San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

HEALTHY AIR LIVING™

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DATE: April 21, 2011

TO: SJVUAPCD Governing Board

FROM: Seyed Sadredin, Executive Director/APCO
Project Coordinator: Samir Sheikh/Jaime Holt

RE: END-OF-SEASON REPORT ON THE 2010-2011 WOOD-BURNING SEASON

RECOMMENDATIONS:

Receive and file the District's end-of-season report on the 2010-2011 wood-burning season detailing the following:

1. Continued effectiveness of the "Check Before You Burn" outreach messages as part of the Healthy Air Living Initiative and program promoting changes since amendment of District Rule 4901 in 2008 including: air quality and health impacts from wood burning; identification and promotion of cleaner wood-burning options such as the use of EPA-certified wood-burning devices, pellet stoves, processed logs and seasoned firewood; and results of incentive grants for Valley residents.

2. Public health benefits from the implementation of Rule 4901 (Wood-burning Fireplaces and Wood-burning Heaters).

3. Implementation efforts including statistics and progress in compliance activities.

BACKGROUND:

During the 2010-2011 wood-burning season, the public continued to play a big role in improving the Valley's air quality by observing wood-burning curtailments and by taking advantage of the District's incentive programs for cleaner-burning devices.

This report details the District's continued activities and community response related to Rule 4901 (Wood-burning Fireplaces and Wood-

burning Heaters) and summarizes the improved air quality and meteorological conditions experienced during the 2010-2011 wood-burning season subsequent to lowering the wood-burning curtailment threshold to 30 micrograms per cubic meter ($\mu g/m^3$).

Per federal regulations, the District has been monitoring ambient PM2.5 (particulate matter that is 2.5 microns or less in diameter) concentrations since 1999. The third full wood-burning season (November 2010 – February 2011) under the District's amended Rule 4901 ended with the fewest number of days on record in which the recorded 24-hour average PM2.5 concentration was above 35 $\mu g/m^3$, the level of the 2006 PM2.5 national ambient air quality standard (NAAQS).

DISCUSSION:

District Rule 4901 provides for the most cost-effective means to reduce wintertime PM2.5 emissions concentrations. Businesses and industries within the San Joaquin Valley Air Basin (Valley) already play a significant role in reducing emissions in the Valley through adherence to some of the toughest air regulations in the nation. Rule 4901 reaches beyond the commercial sector and provides for meaningful participation by the general public in playing a key role to improve the Valley's air quality. Residential wood burning is the Valley's largest source of directly-emitted PM2.5. Valley-wide, Rule 4901 can reduce as much as 16 tons per day of PM2.5 emissions during winter evenings, when the Valley routinely experiences the highest PM2.5 concentrations.

The most recent winter was the third wood-burning season under the amended Rule 4901, which was approved by your Board in October 2008 and took effect upon initiation of the wood-burning season November 1, 2008. The amendment lowered the wood-burning curtailment threshold level from 65 to 30 $\mu g/m^3$ and was based on the District's public health study and review of the previous Rule 4901 in support of a lower curtailment level. Subsequent to the lowering of the curtailment threshold, the Valley has seen an overall increase in the number of GOOD and MODERATE air quality days, an overall decrease in the number of UNHEALTHY FOR SENSITIVE GROUPS days, and most importantly, a dramatic decrease in the number UNHEALTHY days over the past three wood-burning seasons.

The increase in "cleaner" days and decrease in unhealthy days is consistent with the Valley's long-term trend in improved air quality. The District's continuation of its expanded outreach activity in support of Rule 4901, with resulting increased public awareness and participation in winter clean-air programs, have all been important factors in the improvement of air quality and public health relative to PM2.5 during the 2010-2011 wood-burning season.

EFFECTIVENESS OF DISTRICT OUTREACH PROGRAMS

The third season of the strengthened Rule 4901 culminated in further improvements in winter air quality. The air basin experienced a 44 percent decline in the number of "Unhealthy" air quality days from November 1, 2010 through February 28, 2011—down to five from nine in the previous season.

New research, growing public support and awareness, and perceptual and behavioral changes by residents about wood burning added up to continued progress in reducing winter air pollution.

Healthy Air Living continues to be an effective year-round vehicle for incorporating the District's voluntary and regulatory programs with flexible, relevant and immediate outreach. The 2010-2011 wood-burning season was an example of Healthy Air Living's usefulness and efficacy as a universal branding tool.

New Research

Periodically, the District commissions in-depth surveys to gauge and scientifically measure the effectiveness of its outreach programs.

In 2010, the District commissioned a new public opinion survey, involving 640 random telephone quantitative interviews and 31 targeted, qualitative stakeholder interviews. Through a competitive RFP process, the District contracted with Corey, Canapary and Galanis, a San Francisco public relations firm with a strong background in assessing public opinion regarding environmental issues, to conduct the survey. They worked for four months to complete the survey and compile the results.

The key objectives of this survey were to

- More effectively direct the District's media campaigns
- Determine educational priorities
- Discover residents' level of understanding about air quality
- Assess what behavioral changes residents are willing to make

The survey asked questions in the following general categories:

1. General air quality
2. The District and its programs
3. Household behavior

The survey revealed that the Check Before You Burn program is the most widely known outreach program of the District. More than eight out of 10 Valley residents (83 percent) are aware of it, and most of those are aware of it through TV.

Q18. Have you heard of the Check Before You Burn program?

		Region			Type of Res. Area		
	Total	North	Central	South	Rural	Mid	City
Base (All Respondents)	(640)	(230)	(202)	(208)	(163)	(187)	(289)
	%	%	%	%	%	%	%
Yes	83	79	86	86	80	83	86
No	12	16	12	9	14	11	12
Maybe	4	6	3	4	5	6	2
Don't know	<1	-	-	1	1	-	-
	100	100	100	100	100	100	100

Note: Full survey results are available at http://valleyair.org/Board_meetings/GB/agenda_minutes/Agenda/2010/Study_Session/Agenda_Item_13_Sep_29_2010.pdf

About four in 10 respondents have either a fireplace or wood-burning stove. Those in the northern region and larger cities were more likely to have a fireplace or stove; however, half the respondents (49 percent) who have fireplaces or wood-burning stoves *never* use them during winter. Of those who do use them, 17 percent use them several times per week during the winter. Respondents with a fireplace or stove in rural areas are most likely to use them; those in larger cities are least likely to use them.

QH. Do you have a wood burning fireplace or a wood burning stove in your home?

		Region			Type of Res. Area		
	Total	North	Central	South	Rural	Mid	City
Base (All Respondents)	(640)	(230)	(202)	(208)	(163)	(187)	(289)
	%	%	%	%	%	%	%
Yes - Fireplace	38	44	39	31	30	37	44
Yes - Stove	5	5	6	4	9	3	4
Yes - Both	2	2	2	2	2	3	1
No	55	49	54	63	60	57	51
Don't know	<1	-	1	-	-	-	<1
	100	100	100	100	100	100	100

(See Statistical Table 44)

Q1. On average, how often do you use your wood burning stove or fireplace during the winter months - November through February?

		Region			Type of Res. Area		
	Total	North	Central	South	Rural	Mid	City
Base (have fireplace/stove)	(288)	(117)	(93)	(78)	(66)	(81)	(141)
	%	%	%	%	%	%	%
Several times a week.....	17	17	17	18	26	15	15
Once a week	7	9	5	5	5	10	6
2 - 3 times a month.....	8	11	8	5	11	10	6
Once a month	3	3	4	1	5	1	4
2 - 3 times a season.....	9	5	7	17	9	11	7
Once a season or less....	5	3	7	6	8	5	4
Never.....	49	50	50	47	35	47	57
Don't know.....	1	1	3	-	3	1	1
	100	100	100	100	100	100	100

Respondents acknowledged the importance of programs such as Check Before You Burn in providing valuable encouragement to consider the ramifications on air quality of their behavior.

Q20. In your opinion, how important are the Healthy Air Living and the Check Before You Burn type programs in encouraging residents in your county to reduce air pollution?

		Region			Type of Res. Area		
	Total	North	Central	South	Rural	Mid	City
Base (All Respondents)	(640)	(230)	(202)	(208)	(163)	(187)	(289)
	%	%	%	%	%	%	%
Very important .....(4)	64	60	64	67	67	64	62
Somewhat important (3)	26	30	25	22	23	27	27
Not too important.....(2)	6	5	6	6	4	6	6
Not at all important..(1)	4	5	3	4	4	3	5
Don't know.....	1	<1	2	1	2	-	1
	100	100	100	100	100	100	100

And, of the respondents who do have wood-burning units, the majority attributed air quality concerns with reduced wood burning in their homes.

Q22b. Have you or other members of your household reduced the amount of wood burning that you would have normally done, specifically because of concerns about air quality?

		Region			Type of Res. Area		
	Total	North	Central	South	Rural	Mid	City
Base (All Respondents)	(640)	(230)	(202)	(208)	(163)	(187)	(289)
	%	%	%	%	%	%	%
Yes	32	34	32	29	33	33	30
No	24	25	22	23	26	21	24
Maybe	<1	-	1	1	1	-	<1
Not applicable	44	40	45	48	41	46	45
Don't know.....	<1	<1	1	-	-	-	1
	100	100	100	100	100	100	100

New Multimedia Public Education and Outreach Campaign

The District continued its effective, personable media campaign for Check Before You Burn during the 2010-2011 season through incorporating the faces and voices of Governing Board members into its billboards, TV, and radio advertising. Newer representatives on the Board, such as Visalia Councilmember Mike Lane and Stockton Mayor Ann Johnston, were reflected in the campaign, establishing the important connection at the local level with residents' representatives and their role with the Air District. Additionally, where possible, these messages appeared in Spanish.

The District also produced a five-minute video with Governing Board members discussing the Valley's air quality challenges and urging public action to reduce air pollution. This video was circulated to medical providers throughout the Valley for viewing in their waiting rooms.

Continuation of Revised "Check Before You Burn" Messaging

Beginning in 2008, the District condensed its wood-burning notifications from three levels into two: Wood-burning Prohibited and Please Burn Cleanly. The third season of Check Before You Burn's revised, more concise messaging continued to improve residents' understanding of the rule's components. The simplification of two messaging levels has increased the ability of residents to integrate the program into their daily behavior and has minimized confusion regarding the daily wood-burning status.

Expanding New Media Outreach

New media vehicles such as Facebook and Twitter continue to expand their reach, and have escalated in their importance to Valley residents as sources of up-to-the-minute, localized information.

The District's Outreach and Communications department has incorporated posting wood-burning prohibition notices into its standard operating procedures, and is investigating other new media resources to complement its traditional media outreach.

Retaining Valuable Partners

The District continued its valuable partnership with an important member of the hearth industry, Duraflame Corp. In addition to leveraging outreach dollars with Duraflame, the District promotes manufactured fire logs as a "burn cleanly" option.

Wood-Burning Season Statistics

The public is engaged in many ways throughout wood-burning season to embrace Check Before You Burn, including participation in media coverage; calls placed to the District to express support for the program or to report suspected illegal wood-burning activity; and actively pursuing more information about the reasons and benefits of Check Before You Burn through District resources, including the toll-free number and website.

During the 2010-2011 wood-burning season:

- The 1-800-SMOG-INFO number received 131,528 inquiries, both in Spanish and English, for wood-burning status.
- The District's wood-burning website page received 276,681 "hits."
- The Compliance Department received 357 complaints for suspected wood-burning activity.
- The District received more than 200 public calls regarding the wood-burning rule, many to express support.
- The District received more than about 40 media inquiries regarding the wood-burning rule.

Additionally, the Check Before Your Burn program received supportive news stories and editorials in Valley newspapers, including the Bakersfield Californian, the Fresno Bee, the Modesto Bee, and numerous smaller papers Valley-wide. An end-of-season story noted, "The numbers are encouraging, with each of the past three winters showing progressively cleaner air quality." *(Bakersfield Californian, Tuesday, March 1, 2011)*

Overall public support remains strong for Check Before Your Burn. The District's Outreach and Communications Department continues to receive calls from residents favoring the tightened rule enacted two seasons ago and, in some cases, requesting even more stringent regulation.

Community Incentive Grants

The District's Burn Cleaner Wood Stove Change-out Program is an important resource to help Valley residents make changes in their residential wood-burning practices. The program helps residents overcome some of the financial obstacle in purchasing a cleaner-burning device through multiple levels of incentive funding:

- $500 for changing out a wood-burning or pellet stove to gas
- $250 for changing out a wood burning or pellet to clean pellet device
- $100 for changing out a non-EPA Phase II-certified, wood-burning units to an EPA Phase II-certified wood-burning unit

The District's low-income incentive has become increasingly more critical in addressing the realities of the Valley's economic situation. The low-income incentive offers $1,500 per unit to those applicants that meet the District's low-income criteria.

Between the 2008-2009 and 2010-2011 fiscal years, the District allotted $1,075,000 to the Burn Cleaner Wood Stove Change-out Program, which is actually a year-round program. During the 2010-2011 wood-burning season, the District issued vouchers under the standard incentive funding levels totaling $343,800 for the change out of 610 devices. Under the low-income incentive component, the District distributed $166,500 for the change out of 111 devices.

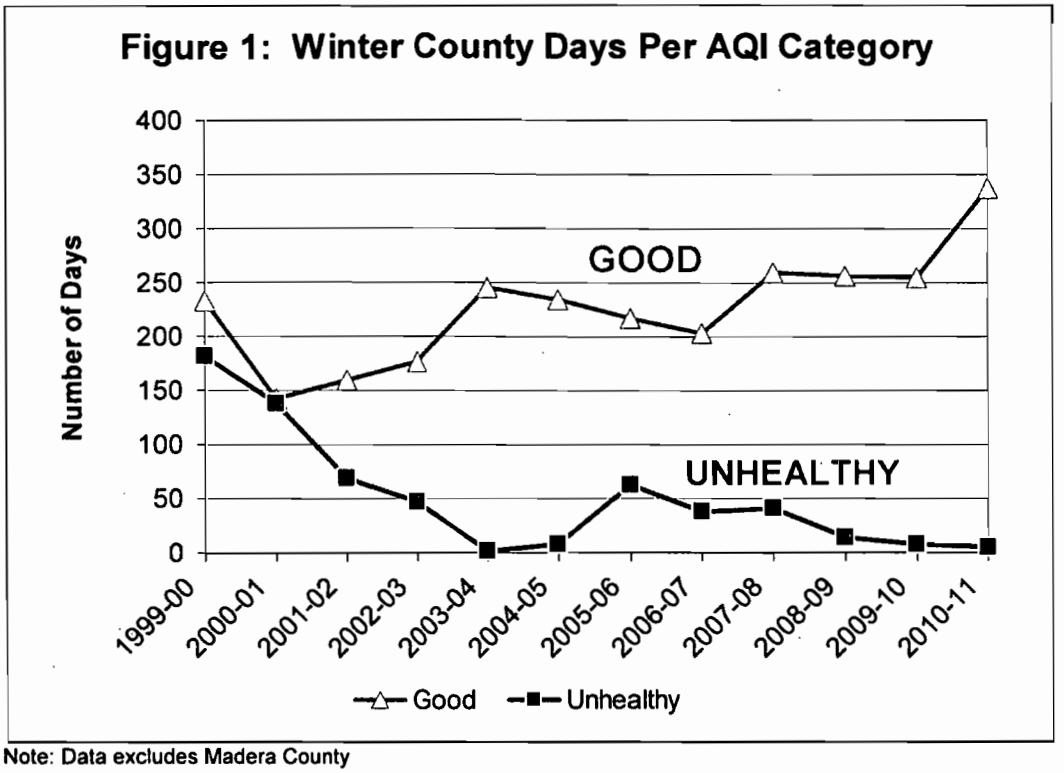
PUBLIC HEALTH BENEFITS & AIR QUALITY

Based on an independent scientific assessment, the District's wood-burning program is its most effective and efficient means of reducing the health impacts from winter PM2.5. Favorable weather conditions coupled with the District's continued outreach and incentive efforts during the 2010-2011 wood-burning season contributed to further improvements in winter air quality relative to the previous season.

