Sonoma Technology, Inc.
Air Quality Research and Innovative Solutions

State of Arizona Exceptional Event Documentation for the Event of September 2, 2011, for the Phoenix PM_{10} Nonattainment Area

Final Report Prepared for

Arizona Department of Environmental Quality
Phoenix, AZ

January 23, 2013

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State of Arizona Exceptional Event Documentation for the Event of September 2, 2011, for the Phoenix PM_{10} Nonattainment Area

Final Report
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Cover image depicts suspended dust and haze in the Phoenix area at 0910 LST on September 2, 2011, resulting from thunderstorm outflow that transported dust into the region several hours prior. This photo was taken by an ADEQ visibility camera in downtown Phoenix, looking northeastward toward Camelback Mountain.

Acknowledgments

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1. Introduction

On September 2, 2011, 11 air quality monitors in the Phoenix PM_{10} nonattainment area recorded 24-hr average PM_{10} concentrations in excess of the National Ambient Air Quality Standard (NAAQS) of 150 µg/m^3. The purpose of this report is to demonstrate that this exceedance was due to naturally occurring windblown dust, was not reasonably controllable or preventable, was historically unusual, and would not have occurred "but-for" the windblown dust and, therefore, is an Exceptional Event as defined by the U.S. Environmental Protection Agency's (EPA) Exceptional Events Rule (EER).

1.1 Report Contents

Section 2 of this assessment contains a conceptual model of the wind-blown dust event that transpired on September 2, 2011, providing a background narrative of the exceptional event and an overall explanation that the event affected air quality. Section 2 also provides evidence that the event was a natural event.

Section 3 of this assessment establishes a clear causal connection between the natural event on September 2, 2011, and the exceedances of the 24-hr PM_{10} standard at the monitoring stations. The evidence in this section also confirms that the event in question both affected air quality and was the result of natural events.

Section 4 of this assessment illustrates that the event of September 2, 2011, produced PM_{10} concentrations in excess of normal historical fluctuations.

Section 5 of this assessment details the existing dust control measures and demonstrates that despite the presence and enforcement of these controls, the event of September 2, 2011, was not reasonably controllable or preventable.

Section 6 of this assessment builds upon the demonstration, showing a clear causal connection between the natural event and the exceedances, and concludes that the exceedances of the 24-hr PM_{10} standard on September 2, 2011, would not have occurred "but for" the event.

Appendix A contains time-series graphs and data tables to supplement Section 3. **Appendix B** contains links to media coverage pertaining to this dust storm event. **Appendix C** contains time-series graphs to supplement Section 4. **Appendix D** contains air quality forecasts issued by the Arizona Department of Environmental Quality (ADEQ) and weather statements and warnings issued by the National Weather Service. **Appendix E** contains a copy of the affidavit of public notice concerning this assessment report.

1.2 Exceptional Event Rule Requirements

In addition to the technical requirements that are contained within the EER, procedural requirements must also be met in order for the EPA to concur with the flagged air quality

monitoring data. This section of the report contains the requirements of the EER and associated guidance, and discusses how ADEQ addressed those requirements.

1.2.1 Public Notification That the Event Was Occurring (40 CFR 50.14(c)(1)(i))

ADEQ issued Dust Control Action Forecasts and Air Quality Forecasts for Maricopa County advising citizens of the potential for high wind dust events on September 2, 2011. More information on ADEQ's forecasting program can be found in Section 5.2 of this report. The forecast products that were issued pertaining to the September 2, 2011 event are included in Appendix D.

1.2.2 Place Informal Flag on Data in AQS (40 CFR 50.14(c)(2)(ii))

ADEQ and other operating air quality agencies in Arizona submit data into the EPA's Air Quality System (AQS), the official repository of ambient air quality data. This data submittal to AQS includes particulate matter (PM) data from both filter-based and continuous monitors operated in Arizona.

When ADEQ and/or another agency operating monitors in Arizona suspect that data may be influenced by an exceptional event, ADEQ and/or the other operating agency expedites analysis of the filters collected from the potentially-affected filter-based air monitoring instruments, quality-assures the results, and submits the data into AQS. ADEQ and/or other operating agencies also submit data from continuous monitors into AQS after quality assurance is complete.

If ADEQ and/or other operating air quality agencies have determined that a potential exists that a monitor's reading(s) have been influenced by an exceptional event, a preliminary flag is submitted for the measurement in AQS. The data are not official until they undergo more thorough quality assurance and quality control, leading to certification by May 1 of the year following the calendar year in which the data were collected (40 CFR 58.15(a)(2)). The presence of the flag on the September 2, 2011, data can be confirmed in AQS.

1.2.3 Notify EPA of Intent to Flag Through Submission of Initial Event Description by July 1 of Calendar Year Following Event (40 CFR 50.14(c)(2)(iii))

ADEQ submitted notice to EPA on August 29, 2012, listing all days from calendar year 2011 that ADEQ intends to analyze under the Exceptional Events Rule. The PM_{10} exceedances that occurred on September 2, 2011, in the Phoenix PM_{10} nonattainment area were included on this list. This assessment report serves as demonstration supporting the flagging of these data.

1.2.4 Document That the Public Comment Process Was Followed for Event Documentation (40 CFR 50.14(c)(3)(iv))

ADEQ posted this assessment report on the ADEQ webpage and placed a hard copy of the report in the ADEQ Records Management Center for public review. ADEQ opened a 30-day

public comment period on December 3, 2012. A copy of the public notice certification, along with any comments received, will be submitted to EPA, consistent with the requirements of 40 CFR 50.14(c)(3)(iv). See Appendix E for a copy of the affidavit of public notice.

1.2.5 Submit Demonstration Supporting Exceptional Event Flag (40 CFR 50.14(a)(1-2))

At the close of the public comment period, and after ADEQ has had the opportunity to consider any comments submitted on this document, ADEQ will submit this document, the comments received, and ADEQ's responses to those comments to EPA Region 9 headquarters in San Francisco, California. The deadline for the submittal of this package is September 30, 2014.

1.2.6 Documentation Requirements (40 CFR 50.14(c)(3)(iii))

The EER states that in order to justify the exclusion of air quality monitoring data, evidence must be provided for the following elements:

1. The event satisfies the criteria set forth in 40 CFR 501(j) that
    a. the event affected air quality,
    b. the event was not reasonably controllable or preventable, and
    c. the event was caused by human activity unlikely to recur in a particular location or was a natural event;
2. There is a clear causal relationship between the measurement(s) under consideration and the event;
3. The event is associated with a measured concentration(s) in excess of normal historical fluctuations; and
4. There would have been no exceedance or violation but for the event.

2. Conceptual Model

This section provides a narrative background and summarizes the meteorological and air quality conditions in place on September 2, 2011, in the Phoenix area. Elements described in this section include

- A description and map of geographic setting of the air quality and meteorological monitors.
- A description of Phoenix's climate.
- An overall description of meteorological and air quality conditions on the event day.

2.1 Geographic Setting and Monitor Locations

Phoenix is located in the Salt River Valley in south-central Arizona. It lies at an elevation of 1,090 feet above mean sea level (msl) in the northeastern part of the Sonoran Desert. Other than the mountains in and around the city, the topography of Phoenix is generally flat. The Phoenix area is surrounded by the McDowell Mountains (~4,200 ft msl) to the northeast, the foothills of the Bradshaw (~7,900 ft msl) and Mazataal (~7,900 ft msl) ranges to the north, the White Tank Mountains (~4,500 ft msl) to the west, the Sierra Estrella (~4,450 ft msl) to the southwest, and the Superstition Mountains (~5,000 ft msl) far to the east. Within the City are the Phoenix Mountains (~2,600 ft msl) and South Mountain (~2,600 ft msl). Current development is pushing north, west, and south into Pinal County.

A fairly dense network of air quality and meteorological monitors exists throughout the Phoenix area, with a much less dense network of monitors throughout the rest of Arizona. **Figure 2-1** shows the general geographic setting of Phoenix, as well as the locations of meteorological monitors and the PM_{10} monitors that recorded exceedances on September 2, 2011. It should be noted that some of the monitors shown in Figure 2-1 are filter-based monitors; therefore, monitoring data from all locations may only be available for select days (i.e., 1-in-6 run days). AQS monitors measure both air quality and meteorological data. Some of the AQS monitors in the Phoenix area are run by the Maricopa County Air Quality Department (MCAQD) while others are run by ADEQ. Arizona Meteorological Network (AZMET) and National Weather Service (NWS) monitors measure meteorological data only. Several Arizona AZMET and NWS sites are in operation in the Phoenix area. Phoenix Sky Harbor International Airport (KPHX) was the primary NWS site used in this demonstration package because of that site's high data quality, data completeness, proximity to AQS sites, and representativeness of meteorological conditions in the Phoenix area. **Figure 2-2** shows monitors statewide measuring PM_{10} on September 2, 2011.

Figure 2-3 depicts the drainage systems or watersheds for the State of Arizona. Many of the rivers that form Arizona's drainage system are dry for most of the year and, consequently, are sources of silt and fine soils that become suspended and add to regional PM_{10} loadings during high wind events. Much of this alluvial matter and fine soil is deposited in the low lying areas of central and southern Arizona, with larger depositional areas focused in and around the confluences of dry river channels.

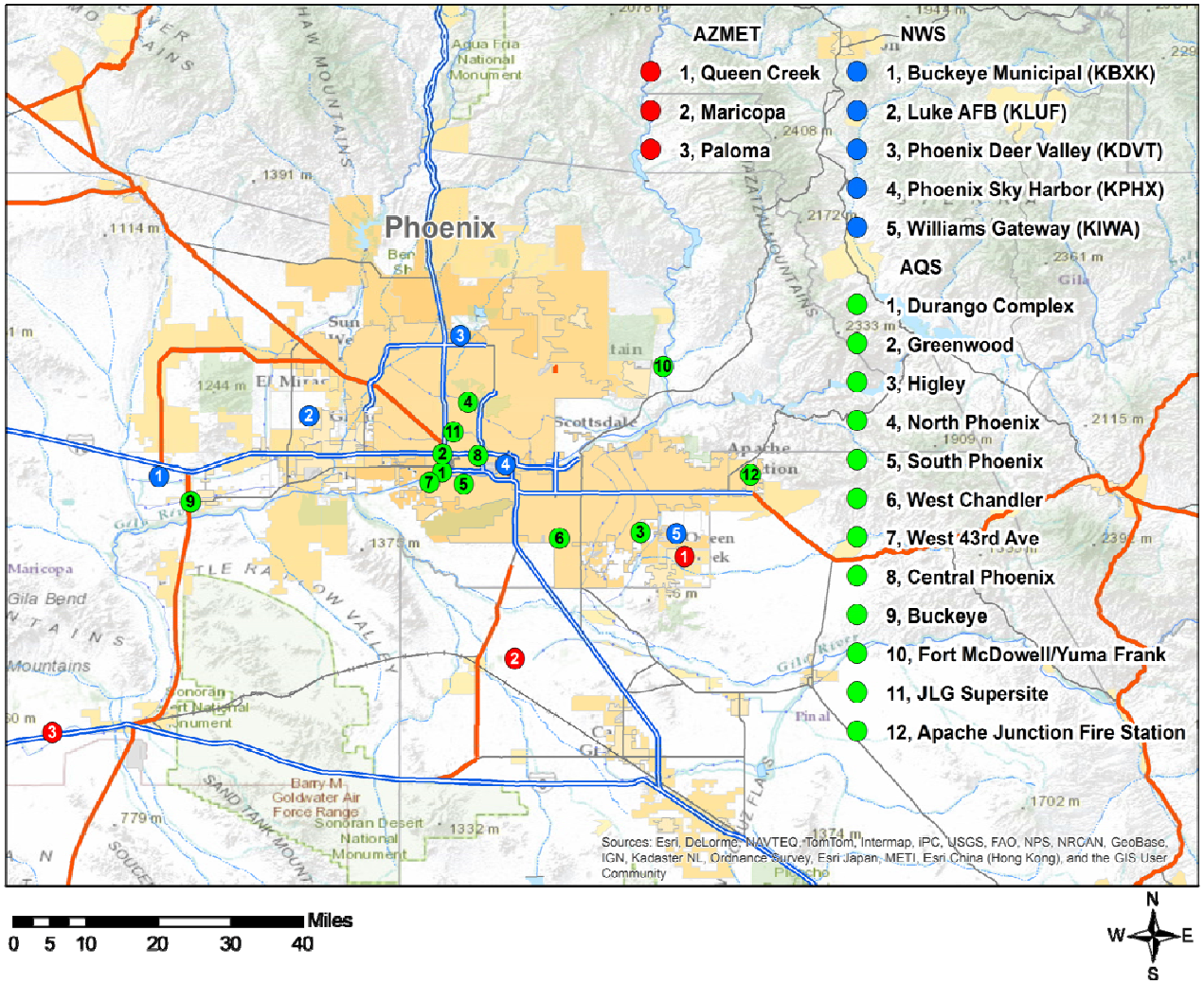


Figure 2-1. Locations of air quality monitors that recorded exceedances of the 24-hr PM_{10} NAAQS and meteorological monitors in the Phoenix area.

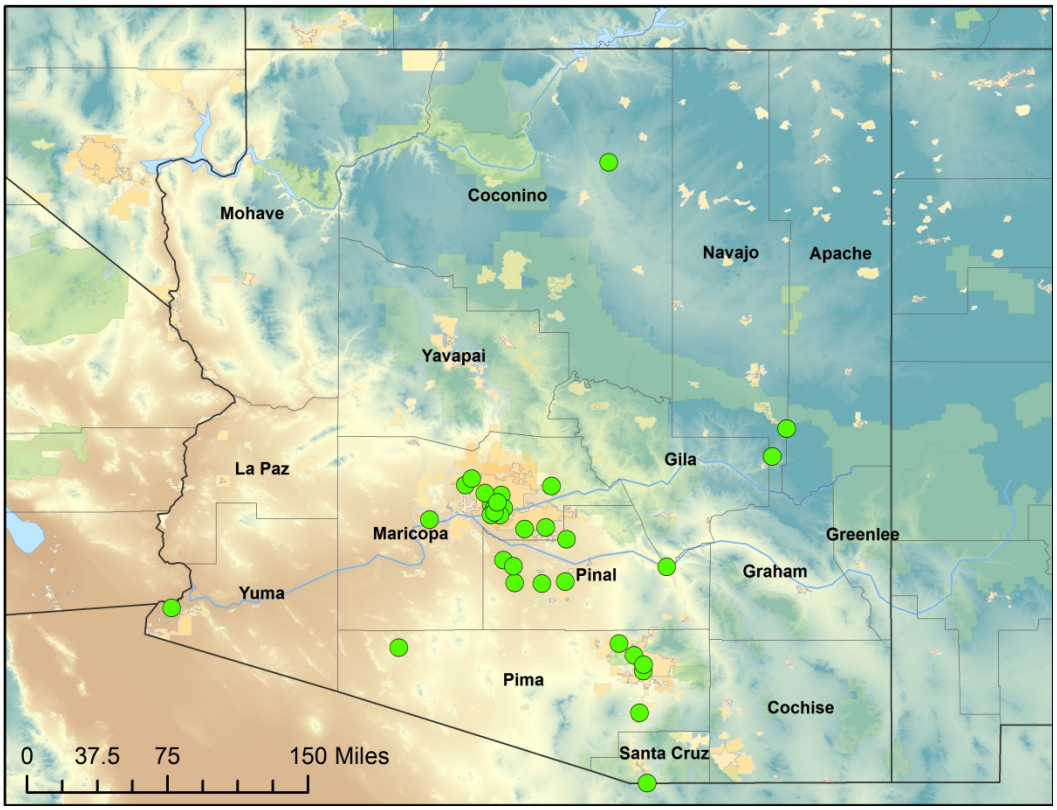


Figure 2-2. Location of sites monitoring PM_{10} in Arizona on September 2, 2011.

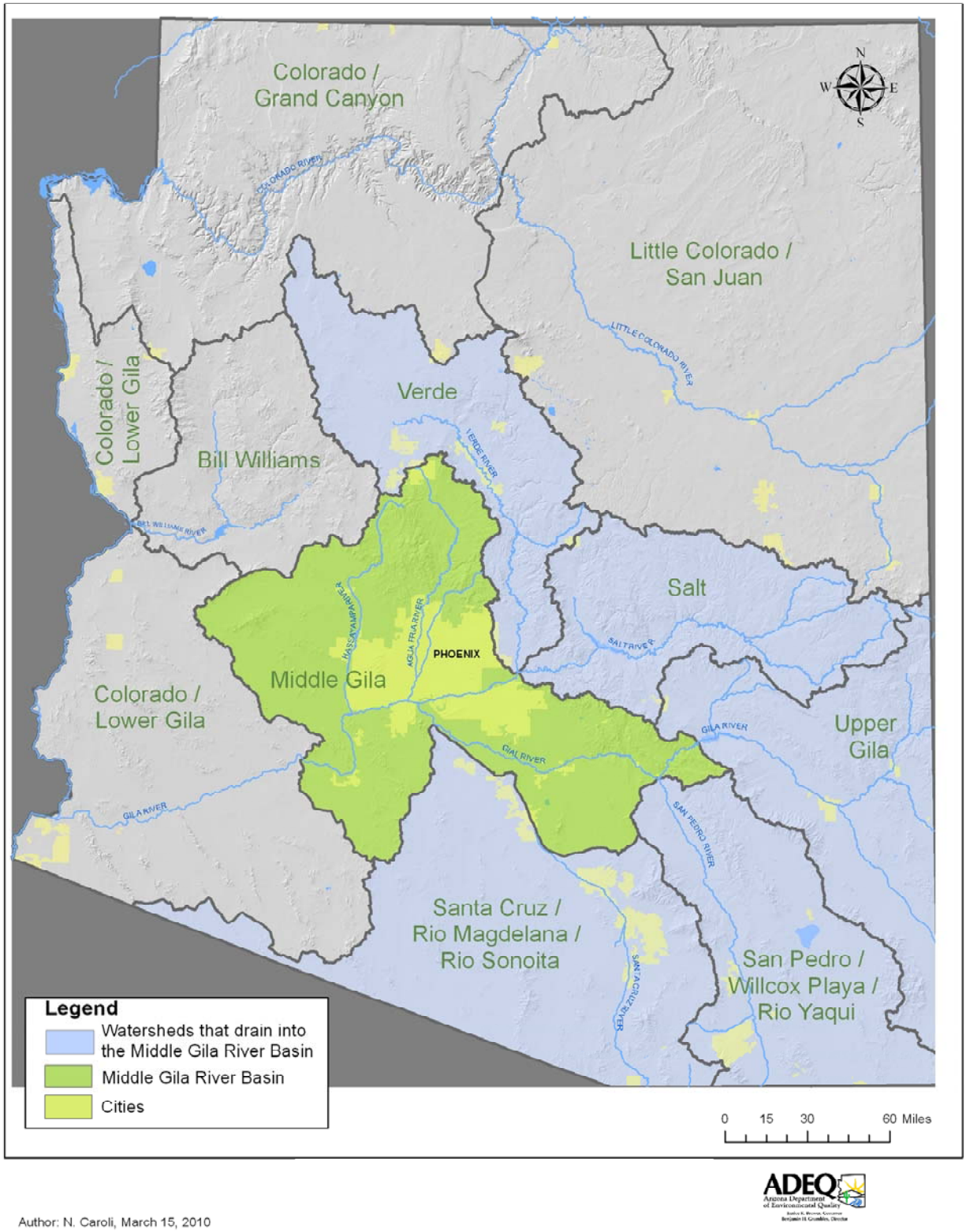


Figure 2-3. Drainage system of Phoenix, Arizona.

2.2 Climate, Monsoon, and Thunderstorms

Phoenix has an arid climate, with very hot summers and temperate winters. The average summer high temperatures are among the hottest of any populated area in the United States (**Figure 2-4**). Temperatures reach or exceed 100°F an average of 110 days annually, and reach or exceed 110°F an average of 18 days annually. Phoenix receives an average of 7.66 inches of rain per year. The bulk of this rain usually falls during the December through March and July through August time periods. During the December through March period, winter storms originating from the Pacific Ocean can produce significant rains in southwestern Arizona. During the July through early September time period, monsoonal moisture originating from the Gulf of California, Gulf of Mexico, and large thunderstorm complexes over the Sierra Madre Occidental Mountains in Mexico move northward into Arizona.

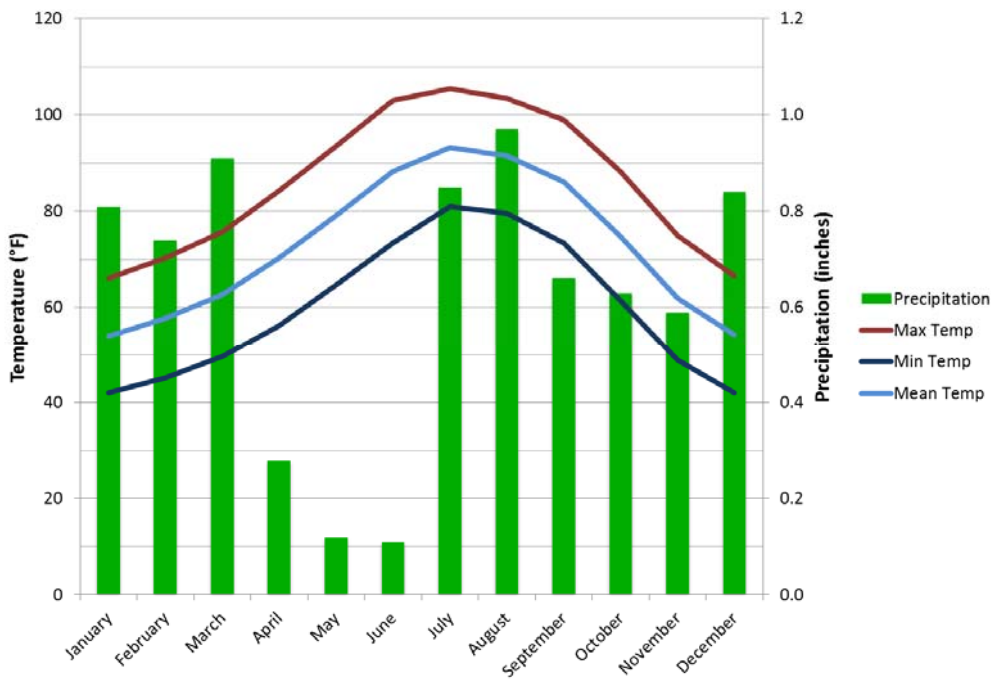
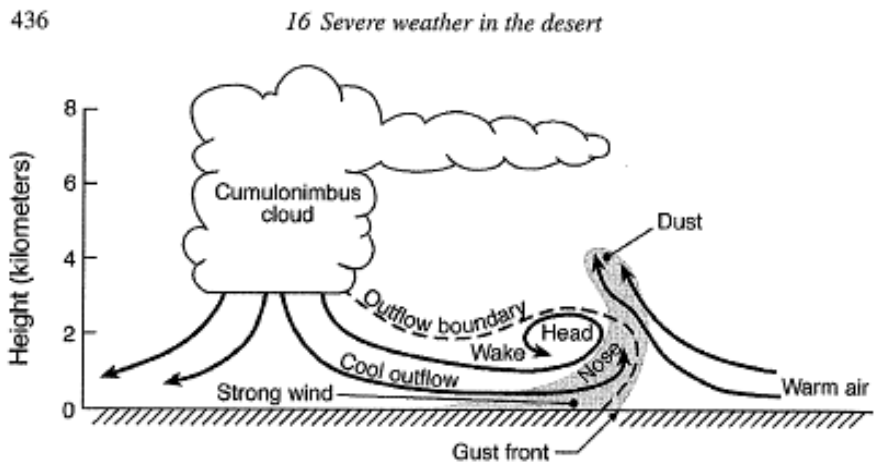


Figure 2-4. Average monthly temperatures and precipitation for Phoenix, 1981–2010.

