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Air Quality

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Exceptional Event Documentation for the May 4, 2013, 8-Hour Ozone NAAQS Exceedance in Clark County Caused by a Wildland Fire Event

September 2015

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ACRONYMS AND ABBREVIATIONS

Acronyms

AERONET	Aerosol Robotic Network
AOD	Aerosol Optical Depth
AOT	Aerosol Optical Thickness
AQI	Air Quality Index
CAA	Clean Air Act
CFR	Code of Federal Regulations
DAQ	Clark County Department of Air Quality
EER	Exceptional Events Rule
EPA	U.S. Environmental Protection Agency
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory Model
MDA8	Maximum Daily 8-hr Average
NAAQS	National Ambient Air Quality Standards
NOAA	National Oceanic and Atmospheric Administration

Abbreviations

°C	degrees Celsius
CO	carbon monoxide
mb	millibars
MSL	mean sea level
NO_x	oxides of nitrogen
O_3	ozone
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
ppb	parts per billion
VOC	volatile organic compound

1.0 INTRODUCTION

1.1 STATEMENT OF PURPOSE

Clark County has determined that ozone (O_3) concentrations exceeding the National Ambient Air Quality Standards (NAAQS) on May 4, 2013, qualify as an exceptional event under Title 40, Part 50 of the Code of Federal Regulations (40 CFR 50), the final Exceptional Events Rule (EER). The purpose of this document is to petition the Regional Administrator for Region 9 of the U.S. Environmental Protection Agency (EPA) to exclude air quality monitoring data from specific monitors for ozone from the normal planning and regulatory requirements under the Clean Air Act (CAA) in accordance with the EER.

On May 4, 2013, Clark County recorded elevated ozone concentrations and exceedances of the ozone NAAQS across its air quality monitoring network because smoke plumes from the Springs wildfire in California impacted Clark County. This document demonstrates, in accordance with the EER, that these NAAQS violations would not have occurred without the wildfire impacts. This exceptional event demonstration underwent public review and comment before submittal to EPA.

1.2 SCOPE OF DEMONSTRATION

The EER governs the review and handling of air quality monitoring data influenced by exceptional events (e.g., wildfires). Exceptional events are "events for which the normal planning and regulatory process established by the CAA is not appropriate" (*Federal Register*, Volume 72, p. 13560). In its final rule, EPA intended to:

> Implement section 319(b)(3)(B) and 107(d)(3) authority to exclude air quality monitoring data from regulatory determinations related to exceedances or violations of the National Ambient Air Quality Standards (NAAQS) and avoid designating an area as nonattainment, redesignating an area as nonattainment, or reclassifying an existing nonattainment area to a higher classification if a State adequately demonstrates that an exceptional event has caused an exceedance or violation of a NAAQS.

The EER contains procedures and criteria whereby states can petition EPA to exclude data from regulatory considerations because of an exceptional event that caused an area to exceed the NAAQS for a particular pollutant. The term "exceedance" refers to a measured or modeled concentration greater than the level of one or more NAAQS at a specific air quality monitoring location.

EPA requires states to take reasonable measures to mitigate the impacts of an exceptional event. In accordance with Section 319 of the CAA, EPA defines the term "exceptional event" to mean an event that:

(i) Affects air quality;
(ii) Is not reasonably controllable or preventable;

(iii) Is an event caused by human activity that is unlikely to recur at a particular location or a natural event; and

(iv) Is determined by EPA through the process established in the regulations to be an exceptional event. (*Federal Register*, Vol 72, p. 13562, Section IV.D)

EPA notes that natural events, which are one form of exceptional events, may recur, sometimes frequently. This is certainly true for natural events such as western wildfires.

The ozone concentrations for May 4, 2013, were flagged in EPA's AQS on October 9, 2013, to indicate that NAAQS exceedances were likely caused by ozone precursor emissions produced by smoke plumes from the Springs wildfire.

In this exceptional event demonstration, Section 2 addresses a conceptual model for ozone air pollution and wildfire impacts in Clark County based on technical studies completed to date. That section describes topography, land use, and meteorology in the context of conditions leading to elevated ozone concentrations, then summarizes the role of local emissions and transport into southern Nevada.

Section 3 describes the Clear Causal Relationship between the NAAQS concentrations and the exceptional event, including laboratory speciation, historical fluctuation, smoke trajectories, and the wildfire impacts on the pollutant concentrations. The EER requires a demonstration of the following criteria to exclude air quality data from the normal planning and regulatory process established by the CAA:

1. The event satisfies the criteria set forth in 40 CFR 50.1(j), which defines an exceptional event.

2. There is a clear causal relationship between the measurements under consideration and the event that is claimed to have affected the air quality in the area.

3. The event is associated with measured concentrations in excess of normal historical fluctuations, including background.

4. There would have been no exceedance or violation but for the event.

5. Documentation is provided with the submission of the demonstration that the public comment process was followed.

Section 4 provides evidence for the "but for" argument; this section outlines concentration calculations in lieu of measured concentrations to show that the exceedance would not have occurred but for the event.

The EER further requires that Clark County prove it took reasonable and appropriate actions to inform the public of deteriorating air quality caused by wildfire smoke plumes and a possible exceedance of the ozone NAAQS.

An effort was made to identify separate documentation or explanation for each element of the EER; however, some of the explanation can and should overlap with different elements.

Table 1-1. EER Required Elements and Demonstration

Element	Section Containing Explanation
Regional background and conceptual model	Section 2.0
Clear causal relationship between exceedance and the event	Section 3.0
Concentration is in excess of historical fluctuation	Section 3.3
But For demonstration	Section 4.0
Public participation	Section 5.0

1.3 COMPLIANCE WITH CRITERIA FOR EXCEPTIONAL EVENTS

An exceptional event, as defined in 40 CFR 50.1(j), is

> an event that affects air quality, is not reasonably controllable or preventable, is an event caused by human activity that is unlikely to recur at a particular location or a natural event, and is determined by the Administrator in accordance with 40 CFR 50.14 to be an exceptional event. It does not include stagnation of air masses or meteorological inversions, a meteorological event involving high temperatures or lack of precipitation, or air pollution relating to source noncompliance.

1.3.1 Wildfire Season in the West.

The wildfire season in 2013 was somewhat mild, with 5.6 million acres burned in the US. According to the National Interagency Fire Center, approximately 2.7 million acres were burned in the Western US. Table 1-2 shows the number of fires and acreage burned per state (http://www.nifc.gov/fireInfo/fireInfo_stats_YTD2013.html). Several catastrophic fires occurred in California throughout the wildfire season in 2013. The Springs fire was one of them, lasting for eleven days and consuming over 24,000 acres.

Table 1-2. Fires in the West in 2013

State	# Fires	# Acres
AZ	1,694	136,296
CA	8,457	590,391
CO	1,244	201,243
ID	1,560	754,549
MT	1,930	141,610
NM	1,064	233,037
NV	710	189,314
OR	2,164	250,009
UT	1,321	80,301
WA	1,200	105,402
WY	458	48,667
Totals	**21,802**	**2,730,819**

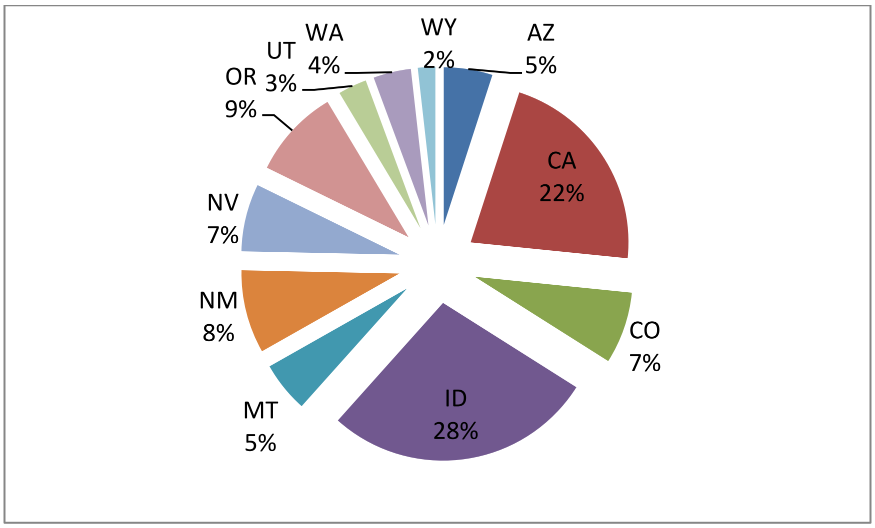


Figure 1-1. Percentage acres burned per state.

1.3.2 Springs Fire Near Camarillo, CA.

On May 2, 2013, an explosive wildfire ignited in Southern California near Camarillo. Fueled by unusually dry conditions and strong winds, the Springs Fire blazed through more than 24,000 acres of chaparral on the Santa Monica Mountains, forcing the closure of parts of Highway 101 and threatening thousands of homes in Camarillo, Newbury Park, and Thousand Oaks. A wind shift on May 3 pushed the smoke plume inland and toward southern Nevada (see Figure 1-4).

Over 120 fire personnel and five engines were on-scene, a total of 24,250 acres was burned, and the fire was under control on May 11, 2013.

On May 3, a Pacific Trough began to dig down and retrogress to the southwest. Consequently, on May 4 the trough—or low-pressure system—moved far enough to the southwest to cause a directional change in flow from the southwest at all levels. By May 5, the low-pressure system dug deep enough to the southwest to cause another directional shift from the south-southwest.

Surface smoke impacts were documented through laboratory analysis of samples of particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) to determine concentrations of wildfire markers (e.g., levoglucosan).

On May 4, 2013, regional transport overwhelmed any local contribution to elevated ozone levels. This one-day episode was characterized by the greatest number of sites exceeding the NAAQS, and the highest ozone concentrations reached 84 parts per billion (ppb) as the maximum daily 8-hour average (MDA8). Table 1-3 lists maximum ozone levels by monitoring site for May 4, as well as the days before and after. Figure 1-2 depicts the diurnal ozone cycles for May 3-May 5.

Table 1-3. Maximum 8-hour Ozone Concentrations (ppb)

Site	May-13						
	1	2	3	4	5	6	7
Apex	59	65	59	73	73	52	55
Mesquite	58	57	50	63	65	49	51
Paul Meyer	64	62	60	80	71	51	53
Walter Johnson	63	63	60	80	70	50	51
Palo Verde	64	61	58	82	69	51	49
Joe Neal	63	63	63	77	71	51	54
Winterwood	60	62	58	76	71	48	51
Jerome Mack	58	61	57	74	69	46	50
Boulder City	59	62	57	71	71	50	53
Jean	64	65	61	84	74	51	55
JD Smith	60	62	61	74	70	50	52

The colors in Table 1-3 represent the AQI rating scale, the yellow color means moderate air quality; while the red color means unhealthy for sensitive groups.

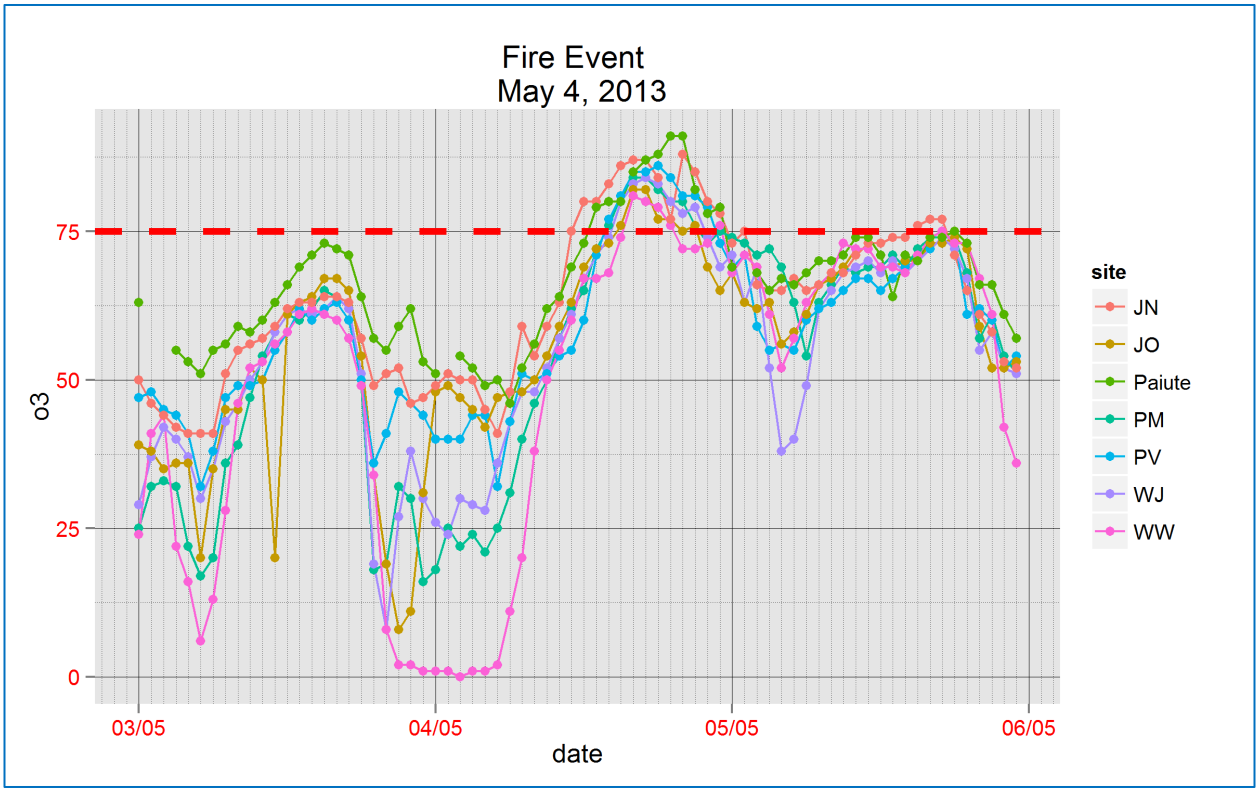


Figure 1-2. Diurnal ozone cycles around May 4.

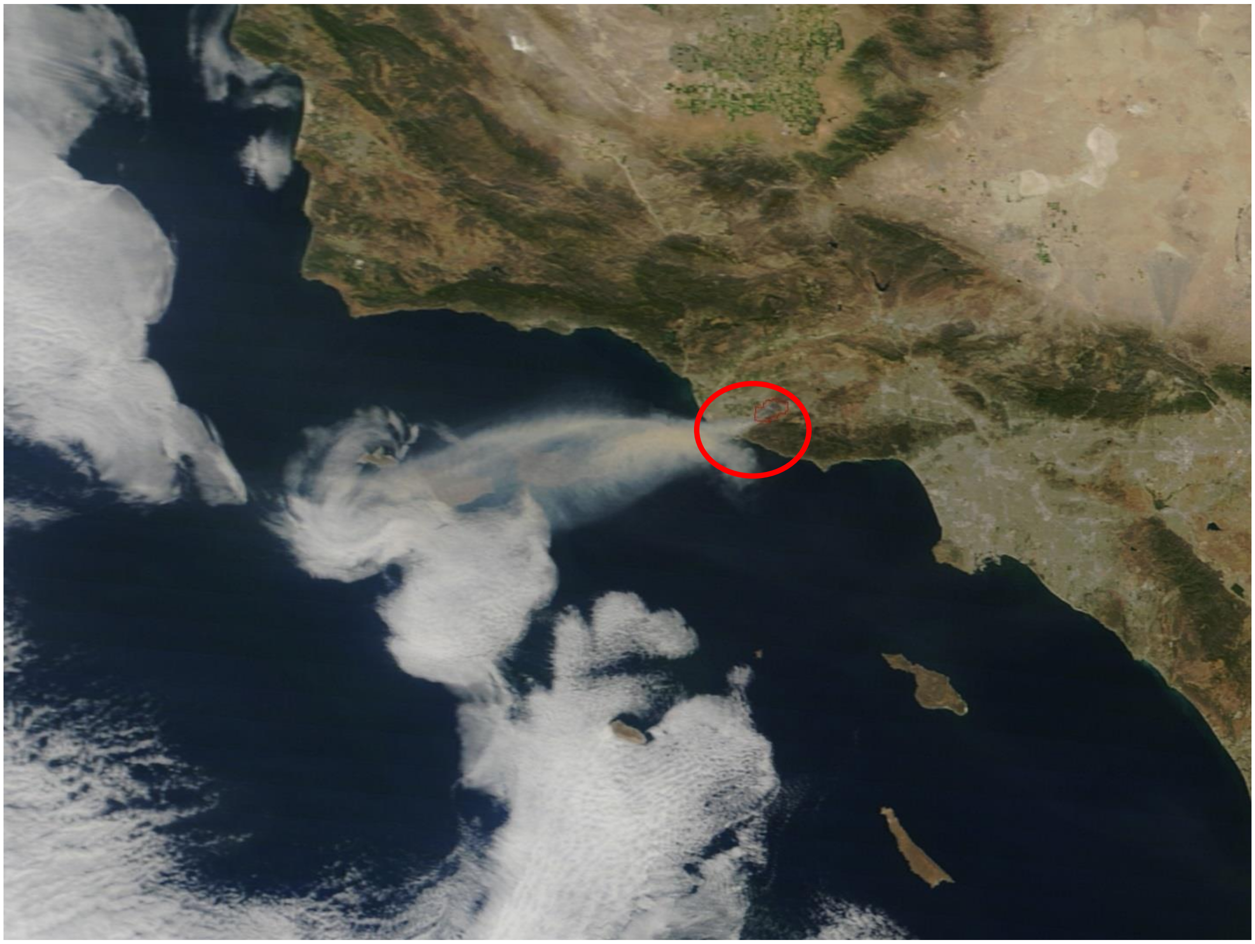


Figure 1-3. Fire location.

Figure 1-3 is a satellite image showing the location of the Springs Fire. During the first days of the event, the wind was from the East, blowing the smoke plume over the Pacific Ocean (see Figure 1-3); however, starting on Saturday, the winds shifted and blew the plume inland (see Figure 1-4). Smoke plumes covered most of the Central Valley and Southern California (see Figure 1-5).

Figure 1-4. Major wind shift May 3.

Figure 1-5. Smoke plumes cover California (http://maps.ngdc.noaa.gov/viewers/firedetects/).

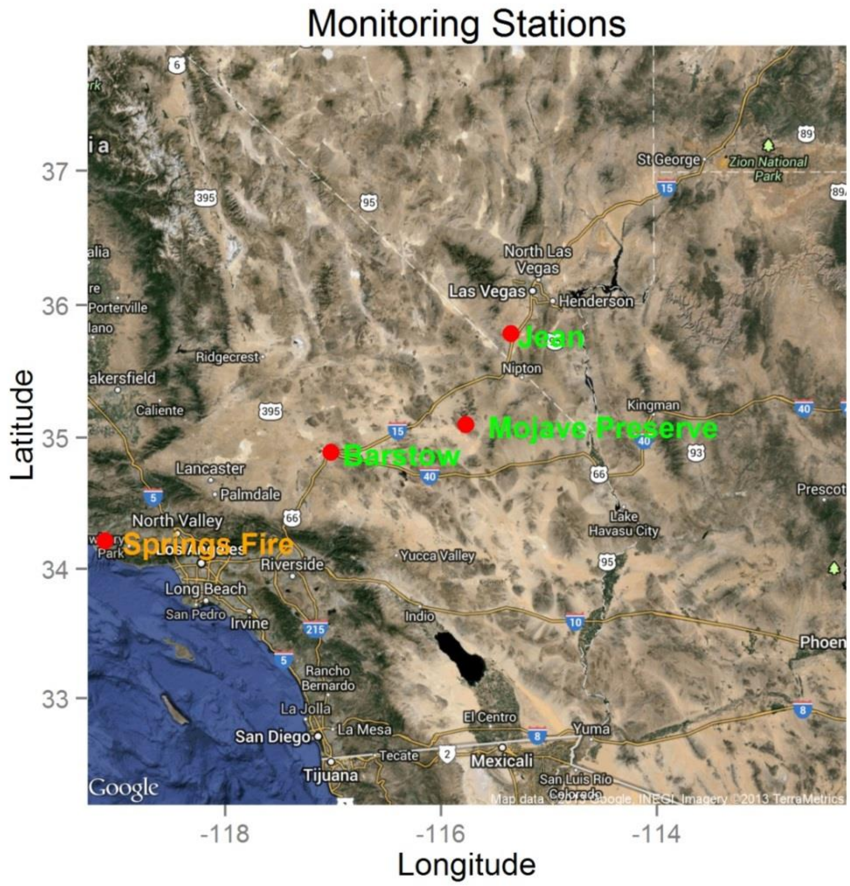


Figure 1-6. Location of monitoring stations in relation to fire.

Figure 1-6 shows the location of the Barstow, Mojave Preserve, and Jean monitoring sites in relation to the Springs Fire. These stations were in the path of the air parcels, according to the back trajectory depicted in Figure 1-7. The graph in Figure 1-8 shows the diurnal patterns for the Barstow (BA), Mojave Preserve (MO), and Jean (JN) monitoring sites prior to, during, and after the event. Note the Barstow site was impacted first, followed by the Mojave Preserve site, and finally the Jean site and the Las Vegas Valley. The sites closest to the fire had the highest hourly values. Figure 1-9 is a map showing the highest hourly values across the Clark County monitoring network on May 4, and it also includes the Paiute monitoring site just outside the valley, with a concentration of 91 ppb.

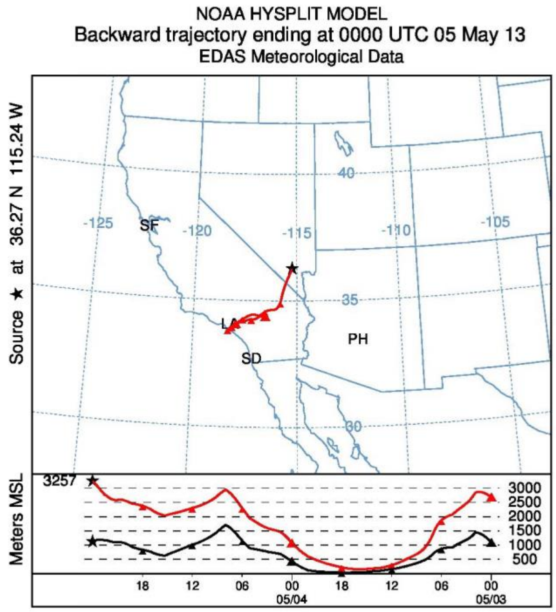


Figure 1-7. Back trajectory from Springs Fire.

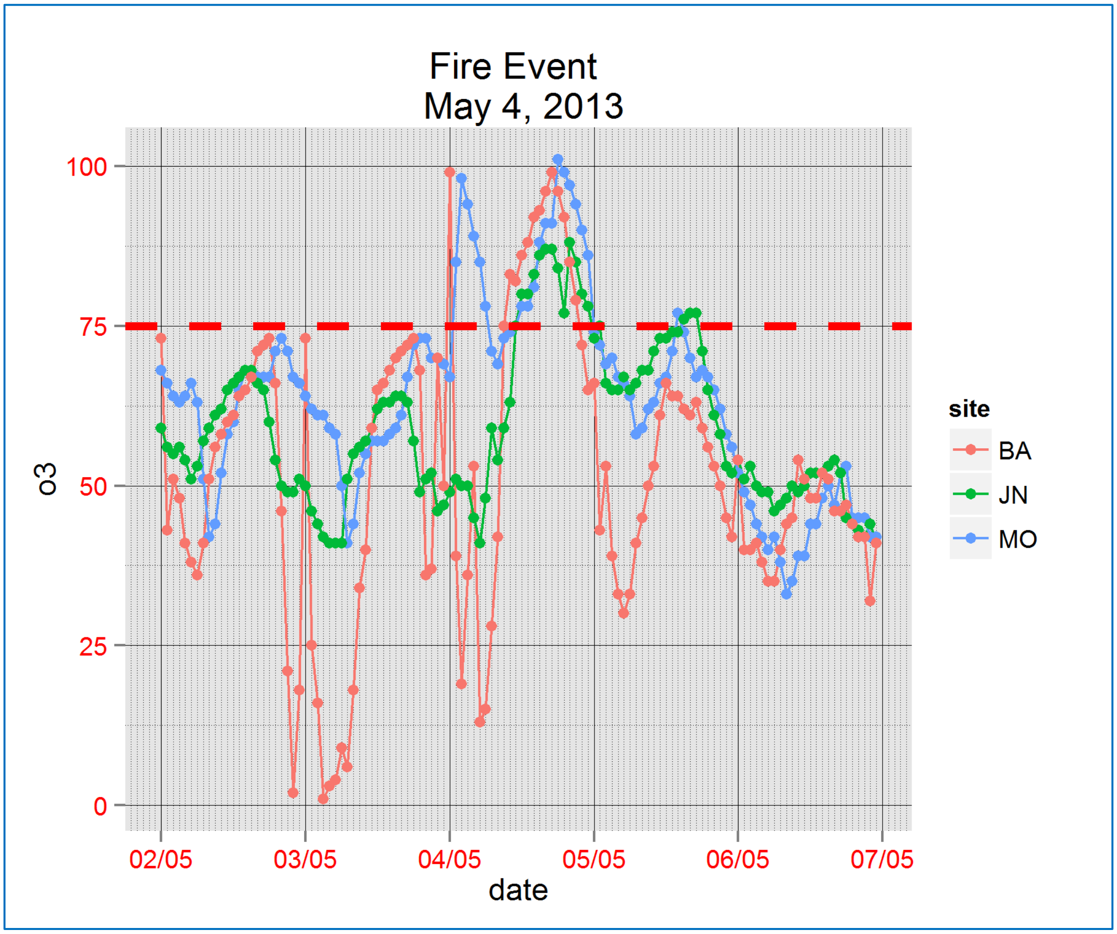


Figure 1-8. Diurnal patterns for Barstow, Mojave Preserve, and Jean.

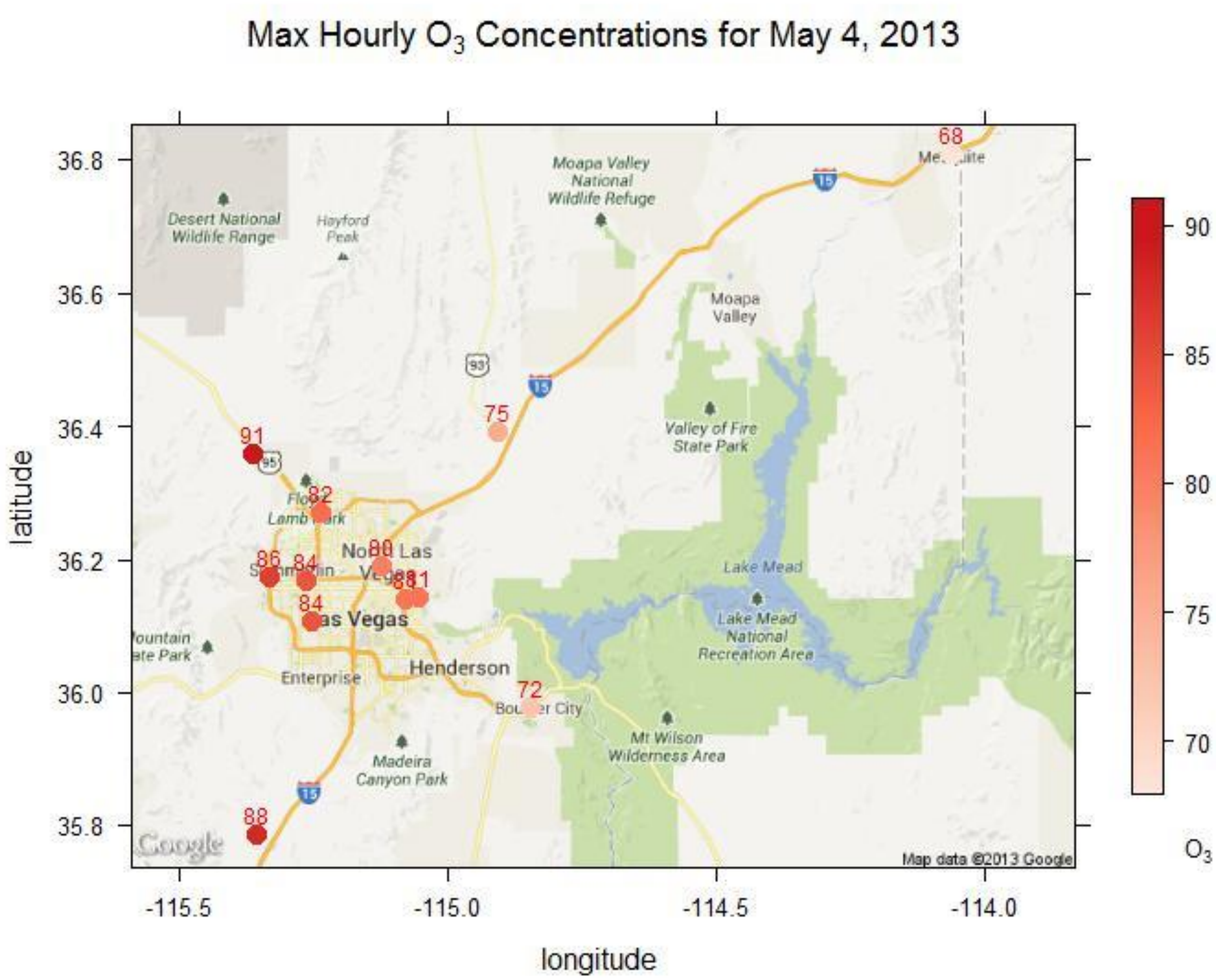


Figure 1-9. Ozone concentrations on May 4, 2013.