In the Valley, PM2.5 concentrations tend to be highest during winter nights as a result of source activity and strong temperature inversions. The majority of residential wood-burning occurs in the evenings, which produces a significant amount of PM2.5 and ultrafine particles. Temperature inversions in the atmosphere act as a lid and concentrate pollution near ground level. As a result of the Valley's inversion phenomenon, population exposure to wood smoke is magnified. People are exposed to wood smoke while they are outdoors, as well as when they are indoors using their own wood-burning devices. Residents can also be exposed to wood smoke in their homes as their neighbors' wood smoke enters through heating systems and windows. By prohibiting the use of wood-burning devices on poor air-quality days on a per-county (or forecast area) basis, Rule 4901 plays a key role in lowering daily PM2.5 concentrations when and where these reductions are most needed.

Wood smoke disproportionately impacts the Valley's most vulnerable population groups, including children, asthmatics, diabetics, heart attack victims, the elderly, and those with inadequate access to health care. Scientists are also increasingly documenting how subtle genetic variations can place certain groups at risk from PAH and other chemicals. By the same token, those groups most at risk also receive the most benefit from reductions in wood smoke exposure attributable to Rule 4901. As such, District controls on wood burning are particularly important in a region known to have a very high rate of chronic disease and poverty.

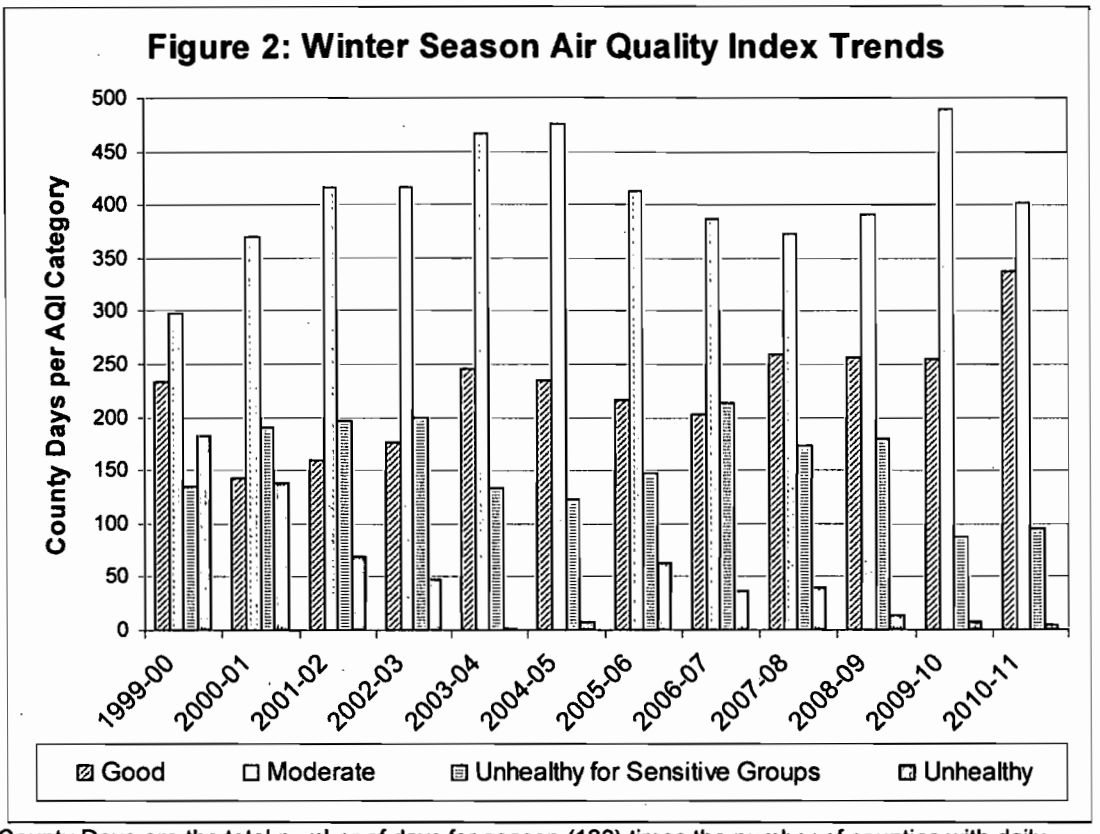
Through implementation of Rule 4901, the District continues to help reduce PM2.5 pollution that affects Valley residents. Analysis of air monitoring data from the 2010-2011 wood-burning season (November 1, 2010 through February 28, 2011) shows that PM2.5 concentrations are continuing to decrease throughout the Valley. Figure 1 shows an overall increase in the number of GOOD days and a decrease in the number of UNHEALTHY days during the wood-burning season.



Note: Data excludes Madera County

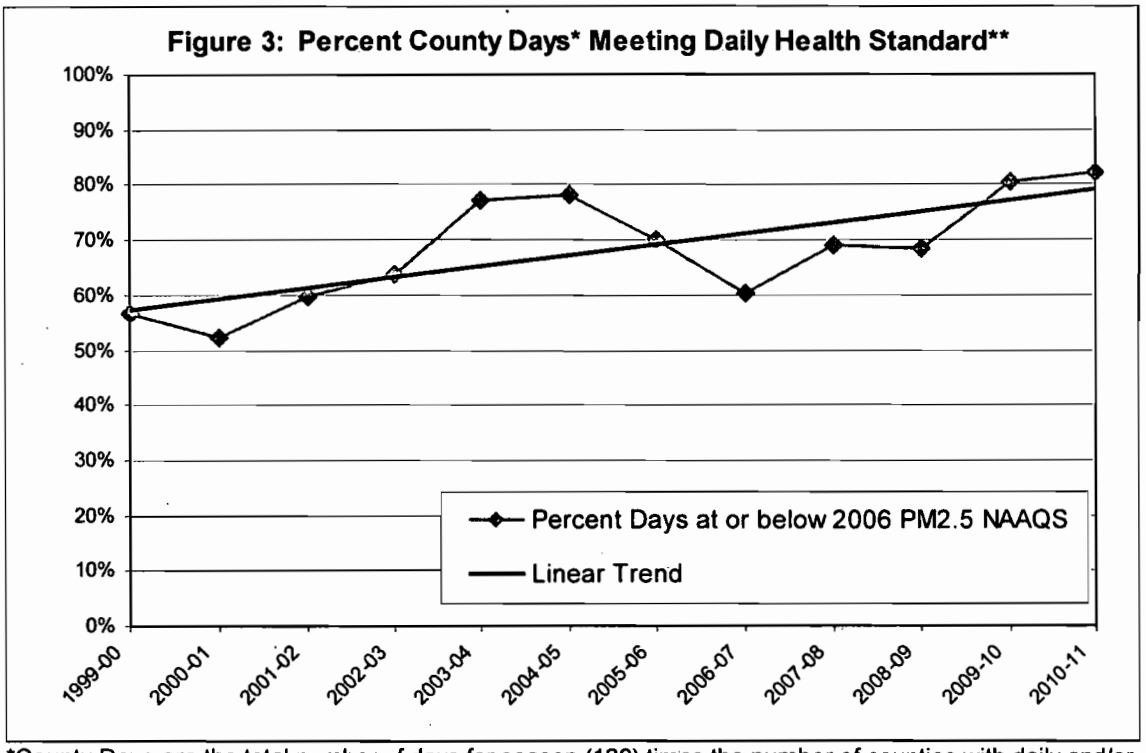
More specifically, Figure 2 shows the aggregate number of days in each of the AQI categories for counties in which the District evaluates daily and/or filter monitoring data. The data portrayed in Figures 1 and 2 account for only seven of the eight counties within the District; last year was the first year the District measured and recorded PM2.5 concentrations specific to Madera County. Therefore, excluding Madera County, over the 120 days of the wood-burning season, there are total of 840 categorized county days.

Overall, the data trends show a steady increase in the number of GOOD and MODERATE days, a steady decrease in the number of UNHEALTHY FOR SENSITIVE GROUPS (USG) days, and a more rapid decline in the number of UNHEALTHY days since 1999. The significant decrease in USG and UNHEALTHY days in the 2010-2011 wood-burning season, compared to those seen in the 2008-09 season, coincides with the continued strong multi-media outreach by the District and a resultant increase in public awareness and participation in winter District programs.



County Days are the total number of days for season (120) times the number of counties with daily and/or filter data (7) equal 840 possible days. Madera County is not included in this data.

In addition to improving trends in the number of GOOD and MODERATE AQI days in the Valley since 1999 and the relative improvement since the amendment of Rule 4901, there is marked improvement in the number of days in which the recorded PM2.5 concentrations were at or below the 2006 PM2.5 daily public health standard, as shown in Figure 3. Compared to the previous wood-burning season, the District had nine percent fewer PM2.5 exceedances, which equates to 82 percent of the days below the PM2.5 daily public health standard for the entire wood-burning season.



*County Days are the total number of days for season (120) times the number of counties with daily and/or filter data (7), which equals 840 possible days.
**2006 PM2.5 National Ambient Air Quality Standard is 35 µg/m³.

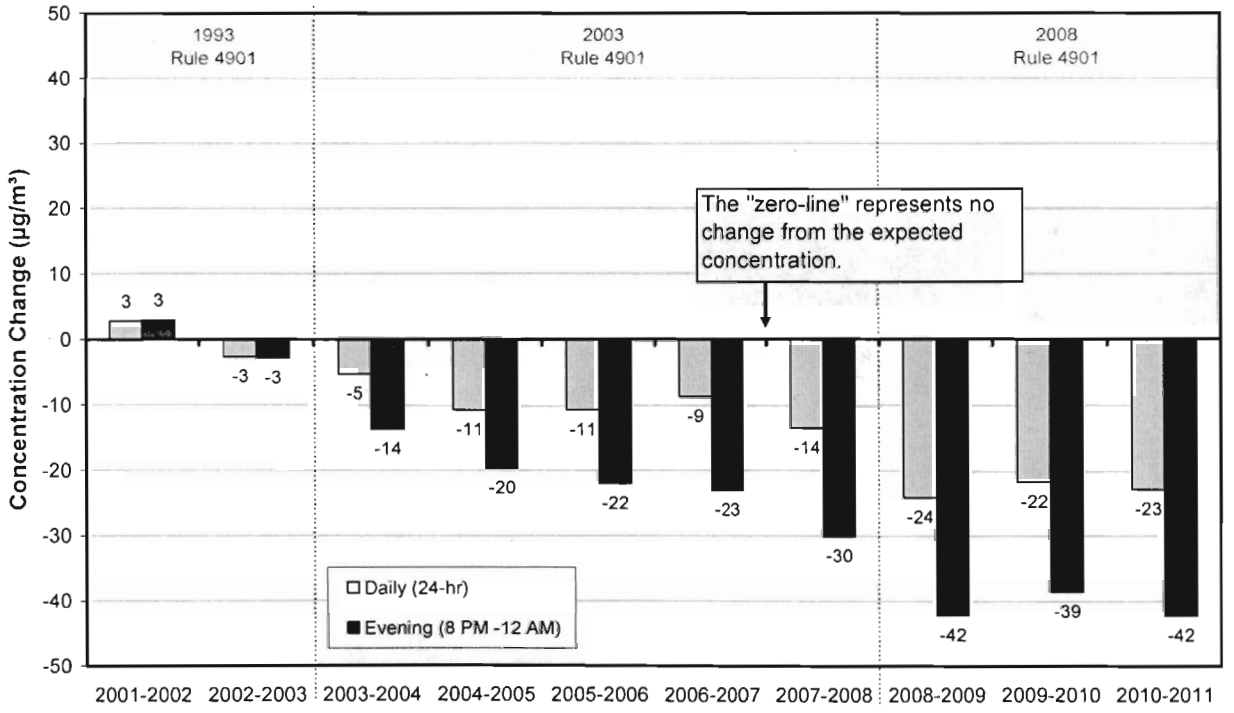
Empirical evidence shows improved air quality in the Valley during progressive winter wood-burning seasons; however, it is important to evaluate other factors affecting such improvement. Certainly, the largest uncontrollable factor is meteorology. Air quality improvements and evaluation of the effects of regulatory measures must take into account the role that seasonal weather patterns play in air quality measurements.

METEOROLOGY VERSUS RULE IMPACTS DURING THE 2010-2011 WOOD-BURNING SEASON

Meteorological patterns influence ambient PM2.5 concentrations by affecting emissions rates (for example, temperature-linked evaporation rates, or cooler temperatures that might lead to increased wood-burning activity), by influencing the atmospheric chemistry of secondary particle formation, and by controlling the rate of air pollutant dispersion. The San Joaquin Valley's stagnant meteorological conditions and strong temperature inversions tend to favor the formation and retention of PM2.5, particularly between October and March. From year to year, the magnitude and timing of these effects can vary. The District has been developing and refining its statistical model to evaluate the effects of observed meteorology as well as the effects of amended Rule 4901. The District can compare observed PM2.5 concentrations to the PM2.5 concentrations that were expected based on emissions and meteorology.

For example, the District's statistical model can generate the PM2.5 concentrations that would be expected based on meteorology and without the benefits of Rule 4901 for every day in the wood-burning season. The District can then compare these values to the PM2.5 concentrations that were actually observed on each of these days, with these observed concentrations actually benefitting from Rule 4901. At Fresno-First, for the 2010-2011 wood burning season, the observed 24-hour average PM2.5 concentrations were about 23 µg/m³ lower than would be expected without Rule 4901 curtailments (Figure 4). The observed hourly average PM2.5 concentrations over the four-hour period of 8pm to midnight were even lower, at about 42 µg/m³ lower than expected (Figure 4). This greater improvement observed during the evening hours is a strong indicator that reduced PM2.5 concentrations are attributable to decreases in residential wood burning (most typical in the evenings). The District's analysis also shows that the 2008 amendments to Rule 4901 have approximately doubled the seasonal improvements attributable to the 2003 amendments. The District's full statistical analysis of the 2010-2011 residential wood-burning season is included as an attachment to this report.

Figure 4 Fresno First Street, PM2.5 Concentration Change by Season



COMPLIANCE WITH RULE 4901

The District's Compliance Department plays an integral role in reducing the public health impact of wood smoke. This role consists of both compliance assistance and enforcement activities. Compliance staff respond to numerous calls from members of the public who have questions about the wood-burning rule. The calls range from general questions about the rule, such as how to determine when it is okay to burn cleanly, to more specific questions, such as whether there are exemptions that allow burning on curtailment days. During the 2010-2011 wood-burning season, the District granted a limited number of exemptions, with the primary reason for an exemption being the resident's natural gas heater was inoperable and the cost to repair the unit was beyond their means.

On curtailment days, District field staff surveyed neighborhoods for compliance with the rule. When staff visually detected smoke, they noted the address, and a notice of violation (NOV) was issued by mail. By policy, field staff does not enter private property when enforcing wood-burning curtailments. As shown in Table 2, the number of NOVs issued decreased during the 2010-2011 season from the previous year. To more effectively and equitably enforce the provisions of the rule and to better respond to public complaints received on weekend curtailment days, the District increased staff hours for weekend surveillance during this wood-burning season. As in the previous two wood-burning seasons since Rule 4901 was amended to a lower curtailment threshold, the District shifted staff hours to allow for more weekend and night surveillance during the 2010-2011 wood-burning season.

Table 2: Compliance Activity by Season

Wood-Burning Season	Total Staff Hours	Number of NOVs
2006-2007	834	187
2007-2008	528	92
2008-2009	1604	402
2009-2010	1438	417
2010-2011	1350	413

As has been the case in previous wood-burning seasons, in 2010-2011 the majority of the violations were first-time offenses. In these situations, residents could either pay a $50 penalty, or they could review literature provided on the regulation and complete a take-home examination. If a resident chose the latter option, the District mailed the literature and examination to the resident, who, in turn, mailed back the completed test, saving them a trip to a District office. If a resident passed the examination, the District waived the $50 penalty. The vast majority of residents that were issued NOVs took the examination, thus avoiding the monetary penalty.

