

State of Arizona
PM_{2.5} Exceptional Event Documentation Supplement for
the Previously Submitted July 18, 2011
PM₁₀ Windblown Dust Exceptional Event

Produced by:

Arizona Department of Environmental Quality
Maricopa County Air Quality Department
Maricopa Association of Governments

Final Report
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1. INTRODUCTION

On July 18, 2011, the Durango Complex monitor (04-013-9812-88101-3) exceeded both¹ the 24-hour and annual PM_{2.5} standards as a result of a high wind exceptional event. The PM₁₀ Exceptional Event documentation for July 18, 2011 was submitted to EPA on January 28, 2013 and the exceedances included therein received concurrence from EPA on May 6, 2013. This supplemental document related to PM_{2.5} exceedances that occurred during the same time period builds upon the initial documentation for the high wind exceptional events that caused eight Phoenix area monitors to exceed the PM₁₀ standard on July 18, 2011.

The information provided in the following sections of this supplemental document show that the PM_{2.5} exceedance at the Durango Complex monitor occurring on July 18, 2011 was due to a high wind exceptional event by showing that:

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

¹ As stated in EPA's *Interim Exceptional Events Rule Frequently Asked Questions*, May 2013, on pages 34-35, "The preamble [to the Exceptional Events Rule] states that in the particular case of PM_{2.5}, the direct comparison of a single 24-hour average concentration (determined from a single filter-based measurement or by averaging 24 1-hour measurements from a continuous equivalent instrument) to the level of the annual NAAQS can be the basis for meeting the 'but for' criterion for exceedances or violations of the annual NAAQS.²⁴ In context, it is clear that based on this comparison, a 24-hour concentration can be excluded from the calculation of the annual PM_{2.5} design value, if other rule criteria are also met. It is therefore not necessary to show that the annual average PM_{2.5} concentration was above 12 or 15 µg/m³ with the event and would have been below 12 or 15 µg/m³ 'but for' the single event at issue."

2. CONCEPTUAL MODEL

As explained in detail in Section II of the previously approved PM₁₀ main document, on the evening of July 18, 2011, the active monsoon led to numerous thunderstorms and thunderstorm outflows that produced blowing dust in many parts of Arizona, including the Phoenix Metropolitan area. Thunderstorms originating in the open and natural desert areas of Pinal County generated strong south-southeasterly winds leading to a widespread windblown dust event that resulted in eight PM₁₀ exceedances in the central and western Phoenix PM₁₀ nonattainment area. In addition to generating and transporting extremely high hourly and five-minute concentrations of PM₁₀, windblown dust carried by the outflows produced hourly PM_{2.5} concentrations as high as 314 µg/m³ at the Durango Complex monitor. The PM_{2.5} from the dust storm ultimately caused the Durango Complex monitor to exceed the PM_{2.5} standard on this date with a 36.0 µg/m³ 24-hour average. A map of current PM_{2.5} monitors in Maricopa County is provided in Figure 1. As a summary of the event, Table 1 contains PM_{2.5} concentration data from all recorded monitors throughout Maricopa County, as well as PM₁₀ concentrations co-located at PM_{2.5} monitoring sites. Figure 2 and 3 displays hourly graphs of PM_{2.5} and PM₁₀ concentrations, respectively, throughout Maricopa County before, during, and after the July 18, 2011 windblown dust event.

