Characterizing Ozone Transport and Wild-fire Impacts on Clark County Air Quality during the 2011 Summer Season

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Executive Summary

The goal of this project was to validate air quality modeling for ozone, to characterize the role of ozone transport on air quality in Clark County and, in the instance of wildfires, to acquire a sufficient database for air quality analyses to support exceptional event demonstrations for ozone and $PM_{2.5}$. Six seasonal ozone analyzers were deployed to augment the permanent monitoring network. These seasonal sites, where sampling was limited to the 2011 summer season (May 15—September 15), consisted of three elevated sites to measure ozone aloft and three sites on the valley floor to characterize transport pathways.

Meteorological patterns during the 2011 season were not consistent with those that occurred during previous technical studies., The passage of low-level troughs which initiate southwesterly winds and pollutant transport from population centers in California occurred in 2011, but the predominating high pressure systems preceding trough passage were largely absent.. HYSPLIT Model back trajectories for trough passages in 2011, as in previous technical studies, show source areas that include the Los Angeles Basin, the western Mohave Desert, and central California. Elevated ozone concentrations occur more often in June and July, before the onset of the monsoonal season, with the highest concentrations in the northwest quadrant of Clark County. Local emissions of ozone precursor pollutants can be a significant factor contributing to elevated ozone concentrations, particularly under stagnant conditions.

During the 2011 ozone season, there were ten days when 8-hour average ozone concentrations at one or more permanent monitoring sites exceeded 75 parts per billion. Air quality and meteorological data were evaluated to determine the influence of pollutant transport versus local emissions on elevated concentrations, and whether the ozone reservoir aloft was affecting measurements on the valley floor. Local emissions of ozone precursor pollutants appeared to be the dominant variable in five of the ten ozone episode days this season. Four of the ten were due primarily to transport into Clark County, and on one day, July 2, both transport and local emissions contributed significantly to elevated ozone concentrations. Ozone aloft appears to have affected measurements on the valley floor on five of the ten episode days.

Ozone concentrations measured at elevated sites indicate that the ozone reservoir aloft is widespread with deep vertical dimensions, which confirms air quality modeling for an ozone episode in 2003. Ozone episodes at permanent monitoring sites at the valley floor generally occur in conjunction with high hourly ozone concentrations at elevated sites. Suggestions for further research during the 2012 summer season include locating seasonal ozone analyzers at Laughlin, further northwest (e.g., Indian Springs), and at elevated sites on the east and north side of the Las Vegas Valley. A cooperative arrangement with another agency should be pursued for measurements of the ozone reservoir aloft to quantify impacts at valley floor sites during ozone episodes. It is also recommended that the air quality modeling program be updated to address a more recent ozone episode. This would provide a more comprehensive validation program for the model, including emission inventories.

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ACRONYMS AND ABBREVIATIONS

AGL	above ground level
MLS	mean sea level
NAAQS	National Ambient Air Quality Standards
ppb	parts per billion
SIP	state implementation plan

1.0 INTRODUCTION

1.1 STATEMENT OF GOAL AND IMPLEMENTATION PLAN SUMMARY

The goal of this project is to characterize the role of ozone transport on air quality in Clark County, and, in the event of wildfires, to acquire a sufficient database for air quality analyses to support exceptional event demonstrations for ozone and particulate matter less than 2.5 microns in diameter. The air quality monitoring and meteorological data collected was also used to confirm modeling programs in support of the development of future state implementation plans (SIPs) to attain and maintain National Ambient Air Quality Standards (NAAQS) for ozone.

The project implementation plan called for the deployment of six seasonal ozone analyzers to augment the existing monitoring network. These seasonal sites, where sampling was limited to the 2011 ozone season (May 15—September 15), included three elevated sites: the Spring Mountain Youth Camp (SMYC), Mountain Springs, and Arden Peak. These sites monitored ozone concentrations in the upper atmosphere. The other three seasonal sites—Sandy Valley, Apex, and Mesquite—monitored ozone levels on the floor of the Las Vegas Valley. All other sites providing data were part of the permanent ozone sampling network. Figure 1 shows the locations of the permanent and seasonal sites with their corresponding elevations. A Project Oversight Committee, consisting of representatives from the Monitoring and Planning Divisions, was established to carry out the project and complete the draft and final reports.

The implementation plan defined "high ozone episode days" as days where the peak 8-hour average ozone concentrations exceeded 70 parts per billion (ppb) at a permanent monitoring site, and identified these periods for detailed analysis of air quality and meteorological data to develop a coherent explanation of the episode. This focus was based on the expectation that a new NAAQS for ozone would be promulgated soon, with a primary standard ranging from 65 to 70 ppb. In September 2011, the president directed EPA to establish 75 ppb as the primary health standard and to move forward with area designations and implementation programs. In response to this decision, the Project Oversight Committee determined that data analyses would focus on days where 8-hour average ozone concentrations exceeded 75 ppb (high-ozone episodes).