Attachment: Summary and Analysis of the 2010-2011 Wood-Burning Season (31 pages)

San Joaquin Valley Unified Air Pollution Control District
Meeting of the Governing Board
APRIL 21, 2011

END-OF-SEASON REPORT ON THE 2010-2011 WOOD-BURNING SEASON

Attachment:

SUMMARY AND ANALYSIS OF THE 2010-2011 WOOD-BURNING SEASON
(31 Pages)

Summary and Analysis of the 2010-2011 Wood-Burning Season

April 21, 2011

Stephen Shaw, Supervising Air Quality Specialist
David Nunes, Senior Air Quality Specialist
Shawn Ferreria, Senior Air Quality Specialist
Jonathan Klassen, Air Quality Specialist
Jennifer Ridgway, Air Quality Specialist

I. HISTORICAL SUMMARY OF RESIDENTIAL WOOD-BURNING CURTAILMENTS

The 2010-2011 wood-burning season, which was in effect from November 2010 through February 2011, marked the third winter season with a residential wood-burning curtailment threshold defined as either a forecasted 24-hour average PM2.5 concentration of 30 µg/m³ or greater, or a forecasted 24-hour average PM10 concentration of 135 µg/m³ or greater. Amendments to Rule 4901 established these lower thresholds in 2008, which were implemented prior to the 2008-2009 wood-burning season. Since the occurrence of a 24-hour average PM10 concentration greater than or equal to 135 µg/m³ during the winter is very rare, the analyses in this report do not take PM10 concentrations into account. Note that the wood-burning seasons of 2007-08 and earlier had a curtailment threshold defined as a forecasted PM2.5 concentration of 65 µg/m³ or greater. Figure 1 is a summary of the number of wood-burning curtailments issued per county, along with Basin-Days and County-Days totals within the District over the past eight wood-burning seasons. The Basin-Days value counts the number of calendar days in which the District issued at least one curtailment somewhere in the District. County-Days represent the sum of every county-level curtailment over the eight-county region.

Figure 1. Number of Curtailments Issued per Wood-Burning Season

County	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011
San Joaquin	0	0	1	1	0	24	21	7
Stanislaus	0	0	3	9	2	34	25	25
Merced	0	0	2	2	0	32	15	23
Madera	0	0	2	2	4	34	20	37
Fresno	2	2	11	12	7	46	33	44
Kings	0	0	13	2	6	37	36	36
Tulare	0	2	9	3	6	35	17	33
Kern	1	2	16	8	14	54	41	40
Basin-Days	**2**	**3**	**21**	**16**	**18**	**59**	**47**	**50**
County-Days	**3**	**6**	**57**	**39**	**39**	**296**	**208**	**245**

Figure 1 also shows that in the 2010-2011 wood-burning season, most counties had either an equal number of curtailments or an increase in curtailments when compared to the previous wood-burning season. The only exceptions are San Joaquin County, which had a decrease in the number of curtailments compared to the previous season, and Kern County, in which curtailments decreased by one.

II. ANALYSIS OF AIR QUALITY

Figure 2 shows a comparison of air quality among the District's last 12 wood-burning seasons and reflects the continued improvement of winter-time air quality in the San Joaquin Valley. The number of District PM2.5 exceedances during the 2010-2011 season decreased by nine percent compared to the 2009-2010 wood-burning season. The District also experienced a 44 percent decrease in the number of Unhealthy or worse AQI days compared to the previous season, as well as the greatest number of Good AQI days when compared to the previous 11 seasons. The 338 Good AQI days recorded during the 2010-2011 season represent a 32 percent increase over the previous year. This increase in the number of Good AQI days is also reflected in the recordation of the lowest season average PM2.5 concentration on record—22 µg/m³.

Figure 2. Comparison of Historical Wood-Burning Season Air Quality

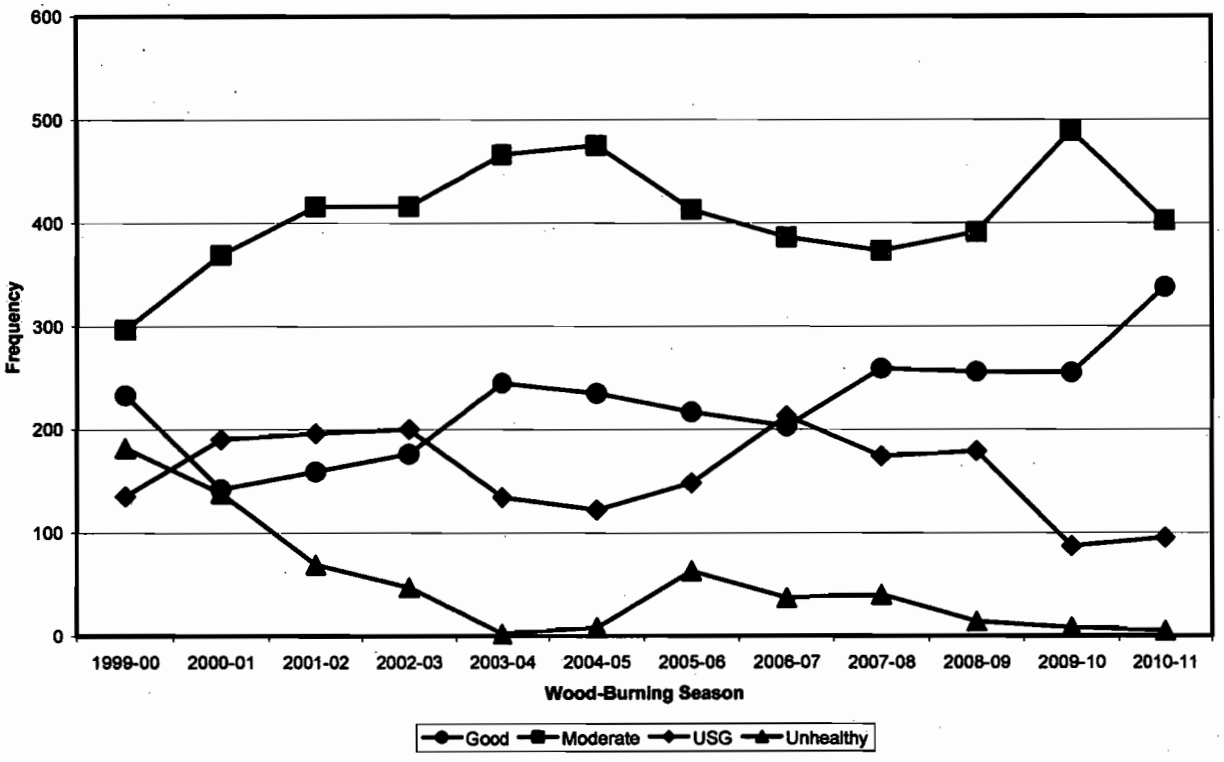
	Air Quality Index (AQI) Category – Number of County Days					
Season	**Good**	**Moderate**	**USG**	**Unhealthy**	**Exceedances (> 35 µg/m³)**	**Average Concentration (µg/m³)**
2010-11	338	402	95	5	149	22
2009-10	255	489	87	8	165	25
2008-09	256	391	179	14	265	27
2007-08	259	373	174	40	261	28
2006-07	203	386	213	37	333	31
2005-06	217	413	148	63	253	30
2004-05	235	475	122	8	183	25
2003-04	245	466	134	2	192	26
2002-03	176	416	200	47	304	32
2001-02	159	416	196	69	339	33
2000-01	142	369	190	138	401	40
1999-00	233	297	135	182	365	39
Average	**227**	**408**	**156**	**51**	**268**	**30**

Note: Designations for Madera County not included in data; the District started PM2.5 data collection in Madera County in 2010.

Figure 2 represents a combination of filter-collected samples and daily average real-time observations; the highest concentration between the two data sources determined the county's daily concentration. The District uses this method to account for historical sampling schedules that only called for the collection of filter data every third day in some counties.

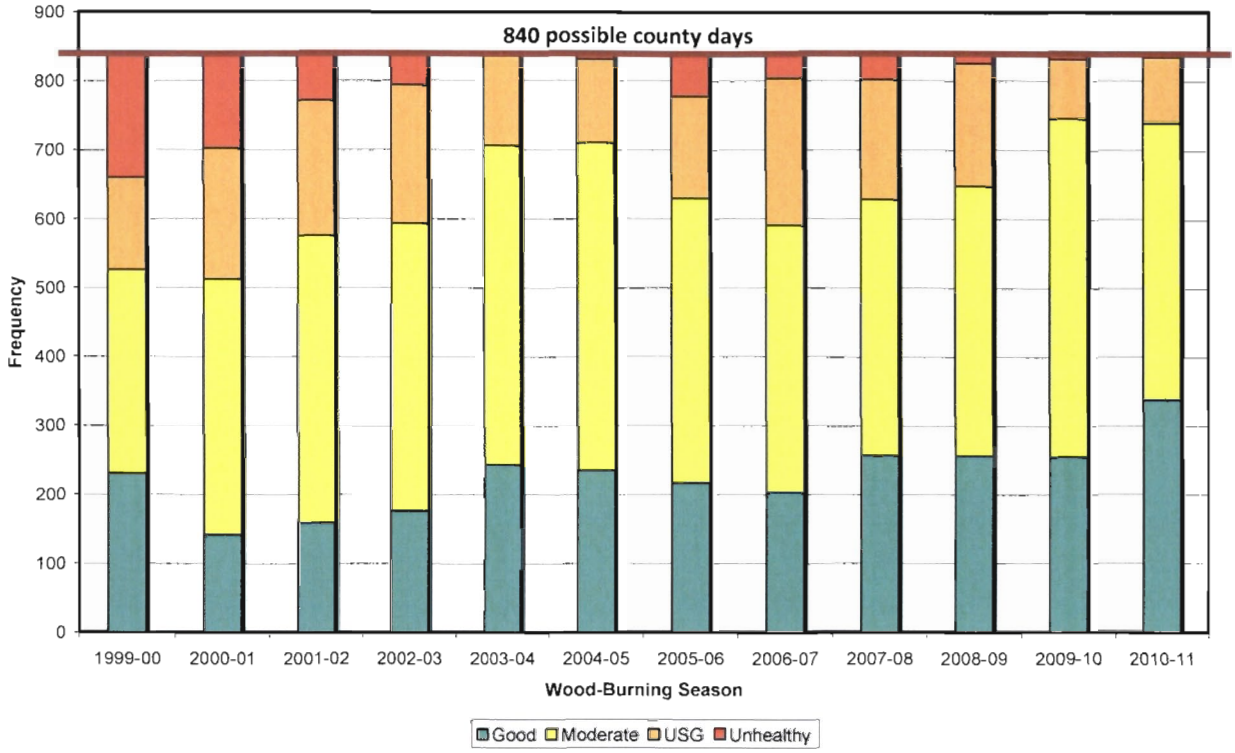
Figure 3 (line chart) and Figure 4 (stacked bar chart) are graphical representations of the AQI category frequencies over the past 12 wood-burning seasons. There is a general increase in the number Good and Moderate AQI days and a general decrease in the number of Unhealthy and Unhealthy for Sensitive Groups (USG) AQI days, consistent with improving air quality in the San Joaquin Valley.

Figure 3. County-Day AQI Category Frequencies per Wood-Burning Season (Line Chart)



Note: Designations for Madera County not included in data; the District started PM2.5 data collection in Madera County in 2010.

Figure 4. County-Day AQI Category Frequencies per Wood-Burning Season (Stacked-Bar Chart)

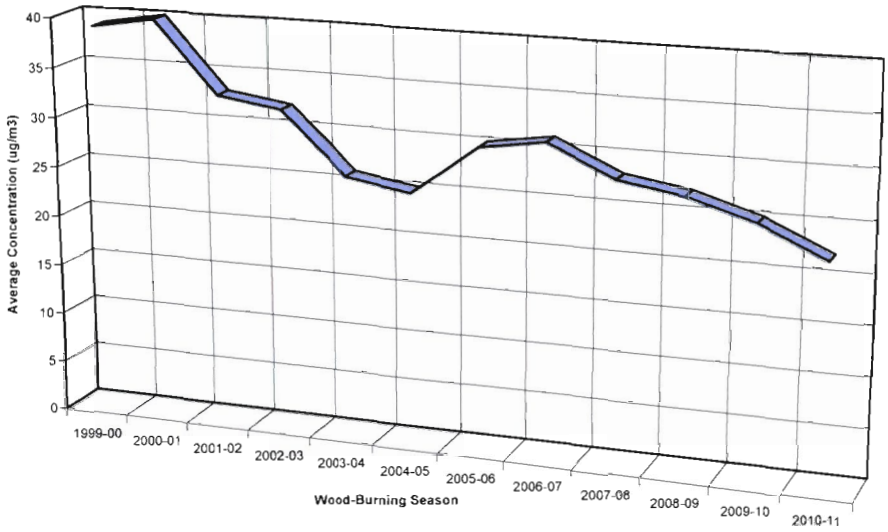


Note: Designations for Madera County not included in data; the District started PM2.5 data collection in Madera County in 2010.

More specifically, over the 12-season time period, the overall percent change for Good and Unhealthy AQI days, 45 percent more and 97 percent fewer, respectively, is higher than the overall percent change for the Moderate and USG AQI days, which are 35 percent more and 30 percent fewer, respectively.

The average daily PM2.5 concentration for the 2010-2011 wood-burning season is the lowest on record. Figure 5 displays the decreasing trend in average seasonal PM2.5 concentration from 1999 to the most recent season. The 2010-2011 average daily PM2.5 concentration is approximately half of average daily PM2.5 concentration as measured in the 1999-2000 wood-burning season, which is when the District began monitoring and recording such measurements.

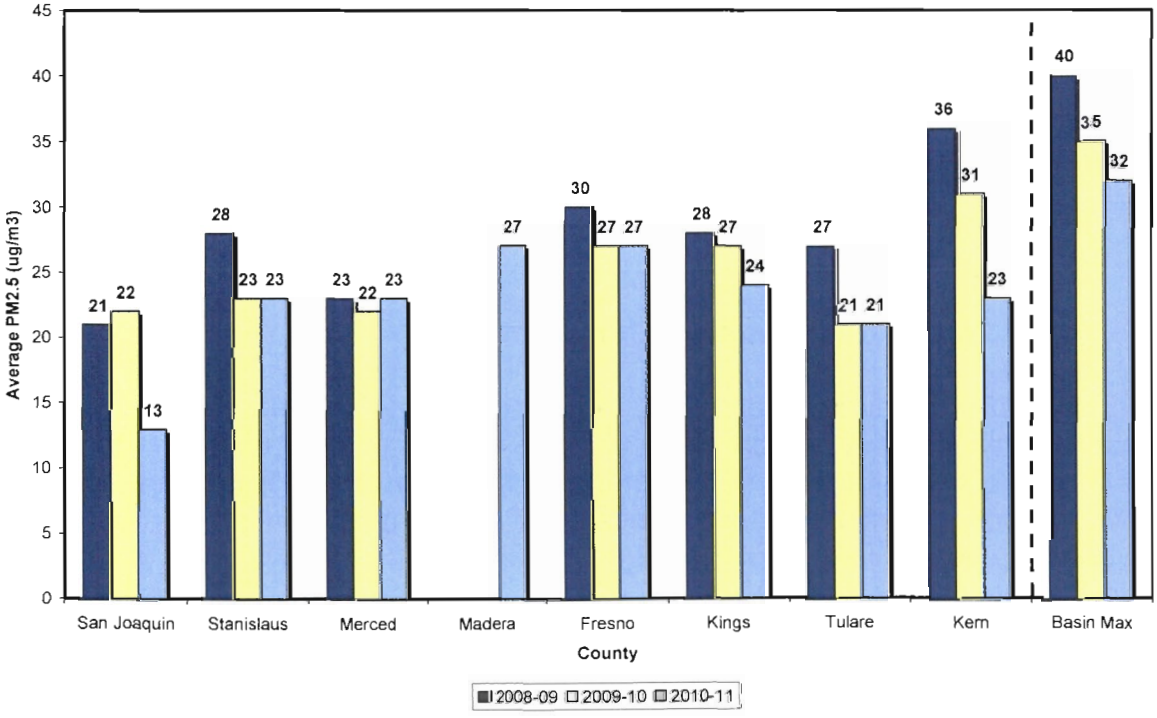
Figure 5. Average PM2.5 Concentration per Wood-Burning Season



Note: Designations for Madera County not included in data; the District started PM2.5 data collection in Madera County in 2010.