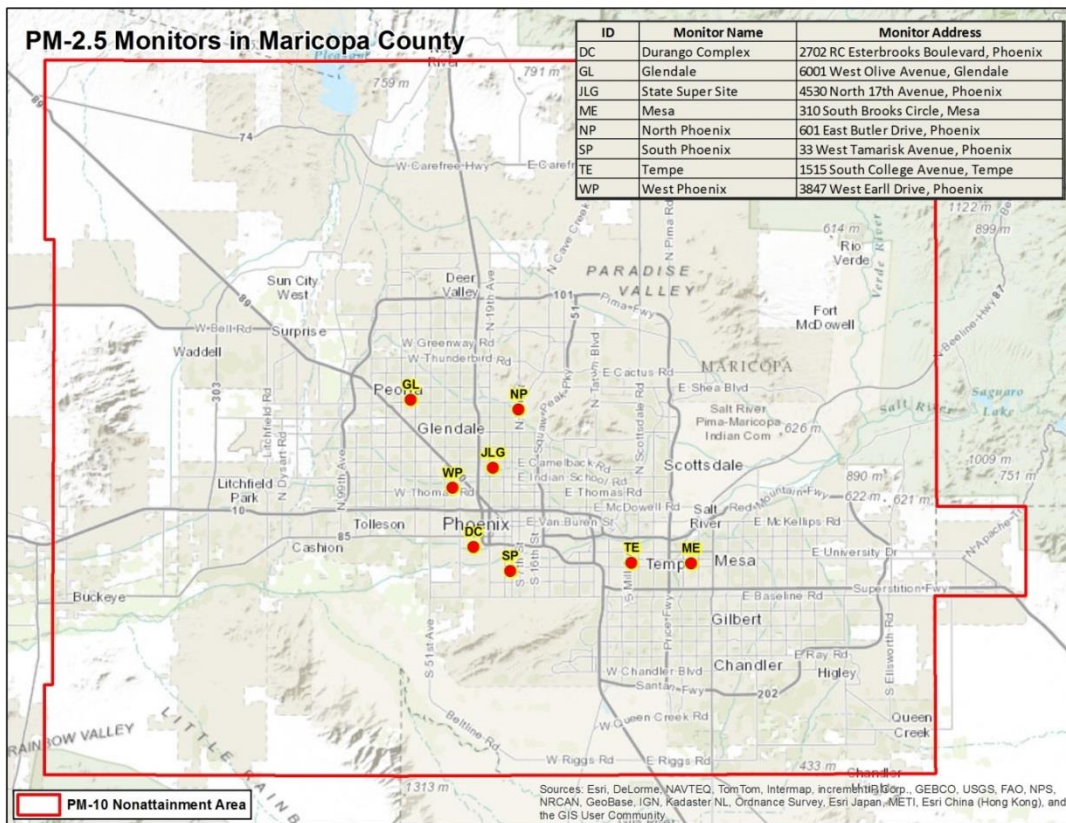


Figure 1. PM_{2.5} monitors in Maricopa County (2013).

Table 1. Summary of PM_{2.5} and PM₁₀ measurements in Maricopa County on July 18, 2011.

MARICOPA COUNTY ¹						
Monitor	AQS Monitor ID	24-Hour Average PM _{2.5} Concentration (µg/m ³)	1-Hour Maximum PM _{2.5} Concentration (µg/m ³)	Maximum PM _{2.5} Concentration Time	24-Hour Average PM ₁₀ Concentration (µg/m ³)	AQS Qualifier Flag
Durango Complex	04-013-9812-88101-3	36.0	314	1800	268.3	RJ
Glendale	04-013-2001-88101-3	23.5	169.5	1800	141.4	
JLG Supersite-BAM	04-013-9997-81102-3	22.1	108	2100	125.7	
JLG Supersite-TEOM	04-013-9997-81102-4	22.2	134.5	1800	152	
North Phoenix*	04-013-1004-81102	NA	NA	NA	NA	
South Phoenix	04-013-4003-88101-3	20.2	172.7	1800	292.1	
West Phoenix	04-013-0019-88101-3	18.5	86.7	1900	155.1	

SOURCE: ¹ Data as reported in EPA's Air Quality System (AQS) database. *Data unavailable for North Phoenix monitor during event.