The influx of moisture associated with the monsoon, combined with strong solar heating, can result in unstable atmospheric conditions that are favorable for the development of thunderstorms. Heavy precipitation associated with thunderstorms, and the eventual collapse or dissipation of thunderstorms, can generate what are known as downbursts. Downbursts are the rapid descent of rain-cooled air in a thunderstorm. Upon reaching the surface, this air rapidly disperses horizontally away from the storm as outflow boundaries (also called gust fronts; see **Figure 2-5**). The high winds associated with outflow boundaries can efficiently loft dust into the air and transport the dust over long distances, resulting in dust storms (also called haboobs) with high PM_{10} concentrations and low visibilities.



Cross-section schematic of a haboob caused by the cool outflow from a thunderstorm, with the leading edge that is propagating ahead of the storm called an outflow boundary. The strong, gusty winds that prevail at the boundary are defined as a gust front. The leading edge of the cool air is called the nose, and the upward-protruding part of the features is referred to as the head. Behind the roll in the windfield at the leading edge is a turbulent wake. The rapidly moving cool air and the gustiness at the gust front raise dust (shaded) high into the atmosphere.

Figure 2-5. Cross-section of a thunderstorm creating an outflow boundary and haboob. (Source: Desert Meteorology, Thomas T. Warner, 2004.)

Dust storms associated with these thunderstorms typically occur in the early part of the monsoon season (July) before subsequent rains moisten the soil and limit potential lofting of soil into the air. However, depending on the amount and frequency of precipitation received during the monsoon season, extremely hot temperatures act to dry the surface soils very quickly; thus, dust storms can occur at any time during the year. Specific PM_{10} source regions are difficult to determine during thunderstorm-driven dust storms because the thunderstorm outflow can carry dust over long distances that encompass many possible sources of dust. Instead, we consider general PM_{10} source regions, which are typically identified based on the locations of the thunderstorms that are believed to have generated the dust-laden outflow winds.

2.3 Event Day Summary

On the early morning of September 2, 2011, gusty winds generated by thunderstorms over northwestern Mexico and south-central Arizona transported dust northward into the Phoenix area (**Figure 2-6**). The windblown dust resulted in 24-hr average PM_{10} concentrations in exceedance of the NAAQS at 11 air quality monitors in the Phoenix area (**Table 2-1**). The PM_{10} concentrations measured at these monitors were in excess of normal historical fluctuations. The dust was naturally occurring and likely originated over undeveloped lands of northwestern Mexico and southern Arizona outside the city of Phoenix, and wind gusts in excess of 40 mph overwhelmed reasonable dust control measures. Monitors across the Phoenix metropolitan area, as well as in Pinal and Pima Counties, recorded high PM_{10}

concentrations as the windblown dust moved through, illustrating the widespread nature of this event.

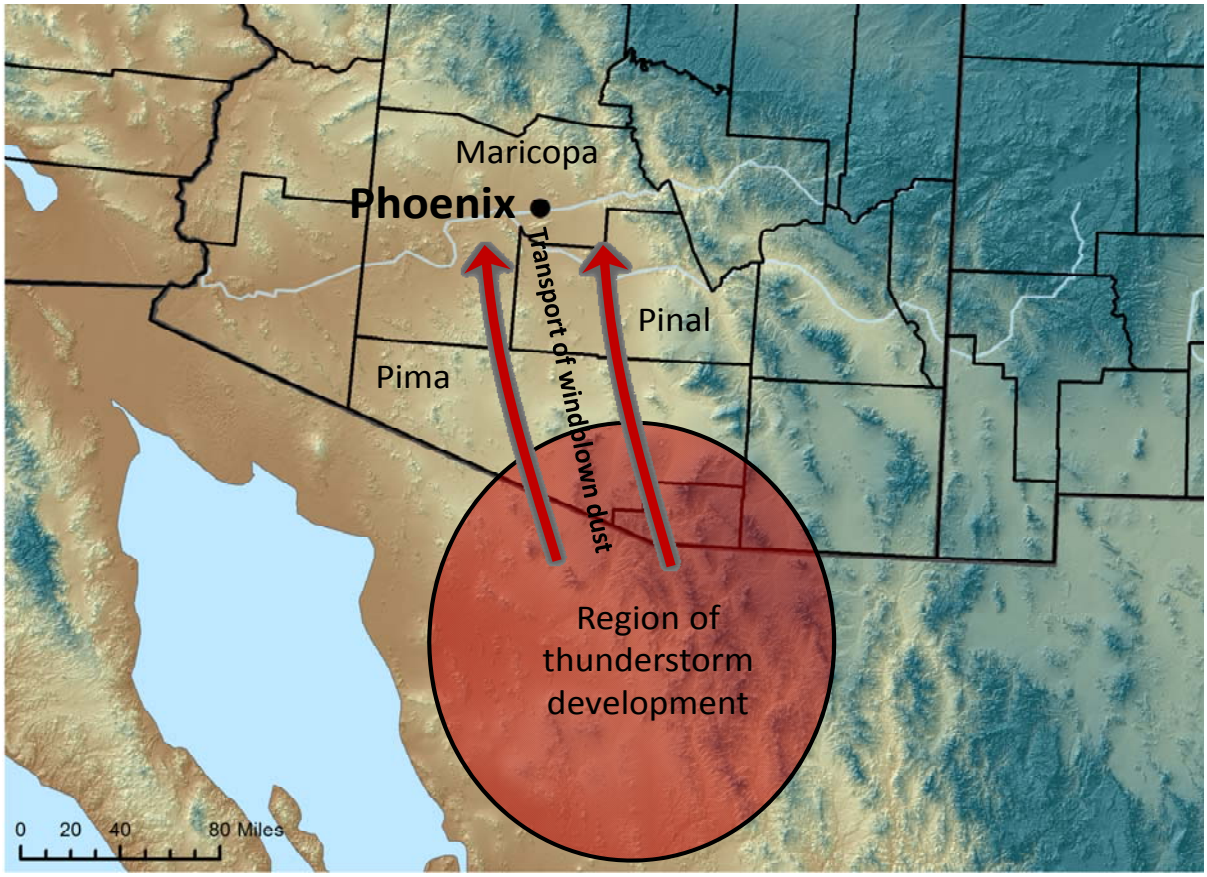


Figure 2-6. Outflow boundaries from thunderstorms over northwest Mexico and south-central Arizona moved northward and transported dust into the Phoenix area on September 2, 2011.

Table 2-1. Statewide monitor information and PM10 measurements on September 2, 2011. The exceedance monitors discussed in this report are shown in bold.

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Monitor	Monitor Type	Operator	AQS Monitor ID	24-hr Avg PM_{10} ($\mu g/m^3$)	1-hr Max PM_{10} ($\mu g/m^3$)	Time of Max 1-hr PM_{10} (LST)	AQS Qualifier Flag
Maricopa County							
Buckeye	TEOM	MC	04-013-4011-81102-1	169	736	200	RJ
Central Phoenix	TEOM	MC	04-013-3002-81102-4	308	4392	200	RJ
Durango Complex	TEOM	MC	04-013-9812-81102-1	255	3217	200	RJ
Dysart	TEOM	MC	04-013-4010-81102-1	119	504	300	

Table 2-1. Statewide monitor information and PM10 measurements on September 2, 2011. The 11 Phoenix-area monitors discussed in this report are shown in bold font.

Monitor	Monitor Type	Operator	AQS Monitor ID	24-hr Avg PM_{10} ($\mu g/m^3$)	1-hr Max PM_{10} ($\mu g/m^3$)	Time of Max 1-hr PM_{10} (LST)	AQS Qualifier Flag
Fort McDowell/Yuma Frank	TEOM	FMIR	04-013-5100-8112-1	195	N/A	N/A	
Glendale	TEOM	MC	04-013-2001-81102-1	132	621	200	
Greenwood	TEOM	MC	04-013-3010-81102-1	198	2062	200	RJ
Higley	TEOM	MC	04-013-4006-81102-1	213	1289	200	RJ
JLG Supersite	BAM	ADEQ	04-013-9997-81102-3	150	985	200	
JLG Supersite	TEOM	ADEQ	04-013-9997-81102-4	208	2600	200	RJ
North Phoenix	TEOM	MC	04-013-1004-81102-1	115*	390	300	
South Phoenix	TEOM	MC	04-013-4003-81102-1	339	4163	200	RJ
West Chandler	TEOM	MC	04-013-4004-81102-1	387	3327	200	RJ
West 43rd Avenue	TEOM	MC	04-013-4009-81102-1	219	2523	200	RJ
West Phoenix	TEOM	MC	04-013-0019-81102-1	133	294	300	
Zuni Hills	TEOM	MC	04-013-4016-81102-1	110	484	300	
Apache County							
N/A	N/A	WMAT	04-001-1003-81102-1	10	24	1500	
Coconino County							
N/A	N/A	ADEQ	04-005-1237-81102-1	N/A	N/A	N/A	
Gila County							
Hayden Old Jail	TEOM	ADEQ	04-007-1001-81102-3	68	180	1300	IJ
Navajo County							
N/A	N/A	WMAT	04-017-1002-81102-1	14	42	1400	
Pima County							
Ajo	TEOM	ADEQ	04-019-0001-81102-3	150	485	200	IJ
Geronimo	BAM	PCDEQ	04-019-1113-81102-1	46	137	1400	
Green Valley	BAM	PCDEQ	04-019-1030-81102-1	27	89	1600	
Orange Grove	FRM	PCDEQ	04-019-0011-81102-2	N/A	N/A	N/A	
Rillito	TEOM	ADEQ	04-019-0020-81102-3	77	222	1300	IJ
South Tucson	FRM	PCDEQ	04-019-1001-81102-1	47	N/A	N/A	
Pinal County							
Apache Junction Fire Station	TEOM	PCAQCD	04-021-3002-81102-3	217	1441	200	RJ
Casa Grande Downtown	TEOM	PCAQCD	04-021-0001-81102-3	235	3143	100	RJ
Combs School	TEOM	PCAQCD	04-021-3009-81102-3	186	2218	200	RJ
Cowtown	TEOM	PCAQCD	04-021-3013-81102-3	588	7909	200	RJ
Maricopa	TEOM	PCAQCD	04-021-3010-81102-3	257	2786	200	RJ

Table 2-1. Statewide monitor information and PM10 measurements on September 2, 2011. The 11 Phoenix-area monitors discussed in this report are shown in bold font.

Page 3 of 3

Monitor	Monitor Type	Operator	AQS Monitor ID	24-hr Avg PM_{10} ($\mu g/m^3$)	1-hr Max PM_{10} ($\mu g/m^3$)	Time of Max 1-hr PM_{10} (LST)	AQS Qualifier Flag
Pinal County Housing	TEOM	PCAQCD	04-021-3011-81102-3	310	4135	100	RJ
Stanfield	TEOM	PCAQCD	04-021-3008-81102-3	268	2542	200	RJ
Santa Cruz County							
Nogales Post Office	BAM	ADEQ	04-023-0004-81102-3	27	65	2100	
Yuma County							
Yuma Supersite	TEOM	ADEQ	04-027-8011-81102-3	N/A	N/A	N/A	

* Note: Power failure and/or instrumentation range limitation occurred during expected maximum concentration hour(s) likely resulting in an underestimate of 24-hr average.
TEOM: Tapered element oscillating microbalance monitor
BAM: Beta attenuation monitor
FRM: Federal reference method
WMAT: White Mountain Apache Tribe of Fort Apache Reservation, AZ
MC: Maricopa County Air Quality Department
ADEQ: Arizona Department of Environmental Quality
FMIR: Fort McDowell Indian Reservation
PCAQCD: Pinal County Air Quality Control District
PCDEQ: Pima County Department of Environmental Quality
RJ: qualifier flag for high winds
IJ: qualifier flag for high winds

3. Causal Relationship

3.1 Discussion

Meteorological and air quality observations indicate that dust carried by thunderstorm outflow was directly responsible for the high PM_{10} concentrations observed in the Phoenix area on September 2, 2011. On the evening of September 1, intense thunderstorms developed over the higher terrain of northwestern Mexico northward into far southern Arizona (**Figure 3-1**). These thunderstorms expanded northward and weakened, but the thunderstorms generated dust-carrying outflow boundaries that propagated into the Phoenix area early on September 2. As stated in Section 2.2, thunderstorms associated with the summer monsoon season can generate strong winds and blowing dust across Arizona. The likely source regions for PM_{10} during the September 2, 2011 event were the deserts of far northwestern Mexico and along the path of the outflow boundary from those deserts northward through Pima, Pinal, and southern Maricopa Counties. This region largely consists of natural, undisturbed desert. In addition, the month leading up to the September 2, 2011 event was very dry in the Phoenix area, with the last measureable rainfall at KPHX occurring on August 3. This combination of geography and lack of rainfall preceding the event resulted in a large fetch of soils that were particularly vulnerable to particulate suspension.

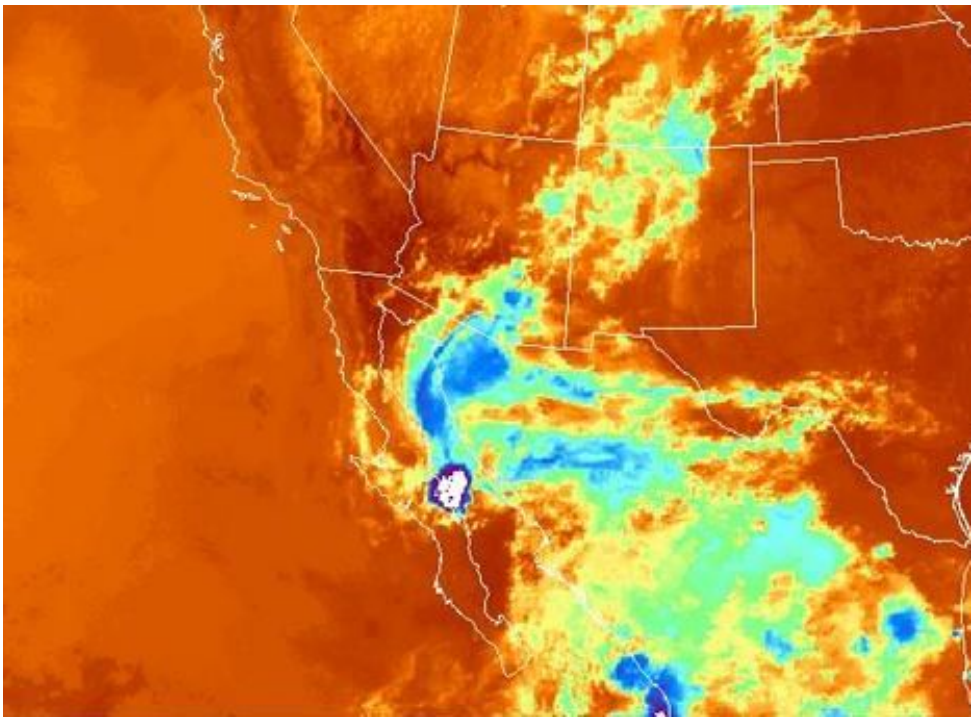

Figure 3-1. Infrared satellite image from midnight LST on September 2, 2011 (GOES-West). Colder temperatures (blues, purples, and white) indicate tall, convective (thunderstorm) clouds. Thunderstorms over northwestern Mexico generated outflow boundaries that carried dust northwestward into Arizona.

Figure 3-2 and **Table 3-1** summarize the progression of the thunderstorm outflow and windblown dust as it moved into the Phoenix area. The dust-laden outflow arrived in the Phoenix area around 0100 LST on September 2. PM_{10} concentrations at the West Chandler (**Figure 3-3**), Higley (**Figure 3-4**), and other monitors (**Appendix A**) increased sharply over this time period, with 1-hr PM_{10} concentrations exceeding 3,000 $\mu g/m^3$ at some monitors. Several wind monitors in the Phoenix area measured sustained winds of over 20 to 25 mph and wind gusts in excess of 30 mph coincident with the sharp increase in PM_{10} concentrations. The thunderstorm outflow and associated strong winds were also evident on the NWS Doppler radar in Phoenix (**Figure 3-5**). In addition, visibility at KPHX and other regional airports decreased significantly with the arrival of the strong winds and blowing dust (**Figure 3-6**). Visibility cameras in the Phoenix area showed hazy conditions after sunrise on September 2, 2011, likely due to suspended dust from the outflow boundary that moved through earlier that morning. Links to these videos and other media coverage and images pertaining to this windblown dust event are shown in **Appendix B**. It is also important to note that before the abrupt increase in PM_{10} in the Phoenix area, winds were lighter and PM_{10} concentrations were much lower, illustrating the correlation between the high winds and the dust.

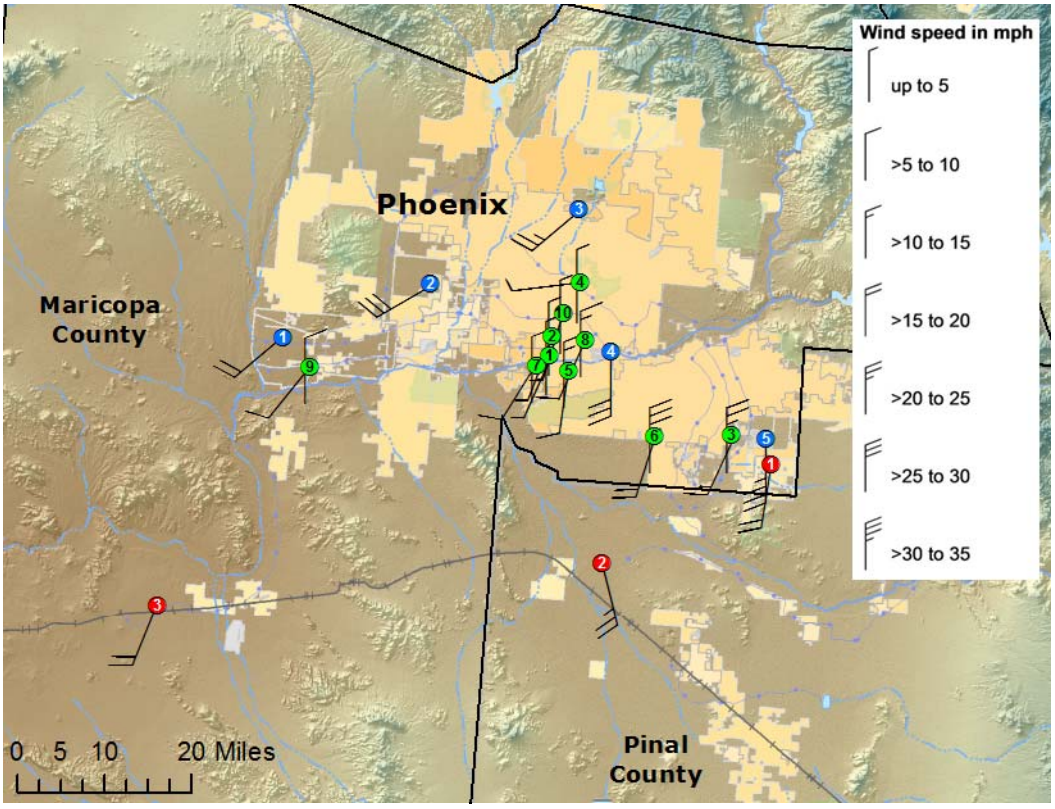

Figure 3-2. Phoenix area air quality and meteorological monitors. Wind and PM_{10} data and time of observation are shown in Table 3-1. Gusty south-to-southwesterly winds transported dust into the Phoenix area early on September 2, 2011. Circular symbols and numbers are placed at the location of the monitor site; wind barbs are offset for visual clarity.

Table 3-1. Observed wind speeds and wind gusts at Phoenix area monitors on September 2, 2011. Symbols in the first column correspond to monitor locations in Figure 3-2. All exceedance monitors reported high PM_{10} concentrations at 0200 LST on September 2, 2011, coincident with high wind gusts.

