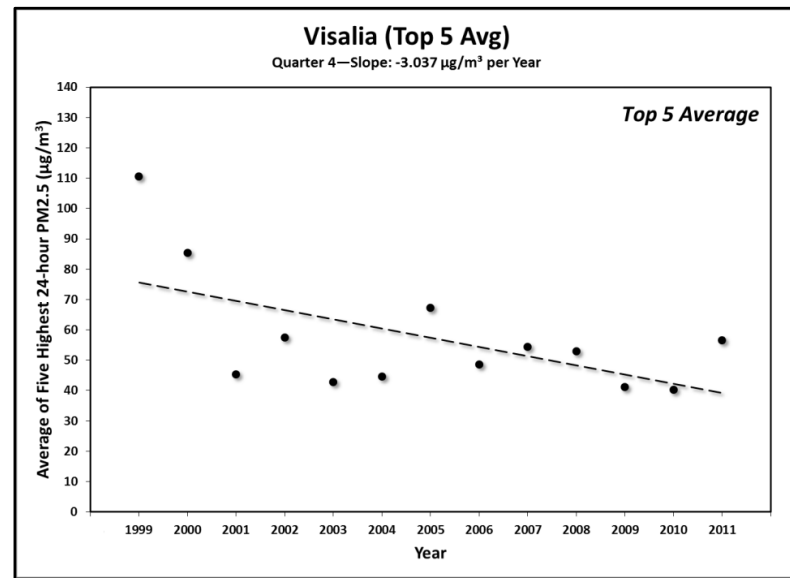
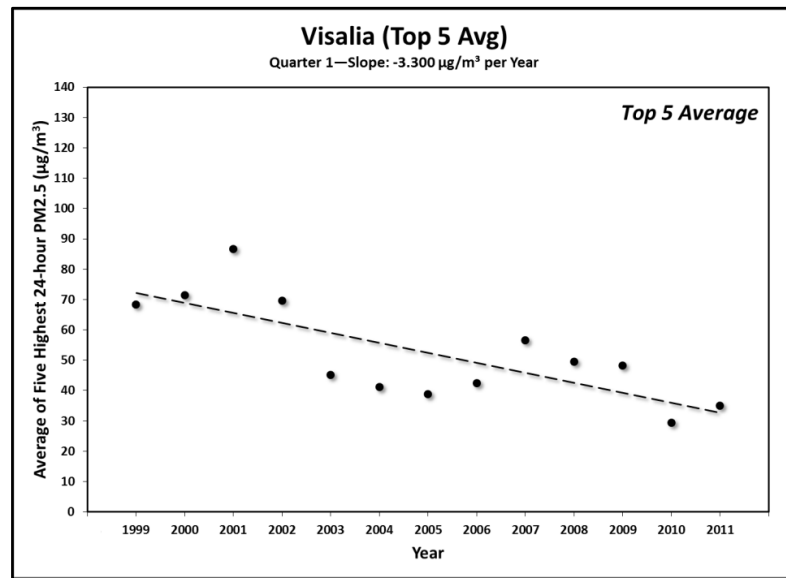
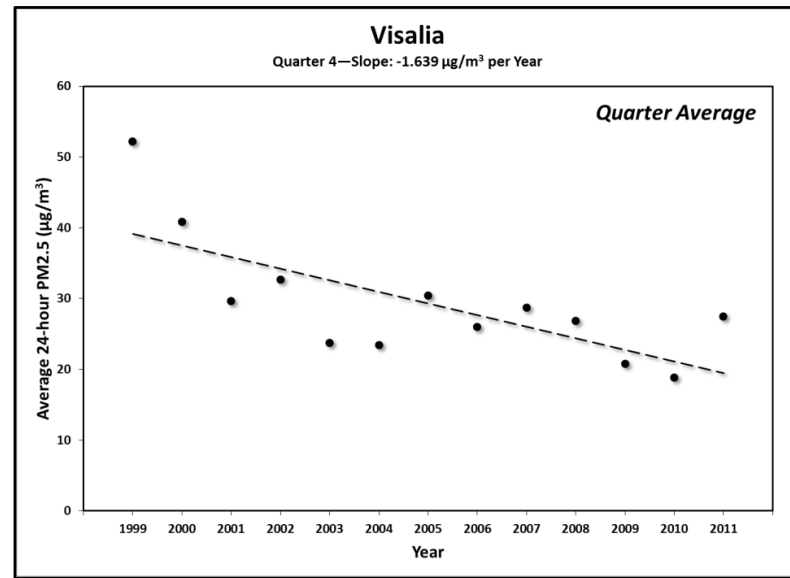
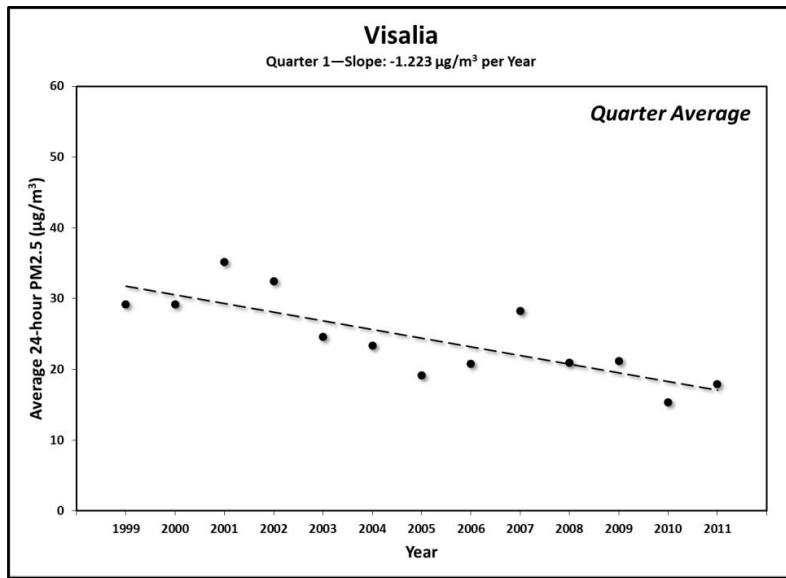
Figures A-9.5 through A-9.8 1st and 4th Quarter PM2.5 Average Trends at Fresno-First



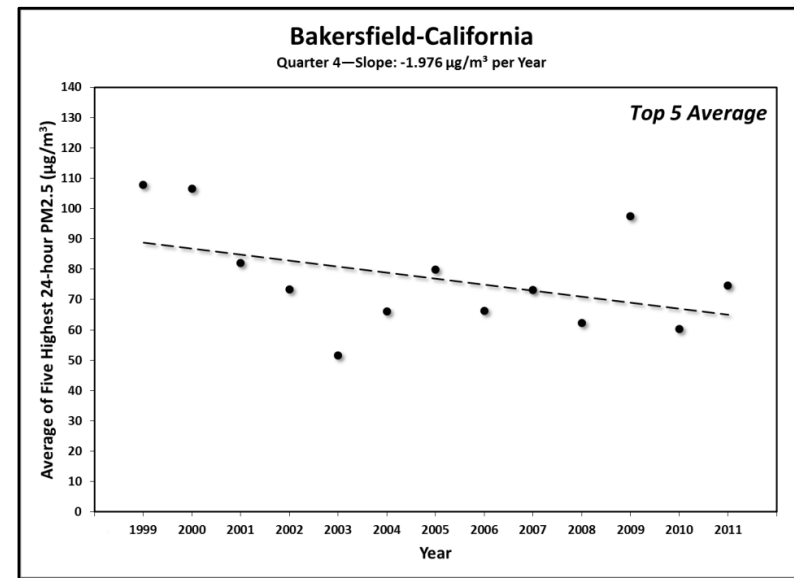
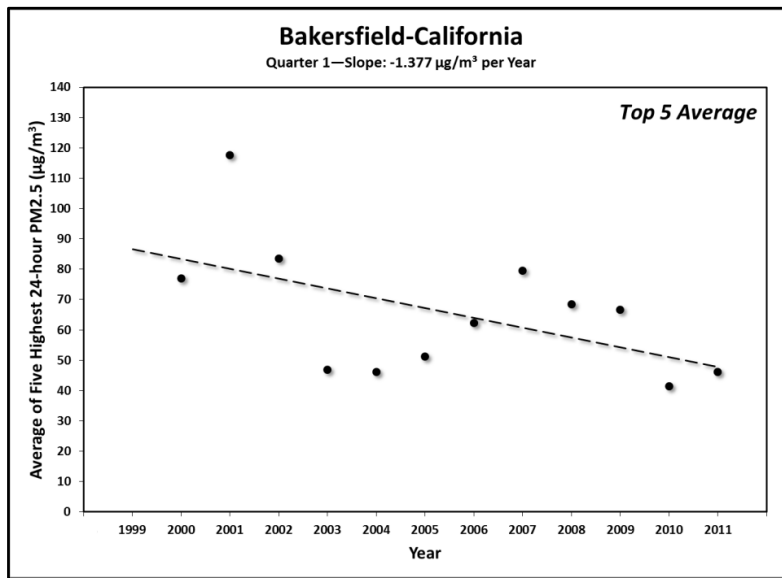
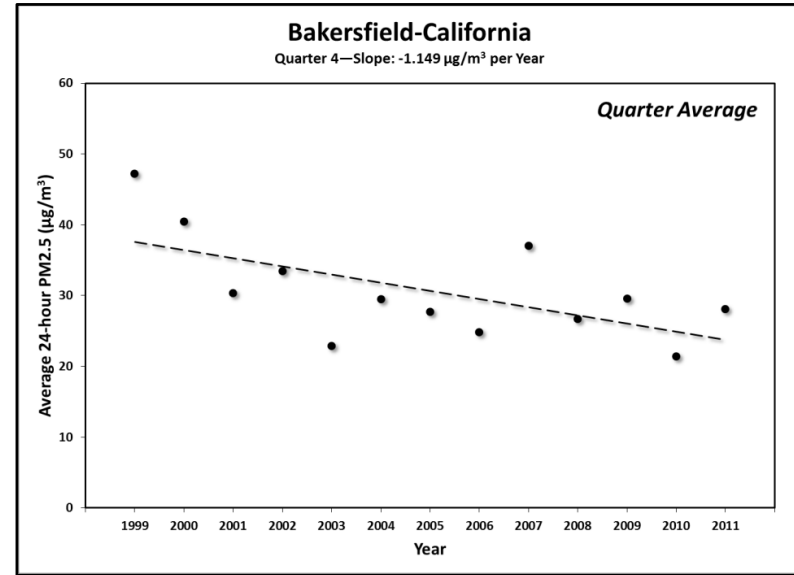
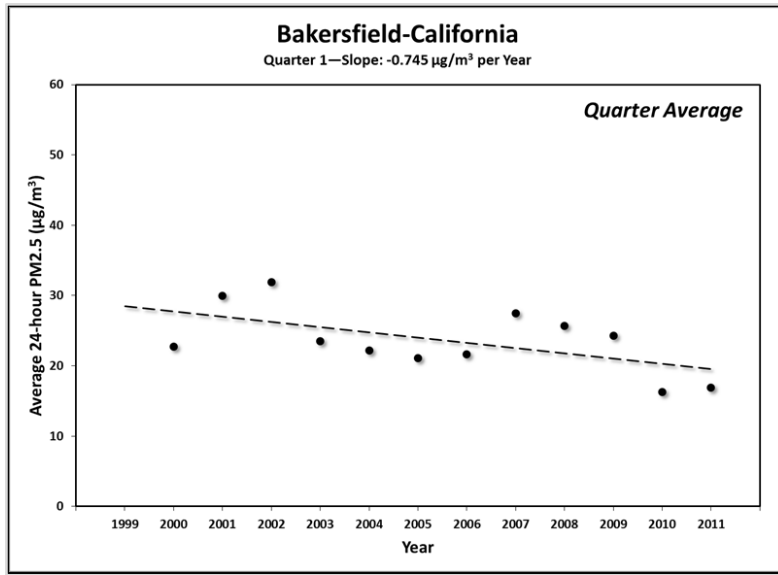
Figures A-9.9 through A-9.12 1st and 4th Quarter PM2.5 Average Trends at Corcoran



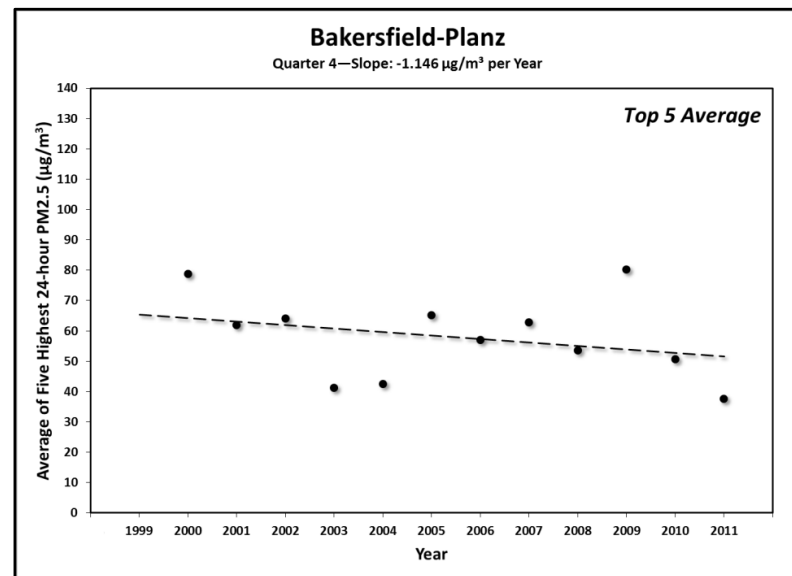
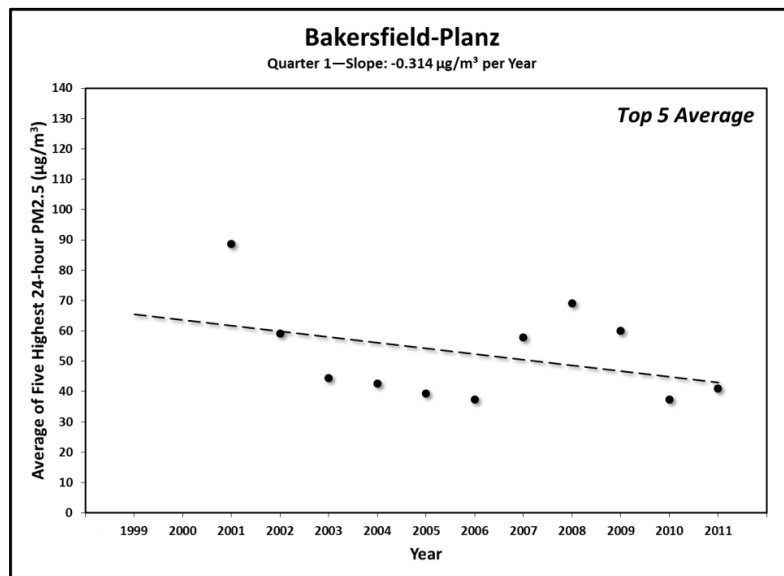
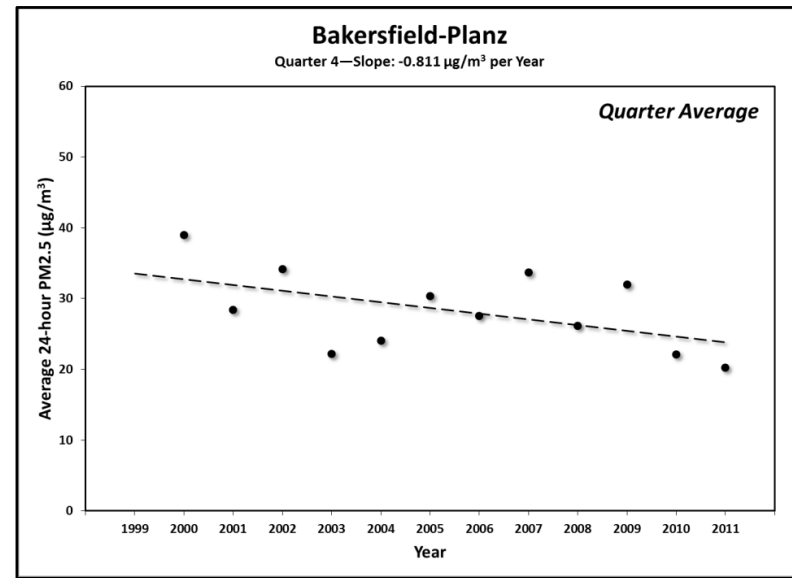
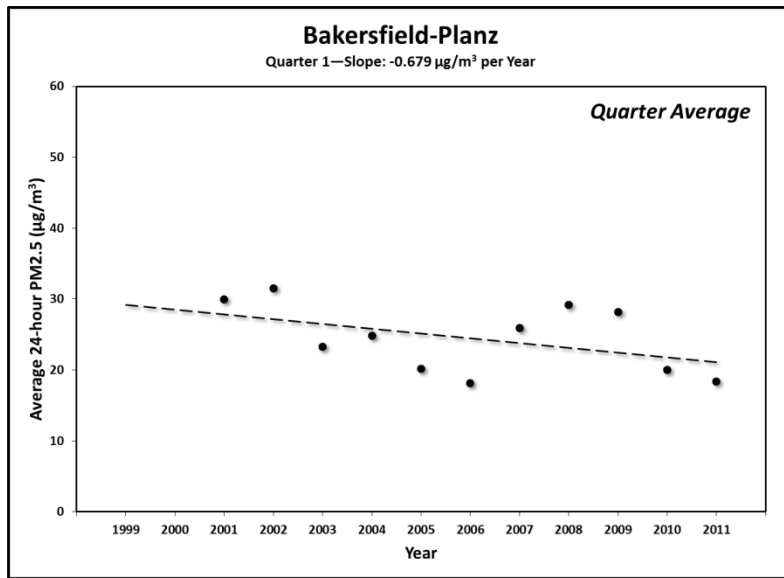
Figures A-9.13 through A-9.16 1st and 4th Quarter PM2.5 Average Trends at Visalia



Figures A-9.17 through A-9.20 1st and 4th Quarter PM2.5 Average Trends at Bakersfield-California



Figures A-9.21 through A-9.24 1st and 4th Quarter PM2.5 Average Trends at Bakersfield-Planz



A.3.3 Annual Trends of Diurnal PM_{2.5} Concentration Profiles

The District collects hourly PM_{2.5} concentration data from 17 of the 34 air monitoring stations in the Valley using real-time PM_{2.5} monitors. The District uses this data every day to produce daily air quality forecasting, wood burning declarations, public health notifications, and Real-time Air Advisory Network (RAAN) notifications for schools. Based on historical hourly data, the District has compiled long-term diurnal profiles to evaluate how PM_{2.5} concentration vary throughout the day at each of the Valley monitoring sites that measure such data. An understanding of such profiles helps to develop control strategies and programs that target activities during times of peak concentrations.