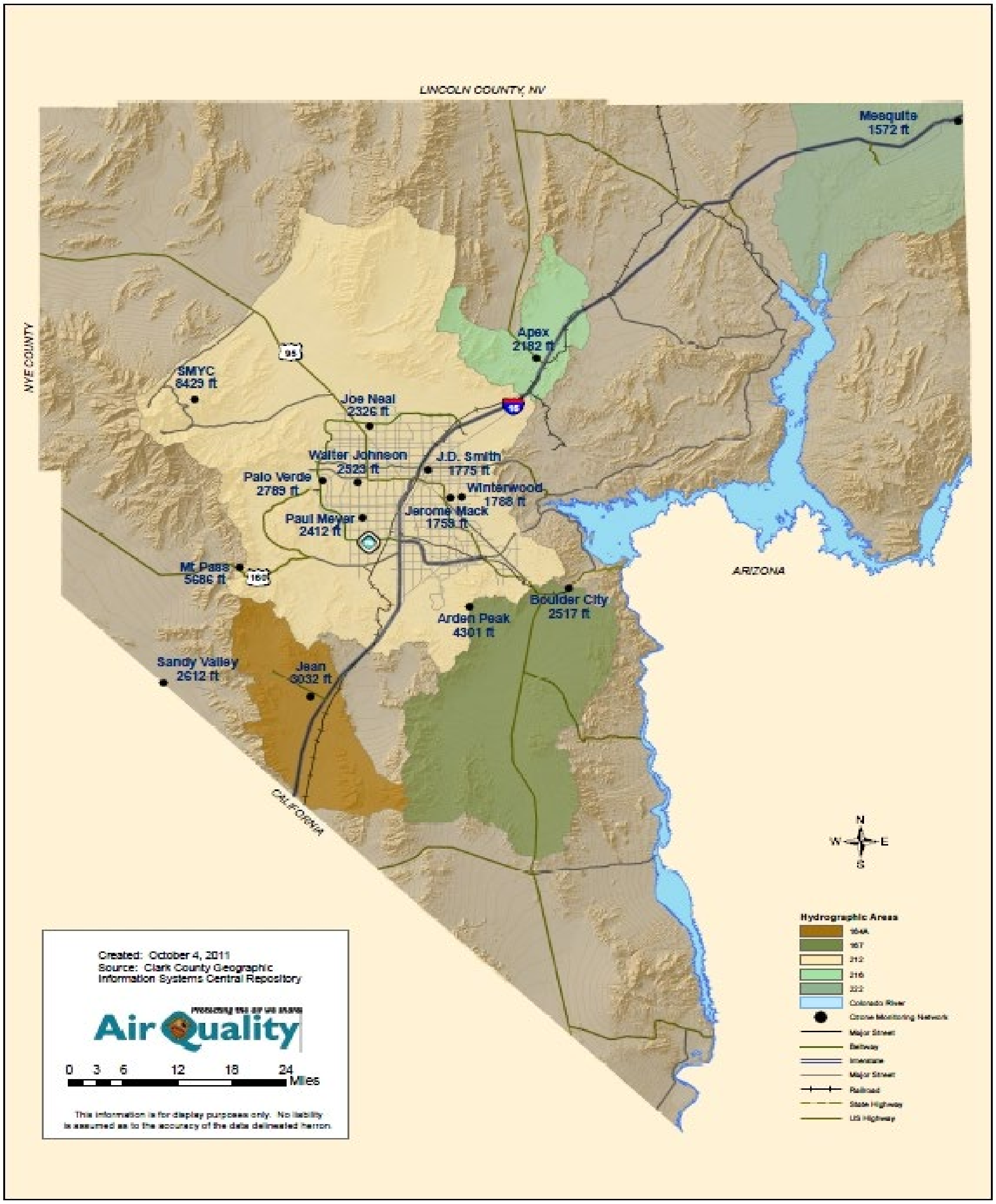


Figure 1. Ozone Monitoring Sites and Corresponding Elevations.

1.2 PREVIOUS TECHNICAL STUDIES

Previous technical studies on ozone air quality in Clark County include the Ozone Characterization Study (January 2006), the Clark County Regional Ozone and Precursor Study (September 2006), and the Southwest Desert/Las Vegas Ozone Transport Study (July 2008). These projects were implemented to improve our understanding of the causes of elevated ozone in Clark County, to determine whether the existing air quality monitoring network is adequate to define regional peak ozone concentrations, and to validate modeling for meteorology and ozone air quality.

The results of these studies support development of State Implementation Plans (SIPs) for submittal to the EPA to attain and maintain NAAQS for ozone.

1.3 SCOPE OF REPORT

Ozone is primarily a summertime problem, so the sampling period for this project was May 15–September 15, 2011. A wildfire may have exacerbated ozone concentrations on July 21 and August 28, but the effects were not severe enough to qualify as an exceptional event. Ten high-ozone episode days occurred during the 2011 season:

1. June 14-16, 2011
2. June 18, 2011
3. June 21, 2011
4. June 26, 2011
5. July 1-2, 2011
6. July 21, 2011
7. August 28, 2011.

Section 2 of this report describes the data analyses performed for each episode to determine the respective roles of transport and local emissions in elevated ozone concentrations. Upper-air meteorology and ozone air quality were also evaluated to determine whether ozone aloft affected concentrations at monitoring sites on the valley floor.

Air quality modeling is a critical component in assessing the impact of control measures and developing ozone SIP. Section 3 evaluates the usefulness of the data collected in confirming current methods for modeling the behavior of ozone in Clark County. Section 4 addresses regression modeling for the 2011 summer season. Section 5 outlines conclusions on data analyses and recommendations for further study.

The Project Oversight Committee worked collaboratively to integrate air quality and meteorological data for this project, using analytical tools with supporting narratives and graphics to summarize the important factors leading to elevated ozone concentrations.

2.0 AIR QUALITY AND METEOROLOGICAL DATA ANALYSES

2.1 METEOROLOGY DURING THE 2011 SUMMER SEASON

Meteorology is an important variable in the duration and intensity of high-ozone episodes. The *Ozone Characterization Study* (DAQEM 2006) identified a set of synoptic (regional) meteorological regimes conducive to elevated ozone concentrations in Clark County. Surface winds in Clark County are controlled by local terrain influences superimposed on the larger-scale regional wind fields, and these surface winds were consistent with what would be expected under the synoptic patterns during the 2011 ozone season. Local influences include channeling of winds through passes and gaps in the terrain, along with slope and valley wind systems (i.e., local, thermally-driven flow circulations that form in complex terrain areas).

At night in Clark County, local drainage flows dominate in the lower elevations. These follow the longitudinal axis of the Las Vegas Valley towards Lake Mead. The surface flow pattern during the stable nighttime period is clearly decoupled from the stronger winds aloft, as seen from measurements at higher elevations around the valley. The drainage flows cease by mid-morning and, due to solar-induced terrain heating, shift to an upslope flow, most often to the west and northwest. It is this pattern of wind fields that has led to recurring elevated ozone concentrations in the northwest quadrant of Clark County. By mid-afternoon and continuing into evening, a fairly uniform, moderately strong southwest wind field prevails as flows at all levels become strongly coupled.

The synoptic patterns during the 2011 ozone season were inconsistent with typical summertime patterns. Although low pressure troughs still passed through the region, bringing southwesterly and westerly transport winds from southern and central California into Clark County, the predominant high pressure patterns that usually precede trough passage did not appear. Typically, the Pacific Ridge builds over the West Coast much more strongly, and farther inland, than it did this summer. This increase in high pressure not only blocks and weakens low pressure systems, it allows for much longer periods of stagnation and subsidence that increase the levels of ozone from potential transport sites, as well as locally produced ozone levels.

The lack of high-pressure dominance during the 2011 ozone season caused an increase in weak trough passages and an early onset of monsoonal weather patterns. An increase in cloud cover associated with the early onset of the monsoonal season limited ozone formation. This deviation from typical summertime weather patterns probably limited ozone transport and local contributions to ozone formation.

2.2 JUNE 14-16 EPISODE

2.2.1 Air Quality and Meteorology

Table 1 shows 8-hour average ozone concentrations at monitoring sites in Clark County for June 13-17, 2011. It includes both permanent and seasonal sites deployed for this project; elevated sites are Mountain Pass, SMYC, and Arden Peak (see Figure 1 for site locations and elevations). Values highlighted in red exceed 75 ppb; values highlighted in yellow range from 70–75 ppb.

Table 1. 8-Hour Average Ozone Concentrations, June 13-17, 2011

Sites	Dates				
	Mon (6/13/11)	Tue (6/14/11)	Wed (6/15/11)	Thu (6/16/11	Fri (6/17/18)
Apex	52	66	65	78	60
Mesquite	42	50	58	67	52
Paul Meyer	56	78	74	79	65
Walter Johnson	58	79	72	77	67
Palo Verde	54	74	71	75	63
Joe Neal	60	76	73	76	69
Winterwood	NV	71	68	76	63
Jerome Mack	53	73	70	75	64
Boulder City	51	67	70	81	62
Jean	57	74	79	83	66
Sandy Valley	49	60	66	72	59
J.D. Smith	52	72	67	72	62
SMYC	61	70	75	79	72
Mt. Pass	56	67	76	80	65
Arden Peak	60	NA[1]	84	86	73

[1]Insufficient data.

June 14 was the first day of 2011 on which temperatures in Las Vegas reached 100°F, and saw a brief period of high pressure dominating Clark County. A weak lower-level disturbance moved through the valley between 5 p.m. and 11 p.m. the previous day; the high-pressure system moved in immediately following this trough, which was shifting east into the Rockies, and the morning hours of June 14 were characterized by clear skies and rising temperatures. The primary upper area pattern towards the end of the day was zonal, characterized by a west to east flow.

On June 15, clear skies remained throughout the Southwest, with the nearest clouds located over Oregon in the morning hours. Warm temperatures continued on June 15, increasing to 105°F at McCarran International Airport by early afternoon; however, a broad low-pressure trough was approaching southern Nevada, with increasing southwesterly wind speeds aloft that shifted downward to lower elevations by late morning. The strongest influence of this trough occurred between 11 a.m. and 5 p.m., and its effects were evident throughout the upper-air meteorological charts.