	Monitor	1-hr Max PM_{10} ($\mu g/m^3$)	Time of Observation (LST)	Wind Speed (mph)	Wind Gust (mph)	Wind Direction (degrees)
	KIWA	-	0105	31	37	180
	Buckeye	735	0200	8	25	219
	Central Phoenix	4392	0200	9	28	204
	Durango Complex	3217	0200	5	19	204
	Greenwood	2062	0200	5	17	201
	Higley	1289	0200	12	27	205
	JLG Supersite	2600	0200	5	15	197
	South Phoenix	4163	0200	9	26	188
	West 43rd Avenue	2523	0200	7	19	212
	West Chandler	3327	0200	16	34	198
	Maricopa	-	0200	21	32	166
	Paloma	-	0200	20	28	202
	Queen Creek	-	0200	17	32	189
	KPHX	-	0209	28	35	180
	KBXK	-	0215	20	25	230
	KLUF	-	0229	28	34	240
	KDVT	-	0251	21	26	230
	North Phoenix	390	0300	5	13	263

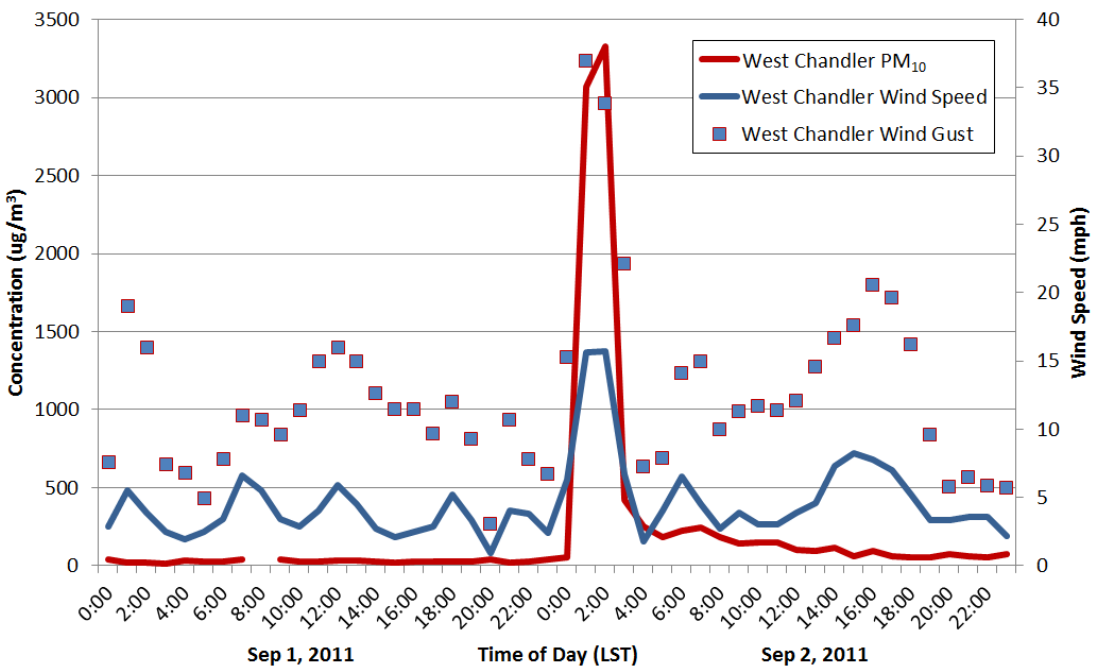

Figure 3-3. Hourly PM_{10} concentrations and wind speeds at the West Chandler monitor on September 2-3, 2011. PM_{10} concentrations sharply increased at 0100 LST on September 2, 2011, coincident with gusty winds, indicating the arrival of windblown dust. Note that PM_{10} concentration was not available at 800 LST on September 1, 2011 at the West Chandler monitor.

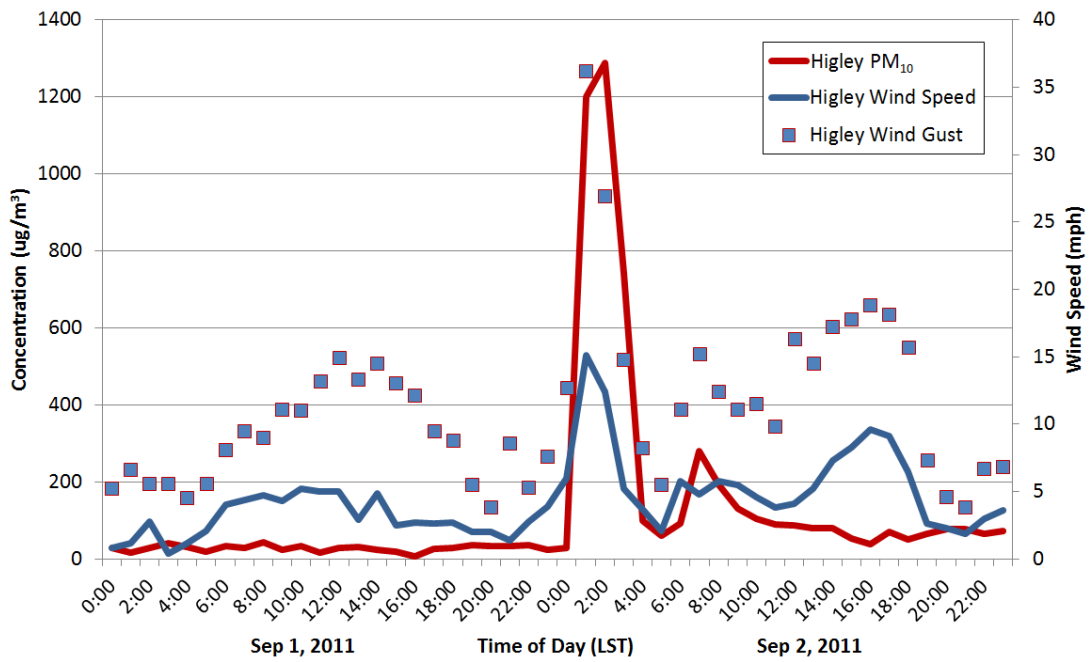

Figure 3-4. Hourly PM_{10} concentrations and wind speeds at the Higley monitor on September 1-2, 2011. PM_{10} concentrations sharply increased at 0100 LST on September 2, 2011, coincident with gusty winds, indicating the arrival of windblown dust.

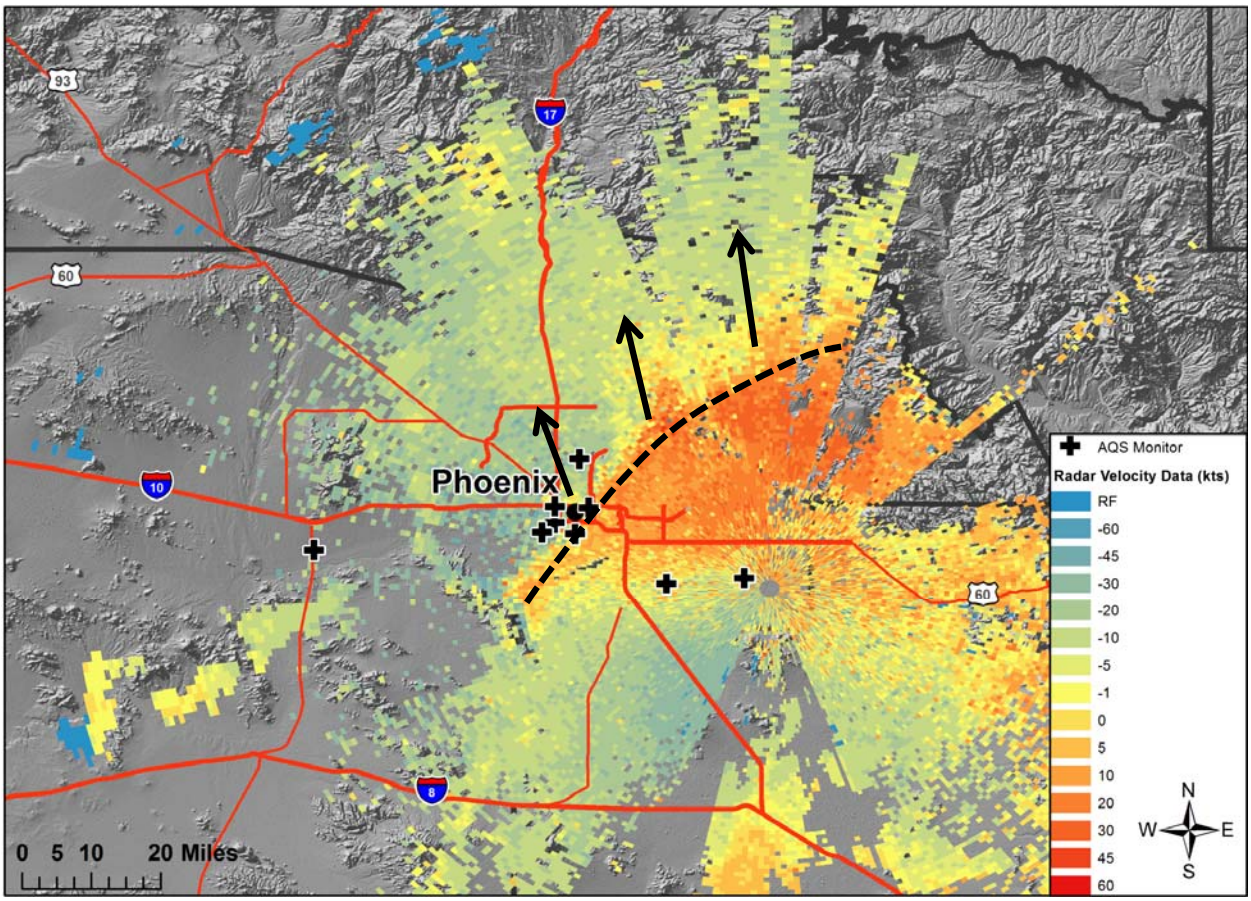

Figure 3-5. Radar base velocity data at 0150 LST on September 2, 2011, from NWS Phoenix Doppler radar. Green indicates flow toward the radar; orange and red indicate flow away from the radar. A well-defined outflow boundary (dashed line) approached the Phoenix area from the south. This boundary carried dust northward and westward across the Phoenix metropolitan area.

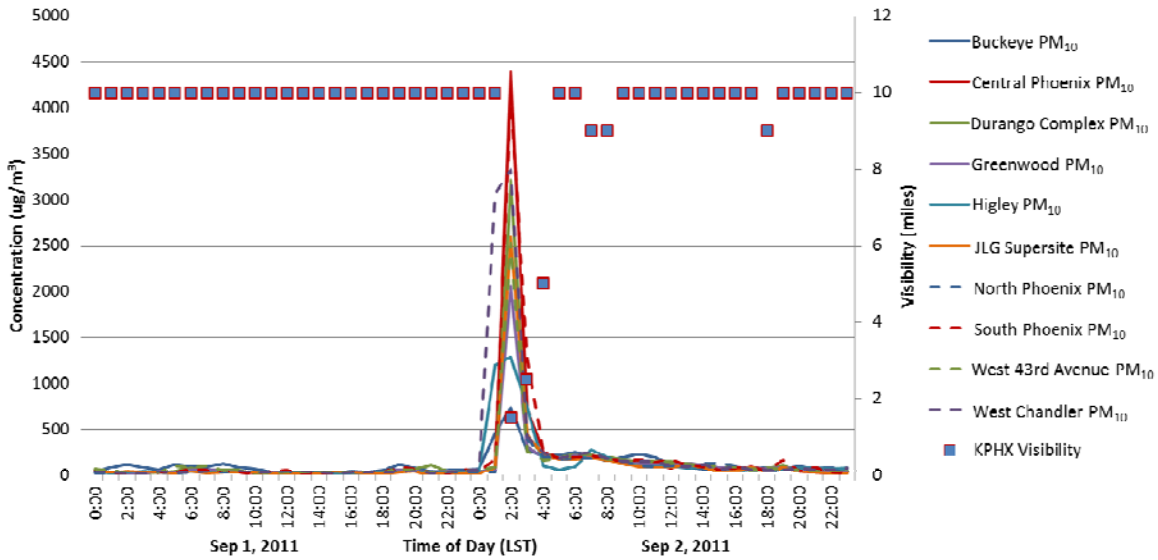

Figure 3-6. Hourly PM_{10} concentrations at Phoenix area monitors and visibility at KPHX. Visibility was greatly reduced at 0200 LST on September 2, coincident with the sharp increase in PM_{10} concentrations at Phoenix area monitors, indicating the arrival of windblown dust.

PM_{10} concentrations decreased after 0400 LST as the dust storm propagated northward out of the Phoenix area. Monitors across the Phoenix metropolitan area and areas further south in Arizona, including Tucson, reported gusty winds and sharp increases in PM_{10} concentrations, illustrating the widespread nature of this dust storm event. No measureable rainfall was reported in Phoenix with the passage of this outflow boundary and the associated dust.

3.2 Summary

The information presented in this section demonstrates a clear causal relationship between the windblown dust and the PM_{10} exceedance measured at Phoenix area monitors on September 2, 2011. The radar and wind data shown in this section illustrate the spatial and temporal representation of the dust storm as it moved through the Phoenix area. In addition, the time series plots of air quality and meteorological data found in this section and in Appendix A show that the sharp increase in PM_{10} concentrations coincided with the strong wind speeds and wind gusts, and that the strong winds were experienced over a large area.

4. Historical Norm

4.1 Analysis

PM_{10} concentrations measured at Phoenix area monitors on September 2, 2011, were unusual and in excess of normal historical fluctuations. To establish the severity of this event, PM_{10} concentrations measured on September 2, 2011, were compared to a historical 2007-2011 five-year annual data set at each monitor (**Figure 4-1** and **Appendix C**). The PM_{10} concentrations measured at the Central Phoenix monitor (Figure 4-1) and other monitors on September 2, 2011, resulted in some of the highest 24-hr averages measured over the five-year period. Similar time-series plots for the other Phoenix area monitors with exceedances are shown in Appendix C. The graphs also highlight the July to September 2011 season, which had many unusually high PM_{10} 24-hr averages, demonstrating the uniqueness of the dust storm events during 2011 relative to previous years.

4.2 Summary

Given the recorded values and using similar methodology to the one accepted by EPA, it is clear that the PM_{10} levels on September 2, 2011, were outside of normal historical fluctuations. This analysis provides evidence that the event affected air quality on a historic scale.

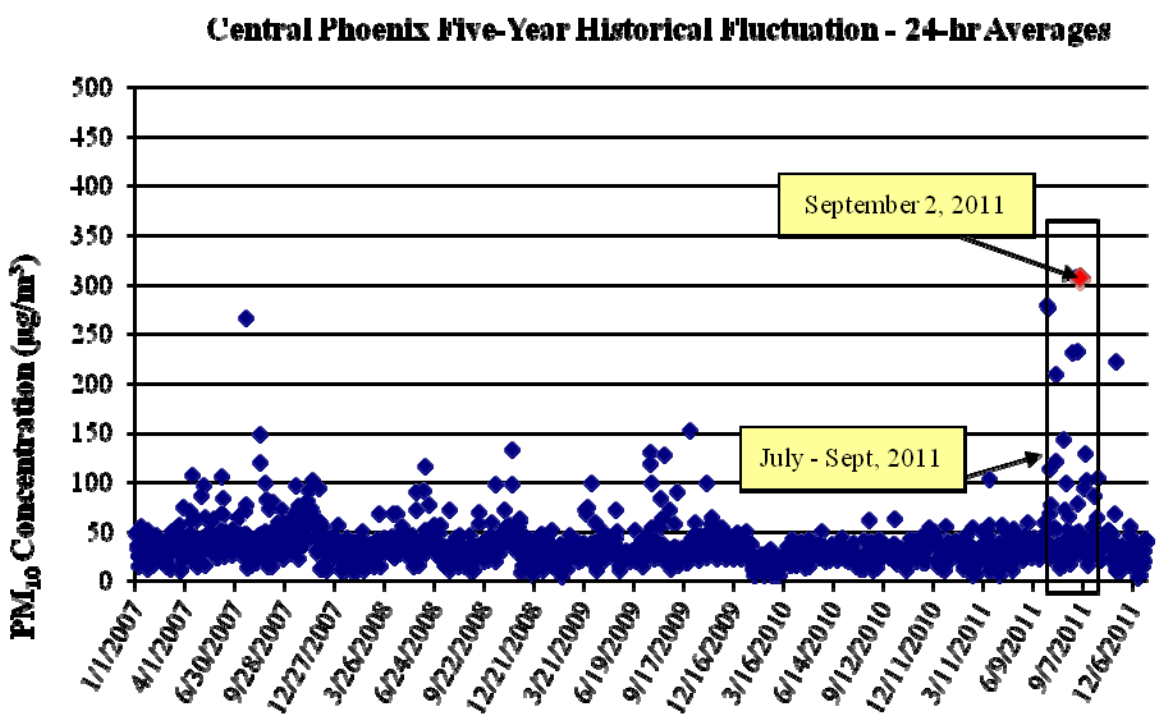

Figure 4-1. 24-hr average PM_{10} concentrations at the Central Phoenix monitor (2007-2011). The 24-hr average PM_{10} concentration on September 2, 2011, is highlighted in red. The period of July to September 2011 is shown by the vertical box.

5. Not Reasonably Controllable or Preventable

5.1 Background

ADEQ and MCAQD are responsible for implementing regulatory measures to control emissions from agricultural sources, stationary sources, fugitive dust sources, and open burning within Maricopa County. Three major programs provide or contribute to air pollution control measures for the Greater Phoenix area. These programs include:

1. ADEQ's Agricultural Best Management Program (AgBMP)
2. Maricopa County's Inspection and Compliance Program
3. ADEQ's Air Quality Forecasting Program

Specifically, ADEQ is responsible for compliance assistance and enforcement of Agricultural Best Management Practices developed by the Governor's Agricultural Best Management Practices Committee, while MCAQD is responsible for compliance assurance for all other significant sources of PM_{10} emissions. In addition to routine inspections and inspections driven by complaints, inspections are often increased when (1) ADEQ forecasters issue a High Risk for the Maricopa County Dust Control Forecast, (2) ADEQ forecasters issue a High Pollution Advisory, or (3) near real-time monitoring data indicate unique activity via high PM concentrations. The forecasting program and inspection/compliance programs work together so that resources can be best used during days of greatest risk for elevated PM emissions.

On July 25, 2002, EPA took initial action to finalize approval of the Best Available Control Measure (BACM) and the Most Stringent Measure (MSM) demonstrations in the Serious Area PM_{10} plan for the Maricopa County portion of the metropolitan Phoenix PM_{10} nonattainment area (67 FR 48718). These BACM and MSM demonstrations were again approved by EPA on July 14, 2006 (71 FR 43979). The Agricultural Best Management Practices General Permit rule and related definitions have been approved into the Arizona Administrative Code as R18-2-610 and R18-2-611, pursuant to Arizona Revised Statutes §49-457[1].

5.1.1 Control Measures

Maricopa County regulations of PM_{10} emissions are listed in **Table 5-1**.

[1] Updates to the AgBMP program in December, 2011, clarified BMPs for crops and added BMPs for animal operations. Effective 12/29/2011, R18-2-611 was renumbered to R18-2-610.01 **Agricultural PM10 General Permit for Crop Operations** and R18-2-611.01 **Animal Operations PM10 General Permit** was added. Definitions for Crop Operations were revised at R18-2-610 and new definitions for Animal Operations were added at R18-2-611.

Table 5-1. Rules and ordinances regulating particulate matter emissions in Maricopa County.

Rule/Ordinance Number & Title	Description
Rule 300: Visible emissions	Establishes standards for visible emissions and opacity.
Rule 310: Fugitive dust from dust-generating operations	Establishes limits for the emissions of particulate matter into the ambient air from any property, operations, or activity that may serve as a fugitive dust source.
Rule 310.01: Fugitive dust from non-traditional sources of fugitive dust	Establishes limits for the emissions of particulate matter into the ambient air from open areas, vacant lots, unpaved parking lots, and unpaved roadways which are not regulated by Rule 310 and which are not required to have either a permit or a dust control plan.
Rule 311: Particulate matter from process industries	Establishes emission rates based on process weight applicable to any affected operations not subject to Rule 316.
Rule 312: Abrasive blasting	Establishes limits for particulate emissions from abrasive blasting operations.
Rule 314: Open outdoor fires and indoor fireplaces at commercial and institutional establishments	Establishes limits for the emissions of air contaminants produced from open burning.
Rule 316: Nonmetallic mineral processing	Establishes limits for the emissions of particulate matter into the ambient air from any nonmetallic mining operation or rock product processing plant.
Rule 317: Hospital/medical/infectious waste incinerators	Establishes limits for the emissions of air pollutants from medical waste incinerators.
Rule 322: Power plant operations	Establishes limits for the emissions of nitrogen oxides, sulfur oxides, carbon monoxide, and particulate matter from existing power plants and cogeneration plants.
Rule 323: Fuel burning equipment from industrial/commercial/ institutional (ICI) sources	Establishes limits for the emissions of nitrogen oxides, sulfur oxides, carbon monoxide and particulate matter from ICI sources.
Rule 324: Stationary internal combustion (IC) engines	Establishes limits for the emissions of carbon monoxide, nitrogen oxides, sulfur oxides, volatile organic compounds, and particulate matter from stationary internal combustion engines, including stationary IC engines used in cogeneration.
Rule 325: Brick and structural clay products (BSCP) manufacturing	Establishes limits for particulate matter emissions from the use of tunnel kilns for curing in the BSCP manufacturing processes.
Ordinance P-25: Leaf blower restriction	Establishes restrictions for leaf blowers in incorporated and unincorporated sections of Area A in Maricopa County.
Ordinance P-26: Residential wood burning restriction	Establishes restrictions for residential wood burning.
Ordinance P-27: Vehicle parking and use on unstabilized vacant lots	Establishes restrictions for vehicle parking and use on unstabilized vacant lots in unincorporated sections of Area A in Maricopa County.
Ordinance P-28: Off-road vehicle use in unincorporated areas of Maricopa County	Establishes restrictions for operating vehicles on unpaved property in unincorporated areas of Maricopa County.

Rule/Ordinance Number & Title	Description
Arizona Administrative Code R18-2-611 & 610: Agricultural PM_{10} general permit	Establishes a requirement for commercial farmers to implement best management practices and maintain a record demonstrating compliance.

5.1.2 Additional Measures

In addition to the rules and regulations listed in **Table 5-1**, other PM_{10}-reducing control measures (e.g., paving unpaved roads, PM_{10}-certified street sweepers, controlling unpaved parking lots, etc.) have been committed to and implemented by local jurisdictions throughout the PM_{10} nonattainment area and incorporated into the Arizona state implementation plan (SIP) through PM_{10} plans such as the Revised Maricopa Association of Governments' (MAG) 1999 Serious Area Particulate Plan for PM_{10} for the Maricopa County Nonattainment Area. The Pinal County Air Quality Control District (PCAQCD) also implements regulatory control measures on emissions from existing and new non-point sources within Pinal County (see **Table 5-2**). Additionally, the PCAQCD implements specific nonattainment rules for that part of the Phoenix PM_{10} nonattainment area that resides in Pinal County (see **Table 5-3**).

Table 5-2. Pinal County rules regulating existing and new non-point sources in Pinal County.

Article Number & Title	Description
Article 2: Fugitive dust	Provides a mechanism to reasonably regulate operations which periodically may cause fugitive dust emissions into the atmosphere.
Article 3: Construction sites – fugitive dust	Improves the control of excessive fugitive dust emissions that have been traditionally associated with construction, earthwork, and land development, and thereby minimize nuisance impacts.

Table 5-3. Pinal County rules regulating fugitive dust in Pinal County portion of Phoenix PM_{10} nonattainment area.

Article Number & Title	Description
Article 4: Nonattainment area rules; dustproofing for commercial parking, drives, and yards	Establishes rules to avoid violations of the prevailing PM_{10} standard and additionally minimize nuisance impacts by improving control of excessive fugitive dust emissions from unpaved parking lots.
Article 5: Nonattainment area rules; stabilization for residential parking and drives	Establishes rules for stabilizing residential properties.
Article 6: Restrictions on vehicle parking and use on vacant lots	Establishes rules for unpaved or unstable vacant lots.
Article 7: Construction sites in nonattainment areas – fugitive dust	Establishes rules to avoid violations of the prevailing PM_{10} standard and additionally minimize nuisance impacts by improving control of excessive fugitive dust emissions from activities associated with construction, earthwork, or land development.