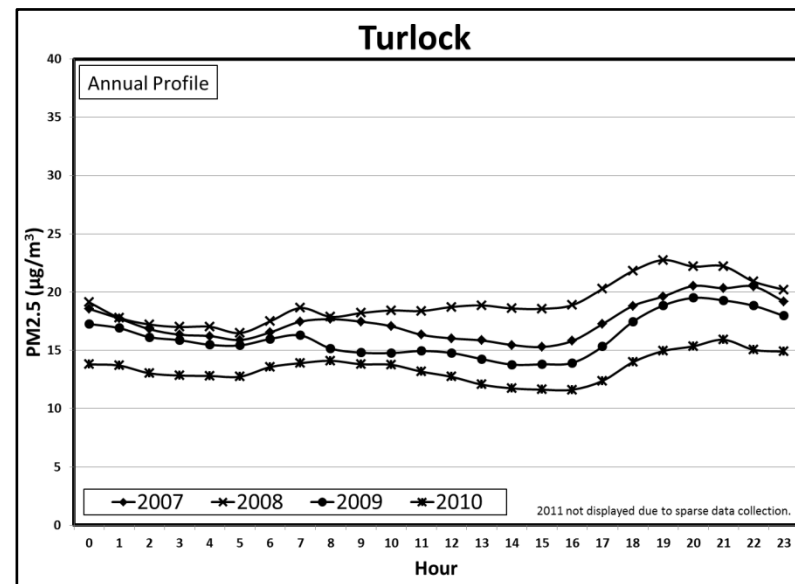
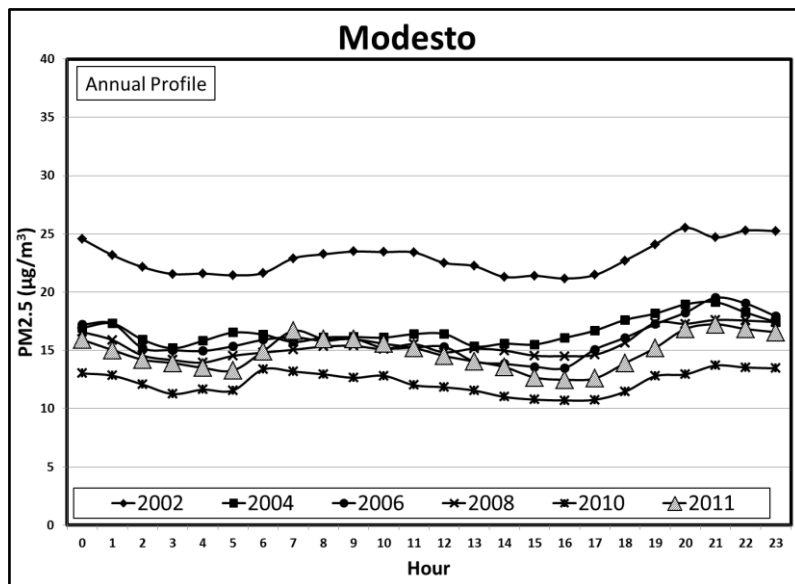
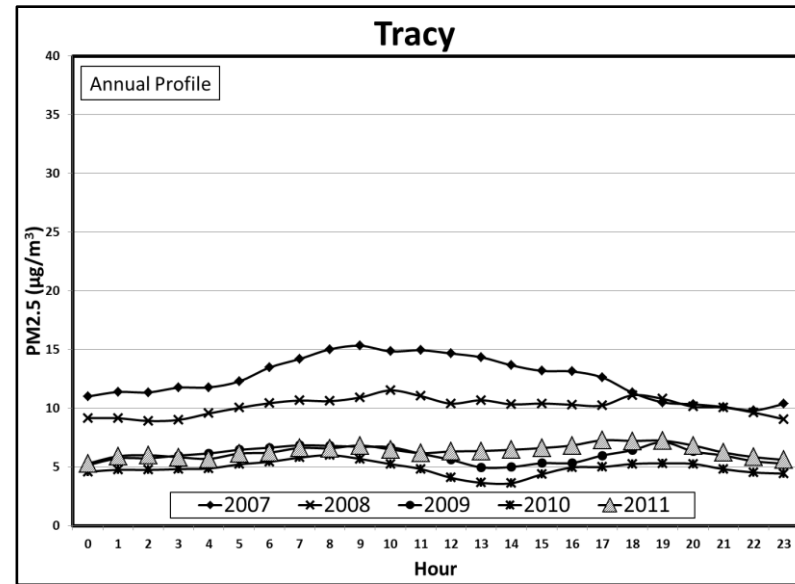
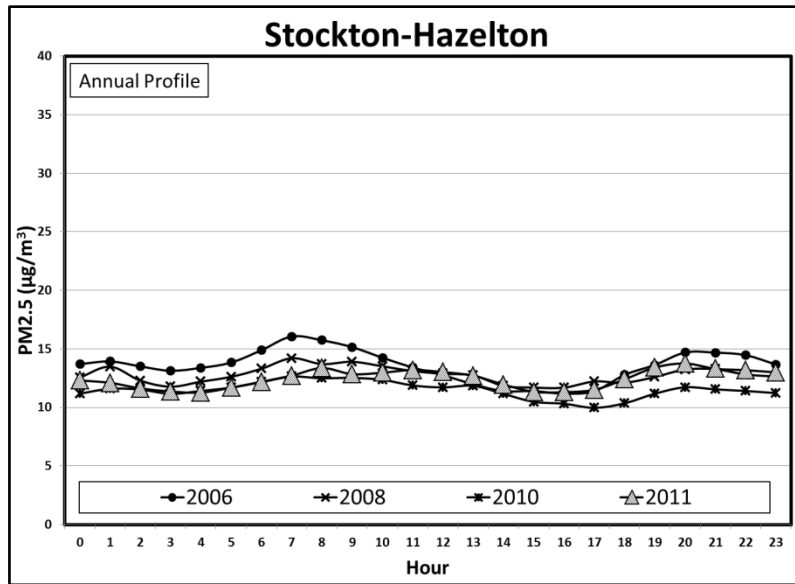
Calculating and comparing annual and 24-hour averages for PM_{2.5} can be helpful in their own right; however, these metrics can often mask the trend in hourly concentrations throughout the day. An hourly analysis of PM_{2.5} measurements can show what portions of the day tend to have the highest concentrations and which portions of the day have the lowest. Comparing the diurnal (or daily) profiles over time shows how this curve has changed from year to year.

The District compares relative changes in hourly PM_{2.5} concentrations from year to year at each monitoring site to better understand the implications and effectiveness of PM_{2.5} control measures, especially the use of wood-burning prohibitions. Such prohibitions became mandatory prior to the 2003–2004 winter season and were strengthened prior to the 2008–2009 winter season.

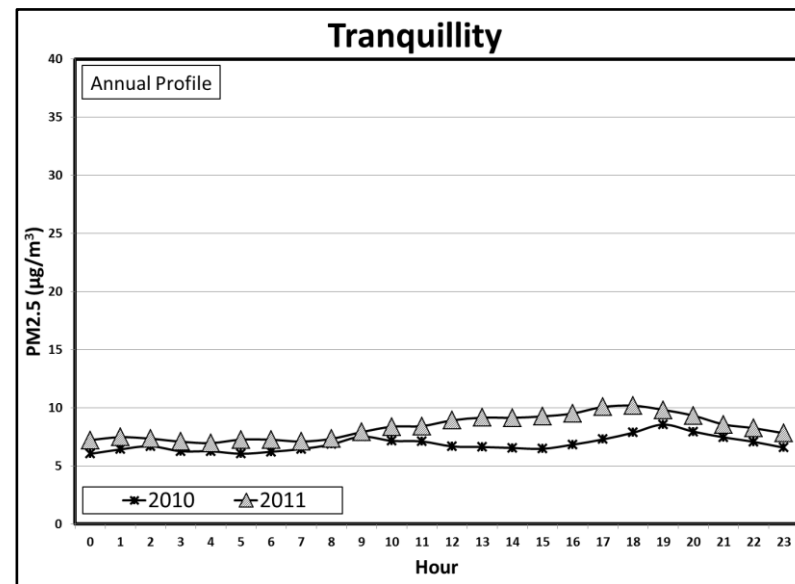
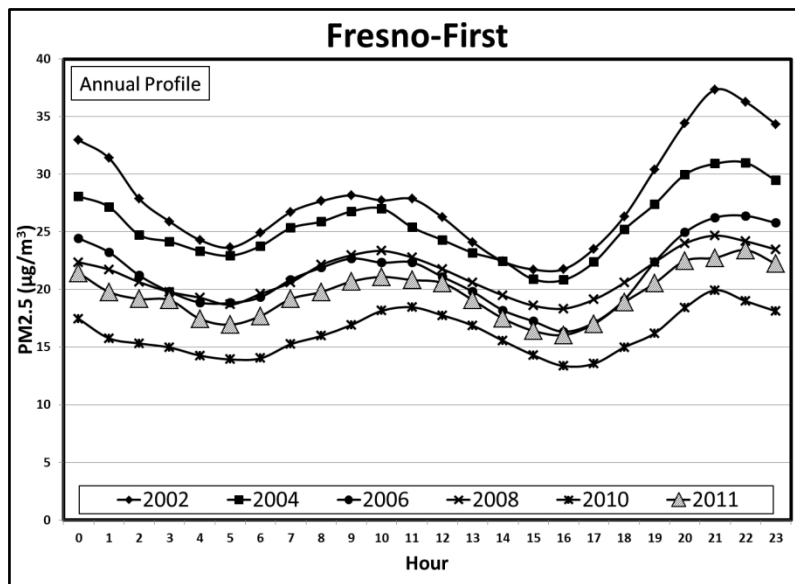
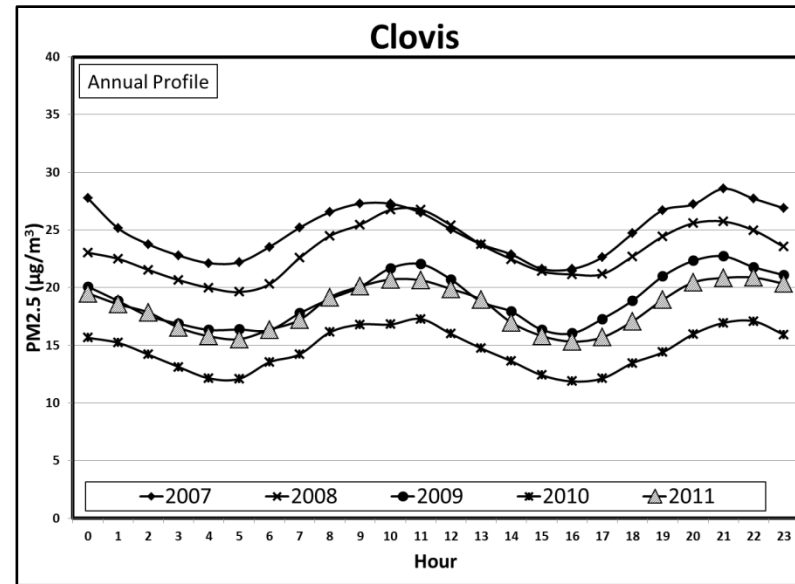
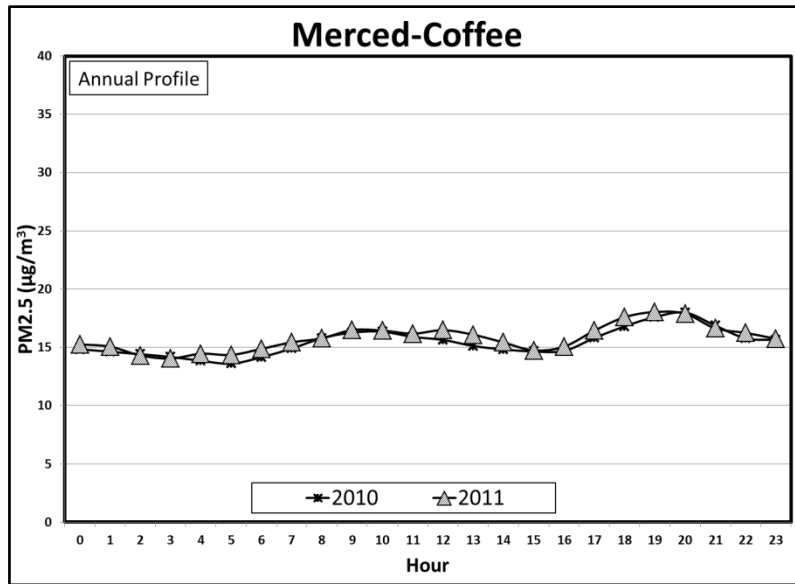
Figures A-10.1 through A-10.14 show the yearly average diurnal profiles of most of the real-time monitoring sites in the Valley. Sites profiled here are those with the most complete data record, in which a comparison could be made with previous years.

As shown in these profiles, the year 2011 (represented by triangles in all of the charts) tended to experience higher hourly PM_{2.5} concentrations when compared to 2010. In the larger metropolitan areas like Bakersfield and Fresno, this difference between 2011 and 2010 was more pronounced. Although concentrations were higher in 2011, partly because of unfavorable meteorology, the evening peaks were “flatter” (less pronounced) than in years past. Focusing on the Bakersfield-California and Fresno-First sites, the higher evening peaks in the year 2002 can be observed. Comparing this to the evening peaks in recent years, including 2011, one can see that the peak is not as pronounced. This could be attributable to more wood-burning prohibitions, which became mandatory during the winter of 2003-04.

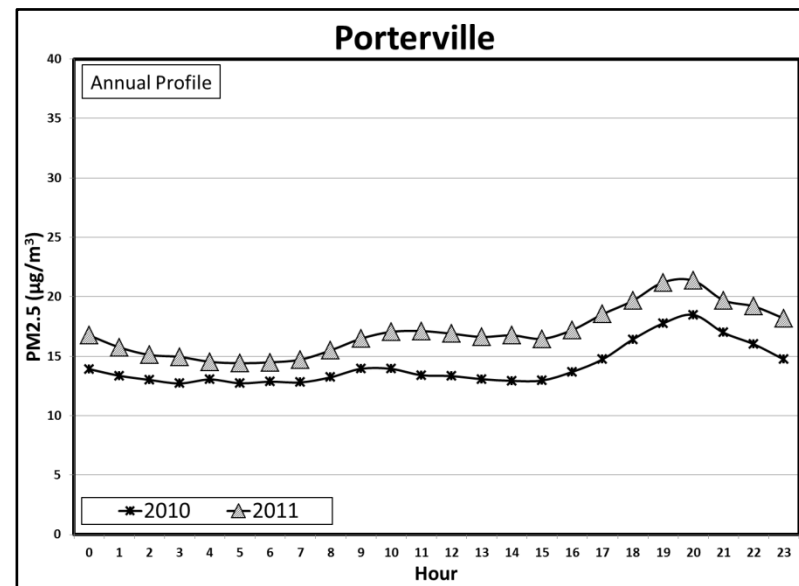
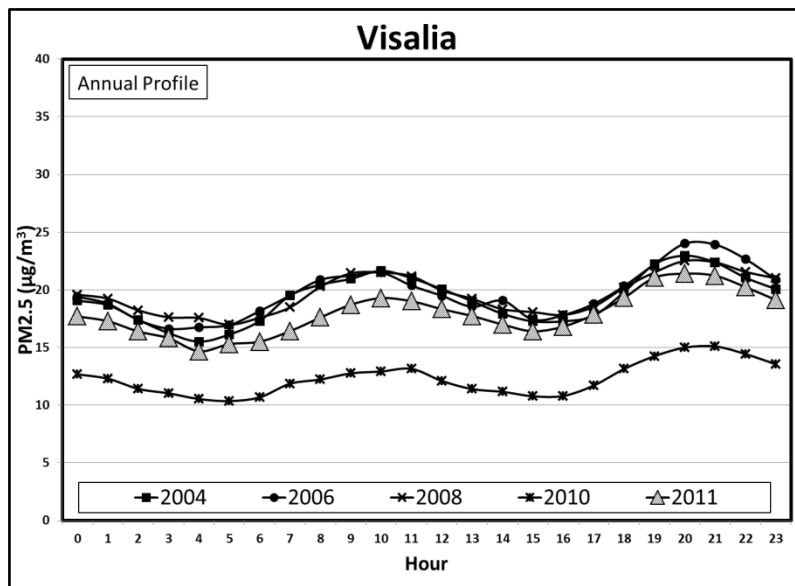
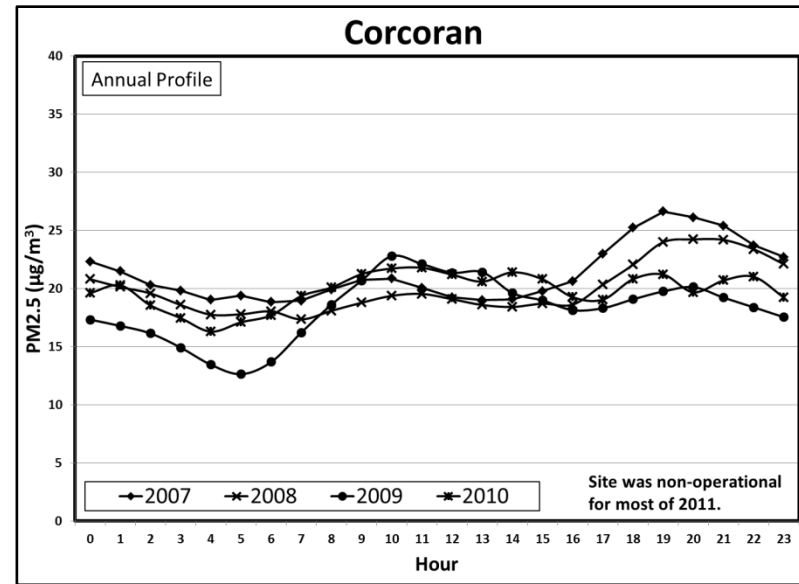
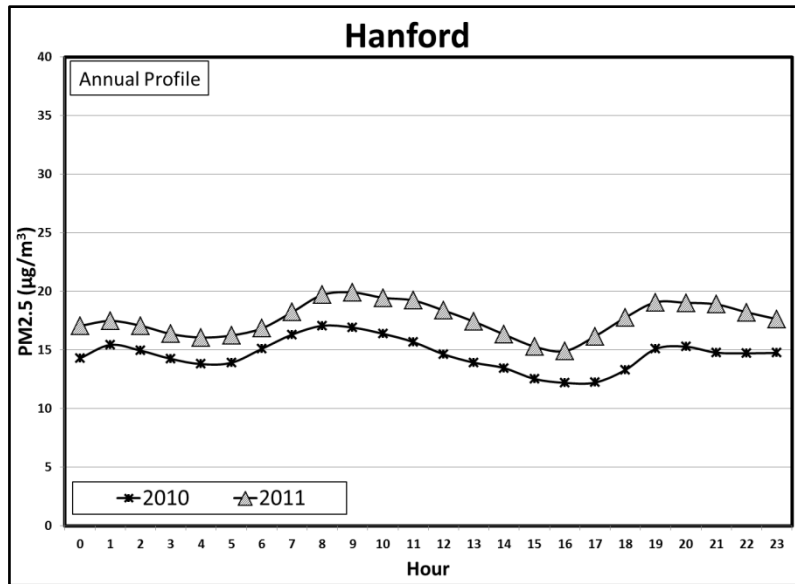
Figures A-10.1 through A-10.4 PM_{2.5} Diurnal Profiles: Stockton-Hazelton, Tracy, Modesto, Turlock