On June 16, the low-pressure system intensified as a deep trough moved into the Las Vegas Valley, causing increased southwesterly wind speeds and gusts. As with June 15, upper-air meteorological charts show the strongest influence occurring between 11 a.m. and 5 p.m. Cooler temperatures prevailed on June 16, with a high of 100°F recorded at McCarran in the early afternoon.

2.2.2 Upper-Air Reservoir and Ground-Level Concentrations

Figure 2 shows a time-series plot of hourly ozone concentrations at the elevated seasonal sites from 12 a.m. June 13 through 12 a.m. June 17. Instrumentation problems at the Arden Peak site prevented data collection on June 14 and the morning of June 15. Increasing hourly ozone concentrations at these sites during June 14–15 reflect the growing dominance of southwesterly winds and the transport of ozone from the southwest in the upper air.

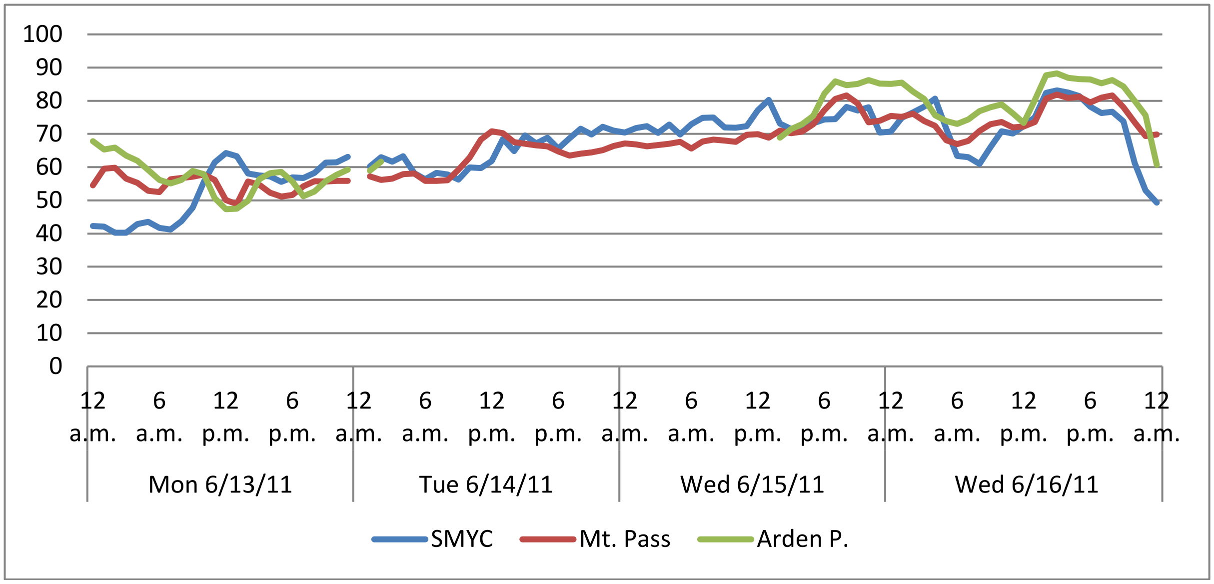


Figure 2. Hourly Ozone Concentrations (ppb) at Elevated Monitoring Sites.

Figure 3 shows a time-series plot of hourly ozone concentrations for selected valley floor monitoring sites during the same time frame. The daytime variation of ozone concentrations follows a typical pattern on June 14, but changes significantly in the early hours of June 15: hourly concentrations remain relatively high, probably reflecting the growing dominance of southwesterly winds and associated transport, as well as possible carry-over from the previous day. The trend of hourly peaks on June 15 and 16 also suggests that the reservoir of ozone aloft may have been mixing downward to ground level, leading to elevated concentrations at monitoring sites in the valley.

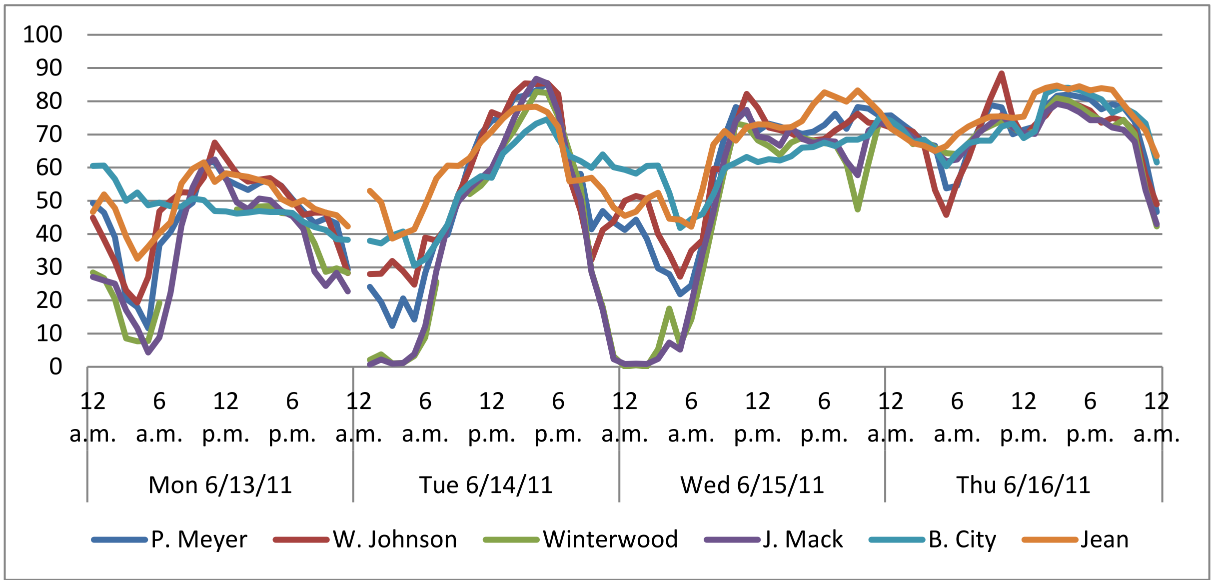


Figure 3. Hourly Ozone Concentrations (ppb) at Selected Valley Floor Sites.

On June 14, the subsidence inversion began to break up at approximately 8 a.m. and mixing began around 10 a.m. The maximum mixing height of 7,900 feet (ft) above mean sea level (MSL) occurred at 2 p.m. Winds remained below 10 miles per hour (mph), although a brief period of gusts occurred between 11 a.m. and 3 p.m. Air quality and meteorological data indicate that the upper-air ozone reservoir had little impact on valley floor monitoring sites. The Arden Peak monitoring site was offline, and the mixing depth was only high enough to reach the Mt. Pass monitoring site.

On June 15, the subsidence inversion began to break up at approximately 8 a.m. and mixing began around 10 a.m. The maximum mixing height of 11,380 ft above MSL occurred at 3 p.m., with mixing heights much greater than the previous day. The strongest sustained winds occurred between 5 p.m. and 11 p.m. Data showing high ozone concentrations at the SMYC and Mt. Pass monitoring sites (Arden Peak remained offline) around 10 a.m. suggest that local drainage flows during the early morning hours may have brought ozone aloft down to the valley floor. Elevated ozone concentrations at the Boulder City and Jean sites between 7 p.m. and 11 p.m. the previous night, just before the inversion set up, indicate these flows may have begun in the evening hours of June 14.