Article Number & Title	Description
Article 8: Nonattainment area rules, requirement for stabilization of disturbed areas at vacant lots	Establishes rules for stabilizing disturbed areas at vacant lots.

5.1.3 PM_{10} Rule Effectiveness

MCAQD analyzed the effectiveness of its fugitive dust rules (Rules 310, 310.01 and 316) in terms of permit compliance rates. This rule effectiveness (RE) study was designed to assess how many sources regulated by MCAQD during the subject time period received no PM_{10} emissions-related violations. As a basis for comparison, the percentage of permitted sources in compliance during calendar year 2007 was 76% for sources subject to Rule 310, 85% for Rule 310.01 sources, and 40% for Rule 316 sources. In early 2008, Rules 310, 310.01, and 316 were strengthened, and new ordinances (covering additional source categories such as leaf blowers, vacant lots, and off-road vehicles) were adopted. These enhancements resulted from MCAQD department's obligations under such agreements as the 2005 Revised PM_{10} State Implementation Plan for the Salt River Area and the Maricopa Association of Governments (MAG) 2007 Five Percent Plan for PM_{10} for the Maricopa County Nonattainment Area to reduce PM_{10} emissions throughout the county. Three major areas that contributed to increased compliance were an increase in departmental staffing (especially inspectors), a robust training program, and regulatory changes that broadened and strengthened control measures under Rules 310, 310.01, and 316.

Source compliance rates were re-assessed for FY 2009 (July 2008–June 2009), a period that allowed time for the new and revised regulations to take effect. The results showed significant increases in compliance compared with the earlier period: to 90% (from 76%) for Rule 310 sources, 95% compliance (from 85%) for Rule 310.01 sources, and 65% (from 40%) for Rule 316 sources. These improvements continued into calendar year 2010 with compliance rates of 94% for Rule 310 sources, 96% for Rule 310.01 sources, and 73% for Rule 316 sources. The timeline below (**Figure 5-1**) illustrates the improvements in RE over the last several years; it also points out significant revisions to previous rules, as well as newly adopted rules and ordinances.

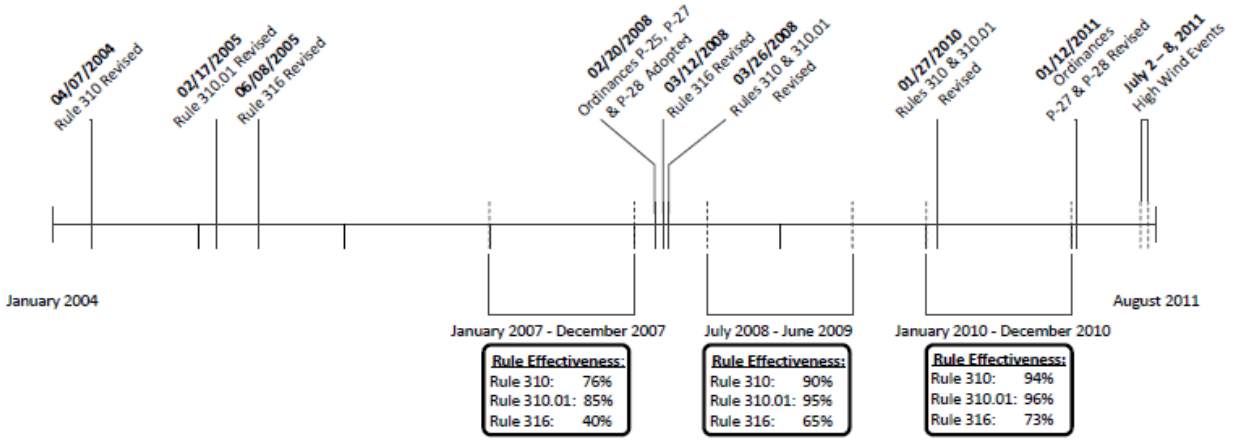

Figure 5-1. Timeline of Maricopa County fugitive dust rules and ordinances.

5.1.4 Compliance and Enforcement Activities

MCAQD is prepared to proactively respond to high wind events and protect human health and well-being. MCAQD 's approach consists of two primary components: routine proactive inspections, as well as surveillance inspections, conducted both during and after significant air quality events. MCAQD routinely inspects dust control-permitted sites and increase the frequency of inspections for permits covering areas of 10 acres or more. Rule 316 sources are also regularly inspected multiple times every year. Maricopa County also responds to the majority of complaints within 24 hours.

Maricopa County monitors the ADEQ Five-Day Dust Control Forecast to identify the potential for elevated PM_{10} pollution levels due to high winds or stagnant conditions. When a High Pollution Advisory (HPA) is issued for Maricopa County, MCAQD conducts additional increased surveillance before, during, and after the forecast event(s). MCAQD also conducts event surveillance and post-event activities during exceedance days that had not been forecast (i.e., those instances in which an HPA had not been issued).

Pre-event surveillance consists of surveying high-risk areas for any dust-generating activities, educating sources of the impending HPA event, and issuing violations for failure to comply with local, state, or federal regulations. During the event, MCAQD inspectors survey high-risk areas to confirm that control measures are in place, document any violations, and contact other regulatory agencies if necessary. Post-event activities include continued surveys of high-risk areas, re-inspecting sources that had received violations within two business days, and an internal MCAQD debriefing of event activities.

During 2011, a total of 14 MCAQD air monitoring sites were upgraded with new equipment that allows the monitoring sites to automatically report measured readings at 5-minute intervals. Previously, only hourly readings were available. The real-time data reporting system includes a mechanism to alert MCAQD field staff when PM concentrations are elevated. The system allows MCAQD responders to review concentrations at the monitors and

to consult the National Weather Service website to check for weather event activity. This capability allows the MCAQD responder to identify regional events and monitor specific issues. If necessary, the MCAQD responders can inform nearby stakeholders and local governments of the elevated PM_{10} concentrations.

In addition to MCAQD's efforts in pre-event surveillance and proactive inspections, ADEQ's AgBMP inspector also monitors the ADEQ Five-Day Dust Control Forecast and the MCAQD air monitoring sites that include real-time data. The ADEQ AgBMP inspector uses specific knowledge of seasonal activities and associations with the local growers and dairymen to communicate the importance of limiting dust-generating activities, especially during high wind events. Additional outreach is conducted with facility representatives prior to forecasted high wind alert days. Should the PM_{10} readings at a MCAQD air monitoring site show notable increase, the ADEQ AgBMP inspector is dispatched to contact the owners and operators of agricultural fields in the area to discern if their activities are causing negative impacts. The AgBMP inspector is prepared to respond to most agriculture complaints within 24 hours.

5.1.5 Review of Source-Permitted Inspections and Public Complaints

ADEQ's Arizona Unified Repository for Information Tracking of the Environment (AZURITE) database was queried to compile a list of inspections for the permitted sources in the Phoenix area around the time of the September 2, 2011, PM_{10} exceedances. An evaluation of all inspection reports, air quality complaints, compliance reports, and other documentation do not indicate any evidence of unusual anthropogenic-based PM_{10} emissions. During the time period of August 30 through September 5, 2011, MCAQD inspectors conducted a total of 112 inspections of permitted facilities, of which 89 were at fugitive dust sources. Additionally, MCAQD conducted 89 inspections on vacant lots and unpaved parking lots during this period.

During this seven-day period, nine violations were issued countywide for PM_{10} and non-PM_{10} related violations. One violation was for PM_{10} emissions within a four-mile radius of an exceeding monitor.

On September 1, 2011, a violation was issued to a permitted construction site within four miles of the Central Phoenix monitor. The violation was issued during a complaint inspection. The site was issued a violation for failing to maintain complete dust control records. The site only kept records of the amount of water applied for dust control, but failed to maintain records of subcontractor registration or maintenance of the trackout control device. The violation was corrected on subsequent inspections.

MCAQD was prepared for any complaints received due to the high wind event. During the seven-day period from August 30 through September 2, 2011, MCAQD received 23 complaints, of which 17 were related to windblown dust. Each complaint was assigned to and investigated by a MCAQD inspector. A review of all pertinent records from this period indicates that MCAQD inspectors observed only one emission violation, as discussed in the previous paragraph, of local, state, or federal PM_{10} regulations within a four-mile radius of the exceeding monitors.

In addition to MCAQD's efforts in pre-event surveillance and proactive inspections, ADEQ's Agricultural Best Management Practice Program (Ag BMP) inspector also monitors the ADEQ Five-Day Dust Control Forecast and the MCAQD air monitoring sites that include real-time data. The ADEQ Ag BMP inspector uses specific knowledge of seasonal activities and associations with the local growers and dairymen to communicate the importance of limiting dust-generating activities, especially during high wind events. Additional outreach is conducted with facility representatives prior to forecast high wind alert days. Should the PM_{10} readings at a MCAQD air monitoring site show a notable increase, the ADEQ Ag BMP inspector is dispatched to contact the owners and operators of agricultural fields in the area to discern whether their activities are causing negative impacts. The Ag BMP inspector is prepared to respond to most agriculture complaints within 24 hours.

Based on a review of the inspection reports and site visit documentation, there is no evidence to suggest that agricultural activities produced unusual PM_{10} emissions. On September 1, 2011, the ADEQ AgBMP inspector received one complaint and made immediate contact with the operation. The subject agriculture field was located in Surprise and was being tilled to prepare the field to plant vegetables. Surprise is located in northwestern Maricopa County, near the Dysart and Zuni Hills AQS monitors. Since both the Dysart and Zuni Hills AQS monitors were not in exceedance on September 2, 2011, this one particular incident is highly unlikely to have caused of the widespread regional dust.

5.2 Forecasts and Warnings

Dust forecasts were released prior to the event by ADEQ (Appendix D). For September 2, 2011, the Maricopa County Dust Control Forecast indicated a moderate risk level for unhealthy PM_{10}. The Dust Control Forecast also indicated a potential for dense blowing dust throughout the area generated by outflow from thunderstorms.

5.3 Wind Observations

Sustained wind speeds of over 20 mph with gusts over 30 were reported at monitors across the Phoenix area, and sustained winds as high as 28 mph at Sky Harbor and 31 mph at Mesa Gateway with gusts as high as 35 mph were reported as the outflow boundary moved through (Figure 3-3, Table 3-1 and Appendix A).

5.4 Summary

The thunderstorm outflow event of September 2, 2011, produced gusty winds that transported dust and PM_{10} into the Phoenix PM_{10} nonattainment area. The source region of the outflows that caused the exceedances was largely located in areas outside the Phoenix PM_{10} nonattainment area, primarily the deserts of Pima, Pinal, and southern Maricopa Counties. The Phoenix area is designated as a serious nonattainment area for PM_{10} and is required to have BACM for all significant sources of PM_{10}. BACM-approved control measures on significant anthropogenic sources were in place and enforced during the events, and proactive tracking and response to the events by regulatory agencies and local governments confirmed the uncontrollable nature of the dust emissions; therefore, these pre-existing/prior-approved

required controls are adequate for meeting the requirements of an exceptional event and should be considered “reasonable” for these purposes.

Despite the deployment of comprehensive control measures and sophisticated response programs, high wind conditions associated with thunderstorms and thunderstorm outflows brought high concentrations of PM_{10} into, and also overwhelmed controls within, the Phoenix PM_{10} nonattainment area. Widespread thunderstorm outflows with sustained winds in excess of 20 mph with gusts over 30 mph were enough to overwhelm available efforts to limit PM_{10} concentrations during the event. The fact that these were natural events involving strong thunderstorm outflow winds that transported PM_{10} emissions into and across the Phoenix area, with a majority of the PM_{10} emissions recorded by Phoenix area monitors coming from sources outside of the Phoenix PM_{10} nonattainment area, provides strong evidence that the exceedances of September 2, 2011, recorded within the Phoenix PM_{10} nonattainment area were not reasonably controllable or preventable.

6. But-For Analysis

6.1 Discussion

Section 50.14(c)(3)(iv)(D) in 40 CFR Part 50 requires that an exceptional event demonstration satisfies that "[t]here would have been no exceedance or violation but for the event." The prior sections of this submittal have provided detailed information that in regard to the PM_{10} exceedances in the Phoenix PM_{10} nonattainment area on September 2, 2011,

- The exceedances were not reasonably controllable or preventable, and
- There was a clear causal relationship between PM_{10} transported from thunderstorm outflow originating in desert areas outside the Phoenix metropolitan area and the measured PM_{10} exceedances.

The weight of evidence in these sections demonstrates that, but for the existence of dust emissions generated by thunderstorm outflow and the associated transport of PM_{10}, there would have been no exceedances of the NAAQS for 24-hr average PM_{10}.

As shown in Section 3, radar velocity data and time-series plots of PM_{10} and wind speeds establish a clear causal relationship between the arrival of dust-laden thunderstorm outflow and elevated PM_{10} concentrations at monitors in the Phoenix area. Multiple independent measurements of wind speed, wind direction, and visibility all show that thunderstorm outflow was the mechanism for transport of PM_{10} into the Phoenix PM_{10} nonattainment area. In addition, PM_{10} concentrations were well below the NAAQS on days immediately before and after the windblown dust event. The source regions for the thunderstorm outflow and PM_{10} are clearly identified as desert areas south of Phoenix. The weight of evidence presented in this submittal provides no alternative that could tie the exceedances of September 2, 2011, to any causal source except PM_{10} transported by thunderstorm outflow, confirming that there would have been no exceedances but for the presence of these uncontrollable natural events.

As detailed in Section 5, all reasonable control measures were in place and/or implemented on a continual basis. Local regulatory agencies, industry, and the general public were alerted to the possibility of dust storms due to thunderstorm activity via daily forecasts and media reports.

6.2 Summary

The weight of evidence presented in this submittal provides no alternative that could tie the exceedances of September 2, 2011, to any causal source except PM_{10} transported by thunderstorm outflow, confirming that there would have been no exceedances but for the presence of these uncontrollable natural events.

7. Conclusions

The PM_{10} exceedances that occurred on September 2, 2011, satisfy the criteria of the EER, which states that in order to justify the exclusion of air quality monitoring data, evidence must be provided for the following elements:

1. The event satisfies the criteria set forth in 40 CFR 501 (j) that
   a. the event affected air quality,
   b. the event was not reasonably controllable or preventable, and
   c. the event was caused by human activity unlikely to recur in a particular location or was a natural event;
2. There is a clear causal relationship between the measurement(s) under consideration and the event;
3. The event is associated with a measured concentration(s) in excess of normal historical fluctuations; and
4. There would have been no exceedance or violation but for the event.

7.1 Affects Air Quality

As stated in the preamble to the Exceptional Events Rule, the event in question is considered to have affected air quality if it can be shown that there is a clear causal relationship between the monitored exceedance and the event, and that the event is associated with a measured concentration in excess of normal historical fluctuations. Given the information presented in Sections 2, 3, 4, and 5, we can reasonably conclude that the event in question affected air quality.

7.2 Not Reasonably Controllable or Preventable

Section 50.1(j) of 40 CFR Part 50 requires that an event must be “not reasonably controllable or preventable” in order to be defined as an exceptional event. This requirement is met by demonstrating that despite reasonable control measures in place within Maricopa County, high winds overwhelmed all reasonably available controls (Section 5). The PM_{10} exceedances discussed in this report were caused by naturally occurring thunderstorm outflow that transported dust into the Phoenix area from areas largely outside the Phoenix PM_{10} nonattainment area. These facts provide strong evidence that the PM_{10} exceedances on September 2, 2011, were not reasonably controllable or preventable.

7.3 Natural Event

As discussed above, the PM_{10} exceedances on September 2, 2011, were shown to be caused by transport of PM_{10} into the Phoenix area from thunderstorm outflow. The event therefore qualifies as a natural event.

7.4 Clear Causal Relationship

The following points demonstrate that the high PM_{10} concentrations were caused by windblown dust:

- Time-series of PM_{10} concentrations show that the timing of high PM_{10} at Phoenix-area monitors was consistent with gusty winds and low visibilities (Section 3).
- High PM_{10} concentrations and gusty winds were reported throughout the Phoenix metropolitan area, illustrating the widespread, regional, and uncontrollable nature of this event (Section 3).
- PM_{10} concentrations were well below the NAAQS on days immediately before and after the windblown dust event (Section3).
- Dry conditions preceding the event resulted in soils that were particularly susceptible to particulate suspension by high winds (Section 3).
- Visibility camera imagery after sunrise on September 2, 2011, indicated hazy conditions in the Phoenix area, likely attributable to suspended dust from the outflow boundary that moved through earlier that morning.

7.5 Historical Norm

The 24-hr average PM_{10} values measured at the exceedance monitors were historically unusually high compared to a multi-year data set (Section 4).

7.6 But For

On the basis of the weight-of-evidence described above and in Section 6, the exceedances of the federal 24-hr PM_{10} standard on September 2, 2011, in the Phoenix PM_{10} nonattainment area would not have occurred but for the thunderstorm-driven high winds and transport of dust from areas largely outside the Phoenix PM_{10} nonattainment area.

Appendix A:
Air Quality and Meteorological Data

This section contains time-series of PM_{10} concentrations and wind data for Phoenix-area monitors on September 1-2, 2011. The data show a region-wide increase in wind gusts coincident with the arrival of dust and high PM_{10}.

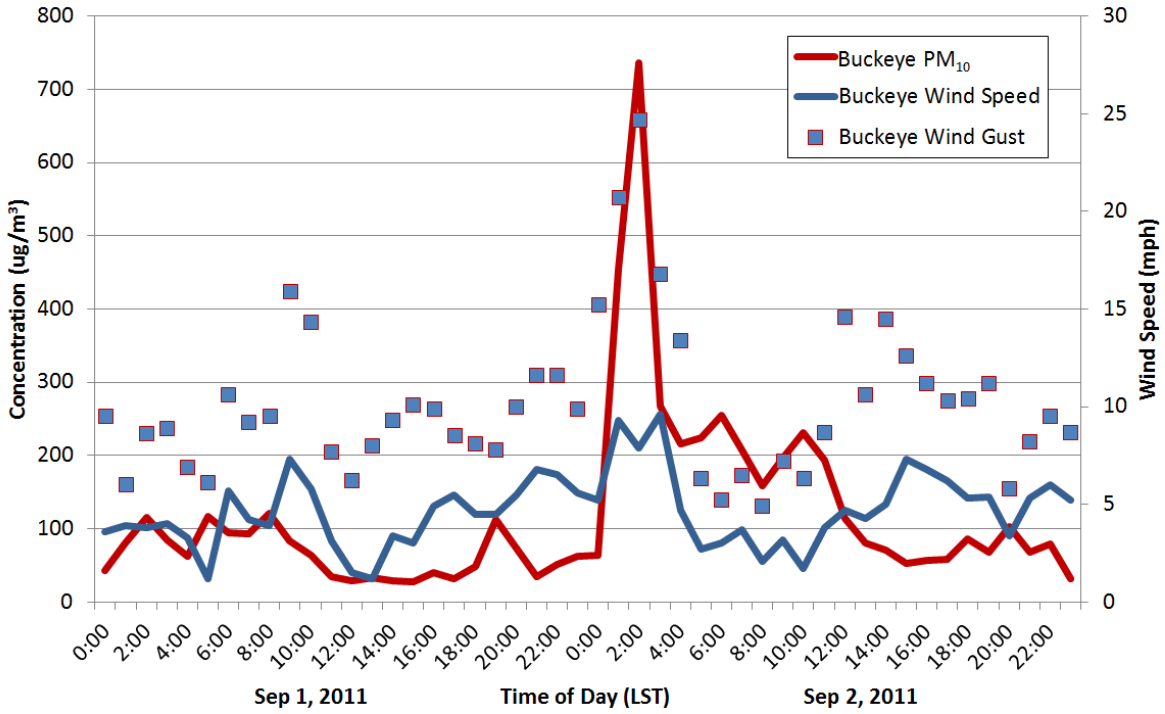

Figure A-1. Hourly PM_{10} concentrations and wind speeds at the Buckeye monitor on September 1-2, 2011. PM_{10} concentrations sharply increased and gusty winds were reported at 0200 LST on September 2, 2011, indicating the arrival of windblown dust.

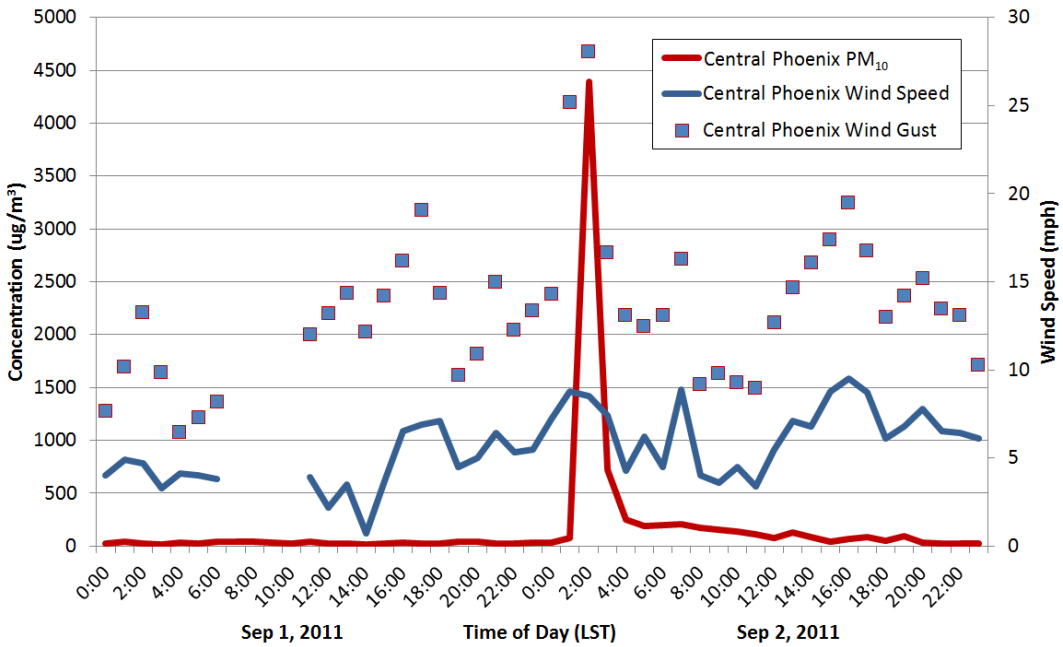

Figure A-2. Hourly PM_{10} concentrations and wind speeds at the Central Phoenix monitor on September 1-2, 2011. PM_{10} concentrations and wind increased sharply at 0200 LST on September 2, 2011, indicating the arrival of windblown dust. Note that wind speed and gust data were not available between 700 and 1000 LST on September 1, 2011 at the Central Phoenix monitor.