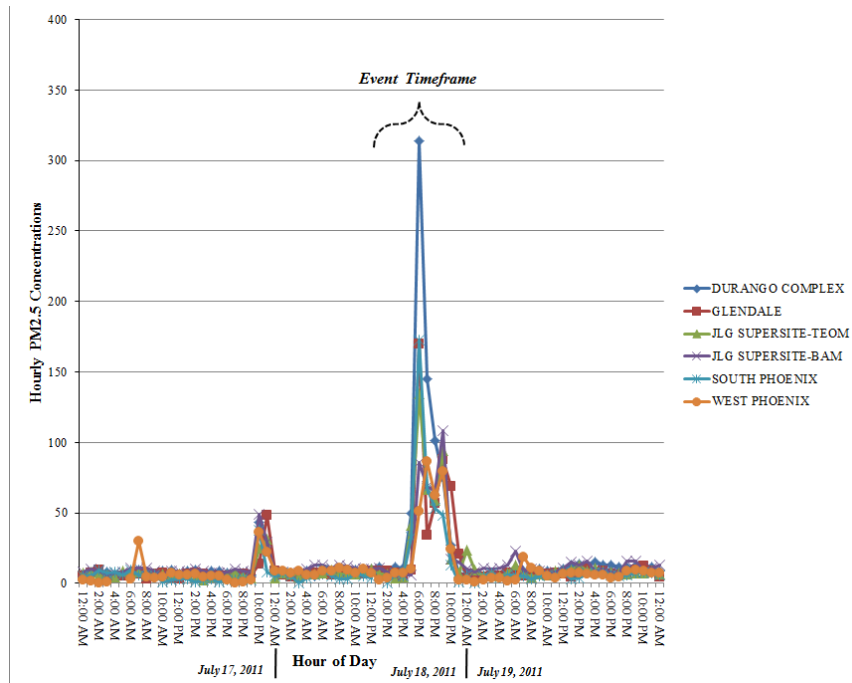


Figure 2. Timeline of hourly average PM_{2.5} concentrations at Maricopa County monitors before, during, and after the July 18, 2011 windblown dust event.

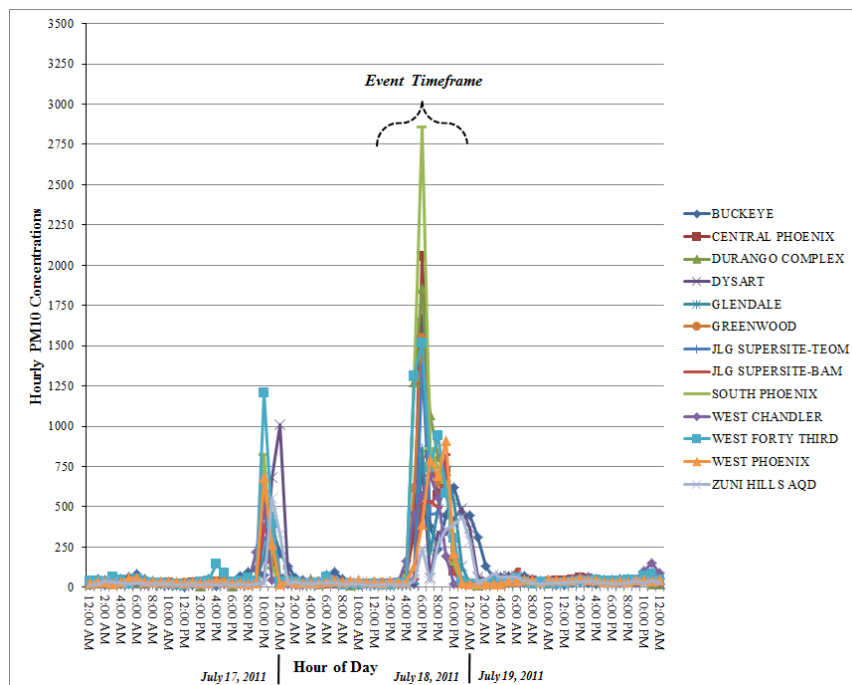


Figure 3. Timeline of hourly average PM₁₀ concentrations at Maricopa County monitors before, during, and after the July 18, 2011 windblown dust event.

3. HISTORICAL FLUCTUATIONS

PM_{2.5} concentrations measured at the Durango Complex monitor on July 18, 2011 were unusual and in excess of normal historical fluctuations. Figure 4 displays a time series plot of the 24-hour PM_{2.5} concentrations for the period of May 1, 2010 (when monitor began reporting to AQS) through August 31, 2013 for the Durango Complex monitor. Figure 4 indicates that exceedances of the 24-hour PM_{2.5} standard have only occurred during the winter holiday season (result of residential and recreational wood burning) and during the monsoon season when high winds from thunderstorm outflows produce dust storms. As such, the PM_{2.5} exceedance on July 18, 2011 was in excess of normal historical fluctuations.