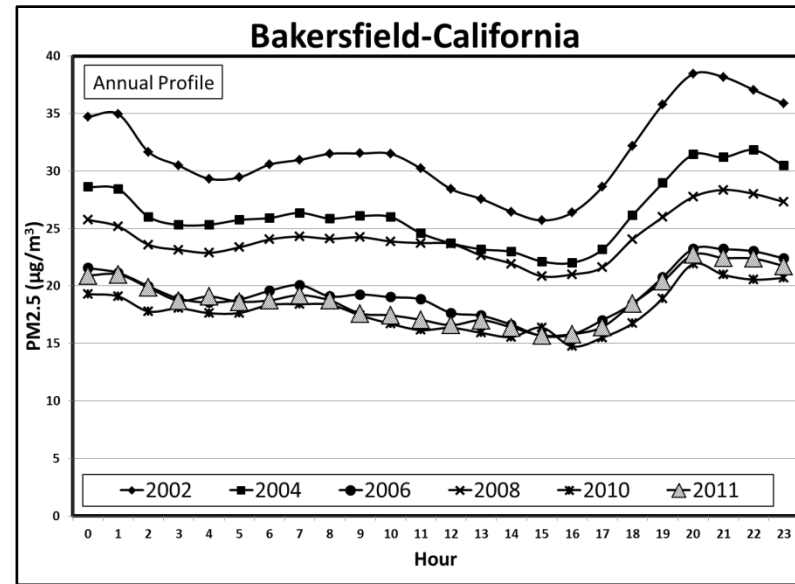
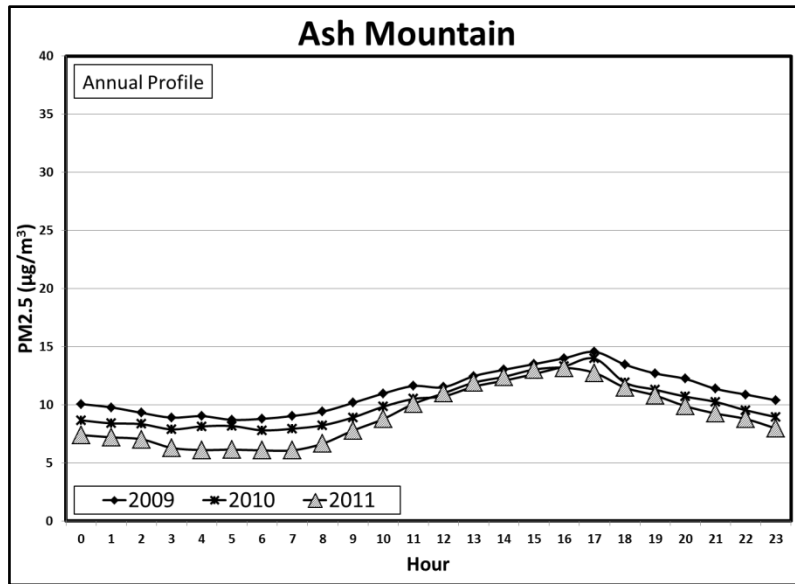
Figures A-10.5 through A-10.8 PM2.5 Diurnal Profiles: Merced-Coffee, Clovis, Fresno-First, Tranquillity



Figures A-10.9 through A-10.12 PM2.5 Diurnal Profiles: Hanford, Corcoran, Visalia, Porterville



Figures A-10.13 through A-10.14 PM_{2.5} Diurnal Profiles: Ash Mountain, Bakersfield-California



A.3.4 PM2.5 Driven Air Quality Index Analysis

The EPA and the District use the Air Quality Index (AQI) to provide daily information about the Valley's air quality, to inform the public about how unhealthy air may affect them, and educate the public about how they can protect their health. AQI scales exist for all of the criteria pollutants regulated by the Clean Air Act, including PM2.5. The current 24-hour average PM2.5 AQI scale is defined in Table A-8.

Table A-8 24-Hour PM2.5 AQI Scale

Concentration ($\mu\text{g}/\text{m}^3$)	AQI Category	AQI Color	AQI Range
0 - 15.4	Good	Green	0-50
15.5 - 40.4	Moderate	Yellow	51-100
40.5 - 65.4	Unhealthy for Sensitive Groups	Orange	101-150
65.5 - 150.4	Unhealthy	Red	151-200
150.5 - 250.4	Very Unhealthy	Purple	201-300
250.5+	Hazardous	Maroon	301+

The District analyzed the trends in the PM2.5 data from the sites with at least two years of daily AQI observations based on real-time data. For this analysis, the AQI reflects only PM2.5 data and not ozone or PM10. By excluding other pollutants, the District is able to isolate the change in air quality related to PM2.5 only.

For the majority of the Valley sites, the observed AQI data for the 2008–2010 timeframe shows an improvement in PM2.5 air quality. Over these three years, the frequency of Good AQI days increased sharply, coupled with a decrease in the frequency of the Moderate and Unhealthy-for-Sensitive-Groups (USG) categories. For example, at the Fresno-First site, the number of Good days increased from 155 in 2008, to 205 in 2009, and to 227 in 2010. At the same time, the USG days at the Bakersfield-California site decreased from 61 in 2008, to 34 in 2009, and to 16 in 2010. This trend shows a progressive “shift in improvement” of the AQI and air quality—as air quality improves there will more AQI days falling within the Good and Moderate categories and fewer in the USG category.

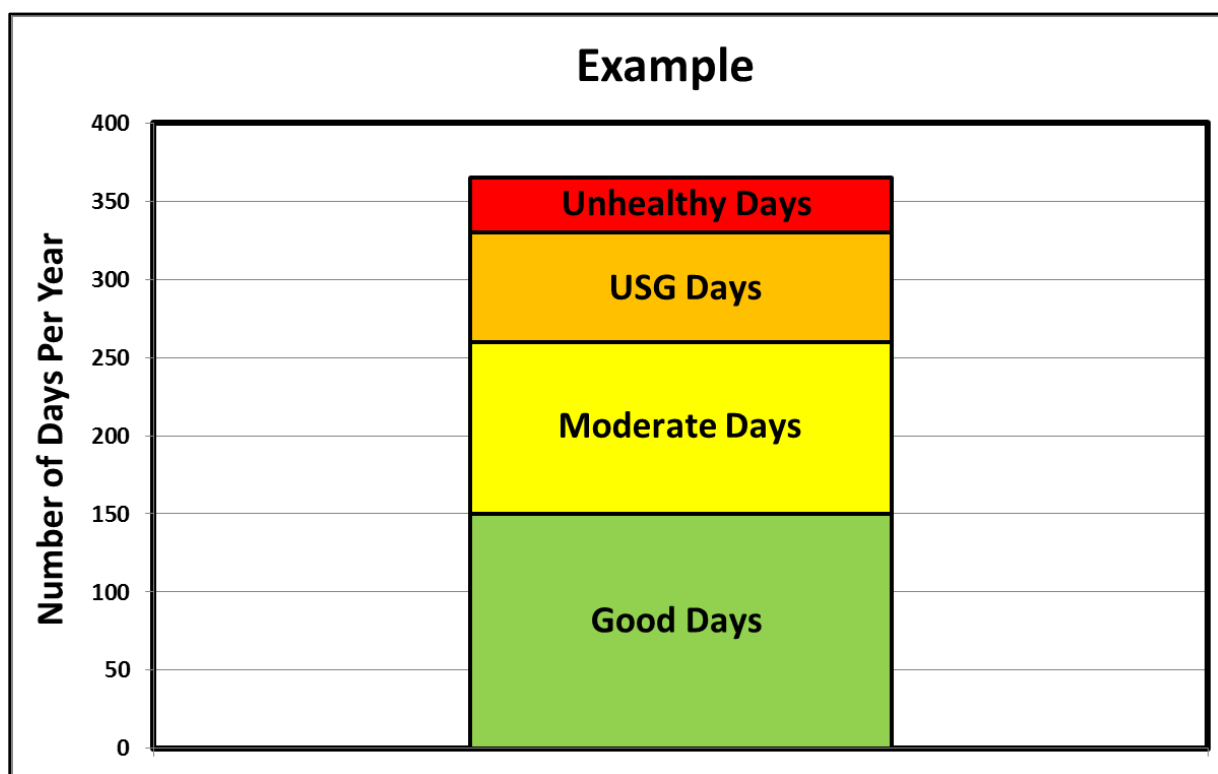
Although the improvement over the 2008–2010 timeframe is partly attributable to favorable meteorology, emissions reductions were also occurring over these three years. The District's Rule 4901 (Wood Burning Fireplaces and Wood Burning Heaters) was strengthened just before the 2008–2009 winter season, lowering the curtailment threshold from $65 \mu\text{g}/\text{m}^3$ to $30 \mu\text{g}/\text{m}^3$. The sharp improvement in PM2.5 air quality began as the amended wood-burning rule took effect, which supports the effectiveness of Rule 4901.

In 2011, the PM2.5 air quality declined throughout the majority of the District as compared to previous years. Abnormally stagnant meteorology during the 2011–2012 winter season contributed greatly to this deterioration. Despite the overall air quality

decline there were still more Good AQI days and fewer USG AQI days than in previous years. For example, in 2011 the Modesto site observed 252 Good AQI days and 16 USG AQI days, compared to 2006 with 233 Good AQI days and 22 USG days. Although the air quality for the year 2011 did not continue the favorable trend from 2008–2010, it was still not as severe as in years prior to 2008.

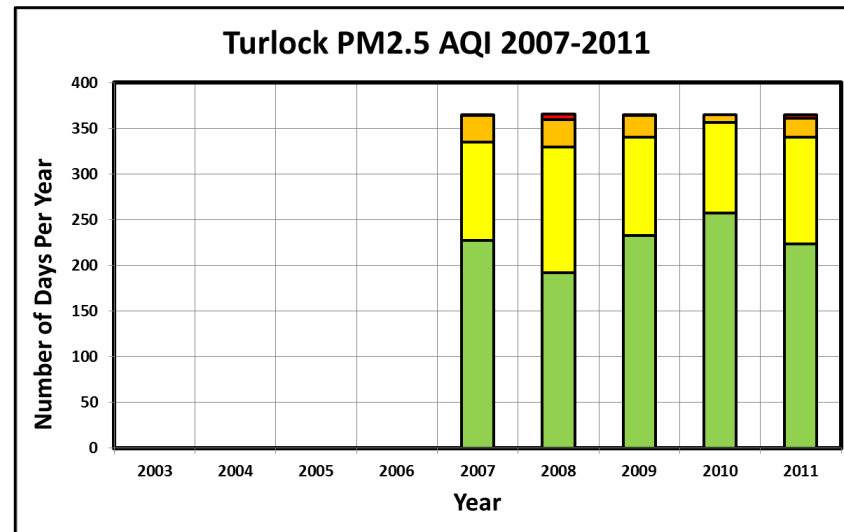
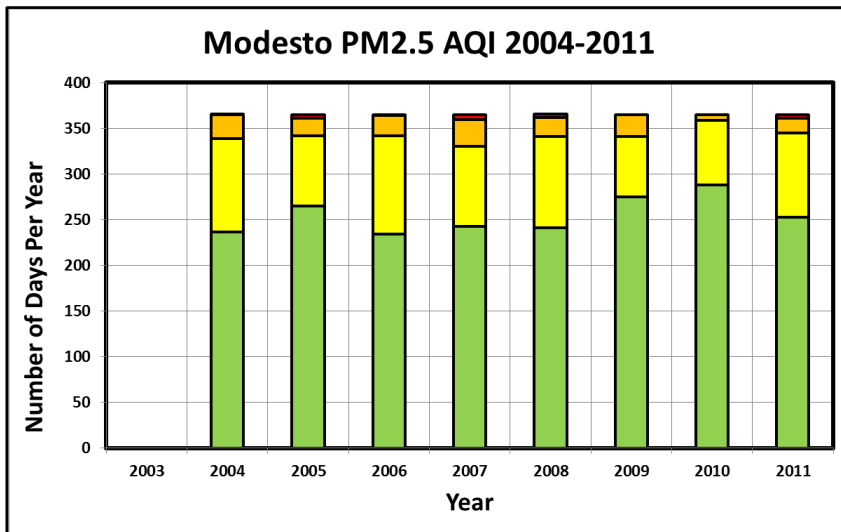
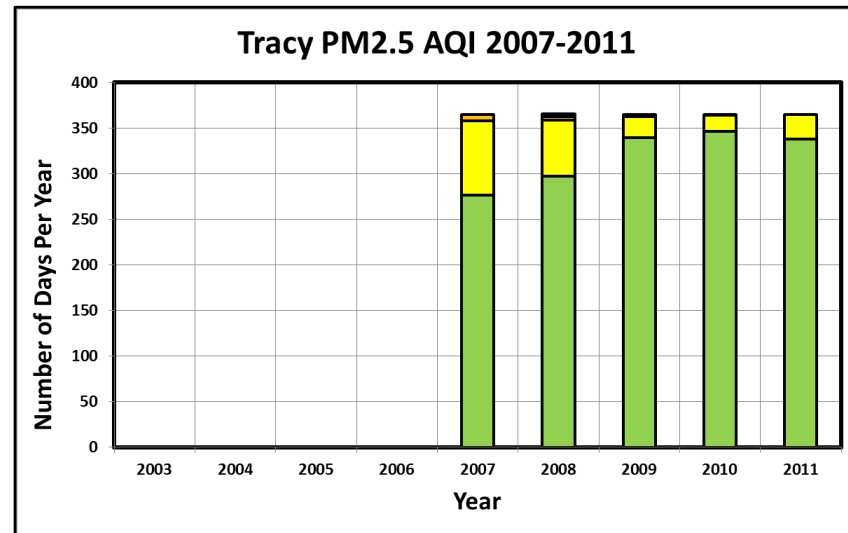
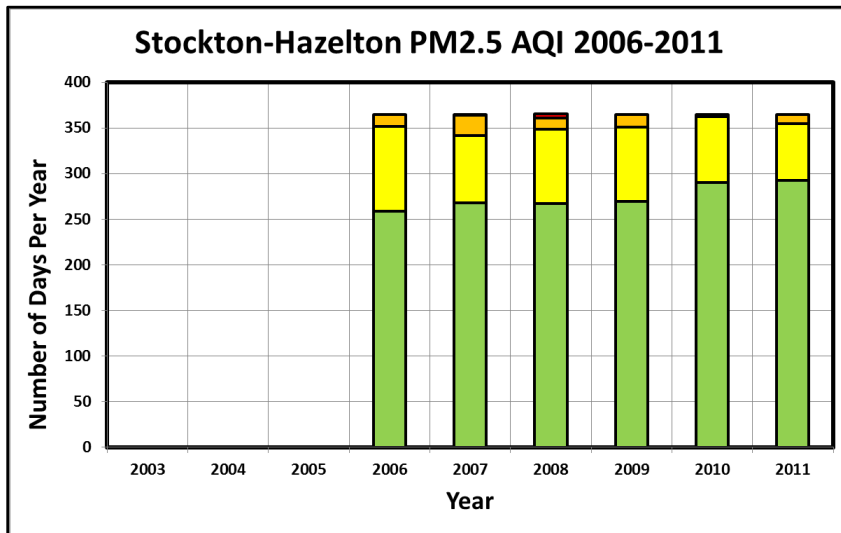
Figure A-11 is shown as a reference for interpreting Figures A-12.1 through A-12.12. The stacked bars represent the number of days within each year that fell within each of the AQI categories (totaling 365 days⁸). Within each stacked bar, the categories are ordered as Good, Moderate, etc. from the bottom up.

Figure A-11 Air Quality Index (AQI) Categories

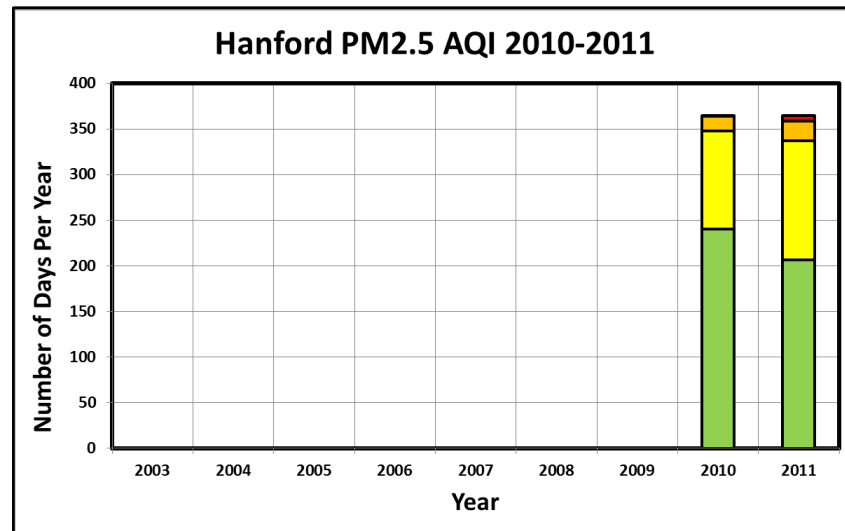
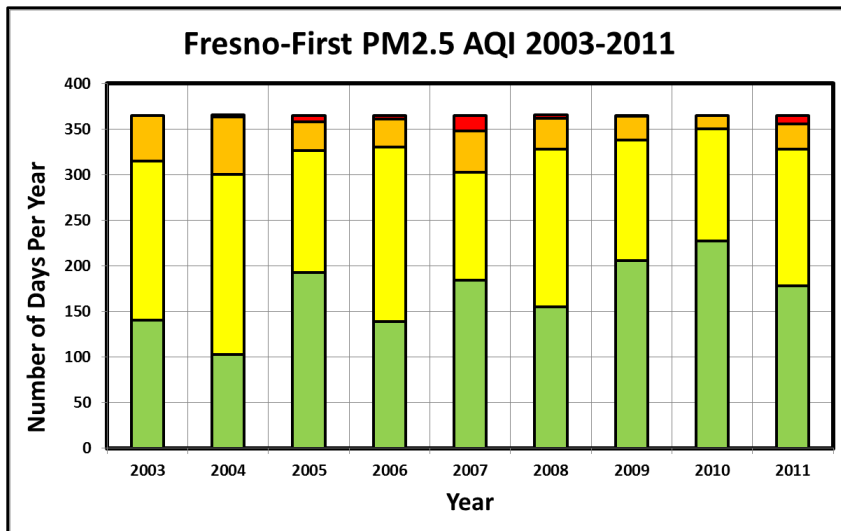
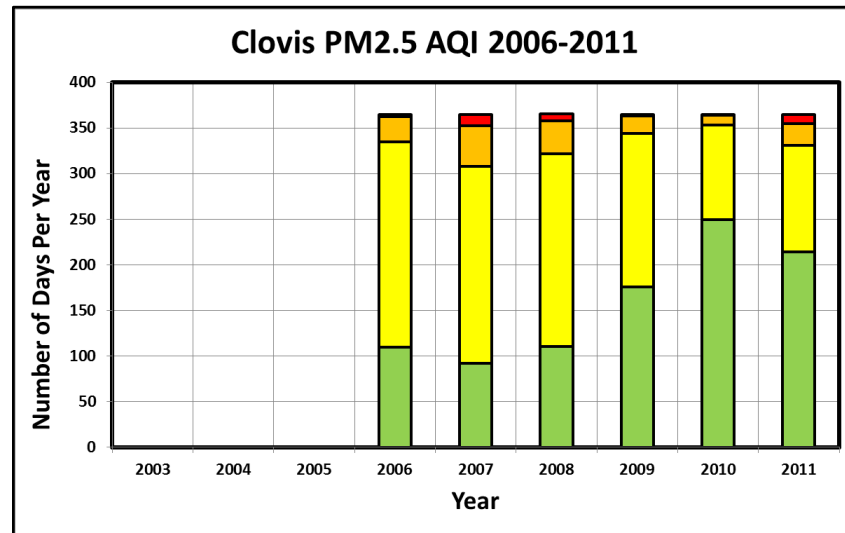
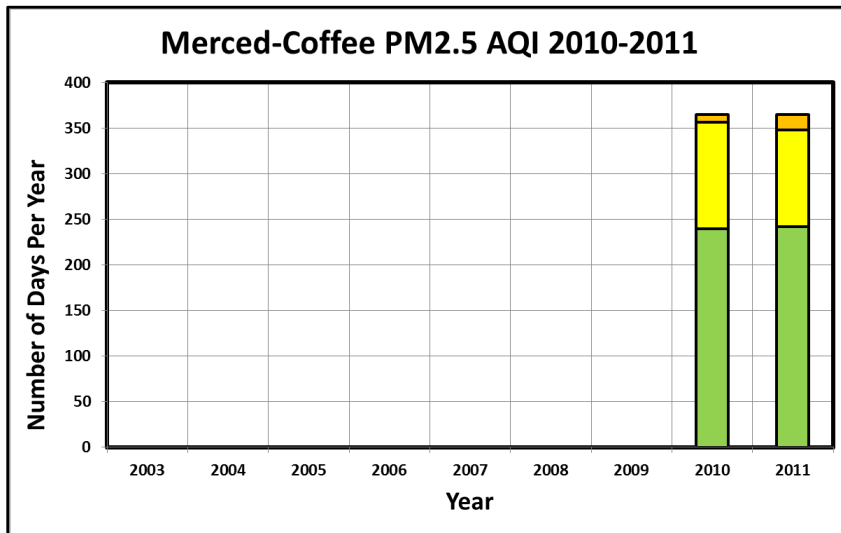


⁸ Note: Because of regular maintenance or repairs, monitors may be non-operational for a day or longer. For years with "missing" days, proportional adjustments are made to estimate the missing days so as to provide a full year's data to display.