On June 16, the data indicate that the upper-air ozone reservoir exacerbated ozone concentrations on the valley floor. The subsidence inversion began to break at 7 a.m. and mixing began around 9 a.m. The maximum mixing height of 11,110 ft above MSL occurred at 2 p.m. This height was slightly lower than on June 15 but well above that on June 14, which was dominated by a brief high-pressure system. Higher early-morning ozone readings at Arden than at Mt. Pass suggest that ozone aloft may have shifted to lower elevations, perhaps just above the inversion layer (approximately 800 ft above ground level (AGL)). Mixing was complete by 1 p.m., so the maximum impact of upper-air ozone at valley floor sites would have occurred after then.

2.2.3 Pollutant Transport and Local Emission Impacts on Ozone Concentrations

Air quality and meteorological data suggest that local emissions of precursor pollutants were the dominating influence on ozone concentrations at valley floor monitoring sites on June 14. Figure 4 shows a HYSPLIT 24-hour back trajectory beginning at the Jean, Walter Johnson, and Boulder City monitoring sites at 6 p.m. on June 14, and the trajectory for Jean shows the urban plume enveloping the site during the daylight hours. In addition, low readings in southern California (a typical transport pathway) on that day indicate that high ozone levels at Jean likely came from local emissions.

The Paul Meyer, Walter Johnson, and Joe Neal sites, in the northwest Las Vegas Valley, recorded the highest 8-hour average ozone concentrations on June 14. This is a typical pattern in summer: local drainage winds flow eastward toward Lake Mead, but solar heating causes them to shift to an upslope flow towards the northwest by midmorning.

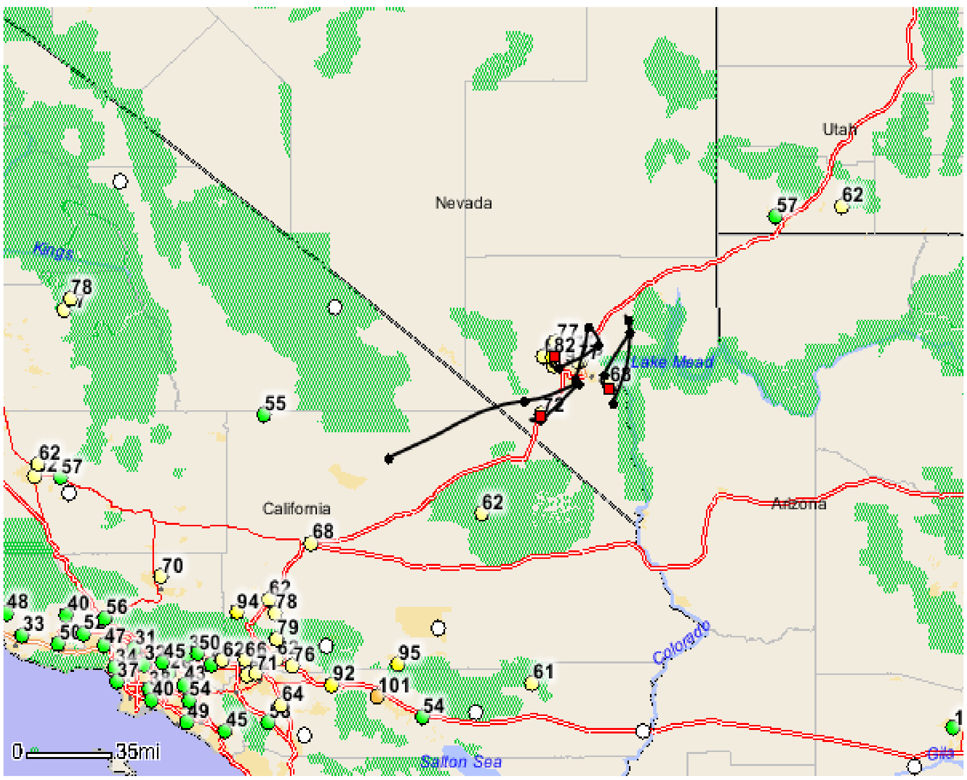


Figure 4. HYSPLIT 24-Hour Back Trajectory at 10 m Height from Jean, Walter Johnson, and Boulder City beginning at 6 p.m. on June 14.

On June 15, a southwesterly flow was the dominating wind pattern. Figure 5, a HYSPLIT 12-hour back trajectory from the Joe Neal, Boulder City, and Jean monitoring sites at 6 p.m. on June 15, illustrates southwesterly wind patterns and likely pollutant transport into Clark County. Elevated hourly ozone concentrations at California sites near the Nevada border indicate pollutant transport. The figure shows 6 p.m. hourly average ozone concentrations of 69 ppb at Joe Neal, 66 ppb at Boulder City, and 74 ppb at Jean. The hourly average level at Jean was the highest of all the valley floor sites on June 15, demonstrating pollutant transport into Clark County.

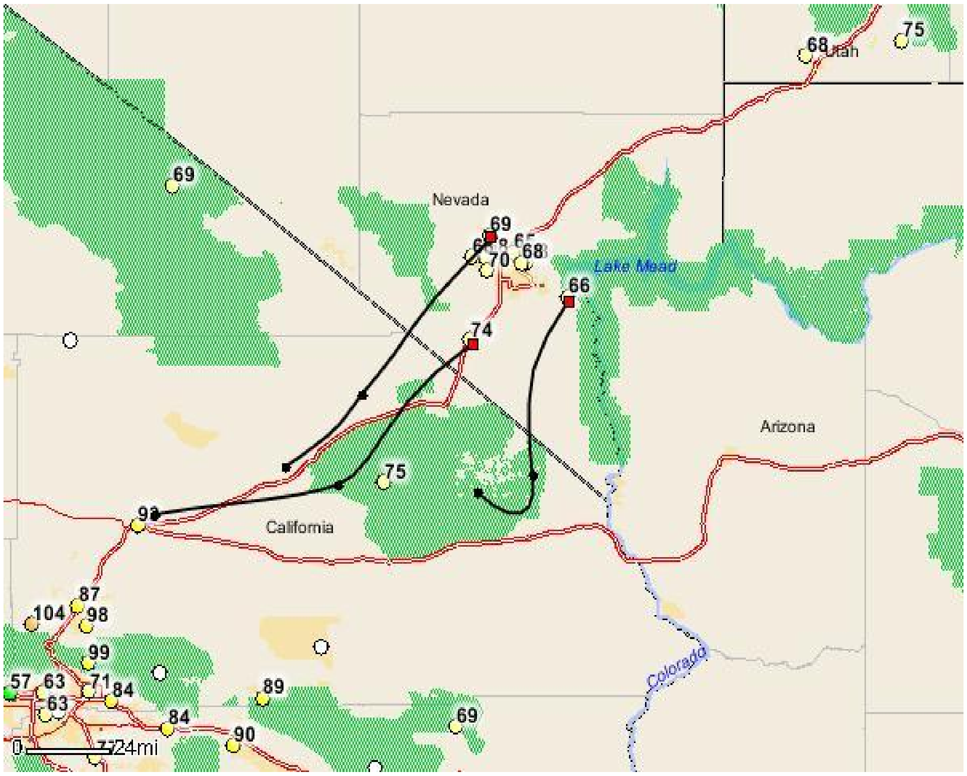


Figure 5. HYSPLIT 12-Hour Back Trajectories (10 meters AGL) at 6 p.m. on June 15 from the Joe Neal, Boulder City, and Jean Monitoring Sites.

Similarly, transport of ozone from the southwest into Clark County was a dominating influence on June 16. Figure 6, a HYSPLIT 12-hour back trajectory from the Joe Neal, Boulder City, and Jean monitoring sites at 6 p.m. on June 16, illustrates southwesterly wind patterns and likely pollutant transport into Clark County. The figure shows 6 p.m. hourly average ozone concentrations of 76 ppb at Joe Neal, 82 ppb at Boulder City, and 83 ppb at Jean. Pollutant transport is clearly evident in the high hourly ozone concentrations at sites in California near the Nevada border and in the high 8-hour average ozone concentrations recorded at Jean and Boulder City on June 16.