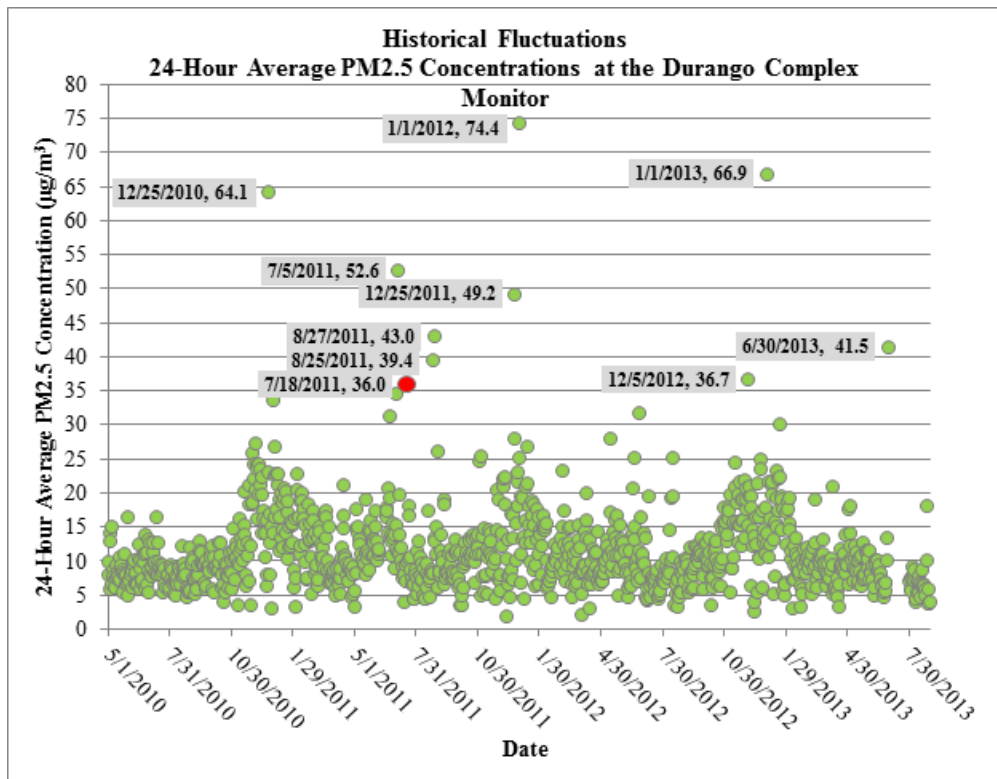


Figure 4. Plot of 24-Hour average PM_{2.5} concentrations (May 2010 – August 2013) at the Durango Complex monitor.

4. NOT REASONABLY CONTROLLABLE OR PREVENTABLE

Maricopa County currently attains both the 24-hour and annual PM_{2.5} National Ambient Air Quality Standards (NAAQS). During a high wind event, PM_{2.5} is generated from windblown fugitive dust sources. The extensive fugitive dust PM₁₀ controls described in Section III of the main document also control the amount of PM_{2.5} generated during a high wind event. When these controls are overwhelmed during a high wind event, exceedances of both the PM₁₀ and PM_{2.5} standards can occur due to fugitive dust emissions that are no longer reasonably controllable or preventable. The PM_{2.5} exceedance on July 18, 2011 was directly related to strong and gusty winds generated by thunderstorm outflows. The gusty outflow winds overwhelmed all reasonably available controls and were also responsible for the transport of particulate matter emissions into Maricopa County.

For July 18, 2011, a Maricopa County Dust Control Forecast was issued indicating a moderate risk level for unhealthy PM₁₀. The Dust Control Forecast also indicated a potential for strong and gusty winds, and a potential for dense blowing and transported dust generated by outflow from thunderstorms.

During the time period of July 15 through July 21, 2011, MCAQD inspectors conducted a total of 165 inspections of permitted facilities, of which 147 were at fugitive dust sources. Additionally, MCAQD conducted 91 inspections on vacant lots and unpaved parking lots. An evaluation of inspection reports and compliance records indicate no evidence of unusual anthropogenic-based particulate emissions or significant violations of particulate matter rules being observed in Maricopa County before, during, or after the high wind blowing dust event that would have impacted PM_{2.5} readings. Detailed information on regulatory measures, control programs, and enforcement activities are described in section III of the main PM₁₀ document.

The *WRAP Fugitive Dust Handbook* (September, 2006), estimates the PM_{2.5}/PM₁₀ ratio of windblown fugitive dust to be 0.15. Figure 5 provides the historical 24-hour average ratios of PM_{2.5}/PM₁₀ as observed at the Durango Complex monitor. On July 18, 2011, the ratio was observed to be 0.13. This provides confirmation that the 24-hour average PM_{2.5} exceedance recorded on July 18, 2011 was the result of windblown dust emissions, as opposed to other common sources of PM_{2.5} such as combustion and industrial activities.