Figure 6 shows the average daily PM2.5 concentrations by county for the past three wood-burning seasons, along with the average daily maximum concentrations observed overall in the air basin over the same time period. This time period represents the time since the most recent amendment to Rule 4901 and the lowering of the curtailment threshold level to 30 µg/m³.

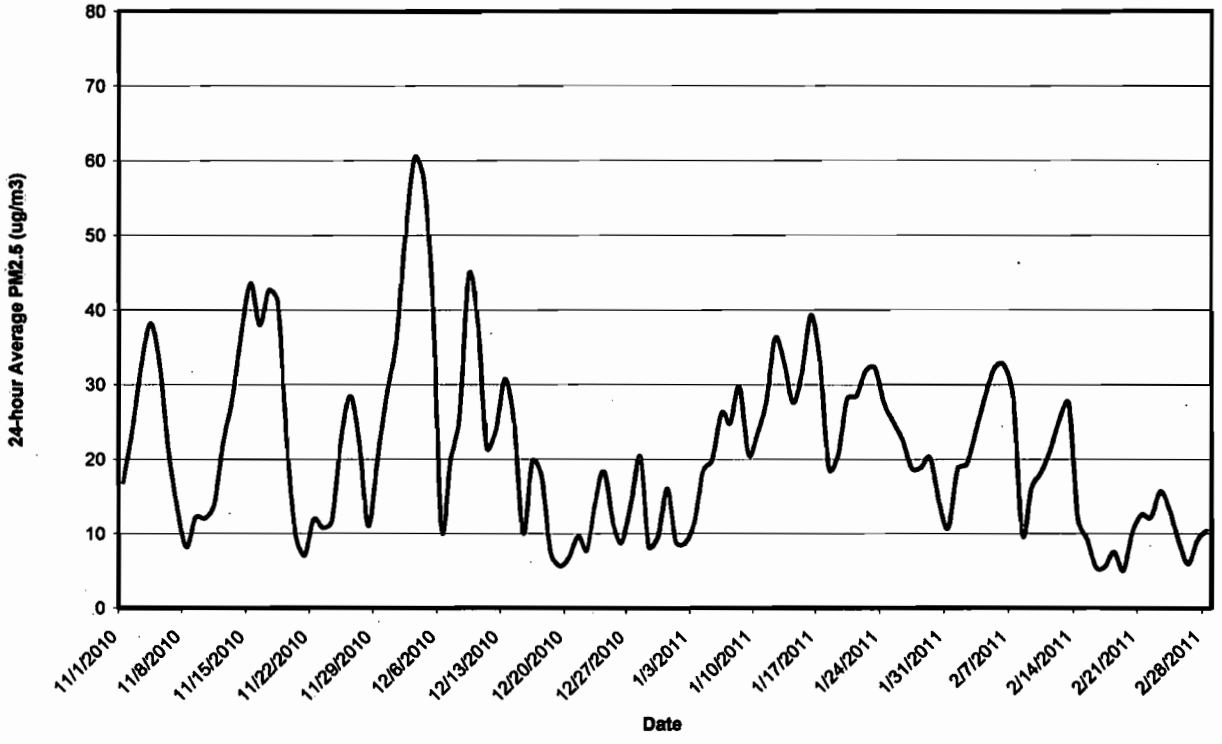
Figure 6. County Average PM2.5 Concentration per Wood-Burning Season



In all but one county, Merced County, the average PM2.5 concentration decreases or remains constant with each progressive wood-burning season. San Joaquin County shows the most drastic improvement at 41 percent over the past two wood-burning seasons. Madera County is only represented by one season of data, since PM2.5 monitoring began there just prior to the 2010-2011 wood-burning season. As with the decline of average PM2.5 concentrations by county, the annual average of the daily basin maximum PM2.5 concentrations is also declining.

Figure 7 shows the valley-wide daily average PM2.5 concentration during the 2010-2011 wood-burning season. The highest concentrations occurred in December 2010, followed by low concentrations, or a clean period, extending into early January 2011. Section IV of this summary discusses the effect of meteorology on the daily averages seen in Figure 7.

Figure 7. Daily Average PM2.5 during the 2010-2011 Wood-Burning Season

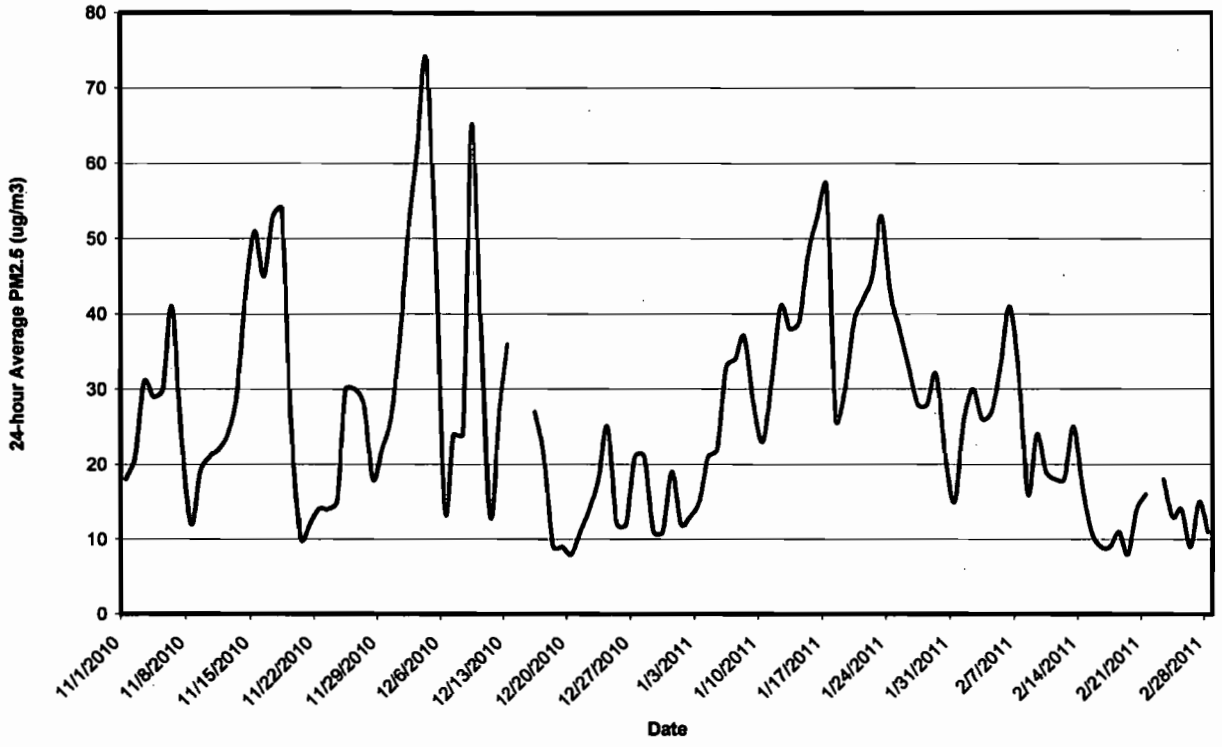


Madera County PM2.5 Monitoring and Conentrations

The District installed a new monitoring site in Madera County in 2010 and began monitoring and recording PM2.5 concentrations for the first time. Data from this site provides real time air quality information for Madera County residents, and helps District staff provide county-specific air quality forecasts. Prior to installation of this monitoring site, the District relied on information from the Turlock, Merced, and Clovis monitoring sites to interpolate a forecast for Madera County.

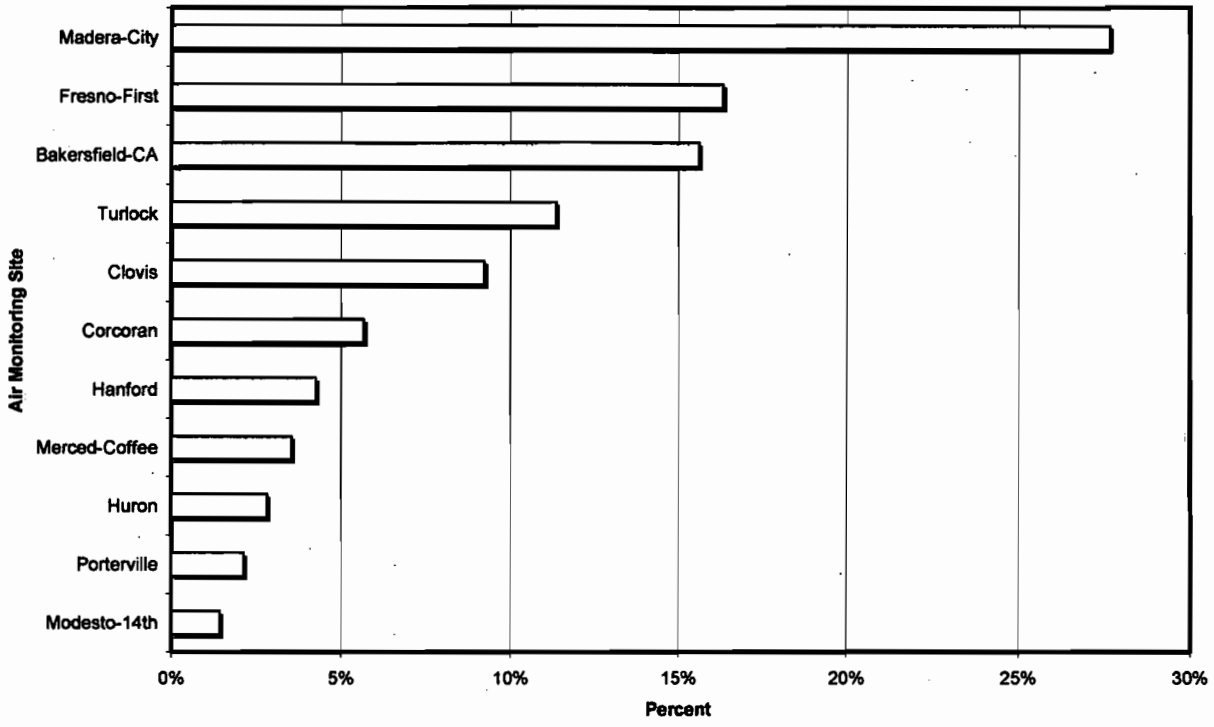
Figure 8 shows the daily 24-hour average PM2.5 concentrations for the first wood-burning season as measured at the Madera-City site. This site recorded the second highest 24-hour average concentration last winter—74 µg/m³. This concentration is second only to the Clovis monitor, which recorded a concentration of 75 µg/m³ on the previous day.

Figure 8. Daily 24-hour Average PM2.5 Concentrations at the Madera-City Air Monitoring Station During the 2010-2011 Wood-Burning Season



Not only did the Madera-City site record the second highest PM2.5 concentration in the Valley during the 2010-2011 wood-burning season, it also had the greatest percentage of days with the highest recoded PM2.5 concentration, as shown in Figure 9. The addition of a monitoring site in Madera County will provide much-needed insight and accuracy as to forecasting PM2.5 concentrations and wood-burning curtailments in subsequent wood-burning seasons.

Figure 9. Percent of Days During the 2010-2011 Wood Burning Season with the Maximum PM2.5 Concentration in the San Joaquin Valley by Air Monitoring Site



The Greater Frazier Park Area

As established during the 2008-2009 wood-burning season, the District issues a daily AQI forecast and wood-burning declaration for the Greater Frazier Park Area (GFPA). These forecasts are separate from those issued for Kern County and are based on PM2.5 concentrations measured at the Lebec monitoring station.

The average PM2.5 concentration during 2010-2011 wood-burning season in the GFPA was only 5 $\mu g/m^3$. By comparison, the Valley-wide maximum 24-hour average concentration during the same time period was 22 $\mu g/m^3$. The District did not declare any wood-burning curtailments for the GFPA during the 2010-2011 wood-burning season.

III. ANALYSIS OF FORECASTING

To produce the residential wood-burning declarations for the counties in the San Joaquin Valley Air Basin (SJVAB), District staff evaluate: (1) meteorological parameters (e.g., barometric pressure, wind speed and direction both at the surface and at certain altitudes, vertical mixing heights, surface temperature, relative humidity, precipitation, etc.); (2) recent and current air pollutant and precursor concentrations at over twenty monitoring sites in the SJVAB; and (3) the potential for changes in emissions, such as

residential wood-burning, hazard reduction burning, vehicle activity, and agricultural burning.

The District determines a projected 24-hr PM2.5 concentration for each county in the SJVAB using a multi-linear regression model and the ongoing air quality trends at the time of evaluation.

The District evaluates its forecasting accuracy by comparing forecasted AQI and curtailment determination with the subsequent observed concentration measurements from air monitoring sites throughout the SJVAB.

AQI Category Forecast Accuracy

The District considers a forecast of a county's AQI category accurate—a hit—if the subsequent observed PM2.5 concentration indicates the same AQI category as predicted, or if the AQI value is within 10 percent of the subsequent observed AQI value. If the AQI forecast does not meet either of these conditions, the District labels the forecast as a miss. Figure 10 summarizes the cumulative AQI category accuracy for each county during the 2010-2011 wood-burning season.

Figure 10. AQI Category Forecast Accuracy for the 2010-2011 Season

County	Forecasts	Hit	Miss	Hit %
San Joaquin	120	88	32	73%
Stanislaus	120	87	33	73%
Merced	120	86	34	72%
Madera	120	86	34	72%
Fresno	120	92	28	77%
Kings	120	90	30	75%
Tulare	120	85	35	71%
Kern	120	72	48	60%
Total	***960***	***686***	***274***	***71%***

During a wood-burning season, the District makes 120 forecasts for each county[1] over the four month period—November through February. As shown in Figure 10, the forecasting accuracy ranged between 60 and 77 percent for the 120 forecasts for each county, for an average valley-wide accuracy of 71 percent.

A miss, as recorded in Figure 10, may be the result of public compliance with Rule 4901. Part of the evaluation and forecasting process includes an estimation of wood-burning activity. A curtailment designation should cause residents to refrain from burning, thus reducing the subsequent observed PM2.5 concentration for a given area,

[1] While the District made a separate forecast for the Greater Frasier Park Area, those statistics are not used to determine forecast accuracy.

as measured the following day. While the District strives to improve the accuracy of its forecasting activity, some level of inaccuracy reflects the effectiveness of Rule 4901.

Wood-Burning Declaration Forecast Accuracy

During a wood-burning season, the District issues one of two possible daily declarations for each county: "Wood Burning is Prohibited (WBP)" or "Please Burn Cleanly (PBC)." The declaration is WBP if the forecasted PM2.5 concentration for a county is 30 $\mu g/m^3$ or higher, and PBC if the forecasted PM2.5 concentration is less than 30 $\mu g/m^3$. For WBP days, the District considers the forecast as accurate—a hit—if the subsequent observed PM2.5 concentration is greater than or equal to 30 $\mu g/m^3$, or a miss if the observed concentration is less than 30 $\mu g/m^3$. Similarly, for PBC days, a hit is declared if the observed concentration is less than 30 $\mu g/m^3$ and a miss if the concentration is 30 $\mu g/m^3$ or higher. Figure 11 summarizes the overall curtailment accuracy statistics by county; or how many times out of the possible 120 days per county, that the forecast was accurate—WBP or PBC. The overall declaration accuracy ranged between 74 and 93 percent for all counties, with a valley-wide average of 83 percent.

Figure 11. 2010-2011 Wood-Burning Season Combined Declaration Accuracy

County	Declarations	Hit	Miss	Hit %
San Joaquin	120	110	10	92%
Stanislaus	120	89	31	74%
Merced	120	103	17	86%
Madera	120	95	25	79%
Fresno	120	96	24	80%
Kings	120	97	23	81%
Tulare	120	111	9	93%
Kern	120	96	24	80%
Total	***960***	***797***	***163***	***83%***

Figures 12 and 13 summarize the individual accuracy, by county, of the District's declaration of a WBP or PBC day. Again, the District declares a curtailment if the forecast concentration is 30 $\mu g/m^3$ or higher and a PBC day otherwise. The separate statistics allow the District to evaluate the forecasting process and make improvements to its modeling and evaluation techniques.