The pollution roses in Figures 1-10 through 1-12 show a westerly wind in Barstow, a southwest flow in Mojave Preserve, and a southern flow into Jean. These winds came from the direction of the fire and the smoke plumes.

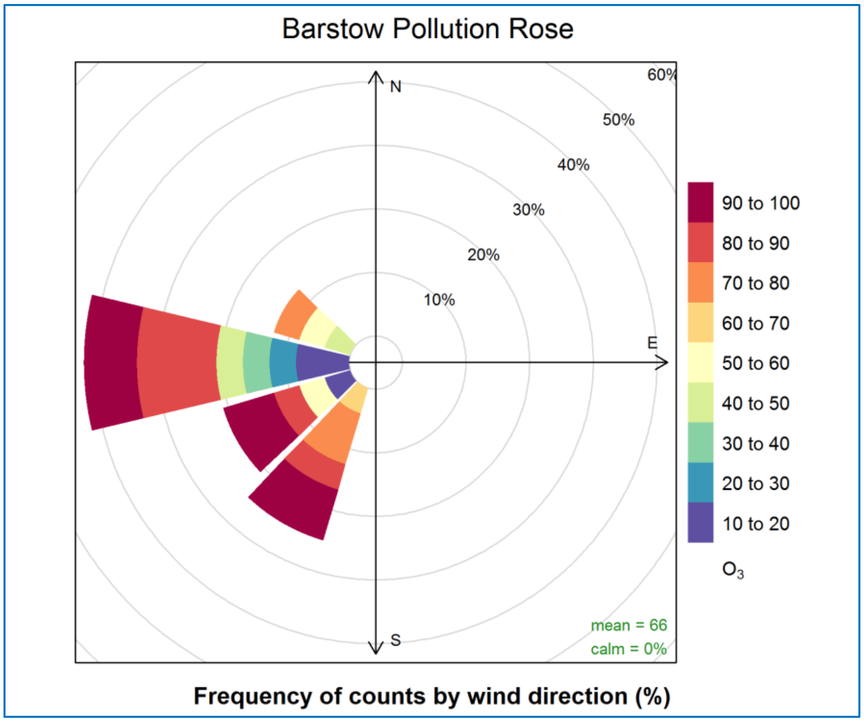


Figure 1-10. Pollution rose for Barstow.

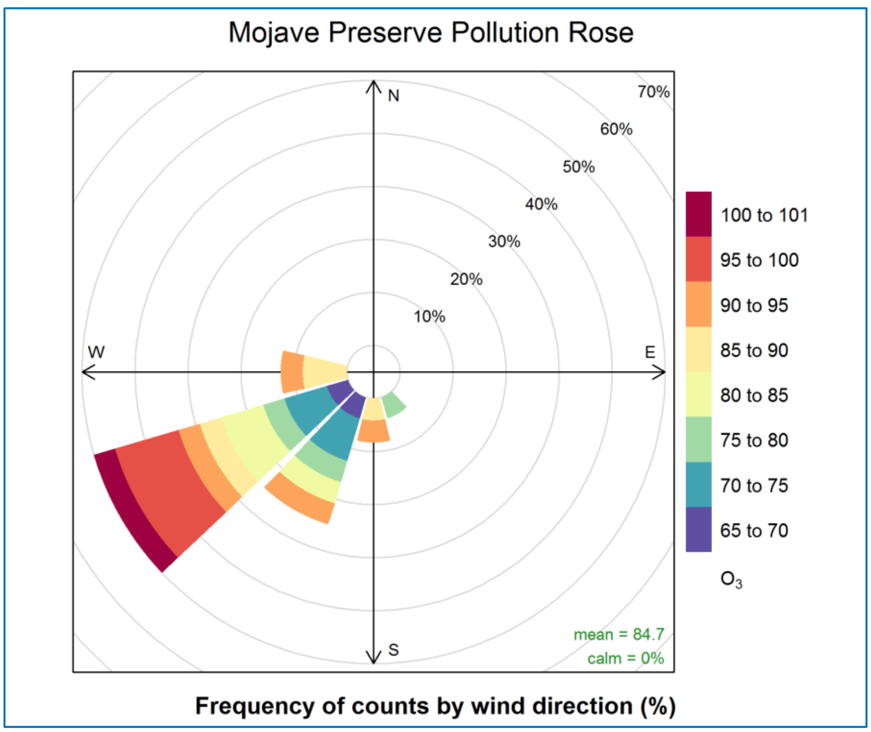


Figure 1-11. Pollution rose for Mojave Preserve.

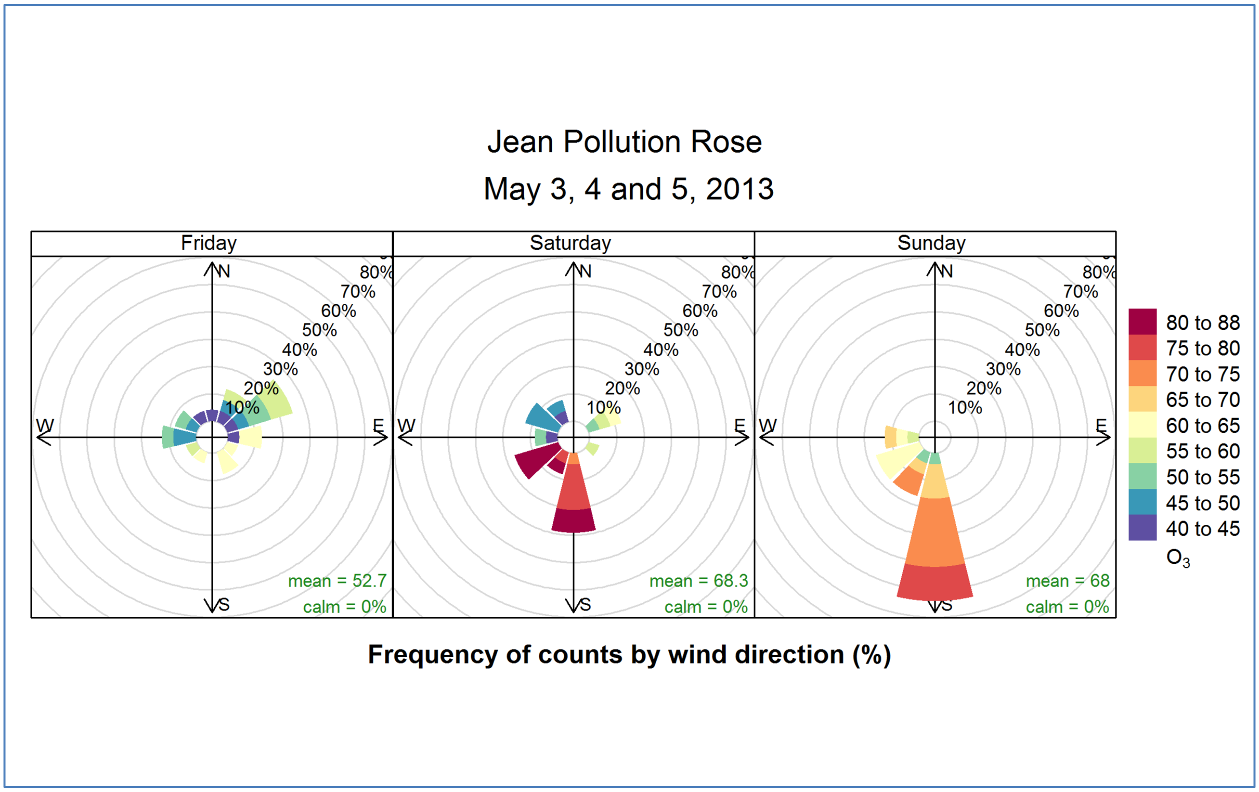


Figure 1-12. Pollution roses for Jean.

1.4 PREVIOUS RESEARCH ON OZONE FORMATION AND SMOKE IMPACTS[1]

Wildfires can generate both oxides of nitrogen (NOx) and Volatile Organic Carbon (VOC) emissions, with different burning stages generating different types of emissions. Biogenic VOCs are generated by vegetation throughout the burning cycle. NOx is generated primarily during the hot, flaming stage of the fire, and small reactive hydrocarbons, such as ethane and acetylene, are generated during the smoldering phase (Finlayson-Pitts and Pitts, 2000; Jaffe et al., 2008).

Very near fires, ozone concentrations are potentially suppressed, despite the increase in ozone precursors generated by the wildfires. Bytnerowicz et al. (2010), Finlayson-Pitts and Pitts (2000), and Sandberg et al. (2002) explain several reasons why ozone can be low at the fire sites: 1) thick smoke can prevent sufficient UV light from reaching the surface, thereby inhibiting photochemical reactions, and 2) the wildfire plume typically contains high NOx concentrations, which can titrate ozone concentrations. Downwind of the fire or at the top of the plume (Sith et al., 1981, qtd. in Sandberg et al., 2002), away from fresh NOx sources and with reduced aerosol optical depth, considerable amounts of ozone can be generated. The plume does not need to be very far downwind of fire emissions to generate ozone. Sith et al. (1981) found ozone beginning 10 kilometers downwind of wildfires in plumes less than one hour old (quoted in Sandberg et al., 2002). Ozone and ozone precursors can also be transported quite far from a wildfire site (Finlayson-Pitts and Pitts, 2000 and Jaffe et al., 2008). Similar to the impacts of anthropogenic emissions in urban airsheds, therefore, the highest ozone concentrations due to wildfires are often found downwind of the area of greatest precursor emissions.

The impact of wildfires on ozone concentrations at both the local and regional level has been extensively evaluated in recent years. Field observations of ozone formation in smoke plumes from fires date back nearly 25 years when aircraft measurements detected elevated ozone at the edge of forest fire smoke plumes far downwind (see *Wildland Fire in Ecosystems Effects of Fire on Air*). More recently, aircraft flights through smoke plumes have demonstrated increased ozone concentrations of 15 to 30 ppb in California (Bush, 2008), while ozonesonde measurements in Texas found enhanced ozone aloft ranging from 25 to 100 ppb attributable to long-range transport of smoke plumes from Canada and Alaska (Morris, 2006).

In addition, air quality modeling has shown increased levels of ozone from a number of large fires. McKeen (2002) found that Canadian fires in 1995 enhanced ozone concentrations by 10 to 30 ppb throughout a large region of the central and eastern United States. Lamb (2007) found similar results simulating the impacts of fires in the Pacific Northwest in 2006, with increases of over 30 ppb. Junquera (2005) further found that within 10 kilometers of a fire, ozone concentrations could be enhanced by up to 60 ppb. Finally, in one of the most recent studies, Pfister (2008) simulated the large 2007 fires in both Northern and Southern California. The author found ozone increases of approximately 15 ppb in many locations and concluded that "Our findings demonstrate a clear impact of wildfires on surface ozone nearby and potentially far downwind from the fire location, and show that intense wildfire periods frequently can cause ozone levels to exceed current health standards."

[1] Exceptional Events Demonstration for 1-Hour Ozone Exceedances in the Sacramento Regional Nonattainment Area Due to 2008 Wildfires, CARB 2011.

2.0 CONCEPTUAL MODEL OF OZONE AIR POLLUTION

2.1 TOPOGRAPHY AND METEOROLOGY

Located in southern Nevada, Clark County consists of 8,091 square miles characterized by basin and range topography. It is one of the nation's largest counties, with an area bigger than the states of Connecticut and Delaware combined. The Las Vegas Valley sits in a broad desert basin surrounded by mountains rising from 2,000 feet to over 10,000 feet above the valley floor. The relief map in Figure 2-1 illustrates the basins and mountain ranges surrounding the valley. Terrain within the Las Vegas Valley rises significantly, from approximately 1,200 feet at Lake Mead to 2,000 feet in downtown Las Vegas, to over 2,800 feet in the suburbs on the west side of the valley, near the Spring Mountain Range.

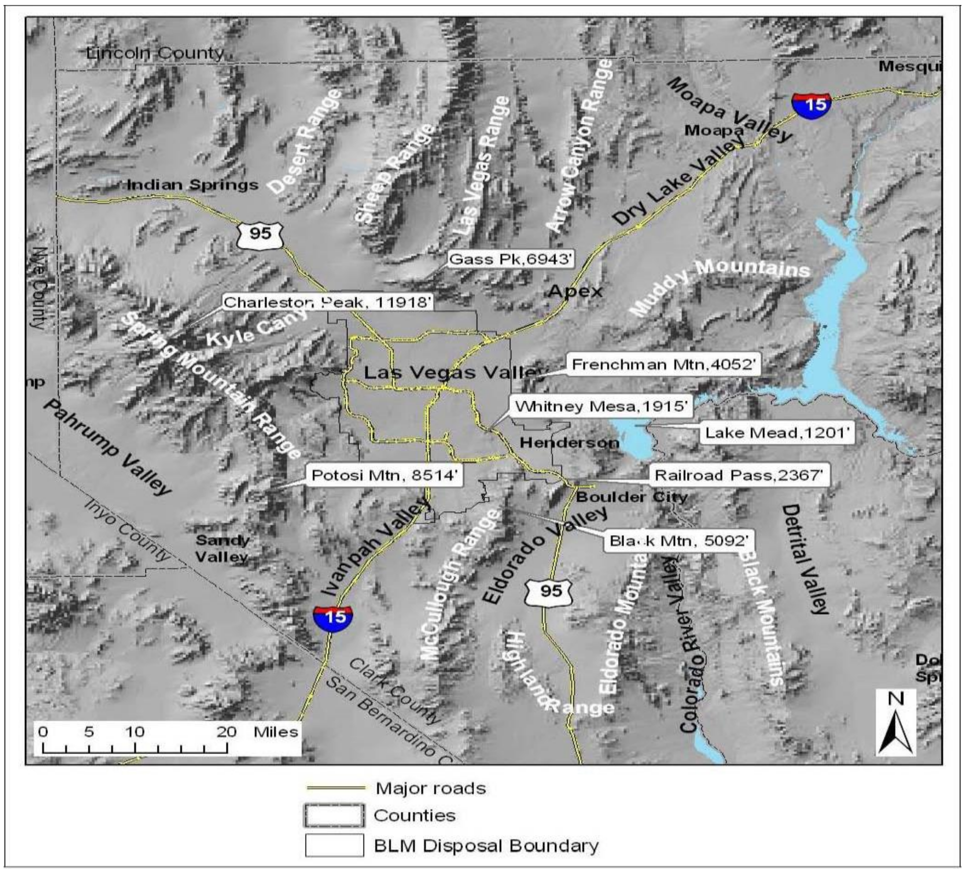


Figure 2-1. Mountain ranges and basins surrounding the Las Vegas Valley.

Although located in the Mojave Desert, Clark County has four well-defined seasons. Summers display the classic characteristics of the desert Southwest: daily high temperatures in the lower elevations often exceed 100 ºF, with lows in the 70s. The summer heat is usually tempered by low relative humidity, which may increase for several weeks during July and August in association with moist monsoonal wind flows from the south. Average annual rainfall in the valley, measured at McCarran International Airport, is approximately 4.5 inches. Table 2-1 lists temperature and rainfall averages in Clark County from 1981-2010.

Table 2-1. Monthly Averages for Temperature and Rainfall (1981-2010).

Month	Maximum (°F)	Minimum (°F)	Average (°F)	Rainfall (inch)
January	58	39.4	48.7	0.54
February	62.5	43.4	52.9	0.76
March	70.3	49.4	59.9	0.44
April	78.3	56.1	67.2	0.15
May	88.9	65.8	77.3	0.12
June	98.7	74.6	86.7	0.07
July	104.2	80.9	92.5	0.4
August	102	79.3	90.6	0.33
September	94	71.1	82.6	0.25
October	80.6	58.5	69.5	0.27
November	66.3	46.5	56.4	0.36
December	56.6	38.7	47.7	0.5

http://www.ncdc.noaa.gov

2.2 POPULATION AND LAND USE

The population of Clark County is just over two million people. More than 95 percent reside in the Las Vegas Valley, which encompasses the cities of Las Vegas, North Las Vegas, and Henderson, along with portions of Boulder City near Hoover Dam. Figure 2-2 depicts land use and vegetation in Clark County along with the two major transportation routes, Interstate 15 and U.S. Highway 95.

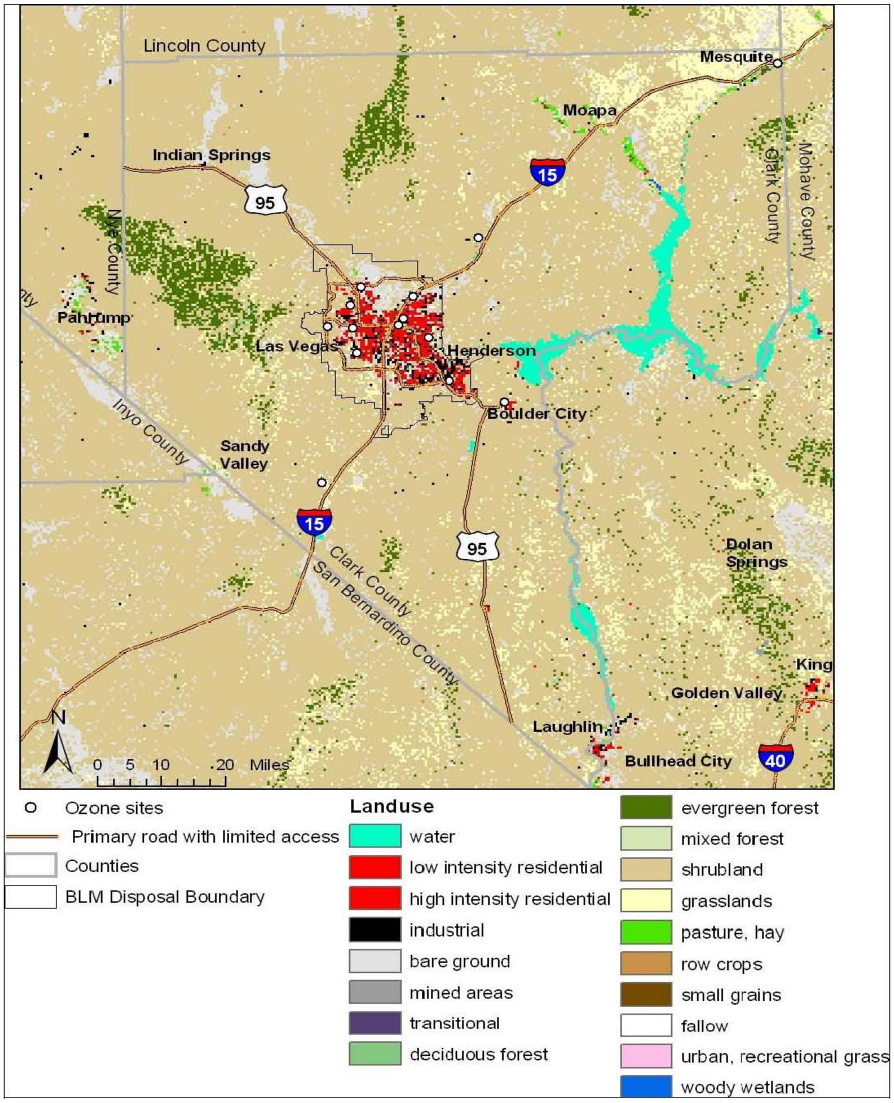


Figure 2-2. Land use and vegetation in Clark County.

2.3 OZONE AIR POLLUTION IN CLARK COUNTY

In 2006, Clark County Department of Air Quality (DAQ) embarked on a research study to characterize and identify the meteorological features that affect the timing and locations of elevated ozone levels in Clark County (*Ozone Characterization Study*, DAQEM 2006a).

In the study, synoptic weather patterns during the ozone season (May through August) were analyzed using 500 millibar (mb) constant-pressure maps. Specific measured weather parameters included the 500 mb height and the ambient air temperature at the 700 mb level at the Desert Rock NWS upper-air site were used. Temperatures aloft at the 700 mb level are indicative of the mixing potential (stability) of the regional air mass presiding in the area at the time of measurement. That is, warmer air at 700 mb (~10,000 feet or 3,000 meters) is indicative of a stable atmosphere and poor dispersion conditions, while cooler air aloft is associated with more vigorous vertical mixing of pollutants and thus better dispersion. Based on the analysis, it was determined that weather patterns could be characterized into five basic weather types: Pacific Trough, Interior Trough, Pacific Ridge, Interior Ridge, and Flat Ridge. The characteristics and criteria for each weather type are described below.

2.3.1 Pacific Trough

The axis of the long-wave 500 mb trough, or series of short wave troughs, is located off or along the Pacific Coast, producing falling 500 mb heights and increases from a westerly to southwesterly flow. By convention, it was decided that the lowest 500 mb heights during this weather type are west of the Sierra Nevada Mountains. This type of trough influences atmospheric dispersion conditions in the interior southwestern U.S. by slowly eroding the strength and longevity of stable anti-cyclonic air masses; this results in the breaking down of the broad scale subsidence needed to sustain poor dispersion conditions. The Pacific Trough designated weather type, also by convention, includes zonal flow situations characterized by light to moderate straight west to east flow across the western U.S. The southerly component of the onshore flow characteristic of the Pacific Trough weather type may also allow for increased moisture aloft over the interior regions. In general, the 700 mb temperature at the Desert Rock upper-air station is less than 10 ^{o}C (degrees Celsius) during Pacific Trough occurrences

2.3.2 Interior Trough

When the axis of a long or short wave trough, or a closed cyclonic system, resides in the interior of the southwestern U.S., the synoptic weather type is designated to be an Interior Trough. In this type, the lowest 500 mb heights are east of the Sierra Nevada Mountains. The most significant characteristic of this pattern is the advent of cool air aloft in the interior southwest, and the resultant well-mixed dispersion conditions. Temperatures at 700 mb are usually below 8 ^{o}C, and may be as low as 0 ^{o}C during the early part of the ozone season. When advected moisture is available aloft, considerable cloudiness and escalated precipitation may also accompany the Interior Trough synoptic type.

2.3.3 Pacific Ridge

The Pacific Ridge synoptic weather type is directly associated with the mean eastern Pacific ridge, with the axis of highest pressure situated along or west of the Pacific coast. The convention for this feature requires that the highest 500 mb heights be located west of the Sierra Nevada Mountains. The maximum 500 mb heights usually exceed 5,900 meters near the core of the ridge, but at the Desert Rock upper-air site, heights may be considerably lower. Another convention for the Pacific Ridge designation requires that the 500 mb flow over southern Nevada be from a northerly direction (west-northwesterly to northeasterly), reflecting the counterclockwise motion around the anti-cyclonic air mass to the west. During the first half of the ozone season, the northerly flow aloft will result in the advection of cooler, less stable air into the region, while during the latter half of the season, the northerly flow often brings in warmer, drier air. The Desert Rock 700 mb temperature may be as high as 12 ^{o}C (late season), or as low 5 ^{o}C (early season). The Pacific Ridge weather type usually marks the beginning of an anti-cyclonic situation, and often will follow a cyclonic event, especially in the earlier part of the season. It is also not unusual for this type to be the result of the retro-gradating of a ridge located farther east. The Pacific Ridge weather type is usually more transient than other ridging situations, and thus tends to occur for shorter durations, often as a transition into other longer-lived anti-cyclonic regimes.

2.3.4 Interior Ridge

The primary characteristic of the Interior Ridge weather type is the existence of a discernible high-pressure ridge at the 500 mb level over the interior southwestern U.S. The convention for this feature is that the highest 500 mb heights be located east of the Sierra Nevada Mountains. Typically, the interior ridge occupies the Great Basin and Inter-Mountain region and is often centered near the Four Corners area east of Las Vegas. The height of the 500 mb surface over the Desert Rock upper-air site is usually greater than 5,900 m, and sometimes as high as 5,990 meters. The 700 mb temperature in this situation usually exceeds 12^{o} C, and can be as high as 16^{o} C. The warm temperatures aloft are indicative of strong air mass subsidence in the interior region, and thus valley capping and limited thermodynamic mixing are prevalent; however, because of the lack of cool air advection, the hottest local surface temperatures of the year are usually recorded during Interior Ridge events, but mixing-layer depths may sometimes be deeper due to intense surface heating. Flow aloft at Desert Rock is usually very light and possibly variable when the ridge axis is over southern Nevada, and easterly to southeasterly when the ridge center is father east.

2.3.1 Flat Ridge

When the eastern pacific ridge broadens to extend over the ocean and the interior west, with little transitory movement, this weak anti-cyclonic air mass is classified as a Flat Ridge. In this pattern, all of the synoptic scale energy is well to the north and the pressure gradients, both at the surface and aloft, are very weak. The 500 mb surface may not always be as high as in the stronger ridging types (such as the Pacific Ridge and Interior Ridge), but they still are typically greater than 5,900 meters over most of the region. Because this is a relatively weak anti-cyclonic situation, significant air mass subsidence is prevalent, and as a result, the interior valleys remain capped and stable. This scenario is the most conducive to increased episodic pollution carryover from one day to the next.

2.4 SYNOPTIC WEATHER PATTERNS ASSOCIATED WITH THE EVENT IN MAY 2013

The 200, 500, and 850 mb time-series images for May 3-4, 2013, and the 500 mb chart for May 5, 2013, were examined to determine the synoptic weather patterns prior to, during, and after the May 4, 2013, event. The synoptic weather patterns are as follows.

<u>May 3</u>
Prior to the event, the four 200 mb and 500 mb time-series images in Figures 2-3 and 2-4 show a low pressure Pacific Trough digging down and retrogressing back to the southwest. The four 850 mb time-series images in Figure 2-5 show a disorganized low pressure developing over Clark County. All levels show a west to east regional airflow.