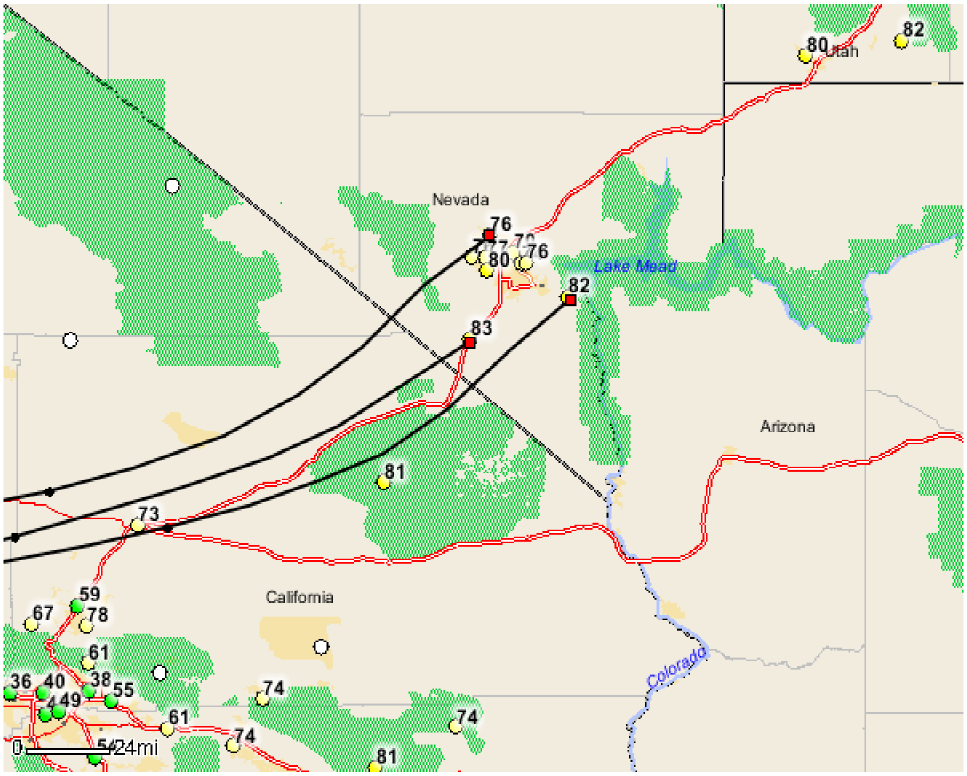


Figure 6. HYSPLIT 12-Hour Back Trajectories (10 m AGL) at 6 p.m. on June 16 from the Joe Neal, Boulder City, and Jean Monitoring Sites.

In summary, high ozone levels on June 14 appear to be due primarily to local emissions of precursor pollutants, with pollutant transport having a small role. Hourly ozone concentrations on June 14 at sites on the valley floor follow the diurnal pattern that would be expected under a high-pressure system with low wind speeds. The pattern of hourly ozone concentrations on June 15-16 changed dramatically, as Figure 3 shows, reflecting the dominant influence of pollutant transport into Clark County from the southwest.

2.3 JUNE 18 EPISODE

2.3.1 Air Quality and Meteorology

Table 2 shows 8-hour average ozone concentrations for June 17-19, 2011. Clear skies prevailed over the Las Vegas Valley on June 18, with a high temperature of 98°F measured at 4 p.m. at McCarran International Airport. An upper low-pressure system moving into the Pacific Northwest led to increasing southwesterly winds during the afternoon of June 18, but Joe Neal was the only permanent site to show ozone concentrations above 75 ppb that day.

Table 2. 8-Hour Average Ozone Concentrations, June 17-19, 2011

Sites	Dates		
	Fri (6/17/11)	Sat (6/18/11)	Sun (6/19/11)
Apex	60	65	56
Mesquite	52	53	48
Paul Meyer	65	69	57
Walter Johnson	67	70	57
Palo Verde	63	68	54
Joe Neal	69	76	56
Winterwood	63	69	56
Jerome Mack	64	71	55
Boulder City	62	67	64
Jean	66	74	68
Sandy Valley	59	66	56
J.D. Smith	62	70	53
SMYC	72	72	58
Mt. Pass	65	70	68
Arden Peak	73	78	66

2.3.2 Upper-Air Ozone Reservoir and Ground-Level Ozone Concentrations

Figure 7 is a time-series plot of hourly ozone concentrations at the elevated seasonal monitoring sites for June 17–19. On June 17, the peak hourly ozone concentrations for SMYC (80 ppb) and Mt. Pass (67 ppb) occurred at 5 p.m., while Arden Peak recorded the highest concentration (74 ppb) at 4 p.m. Ozone concentrations remained high at the three sites through the morning hours of June 18, with SMYC recording a peak of 80 ppb at 1 p.m. Arden Peak recorded its highest concentration (81 ppb) at 7 p.m. that same day. On June 17, upper-air winds (3,000 m AGL) originated from the southwest, but by June 18 they had shifted due west. By June 19, winds were originating from the northwest, a clean air corridor, which probably accounts for the reduction in hourly ozone concentrations in the upper atmosphere that day.

Figure 8 is a time-series plot of hourly ozone concentrations for the same time frame at select monitoring sites on the valley floor. The Joe Neal site recorded the highest hourly ozone concentrations, 76 ppb at 3 p.m. on June 17 and 85 ppb at 11 a.m. on June 18. On June 19, the Jean site recorded the highest hourly ozone concentration: 71 ppb at 7 a.m. In fact, Jean had high ozone concentrations throughout the three-day period.

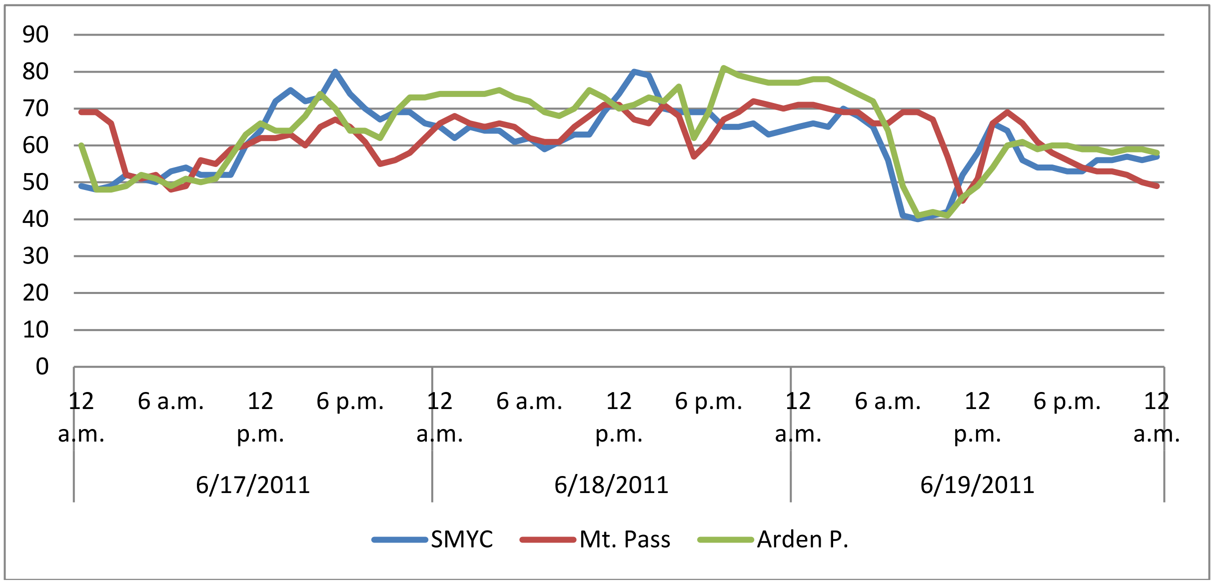


Figure 7. Hourly Ozone Concentrations (ppb) at Elevated Sites.