Figure 12. 2010-2011 Wood-Burning Season Curtailment Accuracy

County	Curtailments	Hit	Miss	Hit %
San Joaquin	7	4	3	57%
Stanislaus	25	18	7	72%
Merced	23	18	5	78%
Madera	37	27	10	73%
Fresno	44	32	12	73%
Kings	36	25	11	69%
Tulare	33	28	5	85%
Kern	40	33	7	83%
Total	***245***	***185***	***60***	***76%***

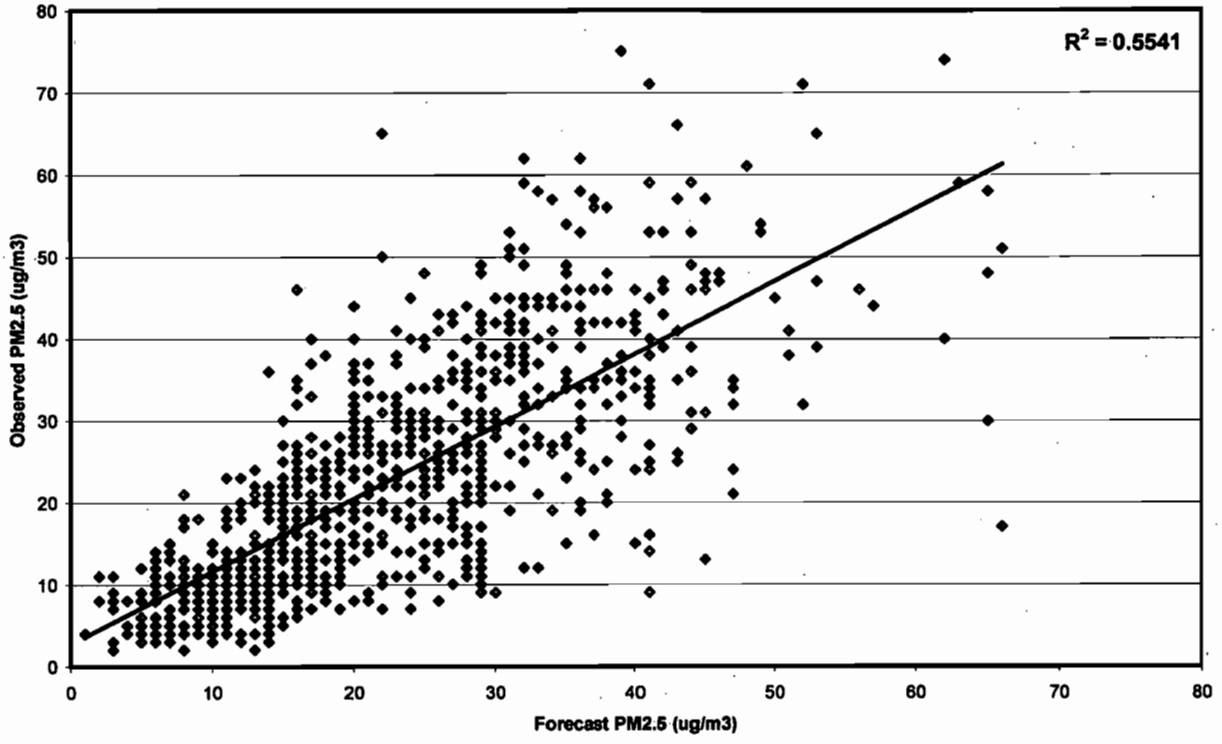
Figure 13. 2010-2011 Wood-Burning Season Please Burn Cleanly Accuracy

County	PBCs	Hit	Miss	Hit %
San Joaquin	113	106	7	94%
Stanislaus	95	71	24	75%
Merced	97	85	12	88%
Madera	83	68	15	82%
Fresno	76	64	12	84%
Kings	84	72	12	86%
Tulare	87	83	4	95%
Kern	80	63	17	79%
Total	***715***	***612***	***103***	***86%***

Forecast versus Observed PM2.5 Concentrations

It is helpful to evaluate the accuracy of not only the forecasting of AQI and wood-burning declarations, but also that of PM2.5 concentrations. Accurate air quality forecasts are a benefit to public health, since many residents of the San Joaquin Valley rely heavily upon the District's air quality forecasts when making decisions regarding outdoor activities. Figure 14 displays the comparison of forecast and observed PM2.5 concentrations among all counties in the District during the 2010-2011 season.

Figure 14. Forecast versus Observed County Maximum PM2.5 During the 2010-2011 Wood-Burning Season



The coefficient of determination (R^2), which is a representation of how well a model predicts actual outcome, between forecast and observed PM2.5 is 0.5541. This value is higher than the calculations from the 2009-2010 season, which had an R^2 of 0.4793. The data shows that PM2.5 forecasts tend to be less than the observed concentration, especially among the higher concentrations, which is similar to last season.

Consecutive Curtailment and PBC Declarations

Figure 15 shows the maximum number of consecutive curtailment declarations and the maximum number of consecutive PBC declarations by county. Although some counties had a long stretch of consecutive curtailments, each county had an even longer stretch of consecutive PBC declarations. Figure 15 also shows the percent of time during the wood-burning season that each county was allowed to burn for each season since Rule 4901 was amended in 2008.

Figure 15. Summary of Consecutive Wood-Burning Declarations and Percent of Time Allowed to Burn During the Past Three Wood-Burning Seasons

County	2010-2011 Maximum Consecutive Curtailments	2010-2011 Maximum Consecutive PBCs	2010-2011 Percent of Time Burning Allowed	2009-2010 Percent of Time Burning Allowed	2008-2009 Percent of Time Burning Allowed
San Joaquin	3	41	94%	83%	80%
Stanislaus	8	32	79%	79%	72%
Merced	8	32	81%	88%	73%
Madera	8	22	69%	83%	72%
Fresno	7	20	63%	73%	62%
Kings	7	22	70%	70%	69%
Tulare	7	31	73%	86%	71%
Kern	7	22	67%	66%	55%

The counties of Stanislaus, Merced, and Madera had the longest stretch of consecutive wood-burning curtailments during the 2010-2011 season, which lasted eight days. In contrast, San Joaquin County had the longest stretch of consecutive PBC declarations, which lasted 41 days. The last three columns in Figure 15 compare the percent of time during the 2008-2009, 2009-2010, and 2010-2011 wood-burning seasons that residential wood-burning was allowed. In the 2010-2011 season, San Joaquin County residents were allowed to burn 94 percent of the time in contrast to Fresno County, where residents were allowed to burn 63 percent of the time. When comparing the last two seasons, it can be seen that most counties were allowed to burn as often or fewer days in the 2010-2011 season than they were during the 2009-2010 season.

IV. METEOROLOGICAL REVIEW OF THE 2010-2011 WOOD-BURNING SEASON

Meteorology has a direct impact on air quality and the dispersion of air pollution; therefore it is important to analyze how the weather affected pollutant concentrations during the wood-burning season. This analysis shows the effects of wind and rainfall on PM2.5 concentrations, a summary of the general weather conditions during the 2010-2011 wood-burning season, and a seasonal comparison of meteorological statistics.

Effects of Dispersion Mechanisms on PM2.5 Concentration

Since there is a perception that rainfall washes out PM2.5, the District receives many inquiries about why curtailments are declared when it is raining. This cleansing process does occur in many precipitation events, but in some cases it does not. Particulate levels are affected more by various meteorological dispersion mechanisms in the atmosphere. Wind flow (horizontal mixing) and temperature instability (decreasing temperature with height leading to vertical mixing) provide the strongest mechanisms for dispersing pollutants.

PM2.5 concentrations can be influenced by a variety of meteorological parameters including wind speed and the 850 millibar (MB) stability temperature. The 850 MB stability temperature parameter is used because of its strong correlation with PM2.5 concentrations. The 850 MB level is approximately 5,000 feet above the Earth's surface. The 850 MB stability temperature parameter is calculated by taking the 12 Z (4:00 AM Pacific Standard Time) 850 MB Oakland sounding temperature and subtracting from it the minimum temperature at Fresno (T850 Mb (Oakland) – TMIN (Fresno)). Higher stability temperature parameter values indicate that the atmosphere is more stable, which, in turn, leads to potentially higher PM2.5 concentrations. Lower stability temperature parameter values indicate a less stable atmosphere and potentially lower PM2.5 concentrations.

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 stagnant periods. During low pressure events, unstable conditions and changes in wind speed occur. The degree of instability and strength of the wind tends to depend on the origin of the low pressure system. PM2.5 concentrations can decrease or increase depending on the characteristics of the low pressure system.

Effects of Rainfall on PM2.5 Concentration

A more detailed analysis of the cause and effect relationship between rainfall and PM2.5 concentrations in Fresno is found in the *Analysis of Data from the 2008-2009 Wood Burning Season*, presented to the Governing Board in April 2009.

This analysis included a review of a scientific research article, Model for Time-dependent Raindrop Size Distributions; Application to the Washout of Airborne Contaminants by Abraham et al.[2] According to the research, depending on the intensity of the rainfall, particles (including fine particulates) may either increase near the surface due to evaporative processes overcoming light intensity rainfall events or particles may be reduced or washed out in higher intensity rainfall events.

During light and high intensity rainfall events, calm to low wind speeds and poor vertical temperature mixing can lead to poor dispersion conditions that result in fine particulate levels remaining high. In order for horizontal mixing to occur, wind speeds must be strong enough to mix out the particulates. Stronger horizontal winds and deeper vertical mixing in the absence or presence of rainfall, typically lead to lower PM2.5 levels.

In summary, higher rainfall intensity events do not necessarily "wash out" PM2.5. Rainfall must be accompanied by either temperature instability (vertical mixing) or wind flow (horizontal mixing) to disperse fine particulates.

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[2] Abraham, F.F., et al, *Model for Time-dependent Raindrop Size Distributions; Application to the Washout of Airborne Contaminants*, IBM Journal of Research and Development, March 1972, pp. 91-96.

Summary of the Weather Conditions during the 2010-2011 Wood-Burning Season

Air quality remained good across the San Joaquin Valley through November 1st in the wake of the trough that moved through the region at the end of October. By November 2nd, a ridge of high pressure built up over California with deteriorating dispersion continuing through the next few days. The month's first trough moved into the region from the central California coast on November 6th and air quality improved throughout the Valley. Two more troughs from the Gulf of Alaska quickly followed with superior dispersion continuing through November 10th. High pressure began building over the region on November 11th and remained the dominant feature for the next six days. PM2.5 concentrations increased across the Valley under the stagnant conditions and resulted in many residential wood-burning curtailments between November 13th and 18th. The ridge weakened into a zonal flow pattern on November 18th and finally gave way to a trough from the Gulf of Alaska. Dispersion improved by November 20th and the trough scoured the pollution out of the San Joaquin Valley over the next four days. A brief ridge of high pressure followed and transitioned into a zonal flow pattern with deteriorating dispersion conditions that continued through the Thanksgiving holiday. Dispersion and air quality improved once again on November 28th and 29th with the passage of the last Gulf of Alaska trough of the month. The month ended with another ridge of high pressure building over the region on November 30th with poor dispersion and deteriorating air quality heading into December.

November ended and December began under a ridge of high pressure with poor dispersion and deteriorating air quality continuing through December 4th. The District declared many residential wood-burning curtailments as a result. The start of a series of alternating weather patterns began on December 5th and 6th with the arrival of a trough from Canada. The system brought precipitation and very cold temperatures to the region and effectively scoured the pollution out of the San Joaquin Valley. High pressure and morning fog followed on December 7th and 8th before another storm system moved through the region with more rain on December 9th and 10th. The next few days were characterized by dense fog in the mornings and cloudy skies under another ridge of high pressure. Light winds and marginal to poor dispersion affected most of the San Joaquin Valley December 9th through 14th requiring the District to declare several residential wood-burning curtailments during that period. By December 15th a trough moved into the region from the Gulf of Alaska and remained the dominant feature for the next seven days. Dispersion improved to superior conditions by December 17th with good air quality across the Valley through December 22nd. The storm system also brought heavy rainfall to the San Joaquin Valley. A brief period of high pressure provided a break from the wet conditions on December 23rd and 24th before rain resumed on Christmas day. December's last storm system continued through December 29th. The month ended under a ridge of high pressure with Good air quality lingering in the wake of the last storm.

In contrast to the abundant rainfall in December 2010, the prominent feature in January 2011 proved to be fog rather than rain. While January began and ended with

precipitation-producing troughs, lengthy high pressure patterns between the troughs routinely produced dense morning fog, afternoon clearing, and fog reformation at night.

January began with wet, windy conditions across central California as a trough moved into the region from the Gulf of Alaska. The storm system brought good dispersion conditions to the San Joaquin Valley which rendered Good air quality across the Valley through January 3rd. The trough moved eastward by January 5th followed by alternating patterns of weak ridges and troughs through January 11th. Dispersion gradually deteriorated through the period and only a small amount of precipitation accompanied the January 11th trough. On January 12th a ridge of high pressure built over the region and remained the dominant feature through January 18th. Dispersion and air quality deteriorated, and the District declared many residential wood-burning curtailments during this time. The saturated ground from the December and early January rains made the San Joaquin Valley conducive to fog formation. Afternoon heating under clear skies led to dense fog formation during the night and morning hours. Enough moisture became available in the fog and low cloud deck to produce drizzle and measureable precipitation in some areas on January 13th. On January 19th, a trough moved southward along the Sierra Nevada and broke the stretch of high pressure. Dispersion improved enough to lower PM2.5 concentrations but did not completely scour out the pollution in the San Joaquin Valley.

The first seven days of February were characterized by high pressure and deteriorating dispersion conditions over the region with many residential wood-burning curtailments declared across the Valley through the period. The first trough of the month moved southward into the region from Canada on February 8th and brought cold temperatures and good dispersion to the San Joaquin Valley. The west side of the valley became especially windy after the cold front passed through. Between February 9th and 11th, marginal dispersion conditions developed over the region and a ridge off the California coast allowed cold northerly air to continue to funnel into the valley. Morning temperatures dipped to near the freezing mark in some areas. By February 13th, the ridge moved inland over California and valley temperatures warmed. The first of a series of storm systems began on February 14th and 15th with a cold fronts that brought cold temperatures, windy conditions, and superior dispersion conditions to the San Joaquin Valley. Air quality remained in the Good to low end of the Moderate AQI range across the Valley for the remainder of the month. By February 16th, the San Joaquin Valley and Sierra Nevada received abundant precipitation that continued falling until the 19th. A weak ridge developed over the region February 20th through 24th and provided a brief drying period before more precipitation arrived on February 25th and 26th. The month's last storm system brought very cold temperatures, good dispersion, and heavy precipitation to California. Snow fell at low elevations and trace amounts were also reported in several locations on the valley floor. As the storm system moved eastward on February 27th and 28th, very cold air lingered behind. The month came to a close with night and morning temperatures at or below the freezing mark in many areas and a ridge of high pressure over the region.

Comparison of Meteorological Parameters

During the winter months, low pressure systems can move into the region, increase wind speeds and bring good dispersion to the San Joaquin Valley. In contrast, high pressure systems that build over the region during the winter tend to produce weak winds and deteriorating dispersion conditions in the San Joaquin Valley. When weather patterns change, stability also changes. Higher stability temperatures indicate the presence of high pressure and lower stability temperatures indicate the presence of low pressure.

As shown in Figures 16-19, average stability temperature tends to be lower during December and February and higher during November and January. The majority of precipitation-producing storm systems tend to favor December, January, and February while November is characteristically drier. The winter season's alternating weather patterns generally render light winds characteristic of the San Joaquin Valley with average wind speeds ranging two to six miles per hour. Average temperatures indicate that December and January are the coldest months in the valley with minimum temperatures ranging in the 30s and 40s, and maximum temperatures generally in the 50s.