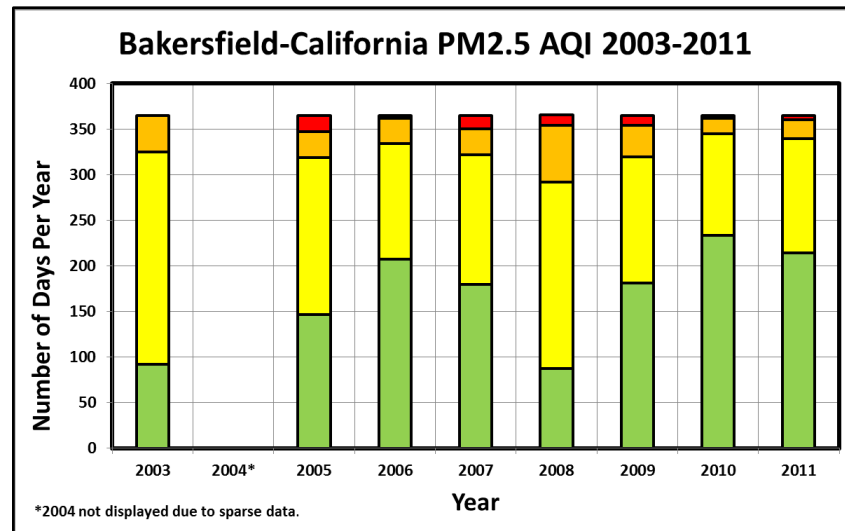
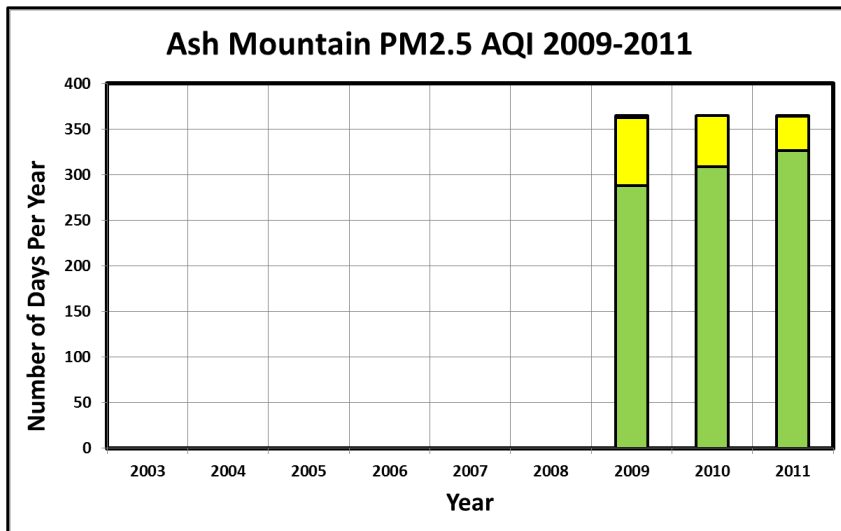
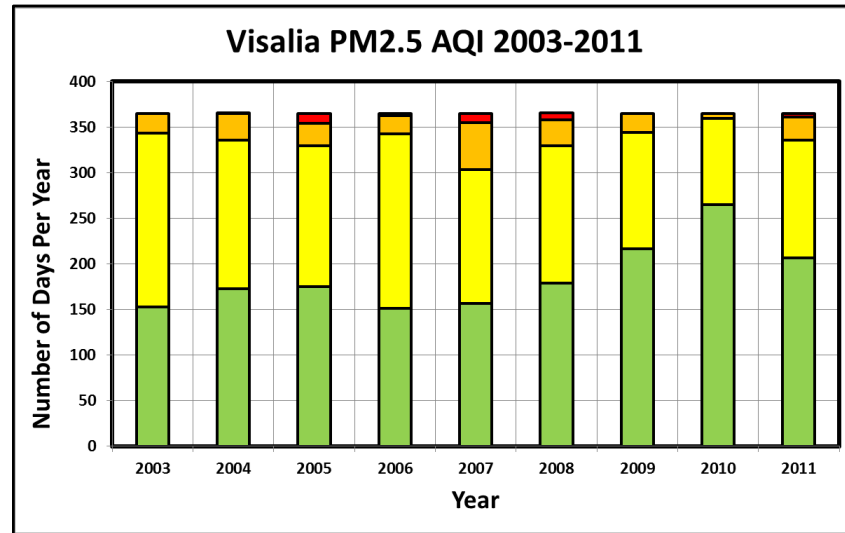
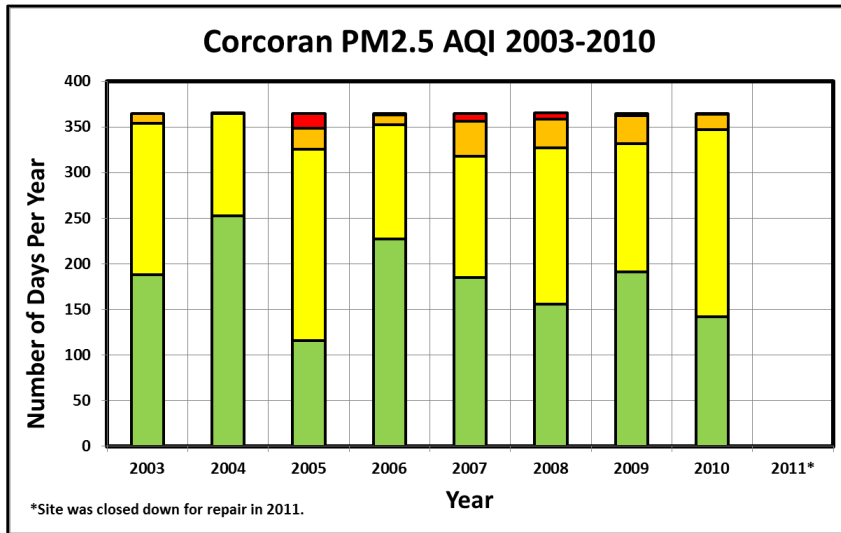
Figures A-12.1 through A-12.4 Number of Days per AQI Category per Year: Stockton-Hazelton, Tracy, Modesto, and Turlock



Figures A-12.5 through A-12.8 Number of Days per AQI Category per Year; Merced, Clovis, Fresno-First, and Hanford



Figures A-12.9 through A-12.12 Number of Days per AQI Category per Year; Corcoran, Visalia, Ash Mountain, and Bakersfield-California

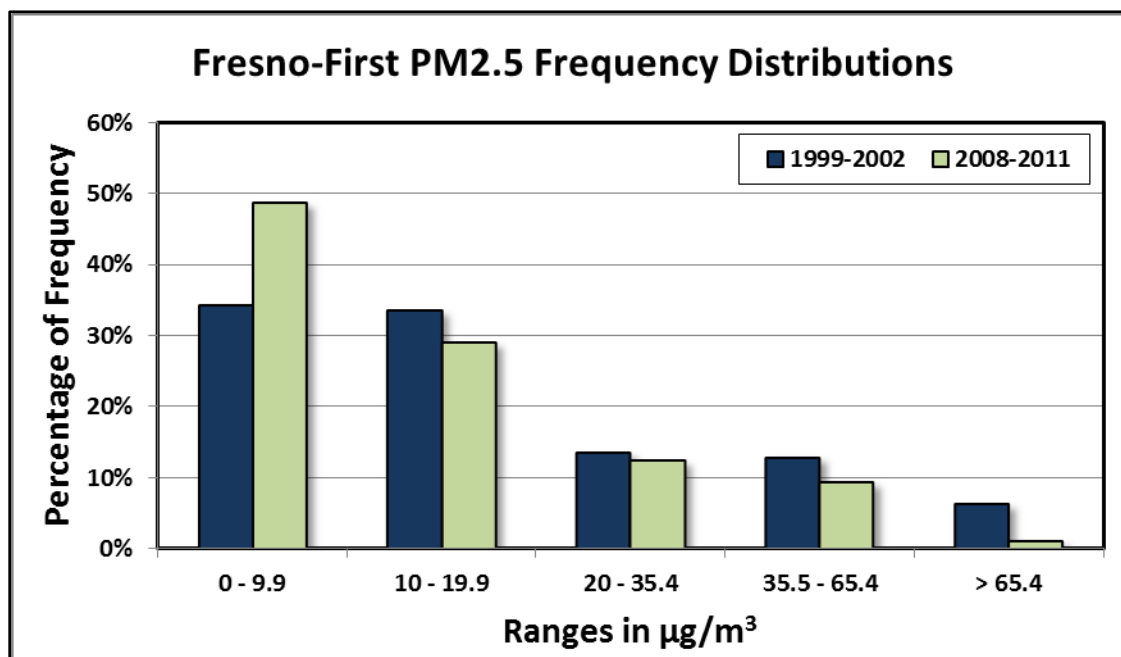


A.3.5 PM_{2.5} Concentration Frequency Distributions

The District analyzed filter-based PM_{2.5} data from various sites throughout the Valley to form histograms based on the distribution of concentrations over the time periods of 1999–2003 and 2008–2011. In this analysis, the concentrations were separated into the concentration categories of 0–9.9 $\mu\text{g}/\text{m}^3$, 10–19.9 $\mu\text{g}/\text{m}^3$, 20–35.4 $\mu\text{g}/\text{m}^3$, 35.5–65.4 $\mu\text{g}/\text{m}^3$, and greater than 65.4 $\mu\text{g}/\text{m}^3$. For each air monitoring site, the observations for each time period were grouped into the appropriate categories depending upon their concentration. The frequency of the observations within each category were converted to a percentage of the total time period and displayed as a bar chart comparing the distribution of 1999–2002 with 2008–2011. The air monitoring sites included in this analysis were Modesto, Fresno-First, Corcoran, Visalia, and Bakersfield-Planz because of these sites had a robust set of measurements beginning in 1999, except Bakersfield-Planz, which began operation in 2000.

The data, as represented in Figure A-13 for the Fresno-First site, shows that in the most recent four years (2008–2011) there has been a significant increase in the percentage of days with low PM_{2.5} concentrations (under 10 $\mu\text{g}/\text{m}^3$) when compared to 1999–2002. This increase is observed among all of the sites in this analysis, as seen in Figures A-14 through A-17. Data from all the sites reveals a dramatic decrease in the percentage of days that exceed the 1997 24-hour PM_{2.5} standard of 65 $\mu\text{g}/\text{m}^3$.

Figure A-13 Histogram Comparison for Fresno-First



While the Corcoran, Visalia, and Bakersfield-Planz sites show an increase in the frequency of measurements in the 20–35.4 $\mu\text{g}/\text{m}^3$ category, as progress continues to be made in reducing PM_{2.5}, the curve of the overall distribution will become more sharply

pushed to the left as higher concentrations become less frequent and lower concentrations become more frequent.

Figure A-14 Histogram Comparison for Modesto

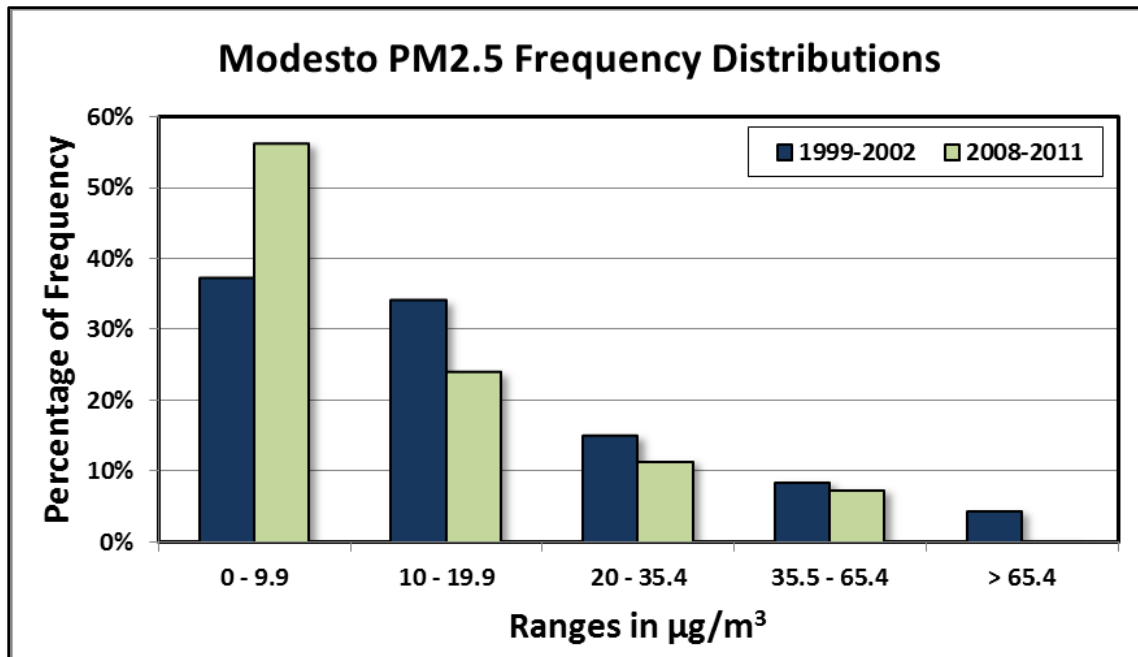
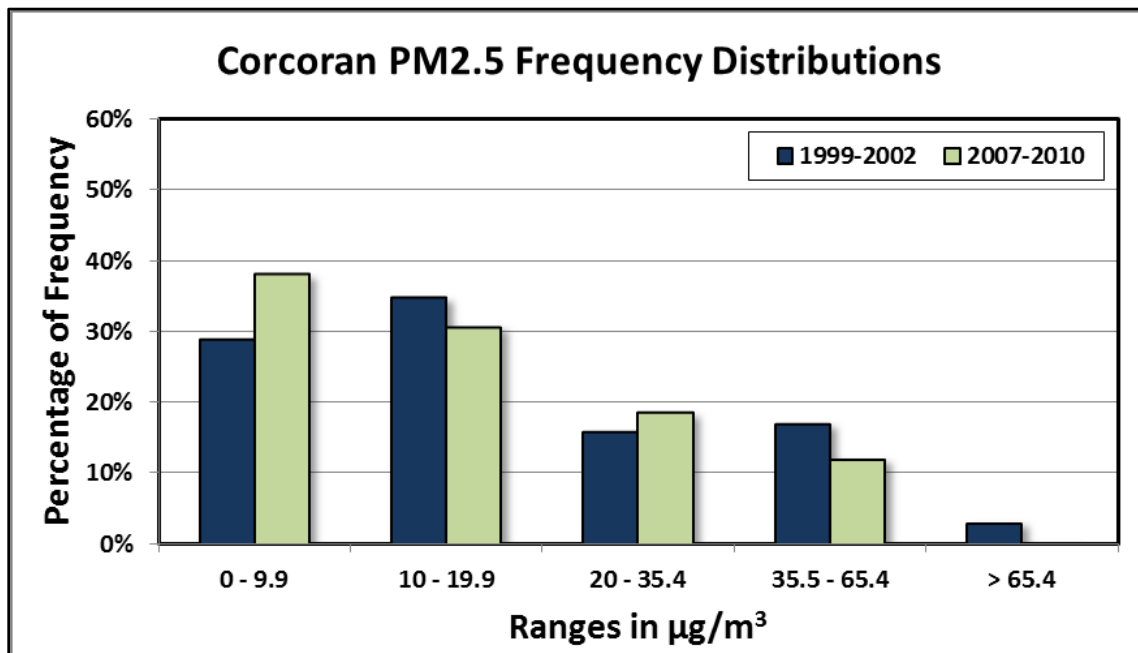


Figure A-15 Histogram Comparison for Corcoran⁹



⁹ The Corcoran site was non-operational during 2011, thus data is only represented through 2010