<u>May 4</u>

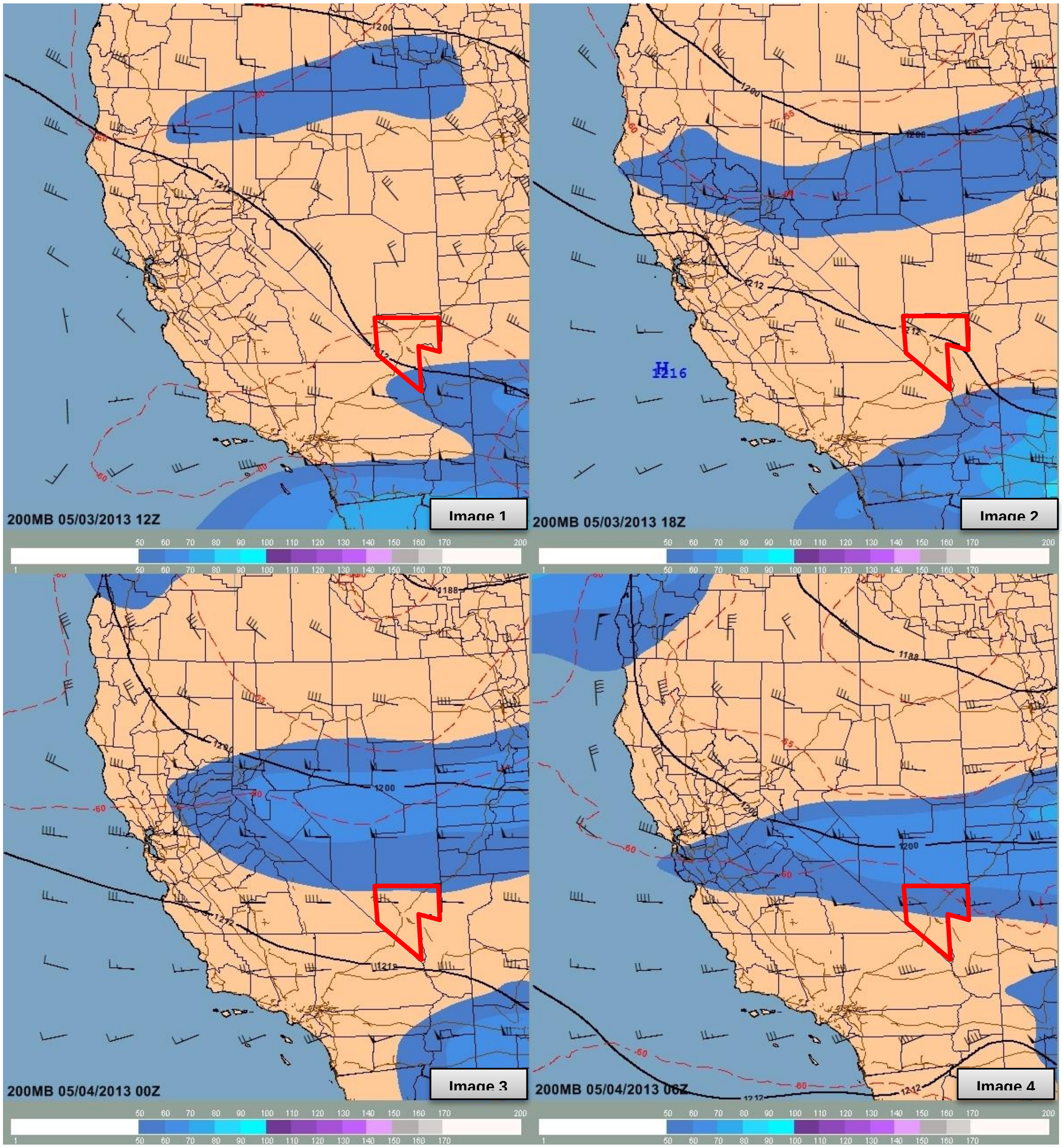
During the event, the Pacific Trough strengthened and continued to dig down and retrogressed to the southwest (see 200 mb time-series images#1-6 in Figure 2-6). As a result, the directional flow repositioned from the southwest. The six 500 mb time-series images #1-6 in Figure 2-7 show the formation of a closed low and a retrograding to the southwest over Northern California. The 850 mb time-series images #1-6 in Figure 2-8 show the formation of a closed low and a retrograding to the southwest off the California coastline. All levels show a southwesterly to northeasterly regional airflow.

May 5

After the event, the four 500 mb time-series images in Figure 2-9 show that the closed low continued to deepen and move southwesterly. The deepening and repositioning of the closed low resulted in a shift of the directional airflow from south-southwesterly to north-northeasterly.

Conclusion

On May 3, a Pacific Trough began to dig down and retrogress back to the southwest. Consequently, on May 4 the trough—or low-pressure system—moved far enough to the southwest to cause a directional change in flow from the southwest at all levels. By May 5, the low-pressure system dug deep enough to the southwest to cause another directional shift from the south-southwest.




Represents Clark County, NV

Figure 2-3. 200 mb weather images for May 3, 2013.

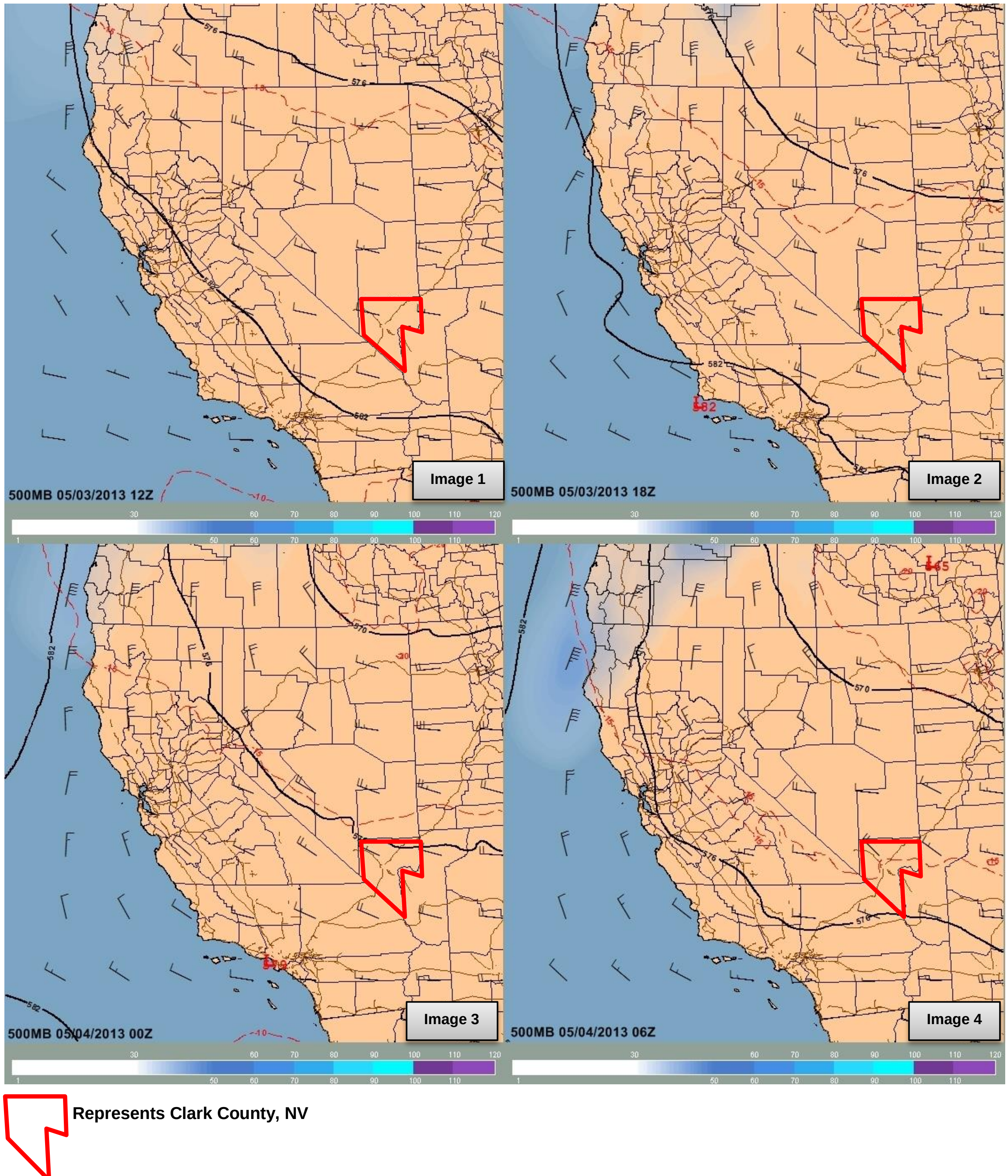


Figure 2-4. 500 mb weather images for May 3, 2013.

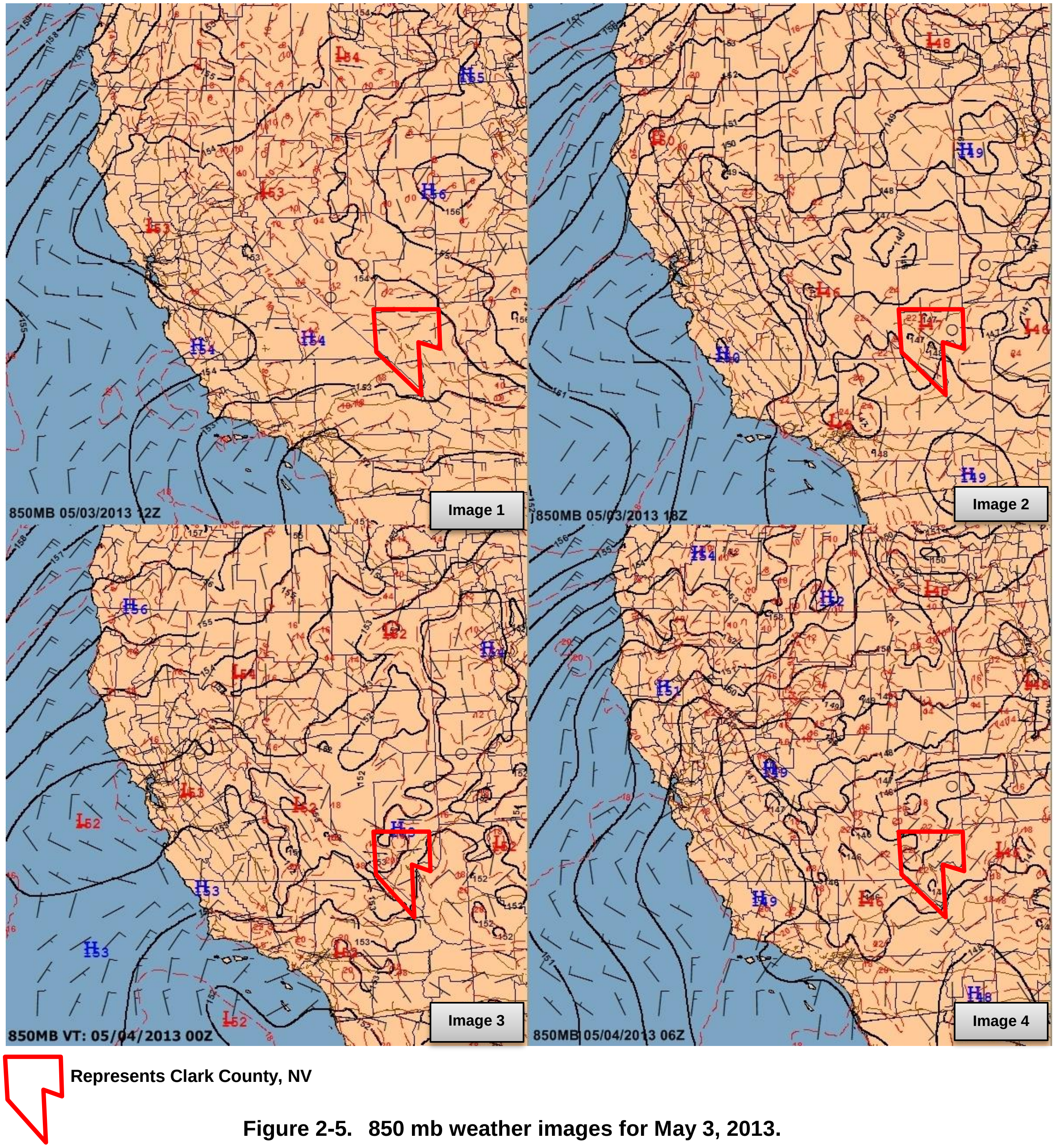
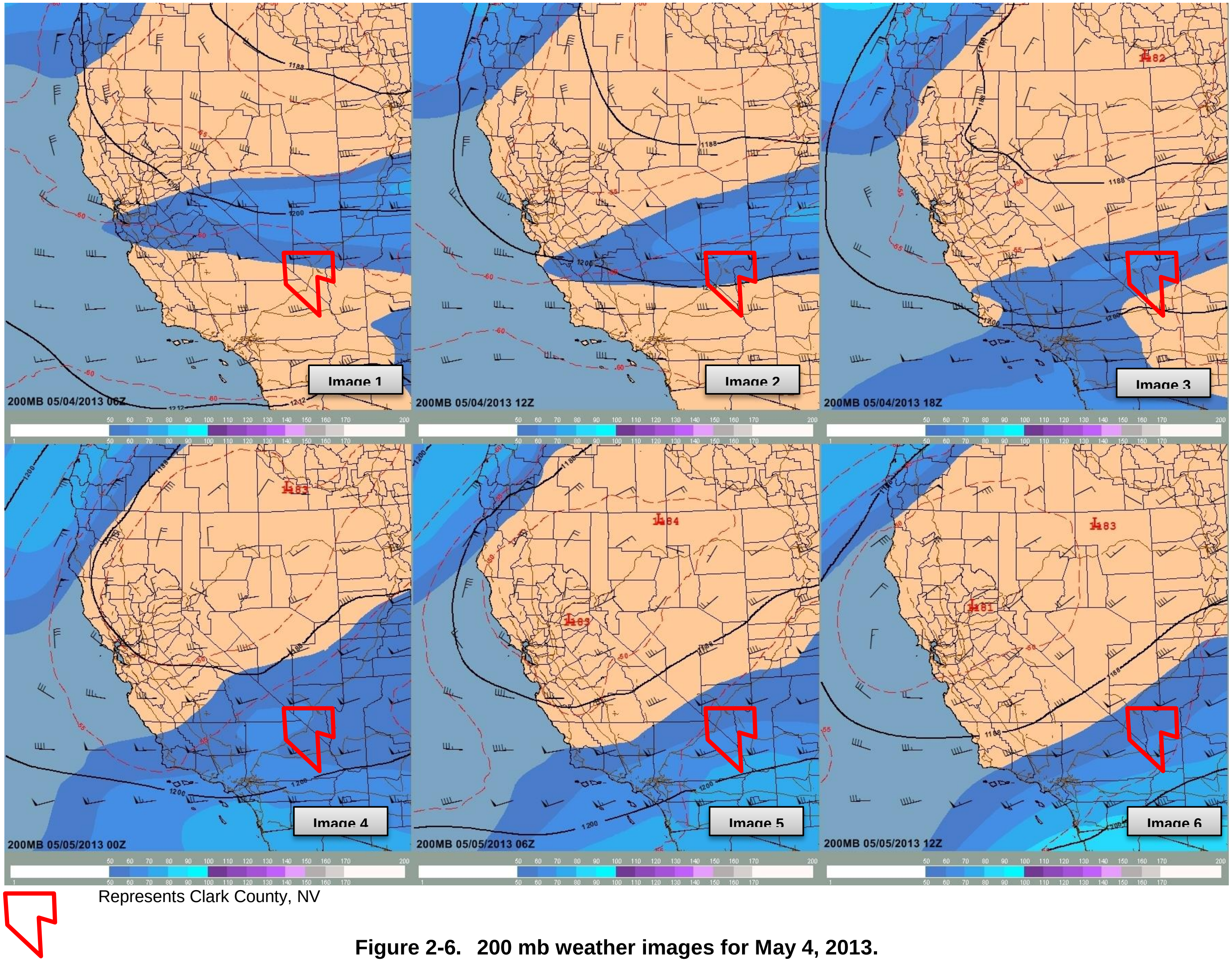


Figure 2-5. 850 mb weather images for May 3, 2013.



Represents Clark County, NV

Figure 2-6. 200 mb weather images for May 4, 2013.

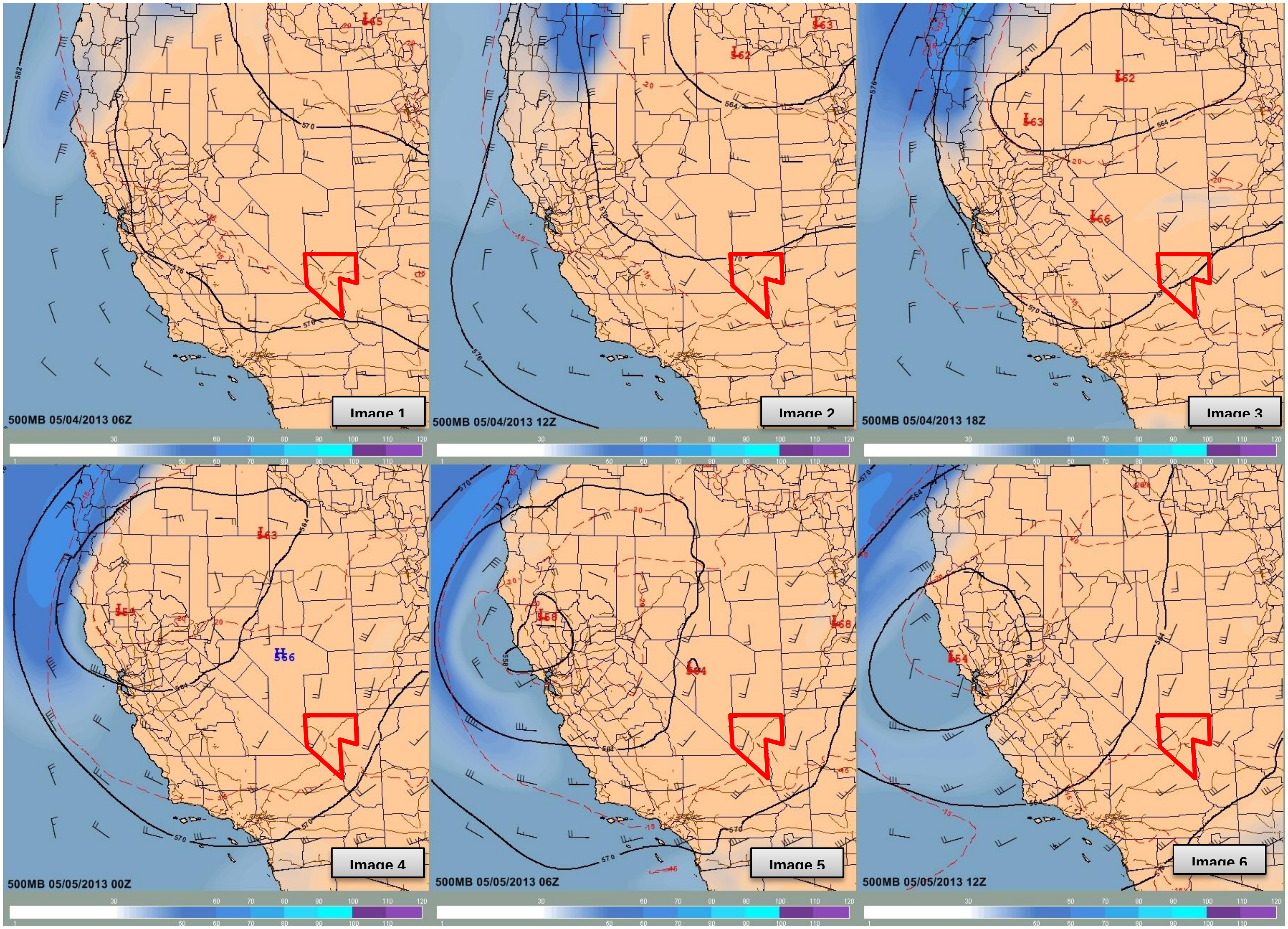


Figure 2-7. 500 mb weather images for May 4, 2013.

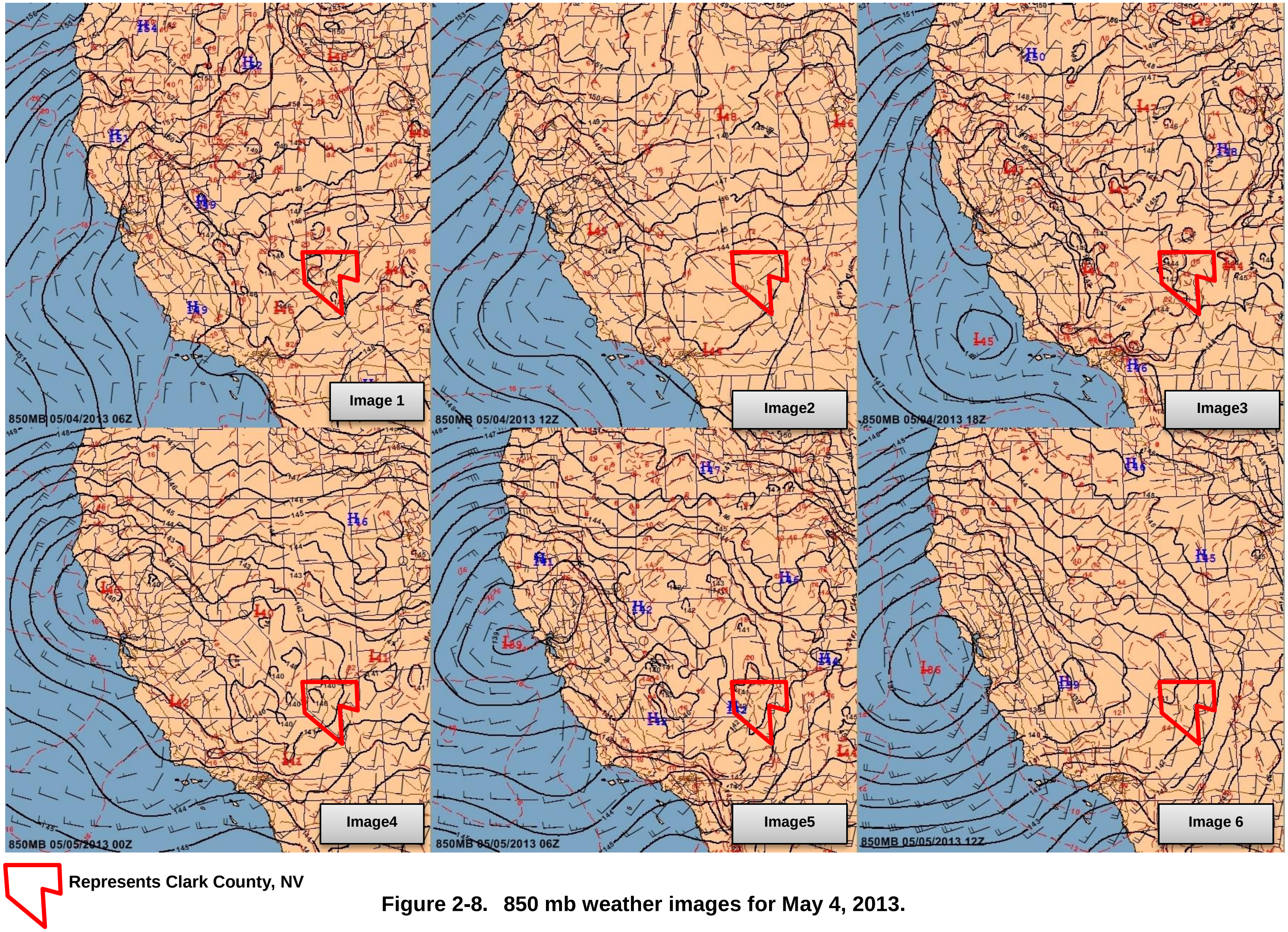


Figure 2-8. 850 mb weather images for May 4, 2013.

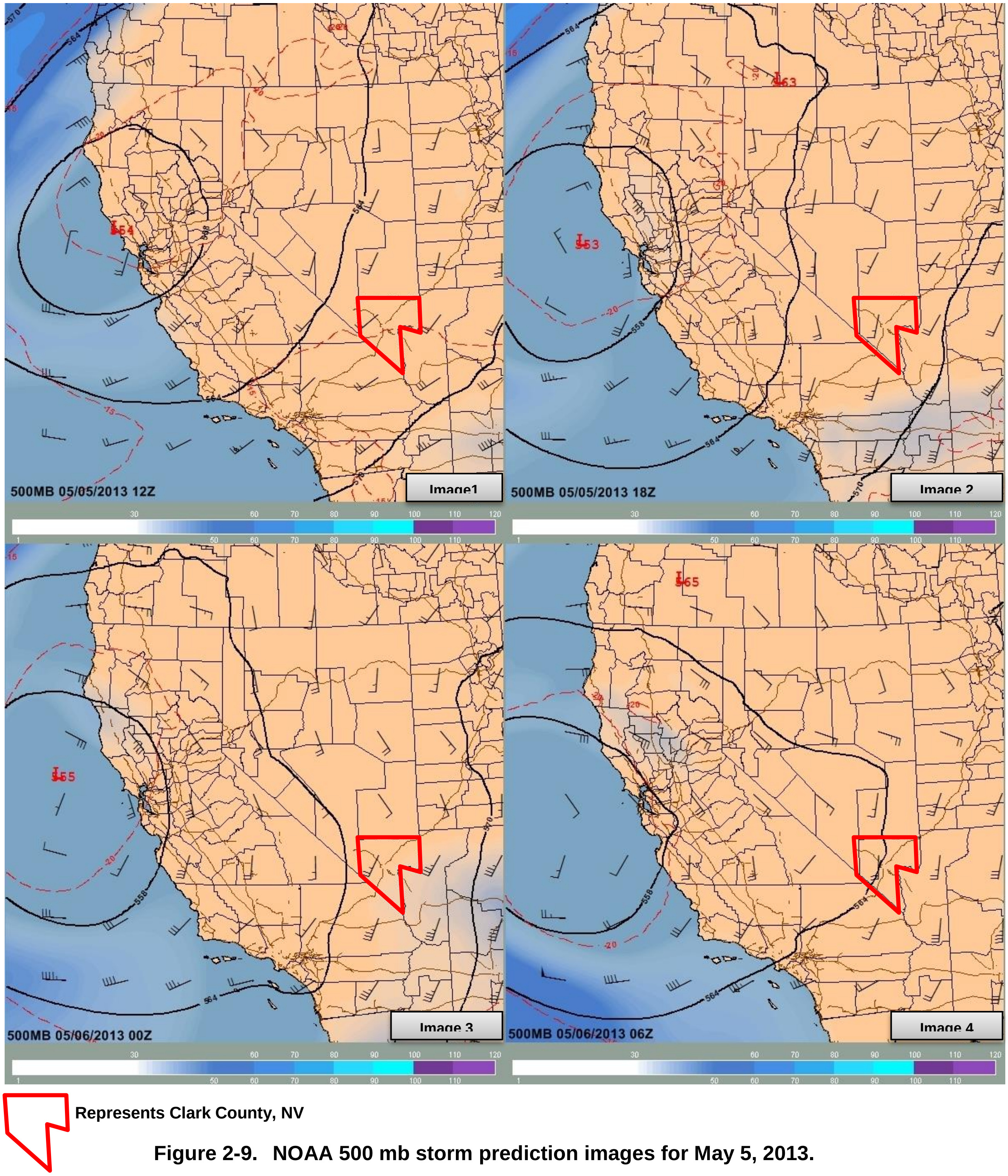


Figure 2-9. NOAA 500 mb storm prediction images for May 5, 2013.

3.0 CLEAR CAUSAL RELATIONSHIP

3.1 INTRODUCTION

Smoke plumes from wildfires contain a variety of pollutants, including VOCs and NO_x (both of which are precursor pollutants in the formation of ozone) and particulate organic and inorganic compounds. Wildfire smoke plumes affect air quality not only through the emissions of primary pollutants, such as carbon monoxide (CO), particulate matter, VOCs, and NO_x, but also through the production of secondary pollutants (i.e., ozone and secondary organic aerosols) when VOCs and NO_x undergo photochemical processing during atmospheric transport. Table 3-1 lists a range of pollutants emitted, expressed as emission factors, which are defined as the mass of compounds released per mass of dry fuel consumed. The table demonstrates that significant amounts of VOCs are released during wildfires. Total VOC emissions exceed those of $PM_{2.5}$, and account for 1 to 2 percent of the carbon fuel burned.

Table 3-1. Chemical Compositions and Emission Factors for Wildfires.

Compound or Compound Class	Emission Factors (g/kg)	
	Temperate Forest	Temperate Rangeland
$PM_{2.5}$	11.7	9.7
Organic carbon (wt. percent of $PM_{2.5}$)	45-55	40-70
Elemental carbon (wt. percent of $PM_{2.5}$)	4-8	4-10
Elemental Species (wt. percent of $PM_{2.5}$):	~ 3	~ 6
• Potassium (K, wt. percent of $PM_{2.5}$)	~ 1	~ 3
• Chloride (Cl, wt. percent of $PM_{2.5}$)	0.3	2
CO	89.6 ± 13.2	69 ± 17
CO_2	1,619 ± 112	1,684 ± 45
Alkanes (C2-C10)	0.8	0.4
Alkenes (C2-C9)	2.2	1.8
Aromatics (BTEX)	0.64	0.42
Oxygenated VOCs:	10.9–12.9	N/A
• Methanol	0.31–2.03	0.14
• Formic acid	1.17	N/A
• Acetic acid	3.11	N/A
• Formaldehyde	2.25	N/A
• Acetaldehyde	0.24	0.25
• Acetone	0.347	0.25
• Acrolein (propenal)	0.123	0.08
• Furan	0.445	0.1
• 2-methyl-furan	0.521	N/A
• 3-methyl-furan	0.052	N/A
• 2,5-dimethyl-furan	0.053	N/A
• Benzofuran	0.038	N/A
N/A = not available; BTEX = benzene, toluene, ethylbenzene, and xylenes.		