Figure 16. Modesto Meteorological Parameter Comparison

Modesto						
		Avg Wind Speed (mph)	Avg Min Temp (F)	Avg Max Temp (F)	Total Precip (inches)	Avg Morning Stability (C)
November	2010	4.2	43	63	2.2	1.4
	2009	4.2	41	65	0.2	4.1
	2008	3.8	47	68	0.6	1.6
	2007	3.9	45	70	0.4	4.0
	2006	5.1	47	64	1.0	0.1
December	2010	4.6	44	56	3.6	-1.9
	2009	4.0	39	54	1.6	2.0
	2008	4.2	39	53	1.4	1.7
	2007	5.4	39	56	2.0	-0.2
	2006	5.2	38	57	2.0	3.7
January	2011	3.1	40	51	1.2	4.6
	2010	4.8	43	53	4.2	0.4
	2009	3.1	38	59	1.3	5.9
	2008	5.1	41	55	5.0	-0.8
	2007	4.8	33	57	0.4	5.2
February	2011	4.8	38	59	2.4	0.0
	2010	4.5	45	60	2.9	-2.3
	2009	5.3	44	61	2.4	-5.8
	2008	5.3	42	62	1.8	0.1
	2007	5.5	43	61	2.1	-1.2
Wood-Burning Season	2010-2011	4.2	41	57	9.4	1.0
	2009-2010	4.4	42	58	8.9	1.1
	2008-2009	4.1	42	60	5.7	1.6
	2007-2008	4.9	42	60	9.1	0.8
	2006-2007	5.1	40	60	5.5	2.0

Figure 17. Fresno Meteorological Parameter Comparison

Fresno						
		Avg Wind Speed (mph)	Avg Min Temp (F)	Avg Max Temp (F)	Total Precip (inches)	Avg Morning Stability (C)
November	2010	3.5	44	64	1.9	0.8
	2009	2.9	43	66	0.2	3.3
	2008	2.8	48	67	1.4	1.3
	2007	2.8	46	69	0.1	3.5
	2006	4.3	47	64	0.2	-0.1
December	2010	3.9	44	57	5.9	-1.9
	2009	3.6	39	55	2.6	1.6
	2008	3.4	38	52	1.1	1.7
	2007	3.7	37	54	2.3	0.7
	2006	3.7	38	57	1.0	3.8
January	2011	2.5	41	52	1.7	4.0
	2010	4.3	42	55	2.0	0.7
	2009	2.1	39	57	1.1	5.4
	2008	4.8	39	55	3.3	-0.2
	2007	3.3	33	55	0.6	5.7
February	2011	4.2	39	59	1.6	-0.6
	2010	3.4	45	59	2.9	-2.7
	2009	4.6	43	60	2.6	-4.2
	2008	4.2	42	61	2.1	0.2
	2007	5.3	43	60	2.3	-1.2
Wood-Burning Season	2010-2011	3.5	42	58	11.1	0.6
	2009-2010	3.5	42	59	7.8	0.7
	2008-2009	3.2	42	59	6.2	1.6
	2007-2008	3.9	41	60	7.8	1.1
	2006-2007	4.1	40	59	4.2	2.0

Figure 18. Bakersfield Meteorological Parameter Comparison

Bakersfield						
		Avg Wind Speed (mph)	Avg Min Temp (F)	Avg Max Temp (F)	Total Precip (inches)	Avg Morning Stability (C)
November	2010	4.2	44	66	0.8	0.7
	2009	3.9	45	67	0.1	2.3
	2008	3.8	49	67	1.1	0.8
	2007	3.6	49	68	0.1	2.0
	2006	4.5	47	65	0.0	0.0
December	2010	4.1	45	60	5.8	-2.2
	2009	3.6	40	57	1.8	1.2
	2008	3.9	39	52	0.6	1.2
	2007	3.9	37	56	0.4	0.6
	2006	4.9	38	59	0.6	3.3
January	2011	3.4	40	54	0.4	4.6
	2010	4.3	43	57	1.9	0.2
	2009	3.0	42	60	0.4	3.9
	2008	6.2	41	57	0.6	-1.1
	2007	4.6	34	56	0.3	5.0
February	2011	4.4	39	61	0.5	-0.6
	2010	3.9	45	61	1.9	-2.7
	2009	5.2	45	66	1.8	-5.4
	2008	4.9	43	62	0.9	-0.5
	2007	5.5	43	63	0.8	-1.1
Wood-Burning Season	2010-2011	4.0	42	60	7.5	0.7
	2009-2010	3.9	43	60	5.7	0.3
	2008-2009	4.0	44	61	4.0	0.7
	2007-2008	4.6	42	61	2.0	0.2
	2006-2007	4.9	40	61	1.7	1.8

Figure 19. Fresno Meteorological Parameter Comparison per Wood-Burning Season

Fresno					
Wood-Burning Season	Avg Wind Speed (mph)	Avg Min Temp (F)	Avg Max Temp (F)	Total Precip (inches)	Avg Morning Stability (C)
1999-2000	4.5	42	62	10.0	0.7
2000-2001	4.0	39	57	5.0	1.6
2001-2002	4.3	42	59	5.4	0.6
2002-2003	3.8	44	60	5.8	0.9
2003-2004	4.4	42	58	11.7	-1.1
2004-2005	4.4	43	57	5.8	-0.1
2005-2006	4.2	44	62	6.0	0.8
2006-2007	4.1	40	59	4.2	2.0
2007-2008	3.9	41	60	7.8	1.1
2008-2009	3.2	42	59	6.2	1.6
2009-2010	3.5	42	59	7.8	0.7
2010-2011	3.5	42	58	11.1	0.6

Seasonal Comparison of Meteorological Statistics

As a part of the 2010-2011 wood-burning season analysis, the District compared the distribution of key meteorological parameters that can influence PM2.5 concentrations against the same parameters in previous seasons. The analysis uses daily average wind speed and morning stability as parameters for comparison against each wood-burning season in Modesto, Fresno, and Bakersfield. Figures 20 through 25 display box-whisker plots, which represent the distribution of all observed values during each wood-burning season. The center line in the box represents the median value (50^{th} percentile, or Q2), while the bottom and top lines of the box represent the 25^{th} and 75^{th} percentiles (or Q1 and Q3), respectively. The interquartile range (IQR) is defined as the difference between the 75^{th} and 25^{th} percentile values, so that IQR = Q3 – Q1. Statistical outliers are shown as an "X" and are defined here as any value that resides outside of the range [Q1 – 1.5*IQR, Q3 + 1.5*IQR].

As shown in Figures 20, 22, and 24, the wind speed distribution Q2 values remained stable this past season when compared to the 2009-2010 wood-burning season, yet the Q3 value increased at all three locations. This shows that although the median wind speed was fairly similar, each location was more prone to experiencing higher wind speeds than they were last season. The exception to this was in Modesto, where the wind speed Q2 value for the 2010-2011 wood-burning season shows a distinct decrease when compared to last season.

As shown in Figures 21, 23, and 25, the temperature stability Q2 value at all locations remained similar this season when compared to the last, yet the IQR value increased across the board. This indicates a greater variation in temperature stability across the San Joaquin Valley.