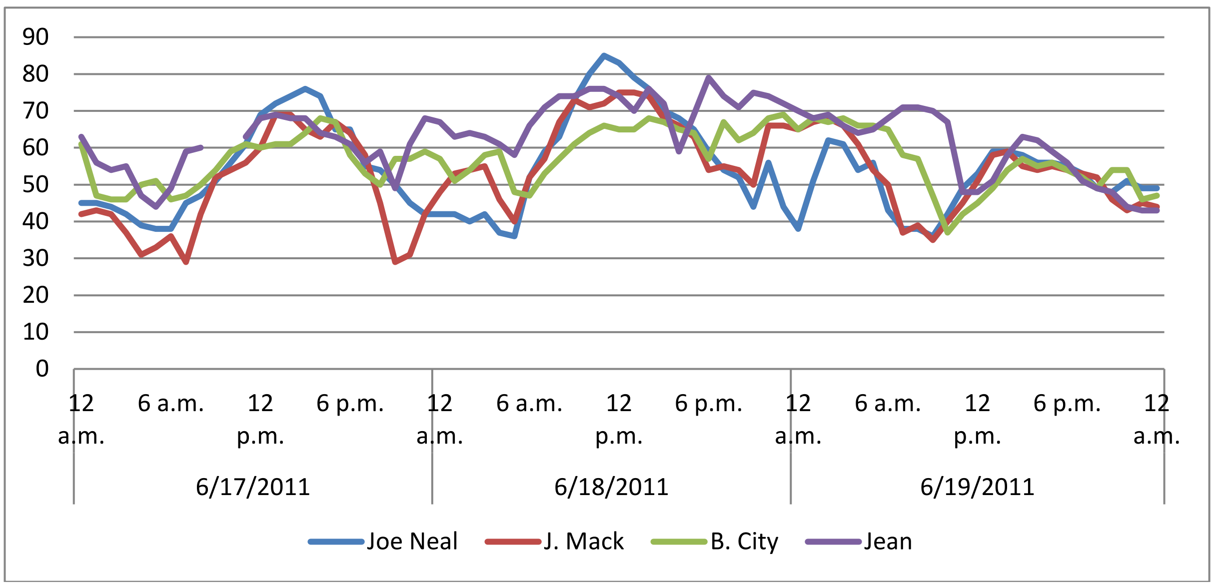


Figure 8. Hourly Ozone Concentrations (ppb) at Select Permanent Sites.

Surface winds (10 m AGL) were southwesterly on June 17 and 18, but shifted to the northwest on June 19. High hourly ozone concentrations early on June 18 indicated pollutant carryover from the previous day. The inversion broke around 9 a.m.; mixing heights reached 5,790 ft at 11 a.m., 6,765 ft at 12 p.m., and 8,595 ft at 4 p.m.

The collected data offer little evidence that ozone aloft affected valley floor monitoring sites during this episode; readings at the elevated monitoring sites were not unusually high before ozone concentrations rose at sites on the valley floor. The increasing mixing depth over the course of the day on June 18 equalized the ozone plume, with Arden Peak recording the highest concentrations in the evening hours among elevated sites.

2.3.3 Pollutant Transport and Local Emission Impacts on Ozone Concentrations

The 8-hour average ozone level at Jean on June 18 (74 ppb) indicates that pollutant transport was the dominating variable. The HYSPLIT 24-hour back trajectory in Figure 6 illustrates the potential transport of ozone and precursor pollutants into Clark County. The levels shown are hourly values recorded at 6 p.m. on June 18. The high hourly values seen in California demonstrate that pollutant transport into Clark County overwhelmed local emissions, even if ozone from local sources increased concentrations somewhat in the northwest part of Clark County, where the Joe Neal site is located.

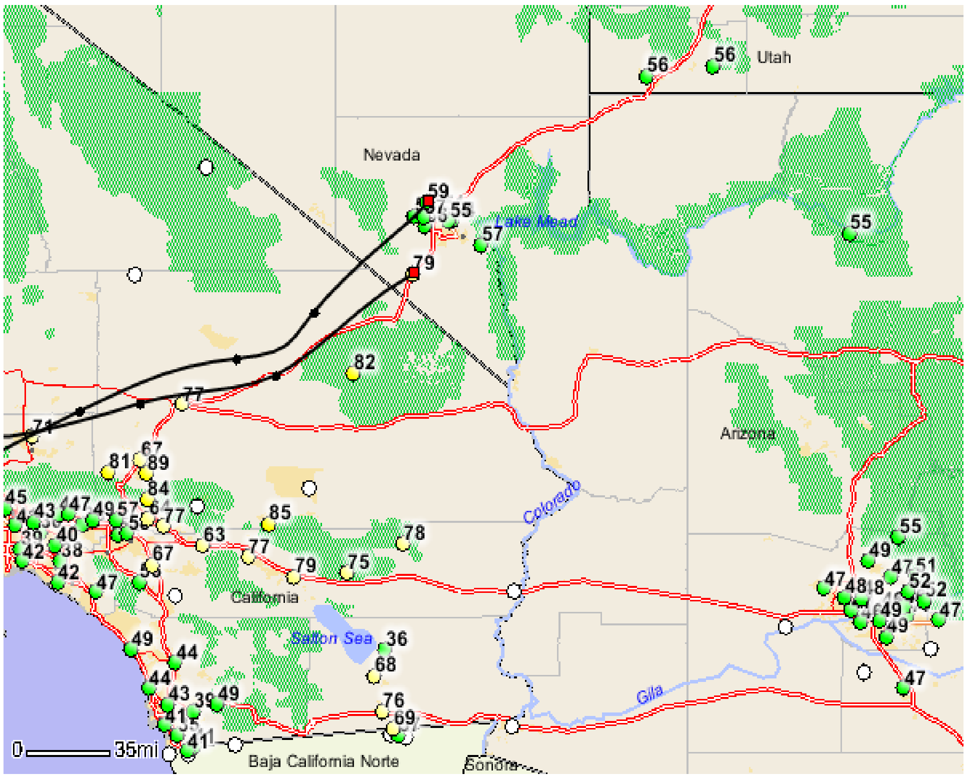


Figure 9. HYSPLIT 24-Hour Back Trajectory at 6 p.m. on June 18 from the Jean (76 ppb) and Joe Neal (85 ppb) Monitoring Sites.

2.4 JUNE 21 EPISODE

2.4.1 Air Quality and Meteorology

Table 3 shows 8-hour average ozone concentrations at Clark County monitoring sites for June 20-22, 2011. Values highlighted in red exceed the NAAQS (75 ppb); values highlighted in yellow range from 70 to 75 ppb. On June 21, Paul Meyer was the only permanent site that recorded levels exceeding 75 ppb. A ridge of high pressure was strengthening over the Southwest that morning, with scattered clouds and warm temperatures in the Las Vegas Valley. A high of 102°F was recorded at 5 p.m. at McCarran International Airport.