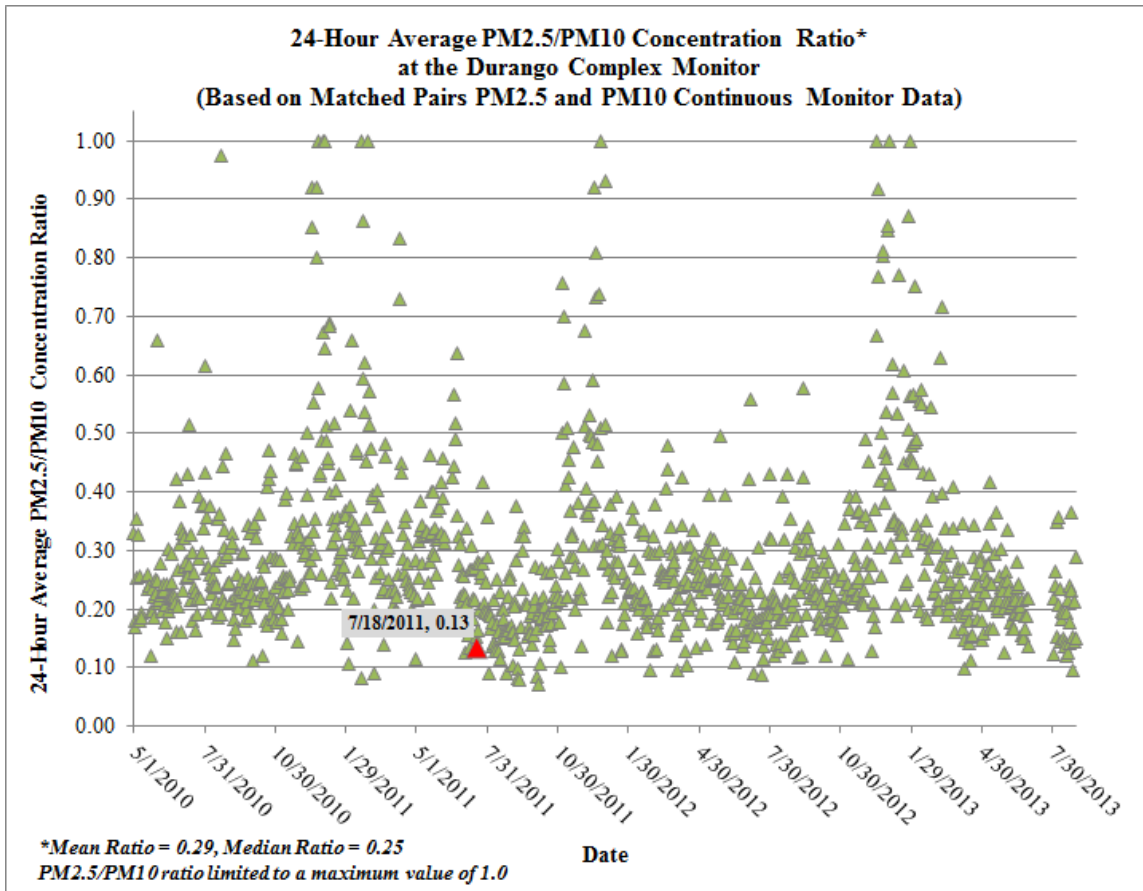


Figure 5. 24-Hour average PM_{2.5}/PM₁₀ concentration ratios at the Durango Complex monitor.

In summary, the same thunderstorm outflow winds that overwhelmed PM₁₀ controls and led to exceedances of the PM₁₀ standard at eight Maricopa County monitors (including the Durango Complex monitor) also caused the PM_{2.5} exceedance at the Durango Complex monitor. Despite the deployment of comprehensive control measures and sophisticated response programs, high wind conditions associated with thunderstorms and thunderstorm outflow winds brought high concentrations of PM_{2.5} emissions into, and also overwhelmed controls within, Maricopa County. Strong thunderstorm outflows with sustained winds typically ranging from 20-30 mph, and even greater nearest the source regions, were more than enough to overwhelm all available efforts to limit PM_{2.5} concentrations from fugitive dust sources during the event. The fact that this was a natural event involving strong thunderstorm outflow winds that transported and generated PM_{2.5} emissions into Maricopa County from source regions outside of the county provides strong evidence that the event and PM_{2.5} exceedance of July 18, 2011 for the Durango Complex monitor was not reasonably controllable or preventable.