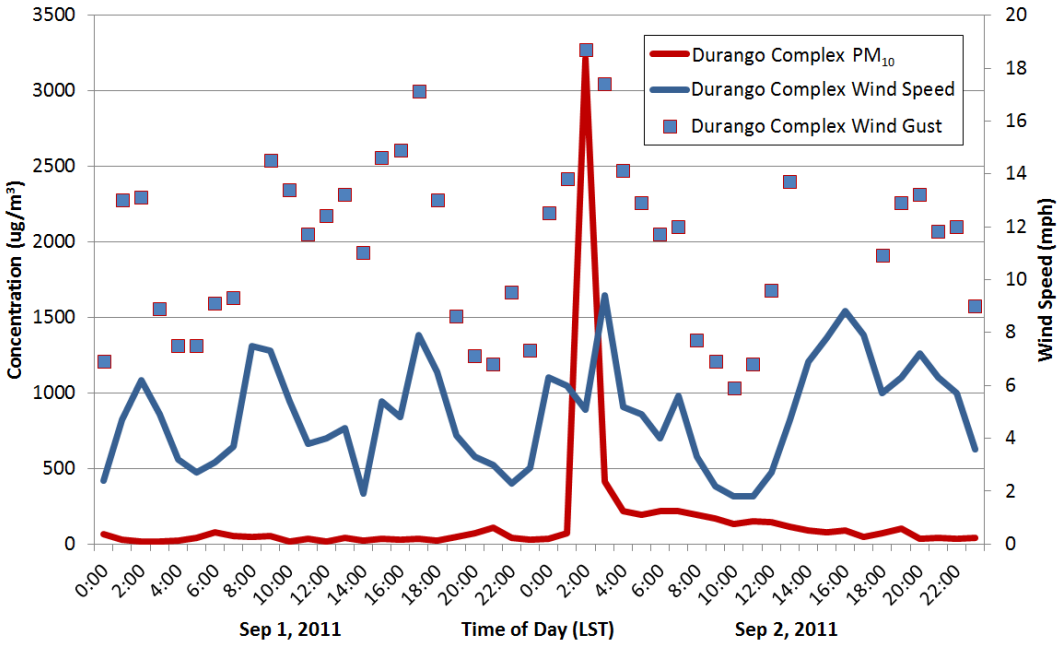

Figure A-3. Hourly PM_{10} concentrations and wind speeds at the Durango Complex monitor on September 1-2, 2011. PM_{10} concentrations increased sharply at 0200 LST on September 2, 2011, indicating the arrival of windblown dust.

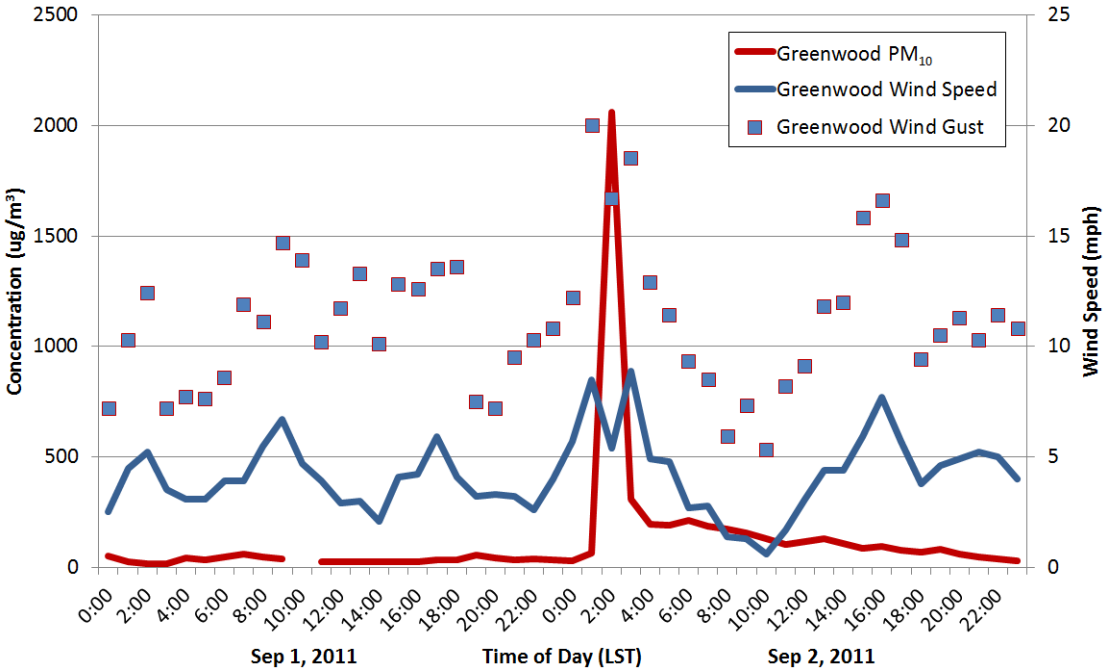

Figure A-4. Hourly PM_{10} concentrations and wind speeds at the Greenwood monitor on September 1-2, 2011. PM_{10} concentrations sharply increased at 0200 LST on September 2, 2011, coincident with gusty winds, indicating the arrival of windblown dust. Note that PM_{10} concentration was not available at 1000 LST on September 1, 2011 at the Greenwood monitor.

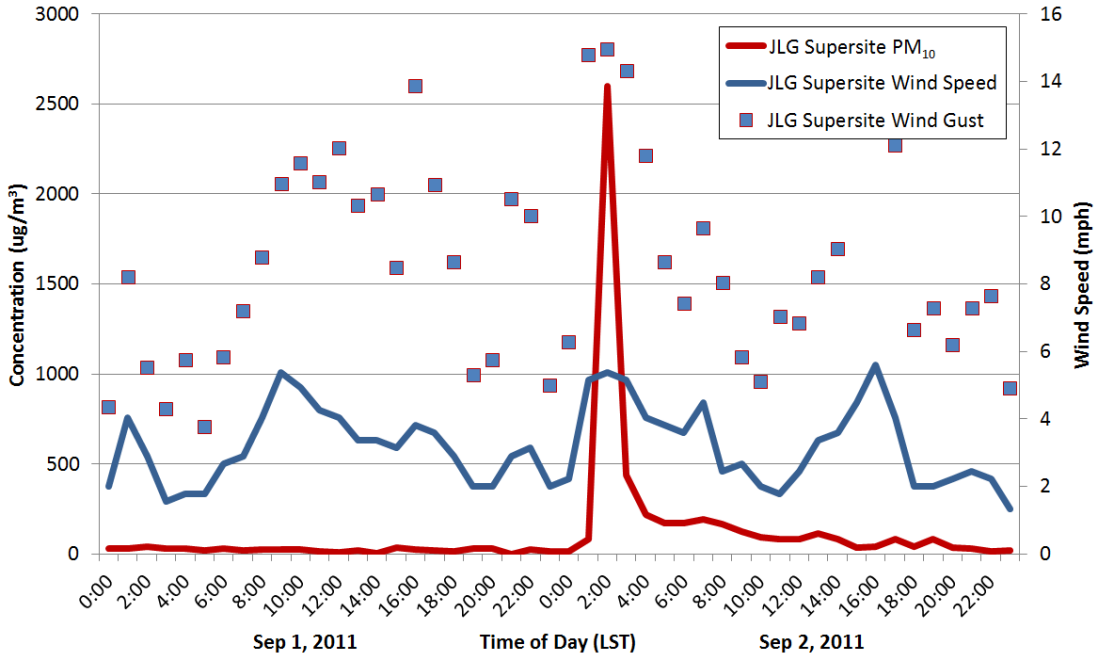

Figure A-5. Hourly PM_{10} concentrations and wind speeds at the JLG Supersite monitor on September 1-2, 2011. PM_{10} concentrations sharply increased at 0200 LST on September 2, 2011, indicating the arrival of windblown dust.

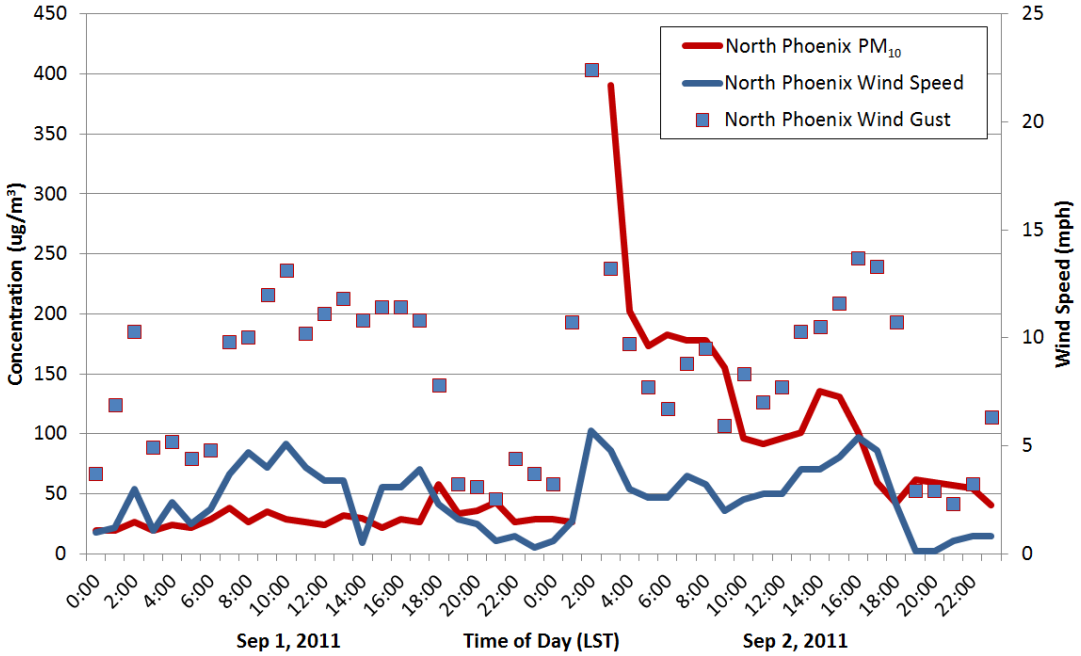

Figure A-6. Hourly PM_{10} concentrations and wind speeds at the North Phoenix monitor on September 1-2, 2011. PM_{10} concentrations sharply increased at 0300 LST on September 2, 2011, coincident with gusty winds, indicating the arrival of windblown dust. Note that PM_{10} concentrations were not available at 200 LST on September 2, 2011 at the North Phoenix monitor.

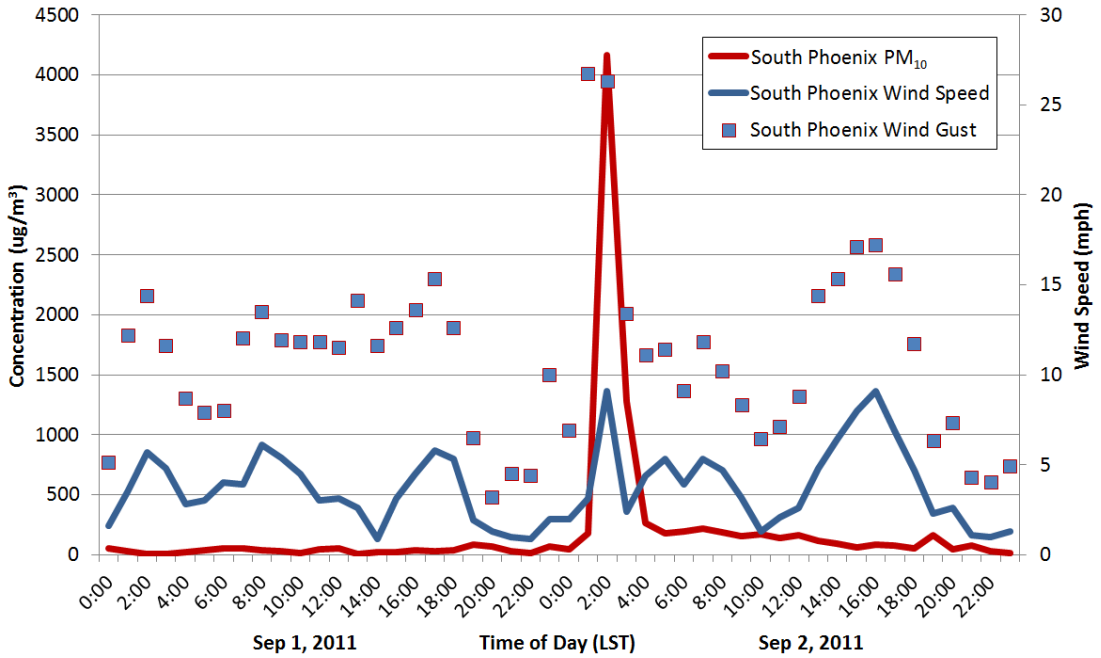

Figure A-7. Hourly PM_{10} concentrations and wind speeds at the South Phoenix monitor on September 1-2, 2011. PM_{10} concentrations sharply increased at 0200 LST on September 2, 2011, coincident with gusty winds, indicating the arrival of windblown dust.

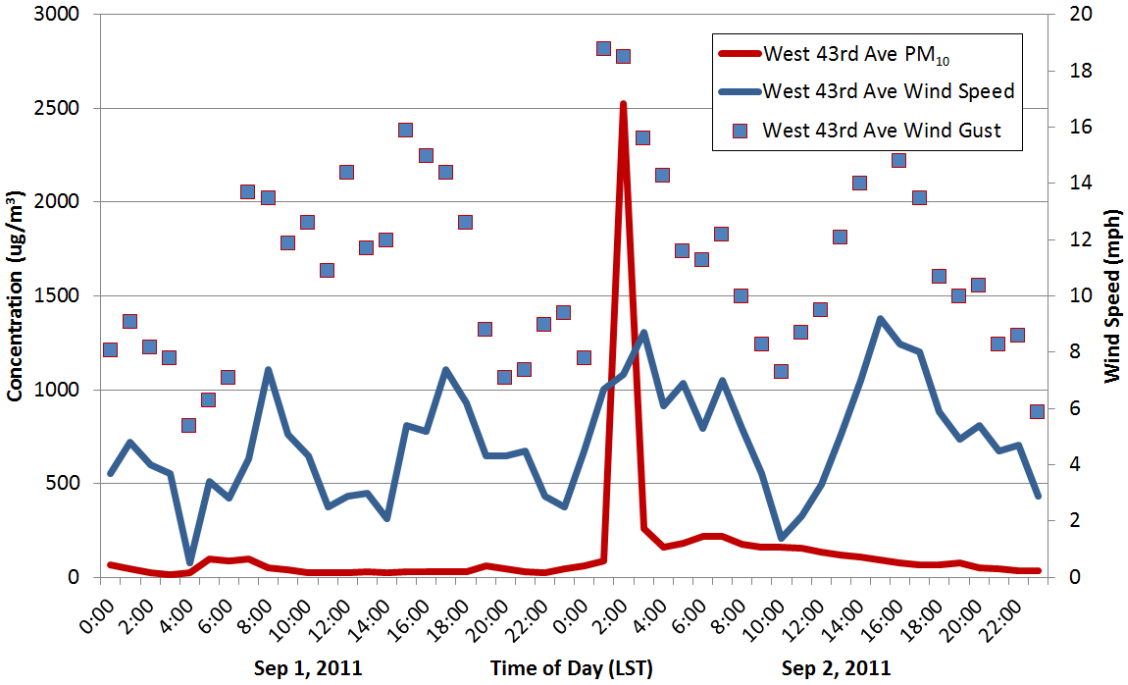

Figure A-8. Hourly PM_{10} concentrations and wind speeds at the West 43rd Avenue monitor on September 1-2, 2011. PM_{10} concentrations sharply increased at 0200 LST on September 2, 2011, coincident with gusty winds, indicating the arrival of windblown dust.

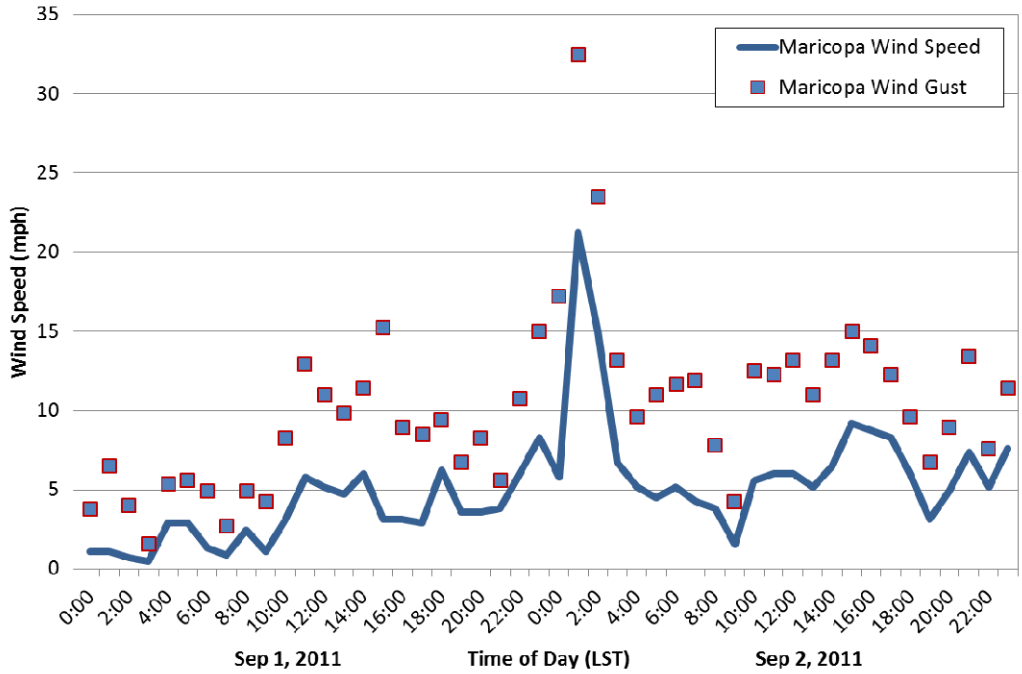

Figure A-9. Hourly wind speeds at the Maricopa monitor on September 1-2, 2011. Wind speeds and gusts sharply increased at 0200 LST on September 2, 2011.

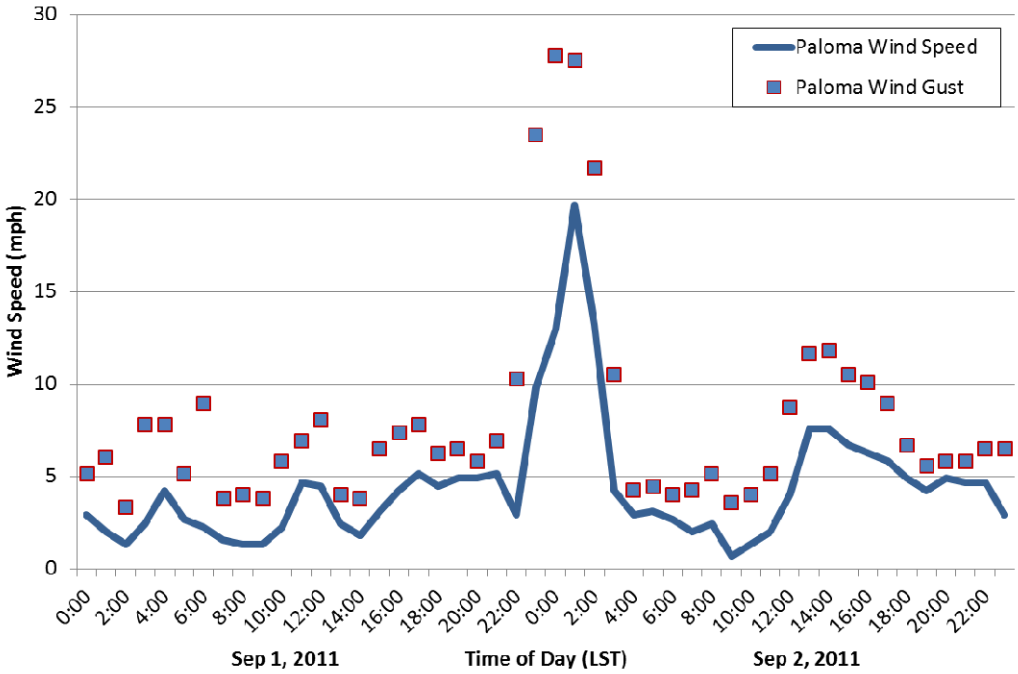

Figure A-10. Hourly wind speeds at the Paloma monitor on September 1-2, 2011. Wind speeds and gusts sharply increased at 0200 LST on September 2, 2011.

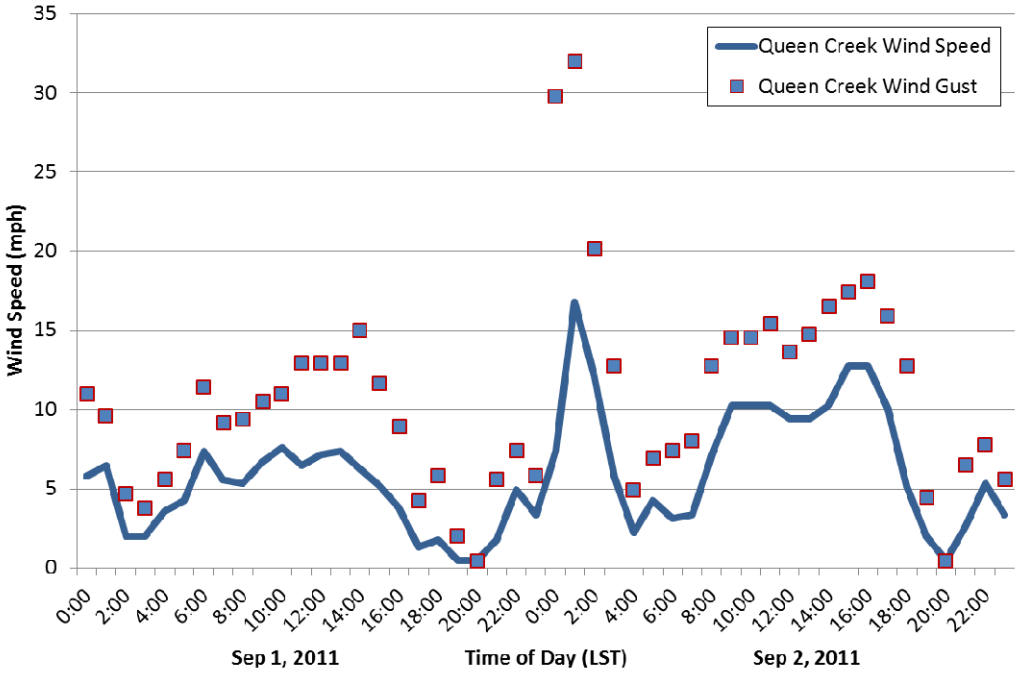

Figure A-11. Hourly wind speeds at the Queen Creek monitor on September 1-2, 2011. Wind speeds and gusts sharply increased at 0200 LST on September 2, 2011.