3.2 CAUSAL RELATIONSHIP

3.2.1 Meteorological Conditions

On May 3, a Pacific Trough began to dig down and retrogress back to the southwest. Consequently, on May 4 the trough—or low-pressure system—moved far enough to the southwest to cause a directional change in flow from the southwest at all levels. By May 5, the low-pressure system dug deep enough to the southwest to cause another directional shift from the south-southwest.

3.2.2 Laboratory Analysis of $PM_{2.5}$ Samples

Smoke plume impacts at the surface during the study period were determined by wildfire markers detected through laboratory analyses of $PM_{2.5}$ samples obtained from the Clark County monitoring network. Figure 3-1 shows the air quality monitoring sites within the County.

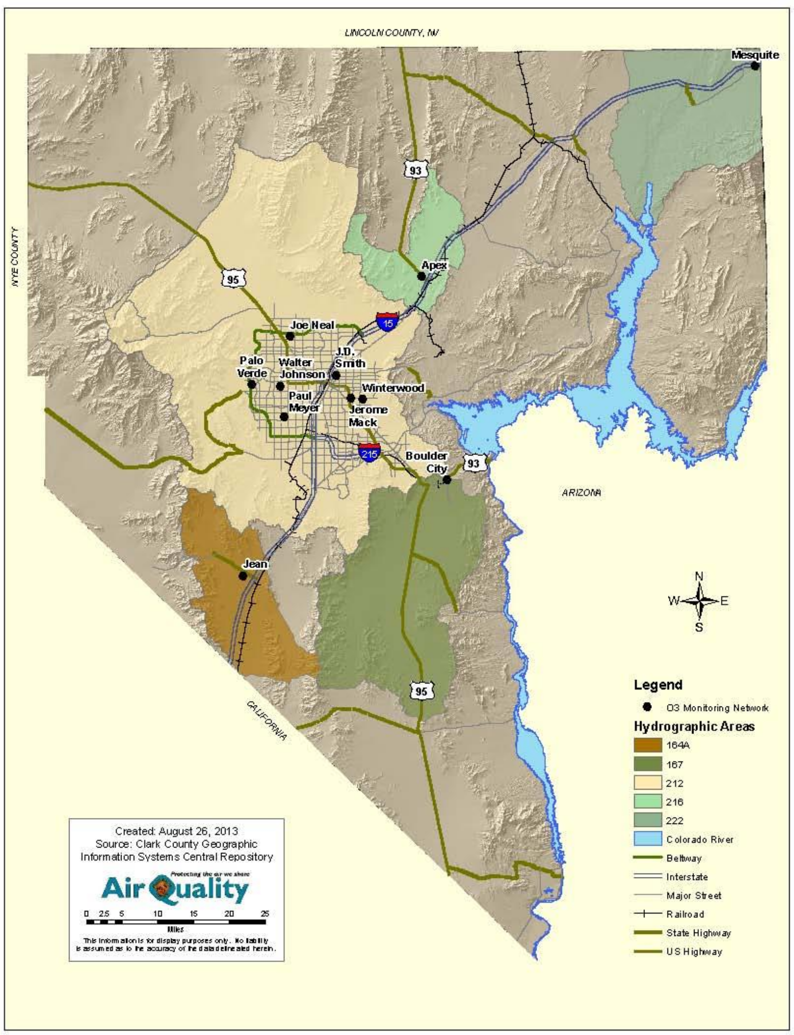


Figure 3-1. Clark County ozone monitoring network.

Levels of $PM_{2.5}$ track closely with those of levoglucosan, a unique tracer for burning biomass, due to its relationship with cellulose. When heated to more than 300 °C, cellulose undergoes various pyrolytic processes that yield tarry anhydro-sugars and volatile products; these give rise to source-specific molecular tracers, primarily the 1,6-anhydride of glucose known as levoglucosan.

Although levoglucosan is widely reported to be abundant in biomass smoke compared to other organic compounds (Fine et al. 2001; Nolte et al. 2001; Schauer et al. 2001; Fine et al. 2002; Hays et al. 2002; Sheesley et al. 2003; Mazzolini et al. 2007), concentrations are highly variable. In Mazzoleni et al. (2007), the overall range of levoglucosan varied from 3 to 36 percent of $PM_{2.5}$ mass. The highest percentage of levoglucosan was observed for grasses, white pine needles, straws, and mixed woods. Since wildfires typically consume a high percentage of these materials, the concentration of levoglucosan in wildfire emissions is significant in determining where a wildfire originated.

In addition to levoglucosan, methoxylated phenols (methoxyphenols) are often found in biomass combustion emissions and can be significant in determining where a smoke plume originated. Cellulose fibers in plants are bound together in lignin, a complex polymer. The pyrolysis of wood lignins gives rise to methoxyphenols, most often guaiacols and syringols. In the lignin of hardwoods, structural units of guaiacol and syringol are present in even proportions. In the lignin of softwoods, guaiacols are the predominant structural unit.

Mazzoleni et al. (2007) reported that sagebrush and grasses, like hardwoods, emit guaiacols and syringols in similar quantities; however, Mazzoleni noted that pine needles have a high particulate fraction of guaiacols with very few syringols, similar to softwoods. The prescribed burn samples Mazzoleni collected in mixed coniferous forests—Yosemite National Park, California, and the Toiyabe National Forest near Lake Tahoe, Nevada—had a high percentage of particulate represented by guaiacols and a very low percentage represented by syringols, as hardwoods do. The prescribed burn samples of desert brushes from central rural Nevada had even percentages of guaiacols and syringols, similar to sagebrush. Mazzoleni et al. (2007) also identified methoxy acids originating from pyrolysis of wood lignin (e.g., vanillic, homovanillic, and syringic acids) in biomass combustion source samples and in-field prescribed burn samples. In general, methoxy acids were found in low levels in wildland fuels.

In 2011, RTI International, in Research Triangle Park, North Carolina, analyzed six $PM_{2.5}$ filters for traces of levoglucosan to determine the background concentrations at the Jean and Jerome Mack monitoring sites. Three days (one in June, one in July, and one in August) without any fire impacts were chosen for the analysis. Table 3-2 shows the filter numbers and dates.

Table 3-2. Filter and Sample Days.

Jerome Mack	Jean
FD-T0728928-110620	FD-T0728929-110620
FD-T0728978-110720	FD-T0728979-110720
FD-T0729017-110810	FD-T0729018-110810

The results of the analysis (outlined in Table 3-3) shows that there were no detectable levoglucosan concentrations for non-fire days, and therefore, the background concentration for levoglucosan during non-fire days is zero.

Table 3-3. Filter Analysis Results.

Sample Name	µg/mL
FD-T0728928-110620	0.000
FD-T0728929-110620	0.000
FD-T0728978-110720	0.000
FD-T0728979-110720	0.000
FD-T0729017-110810	0.000
FD-T0729018-110810	0.000

During the May 4 wildfire event, DAQ collected ambient $PM_{2.5}$ samples at Jerome Mack, Jean, and Sunrise Acres. After gravimetric mass measurements, all filters were archived and kept in airtight containers in a freezer. RTI International performed a speciation analysis for traces of levoglucosan. Results of the analyses are listed in Table 3-4. Levoglucosan concentrations were elevated during the event on May 4, with some residual levels the following day. The results show that the monitors were impacted by the smoke plume from the Springs Fire.

Table 3-4. Analyses Results for May Fire.

Sample ID	Run Date	Levoglucosan (µg)
T1644750	4-May	0.305
T3536308	5-May	0.493
T3536310	6-May	0.048
T1644783	4-May	0.455
T1644787	4-May	0.388

The concentration comparison between $PM_{2.5}$, levoglucosan, and ozone (for Jean) is shown in Table 3-5.

Table 3-5. Pollutant Concentrations.

Jean			
Date	Levo	$PM_{2.5}$	O_3
4-May	0.388	17.84	84
5-May		21.57	74
6-May	0.048	14.95	51

Since levoglucosan is the most abundant, stable, and universal biomass burning emission marker, the correlation between $PM_{2.5}$, ozone and levoglucosan concentrations were examined as shown in Figure 3-2. There is a very good correlation between ozone and levoglucosan on May 4, proving that the Las Vegas Valley was impacted at ground level by smoke plumes.

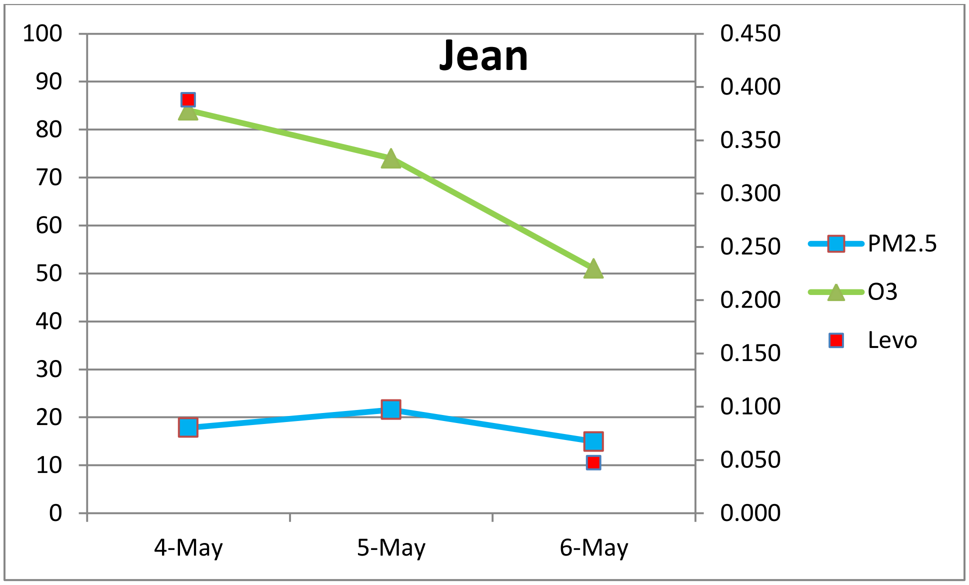


Figure 3-2. Correlation of average ozone and levoglucosan concentrations.

3.2.3 Smoke Plume Trajectory Model

The Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model computes simple air parcel trajectories. Its calculation method is a hybrid between the Lagrangian approach, which uses a moving frame of reference as the air parcels move from their initial location, and the Eulerian approach, which uses a fixed three-dimensional grid as a frame of reference. HYSPLIT back-trajectories show the path an air parcel took to reach an area. Applications include tracking and forecasting the release of radioactive material, volcanic ash, and wildfire smoke.

The HYSPLIT plots in Figures 3-3 show 24-hour back-trajectories for the afternoon hours on May 4. The highest ozone values occurred in the afternoon, starting at 12:00. The 24-hour back-trajectories demonstrate that the air masses and smoke plume on May 4 originated in from the Springs Fire area Southern California.

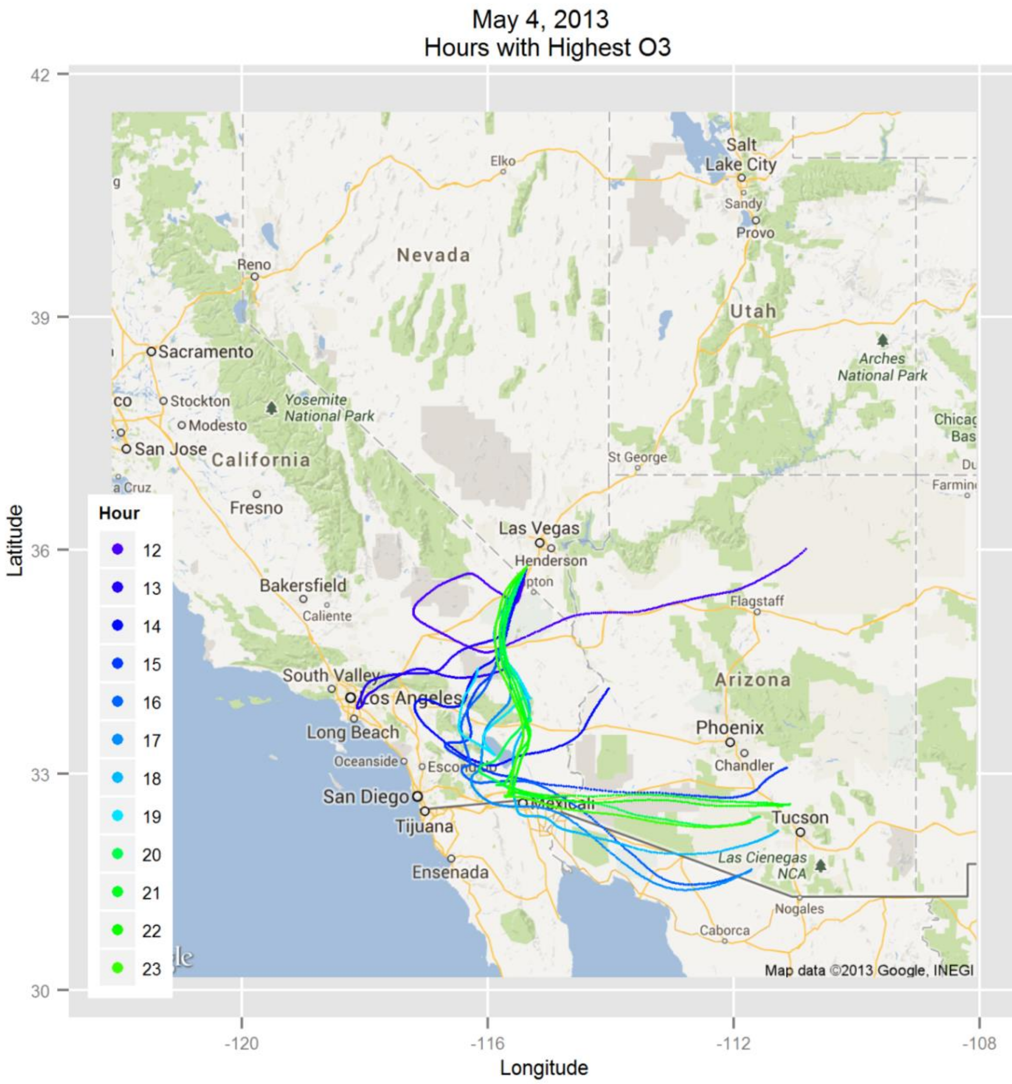


Figure 3-3. Back trajectories.

3.2.4 Pollutant Concentrations and Wildfire Impacts

Ozone concentrations started to increase at 10:00 at all stations within the Las Vegas Valley and at Jean, with concentrations reaching 88 ppb at Jean at 20:00. High ozone concentrations early in the ozone season are very unusual for Clark County. A total of six out of eleven stations violated the ozone NAAQS in Clark County on May 4. Table 3-6 lists all the hourly concentrations for all of the ozone monitors in the network.

Table 3-6. Ozone Concentrations for May 4.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Apex	44	30	33	35	40	30	36	39	50	53	58	64	70	71	72	73	73	74	73	72	**75**	72	57	61
Mesquite	25	26	16	19	21	16	19	32	37	42	52	55	56	60	63	63	65	65	61	61	65	**68**	49	59
Paul Meyer	18	25	22	24	21	25	31	40	46	50	57	62	65	72	76	81	**84**	84	82	80	80	76	73	75
Walter Johnson	26	24	30	29	28	36	43	48	48	52	57	61	67	71	74	80	83	**84**	83	80	78	79	74	69
Palo Verde	40	40	40	44	44	32	43	51	50	51	54	55	60	71	77	81	85	85	**86**	84	81	81	79	73
Joe Neal	48	49	47	45	42	47	48	48	50	54	59	63	69	72	73	76	**82**	82	77	77	75	76	69	65
Winterwood	1	1	0	1	1	2	11	20	38	50	55	60	67	67	68	74	**81**	80	79	76	72	72	73	76
Jerome Mack	1	1	1	1	1	6	10	22	39	48	54	60	65	66	67	75	**81**	80	74	73	71	73	71	73
Boulder City	53	54	53	56	56	45	38	46	50	56	58	63	68	71	70	71	70	**72**	72	70	69	71	70	71
Jean	49	51	50	50	45	41	48	59	54	59	63	75	80	80	83	86	87	87	84	77	**88**	85	80	78
JD Smith	5	5	9	18	11	9	14	35	47	53	56	61	68	70	70	77	**80**	80	76	75	67	71	67	70

Through a weight-of-evidence approach, this report shows that ozone concentrations on May 4 would not have exceeded the NAAQS “but for” the wildfires.

Figures 3-4 through 3-13 illustrate the diurnal cycle at ten ozone monitoring sites from May 1 through May 8. On a normal day, ozone values climb in the morning, peak around noon, plateau through the afternoon, and recede in the early evening. The highest ozone concentrations occur during the most intense hours of sunlight, often referred to as the prime ozone cooking period. On May 4, however, the highest ozone concentrations occurred in the early afternoon throughout the evening and into the night.

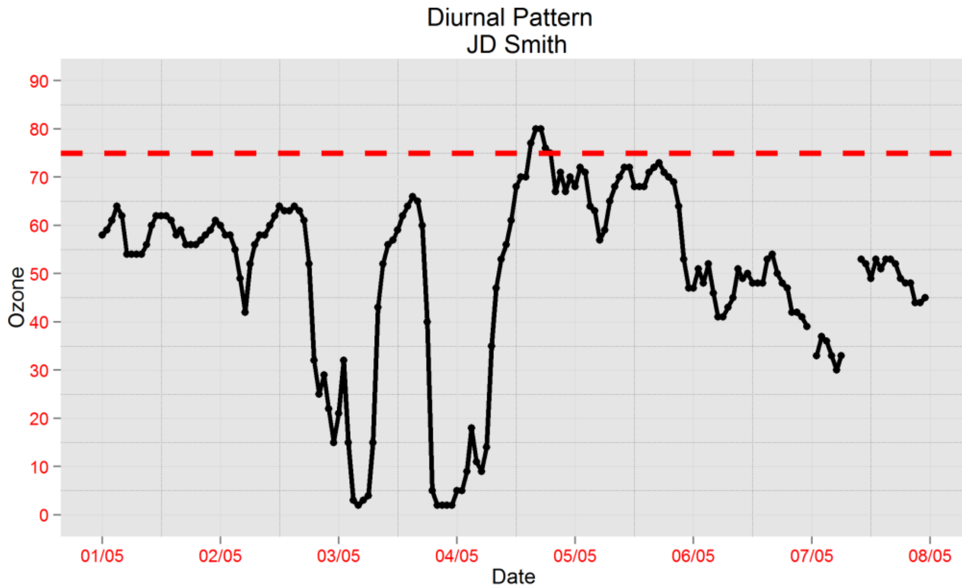


Figure 3-4. Diurnal cycle for J.D. Smith.

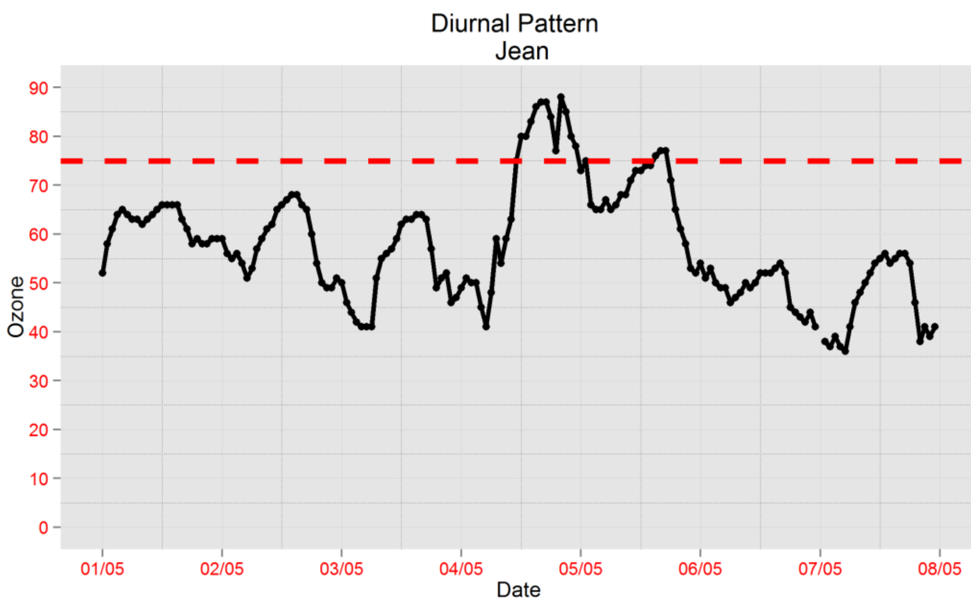


Figure 3-5. Diurnal cycle for Jean.

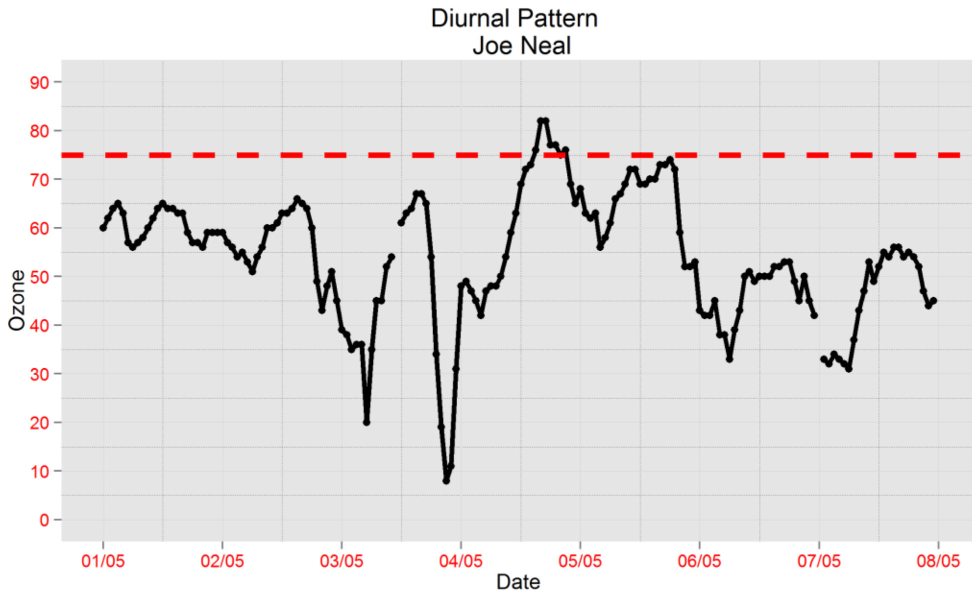


Figure 3-6. Diurnal cycle for Joe Neal.

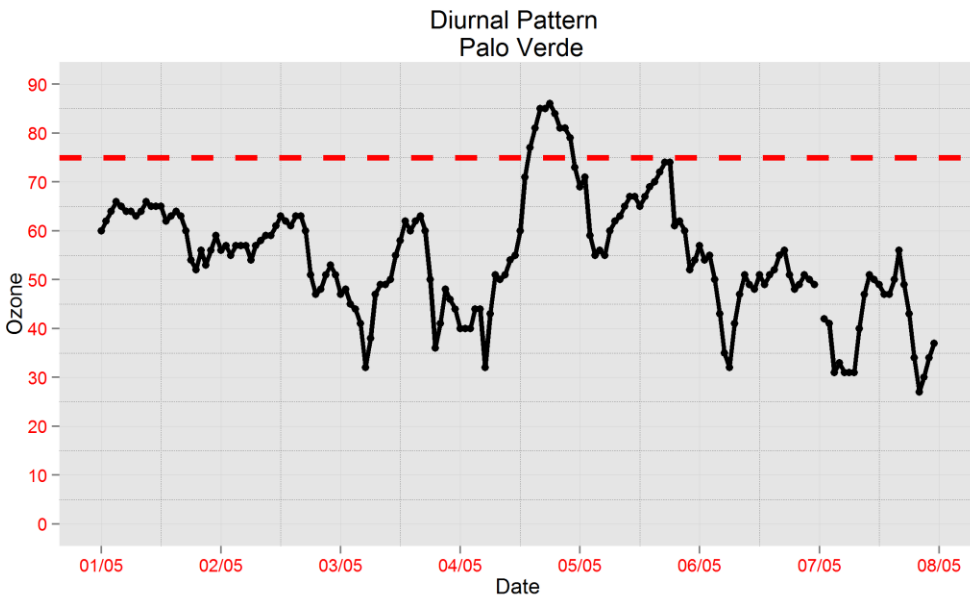


Figure 3-7. Diurnal cycle for Palo Verde.

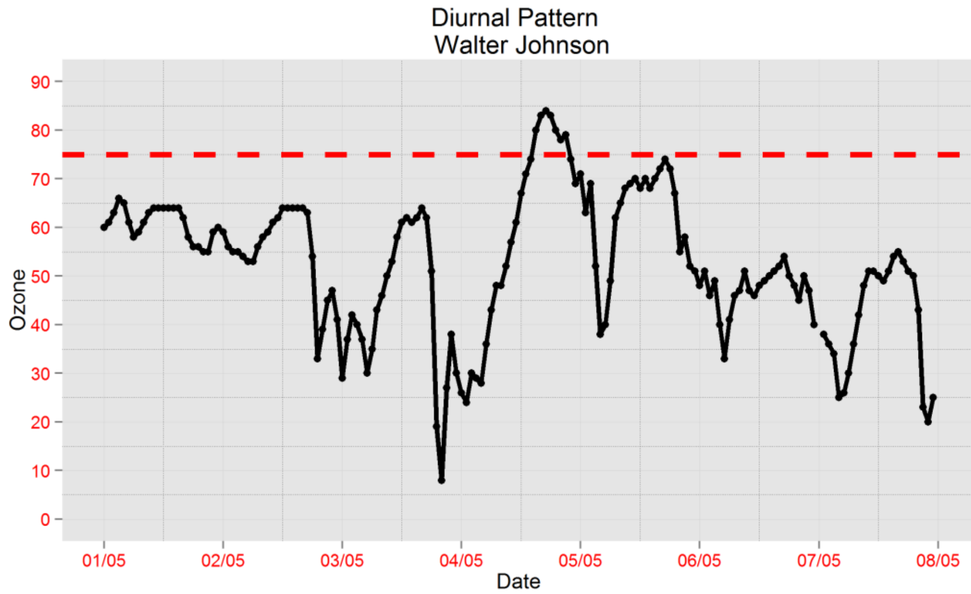


Figure 3-8. Diurnal cycle for Walter Johnson.

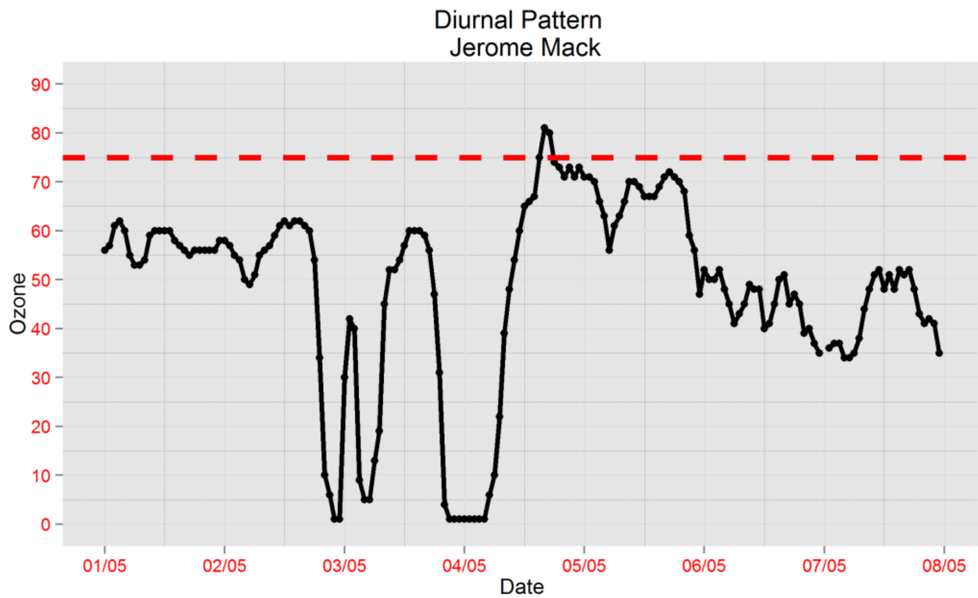


Figure 3-9. Diurnal cycle for Jerome Mack.