Table 3. 8-Hour Average Ozone Concentrations, June 20-22, 2011

Sites	Dates		
	Mon (6/20/11)	Tue (6/21/11)	Wed (6/22/11)
Apex	52	53	65
Mesquite	44	56	51
Paul Meyer	66	78	71
Walter Johnson	65	72	70
Palo Verde	59	70	69
Joe Neal	60	65	71
Winterwood	57	56	69
Jerome Mack	60	61	71
Boulder City	54	54	63
Jean	67	68	68
Sandy Valley	55	54	57
JD Smith	59	61	69
SMYC	58	66	70
Mt. Pass	60	80	76
Arden Peak	69	77	78

2.4.2 Upper-Air Ozone Reservoir and Ground-Level Ozone Concentrations

Figure 10 is a time-series plot of hourly ozone concentrations at the elevated seasonal sites for June 20-22, 2011. Mt. Pass recorded the highest 8-hour average ozone concentration on June 21 (Table 3), but Arden Peak recorded the highest hourly concentrations on all three days: 74 ppb at 4 p.m. on June 20, 90 ppb at 6 p.m. on June 21, and 82 ppb at 12 p.m. on June 22. On June 20 and 21, upper-air winds (3,000 m AGL) originated from the north to northwest, but on June 22 they shifted to the southwest. Elevated ozone levels on June 21 were probably caused by solar heating of the terrain and an upward shift of ozone from the surface to the upper atmosphere.

Figure 11 is a time-series plot of hourly ozone concentrations at select permanent sites for the same time frame. The diurnal pattern of ozone concentrations is typical under a high-pressure system with light and variable winds. Upper-air meteorological data (e.g., onset of inversion, mixing heights, etc.) is unavailable because instruments at the North Las Vegas Airport were offline during this period; therefore, the potential effects of the upper-air ozone reservoir on ground-level conditions cannot be accurately assessed.

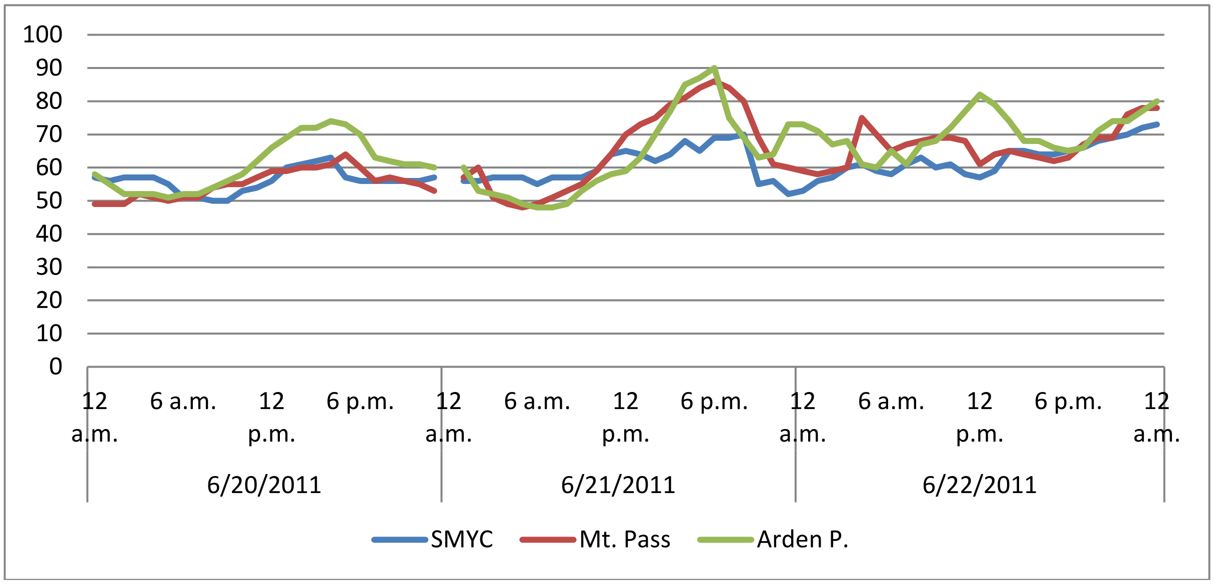


Figure 10. Hourly Ozone Concentrations (ppb) at Elevated Sites.

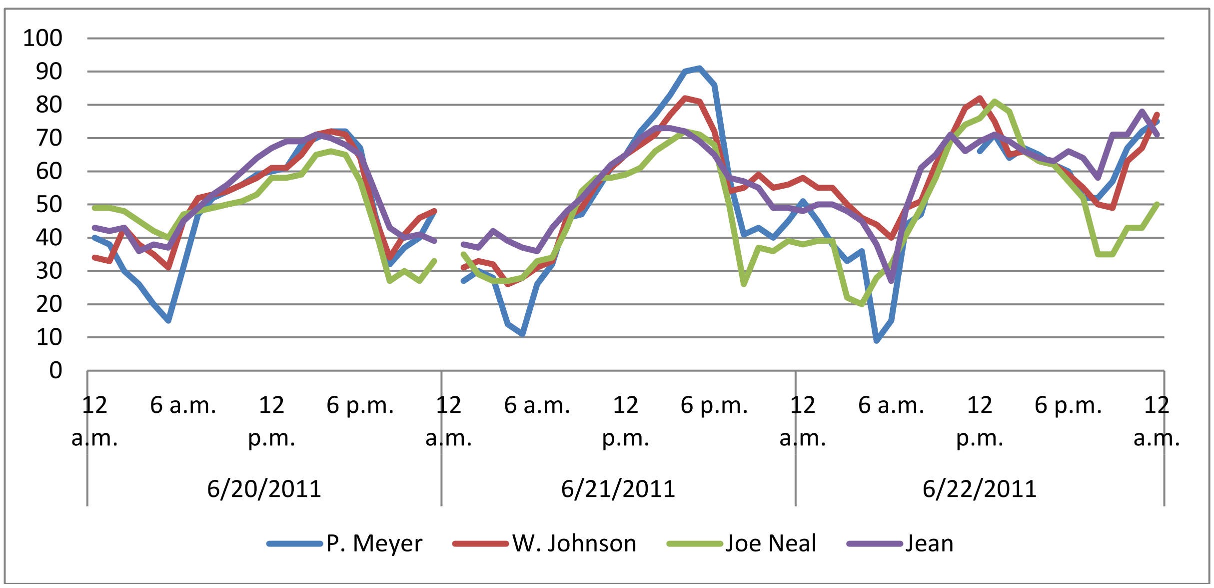


Figure 11. Hourly Ozone Concentrations (ppb) at Selected Permanent Sites.

2.4.3 Pollutant Transport and Local Emission Impacts on Ozone Concentrations

Figure 12 provides HYSPLIT 24-hour back trajectories from the Jean and Paul Meyer sites on June 21, showing 6 p.m. hourly ozone concentrations of 65 ppb at Jean and 86 ppb at Paul Meyer. The air parcel flow was from the northeast, unusual because prevailing summer winds in the valley are typically from the southwest. High ozone readings at the Paul Meyer, Walter Johnson, and Palo Verde sites were primarily influenced by local emissions of precursor pollutants, e.g., the highest 8-hour average ozone concentration at Paul Meyer (78 ppb) may have been exacerbated by VOC emissions from nearby paving operations (Figure 13).