Figure A-16 Histogram Comparison for Visalia

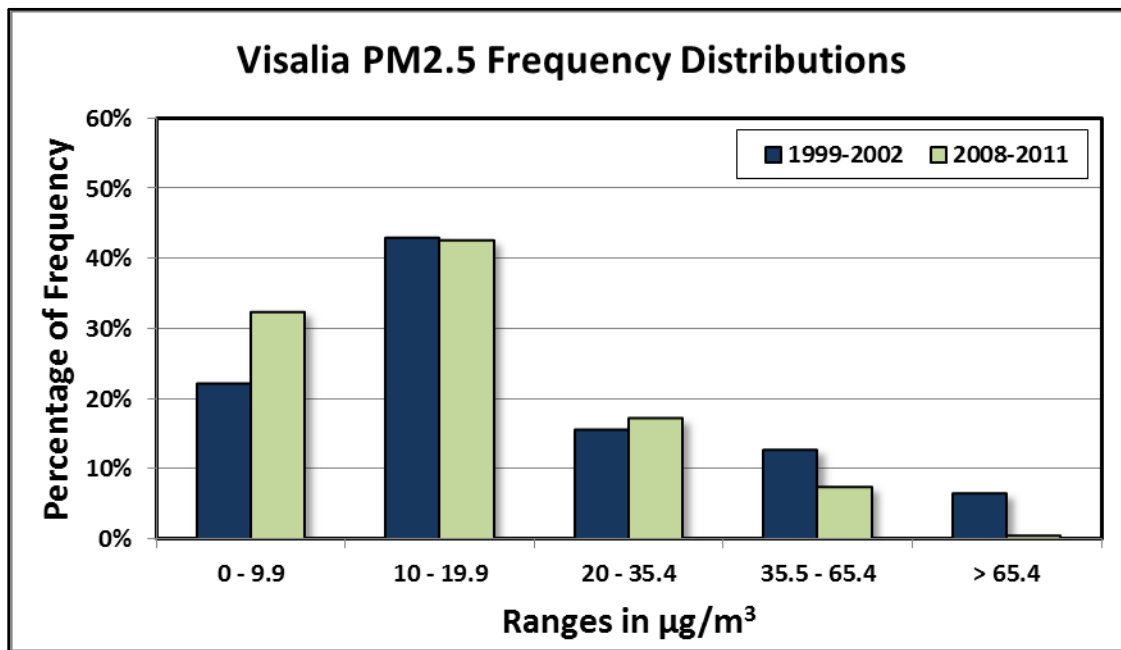
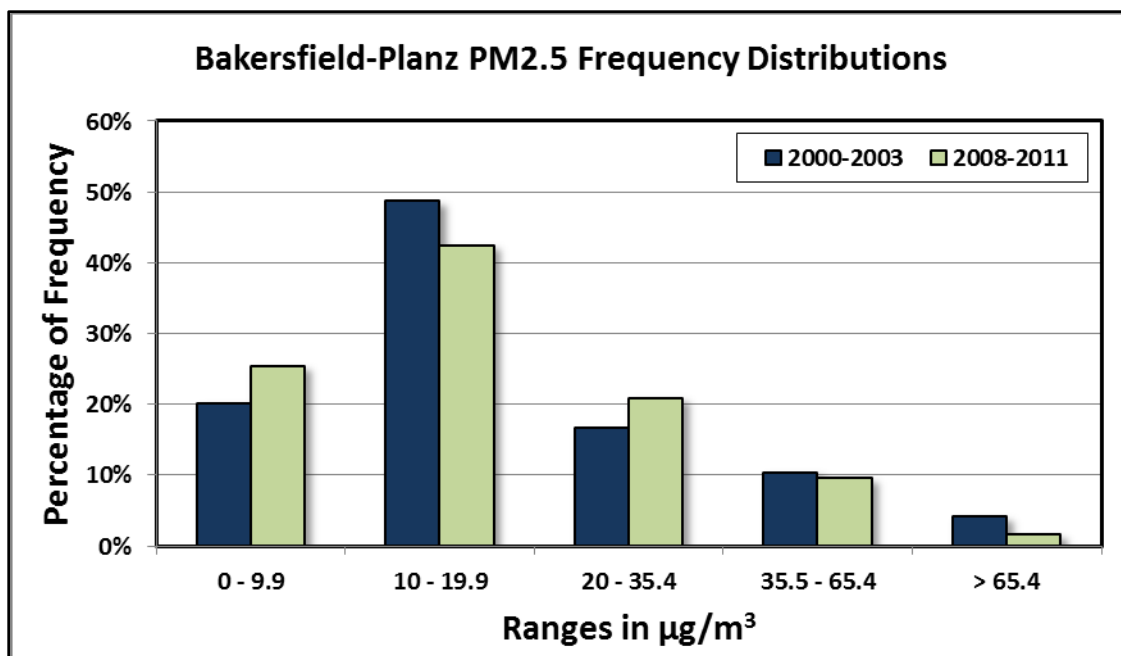


Figure A-17 Histogram Comparison for Bakersfield-Planz

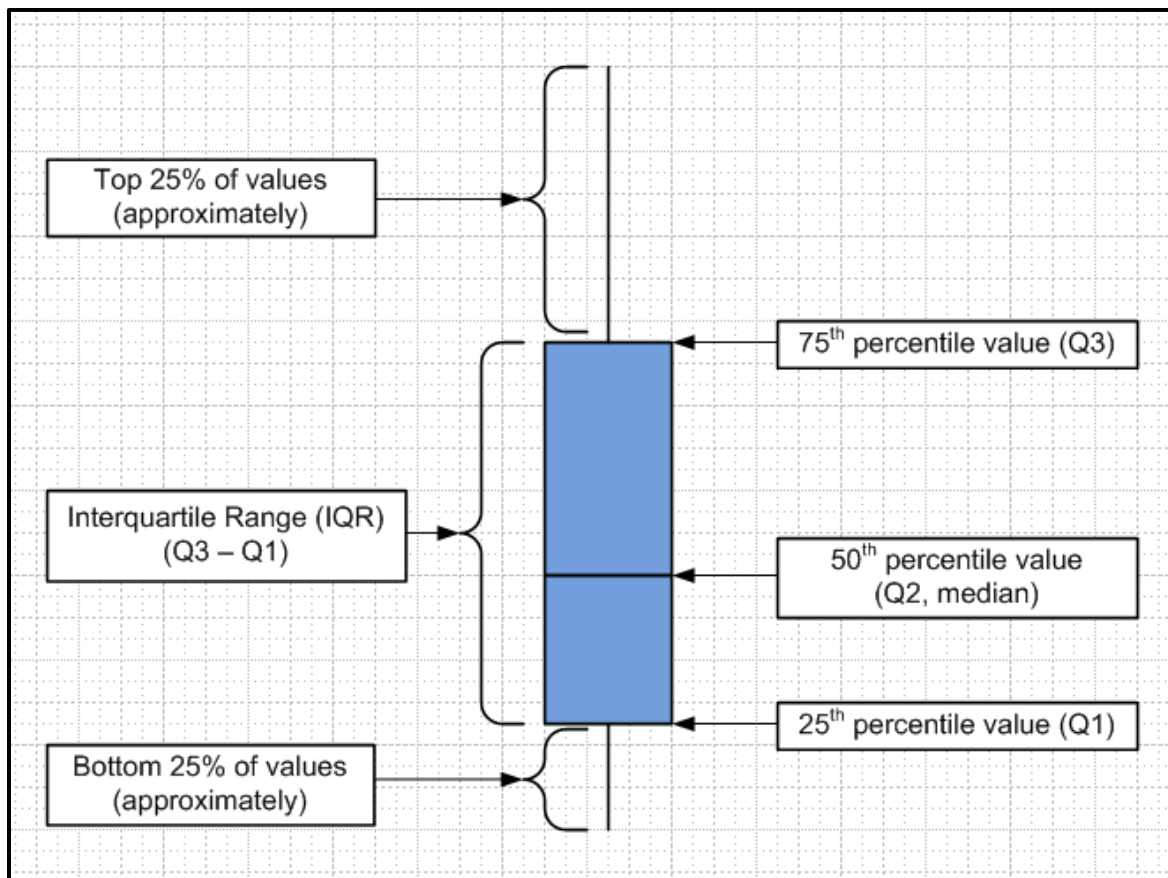


A.3.6 PM2.5 Concentration Distributions

While evaluating changes in peak PM2.5 concentrations increases our understanding of air quality and informs the attainment planning process, evaluation of non-peak concentrations can also be useful in providing a wider perspective on the progress of air quality improvement.

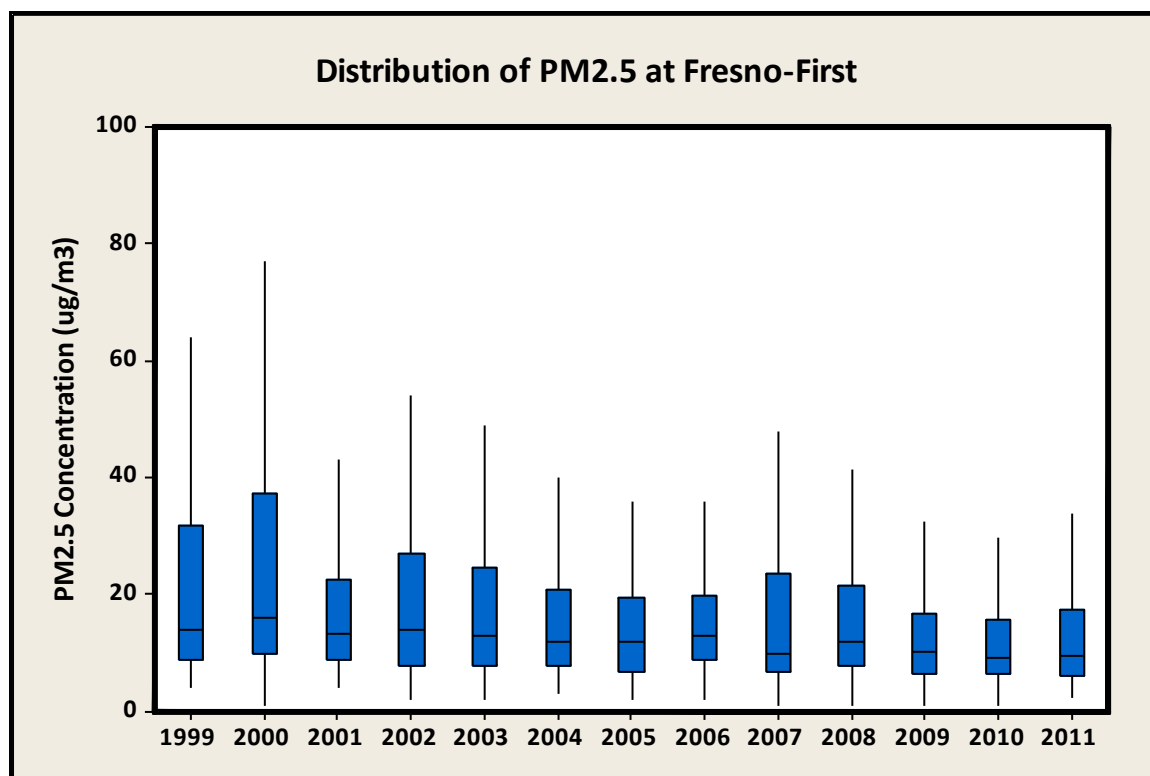
To accomplish such an evaluation, the District constructed box-and-whisker plots for a number of air monitoring sites in Valley using data collected from filter-based PM2.5 monitors. Figure A-18 diagrams the use of the box-and-whisker plots as follows: the box-and-whisker diagram for each year is a representation of the 25th (Q1), 50th (Q2), and 75th (Q3) percentile values in the PM2.5 concentration dataset. The “whiskers” extending from each end of the box represent the outer ends of the dataset (approximately the top and bottom 25% of the values), where any point outside of these boundaries is considered an outlier for this analysis method. The difference between Q3 and Q1 is called the interquartile range (IQR). For ease of viewing, the outlier values are not displayed in these plots.

Figure A-18 Box-and-Whisker Plot Interpretation



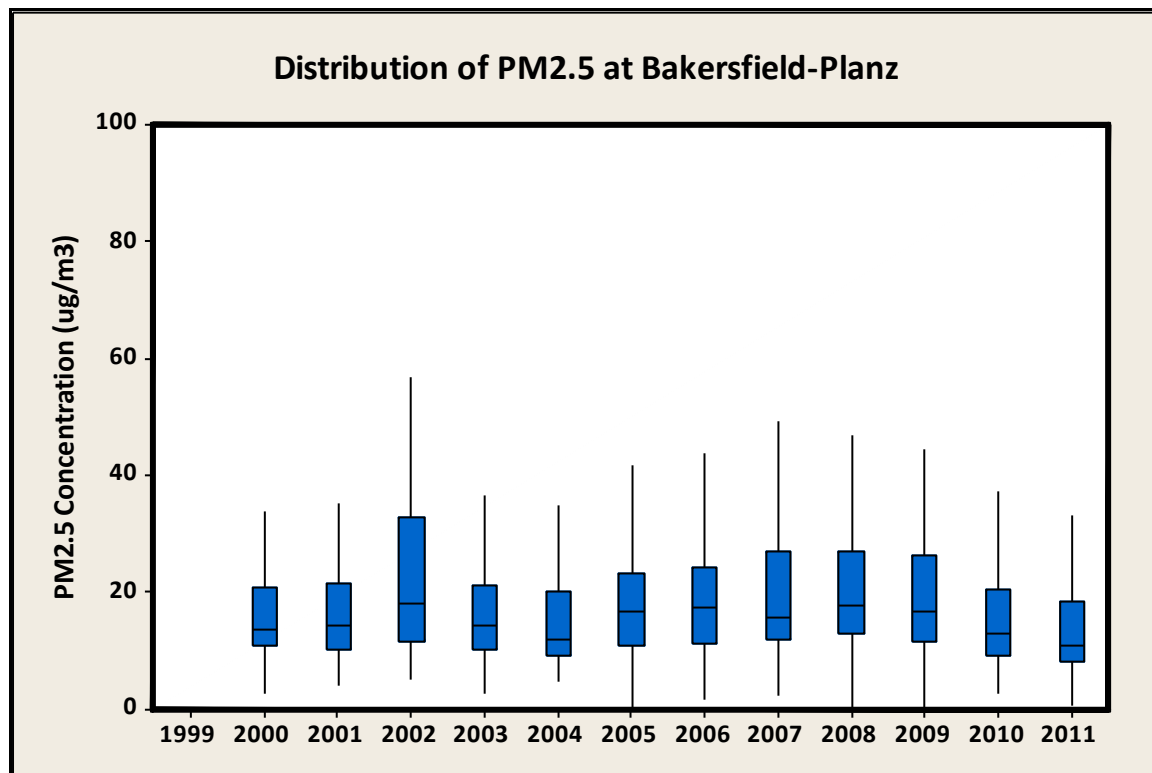
Focusing on the Fresno-First plot in Figure A-19, air quality improvement is evident when comparing the 1999 and 2000 box-and-whisker diagrams to those of recent years. Not only has the IQR been reduced, but the top 25% of the values has decreased sharply. This shows that the entire dataset of PM_{2.5} concentrations has been shifting downward in addition to the reduction of peak values. Since the winter of 2011–2012 experienced meteorology conducive to the formation of high PM_{2.5} concentrations, an increase in the IQR, Q3, and top 25% values is evident when comparing 2011 to 2010. This increase in 2011 is observed among most of the sites in the Valley.

Figure A-19 Box-and-Whisker Plot of PM_{2.5} at Fresno-First



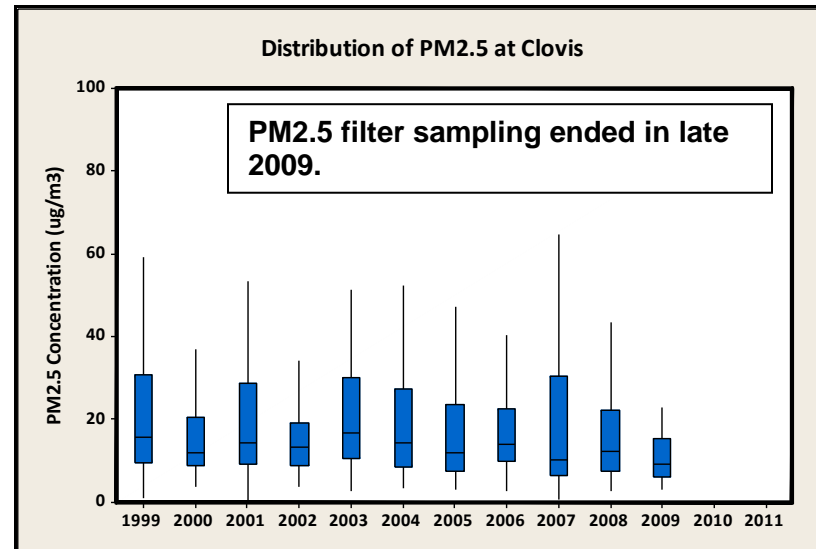
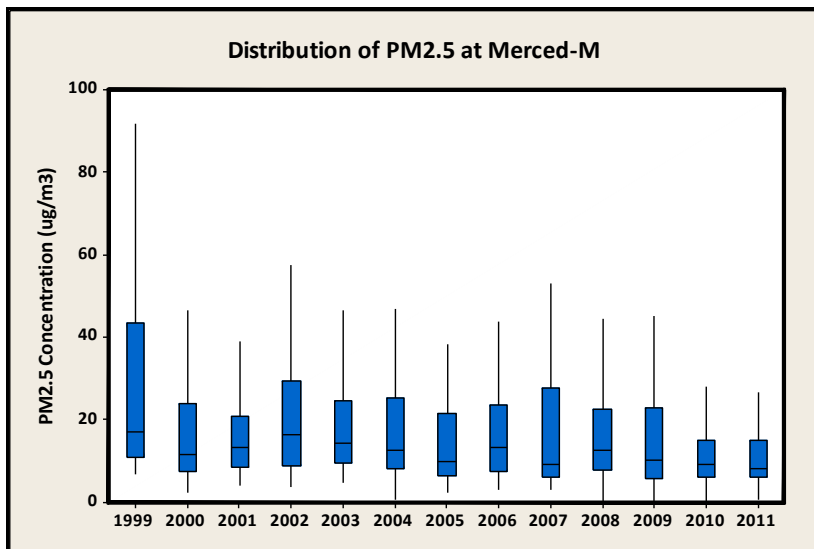
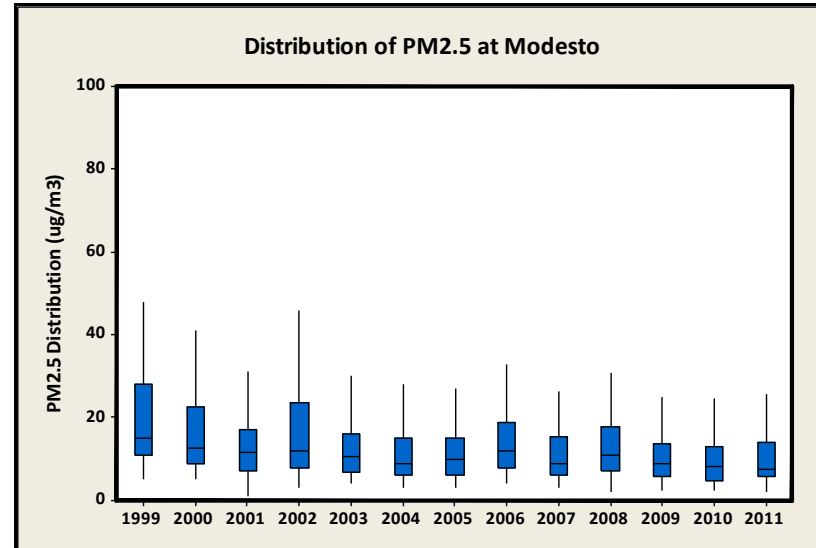
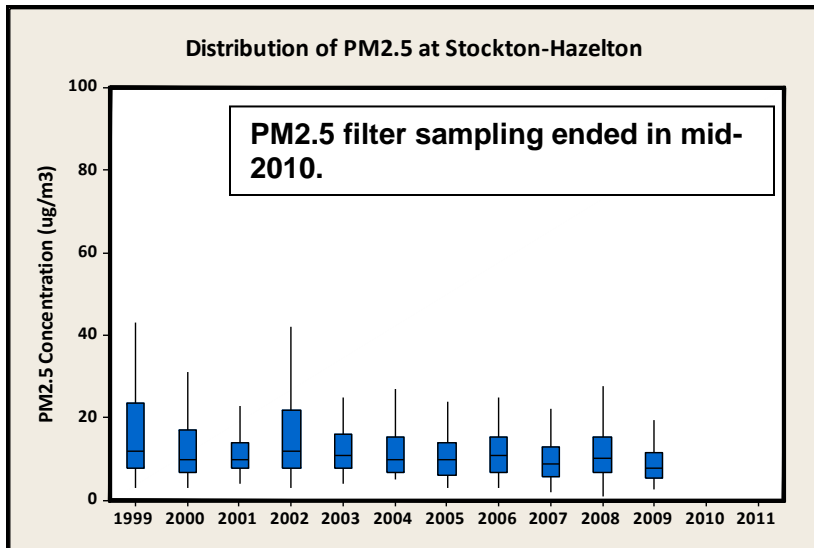
An exception to the increase in 2011 was at the Bakersfield-Planz air monitoring site, where a steady downward slope among most of the components of the plot has occurred from 2008 through 2011, as seen in Figure A-20. Since Bakersfield-Planz has historically been one of the highest PM_{2.5} sites in the Valley, this improvement is important and needs to continue to occur not only at this site but all other sites in order for the region to attain current and future PM_{2.5} standards.