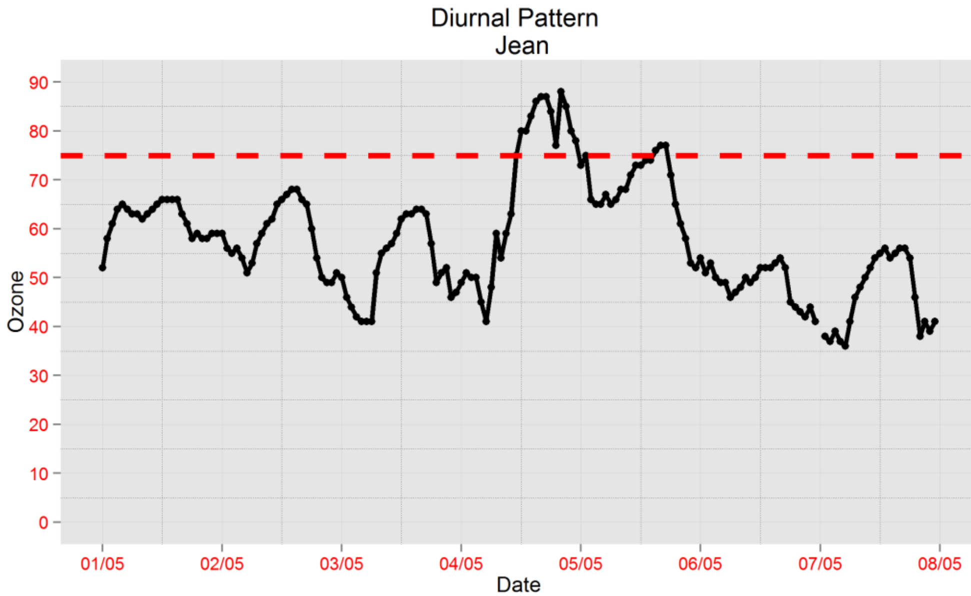


Figure 3-10. Diurnal cycle for Jean.

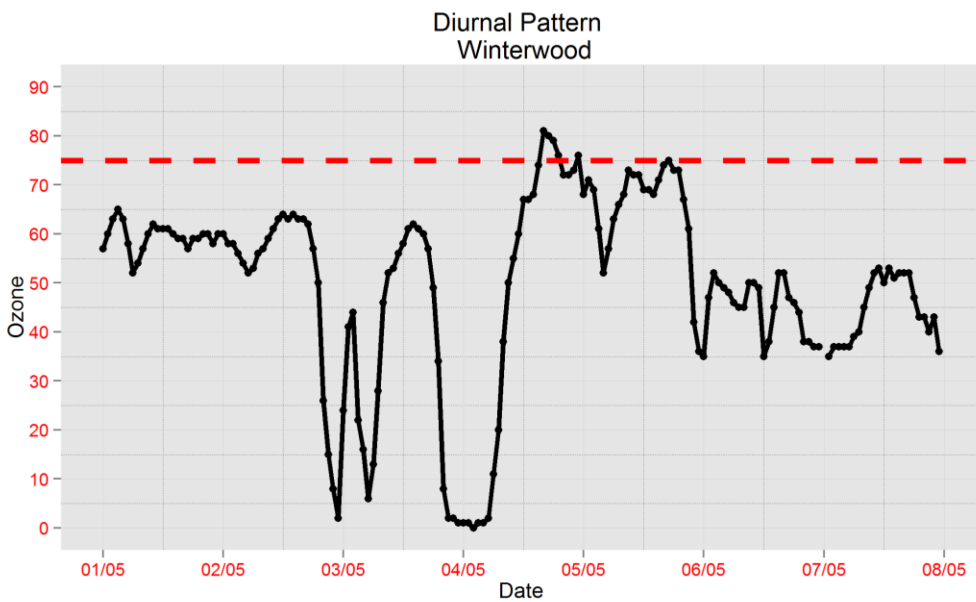


Figure 3-11. Diurnal cycle for Winterwood.

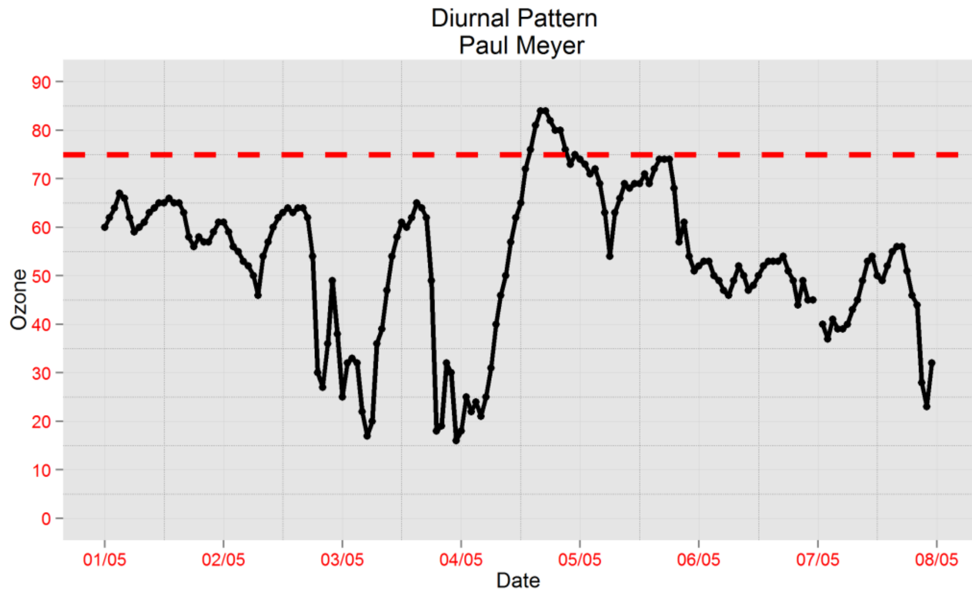


Figure 3-12. Diurnal cycle for Paul Meyer.

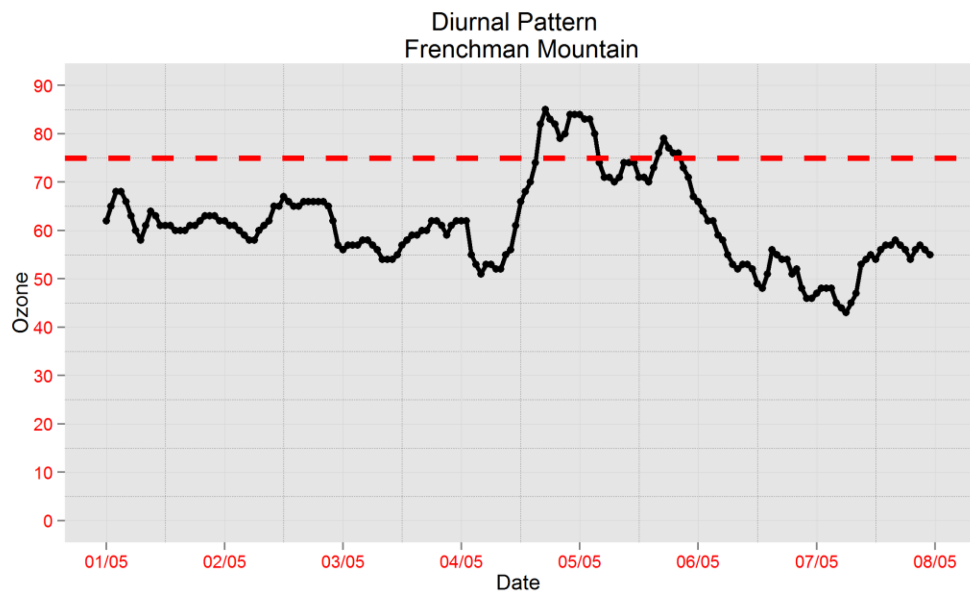


Figure 3-13. Diurnal cycle for Frenchman Mountain.

To further illustrate that ozone concentrations on May 4 were due to an exceptional event, $PM_{2.5}$, carbon monoxide, and ozone concentrations were compared before, during, and after the event. The data shows the relationship between the different pollutants, and this provides strong evidence that the elevated concentrations were due to the smoke from the wildfire, since these pollutants are the products of combustion. Figures 3-14 and 3-15 show the normalized time series for ozone, carbon monoxide, and $PM_{2.5}$ levels at the J.D. Smith and Jerome Mack stations. All values were elevated on May 3 and 4, and remained high through the evening of May 4 (Saturday). There is some residual $PM_{2.5}$ and ozone on May 5.

Figures 3-16 through 3-18 depict the relationships between values of $PM_{2.5}$, levoglucosan, and ozone before, during and after the event.

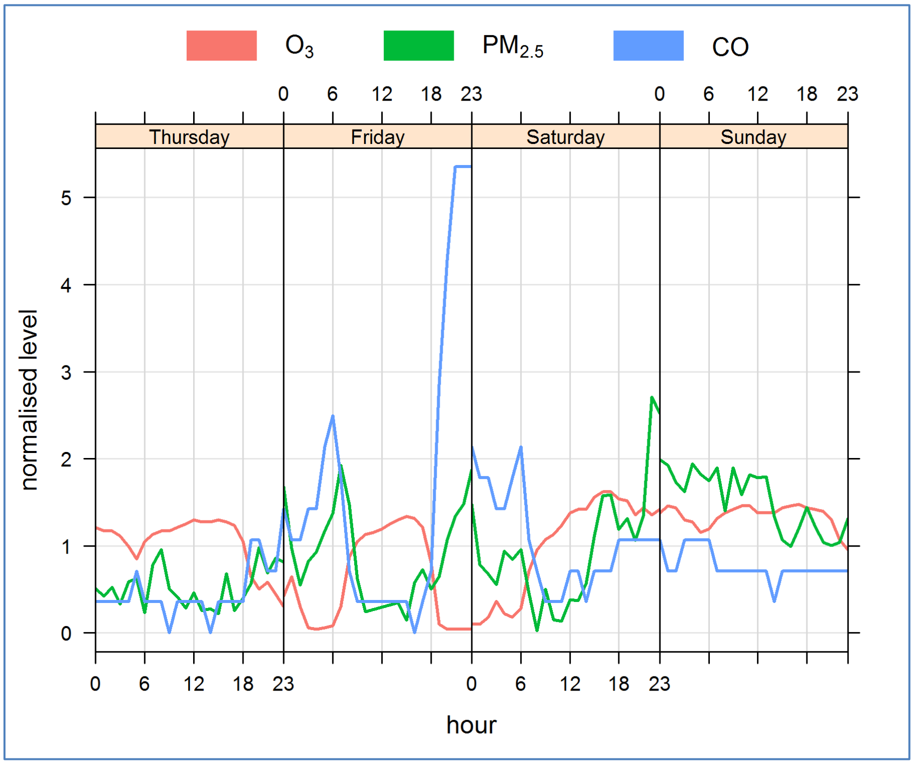


Figure 3-14. Diurnal cycle at J.D. Smith (normalized).

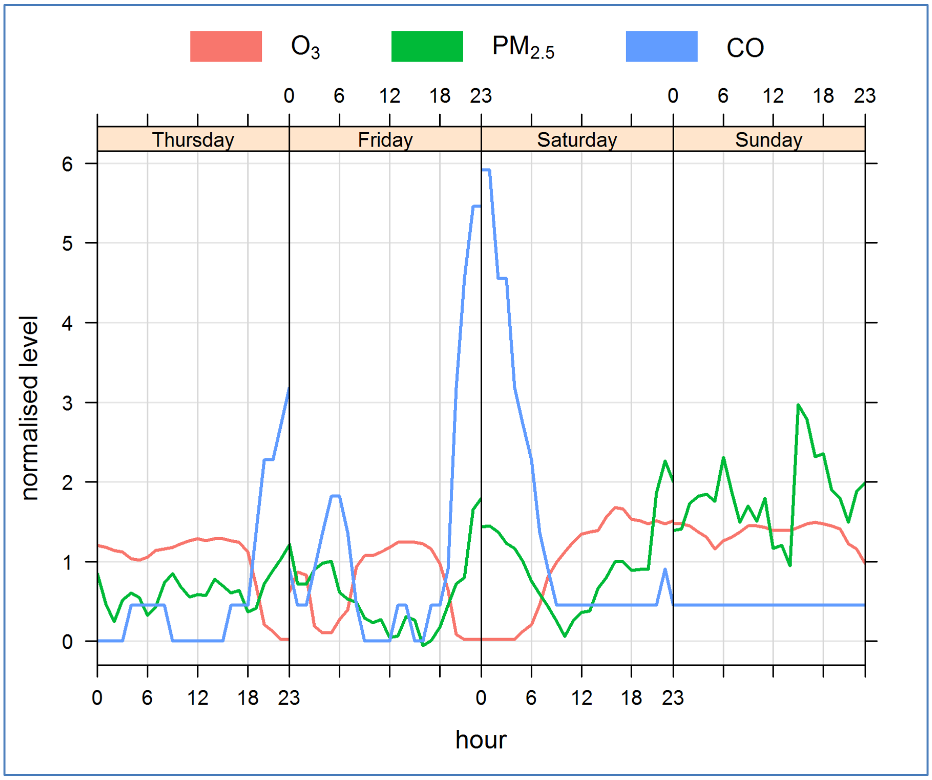


Figure 3-15. Diurnal cycle at Jerome Mack (normalized).

Figures 3-16 through 3-17 show the relationship between ozone, $PM_{2.5}$, and levoglucosan during the $PM_{2.5}$ sampling days at Jerome Mack and Jean.

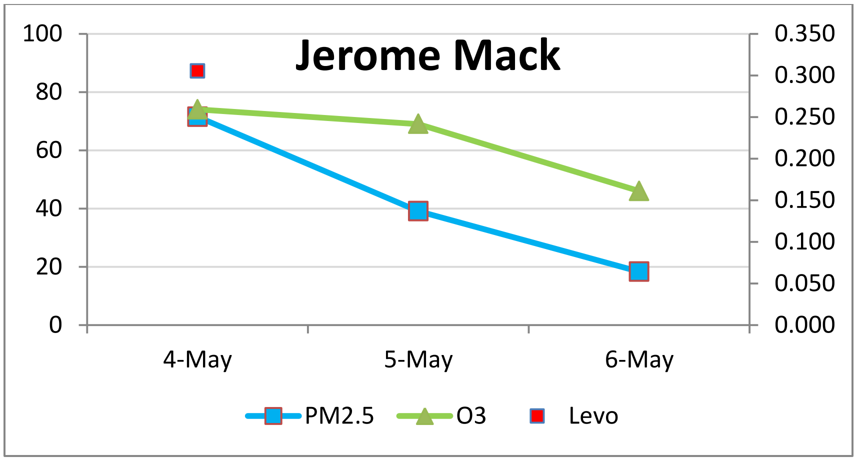


Figure 3-16. $PM_{2.5}$ and levoglucosan concentrations.

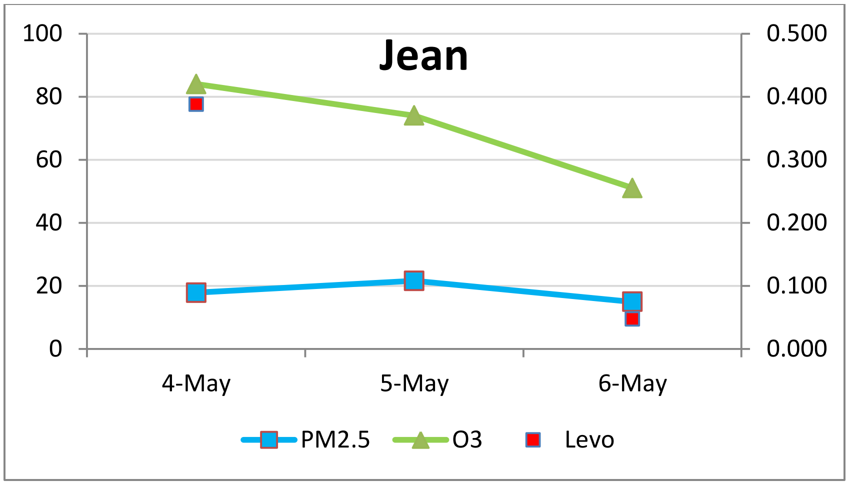


Figure 3-17. Ozone and levoglucosan concentrations.

The ozone and $PM_{2.5}$ concentrations at JD Smith indicate a strong correlation between these two pollutants.

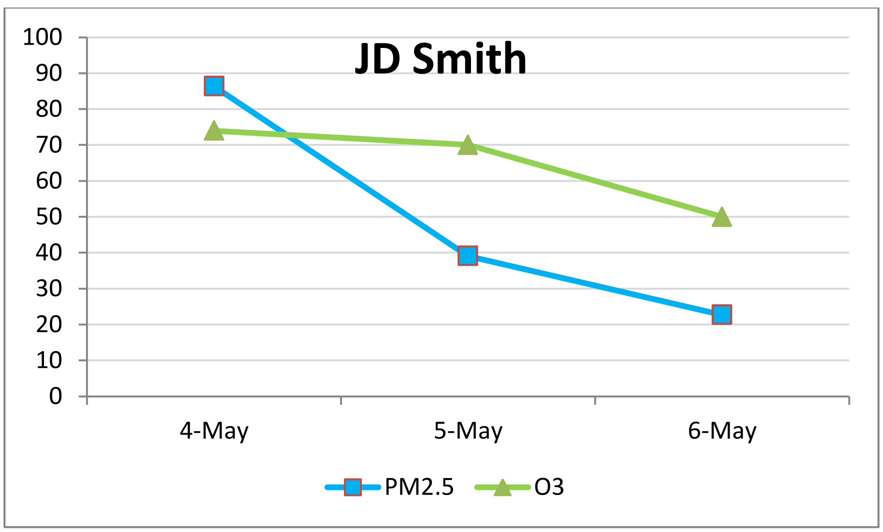


Figure 3-18. Ozone and $PM_{2.5}$ concentrations.

Table 3-7 lists Air Quality Index (AQI) values for ozone, carbon monoxide, and $PM_{2.5}$ between May 1 and May 7, 2013. Figure 3-19 demonstrates how well the AQI values for ozone**,** $PM_{2.5}$, and carbon monoxide tracked wildfire impacts. Concentrations of the three pollutants were elevated on wildfire days, providing strong evidence of contributions from the wildfires. Figure 3-20 shows the increase in pollutant concentrations during wildfire days; the concentration of ozone during the fire day increased by 81 percent; concentrations of carbon monoxide and $PM_{2.5}$ increased by 16 and 80 percent, respectively.

Table 3-7. Pollutant AQI Values.

Date	PM_{10}	O_3	$PM_{2.5}$	CO
1-May	56	64	50	4
2-May	24	67	26	8
3-May	30	61	48	16
4-May	37	122	92	9
5-May	56	97	78	4
6-May	24	44	53	3
7-May	30	47	29	4

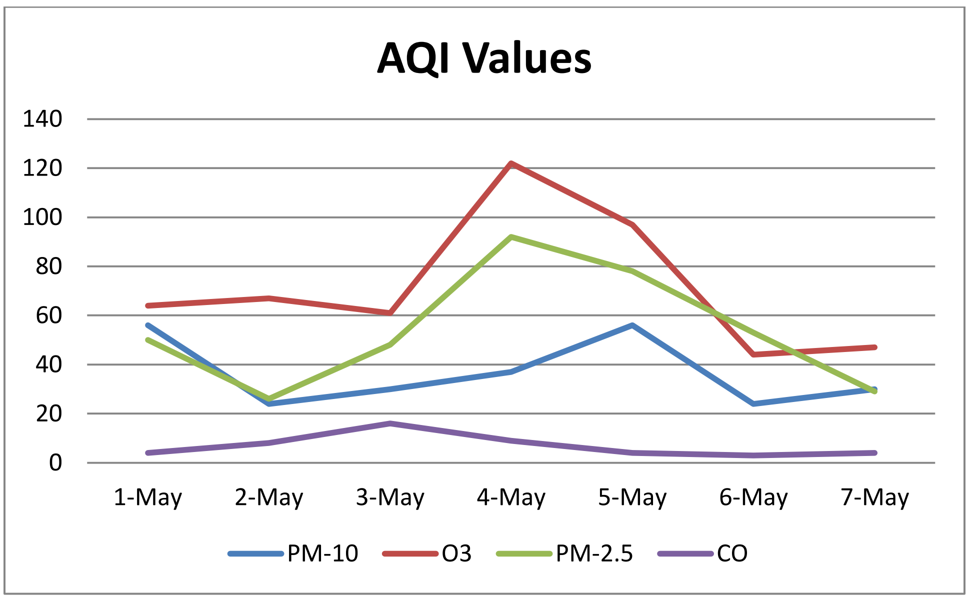


Figure 3-19. Correlation for May 1, 2013, through May 7, 2013.

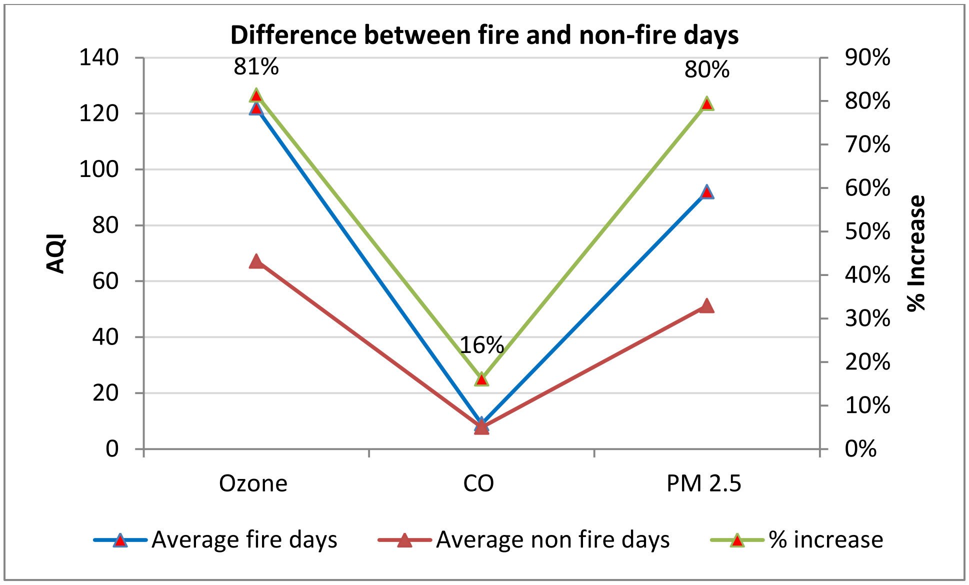


Figure 3-20. Fire and nonfire days.

The National Oceanic and Atmospheric Administration (NOAA) uses FLEXPART, a Lagrangian Particle Dispersion Model with the GFS and WRF models, to produce tracer forecasts. Figure 3-21 is the model output from a run on May 4. This figure shows high carbon monoxide concentrations near the Springs Fire and relative high carbon monoxide concentrations near Clark County, evidence that the plume reached the County.

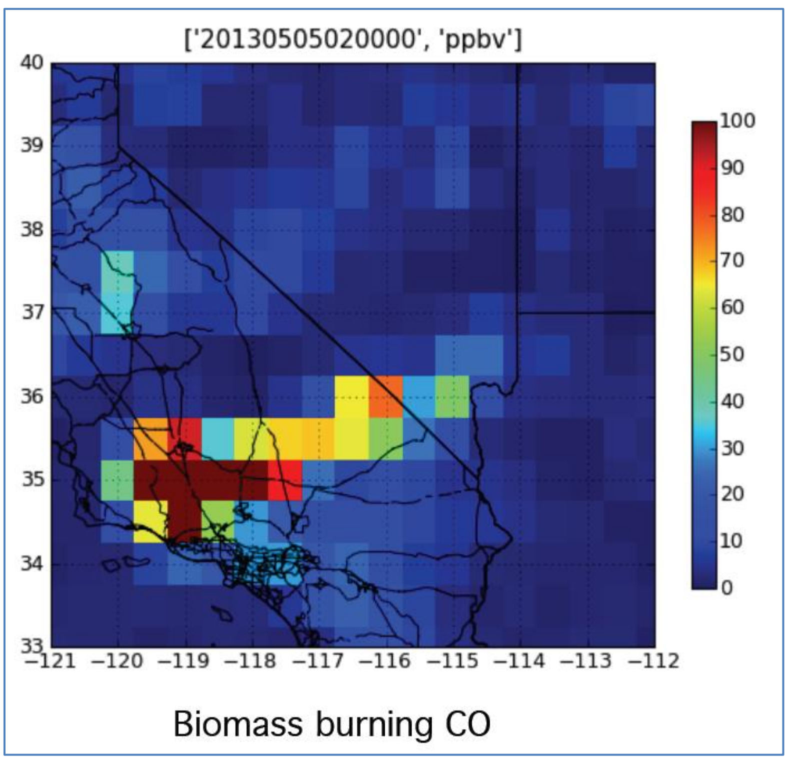


Figure 3-21. The FLEXPART output for CO on May 4.

3.3 OZONE CONCENTRATIONS RELATIVE TO HISTORICAL FLUCTUATIONS

In the preamble to the final EER, EPA states that the magnitude of measured concentrations on days affected by an exceptional event relative to historical, temporally adjusted air quality levels can guide the level of analysis and documentation needed to demonstrate that the event affected air quality. For example, EPA acknowledges that for extremely high concentrations relative to historical values (i.e., concentrations greater than the 95th percentile), less documentation or evidence may be required to demonstrate that the event affected air quality. This "weight of evidence" approach reflects how the EPA has historically treated exceptional events.

On May 4, smoke plumes from the Springs Fire resulted in some of the highest ozone readings for the season throughout the Clark County air quality monitoring network. Hourly concentrations reached up to 88 ppb (see Table 3-6), while one of the highest MDA8 of the season was recorded at Jean (see Table 3-8).

Table 3-8. Four Highest Concentrations in 2013.

Station	Highest		Second Highest		Third Highest		Fourth Highest	
	Date	Value	Date	Value	Date	Value	Date	Value
Apex	6/21/2013	**78**	4/30/2013	**74**	5/5/2013	**73**	5/4/2013	**73**
Paul Meyer	7/3/2013	**87**	5/4/2013	**80**	5/25/2013	**76**	6/21/2013	**75**
Walter Johnson	7/3/2013	**87**	5/4/2013	**80**	5/25/2013	**75**	7/19/2013	**74**
Palo Verde	7/3/2013	**83**	5/4/2013	**82**	5/25/2013	**76**	7/19/2013	**74**
Joe Neal	7/3/2013	**81**	6/21/2013	**77**	5/4/2013	**77**	7/20/2013	**76**
Winterwood	5/4/2013	**76**	6/21/2013	**75**	5/25/2013	**73**	5/21/2013	**71**
Jerome Mack	5/4/2013	**74**	5/25/2013	**73**	6/21/2013	**72**	5/21/2013	**69**
Boulder City	6/21/2013	**74**	5/22/2013	**72**	5/21/2013	**72**	6/22/2013	**71**
Jean	5/4/2013	**84**	5/21/2013	**78**	5/25/2013	**76**	6/21/2013	**75**
JD Smith	6/21/2013	**76**	5/25/2013	**74**	5/4/2013	**74**	6/5/2013	**72**

Ozone concentrations recorded during the wildfire event were compared to temporally adjusted air quality levels for the previous three years (2010-2012). A four-year historical analysis was considered reasonable in that attainment/non-attainment classifications are based on a three-year average; ozone concentrations before 2010 would not reflect emission control programs implemented recently.

The technical analyses provided in this document, combined with documentation on the location and extent of the wildfire and laboratory analysis of $PM_{2.5}$ samples showing high concentrations of wildfire markers on May 4, 2013, demonstrate that elevated concentrations of ozone on this date are exceptional relative to historical fluctuations and were caused by wildfire impacts.

Figures 3-22 through 3-27 depict four years of MDA8 ozone data from five ozone monitoring sites in Clark County, and show that concentrations on May 4 reflect an exceptional event.

Ozone concentrations were exceptionally high in May 2012, compared with other years. Some of the high values were due to regional or international transport, such as ozone transport from Asia in the spring.