5. CLEAR CAUSAL RELATIONSHIP

A detailed description of the meteorology that caused the natural windblown dust exceedance event at the Durango Complex monitor is presented in Section V of the PM₁₀ main document via time series graphs, infrared satellite imagery, links to visibility camera data, and National Weather Service (NWS) data tables for representative airports. In summary, on July 18, 2011 between 3 pm Mountain Standard Time (MST) and 5 pm MST, severe thunderstorms developed over portions of Arizona to the southeast of the Phoenix region and by 4 pm, outflows from the thunderstorms entrained dust from desert areas of Pinal County and generated a dust storm that progressed northwestward into Maricopa County, transporting large amounts of PM₁₀ and PM_{2.5}. With the arrival of the dust storm around 6 pm, a) southeasterly winds across the Phoenix area increased to 21-25 mph, with gusts up to 37 mph, b) visibility dropped from 10 miles to 1 mile, c) weather conditions were reported as “haze” and “blowing dust”, d) and hourly PM₁₀ concentrations increased to nearly 3000 µg/m³ at the South Phoenix monitoring site and exceeded 1500 µg/m³ at six sites. Additionally, elevated PM_{2.5} concentrations were observed with average hourly concentrations as high as 341 µg/m³ at the Durango Complex monitor. Sudden increases in PM₁₀ and PM_{2.5} area wide coincide with the arrival of elevated winds and diminished visibilities. Once winds subsided, visibility remained below 10 miles and PM concentrations remained high for several hours. In total, eight monitoring sites in the region exceeded the PM₁₀ NAAQS with the Durango Complex monitor also exceeding the PM_{2.5} 24-hour standard. Without the existence of emissions generated by the thunderstorm outflow, there would not have been any exceedances of the 24-hour PM₁₀ or PM_{2.5} standard in the Phoenix PM₁₀ nonattainment area.

Figure 6 below shows the highest hourly PM_{2.5} concentrations at the Durango Complex monitor coinciding with the arrival of the thunderstorm outflow winds from the southeast. In addition to the exceedance recorded at the Durango Complex monitor, all other Phoenix area monitors recorded 24-hour PM_{2.5} concentrations that were elevated as a result of the thunderstorm outflow generated dust storm (see Figure 2).