Figure A-20 Box-and-Whisker Plot of PM2.5 at Bakersfield-Planz

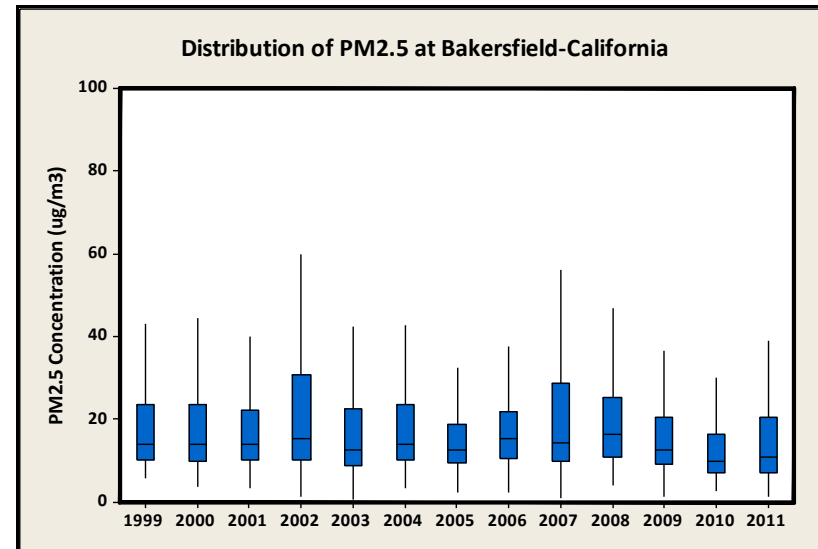
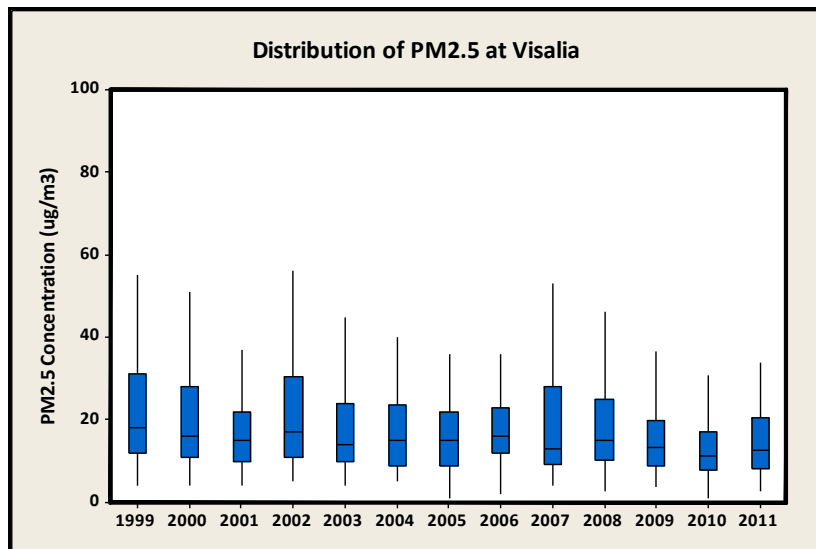
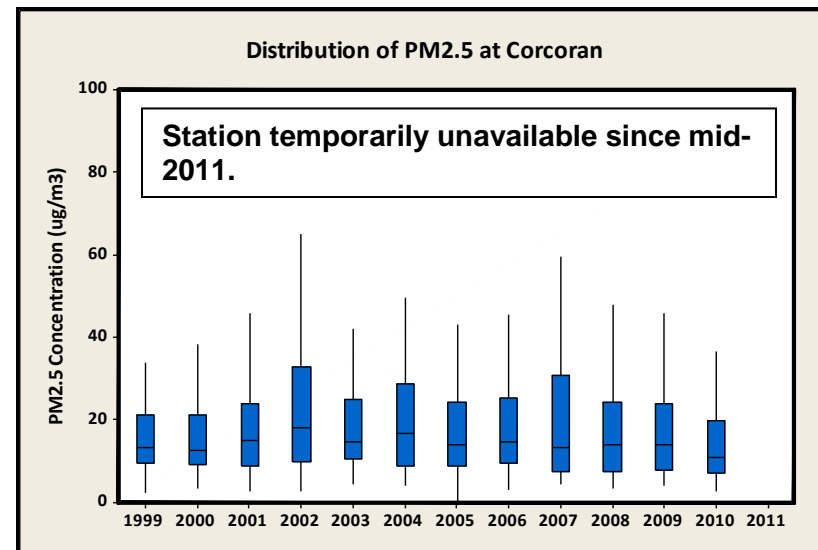
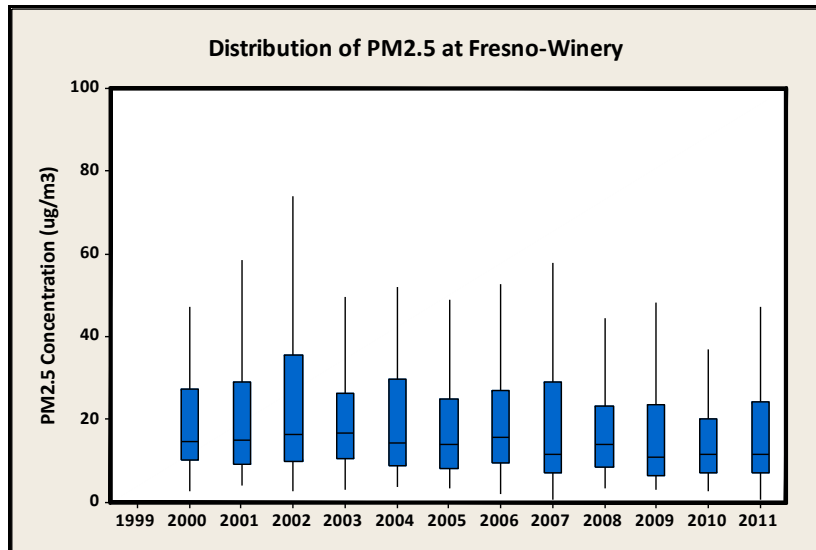


The northern most air monitoring sites (Stockton-Hazelton and Modesto) tend to have smaller IQRs than the sites in the central and southern portions of the San Joaquin Valley. This shows that PM2.5 in the northern part of the Valley tends to have a tighter dataset, where less variance occurs. Since the highest concentrations of PM2.5 usually occur in the central and southern portions of the Valley, the IQR values for the sites in these regions are higher, showing greater variance.

Figures A-21.1 through A-21.4 PM2.5 Distributions for Stockton-Hazelton, Modesto, Merced-M, and Clovis



Figures A-21.5 through A-21.8 PM2.5 Distributions for Fresno-Winery, Corcoran, Visalia, and Bakersfield-California



A.3.7 PM_{2.5} Concentration by Day of Week

Just as public activity varies throughout the week, so do the daily average PM_{2.5} concentrations. The District evaluated real-time 24-hour average concentrations from a number of monitoring sites in the Valley to quantify such variance from three wood-burning seasons (November through February): 2008–2009, 2009–2010, and 2010–2011. The air monitoring sites included in this analysis were Modesto, Fresno-First, Corcoran, Visalia, and Bakersfield-California.

Figures A-22 through A-26 show the results of the District's analysis for the five air monitoring sites. In general, Thursday and Friday recorded the highest 24-hour average PM_{2.5} concentrations over the seven-day week. This suggests a build-up of emission beginning on Monday and progressing toward the end of the work week. This pattern would be more pronounced during stagnation episodes, where emissions would not have a chance to disperse.