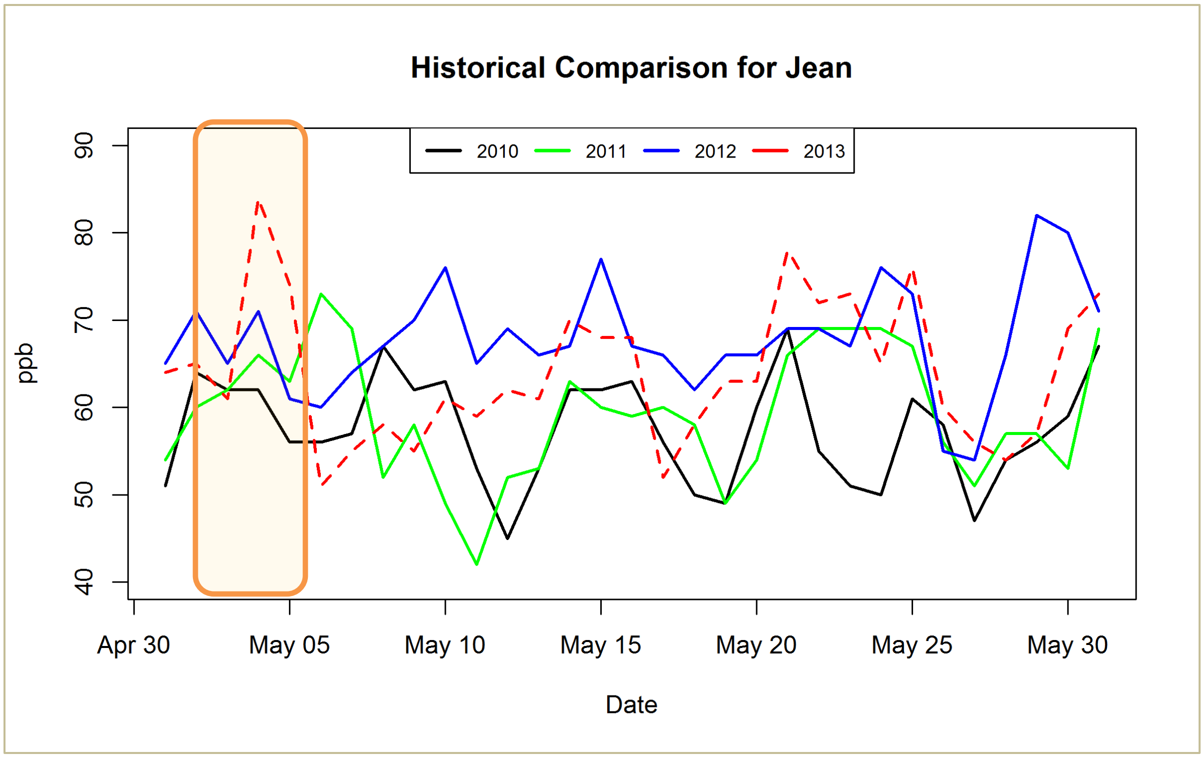


Figure 3-22. Four-year comparison for Jean.

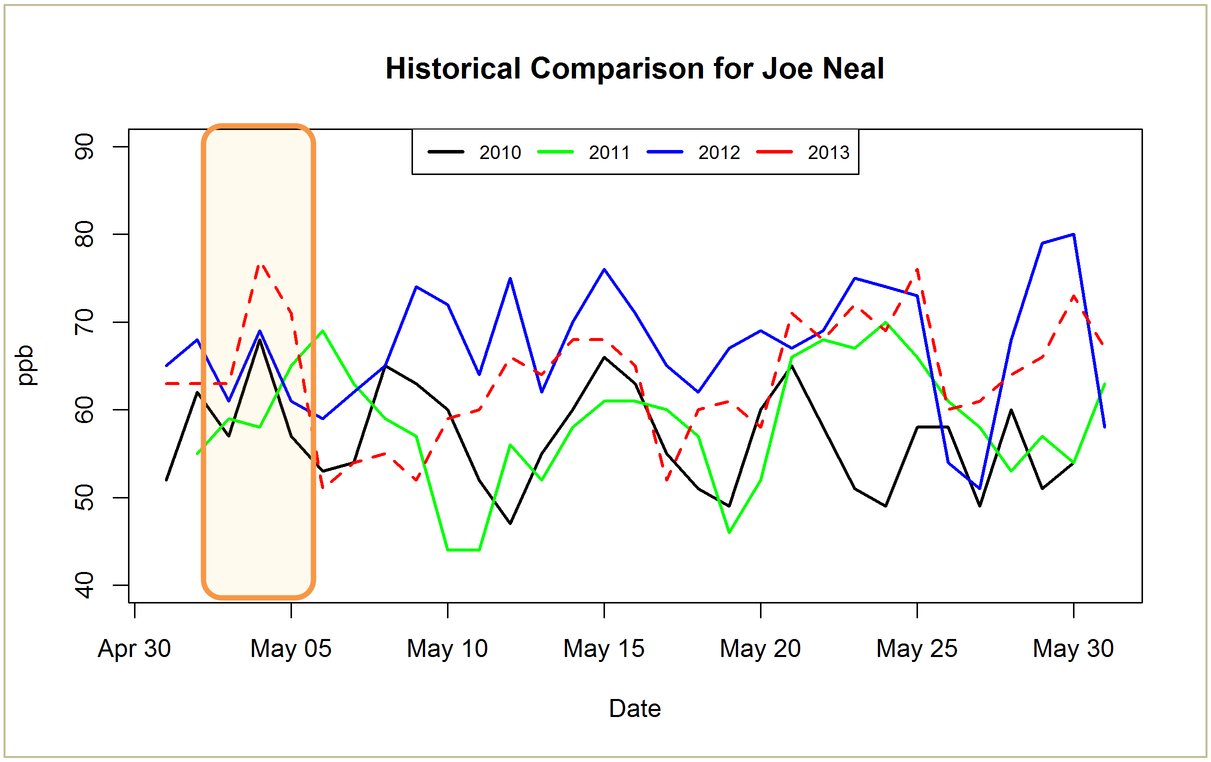


Figure 3-23. Four-year comparison for Joe Neal.

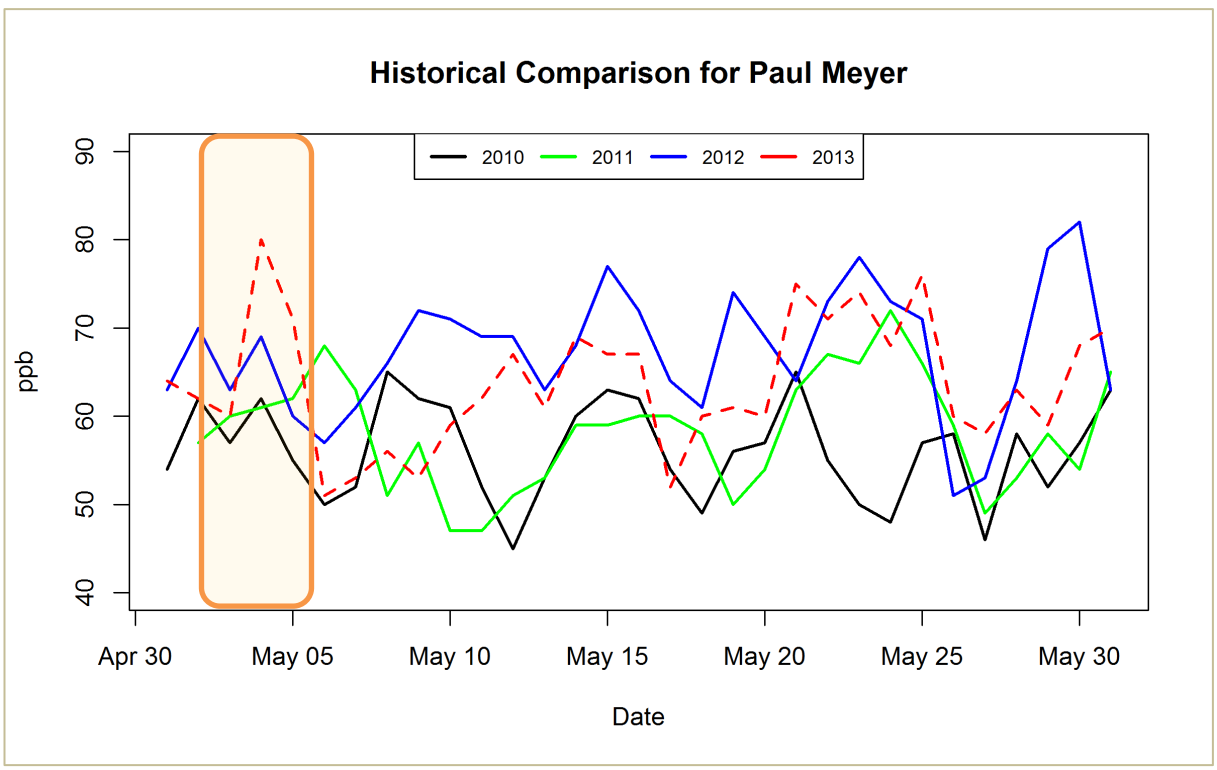


Figure 3-24. Four-year comparison for Paul Meyer.

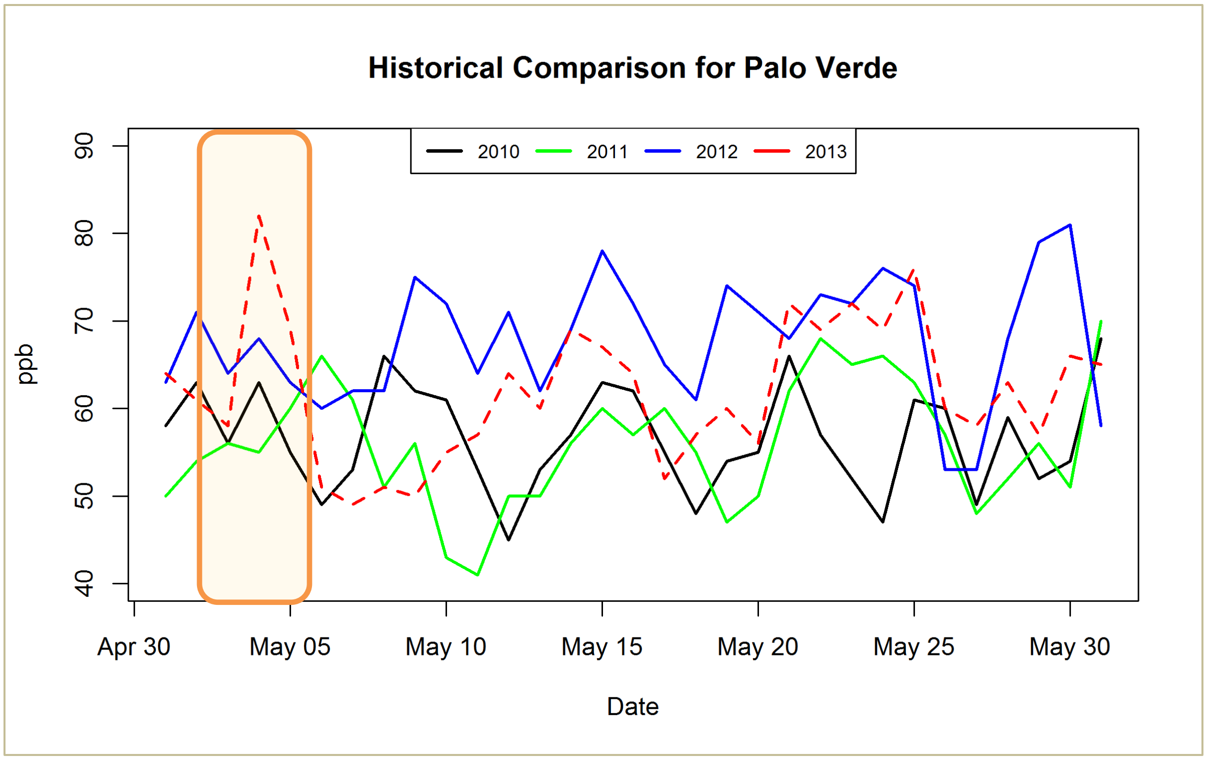


Figure 3-25. Four-year comparison for Palo Verde.

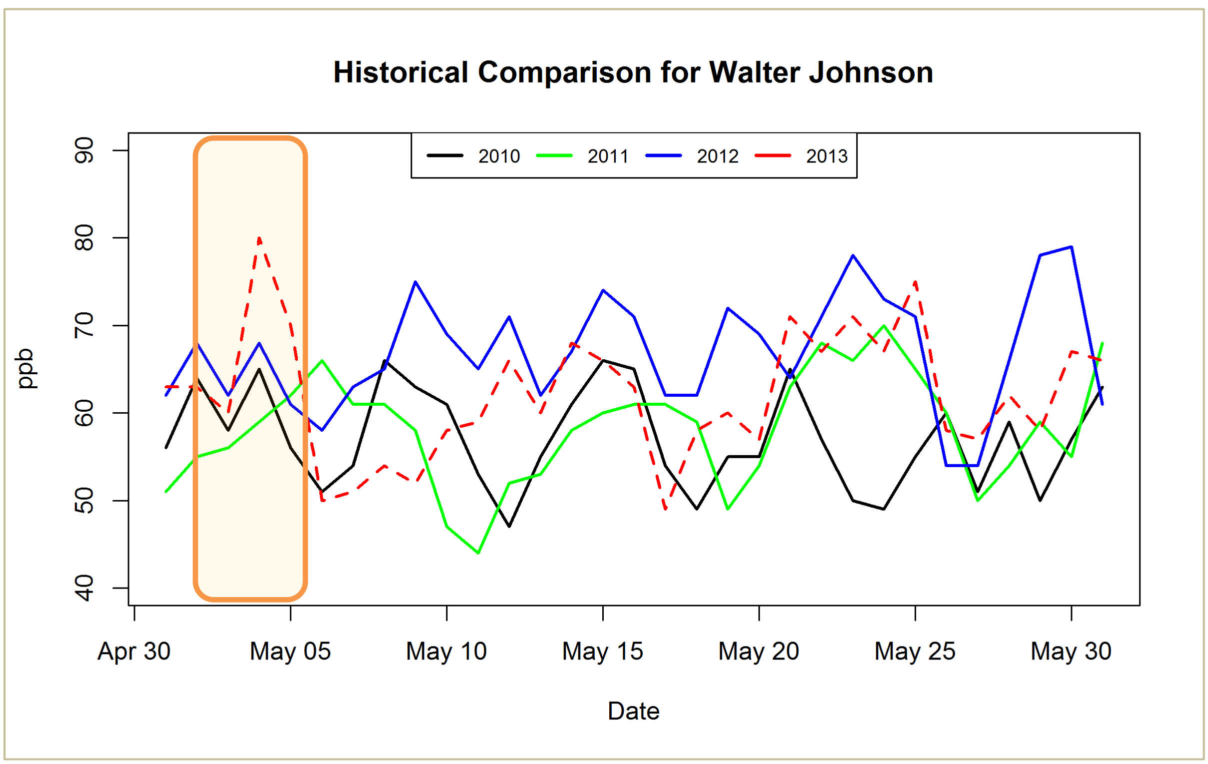


Figure 3-26. Four-year comparison for Walter Johnson.

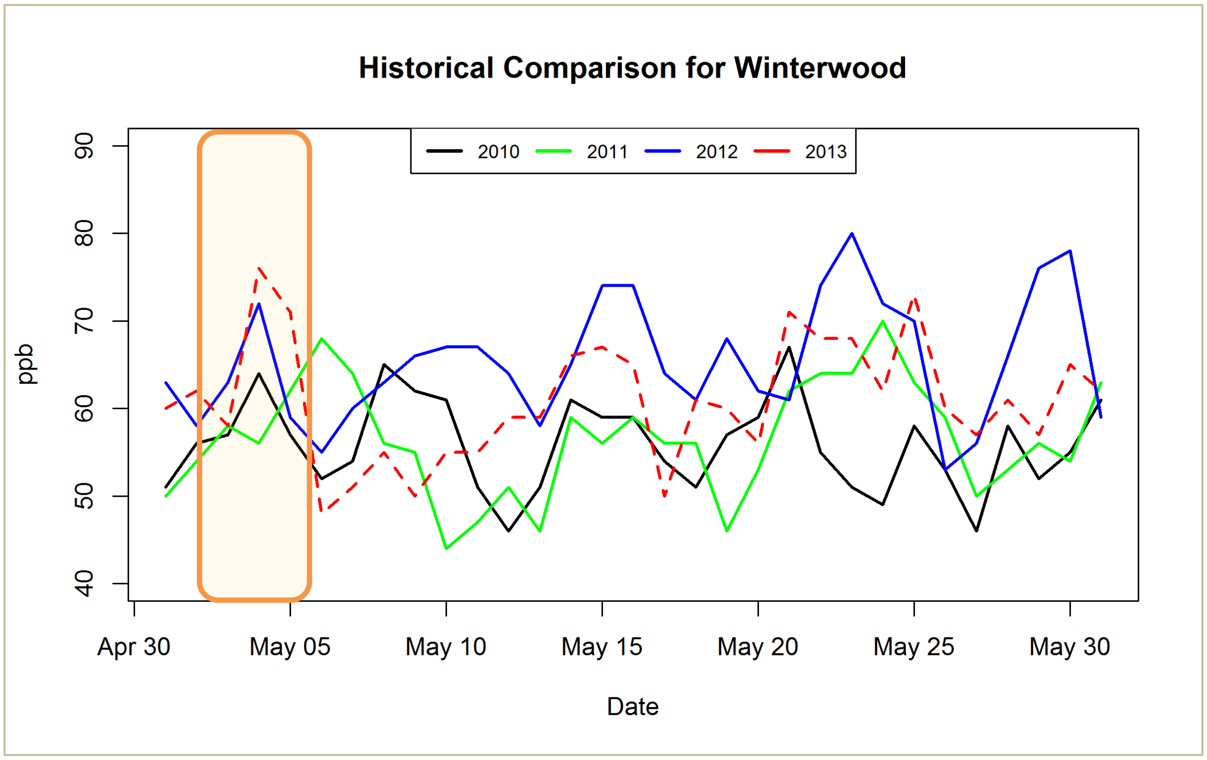


Figure 3-27. Four-year comparison for Winterwood.

For a statistical perspective, average MDA8 ozone concentrations were calculated for all days in May over the three-year period of 2010–2012. The data was plotted against the MDA8 concentrations for May 2013 (Figure 3-28). The MDA8 values for May 4 were much higher than the average of the three previous years.

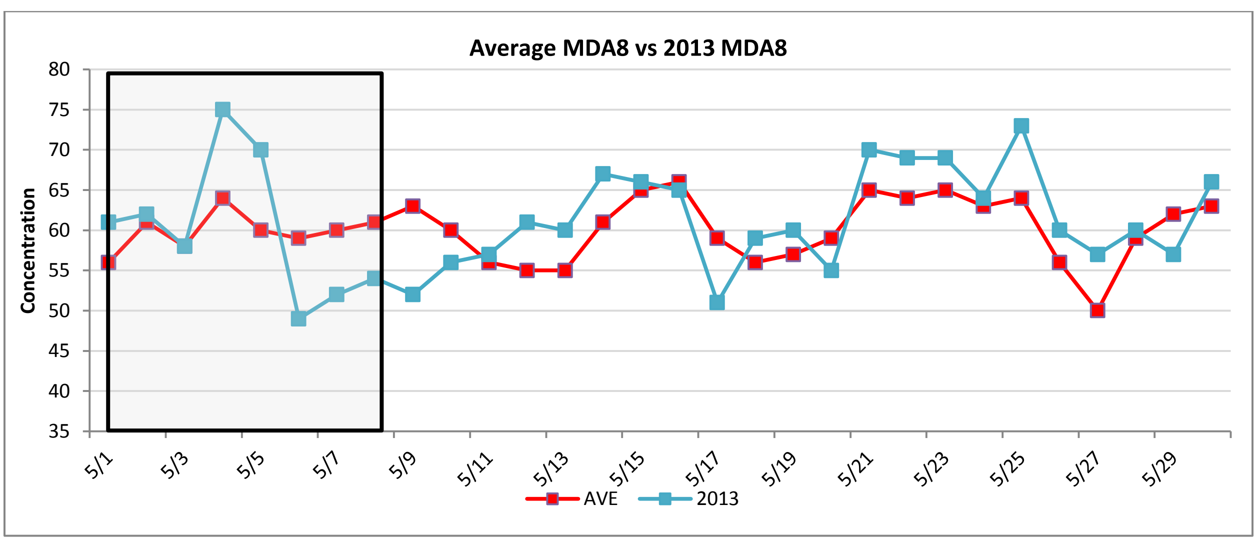


Figure 3-28. Three-year average vs. 2013.

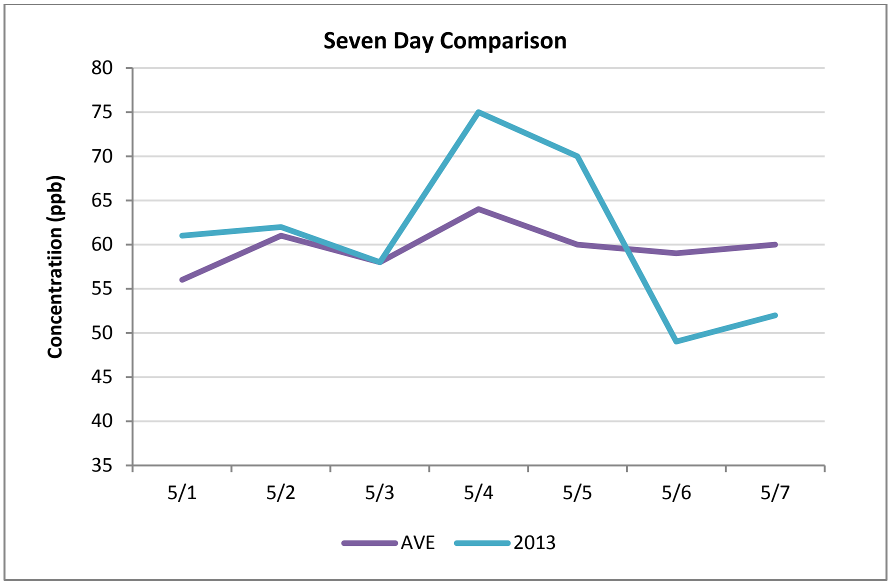


Figure 3-29. Seven-day period.

During the seven-day period depicted in Figure 3-29, concentrations on May 4 are 10 ppb higher than the average for that day during 2010-2012.

The following figures (3-30 through 3-33) show the AQI values for ozone, $PM_{2.5}$, and carbon monoxide from May 1 to May 7 of each year during a four-year period. As noted in previous sections, some years were impacted by significant regional transport; however, ozone, $PM_{2.5}$, and carbon monoxide never reached the AQI values they reached in 2013. The data show that concentrations for the event on May 4 were exceptionally high.

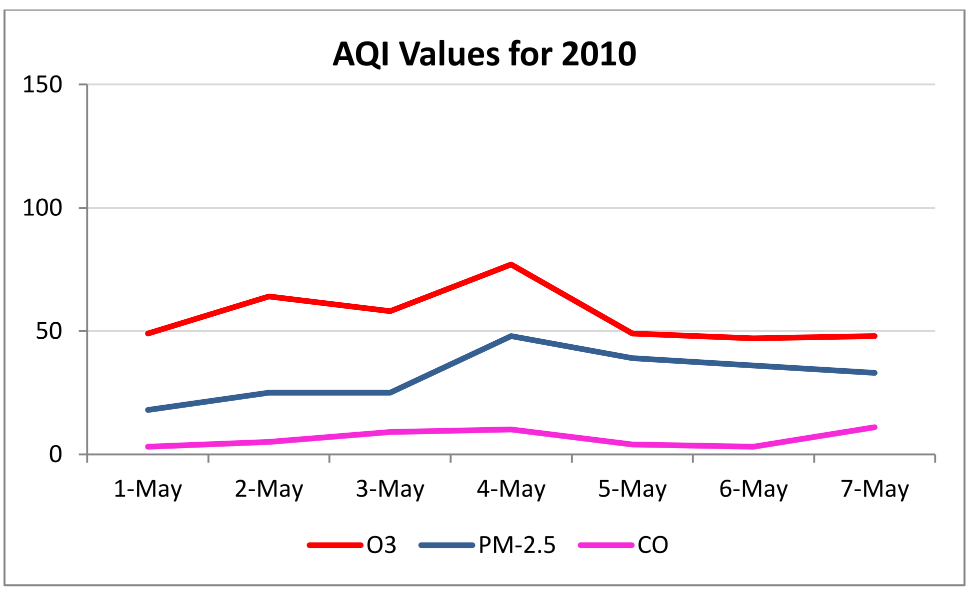


Figure 3-30. O_3, CO, and $PM_{2.5}$ concentrations in 2010.

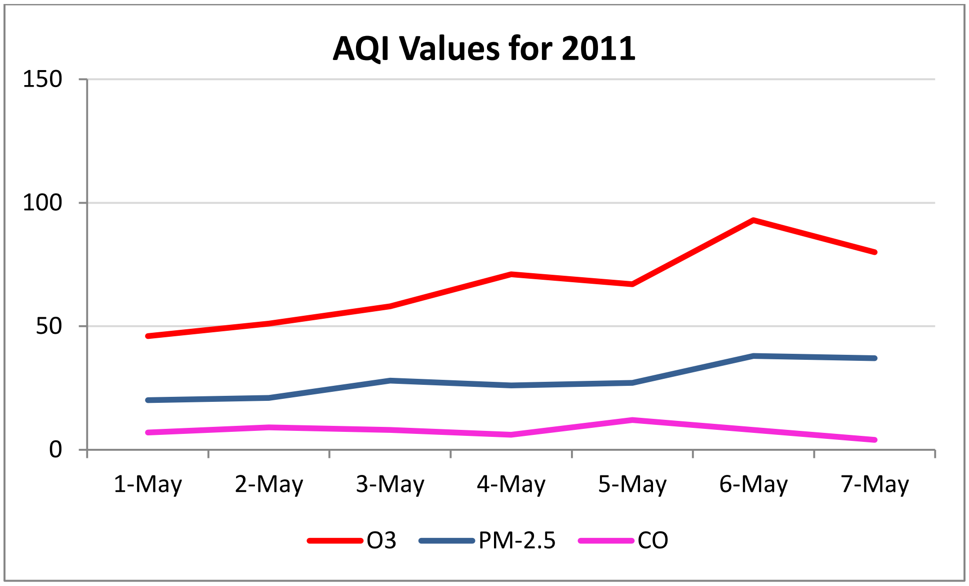


Figure 3-31. O_3, CO, and $PM_{2.5}$ concentrations in 2011.

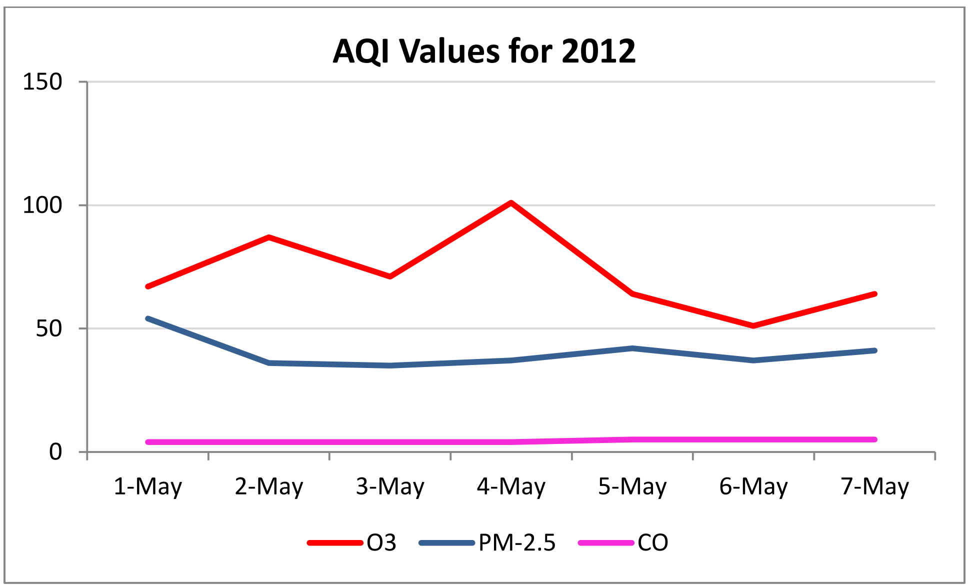


Figure 3-32. O_3, CO, and $PM_{2.5}$ concentrations in 2012.