U.S. Department of Commerce
National Oceanic &
Atmospheric Administration

QUALITY CONTROLLED LOCAL CLIMATOLOGICAL DATA
HOURLY OBSERVATIONS TABLE
PHOENIX SKY HARBOR INTL AIRPORT (23183)
PHOENIX, AZ (09/2011)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Elevation: 1107 ft. above sea level **Latitude:** 33.427 **Longitude:** -112.003 **Data Version:** VER3

Date	Time (LST)	Station Type	Sky Conditions	Visibility (SM)	Weather Type	Dry Bulb Temp		Wet Bulb Temp		Dew Point Temp		Rel Humd %	Wind Speed (MPH)	Wind Dir	Wind Gusts (MPH)	Station Pressure (in. hg)	Press Tend	Net 3-hr Chg (mb)	Sea Level Pressure (in. hg)	Report Type	Precip. Total (in)	Alti-meter (in. hg)
						(F)	(C)	(F)	(C)	(F)	(C)											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
02	0051	11	FEW140 BKN190	10.00		95	35.0	64	17.5	40	4.4	15	6	230		28.54			29.64	AA		29.71
02	0149	11	FEW120 BKN160	2.50	HZ	97	36.0	66	18.8	45	7.0	17	26	170	34	28.60			M	SP		29.77
02	0151	11	SCT020 BKN140	1.50	BLDU	95	35.0	68	20.0	52	11.1	23	22	180	34	28.60	3	024	29.70	AA		29.77
02	0154	11	SCT020 BKN140	0.75	BLDU	93	34.0	70	20.9	57	14.0	30	16	160	34	28.61			M	SP		29.78
02	0156	11	VV006	0.75	BLDU	93	34.0	71	21.5	59	15.0	32	18	170	34	28.61			M	SP		29.78
02	0209	11	VV008	1.00	-RA BLDU	91	33.0	73	22.6	64	18.0	41	28	180	34	28.60			M	SP		29.77
02	0239	11	BKN010	1.25	BLDU	91	33.0	71	21.7	61	16.0	37	17	180	30	28.62			M	SP		29.79
02	0247	11	BKN013 BKN110	2.00	BLDU	91	33.0	71	21.7	61	16.0	37	14	210		28.62			M	SP	T	29.79
02	0251	11	BKN013 BKN110	2.50	BLDU	92	33.3	71	21.6	60	15.6	34	15	220		28.62			29.72	AA		29.79
02	0255	11	BKN019 BKN110 BKN160	3.00	BLDU	91	33.0	70	21.2	59	15.0	34	13	210		28.62			M	SP		29.79
02	0315	11	SCT019 BKN110 BKN160	3.00	BLDU	91	33.0	71	21.7	61	16.0	37	11	220		28.63			M	SP		29.80
02	0351	11	FEW110 BKN160 BKN200	5.00	DU	91	32.8	70	21.2	59	15.0	34	0	000		28.65			29.75	AA		29.82
02	0451	11	FEW110 SCT160 BKN200	10.00		90	32.2	73	22.8	65	18.3	44	9	360		28.65	1	016	29.75	AA		29.82
02	0551	11	FEW110 BKN160 BKN200	10.00		88	31.1	74	23.4	68	20.0	52	7	340		28.66			29.77	AA	T	29.83
02	0651	11	SCT130 BKN160 BKN250	9.00	-RA	87	30.6	74	23.3	68	20.0	53	5	VR	18	28.66			29.76	AA	T	29.83
02	0751	11	FEW110 BKN130 BKN170	9.00	-RA	88	31.1	73	22.8	66	18.9	48	8	320		28.66	1	005	29.77	AA		29.83
02	0851	11	FEW110 BKN140 BKN170	10.00		89	31.7	73	22.9	66	18.9	47	7	300		28.68			29.78	AA		29.85
02	0951	11	FEW110 SCT140 BKN180	10.00		90	32.2	74	23.1	66	18.9	45	5	300		28.69			29.79	AA		29.86
02	1051	11	FEW110 SCT140 BKN180	10.00		91	32.8	73	22.9	65	18.3	42	5	290		28.69	1	007	29.79	AA		29.86
02	1151	11	FEW140 SCT180 BKN210	10.00		93	33.9	73	22.6	63	17.2	37	3	260		28.66			29.77	AA		29.84
02	1251	11	FEW140 SCT190 BKN220	10.00		97	36.1	72	22.4	60	15.6	29	10	280		28.65			29.75	AA		29.82
02	1351	11	FEW140 SCT190 BKN220	10.00		97	36.1	73	22.9	62	16.7	31	3	290	18	28.62	8	021	29.73	AA		29.79
02	1451	11	FEW140 SCT190 BKN220	10.00		99	37.2	71	21.9	57	13.9	25	8	330		28.60			29.70	AA		29.77
02	1551	11	FEW140 SCT190 SCT220	10.00		101	38.3	70	21.2	53	11.7	20	14	320		28.57			29.67	AA		29.74
02	1651	11	FEW140 SCT190 SCT220	10.00		101	38.3	70	21.0	52	11.1	19	14	290		28.55	6	024	29.65	AA		29.72
02	1751	11	FEW140 SCT190 SCT250	10.00		101	38.3	69	20.5	50	10.0	18	13	300		28.54			29.64	AA		29.71
02	1851	11	FEW140 SCT250	10.00		101	38.3	69	20.3	49	9.4	17	11	280		28.53			29.63	AA		29.70
02	1951	11	FEW140 SCT250	10.00		98	36.7	69	20.7	53	11.7	22	7	250		28.54	5	003	29.65	AA		29.71
02	2051	11	FEW140 SCT250	10.00		97	36.1	68	19.9	50	10.0	20	10	260		28.55			29.66	AA		29.72
02	2151	11	CLR	10.00		95	35.0	67	19.5	50	10.0	22	6	250		28.56			29.66	AA		29.73
02	2251	11	CLR	10.00		93	33.9	66	19.0	49	9.4	22	5	250		28.57	1	008	29.67	AA		29.74
02	2351	11	FEW170	10.00		93	33.9	65	18.5	47	8.3	21	6	280		28.57			29.67	AA		29.74

Figure A-12. Quality-controlled local climatological data hourly observations table for Phoenix Sky Harbor International Airport, Phoenix, Arizona (09/02/2011). Note in the Weather Type column that BLDU (blowing dust) was reported for several hours. For a more detailed explanation of the weather codes shown in the table above, please see http://www.nws.noaa.gov/oso/oso1/oso12/document/guide.shtml. Data dynamically generated via http://cdo.ncdc.noaa.gov/qclcd/QCLCD.

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

QUALITY CONTROLLED LOCAL CLIMATOLOGICAL DATA
(final)
HOURLY OBSERVATIONS TABLE
WILLIAMS GATEWAY AIRPORT (23104)
PHOENIX, AZ
(09/2011)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Elevation: 1382 ft. above sea level
Latitude: 33.3
Longitude: -111.666
Data Version: VER2

Date	Time (LST)	Station Type	Sky Conditions	Visibility (SM)	Weather Type	Dry Bulb Temp		Wet Bulb Temp		Dew Point Temp		Rel Humd %	Wind Speed (MPH)	Wind Dir	Wind Gusts (MPH)	Station Pressure (in. hg)	Press Tend	Net 3-hr Chg (mb)	Sea Level Pressure (in. hg)	Report Type	Precip. Total (in)	Alti-meter (in. hg)
						(F)	(C)	(F)	(C)	(F)	(C)											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
02	0015	0	CLR	10.00		97	36.0	65	18.4	43	6.0	16	0	000		28.30			M	AA		29.76
02	0035	0	CLR	10.00		97	36.0	64	17.6	39	4.0	13	6	120		28.31			M	AA		29.77
02	0055	0	CLR	10.00		97	36.0	64	18.0	41	5.0	14	8	130		28.33			M	AA		29.79
02	0115	0	BKN002	1.00	HZ	97	36.0	70	21.0	55	13.0	24	31	180	37	28.35			M	AA		29.81
02	0135	0	OVC002	2.00	HZ	93	34.0	72	22.0	61	16.0	34	20	200	29	28.36			M	AA		29.82
02	0155	0	M	2.00	HZ	93	34.0	73	22.6	63	17.0	37	20	210	26	28.36			M	AA		29.82
02	0215	0	M	2.50	HZ	93	34.0	73	22.6	63	17.0	37	20	210	25	28.37			M	AA		29.83
02	0235	0	SCT001	7.00		93	34.0	73	22.6	63	17.0	37	10	170		28.39			M	AA		29.85
02	0255	0	CLR	10.00		91	33.0	72	22.3	63	17.0	39	8	120	17	28.40			M	AA		29.86
02	0315	0	CLR	10.00		88	31.0	72	22.1	64	18.0	45	10	110		28.41			M	AA		29.87
02	0335	0	CLR	10.00		88	31.0	73	22.8	66	19.0	48	7	120		28.41			M	AA		29.87
02	0355	0	CLR	10.00		88	31.0	72	22.1	64	18.0	45	7	110		28.41			M	AA		29.87
02	0415	0	CLR	10.00		88	31.0	72	22.1	64	18.0	45	5	120		28.41			M	AA		29.87
02	0435	0	CLR	10.00		88	31.0	72	22.1	64	18.0	45	3	100		28.41			M	AA		29.87
02	0455	0	CLR	10.00		88	31.0	72	22.1	64	18.0	45	3	090		28.41			M	AA		29.87
02	0515	0	CLR	10.00		88	31.0	72	22.1	64	18.0	45	0	000		28.41			M	AA		29.87
02	0535	0	CLR	10.00		88	31.0	71	21.8	63	17.0	43	0	000		28.41			M	AA		29.87
02	0549	0	SCT120 BKN150 OVC200	10.00		88	31.0	72	22.1	64	18.0	45	3	VR		28.40			M	AA		29.86
02	0649	0	SCT120 BKN150 OVC200	10.00		90	32.0	72	22.1	63	17.0	41	7	350		28.40			M	AA		29.86
02	0747	0	SCT120 BKN150 OVC200	3.00	HZ	91	33.0	71	21.7	61	16.0	37	7	350		28.42			M	AA		29.88
02	0847	0	FEW120 BKN150 BKN200	5.00	HZ	91	33.0	73	22.6	64	18.0	41	7	330		28.43			M	AA		29.89
02	0954	0	FEW120 BKN150 BKN200	5.00	HZ	93	34.0	74	23.5	66	19.0	41	8	270		28.44			M	AA		29.90
02	1048	0	SCT120 BKN200	10.00	HZ	97	36.0	74	23.5	64	18.0	34	7	300		28.43			M	AA		29.89
02	1148	0	SCT120 BKN200	10.00	HZ	99	37.0	73	22.9	61	16.0	29	8	300		28.42			M	AA		29.88
02	1248	0	FEW150 SCT200	10.00	HZ	102	39.0	72	22.3	57	14.0	23	9	290		28.39			M	AA		29.85
02	1347	0	FEW150 SCT200	10.00	HZ	102	39.0	73	22.8	59	15.0	24	9	280		28.37			M	AA		29.83
02	1447	0	FEW150 SCT200	15.00s	HZ	102	39.0	71	21.6	54	12.0	20	13	280	17	28.34			M	AA		29.80
02	1550	0	FEW150 SCT200	15.00s	HZ	106	41.0	72	22.1	54	12.0	18	14	290	18	28.32			M	AA		29.78
02	1647	0	FEW150 SCT200	15.00s	HZ	106	41.0	70	20.8	48	9.0	14	11	300	18	28.30			M	AA		29.76
02	1747	0	FEW150	15.00s	HZ	102	39.0	68	20.2	48	9.0	16	14	310		28.29			M	AA		29.75
02	1847	0	FEW150	15.00		102	39.0	68	19.8	46	8.0	15	11	300		28.29			M	AA		29.75
02	1950	0	FEW	15.00		100	38.0	M	M	48	9.0	M	3	VR		M			M	AA		29.76
02	1955	0	CLR	10.00		99	37.0	67	19.3	46	8.0	16	0	000		28.31			M	AA		29.77
02	2015	0	CLR	10.00		97	36.0	66	19.0	46	8.0	17	0	000		28.31			M	AA		29.77
02	2035	0	CLR	10.00		97	36.0	69	20.3	52	11.0	22	3	230		28.31			M	AA		29.77

02	2047	0	BKN	20.00		97	36.0	M	M	52	11.0	M	3	VR		M			M	AA		29.77
02	2055	0	CLR	10.00		97	36.0	69	20.3	52	11.0	22	5	250		28.32			M	AA		29.78
02	2115	0	CLR	10.00		97	36.0	69	20.3	52	11.0	22	0	000		28.32			M	AA		29.78
02	2135	0	CLR	10.00		90	32.0	66	18.6	50	10.0	25	3	110		28.32			M	AA		29.78
02	2155	0	CLR	10.00		90	32.0	66	19.1	52	11.0	27	0	000		28.32			M	AA		29.78
02	2215	0	CLR	10.00		90	32.0	66	18.6	50	10.0	25	5	110		28.32			M	AA		29.78
02	2235	0	CLR	10.00		90	32.0	66	18.6	50	10.0	25	7	120		28.33			M	AA		29.79
02	2255	0	CLR	10.00		88	31.0	67	19.3	54	12.0	31	8	130		28.34			M	AA		29.80
02	2315	0	CLR	10.00		88	31.0	67	19.3	54	12.0	31	7	130		28.33			M	AA		29.79
02	2335	0	CLR	10.00		88	31.0	66	18.8	52	11.0	29	6	110		28.33			M	AA		29.79
02	2355	0	CLR	10.00		88	31.0	66	18.8	52	11.0	29	3	110		28.33			M	AA		29.79

Figure A-13. Quality-controlled local climatological data hourly observations table for Williams Gateway Airport, Phoenix, Arizona (09/02/2011). Note in the Weather Type column that HZ (haze) was reported for several hours. Dynamically generated via http://cdo.ncdc.noaa.gov/qclcd/QCLC.

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

QUALITY CONTROLLED LOCAL CLIMATOLOGICAL DATA (final)
HOURLY OBSERVATIONS TABLE
LUKE AFB AIRPORT (23111)
GLENDALE, AZ (09/2011)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Elevation: 1085 ft. above sea level
Latitude: 33.55
Longitude: -112.366
Data Version: VER2

Date	Time (LST)	Station Type	Sky Conditions	Visibility (SM)	Weather Type	Dry Bulb Temp		Wet Bulb Temp		Dew Point Temp		Rel Humd %	Wind Speed (MPH)	Wind Dir	Wind Gusts (MPH)	Station Pressure (in. hg)	Press Tend	Net 3-hr Chg (mb)	Sea Level Pressure (in. hg)	Report Type	Precip. Total (in)	Alti-meter (in. hg)
						(F)	(C)	(F)	(C)	(F)	(C)											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
02	0055	0	FEW140 BKN210	10.00		93	33.8	64	17.9	44	6.6	18	6	180		28.58			29.62	AA		29.73
02	0155	0	FEW140 BKN170	10.00	-RA	96	35.7	66	18.8	46	7.8	18	20	250	34	28.60	3	013	29.63	AA	T	29.75
02	0229	0	FEW010 SCT140	6.00		93	34.0	72	22.0	61	16.0	34	28	240		28.62			29.66	AA	T	29.77
02	0246	0	BKN140	8.00	-DZ	90	32.0	72	22.2	63	17.0	41	18	170		28.65			29.70	AA	T	29.80
02	0249	0	SCT140	8.00	-DZ	90	32.0	73	22.5	64	18.0	42	18	170	23	28.66			29.70	AA	T	29.81
02	0255	0	SCT140	9.00		89	31.4	75	23.6	68	20.0	50	14	190		28.66			29.70	AA	T	29.81
02	0306	0	FEW140	10.00		88	31.0	75	24.1	70	21.0	55	17	190	28	28.66			29.71	AA	T	29.81
02	0355	0	SCT180 BKN200	10.00		88	30.9	75	23.7	69	20.8	53	22	220		28.66			29.70	AA		29.81
02	0455	0	BKN160	10.00		86	30.1	75	23.8	70	21.2	59	9	240		28.67	1	025	29.72	AA		29.82
02	0555	0	CLR	10.00		86	30.2	75	23.8	70	21.0	59	5	200		28.68			29.73	AA		29.83
02	0655	0	FEW190	10.00		87	30.4	75	23.6	69	20.6	55	0	000		28.69			29.74	AA		29.84
02	0755	0	CLR	10.00		87	30.5	75	23.9	70	20.9	57	3	360		28.70	2	009	29.75	AA		29.85
02	0855	0	CLR	10.00		88	31.3	75	23.8	69	20.3	53	0	000		28.71			29.77	AA		29.86
02	0955	0	FEW180	10.00		90	32.0	74	23.4	67	19.6	47	0	000		28.71			29.77	AA		29.86
02	1055	0	FEW180	10.00		91	32.8	73	22.9	65	18.4	42	3	VR		28.71	1	005	29.77	AA		29.86
02	1155	0	FEW130 SCT200	10.00		92	33.1	75	24.0	68	19.8	45	8	190		28.70			29.76	AA		29.85
02	1255	0	FEW160	10.00		92	33.2	75	23.7	67	19.3	44	7	200		28.68			29.74	AA		29.83
02	1355	0	FEW170	10.00		93	33.8	74	23.2	65	18.5	40	3	VR		28.66	8	019	29.71	AA		29.81
02	1455	0	FEW190	10.00		96	35.4	74	23.4	64	17.8	35	5	210		28.63			29.69	AA		29.78
02	1555	0	CLR	10.00		98	36.6	74	23.1	62	16.5	31	0	000		28.60			29.65	AA		29.75
02	1655	0	CLR	10.00		102	39.0	71	21.6	54	12.0	20	6	320		28.58	6	026	29.63	AA		29.73
02	1755	0	CLR	10.00		103	39.7	67	19.6	44	6.8	13	6	300		28.56			29.62	AA		29.71
02	1855	0	CLR	10.00		101	38.2	67	19.5	45	7.3	15	6	230		28.56			29.61	AA		29.71
02	1955	0	CLR	10.00		95	35.1	69	20.7	55	12.8	26	3	230		28.57	5	003	29.63	AA		29.72
02	2055	0	CLR	10.00		94	34.5	67	19.1	49	9.7	22	5	230		28.58			29.64	AA		29.73
02	2155	0	CLR	10.00		91	33.0	66	18.8	50	10.2	25	7	170		28.58			29.65	AA		29.73
02	2255	0	CLR	10.00		89	31.4	66	18.7	51	10.6	27	6	210		28.59	2	008	29.66	AA		29.74
02	2355	0	CLR	10.00		87	30.4	65	18.4	51	10.7	29	6	200		28.60			29.66	AA		29.75

Figure A-14. Quality-controlled local climatological data hourly observations table for Luke Air Force Base, Glendale, Arizona (09/02/2011). Dynamically generated via http://cdo.ncdc.noaa.gov/qclcd/QCLCD.

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

QUALITY CONTROLLED LOCAL CLIMATOLOGICAL DATA (final)
HOURLY OBSERVATIONS TABLE
PHOENIX DEER VALLEY ARPT (03184)
PHOENIX, AZ (09/2011)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Elevation: 1455 ft. above sea level
Latitude: 33.688
Longitude: -112.081
Data Version: VER2

Date	Time (LST)	Station Type	Sky Conditions	Visibility (SM)	Weather Type	Dry Bulb Temp		Wet Bulb Temp		Dew Point Temp		Rel Humd %	Wind Speed (MPH)	Wind Dir	Wind Gusts (MPH)	Station Pressure (in. hg)	Press Tend	Net 3-hr Chg (mb)	Sea Level Pressure (in. hg)	Report Type	Precip. Total (in)	Alti-meter (in. hg)
						(F)	(C)	(F)	(C)	(F)	(C)											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
02	0053	12	CLR	10.00		91	32.8	63	17.3	43	6.1	19	0	000		28.18			29.65	AA		29.74
02	0153	12	CLR	10.00		92	33.3	62	16.7	39	3.9	16	8	220		28.20	3	009	29.67	AA		29.76
02	0234	12	BKN013	2.00	HZ	93	34.0	66	18.7	48	9.0	21	13	170	25	28.24			M	SP		29.80
02	0240	12	VV012	1.00	HZ	93	34.0	67	19.1	50	10.0	23	16	180		28.25			M	SP		29.81
02	0251	12	BKN013	1.50	-RA	91	33.0	65	18.3	48	9.0	23	21	230	26	28.26			M	SP		29.82
02	0253	12	BKN013	2.00	-RA	92	33.3	65	18.3	47	8.3	21	16	230	26	28.26			29.73	AA	T	29.82
02	0256	12	BKN013	4.00	-RA	91	33.0	64	17.9	46	8.0	21	15	230	26	28.26			M	SP		29.82
02	0307	12	BKN017	5.00	HZ	90	32.0	67	19.6	54	12.0	29	14	230		28.27			M	SP		29.83
02	0351	12	BKN031	9.00		86	30.0	71	21.8	64	18.0	48	10	240		28.29			M	SP		29.85
02	0353	12	BKN033	9.00		86	30.0	71	21.8	64	17.8	48	10	240		28.29			29.76	AA		29.85
02	0453	12	OVC032	9.00		85	29.4	72	22.3	66	18.9	53	10	240		28.30	1	031	29.77	AA		29.86
02	0553	12	FEW032	9.00		84	28.9	72	22.1	66	18.9	55	6	250		28.30			29.77	AA		29.86
02	0653	12	FEW028	8.00		85	29.4	73	22.6	67	19.4	55	0	000		28.30			29.78	AA		29.86
02	0753	12	CLR	8.00		85	29.4	72	22.3	66	18.9	53	7	360		28.31	1	004	29.78	AA		29.87
02	0853	12	SCT100 SCT120	10.00		87	30.6	72	22.0	64	17.8	46	9	330		28.31			29.78	AA		29.87
02	0953	12	FEW050	10.00		87	30.6	71	21.6	63	17.2	45	6	300		28.32			29.79	AA		29.88
02	1053	12	FEW110	10.00		88	31.1	71	21.8	63	17.2	43	5	260		28.32	3	004	29.80	AA		29.88
02	1153	12	CLR	10.00		89	31.7	71	21.7	62	16.7	41	3	250		28.31			29.78	AA		29.87
02	1253	12	CLR	10.00		90	32.2	71	21.5	61	16.1	38	0	000		28.29			29.76	AA		29.85
02	1353	12	CLR	10.00		92	33.3	70	21.3	59	15.0	33	3	290		28.26	8	020	29.73	AA		29.82
02	1453	12	CLR	10.00		95	35.0	71	21.7	59	15.0	30	9	270		28.24			29.71	AA		29.80
02	1553	12	CLR	10.00		97	36.1	71	21.8	58	14.4	27	9	260		28.21			29.68	AA		29.77
02	1653	12	CLR	10.00		99	37.2	69	20.6	52	11.1	21	11	270		28.20	7	024	29.66	AA		29.75
02	1753	12	CLR	10.00		100	37.8	66	19.0	44	6.7	15	11	270		28.17			29.65	AA		29.73
02	1853	12	CLR	10.00		99	37.2	64	18.0	39	3.9	12	6	280		28.17			29.64	AA		29.73
02	1953	12	CLR	10.00		96	35.6	64	17.6	40	4.4	14	3	220		28.18	5	003	29.65	AA		29.74
02	2053	12	CLR	10.00		92	33.3	63	17.0	41	5.0	17	0	000		28.20			29.66	AA		29.75
02	2153	12	CLR	10.00		89	31.7	62	16.9	43	6.1	20	0	000		28.20			29.67	AA		29.75
02	2253	12	CLR	10.00		86	30.0	62	16.5	44	6.7	23	5	110		28.20	3	008	29.68	AA		29.76
02	2353	12	CLR	10.00		85	29.4	62	16.8	46	7.8	26	0	000		28.21			29.69	AA		29.77

Figure A-15. Quality-controlled local climatological data hourly observations table for Phoenix Deer Valley Airport, Phoenix, Arizona (09/02/2011). Note in the Weather Type column that HZ (haze) was reported for several hours. Dynamically generated via http://cdo.ncdc.noaa.gov/qclcd/QCLCD.