Figure 20. Modesto Distribution of Wind Speed per Wood-Burning Season

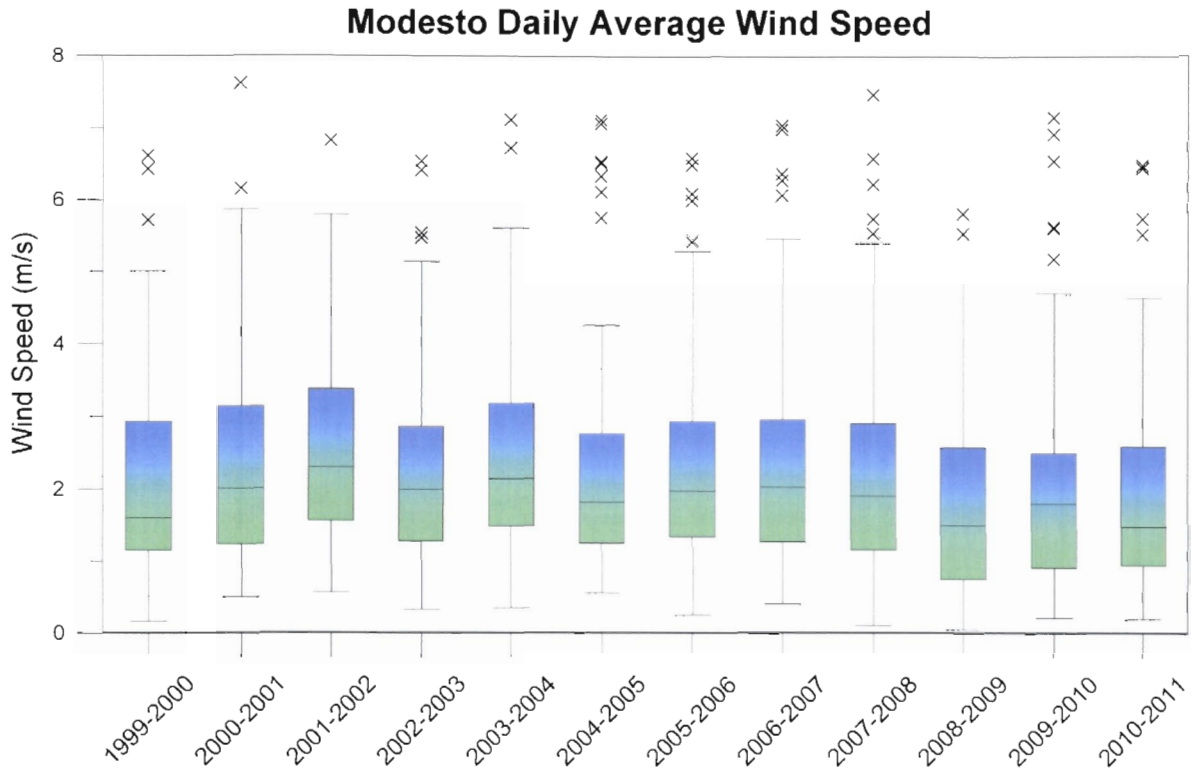


Figure 21. Modesto Distribution of Morning Stability per Wood-Burning Season

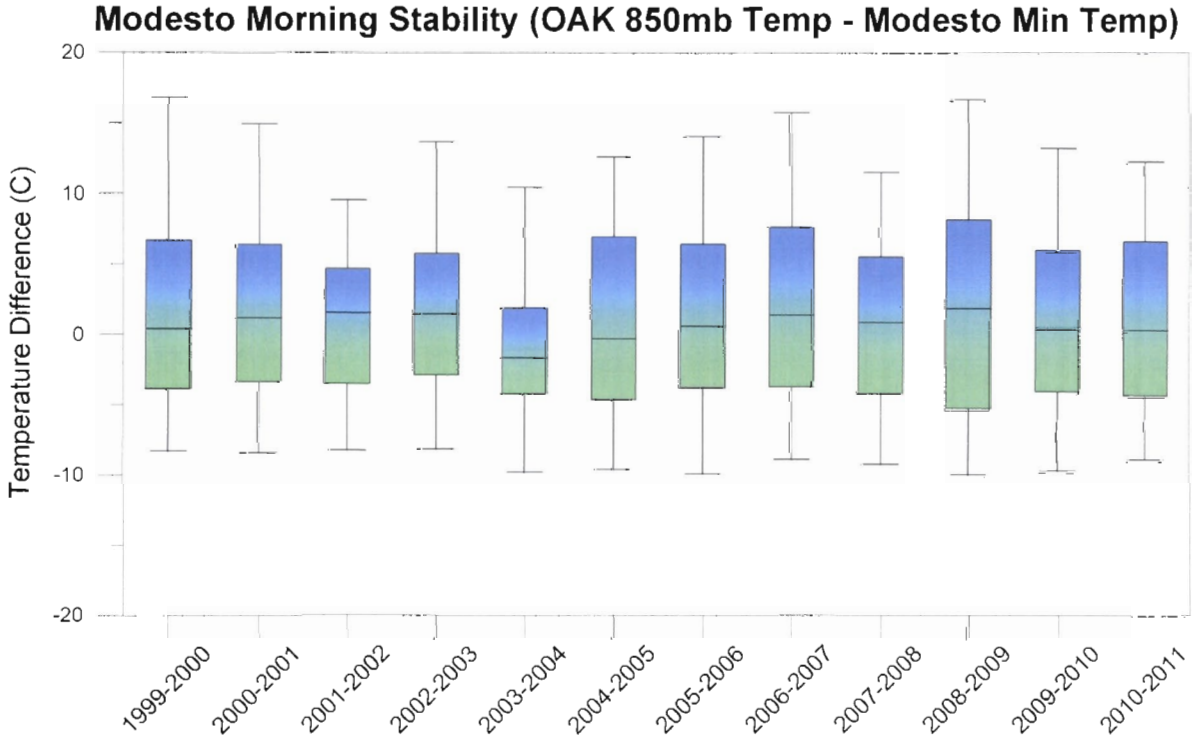


Figure 22. Fresno Distribution of Wind Speed per Wood-Burning Season

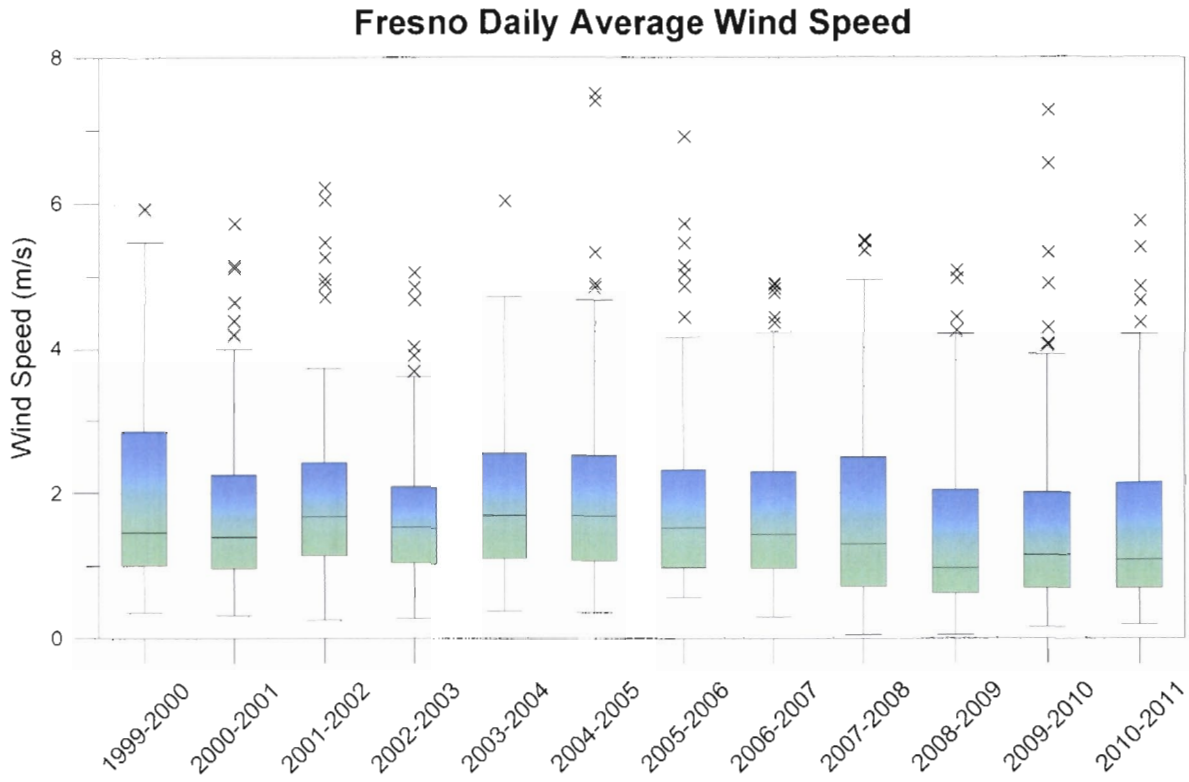


Figure 23. Fresno Distribution of Morning Stability per Wood-Burning Season

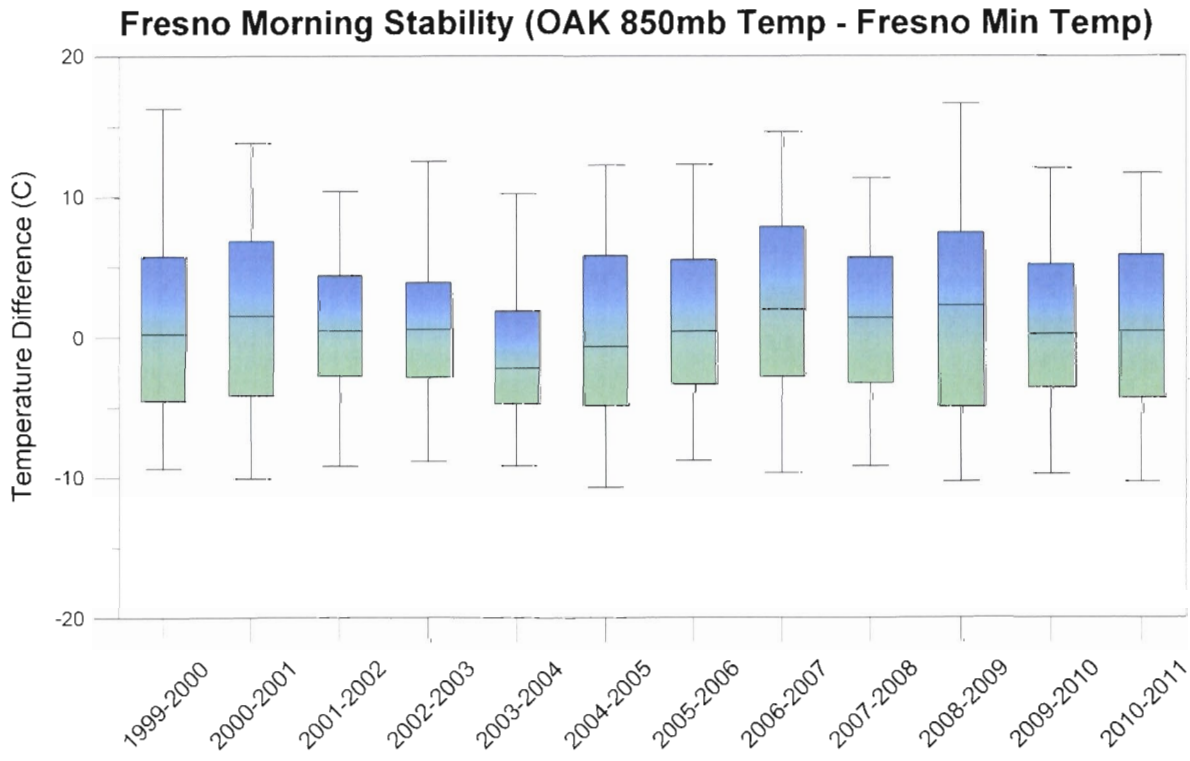


Figure 24. Bakersfield Distribution of Wind Speed per Wood-Burning Season

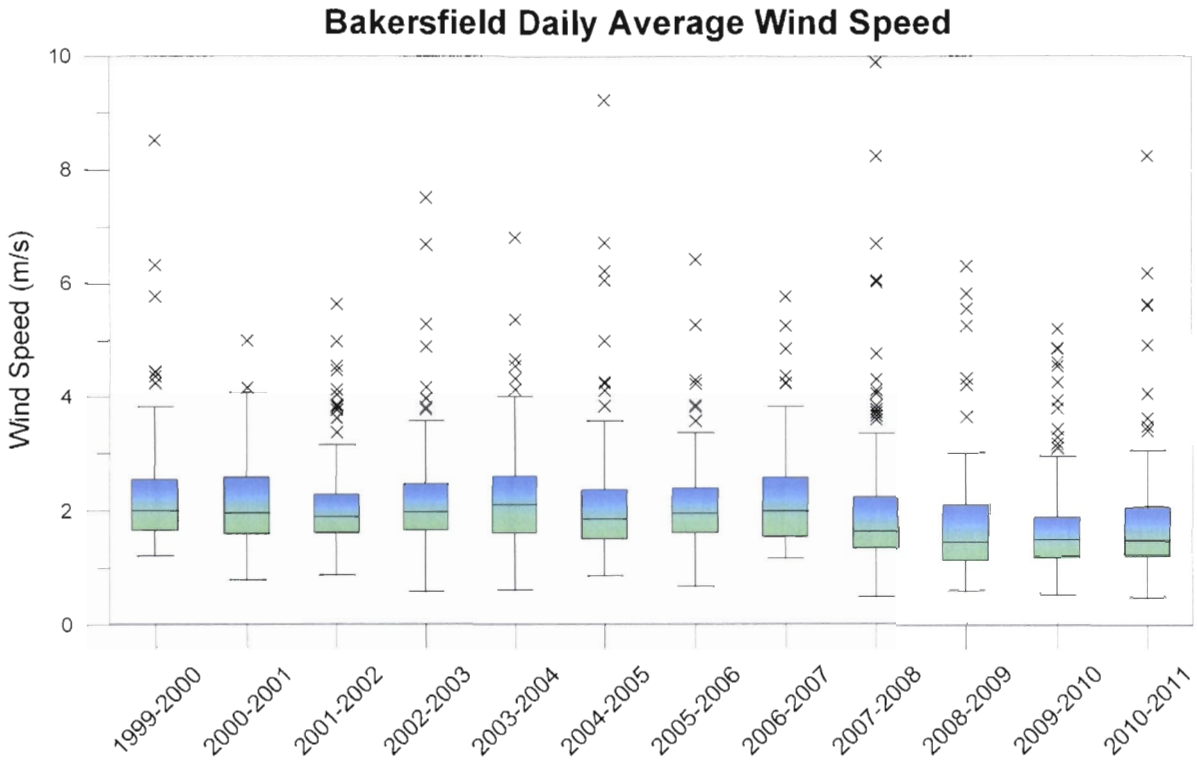
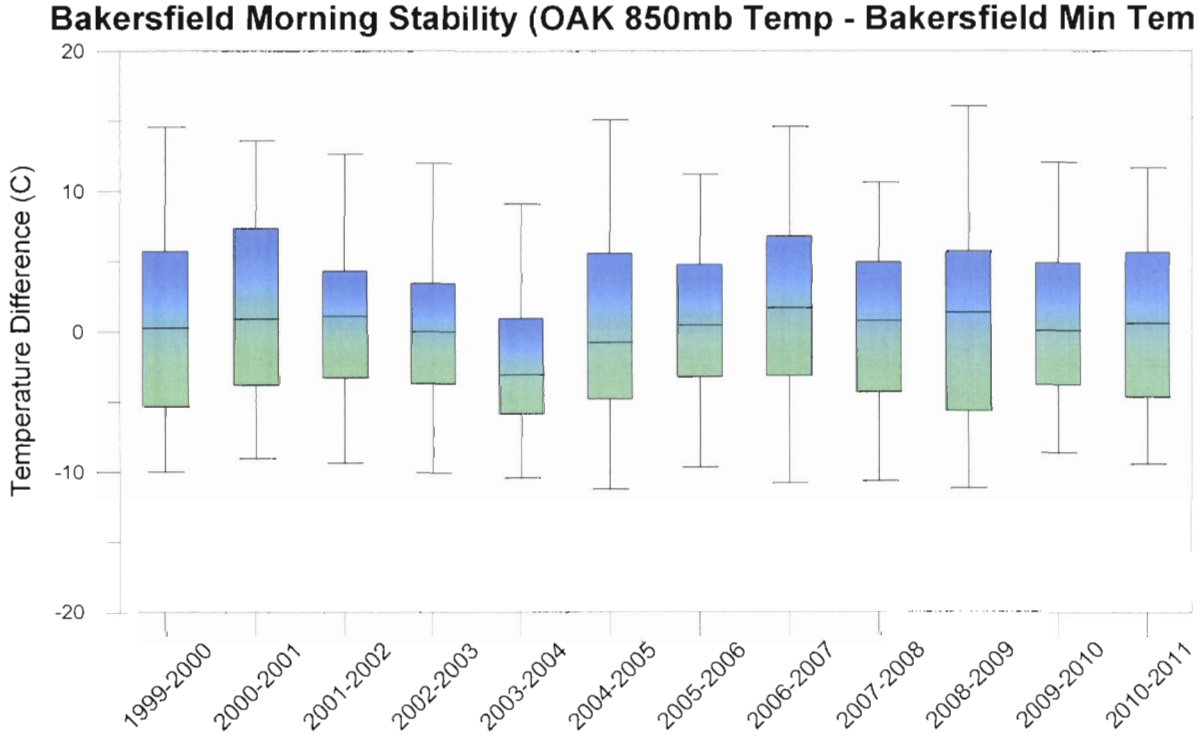


Figure 25. Bakersfield Distribution of Morning Stability per Wood-Burning Season



V. EVALUATION OF RULE 4901 EFFECTIVENESS

The District developed a statistical model to quantify PM2.5 reductions and evaluate air quality improvements attributable to the 2003 and 2008 amendments to Rule 4901. This modeling indicates that as of the 2010-2011 wood-burning season, there has been a 48 percent (23 $\mu g/m^3$) improvement in the 24-hour average PM2.5 concentration at the Fresno-First monitoring site since the 2003 and 2008 amendments to Rule 4901. This improvement is exemplified in PM2.5 concentrations measured during the evening hours of 8:00 p.m. to 12:00 a.m. at the same monitoring site. The average evening PM2.5 concentrations have improved by 57 percent (42 $\mu g/m^3$) over the same time period. As shown in this analysis, the 2008 amendments to Rule 4901 have approximately doubled the seasonal improvements attributable to the 2003 amendments. This analysis focuses on the Fresno First Street air monitoring site, which is representative of other regions in the Valley. Over the next year, the District will be expanding the model to quantify the benefits of Rule 4901 specific to other portions of the Valley.

The District developed the statistical model that uses 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. Results from this model were used to evaluate rule effectiveness through the winter of 2010-2011. 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. This statistical analysis of pre-Rule 4901 meteorology and PM2.5 relationships made it possible to predict daily and hourly PM2.5 levels in the period following the 2003 and 2008 rule amendments, which can be compared to observed PM2.5 concentrations at the monitor sites. 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.

Figure 26 and 27 show changes in daily and evening wintertime PM2.5 concentrations prior to 2003 amendments, after 2003 amendments and after 2008 amendments. Figure 28 and 29 show annual improvements in daily and evening wintertime PM2.5 concentrations. Figure 30 shows the distribution of evening wintertime PM2.5 improvement by year. More improvement during evening hours and sharp improvements after rule amendments are consistent with the assertion that Rule 4901 amendments have significantly reduced PM2.5 concentrations.

Figure 31 shows the expected distribution of daily wintertime PM2.5 without the 2003 and 2008 Rule 4901 amendments. This graph clearly indicates that recent winters have had the potential to produce PM2.5 concentrations as high, if not higher than any year during the past decade. From this, the District concludes that meteorology is not responsible for observed improvements in wintertime PM2.5 concentrations. Section IV of this document further indicates that meteorological fluctuations are inconsistent with the magnitude of observed PM2.5 reductions.

Figure 32 and 33 compare the distribution of evening PM2.5 changes based on expected concentration ranges after 2003 and 2008 Rule 4901 amendments. These charts are consistent with expectations of amendment implementation. Figure 33 shows that amendments in 2008, which lowered curtailment thresholds, had more influence reducing PM2.5 concentrations than amendments in 2003.

Overall, the Valley's PM2.5 concentrations have dramatically decreased since the 2003 and 2008 Rule 4901 amendments. Without this further analysis, it would have been unclear if decreases in PM2.5 concentrations could be attributed to reductions in residential wood-burning or changes in seasonal weather patterns.