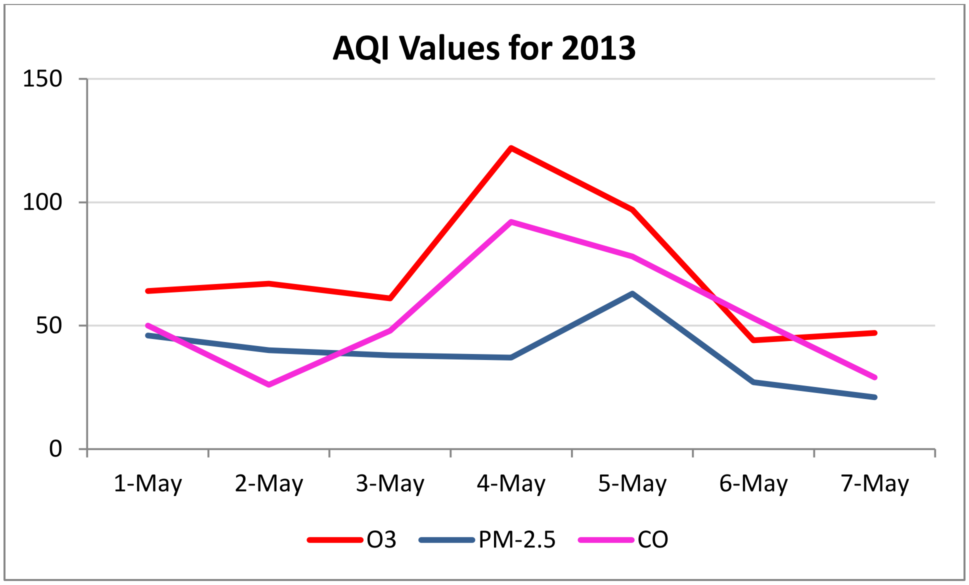


Figure 3-33. O_3, CO, and $PM_{2.5}$ concentrations in 2013.

4.0 THE "BUT FOR" ARGUMENT

4.1 METEOROLOGICAL PARAMETERS AND VISIBILITY CAMERAS

Meteorology is an important variable affecting air quality. Wind patterns maintained smoke plume impacts in southern Nevada during the wildfire episode, and weather data in Figure 4-1 show a remarkably consistent weather pattern before and after the exceptional event. Local anthropogenic emissions of ozone precursor pollutants did not exceed normal weekday or weekend levels. The difference during this period is the accumulation of the wildfire smoke plume, exacerbating ozone concentrations in Clark County.

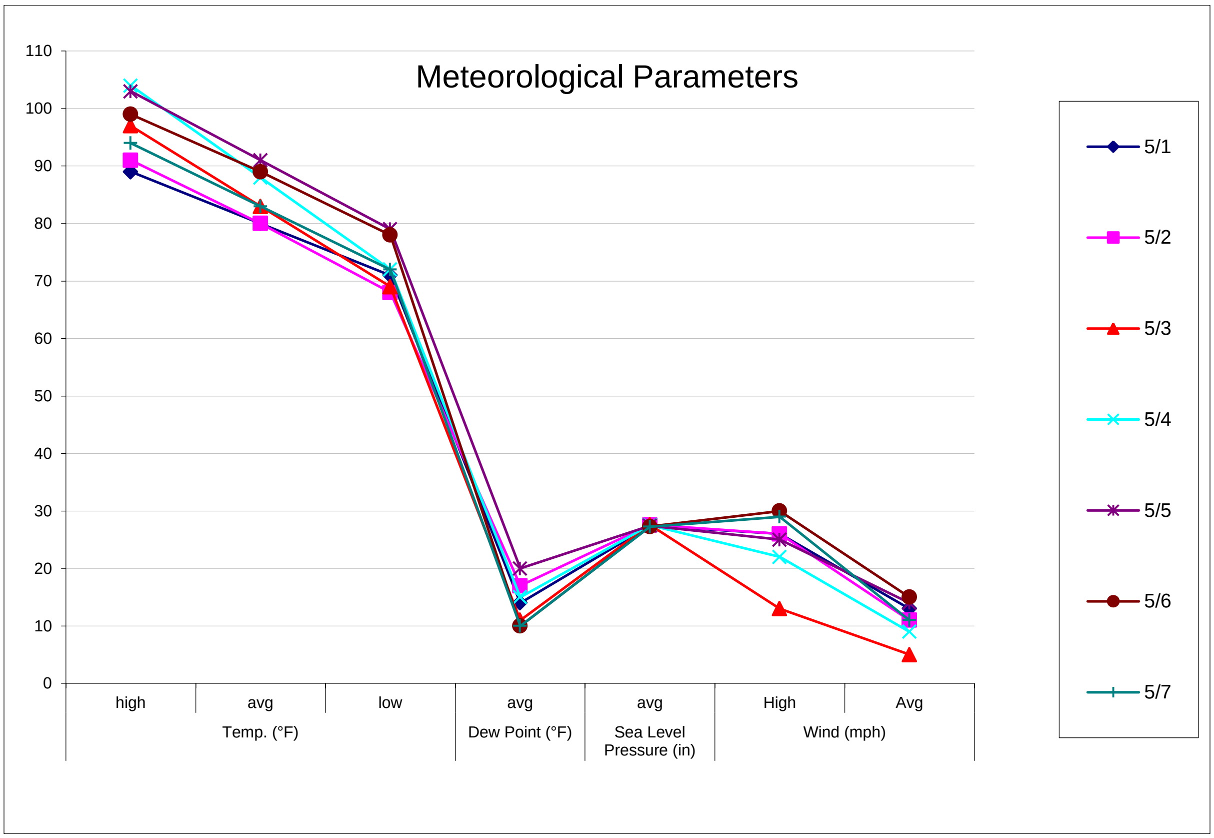


Figure 4-1. Weather data for May 1, 2013, through May 7, 2013.

Documentation provided in previous sections shows that the ozone exceedances on May 4, 2013, would not have occurred but for the fire event in Southern California. The 24-hour forward trajectory in Figure 4-2 shows the path the smoke plume took starting May 3, ending in Clark County on May 4.

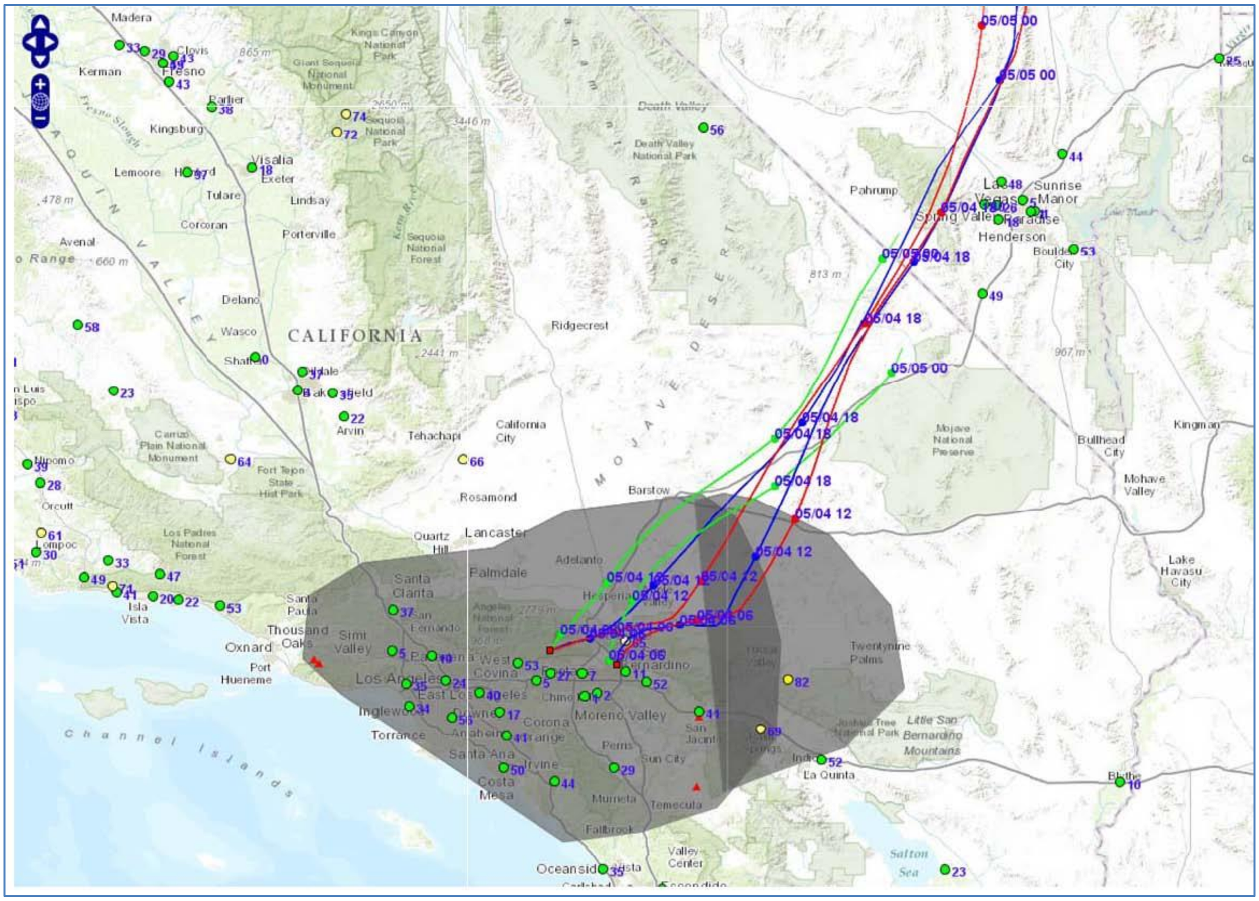


Figure 4-2. Forward trajectory from Springs Fire area.

Visibility cameras at the North Las Vegas Airport capture pictures of the downtown area every 15 minutes. Figure 4-3 shows a picture taken on a non-fire day (May 14) at 18:00. Landmarks such as the Desert Hills and the Potosi Mountain are clearly visible.

The pictures in Figures 4-4 and 4-5 were taken on the afternoon of May 4. The landmarks are not as visible as on a non-fire day. These pictures show the impact of the smoke plume from the fire in Southern California.

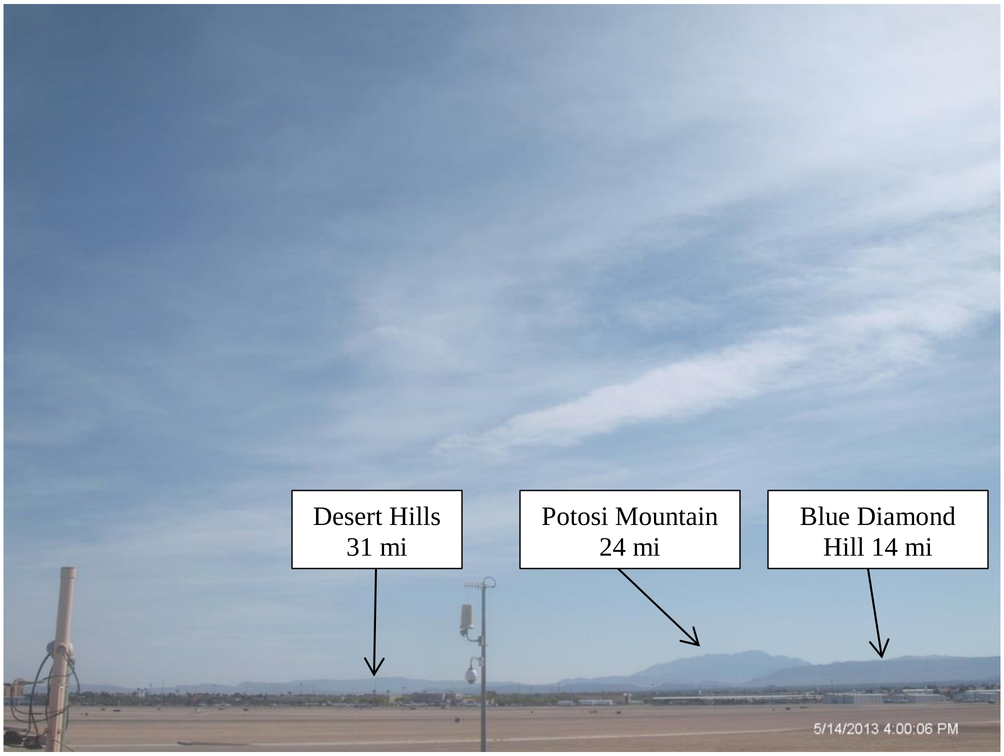


Figure 4-3. Visibility on non-fire day.

Figure 4-4. Visibility on May 4 at 16:00.

Figure 4-5. Visibility on May 4 at 18:00.

4.2 OZONE CONCENTRATION CALCULATIONS

4.2.1 Average Concentrations

In this method, the average daily ozone concentration is calculated for each monitoring site, excluding May 4, for the period of May 2 to May 6. This calculated average concentration is a reasonable surrogate for what would have occurred on May 4 given consistent weather patterns and normal anthropogenic local emissions, but no smoke impacts. Table 4-1 provides the average calculated concentration for May 4. Under this approach, average ozone concentrations for the exceptional event days vary from 55–62 ppb throughout the monitoring network.

Table 4-1. Calculated Averages for May 4.

Date	AP	MS	PM	WJ	PV	JO	WW	JM	BC	JN	JD
2-May	65	57	62	63	61	63	62	61	62	65	62
3-May	59	50	60	60	58	63	58	57	57	61	61
4-May	62	55	61	60	59	62	59	58	60	62	60
5-May	73	65	71	70	69	71	71	69	71	74	70
6-May	52	49	51	50	51	51	48	46	50	51	50

4.2.2 Interpolation

Interpolation is a method of constructing new data points within the range of a set of known data points. In this application it is assumed that the data points for May 4 were missing and linear interpolation was used to estimate their values. As shown in Table 4-2, this method yields a minimum concentration of 58 ppb and a maximum concentration of 68 ppb.

Table 4-2. Interpolated Values.

Date	AP	MS	PM	WJ	PV	JO	WW	JM	BC	JN	JD
3-May	59	50	60	60	58	63	58	57	57	61	61
4-May	66	58	66	65	64	67	65	63	64	68	66
5-May	73	65	71	70	69	71	71	69	71	74	70

4.2.3 Regression Model

The third method is the use of a statistical regression model to predict ozone levels during the days of the exceptional event. An EPA statistical model was used as the initial framework for a generalized additive model, in which the sum of the functions of various predictor variables is used to predict daily maximum 8-hour ozone concentrations. The model does not assume that peak ozone is a linear function of each predictor, but rather uses natural splines to model the functional dependence of ozone on predictor variables other than “day of week” and “year.” The original EPA model was modified through an iterative process to reflect local conditions in Clark County.

The EPA’s Omnibus Meteorological Data Set and daily peak 8-hour ozone of local and upwind areas of the Las Vegas Valley for five summer months during 2004-2008 without suspected wildfire days were used to develop a statistical model to identify wildfire events and study their relationships with high ozone episodes.

In general, trajectories should not be interpreted as accurate tracks of air parcels entering the specific area; however, patterns that emerge when analyzing a relatively large number of trajectories should provide a good indication of potential transport due to a prevailing large-scale flow regime. Using the back-trajectories in the Las Vegas Valley with the cluster analysis of the HYSPLIT model, seven clusters were calculated. A statistical model was then developed for each cluster by using polynomial regression equations with meteorological predictors and observed peak ozone mixing ratios. For a specific date, the predicted peak 8-hour ozone mixing ratio is calculated based on its predictors and assigned cluster.

The application of the Statistical Model for the May 4 fire event

By carefully examining the backward trajectory of May 4 and the mean backward trajectory of each cluster, the cluster 2 is selected for the May 4 fire event. Table 4-3 lists the parameters used in the model for cluster 2. Table 4-4 shows the results of the model, the wildfire could have contributed 10 ppb to the ozone concentration.

Table 4-3. Regression Model Parameters.

Previous-Day peak 8 Hour O_3 in Clark County
Previous-Day 8 Hour O_3 in Northern NV
Previous-Day 8 Hour O_3 in Los Angeles Area
Maximum Surface Temperature in Clark County
Average Morning (7-10 am LST) Wind Speed in Clark County
Average Afternoon (1-4 pm LST) Wind Speed in Clark County
Morning (~1200 UTC) Temperature at 850 mb - Surface Temperature
Maximum Mixing Height (4 am-4 pm LST)

Table 4-4. Regression Model Results.

Date	Peak 8-hour O_3 (ppb)	Predicted Peak 8-hour O_3 (ppb)[1]	Predicted Wildfire Effect (ppb)
5/4/2013	84.9	74.57	10.33

4.3 SATELLITE IMAGERY

4.3.1 Aerosol Optical Depth (AOD) and Aerosol Optical Thickness (AOT)[2]

Optical measurements of light extinction can be used to represent aerosol content in the entire column of the atmosphere. The optical depth expresses the quantity of light removed from a beam by scattering or absorption during its path through a medium (AOD is a unitless quantity). "Aerosol Optical Thickness" is the degree to which aerosols prevent the transmission of light by absorption or scattering of light.

Sample AOD values		Equivalent $PM_{2.5}$ values
0.02	very clean isolated areas	~ 1 μm^{-3}
0.2	fairly clean urban area	~ 12 μm^{-3}
0.4	somewhat polluted urban area	~ 24 μm^{-3}
0.6	fairly polluted area	~ 36 μm^{-3}
1.5	heavy biomass burning or dust event	~ 90 μm^{-3}

Table 4-5. AOD Values.

The higher the AOD value, the more polluted the area. Figure 4-6 shows the AOD for May 4. This AOD value for the Las Vegas area is between 0.293 and 0.40, which implies a fairly polluted area.

[2] http://disc.sci.gsfc.nasa.gov/giovanni/

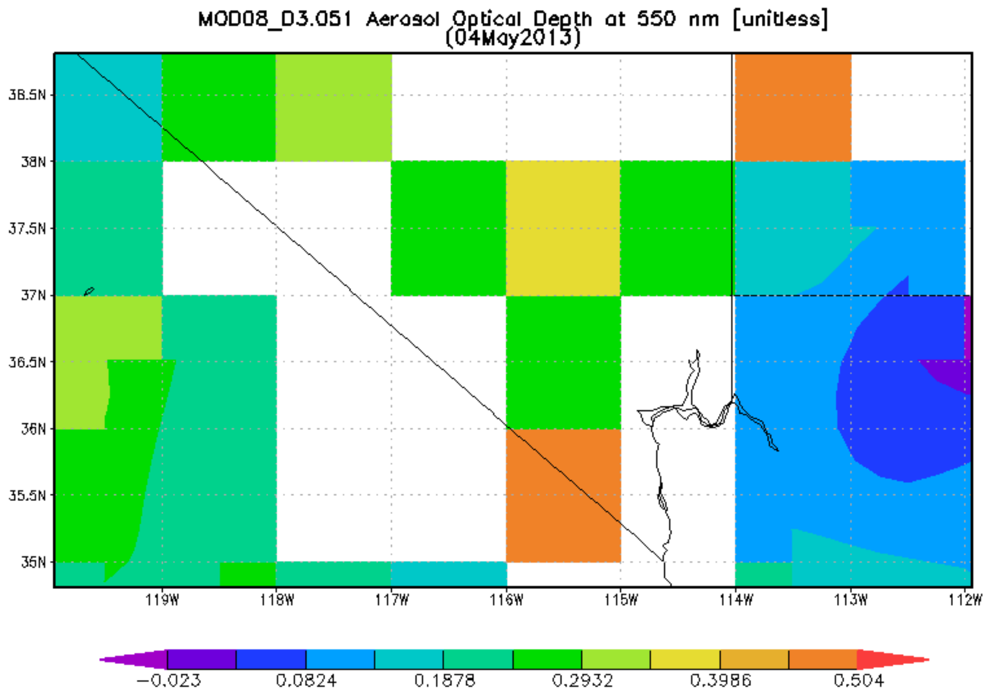


Figure 4-6. AOD for May 4.

4.3.2 UV Aerosol Index

The UV Aerosol Index represents detection of uv-absorbing aerosols such as dust and soot. Positive values for an Aerosol Index generally represent absorbing aerosols (dust and smoke) while small or negative values represent nonabsorbing aerosols. Figure 4-7 shows the UV Aerosol Index for May 4 for the Clark County area. The indexes show that there is a great amount of dust and smoke in the area.

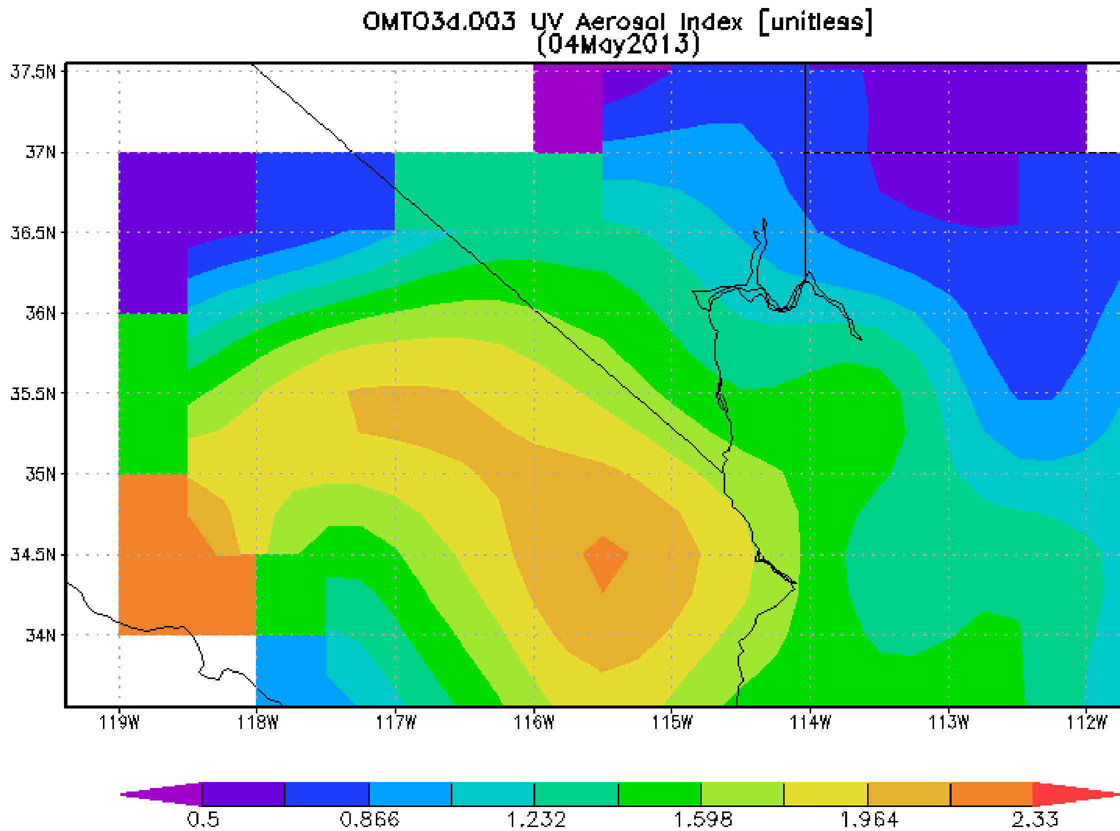


Figure 4-7. The UV Aerosol Index for May 4.

4.3.3 AERONET Data

The AERONET (AErosol RObotic NETwork) program is a federation of ground-based remote sensing aerosol networks established by NASA and other institutions. The data shows the AOT for a daily or monthly timeframe. The three AERONET sites in Southern California and southern Nevada (see Figure 4-8) were severely impacted by smoke plumes from the fire. The $PM_{2.5}$ concentrations at these 3 stations (Table Mountain, Frenchman Flat and Railroad Valley) were some of the highest for the month of May.

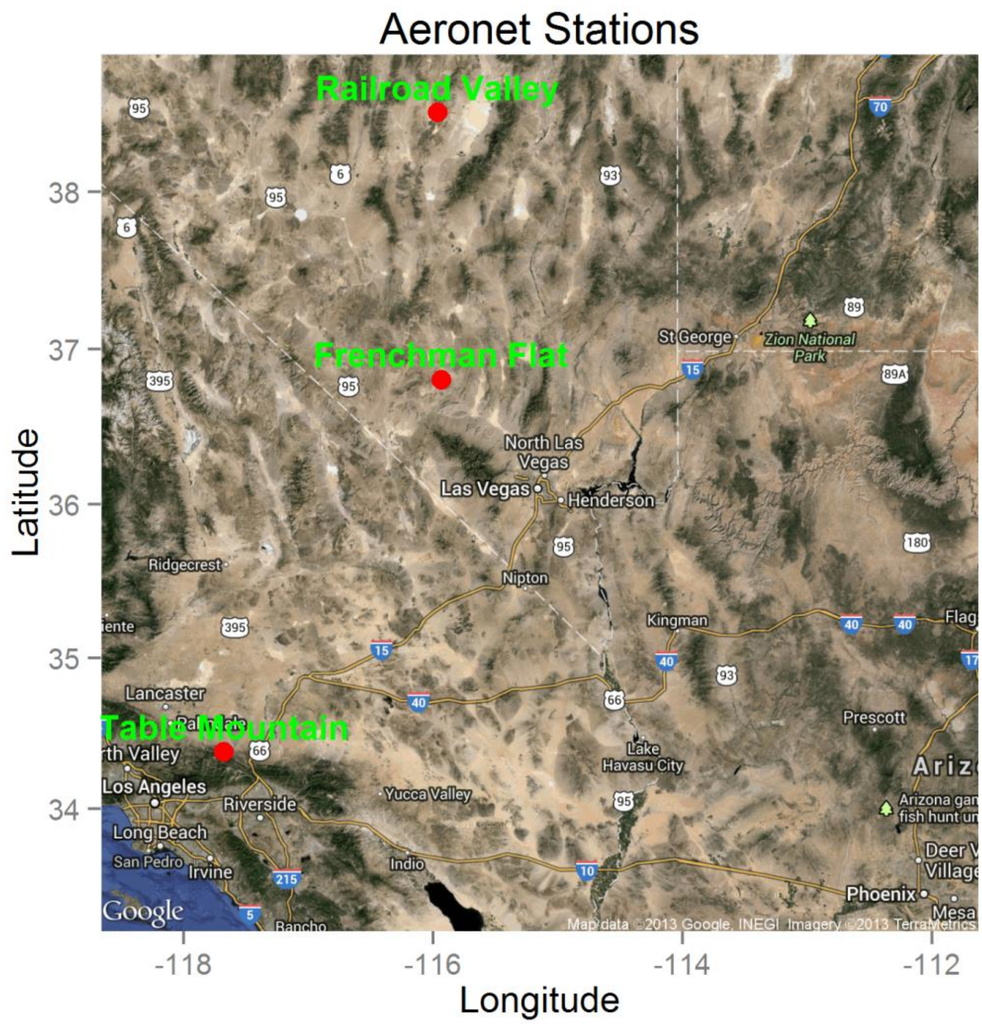


Figure 4-8. Location of Aeronet stations.