Appendix B: Media Coverage, Videos, and Images

ADEQ visibility cameras in the Phoenix area:

South Mountain: www.phoenixvis.net/videos/mpeg4/SOMT_09022011.mp4

Estrella Mountains: www.phoenixvis.net/videos/mpeg4/ESMO_09022011.mp4

Camelback Mountains: www.phoenixvis.net/videos/mpeg4/CAME_09022011.mp4

Superstition Mountains: www.phoenixvis.net/videos/mpeg4/SUPM_09022011.mp4

Other media sources:

http://www.youtube.com/watch?v=0ckZh57Lsx4

http://www.azfamily.com/younews/129081558.html?img=1&mg=t

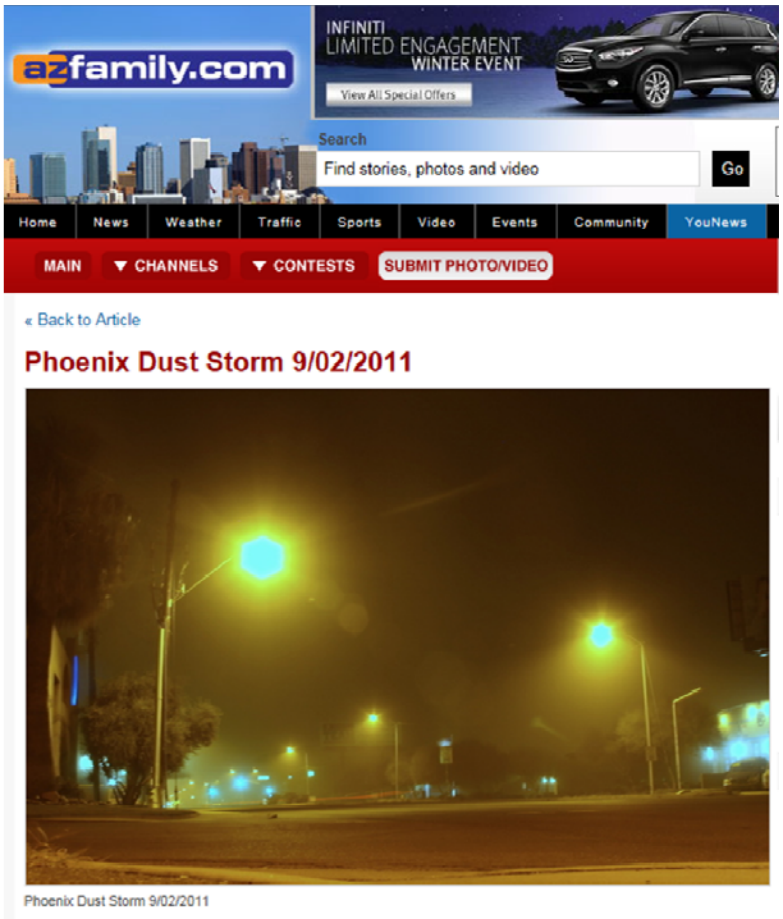

Figure B-1. Dust storm in Phoenix at approximately 0200 LST on September 2, 2011. This photo was taken on 20th Street and Indian School Road. Image source: http://www.azfamily.com/younews/129081558.html?img=1&mg=t.

Appendix C: Historical Fluctuation Time Series Graphs

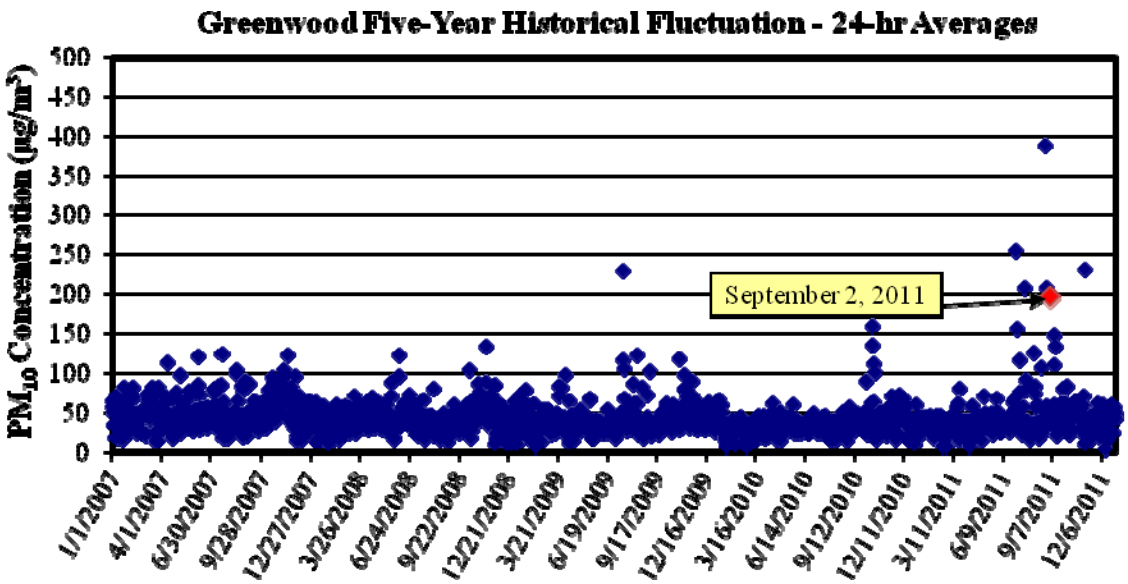

Figure C-1. 24-hr average PM_{10} concentrations at the Greenwood monitor (2007–2011). The 24-hr average PM_{10} concentration on September 2, 2011, is shown in red and highlighted by the arrow.

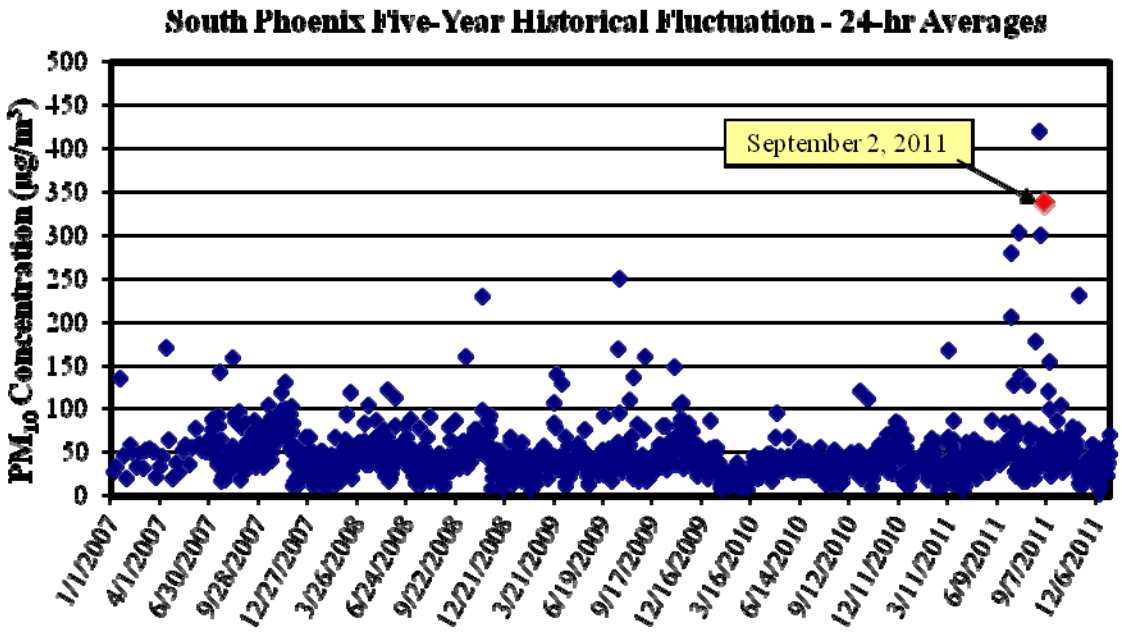

Figure C-2. 24-hr average PM_{10} concentrations at the South Phoenix monitor (2007–2011). The 24-hr average PM_{10} concentration on September 2, 2011, is shown in red and highlighted by the arrow.

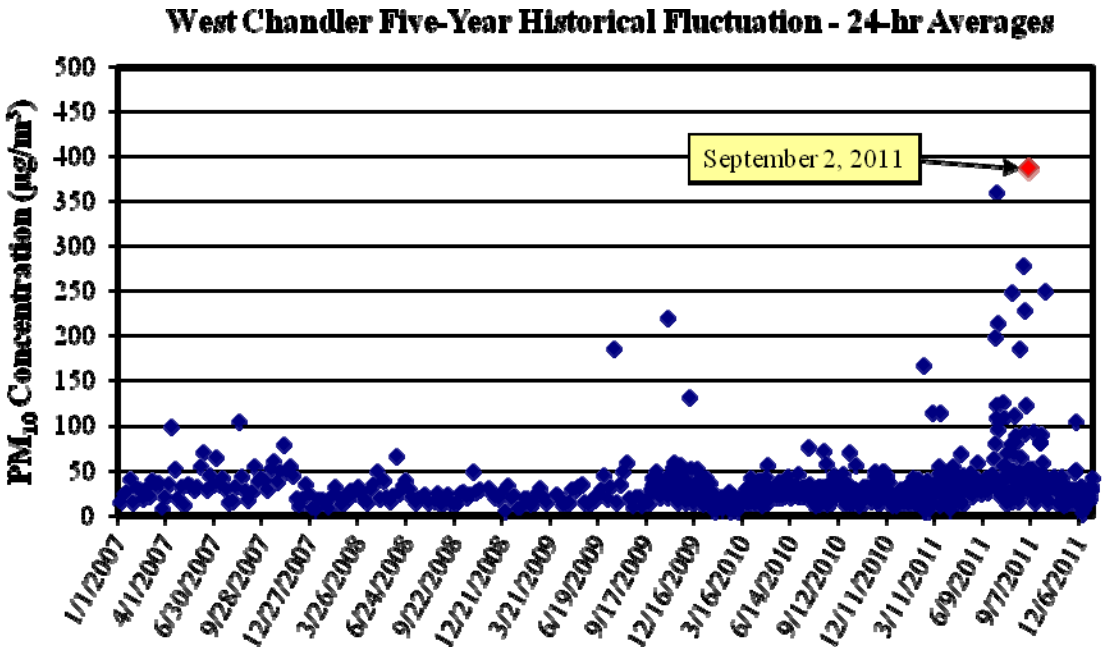

Figure C-3. 24-hr average PM_{10} concentrations at the West Chandler monitor (2007–2011). The 24-hr average PM_{10} concentration on September 2, 2011, is shown in red and highlighted by the arrow.

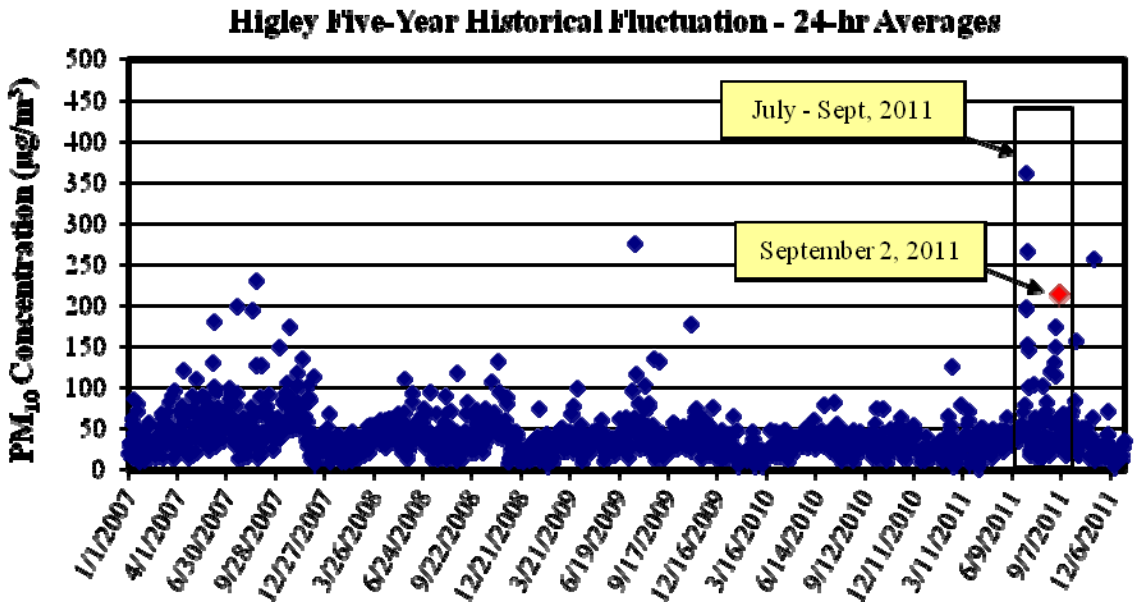

Figure C-4. 24-hr average PM_{10} concentrations at the Higley monitor (2007–2011). The 24-hr average PM_{10} concentration on September 2, 2011, is highlighted in red. The period of July to September 2011, is shown in red and highlighted by the arrow.

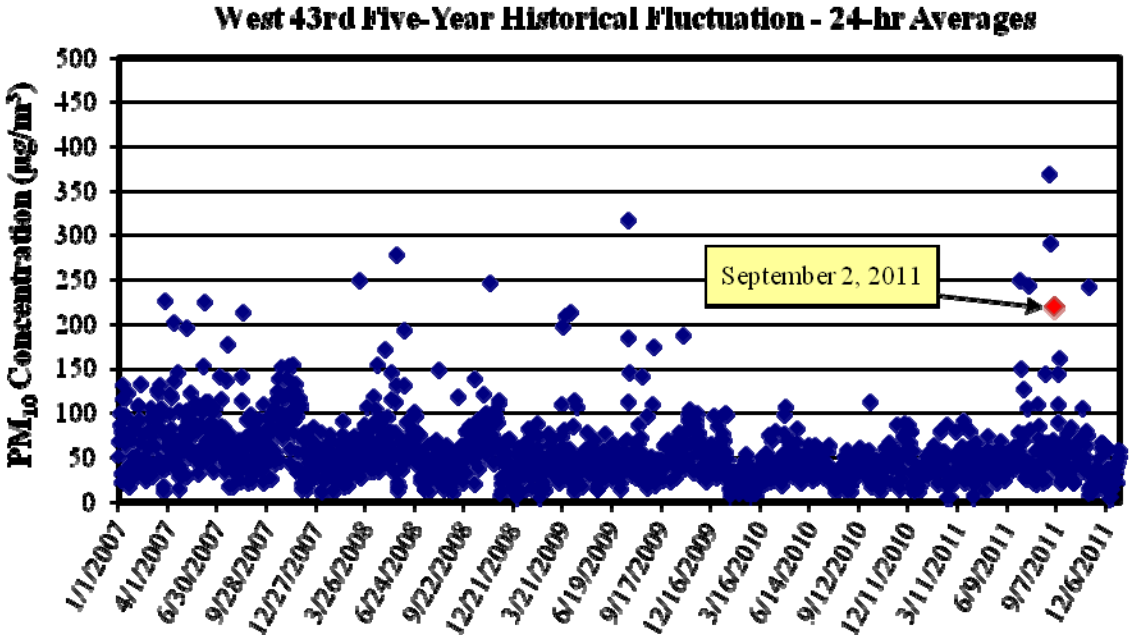

Figure C-5. 24-hr average PM_{10} concentrations at the West 43rd monitor (2007–2011). The 24-hr average PM_{10} concentration on September 2, 2011, is shown in red and highlighted by the arrow.

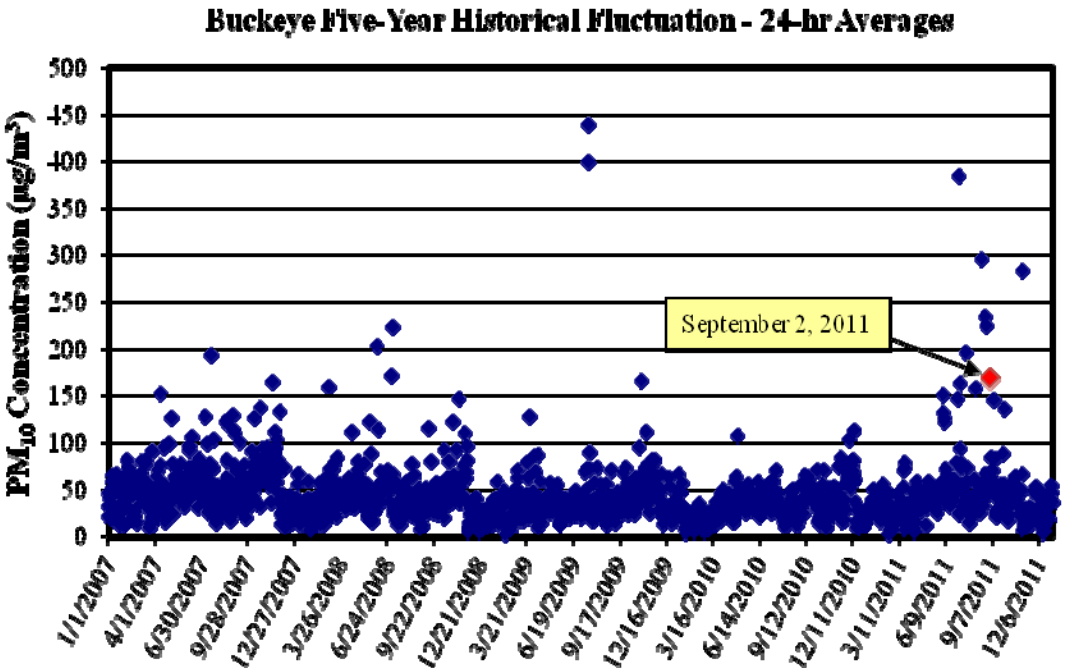

Figure C-6. 24-hr average PM_{10} concentrations at the Buckeye monitor (2007–2011). The 24-hr average PM_{10} concentration on September 2, 2011, is shown in red and highlighted by the arrow.

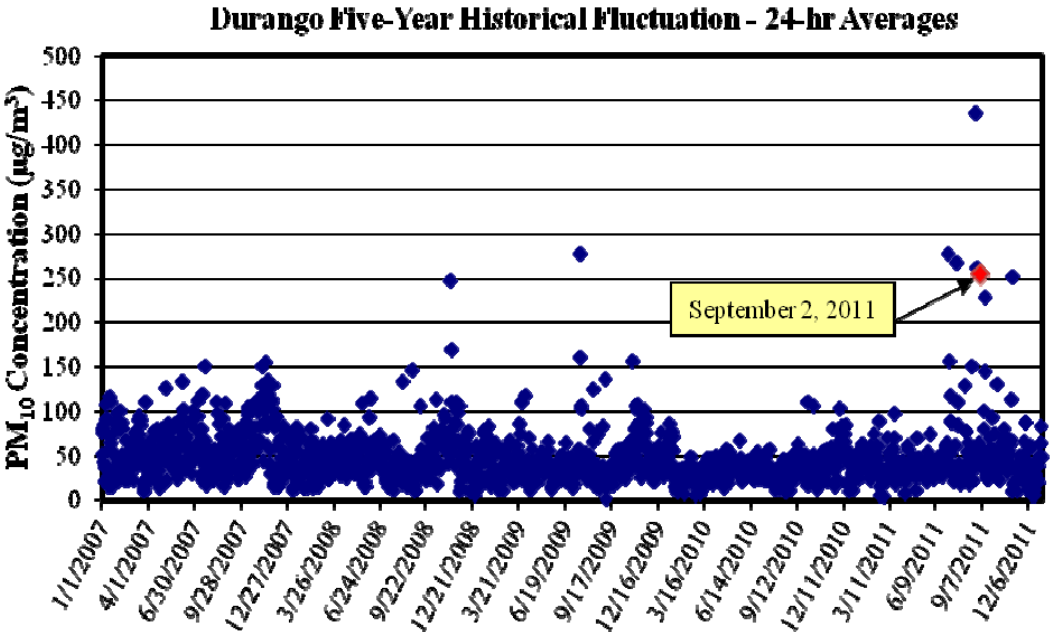

Figure C-7. 24-hr average PM_{10} concentrations at the Durango monitor (2007–2011). The 24-hr average PM_{10} concentration on September 2, 2011, is shown in red and highlighted by the arrow.