Figure 26. Fresno First Street PM2.5 Percent Change by Rule Period

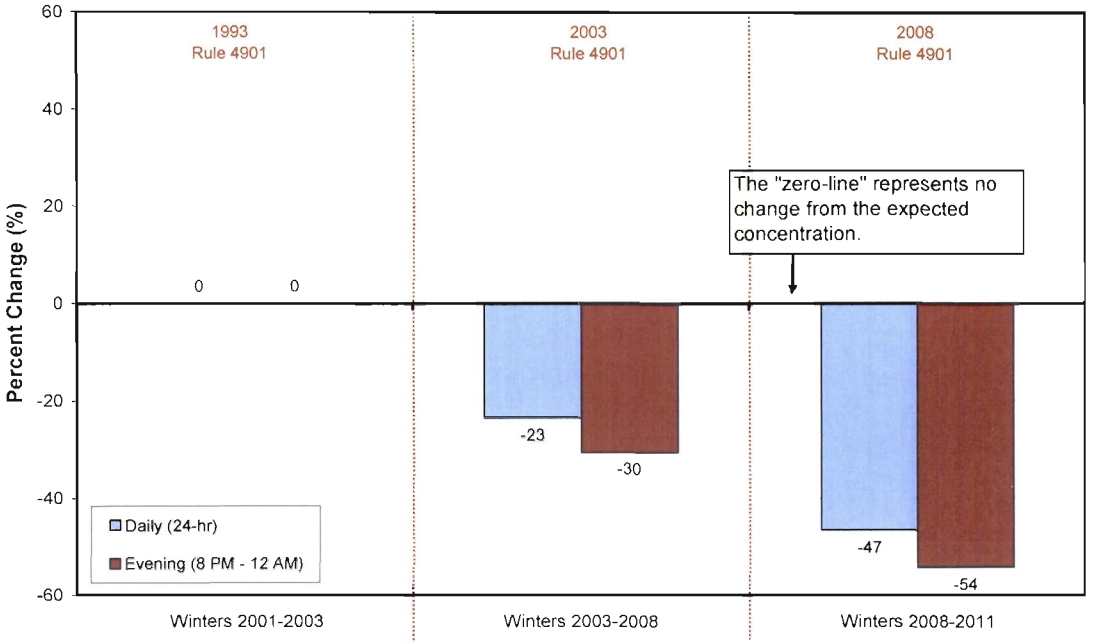


Figure 27. Fresno First Street PM2.5 Concentration Change by Rule Period

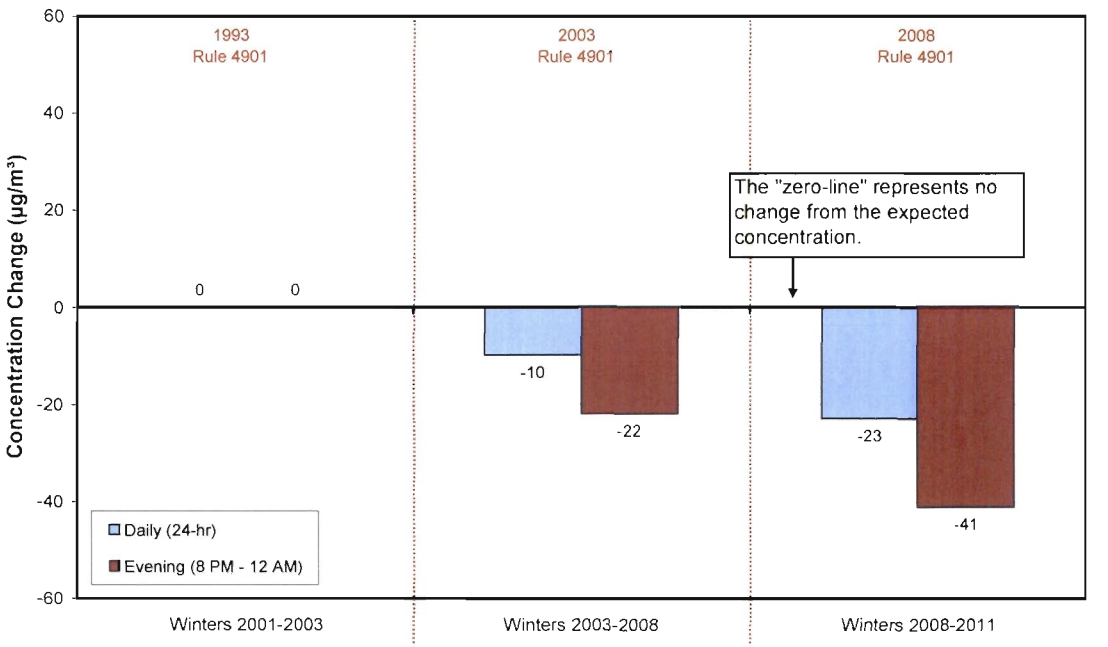


Figure 28. Fresno First Street PM2.5 Percent Change by Season

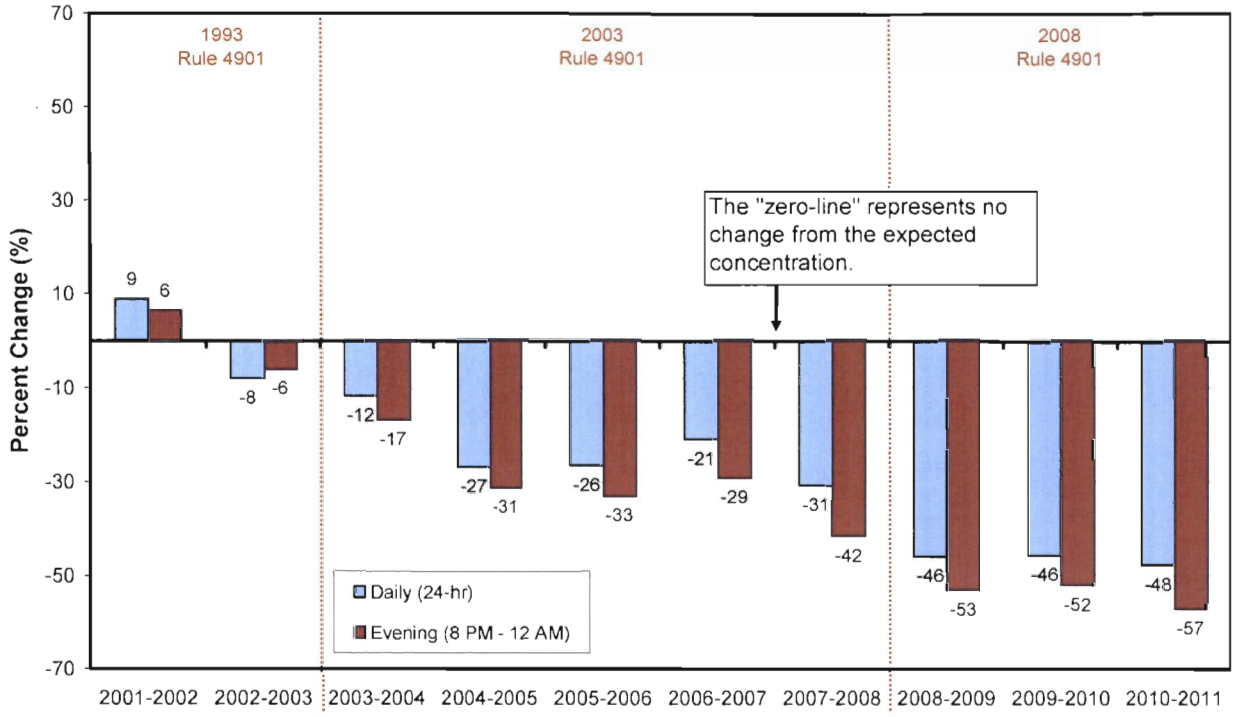


Figure 29. Fresno First Street PM2.5 Concentration Change by Season

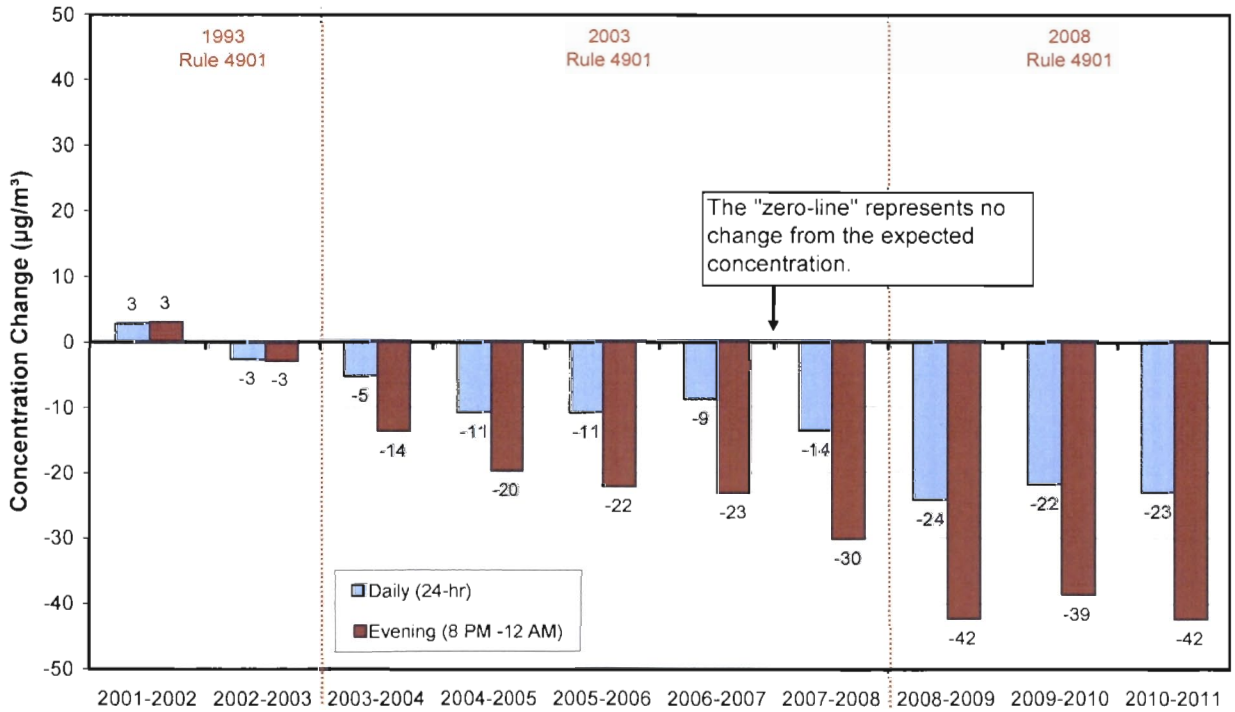


Figure 30. Fresno First Street Distribution of Evening (8 PM to 12 AM) PM2.5 Improvement

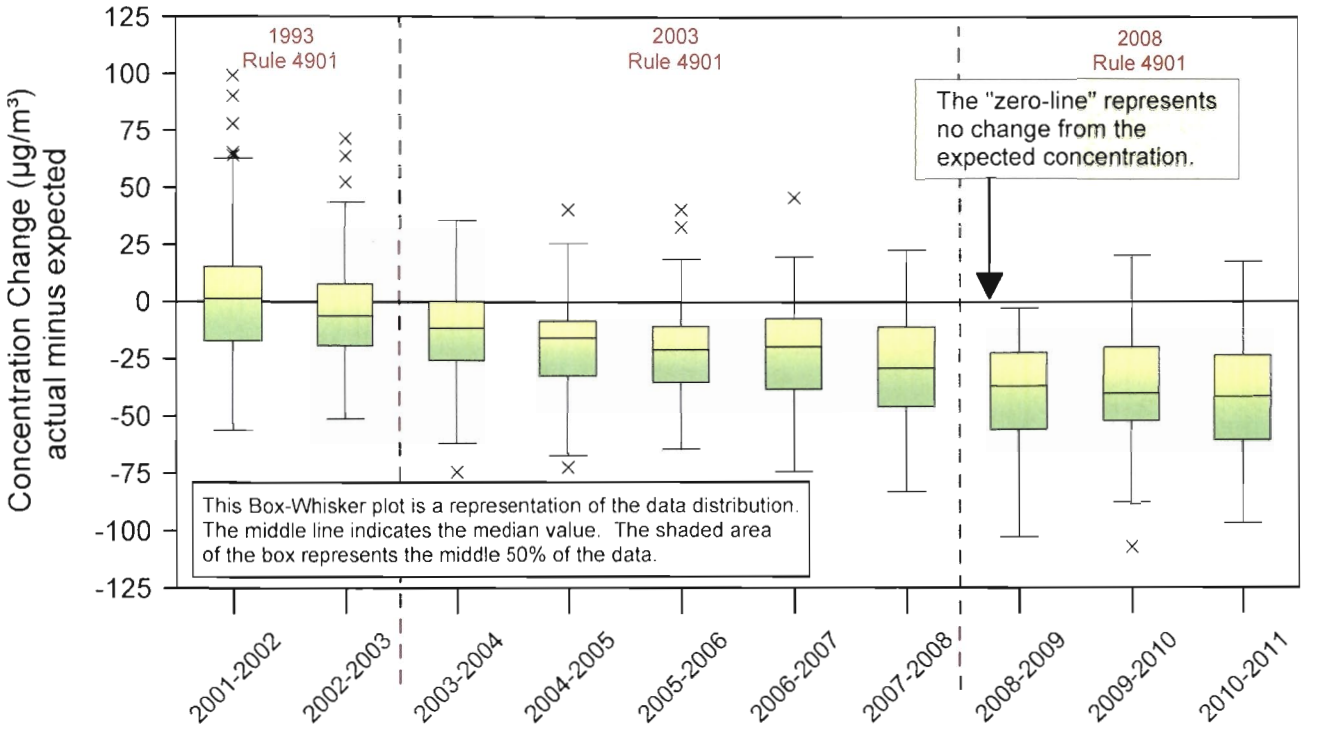


Figure 31. Fresno First Street Expected Distribution of Daily PM2.5 Concentrations from Model

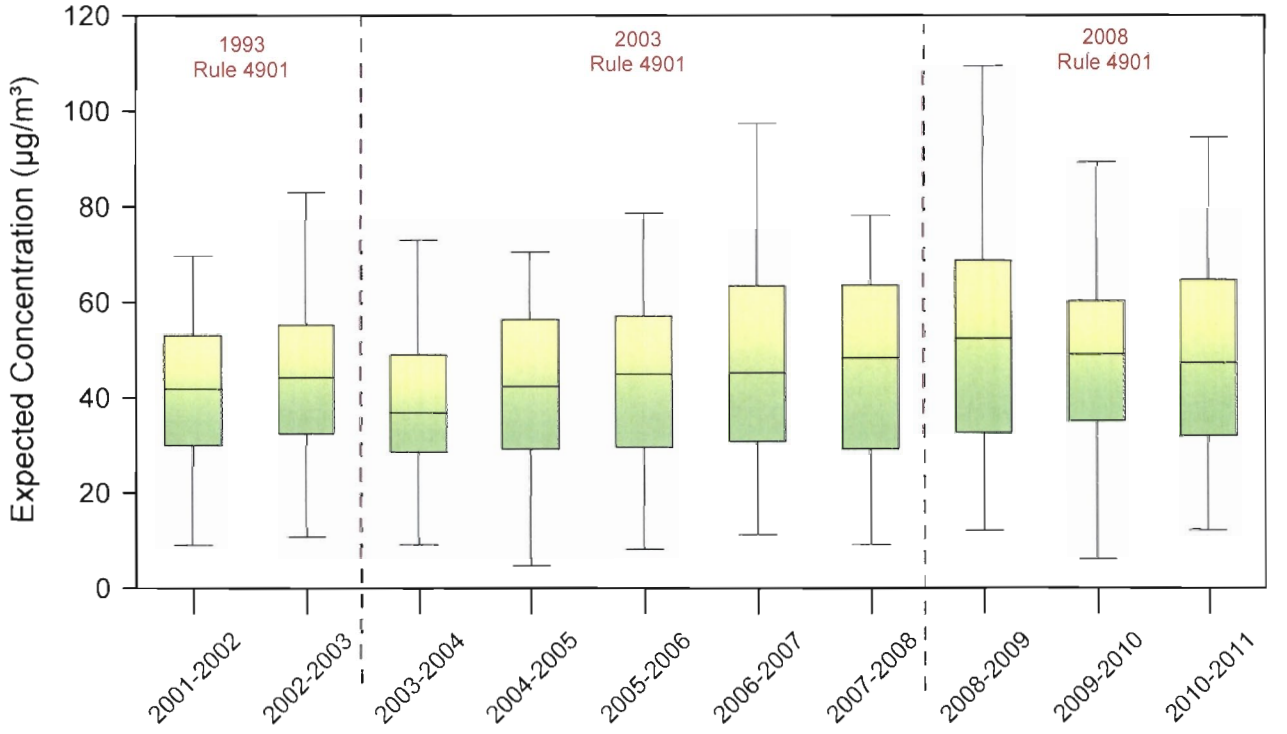


Figure 32. Fresno First Street Reduction in Evening (8 PM to 12 AM) PM2.5 During Winters 2003-04 to 2007-08

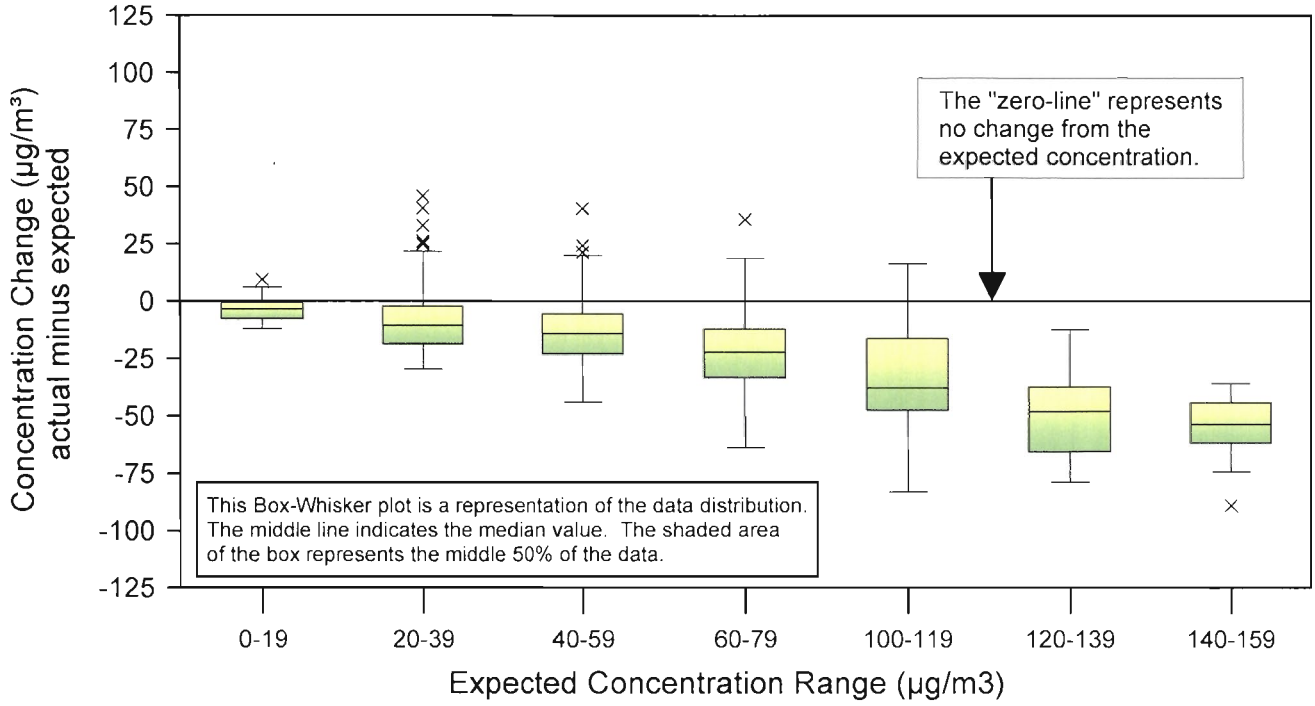


Figure 33. Fresno First Street Reduction in Evening (8 PM to 12 AM) PM2.5 During Winters 2008-2009 to 2010-2011