(http://aeronet.gsfc.nasa.gov/)

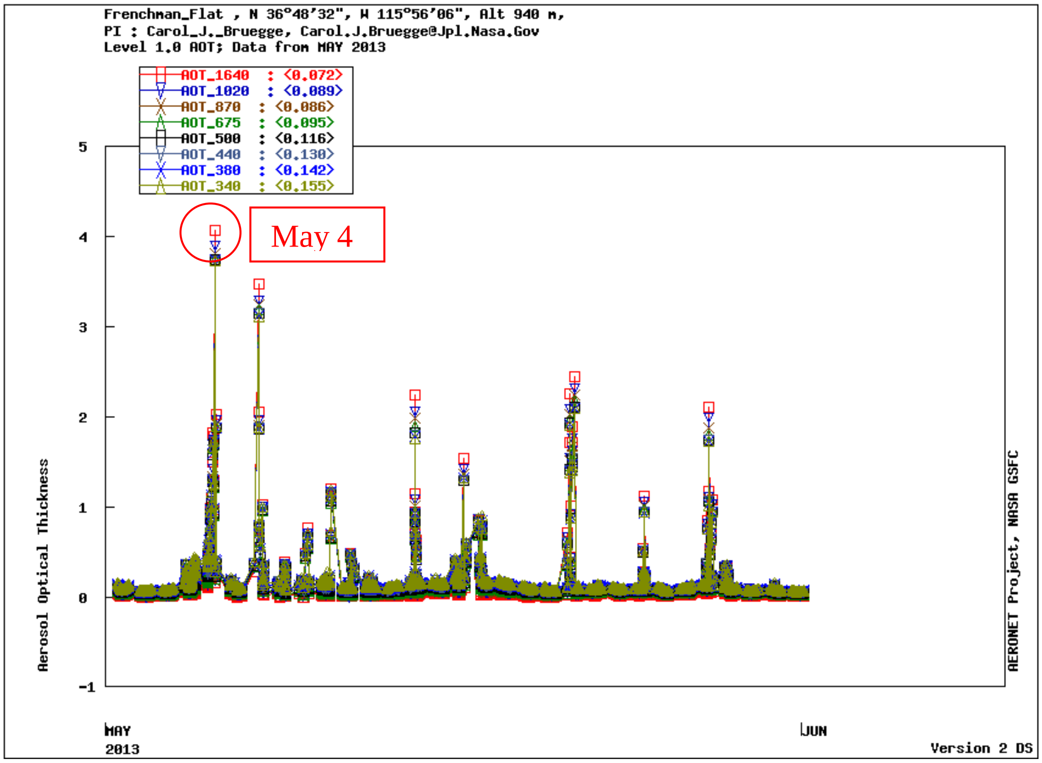


Figure 4-9. AOT for Frenchman Flat.

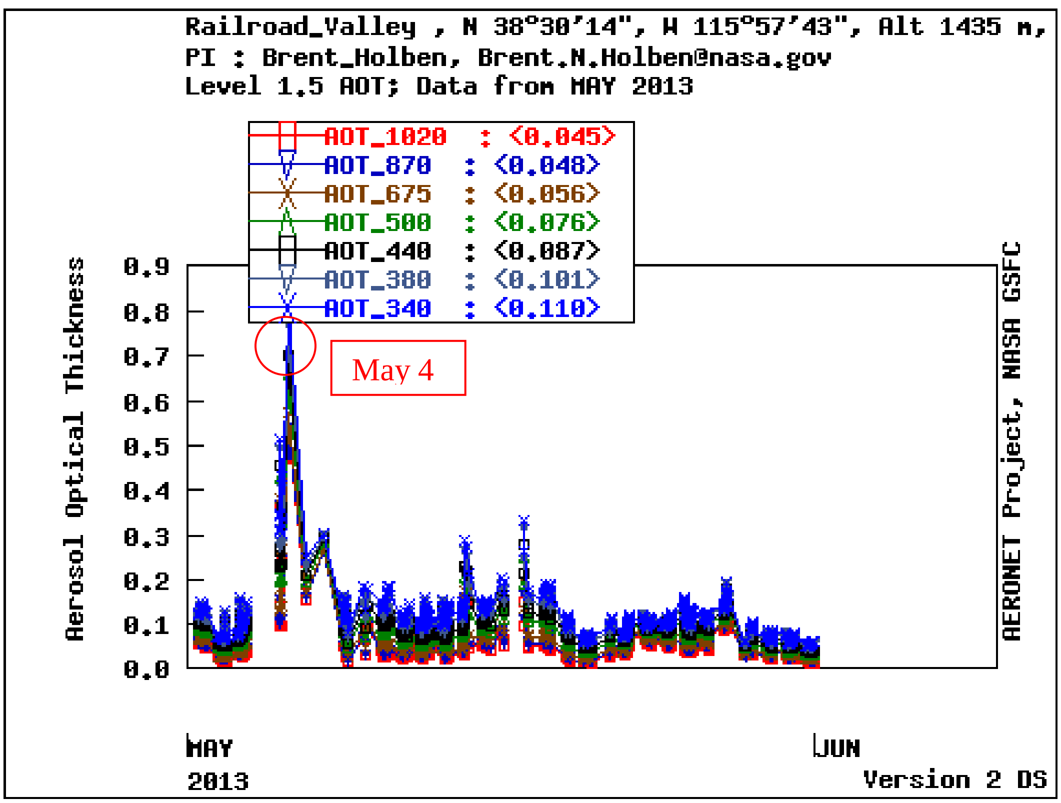


Figure 4-10. AOT for Railroad Valley.

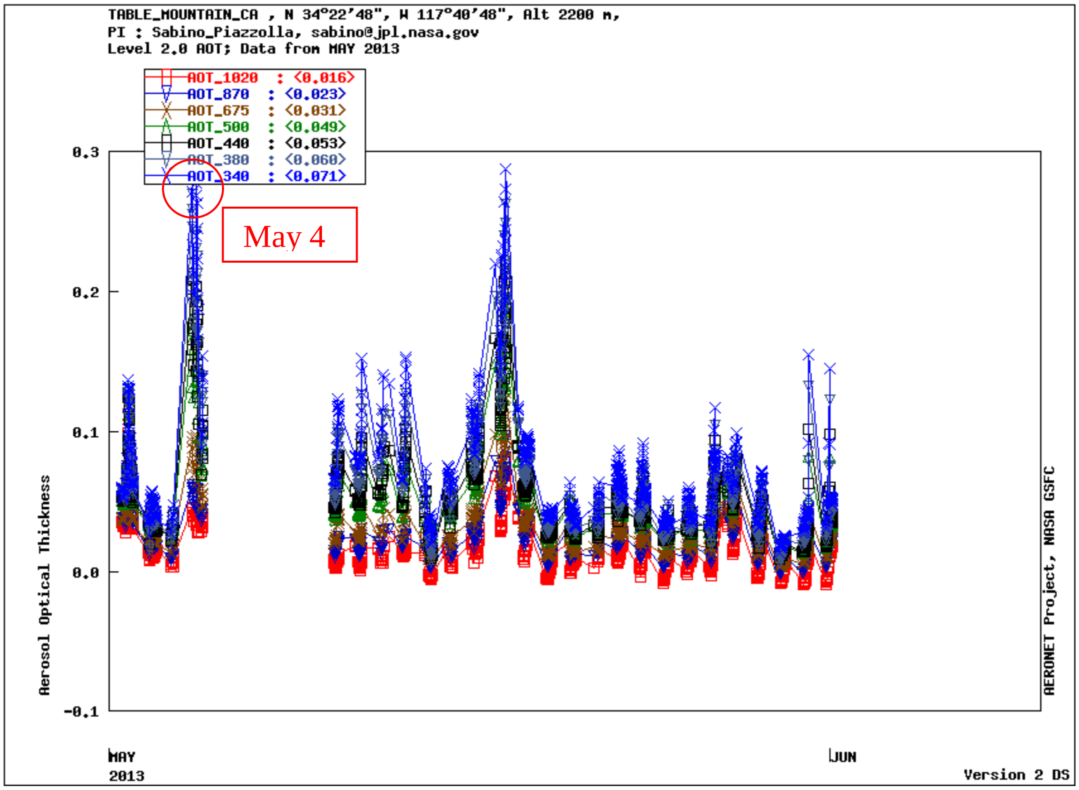


Figure 4-11. AOT for Table Mountain.

4.3.4 Site-specific Time-series and Correlations of AOD and Surface $PM_{2.5}$

The site-specific MODIS/GASP (GOES Aerosol/Smoke Product) AOD/$PM_{2.5}$ mass concentration plot details the temporal behavior of measurements made at a specific monitoring site location. Correlations between the MODIS/GASP AOD observations and $PM_{2.5}$ measurements are also reported. The left vertical axis is mass concentration of $PM_{2.5}$ (scale 0-100) and the right vertical axis is MODIS/GASP aerosol optical depth (scale 0.0-1.6). The graphs in Figure 4-12 and 4-13 show the data for Jean and JD Smith. Both graphs indicate a high concentration of $PM_{2.5}$ and a high AOD on May 4. This data proves that smoke was impacting the monitoring sites.

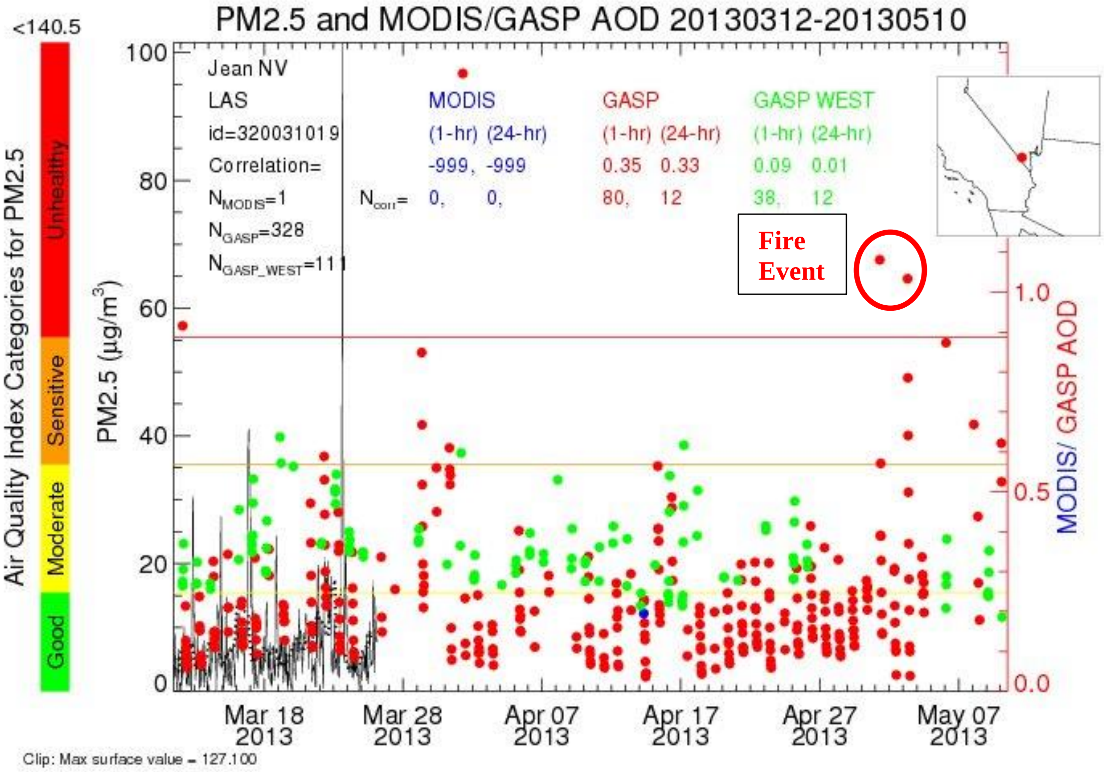


Figure 4-12. Data for Jean.

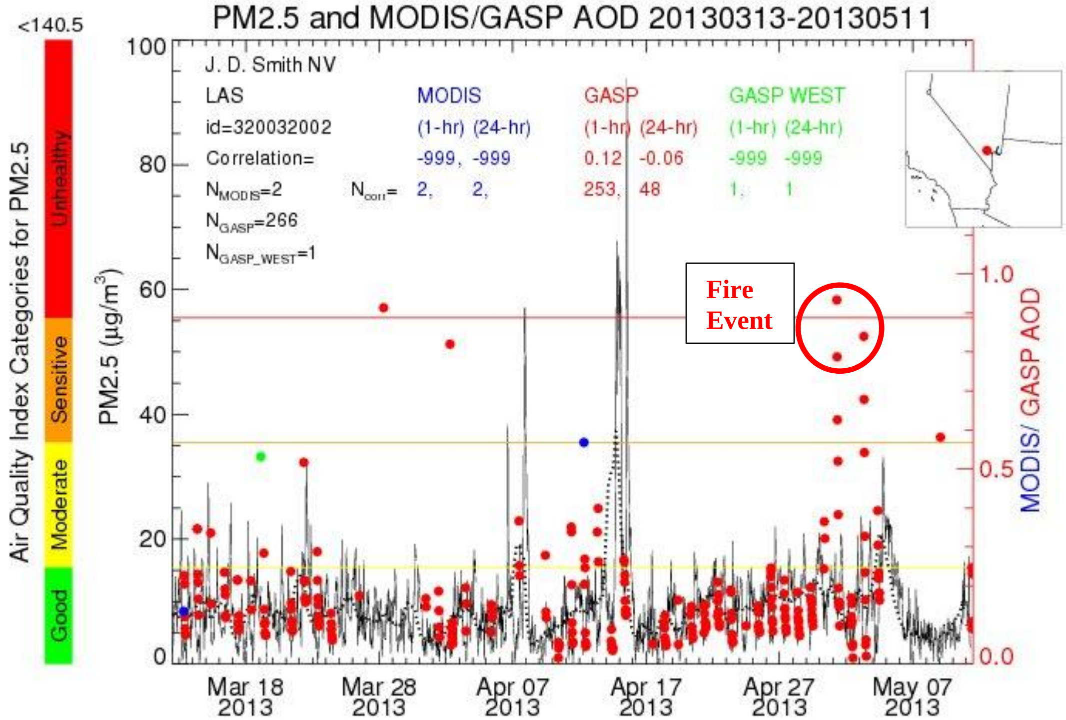


Figure 4-13. Data for JD Smith.

5.0 PUBLIC OUTREACH AND EDUCATION IN RESPONSE TO THE EXCEPTIONAL EVENT

DAQ has in place an education program to protect the public from adverse health problems associated with elevated pollutant levels. Its goals are to inform and educate the public on topics that include:

- How they can avoid exposure and minimize health impacts.
- How they can reduce their contributions to concentrations of the pollutant.
- What types of exceptional events may affect the area's air quality.
- When an exceptional event is imminent or occurring.

To meet these goals, DAQ conducts a comprehensive program that engages in local outreach events to provide information to the public. These include:

- Media press releases issued to the community as needed.
- School and youth outreach programs with classroom and youth group presentations, teacher training, and air quality information packets.
- Participation in community events (e.g., the Clark County Fair, Henderson Parade, Clark County Health and Wellness Fair).
- Training in air quality reporting for local weather anchors.
- Activities with city, county, and local environmental/health professionals to improve methods for reaching and educating the community.

DAQ has also developed a notification system to contact at-risk populations. These notification avenues include:

- The Clark County School District.
- The Southern Nevada Health District.
- The Clark County Parks and Recreation Department.
- Local municipalities comprised of the cities of Henderson, Las Vegas, North Las Vegas, and Boulder City.
- Local media (e.g., newspapers, radio, and television stations).
- Sensitive individuals (through a notification service).

6.0 CONCLUSIONS AND RECOMMENDATION

This demonstration makes a clear and compelling case by weight of evidence that the ozone exceedance on May 4, 2013, was due to the influences of the Springs Fire in Southern California. The demonstration also meets the requirements of the Exceptional Events Rule allowing the EPA to exclude ozone data for that day.

The Tables and Figures used in this report depict the relationships between ozone, $PM_{2.5}$, and carbon monoxide on May 4, as well as days prior to and after the event. Figure 4-1 demonstrates that temperature, humidity, and wind speeds had little influence on the ambient levels of ozone, $PM_{2.5}$, and carbon monoxide during the subject period. Figures 3-16 through 3-18 depicts a clear causal relationship between the ambient levels of ozone, $PM_{2.5}$ and levoglucosan during the event. A strong correlation between ozone, $PM_{2.5}$ and levoglucosan proves that the smoke plume reached ground level and greatly impacted the concentrations. The high AQI for ozone, $PM_{2.5}$, and carbon monoxide tracked nearly identically and were elevated proportionately on the wildfire smoke intrusion days.

In addition, this demonstration also analyzed the AQI values for ozone, $PM_{2.5}$, and carbon monoxide as outlined in Figure 3-19. Figures 3-4 through 3-13 show the variation in diurnal patterns between the non-fire days and the fire day. Section 3.3 shows the historical fluctuation for four years; ozone concentrations were very high in the beginning of May 2013 in comparison with the other years.

Back trajectories and wind data show that Clark County was impacted by the smoke plume. Additional satellite imagery also shows that southern Nevada was impacted by high levels of smoke and dust.

The demonstration contains information that Clark County took steps to protect the public health through release of a public advisory and cooperation with the local media.

Based on the information contained in this demonstration, EPA should exclude the ozone data for May 4, 2013, as an exceptional event in accordance with the EER.

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8.0 APPENDIX A – AIR ADVISORIES AND NEWS ARTICLES

DAQ air quality advisory for Ozone:

News Release

Office of Public Communications • (702) 455-3546 • FAX (702) 455-3558 • www.accessclarkcounty.com

Contact: Stacey Welling
Sr. Public Information Officer

Phone: (702) 455-3201
Cell: (702) 249-3823
E-mail: stac@co.clark.nv.us

For Immediate Release **Monday April 1, 2013**

Air Quality Advisory Issued for Ozone from April 1 through Sept. 30

Clark County Department of Air Quality officials are advising residents that weather conditions and levels of pollutants may trigger a build-up of ground-level ozone in Southern Nevada from April through September.

At this time, unhealthy levels of ozone pollution are not occurring. Air Quality officials will continue to monitor conditions and will post an alert on the forecast page of the department's website if unhealthy levels actually occur. A link to the forecast page is located at http://redrock.clarkcountynv.gov/forecast/.

Ozone is a gas that occurs naturally in the upper atmosphere and protects the earth from the sun's harmful ultraviolet rays. At ground level, ozone is a key ingredient of urban smog during the hottest months of the year in Clark County. Ground-level ozone can build up during the afternoon hours due to a combination of several factors, including strong sunlight, hot temperatures, and pollutants from automobiles and other sources such as transport and wildfires from Southern California and other areas. Unhealthy doses of ground-level ozone can reduce lung function and worsen respiratory illnesses such as asthma or bronchitis. Exposure to ozone also can induce coughing, wheezing and shortness of breath even in healthy people. When ozone levels are elevated, everyone should limit strenuous outdoor activity, especially people with respiratory diseases. Officials suggest these tips to help reduce the formation of ground-level ozone:

- Fill up your gas tank after sunset.
- Plan errands so they can be done in one trip
- Try not to spill gasoline when filling up, and don't top off your gas tank.
- Keep your car well maintained.
- Use mass transit or carpool.
- Don't idle your car engine unnecessarily.
- Walk or ride your bike whenever practical and safe.
- Drive an electric or hybrid vehicle, or low-emission scooter or motorcycle.
- Consider low-maintenance landscaping that uses less water and doesn't require the use of gas-powered lawn tools to maintain.
- Turn off lights and electronics when not in use. Less fuel burned at power plants means cleaner air.

Detailed air quality conditions are posted in the monitoring section of the Department of Air Quality's website. You can receive free text and e-mail advisories and air quality forecasts through the U.S. Environmental Protection Agency's EnviroFlash service at www.enviroflash.org.

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Springs Fire information from the CalFire website

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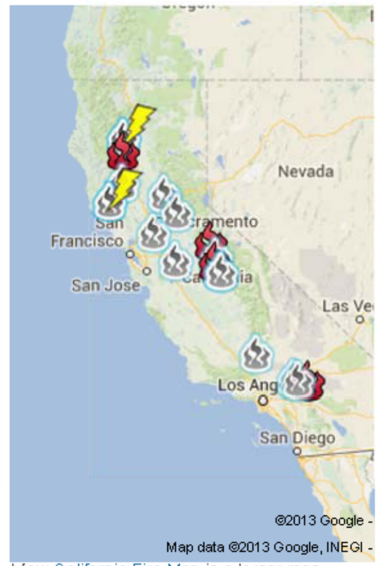
Incident Information

Last modified on May 11, 2013

SPRINGS FIRE

Springs Fire Incident Information:		
Last Updated:	May 11, 2013 6:30 am	FINAL
Date/Time Started:	May 2, 2013 7:01 am	
Administrative Unit:	Ventura County Fire/CAL FIRE	
County:	Ventura County	
Location:	Southbound Highway 101 at Camarillo Springs Road, Camarillo	
Acres Burned - Containment:	24,251 acres	
Estimated Containment	24,251 acres - 100% contained	
Structures Destroyed:	10 outbuildings have been destroyed 6 damaged commerical properties, and 6 damaged outbuildings.	
Evacuations:	All evacuations have been lifted.	
Injuries:	10	
Cause:	Under Investigation	
Cooperating Agencies:	Ventura County Fire Department, CAL FIRE, USFS, Ventura County Sheriff, National Park Service, California State Parks, CHP, Ventura County Animal Control, CalEMA, Department of Corrections and Rehabilitation, California Conservation Corps, Southern California Edison and Red Cross.	
Total Fire Personnel:	121 Firefighters	
Total Fire Engines:	5 Engines	
Total Fire crews:	6 Fire Crews	
Conditions:	Acreage has been reduced based upon more accurate mapping. Continue to mop up in areas very visible to public. Continue demobilization, fire damage inspections, and suppression repair.	

California Statewide Fire Map



View California Fire Map in a larger map

SPRINGS FIRE MORE INFO

- Springs Fire Information
- Incident Maps
- Photos
- News Releases
- Weather Information
- Telephone Numbers
- Special Notices
- Related Links

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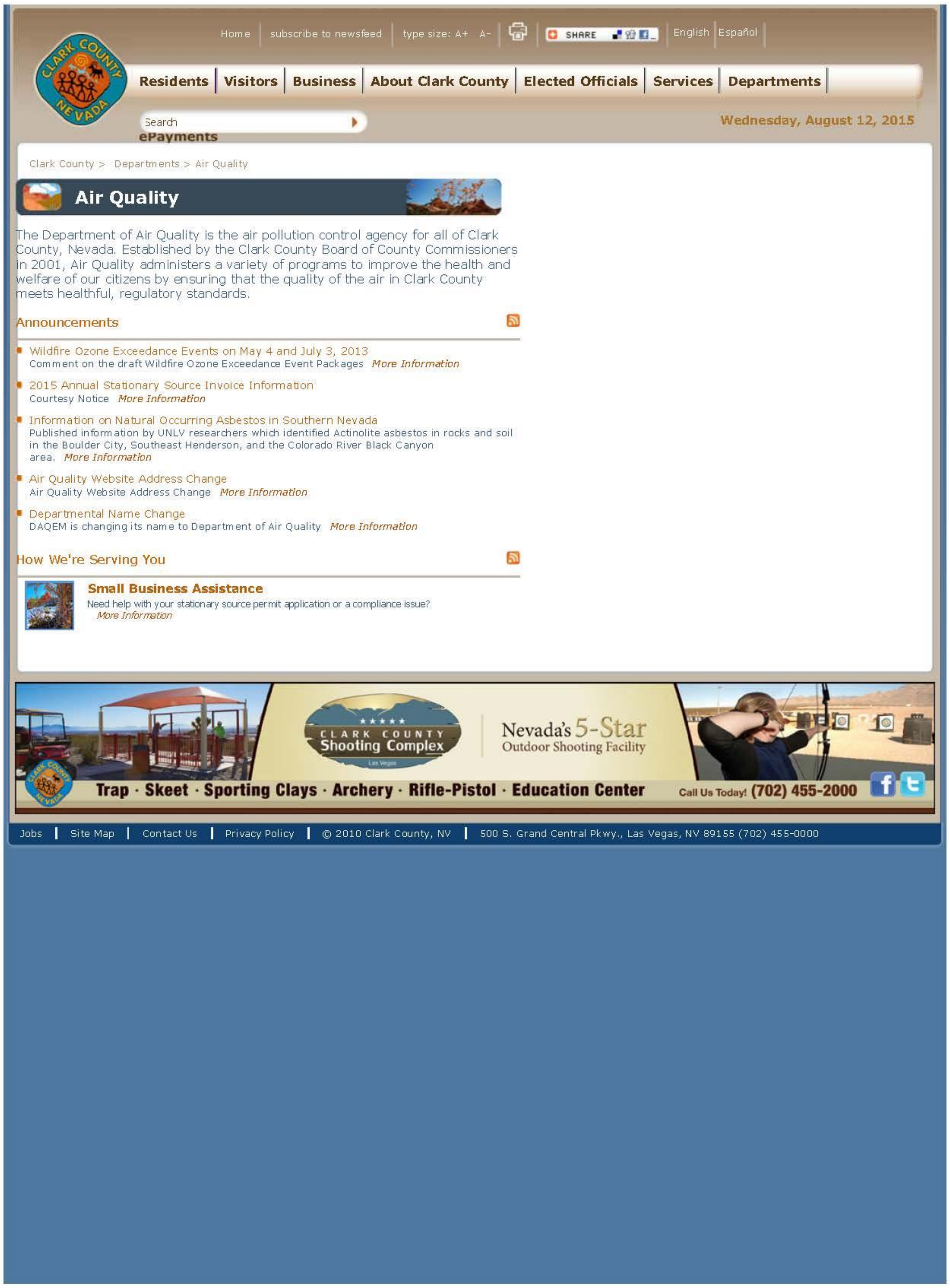
Figure 8-1. Smoke Plume near the Springs Fire.

9.0 PUBLIC REVIEW AND COMMENT PERIOD

9.1 DAQ WEB PAGE

DAQ Page 1 of 1



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Wednesday, August 12, 2015

Clark County > Departments > Air Quality

Air Quality

The Department of Air Quality is the air pollution control agency for all of Clark County, Nevada. Established by the Clark County Board of County Commissioners in 2001, Air Quality administers a variety of programs to improve the health and welfare of our citizens by ensuring that the quality of the air in Clark County meets healthful, regulatory standards.

Announcements

- Wildfire Ozone Exceedance Events on May 4 and July 3, 2013
  Comment on the draft Wildfire Ozone Exceedance Event Packages *More Information*
- 2015 Annual Stationary Source Invoice Information
  Courtesy Notice *More Information*
- Information on Natural Occurring Asbestos in Southern Nevada
  Published information by UNLV researchers which identified Actinolite asbestos in rocks and soil in the Boulder City, Southeast Henderson, and the Colorado River Black Canyon area. *More Information*
- Air Quality Website Address Change
  Air Quality Website Address Change *More Information*
- Departmental Name Change
  DAQEM is changing its name to Department of Air Quality *More Information*

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More Information

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http://www.clarkcountynv.gov/depts/airquality/pages/default.aspx 8/12/2015

Air Quality

Wildfire Ozone Exceptional Event Packages for May 4 and July 3, 2013

The Clark County Department of Air Quality (DAQ) developed two exceptional event documentation packages for exceedances of the Ozone National Ambient Air Quality Standard (NAAQS). On May 4, 2013, Clark County recorded exceedances of the ozone NAAQS across its air quality monitoring network due to smoke plume impacts from a wildfire in California. On July 3, 2013, exceedances of the ozone NAAQS were recorded due to smoke plume impacts from a wildfire in Clark County, NV. The exceptional event documents were written in accordance with the U. S. Environmental Protection Agency (EPA) Exceptional Event Rule, dated March 22, 2007, which defines exceptional events as "... events for which the normal planning and regulatory process established by the federal Clean Air Act (CAA) is not appropriate."

EPA's exceptional event rule and CAA sections 319(b)(3)(B) and 107(d)(3) grant authority to exclude air quality monitoring data from regulatory determinations related to exceedances or violations of the NAAQS, thus avoiding redesignation of an area to a nonattainment status if the agency adequately demonstrates that an exceptional event has caused an exceedance or violation of the NAAQS.

- The documents will undergo a 30-day public comment period commencing on Tuesday July 28, 2015 and ending on Wednesday August 26, 2015 at 5:00 p.m. The Draft documents may be downloaded at: Wildfire Ozone Exceedance Event of May 4, 2013 and Wildfire Ozone Exceedance Event of July 3, 2013

The documents are also available for inspection at the front counter of the DAQ office, located at 4701 W. Russell Road, Suite 200, Las Vegas, NV. 89118. DAQ is located on the second floor of the Clark County Building Department building.

Comments must be submitted in writing to the DAQ at the address above and to the attention of Jean-Paul Huys, Senior Planner. Mr. Huys can be reached at 455-1684. Comments can also be submitted via email to: huys@ClarkCountyNV.gov. All comments must be received by 5:00 pm Wednesday, August 26, 2015, the close of the 30-day comment period. Written comments will be retained and considered prior to the submittal of the Exceptional Event Packages to the EPA, Region 9, San Francisco, California.

9.2 PUBLIC COMMENT PERIOD

Public Notice:	DAQ webpage
Public Comment Period:	July 28, 2015 to August 26, 2015
Comments Received:	None