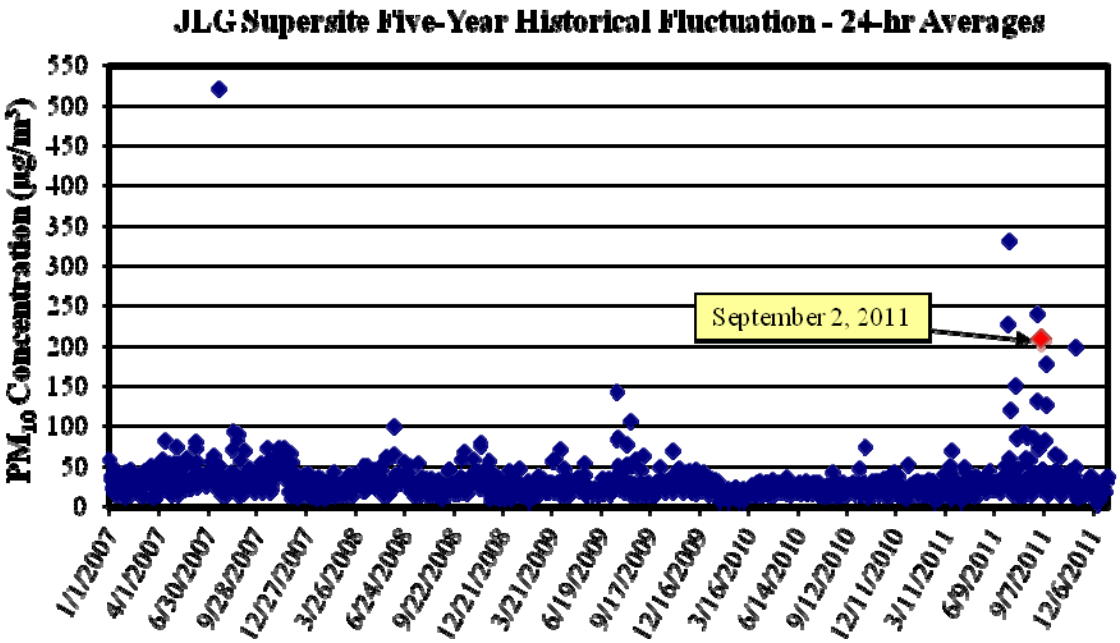

Figure C-8. 24-hr average PM_{10} concentrations at the JLG Supersite monitor (2007–2011). The 24-hr average PM_{10} concentration on September 2, 2011, is shown in red and highlighted by the arrow.

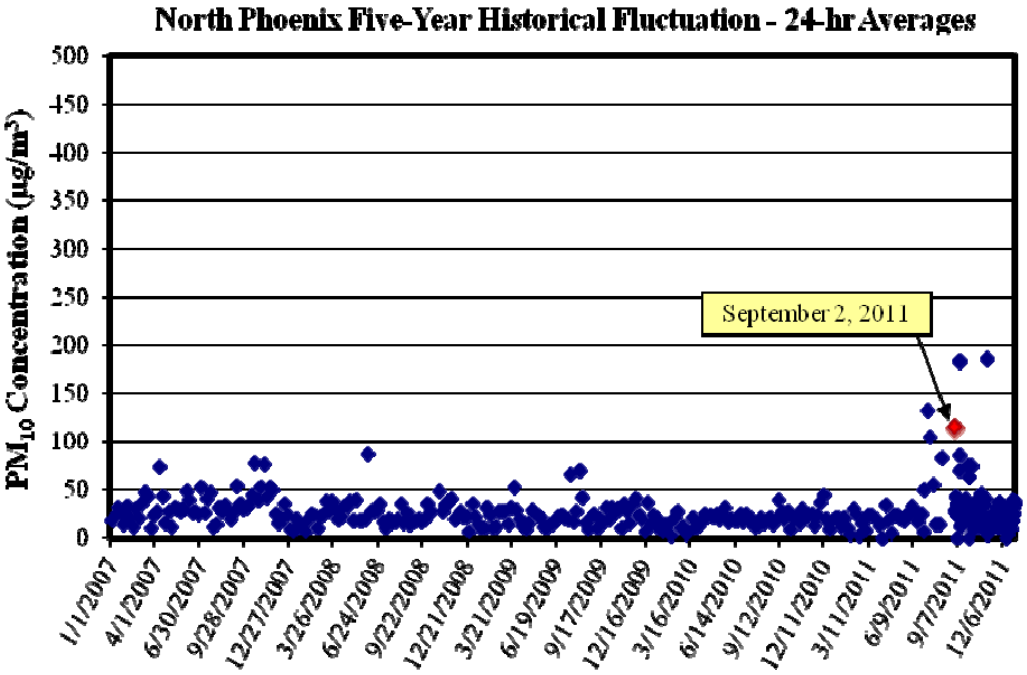

Figure C-9. 24-hr average PM_{10} concentrations at the North Phoenix monitor (2007–2011). The 24-hr average PM_{10} concentration on September 2, 2011, is shown in red and highlighted by the arrow.

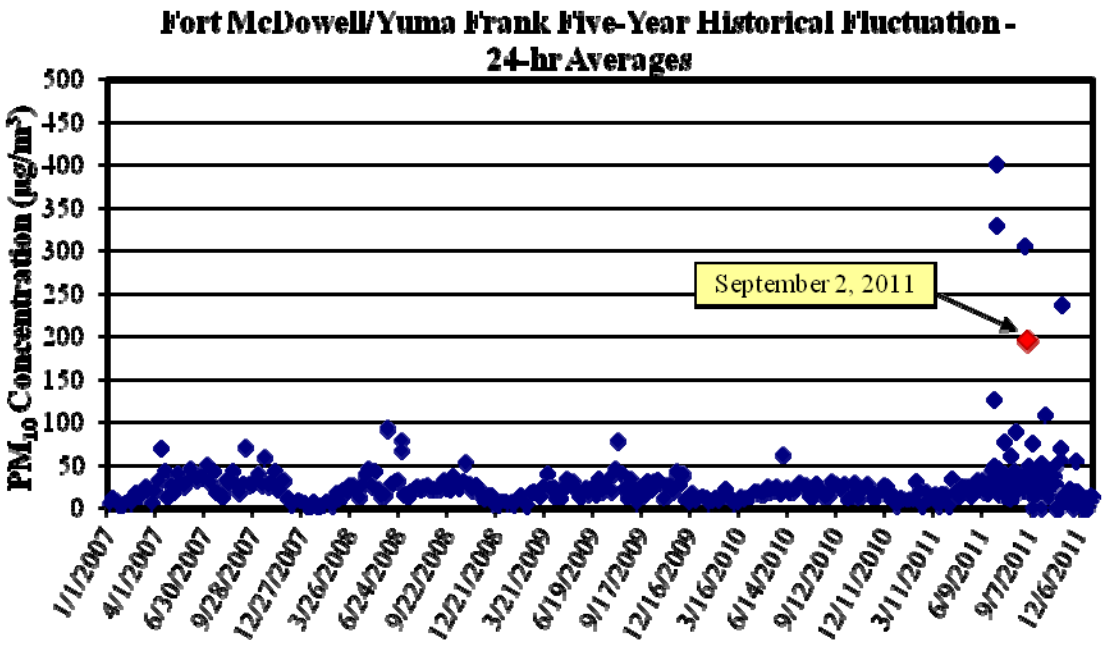

Figure C-10. 24-hr average PM_{10} concentrations at the Fort McDowell/Yuma Frank monitor (2007–2011). The 24-hr average PM_{10} concentration on September 2, 2011, is shown in red and highlighted by the arrow.

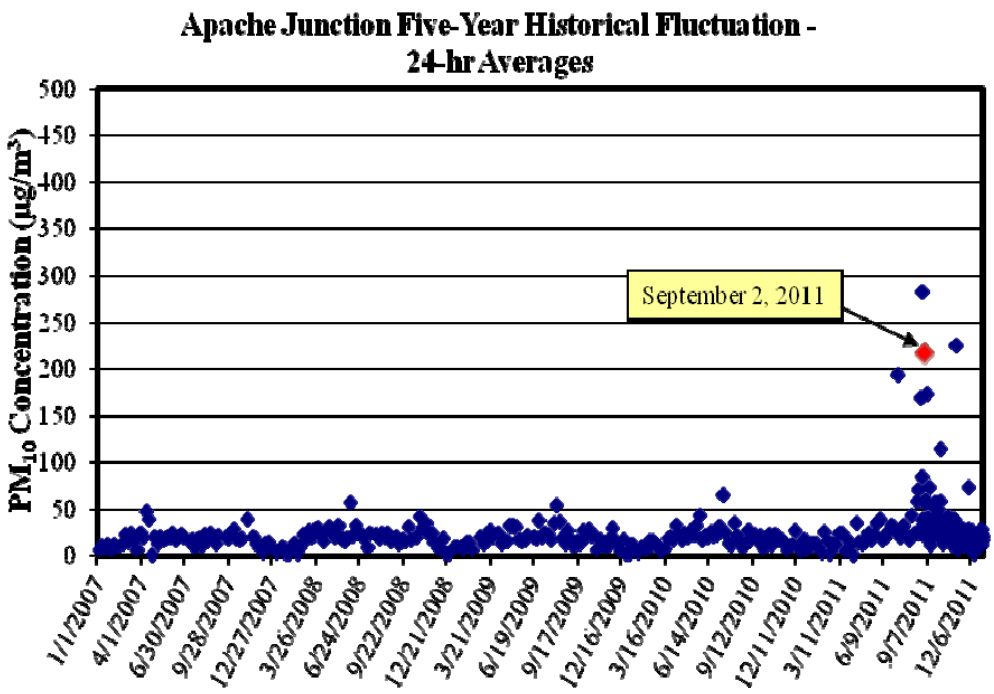

Figure C-11. 24-hr average PM_{10} concentrations at the Apache Junction monitor (2007–2011). The 24-hr average PM_{10} concentration on September 2, 2011, is shown in red and highlighted by the arrow.

Appendix D:
ADEQ and NWS Forecast Products

ADEQ Arizona Department of Environmental Quality

MARICOPA COUNTY DUST CONTROL FORECAST

ISSUED THURSDAY, SEPTEMBER 01, 2011

Five-day weather outlook:

DURING ACTIVE SUMMER MONSOON EPISODES STRONG GUSTY WINDS AND DENSE BLOWING DUST ARE POSSIBLE EVEN FROM DISTANT THUNDERSTORMS

Although the prospects for thunderstorms and significant rainfall in the Valley are remote, an increase in summer monsoon moisture and thunderstorm activity east and southeast of the metro area the next few days will mean a higher risk for unhealthy levels of PM-10 due to dense blowing dust generated by outflow boundaries. Otherwise, low-level gradient winds and upslope flow will yield breezy to gusty conditions at times each afternoon thru Sunday with a light easterly wind regime possible by Monday.

R I S K F A C T O R S

	WINDS		STAGNATION		UNHEALTHY PM-10 RISK LEVEL
Day 1: Fri 09/02/2011	Southwest to westerly 10-20 mph during the afternoon except strong and gusty due to outflow from thunderstorms.	+	No significant stagnation expected.	=	**MODERATE**
Day 2: Sat 09/03/2011	Southwest to westerly 10-20 mph during the afternoon except strong and gusty due to outflow from thunderstorms.	+	No significant stagnation expected.	=	**MODERATE**
Day 3: Sun 09/04/2011	Southwest to westerly 10-20 mph during the afternoon except strong and gusty due to outflow from thunderstorms.	+	No significant stagnation expected.	=	**MODERATE**
EXTENDED OUTLOOK					
Day 4: Mon 09/05/2011	Easterly 5-10 mph except strong and gusty due to outflow from thunderstorms.	+	No significant stagnation expected.	=	**MODERATE**
Day 5: Tue 09/06/2011	Easterly 5-10 mph except strong and gusty due to outflow from thunderstorms.	+	No significant stagnation expected.	=	**MODERATE**

The Maricopa County Dust Control Action Forecast is issued to assist in the planning of work activities to help reduce dust pollution. A recorded message of this forecast can be accessed at 602-771-2368. To review the complete air quality forecast for the Phoenix metropolitan area, as well as the health impacts and reduction methods for different air pollutants, call 602-771-2367 for recorded forecast information or click on ADEQ's Air Quality Forecast at http://www.azdeq.gov/environ/air/ozone/ensemble.pdf.

CKR 04/28/2011

ADEQ
Arizona Department of Environmental Quality

AQI AIR QUALITY INDEX

200
150
100
50

VERY UNHEALTHY (201-300)

UNHEALTHY (151-200)

UNHEALTHY FOR SENSITIVE GROUPS (101-150)

MODERATE (51-100)

GOOD (0-50)

For more information visit:
http://www.airnow.gov/index.cfm?action=aqibasics.aqi

NEW!!! CLICK HERE FOR UPDATED OZONE SEASON STATS NEW!!!

AIR QUALITY FORECAST FOR FRIDAY, SEPTEMBER 02, 2011

This report is updated by 1:00 p.m. Sunday thru Friday and is valid
for areas within and bordering Maricopa County in Arizona

FORECAST DATE NOTICES (*SEE BELOW FOR DETAILS) AIR POLLUTANT	YESTERDAY WED 08/31/2011 DUST NWS EXCESSIVE HEAT WARNING Highest AQI Reading/Site (Preliminary data only)	TODAY THU 09/01/2011 OZONE HEALTH WATCH DUST NWS EXCESSIVE HEAT WARNING	TOMORROW FRI 09/02/2011 OZONE HEALTH WATCH DUST NWS EXCESSIVE HEAT WARNING	EXTENDED SAT 09/03/2011 OZONE HEALTH WATCH POSSIBLE DUST
O3*	**93** **QUEEN VALLEY**	**97** **MODERATE**	**93** **MODERATE**	**90** **MODERATE**
CO*	**07** **GREENWOOD**	**06** **GOOD**	**05** **GOOD**	**06** **GOOD**
PM-10*	**58** **WEST FORTY THIRD**	**75** **MODERATE**	**75** **MODERATE**	**75** **MODERATE**
PM-2.5*	**41** **PHOENIX SUPERSITE**	**50** **GOOD**	**49** **GOOD**	**47** **GOOD**

* O3 = Ozone CO = Carbon Monoxide PM-10 = Particles 10 microns & smaller PM-2.5 = Particles smaller than 2.5 microns

*"Ozone Health Watch" means that the highest concentration of OZONE may approach the federal health standard.

"PM-10 or PM-2.5 Health Watch" means that the highest concentration of PM-10 or PM-2.5 may approach the federal health standard.
"High Pollution Advisory" means that the highest concentration of OZONE, PM-10, or PM-2.5 may exceed the federal health standard.
"DUST" means that short periods of high PM-10 concentrations caused by outflow from thunderstorms are possible.

Health message for Thursday September 01: Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors.
Health message for Friday September 02: Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors.

Synopsis and Discussion

OZONE: AN OZONE HEALTH WATCH HAS BEEN ISSUED FOR TODAY AND FRIDAY SEPT 02
It appears that last evening's thunderstorm outflow boundary has significantly altered the local ozone chemistry due to a suspected increase in ozone precursors. Around 9:00 p.m. Wednesday hourly ozone time series' from nearly all Valley ozone monitoring sites showed a subtle increase in ozone concentrations following east to southeasterly wind gusts of up to 25 mph. Ozone readings at some metro locations subsequently remained elevated thru the overnight period and hourly concentrations Valley-wide were ramping up rapidly as of this writing. As of 10:00 a.m. hourly concentrations were between 20 and 30 parts per billion higher than those of 24 hours ago at sites such South Phoenix, West Phoenix, and South Scottsdale. Since a westerly wind regime remains in place, highest 8-hour average ozone levels are still expected to occur over the eastern portion of the metro area but readings may now approach unhealthy concentrations over some central city locations as well. As a result, an Ozone Health Watch has been issued for the remainder of today. A similar situation looks possible for Friday so the Watch will continue in effect.
PARTICLES: A localized blowing dust event occurred Wednesday evening with the highest PM-10 concentration of 428.1ug/m3 measured at the Higley monitoring site at 8:00 p.m. Visibilities as low as five miles and wind gusts up to 26 mph were recorded. Although the prospects for thunderstorms and significant rainfall in the Valley are remote, an increase in summer monsoon moisture and thunderstorm activity east and southeast of the metro area the next few days will mean a higher risk for unhealthy levels of PM-10 due to dense blowing dust generated by outflow boundaries. Otherwise, low-level gradient winds and upslope flow will yield breezy to gusty conditions at times each afternoon thru Saturday.

MONITORING SITE MAPS: STATIC MAP - **http://www.azdeq.gov/environ/air/monitoring/images/map.jpg**
INTERACTIVE MAPS - **http://aqwww.maricopa.gov/AirMonitoring/SitePollutionMap.aspx**
http://www.airnow.gov/

POLLUTION MONITOR READINGS FOR WEDNESDAY, AUGUST 31, 2011

O3 (OZONE)

Info on current 8-hour ozone standard: **http://www.epa.gov/air/ozonepollution/pdfs/2008_03_aqi_changes.pdf**
For archived AQI maps go to: **http://www.airnow.gov/index.cfm?action=airnow.maps**

SITE NAME	MAX 8-HR VALUE (PPB)	MAX AQI	AQI COLOR CODE
Alamo Lake (La Paz County)	55	47	
Apache Junction (Pinal County)	63	61	
Blue Point	62	58	
Buckeye	42	36	
Casa Grande (Pinal County)	50	42	
Cave Creek	57	48	
Central Phoenix	54	46	
Dysart	47	40	
Falcon Field	61	54	
Fountain Hills	63	61	
Glendale	52	44	
Humboldt Mountain	57	48	
North Phoenix	58	49	
Phoenix Supersite	57	48	
Pinal Air Park (Pinal County)	52	44	
Pinnacle Peak	55	47	
Queen Valley (Pinal County)	73	93	
Rio Verde	62	58	
South Phoenix	53	45	
South Scottsdale	57	48	
Tempe	50	42	
Tonto Nat'l Mon. (Gila County)	63	61	
West Chandler	63	61	
West Phoenix	55	47	
Yuma (Yuma County)	47	40	

CO (CARBON MONOXIDE)

SITE NAME	MAX 8-HR VALUE (PPM)	MAX AQI	AQI COLOR CODE
Central Phoenix	0.5	06	
Greenwood	0.6	07	
Phoenix Supersite	NOT AVBL	NOT AVBL	NOT AVBL
West Phoenix	0.4	05	

PM-10 (PARTICLES)

SITE NAME	MAX 24-HR VALUE (ug/m3)	MAX AQI	AQI COLOR CODE
Buckeye	62	54	
Central Phoenix	48	44	
Combs School(Pinal County	77	59	
Durango	63	55	
Dysart	38	35	
Glendale	41	38	
Greenwood	42	39	
Higley	62	54	
Maricopa (Pinal County)	79	63	
Phoenix Supersite	38	35	
South Phoenix	62	54	
West Chandler	47	44	
West Forty Third	69	58	
West Phoenix	52	48	
Zuni Hills	38	35	

PM-2.5 (PARTICLES)

(Some data derived from light-scattering equipment)

For maps go to: http://www.airnow.gov/

SITE NAME	MAX 24-HR VALUE (ug/m3)	MAX AQI	AQI COLOR CODE
Durango	11.4	37	
Dysart	8.4	27	
Estrella Mountain Park	4.4	14	
Glendale	9.5	31	
Phoenix Supersite	12.6	41	
South Phoenix	8.6	28	
Vehicle Emissions Lab	9.1	30	
West Phoenix	9.9	32	

Appendix E:
Affidavit of Public Notice

AFFIDAVIT OF PUBLICATION

ADEQ
AIR QUALITY DIVISION
12 DEC -6 AM 10: 47

THE ARIZONA REPUBLIC

STATE OF ARIZONA
COUNTY OF MARICOPA } SS.

Tabitha Weaver, being first duly sworn, upon oath deposes and says: That she is a legal advertising representative of the Arizona Business Gazette, a newspaper of general circulation in the county of Maricopa, State of Arizona, published at Phoenix, Arizona, by Phoenix Newspapers Inc., which also publishes The Arizona Republic, and that the copy hereto attached is a true copy of the advertisement published in the said paper on the dates as indicated.

The Arizona Republic

December 3, 2012

Sworn to before me this
3st day of
December A.D. 2012

MANUEL VARGAS
Notary Public - State of Arizona
MARICOPA COUNTY
My Commission Expires
November 30, 2015

Notary Public

PUBLIC NOTICE
Arizona Department of Environmental Quality Request for Public Comments

On Exceptional Events in the Greater Phoenix Area•
In 2005, Congress identified a need to account for events that result in exceedances of the National Ambient Air Quality Standards (NAAQS) that are exceptional in nature (e.g., not expected to reoccur or caused by acts of nature beyond man-made controls.) In response, EPA promulgated the Exceptional Events Rule (EER) to address exceptional events in 40 CFR Parts 50 and 51 on March 22, 2007 (72 FR 13560). On May 2, 2011, EPA released draft guidance documents on the implementation of the EER to State, tribal and local air agencies for review. The EER allows for states and tribes to "flag" air quality monitoring data as an exceptional event. If flagged, these data can be excluded from consideration in air quality planning if EPA concurs with the demonstration submitted by the flagging agency documenting that all procedural and technical requirements have been met. Pursuant to 40 CFR 50.14(c)(3)(i), the Arizona Department of Environmental Quality (ADEQ) is soliciting comments on its final demonstrations of events that have caused elevated concentrations of PM10 in the Greater Phoenix area on February 19; July 18; August 3; August 18; August 25 through 28; September 2; October 4; November 14, 2011; January 21 - 22 and February 27, 2012. ADEQ has decided to flag these episodes based on these analyses. Copies of the demonstrations are available for review beginning Monday, December 3, 2012 on the ADEQ website at www.azdeq.gov/environ/air/plan/. Interested parties can submit written comments throughout the comment period which will end at 5:00 p.m. on Tuesday, January 1, 2013. Any comments received will be responded to and forwarded to EPA with the final demonstrations.
Written comments should be addressed, faxed, or e-mailed to:
Andra Juniel, Air Assessment Section, Arizona Department of Environmental Quality, 1110 W. Washington Street, 3415-A, Phoenix, AZ 85007; PHONE: (602) 771-4417; FAX: (602) 771-2366, E-mail: juniel.andra@azdeq.gov.
In addition to being available on-line, copies of the analyses are available for review at the following location:
Arizona Department of Environmental Quality, Records Retention Center, First Floor, 1110 W. Washington Street, Phoenix, Arizona 85007. Attn: David Olivo, (602) 771-4380, E-mail: olivo.david@azdeq.gov.
Persons with a disability may request reasonable accommodations by contacting Linda Morrison at (602) 771-4793 or 1-800-234-5677 ext. 771-4793. This document is available in alternative formats by contacting ADEQ TDD phone number at (602) 771-4829.
Pub: December 3, 2012