Figure A-22 Day of Week PM_{2.5} Concentrations at Modesto

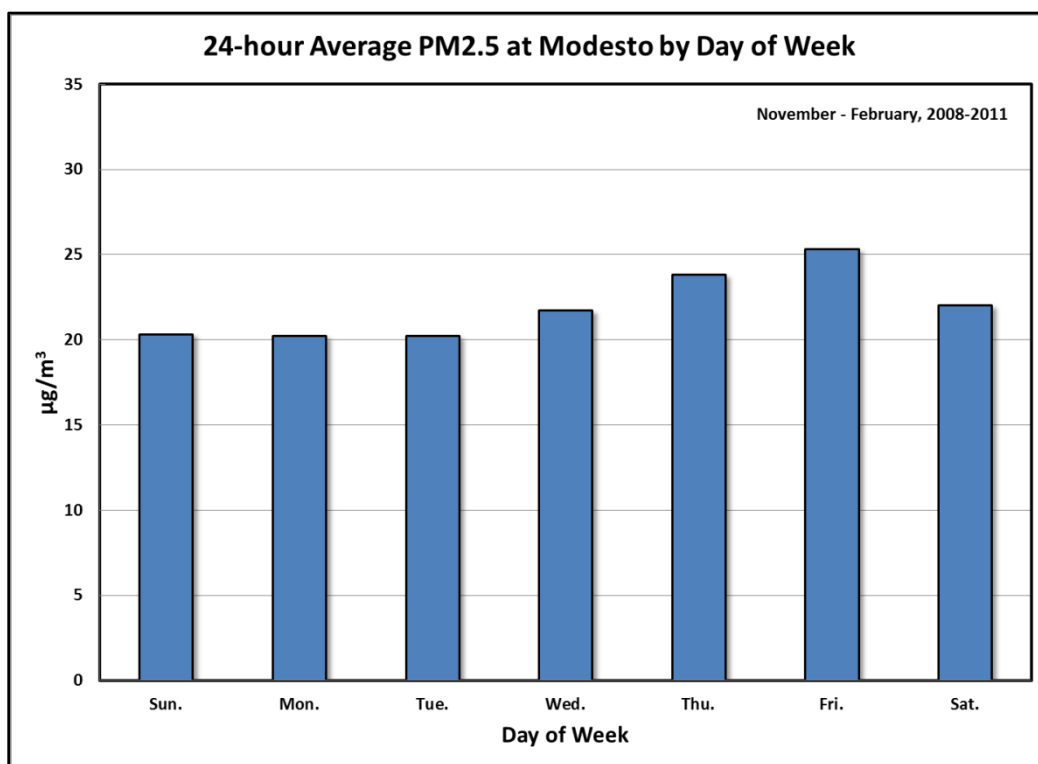


Figure A-23 Day of Week PM2.5 Concentrations at Fresno-First

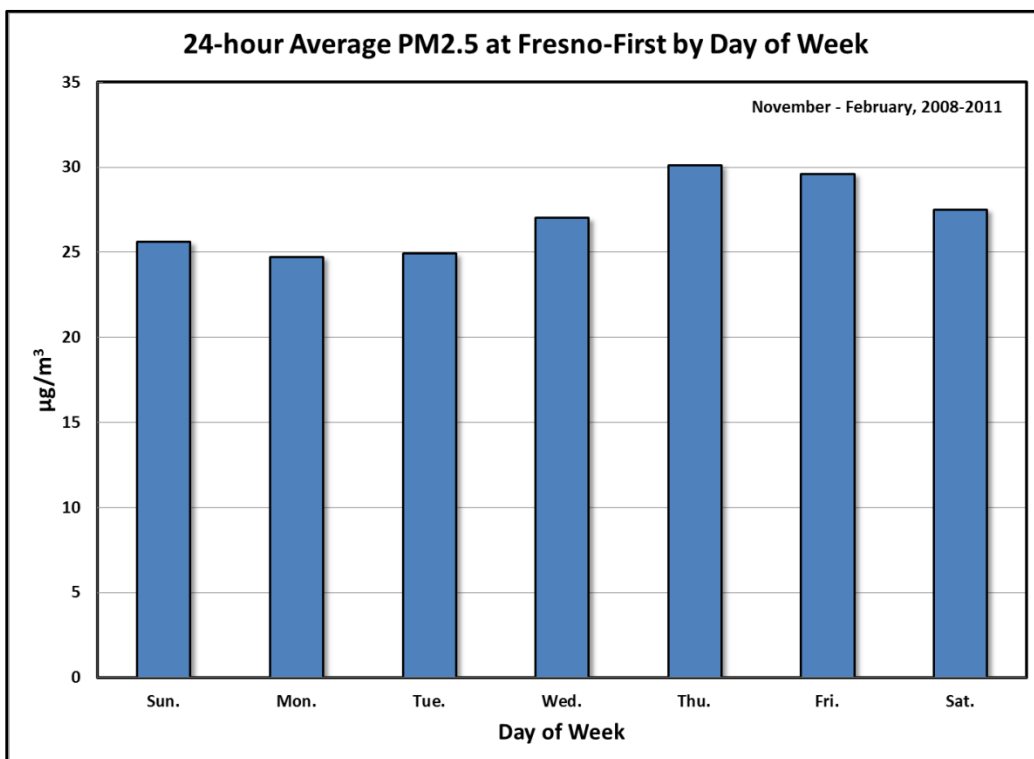


Figure A-24 Day of Week PM2.5 Concentrations at Corcoran

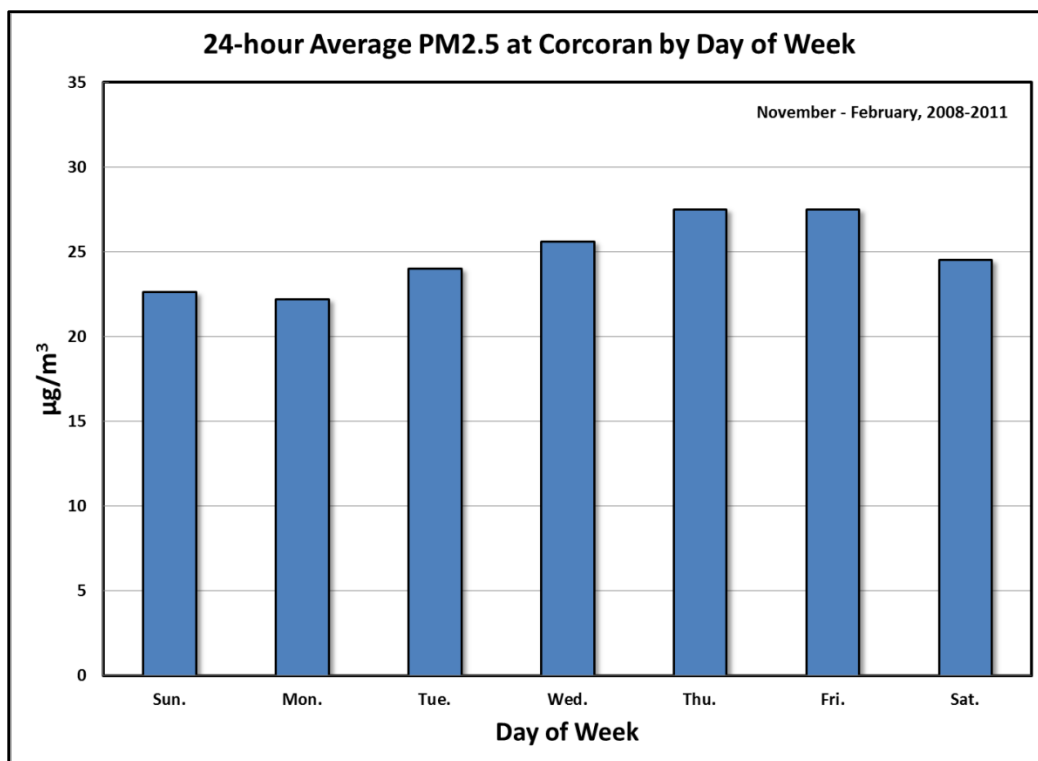


Figure A-25 Day of Week PM2.5 Concentrations at Visalia

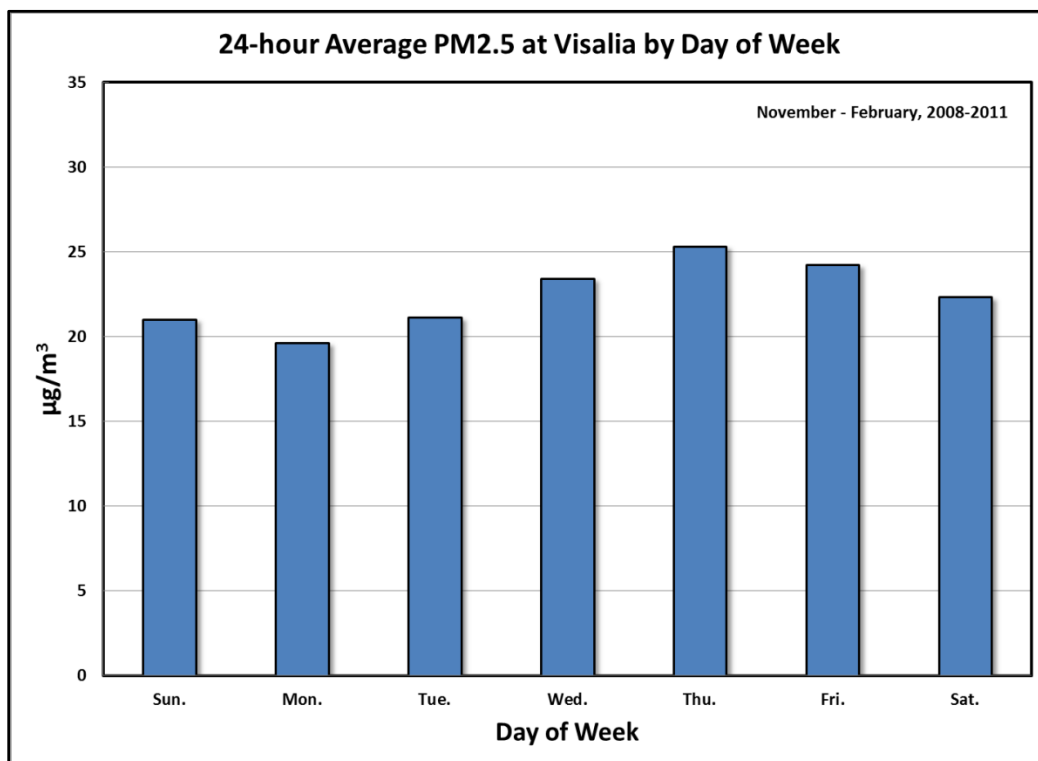
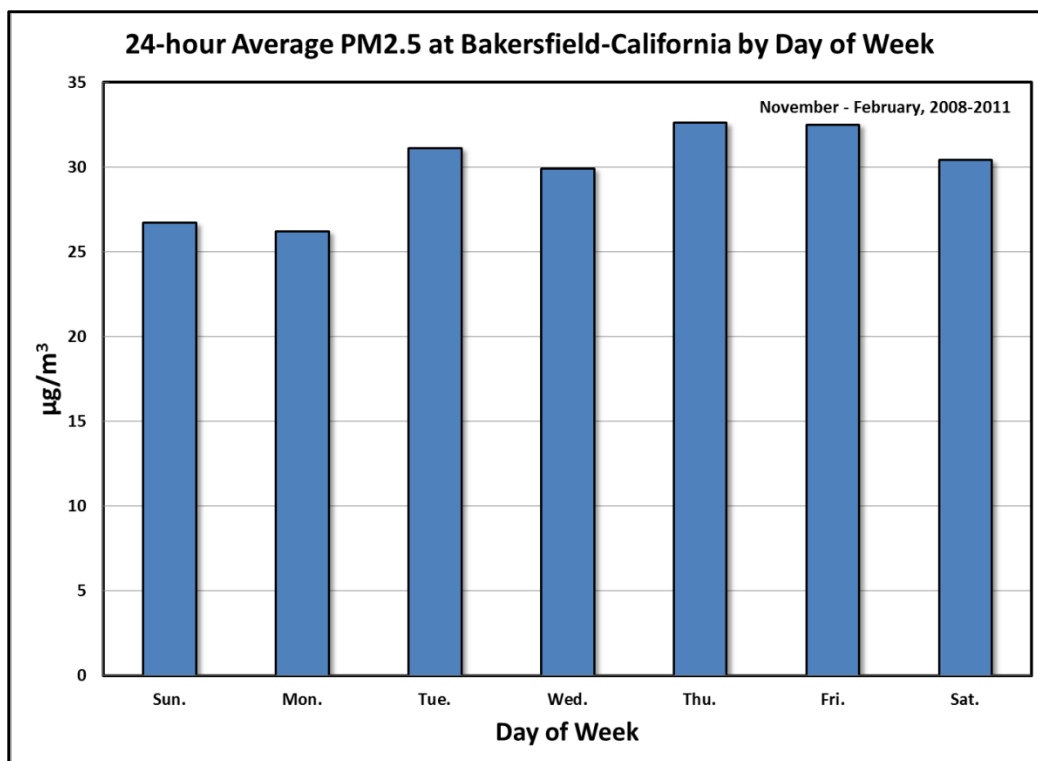


Figure A-26 Day of Week PM2.5 Concentrations at Bakersfield-California



The analysis also shows a declining average PM_{2.5} concentration from Saturday into Monday, perhaps as a result of the variation in vehicle activity when comparing the weekend to the weekday. The typical weekday will have significant vehicle emissions in the morning as people commute to work and school, followed by lighter traffic during the day, and heavy activity again at the end of the day for the commute home. Contrastingly, the weekend activity is spread more uniformly throughout the day. This temporal difference in emissions activity may contribute to lower PM_{2.5} emissions, which tend to carry over into the early days of the next week before the next build-up begins.

Comparing the trends between the air monitoring sites included in this analysis reveals that the Fresno-First and Bakersfield-California sites (the largest urban centers in the central and southern valley) tend to have the highest PM_{2.5} concentrations on Thursday and Friday, ranging from 30 to 35 µg/m³. The difference between the highest concentration and the lowest concentration among the days of the week is about 5 µg/m³ for most of the sites; however this difference at Bakersfield-California is more pronounced.

As the San Joaquin Valley faces the challenges of future PM_{2.5} standards, having this understanding of what days of the week tend to have the highest concentrations may aid in developing a successful attainment strategy. Targeting emissions that contribute to the build-up as the week progresses may help in reducing the peaks at the end of the week.

A.4 METEOROLOGY, PM_{2.5} SPECIATION, AND RULE EFFECTIVENESS

The District takes full advantage of the robust data set produced by the extensive air monitoring network in the Valley, as seen in the previous sections of this appendix. However, there is other information that adds to the comprehensive understanding of PM_{2.5} concentrations and is critical in all aspects of developing and implementing a successful attainment plan, including meteorology, PM_{2.5} speciation, and the overall effectiveness of previous control measures.

A.4.1 Meteorologically Adjusted Trends

In order to understand the effectiveness of emission control strategies and regulations on ambient air pollution levels, it is important to first understand and be able to delineate the effect of meteorology versus changes in emissions as a response to control measures. The strong linkage between meteorological conditions and air pollutant levels can obscure the effects of the change of emission levels over time resulting from a regulatory program. Therefore, the meteorological effects need to be removed so that the emissions-related trends may be studied more effectively.

The District used the Classification and Regression Trees (CART) method to define the relationship between PM_{2.5} concentrations and meteorological conditions in both the

Bakersfield and Fresno areas of the Valley. Three years (2004–2006) were selected as base years to define these relationships. The CART model was able to explain approximately 75–80% of the variation in daily PM_{2.5} concentrations during these years based on the local meteorological conditions. Based on the CART-defined relationships, daily PM_{2.5} concentrations were predicted for all the other years using the observed meteorological data and assuming the emissions stayed constant (i.e. the predicted concentrations only represent the PM_{2.5} conduciveness of meteorology). The measured PM_{2.5} concentrations were then corrected for the influences of meteorology to estimate the meteorologically adjusted trends. For example, in a year with meteorology conditions that were more conducive to PM_{2.5} formation, PM_{2.5} concentrations were adjusted downward. Conversely, PM_{2.5} concentrations were adjusted upward in years with meteorological conditions that were less conducive.

As shown in Figures A-27 and A-28, the meteorologically adjusted trend at Bakersfield indicates a greater decline than the unadjusted trend, while the two trends are generally similar at Fresno. Overall, the meteorologically adjusted trends indicate that the PM_{2.5} annual averages decreased about 40–50% in both the Bakersfield and Fresno areas from 1999 to 2010, with an average rate of decrease of approximately 0.8 $\mu\text{g}/\text{m}^3$ per year. These meteorologically adjusted trends provide a more robust indicator of the impacts of emission reductions from on-going control programs.

Figures A-27 and A-28 show the trend of observed PM_{2.5} represented as a solid line, and the trend of meteorologically adjusted PM_{2.5} is represented by a dashed line.

Figure A-27 Meteorologically Adjusted PM_{2.5} Trend for Bakersfield

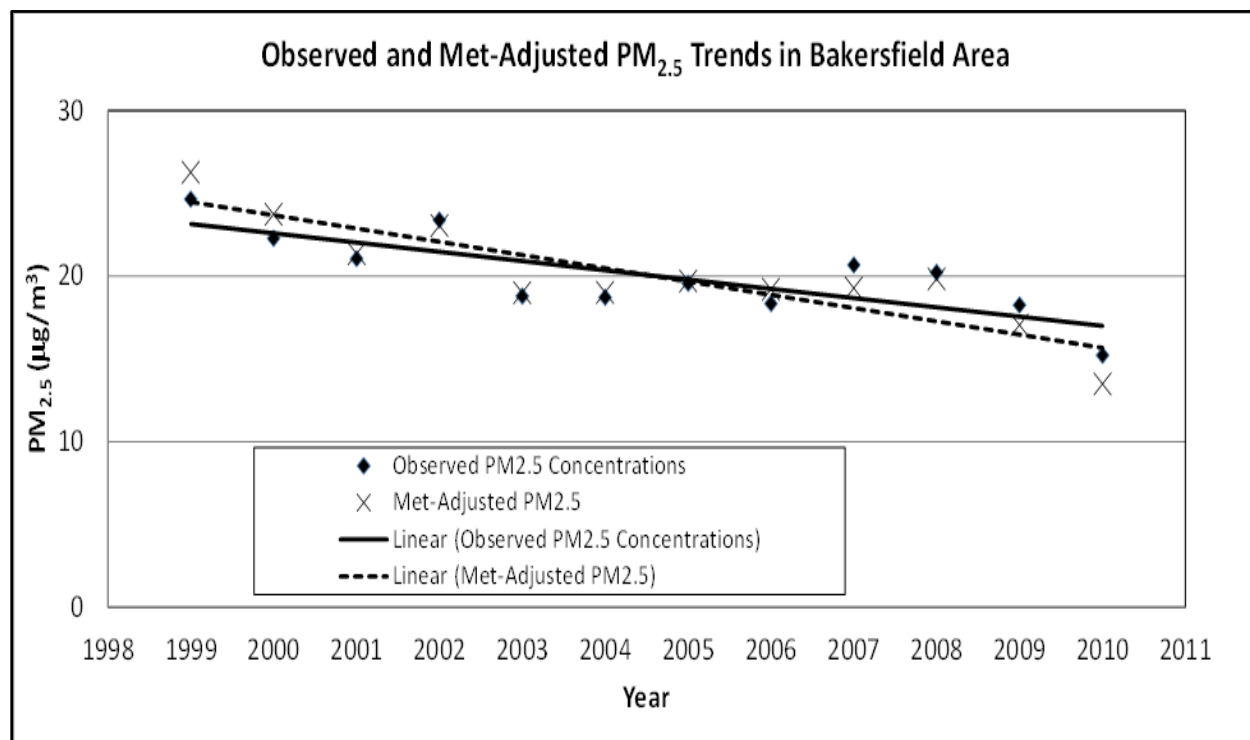
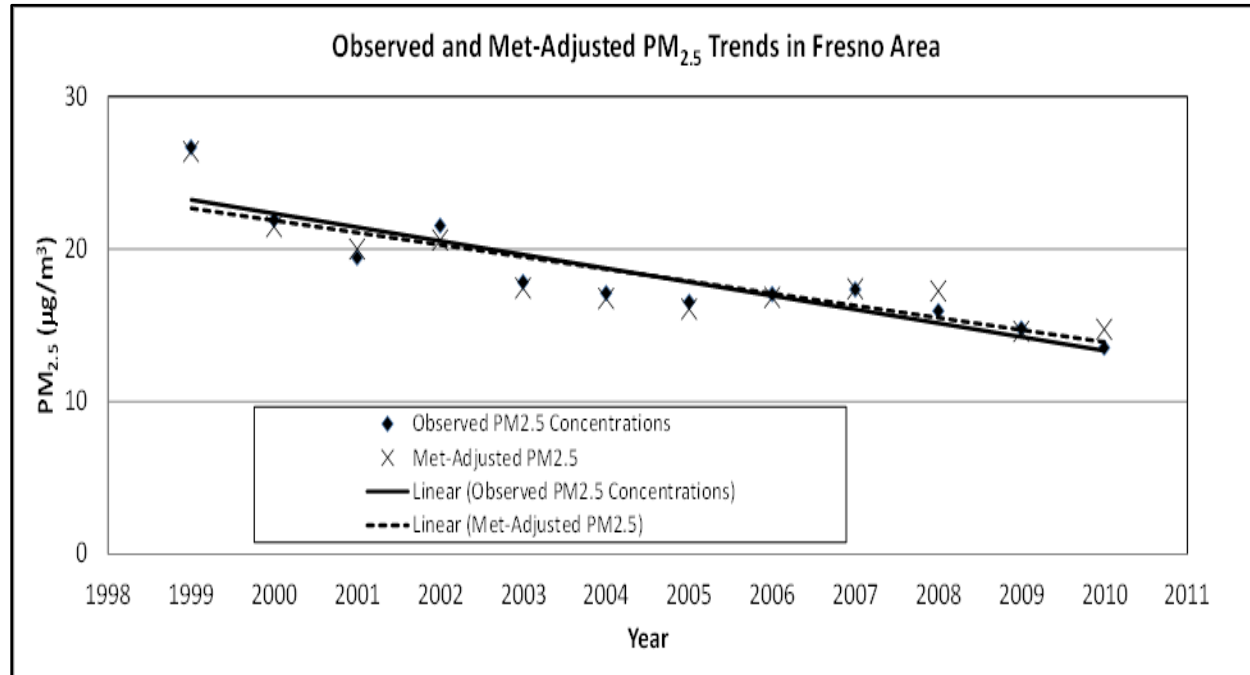


Figure A-28 Meteorologically Adjusted PM_{2.5} Trend for Fresno

A.4.2 Trends in PM_{2.5} Species

Analyzing the trends among the species of PM_{2.5} is often more telling than focusing on the PM_{2.5} mass alone. Valley PM_{2.5} concentrations have been decreasing over time, but some components, or species, of PM_{2.5} may be decreasing more rapidly than others. The results of a speciation analysis can show which species of PM_{2.5} are most dominant for an area, and therefore guide a more targeted control strategy for reducing the overall mass concentration. The following analysis shows the relative contribution and temporal change in the key species of PM_{2.5} at a number of sites in the Valley.

Figures A-29 and A-30 shows the contribution of various species to the overall PM_{2.5} mass concentration in the Fresno and Bakersfield areas, respectively. Figure A-29, for Fresno, shows that on a peak PM_{2.5} day the concentration consists of about 51% ammonium nitrate and 33% organic carbon. In comparison, a peak PM_{2.5} day in Bakersfield (Figure A-30) is comprised of 67% ammonium nitrate and 16% organic carbon. The understanding of this difference can help reveal what sources of pollution are contributing to PM_{2.5} in each area of Valley, which will ultimately aid in developing an effective control strategy.

Figure A-29 Species Contribution to PM2.5 Mass in Fresno

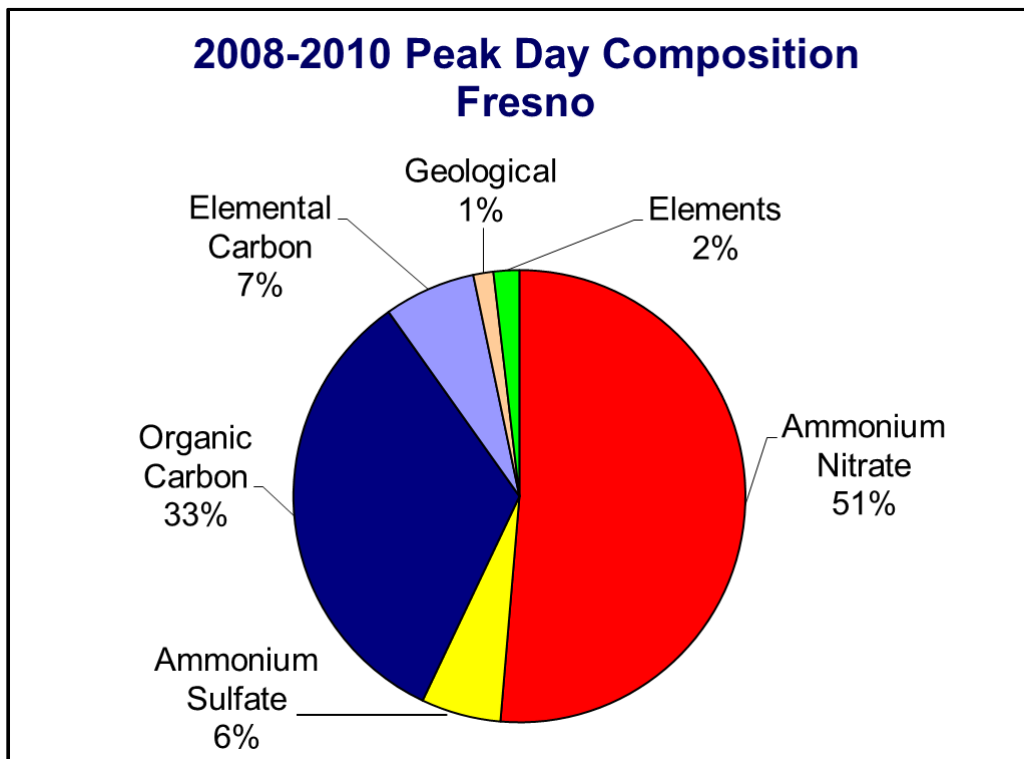
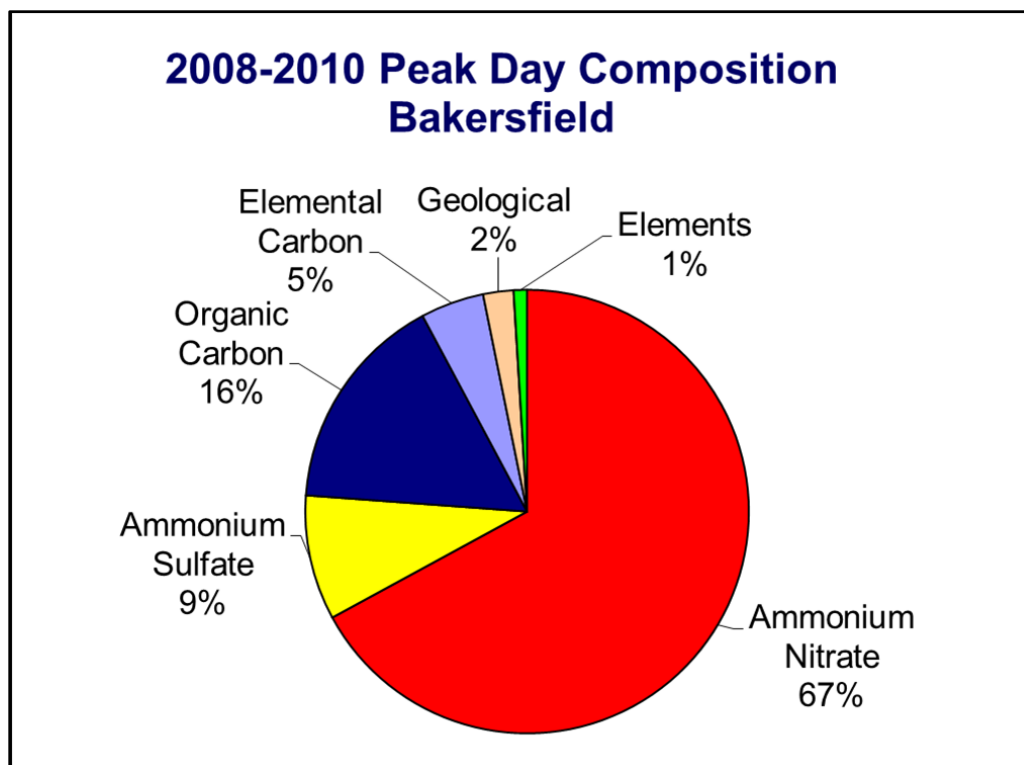


Figure A-30 Species Contribution to PM2.5 Mass in Bakersfield



Chemical speciation data is regularly collected at four sites in the Valley: Modesto, Fresno-First, Visalia, and Bakersfield-California. As previously mentioned, ammonium nitrate, ammonium sulfate, and carbon compounds are the major constituents of PM_{2.5}. In the following trend analysis, concentrations at each site from each of the PM_{2.5} species were averaged over each year from 2002–2010. On an annual average, concentrations of these key constituents have all shown significant decreases. Ammonium nitrate concentrations in the basin declined about 50% between 2002 and 2010. During the same time frame, concentrations of ammonium sulfate and carbon compounds declined about 30%. The most significant declines occurred between 2002 and 2003, and again between 2007 and 2010.