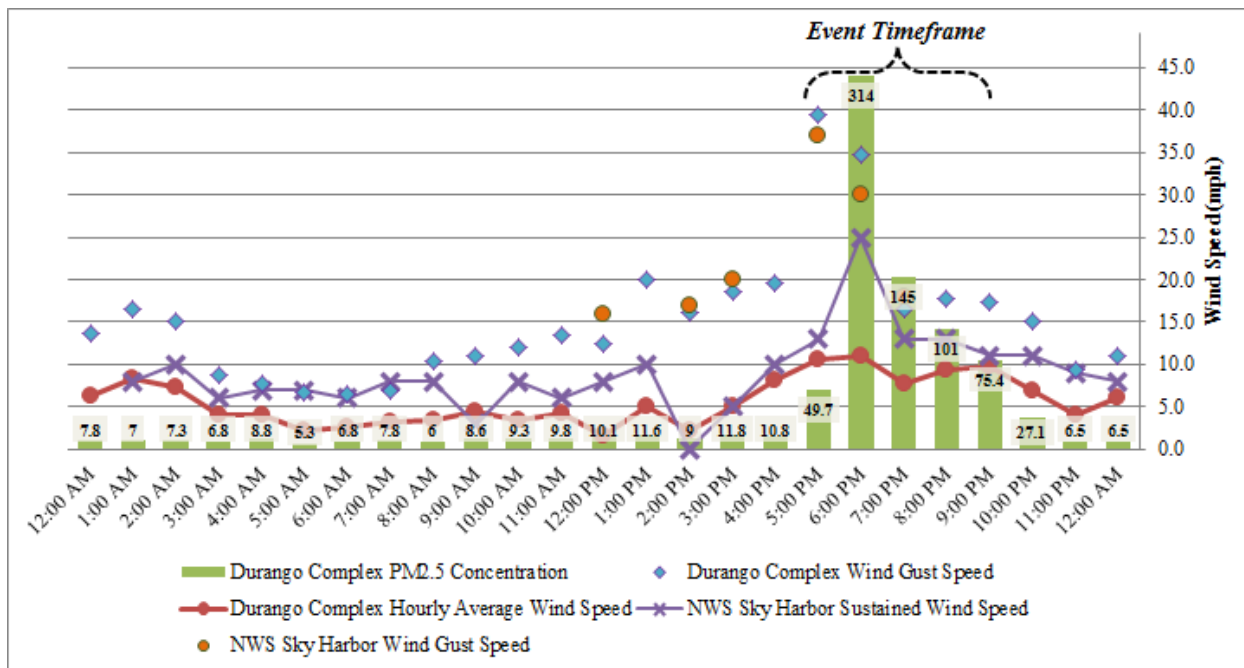


Figure 6. Hourly PM_{2.5} concentrations, wind speeds, and gusts as recorded at the Durango Complex monitor on July 18, 2011. Additionally, sustained wind speeds and gusts at Sky Harbor International Airport are shown.

6. BUT FOR ANALYSIS

Section 50.14(c)(3)(iv)(D) in 40 CFR part 50 requires that an exceptional event demonstration must satisfy that “[t]here would have been no exceedance or violation but for the event.” The prior sections of this PM_{2.5} supplemental document have provided detailed information that the exceedance on July 18, 2011 was not reasonably controllable or preventable and that there is a clear causal relationship between the windblown dust generated and transported by thunderstorm outflow winds and the exceedance at the Durango Complex monitor. The weight of evidence in these sections demonstrates that but for the existence of windblown dust emissions generated and transported by thunderstorm outflow winds, there would have been no exceedance of the 24-hour PM_{2.5} standard. It is also clear from Figure 5, that but for the five hourly concentrations affected by the high wind event (5:00 pm through 9:00 pm), the 24-hour average PM_{2.5} concentration for the Durango Complex monitor would have been substantially under 35.5 µg/m³.

EPA’s *Interim Exceptional Events Rule Frequently Asked Questions* (May, 2013) provides procedures for excluding a 24-hour PM_{2.5} exceedance for comparison against the annual PM_{2.5} NAAQS. On pages 34-35, EPA states,

“The preamble [to the Exceptional Events Rule] states that in the particular case of PM_{2.5}, the direct comparison of a single 24-hour average concentration (determined from a single filter-based measurement or by averaging 24 1-hour measurements from a continuous equivalent instrument) to the level of the annual NAAQS can be the basis for meeting the ‘but for’ criterion for exceedances or violations of the annual NAAQS.²⁴ In context, it is clear that based on this comparison, a 24-hour concentration can be excluded from the calculation of the annual PM_{2.5} design value, if other rule criteria are also met. It is therefore not necessary to show that the annual average PM_{2.5} concentration was above 12 or 15 µg/m³ with the event and would have been below 12 or 15 µg/m³ ‘but for’ the single event at issue.”

Additionally, on page 39, EPA states,

“Also, if the 24-hour average concentration based on 1-hour measurements was above 12.0 µg/m³ (after rounding to one decimal digit, per 40 CFR 50 Appendix N section 4.3(a)) but would have been equal or less than 12.0 µg/m³ in the absence of the event, those 1-hour concentration values that were affected by the single event meet the “but for” test for purposes of comparison to 12 µg/m³ annual PM_{2.5} NAAQS.”

Table 2 displays the hourly PM_{2.5} concentrations at the Durango Complex monitor on July 18, 2011, as reported in EPA’s Air Quality System (AQS) database. The table shows that when the five hours affected by the high wind event are excluded (5:00 pm through 9:00 pm) the 24-hour average concentration at the Durango Complex monitor would have been equal or less than 12.0 µg/m³ in the absence of the event. As such, exclusion of the 24-hour average PM_{2.5} exceedance on July 18, 2011 at the Durango Complex monitor for comparison against the annual PM_{2.5} NAAQS is allowed under EPA interim guidance. The exclusion of PM_{2.5} data beginning 5:00 pm is valid given this time coincides with rapid increases in both wind speeds and PM_{2.5} concentrations that is indicative of the dust storm approach and passage. Thereafter, winds

slowly diminish, but particulate matter remains suspended until around 9:00 pm when PM_{2.5} concentrations eventually drop back and remain near pre-event readings.

Table 2. Hourly average PM_{2.5} concentrations at the Durango Complex monitor on July 18, 2011 and resulting 24-hour average PM_{2.5} concentrations with and without hours affected by the high wind exceptional event.

Durango Complex	
Hour	PM_{2.5} Concentration (µg/m³)
12:00 AM	7.8
1:00 AM	7
2:00 AM	7.3
3:00 AM	6.8
4:00 AM	8.8
5:00 AM	5.3
6:00 AM	6.8
7:00 AM	7.8
8:00 AM	6
9:00 AM	8.6
10:00 AM	9.3
11:00 AM	9.8
12:00 PM	10.1
1:00 PM	11.6
2:00 PM	9
3:00 PM	11.8
4:00 PM	10.8
5:00 PM	49.7
6:00 PM	314
7:00 PM	145
8:00 PM	101
9:00 PM	75.4
10:00 PM	27.1
11:00 PM	6.5
24-Hour Average	36.0
24-Hour Average Excluding Hours Affected by High Wind Event (5:00 PM through 9:00 PM)	9.4

7. CONCLUSION

The PM_{2.5} exceedance that occurred on July 18, 2011 at the Durango Complex monitor satisfies the criteria of 40 CFR 50.1(j) and meets the definition of an exceptional event. These criteria are:

- The event affects air quality.
- The event is not reasonably controllable or preventable.
- The event is unlikely to reoccur at a particular location or [is] a natural event.

A. 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 exceedances and the event, and that the event is associated with measured concentrations in excess of normal historical fluctuations. Given the information presented in this PM_{2.5} supplemental document and the PM₁₀ main document, it is reasonable to conclude that the event in question affected air quality.

B. Not Reasonably Controllable or Preventable

Section 50.1(j) of Title 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 wind conditions overwhelmed all reasonably available controls. Despite the deployment of comprehensive control measures and sophisticated response programs, high wind conditions associated with thunderstorms and thunderstorm outflows generated and brought high concentrations of PM_{2.5} into Maricopa County. Examination of the PM_{2.5}/PM₁₀ ratio on July 18, 2011 is consistent with windblown dust as the source of the PM_{2.5} emissions. The fact that this was a natural event involving strong thunderstorm outflow winds that transported and generated PM_{2.5} emissions into Maricopa County, provides strong evidence that the event and exceedance of July 18, 2011 recorded at the Durango Complex monitor was not reasonably controllable or preventable.

C. Natural Event

As discussed above, the event shown to cause this exceedance were emissions of $PM_{2.5}$ generated by high winds caused by thunderstorm activity and related outflow boundaries on July 18, 2011. The event therefore qualifies as a natural event.

In summary, the exceedance of the $PM_{2.5}$ standards on July 18, 2011 would not have occurred but for the monsoonal thunderstorm driven high winds and windblown dust generated and transported from areas inside and outside of Maricopa County, based on the following weight of evidence:

- Historical fluctuation data in Section 3 shows the active record of 24-hour average $PM_{2.5}$ data for the Durango Complex monitor and demonstrates that the value on July 18, 2011 was atypical and in excess of normal historical fluctuations.
- The exceedance of the $PM_{2.5}$ standards recorded on July 18, 2011 is tied to thunderstorm activity and thunderstorm generated outflow winds, as can be seen in data and analyses in Section V in the PM_{10} main document.
- Figures and tables in Section V of the PM_{10} main document show that the timing of thunderstorm-generated outflow boundary passage and increases in wind speeds at monitoring locations and National Weather Service stations during each of the events during this period is consistent with the timing of elevated PM_{10} and $PM_{2.5}$ concentrations recorded at the monitoring locations in the Phoenix PM_{10} nonattainment area.
- Visibility camera imagery discussed in Section V of the PM_{10} main document indicates that large quantities of PM_{10} were transported into the Phoenix Metro area during the July 18th event. The timing of the dust storms depicted in the visibility camera imagery is consistent with the PM_{10} and $PM_{2.5}$ concentration measurements, elevated wind speeds, and reduced visibility reported during the event.
- Wind directions, thunderstorm generated outflow boundary propagation, and concentration patterns showing elevated levels of PM_{10} in Pinal County prior to levels increasing in Maricopa County, all depicted in Section V of the PM_{10} main document, help to show that dust originating in Pinal County was transported to Maricopa County.
- Section III discusses that the rules in place to control PM_{10} from fugitive dust sources in Maricopa County are the same rules that control $PM_{2.5}$ emissions during high wind events. Inspections conducted in the area before, during, and after the event verify that no unusual anthropogenic activities affected the $PM_{2.5}$ concentrations observed at the exceeding Durango Complex monitor.