The decline in ammonium nitrate provides evidence of a successful NO_x control strategy in the Valley, which in turn has been effective in reducing PM_{2.5} mass. As ammonium nitrate concentrations further decline into the future, and as more stringent federal PM_{2.5} health standards are established, the results of species trends analyses will grow in importance as targeted control strategies will need to be developed.

Note that between 2007 and 2009, the carbon collection and analysis method was changed to improve comparability with rural Interagency Monitoring of Protected Visual Environments (IMPROVE) PM_{2.5} carbon data. Since the change was implemented mid-year, there are gaps in the carbon data for years with partial data from the old and new method.

Figures A-31 through A-34 display the species trends for the four speciation sites in the Valley.

Figure A-31 PM_{2.5} Species Trends at Modesto

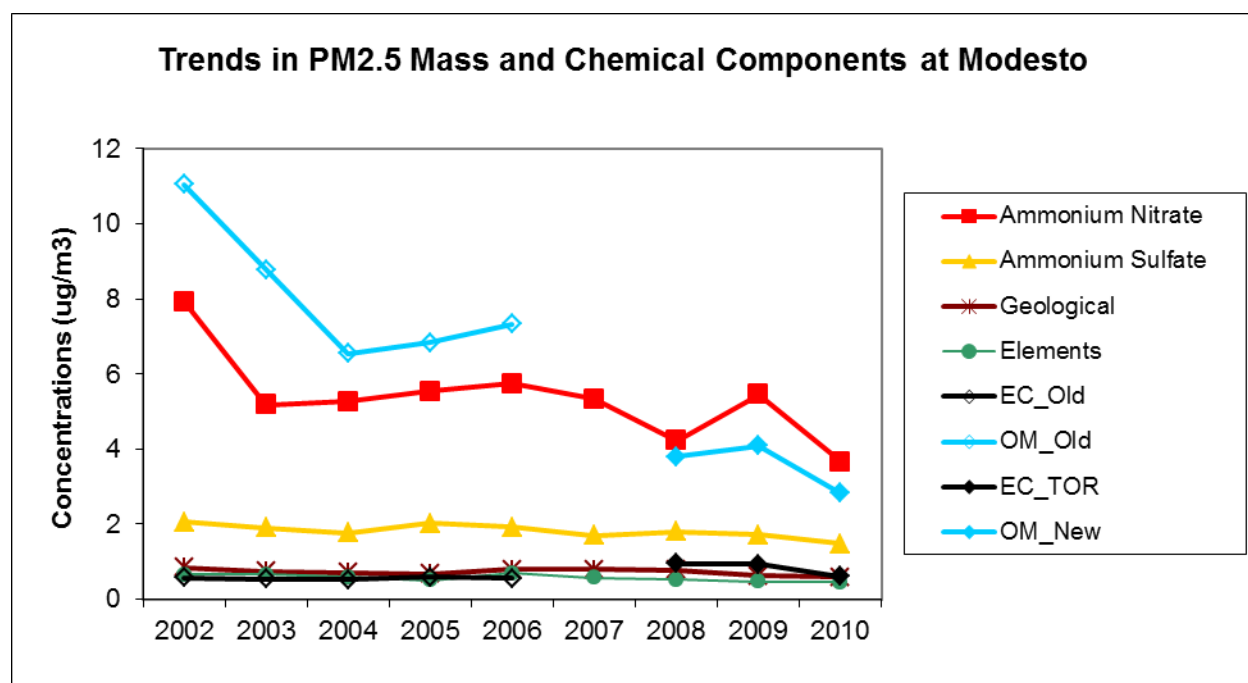


Figure A-32 PM2.5 Species Trends at Fresno-First

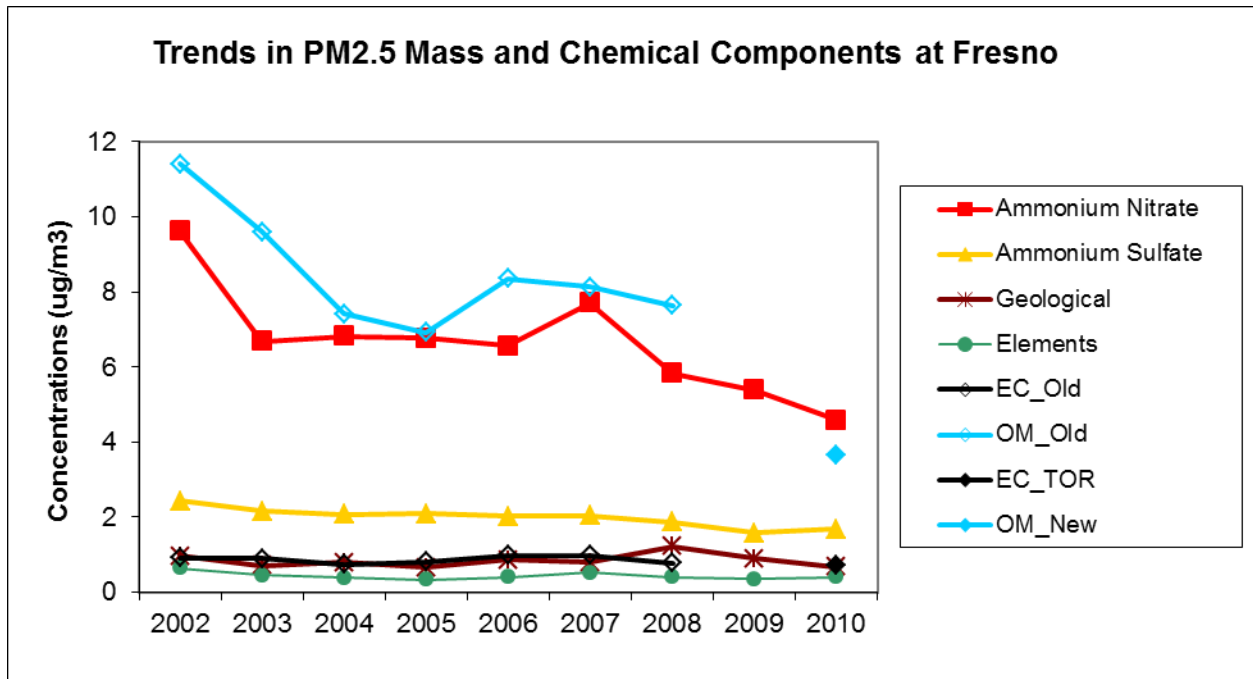


Figure A-33 PM2.5 Species Trends at Visalia

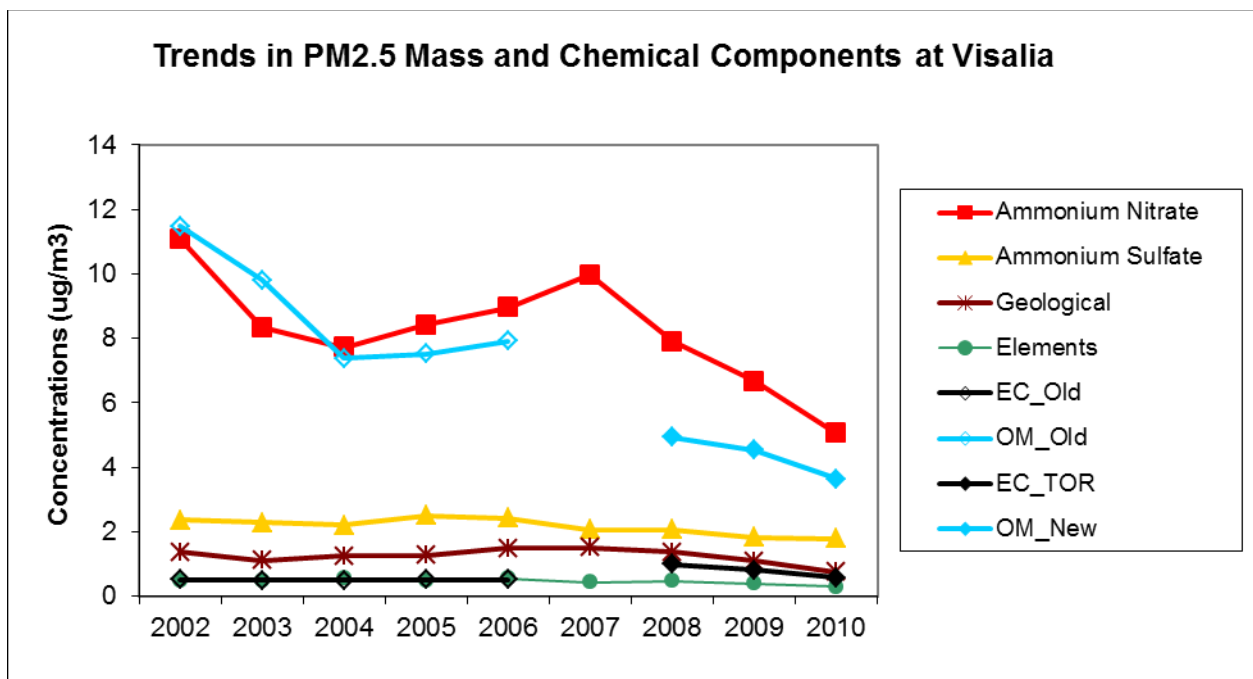
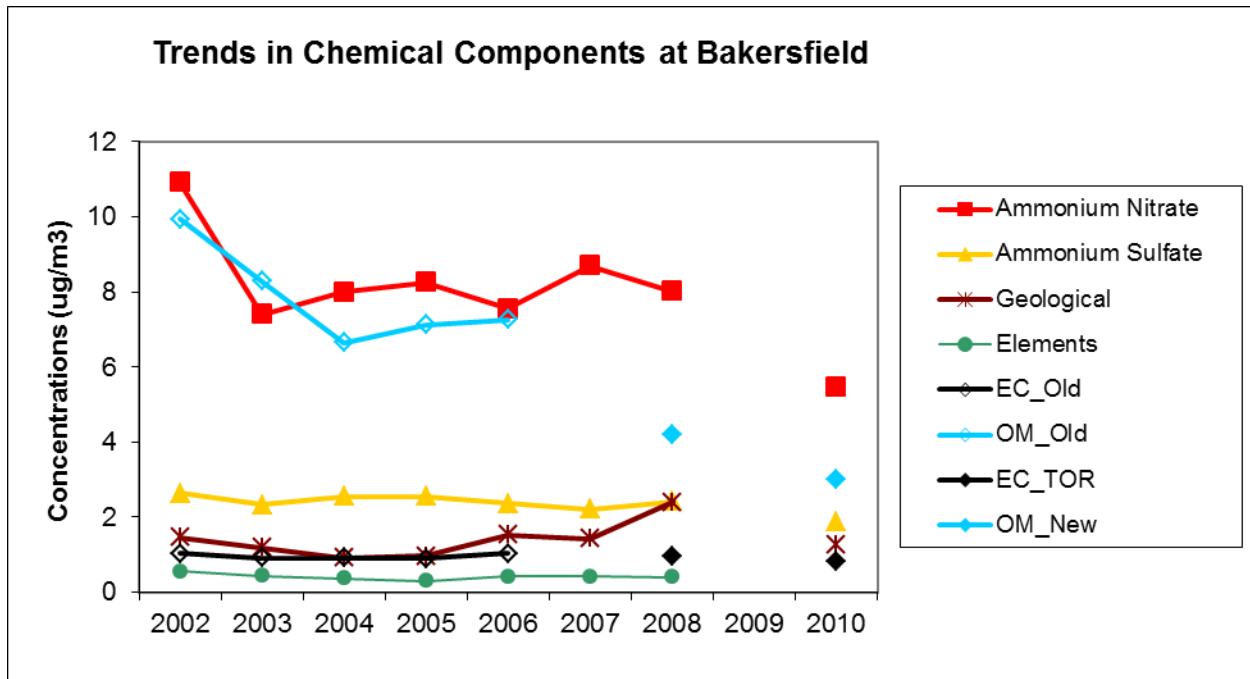


Figure A-34 PM2.5 Species Trends at Bakersfield-California



A.4.3 Effectiveness of District Rule 4901

Emissions from residential wood-burning have historically been one of the greatest sources of directly emitted PM2.5 in the Valley. Before residential wood-burning curtailments became mandatory during episodes of high PM2.5 concentrations, the air quality during the wintertime was often unhealthy in large part due to extensive wood-burning. Through the establishment of District Rule 4901, residential wood-burning is not allowed on days when high concentrations of PM2.5 are predicted. This reduction in wood-burning emissions through the rule has greatly reduced the potential for high PM2.5 concentrations. The following analysis displays the effect that Rule 4901 has had on PM2.5 in the Fresno area.

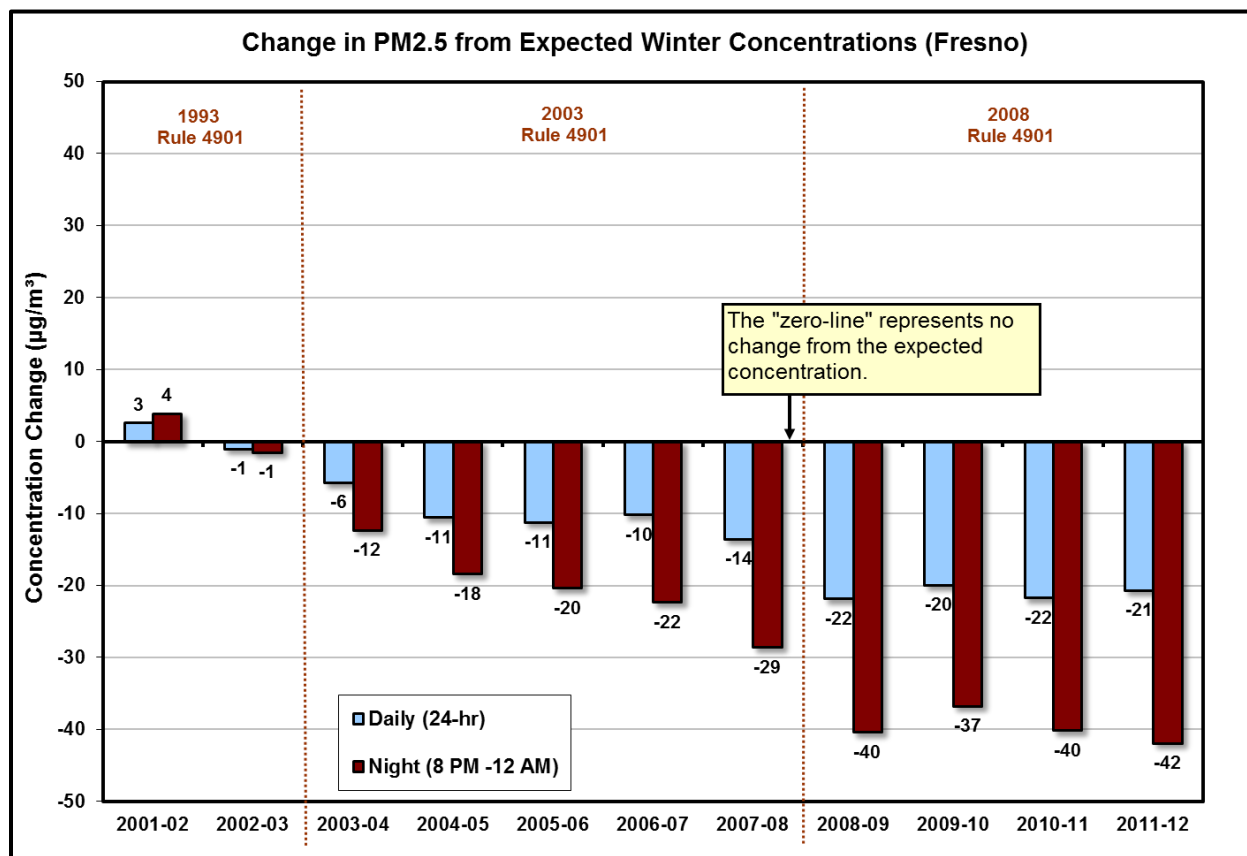
To conduct this analysis, a statistical model was developed to quantify PM2.5 reductions and evaluate air quality improvements attributable to the 2003 and 2008 amendments to Rule 4901. This statistical model was developed through generalized linear model techniques with logarithmic transformations based on the relationships between meteorology and PM2.5 concentrations that existed prior to the 2003 Rule 4901 amendments. Daily and hourly observed PM2.5 concentrations served as dependent variables with meteorological parameters such as wind speed, temperature, and stability serving as independent variables.

Since this model was developed with data before wood-burning curtailments came into effect, its output shows a prediction of what PM2.5 concentrations would be like if Rule 4901 were not in place. Comparing these predicted concentrations against what was

observed, a difference can be calculated that represents the emissions reductions that have occurred since wood-burning curtailments began. As shown in Figure A-35, a consistent pattern of model-predicted values being higher than what was actually observed provides compelling statistical evidence that a control measure, i.e., wood-burning curtailments, was responsible for the discrepancy. Reductions in emissions from other sources may have also attributed to the differences, but these reductions would be minor when compared to the reductions from residential wood-burning.

Note that the 2003 amendment to the rule established a curtailment threshold at 65 $\mu\text{g}/\text{m}^3$ of PM_{2.5}, and the 2008 amendment lowered this threshold to 30 $\mu\text{g}/\text{m}^3$ of PM_{2.5} or 135 $\mu\text{g}/\text{m}^3$ of PM₁₀. This modeling indicates that as of the 2011–2012 wood-burning season, there has been a 41% (21 $\mu\text{g}/\text{m}^3$) improvement in the 24-hour average PM_{2.5} in Fresno since the 2003 and 2008 amendments to Rule 4901. This improvement is exemplified in PM_{2.5} concentrations measured during the evening hours of 8:00 p.m. to 12:00 a.m. The average evening PM_{2.5} concentrations have improved by 50 percent (42 $\mu\text{g}/\text{m}^3$) over the same time period. As shown in this analysis, the 2008 amendment to Rule 4901 has approximately doubled the seasonal improvements attributable to the 2003 amendment.

Figure A-35 Effect of Rule 4901 on Winter (November through February) PM_{2.5} Concentrations in Fresno



Overall, the Valley's PM_{2.5} concentrations have dramatically decreased since the 2003 and 2008 Rule 4901 amendments. Without this further analysis, it would have been unclear if decreases in PM_{2.5} concentrations could be attributed to reductions in residential wood-burning or changes in seasonal weather patterns. Rule 4901 will continue to play an important role in reducing PM_{2.5} concentrations throughout the San Joaquin Valley both within and beyond the timeframe of this plan.

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