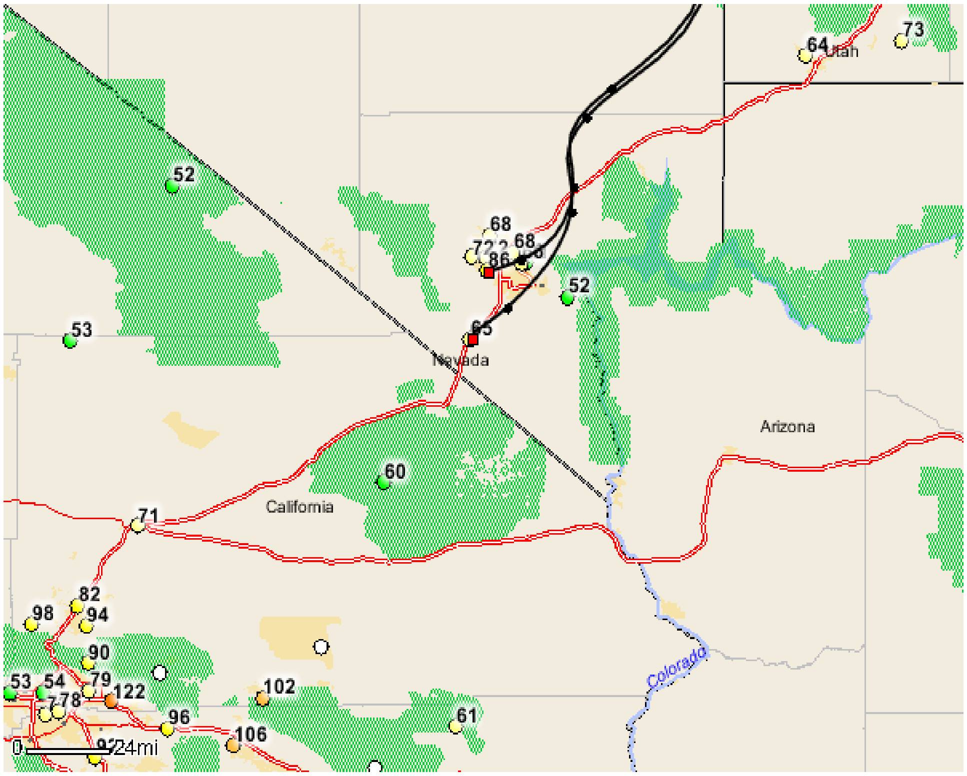


Figure 12. HYSPLIT 24-Back Trajectories (10 m AGL) at 6 p.m. on June 21 from the Jean and Paul Meyer Monitoring Sites.

Figure 13. Paving Operations Adjacent to Paul Meyer Site on June 21.

2.5 JUNE 26 EPISODE

2.5.1 Air Quality and Meteorology

Table 4 shows 8-hour average ozone concentrations for June 25-27, 2011. Walter Johnson and Joe Neal were the only permanent sites that recorded ozone concentrations above 75 ppb, although the Apex, Winterwood, and Jean sites had 8-hour averages at or near 75 ppb on June 26. SMYC and Arden Peak exceeded 75 ppb on June 26, and Arden Peak recorded high ozone levels on June 27 as well.

Table 4. 8-Hour Average Ozone Concentrations, June 25-27, 2011

Sites	Dates		
	Sat (6/25/11)	Sun (6/26/11)	Mon (6/27/11)
Apex	66	74	67
Mesquite	53	59	53
Paul Meyer	66	75	68
Walter Johnson	68	76	69
Palo Verde	65	74	66
Joe Neal	70	76	71
Winterwood	65	75	69
Jerome Mack	65	75	69
Boulder City	61	69	65
Jean	65	72	70
Sandy Valley	62	66	59
JD Smith	64	73	66
SMYC	67	77	71
Mt. Pass	71	72	72
Arden Peak	73	77	76

Meteorological conditions during this period included a weak/flat shortwave ridge moving through the region, passing over Clark County on June 27. Surface winds on June 26 were southwesterly, light, and variable in the late morning, but wind speeds increased during the afternoon. Temperatures reached a high of 103°F at 3 p.m. at McCarran International Airport. On June 26, with the Las Vegas Valley between a trough to the north and this ridge to the south, regional-scale upper-air wind patterns were generally westerly.

2.5.2 Upper-Air Ozone Reservoir and Ground-Level Ozone Concentrations

Upper-air winds originated from the west on June 26. This westerly flow is illustrated in Figure 14, a HYSPLIT 48-hour back trajectory at 3,000 m AGL from the vicinity of the Arden Peak and SMYC monitoring sites.

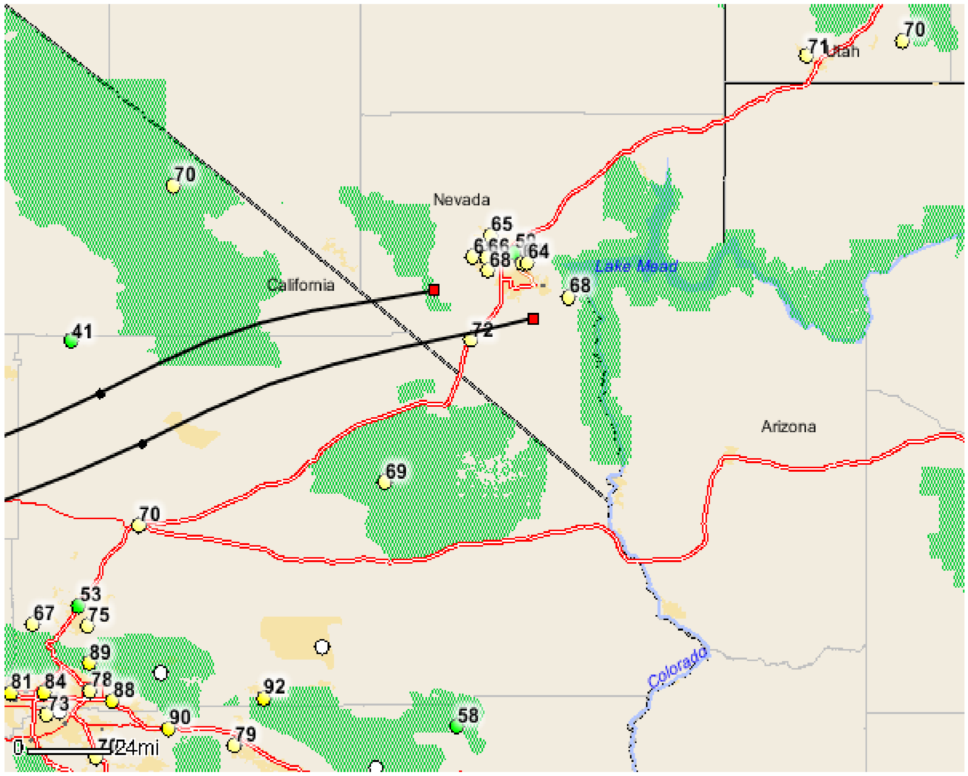


Figure 14. HYSPLIT 48-Hour Back Trajectory (3000 m AGL) at 6 p.m. on June 26.

Figure 15 is a time-series plot of hourly ozone concentrations at seasonal elevated sites for June 25–27. Diurnal variation in ozone concentrations is evident on June 25, but limited on June 26 and 27. Hourly ozone concentrations at SMYC are low (42 ppb) at 11 p.m. on June 25, but quickly rise in the early morning hours of June 26 and remain elevated.

Figure 16 is a time-series plot of hourly ozone concentrations at select permanent sites for the same time frame. The sites show a typical diurnal pattern of ozone concentrations on June 25. Hourly concentrations at the Walter Johnson monitoring site begin to rise at 9 p.m. on June 25, reaching 70 ppb from 12:00 a.m. to 3 a.m. on June 26. The Jean site also shows high ozone levels early on June 26, rising to 70 ppb at 6 a.m. with little variation until the evening hours. These hourly values on June 26 suggest some pollutant carryover from the previous day; with the prevailing southwesterly winds, transport of ozone and precursor pollutants into Clark County was likely a significant factor in elevated ozone concentrations.

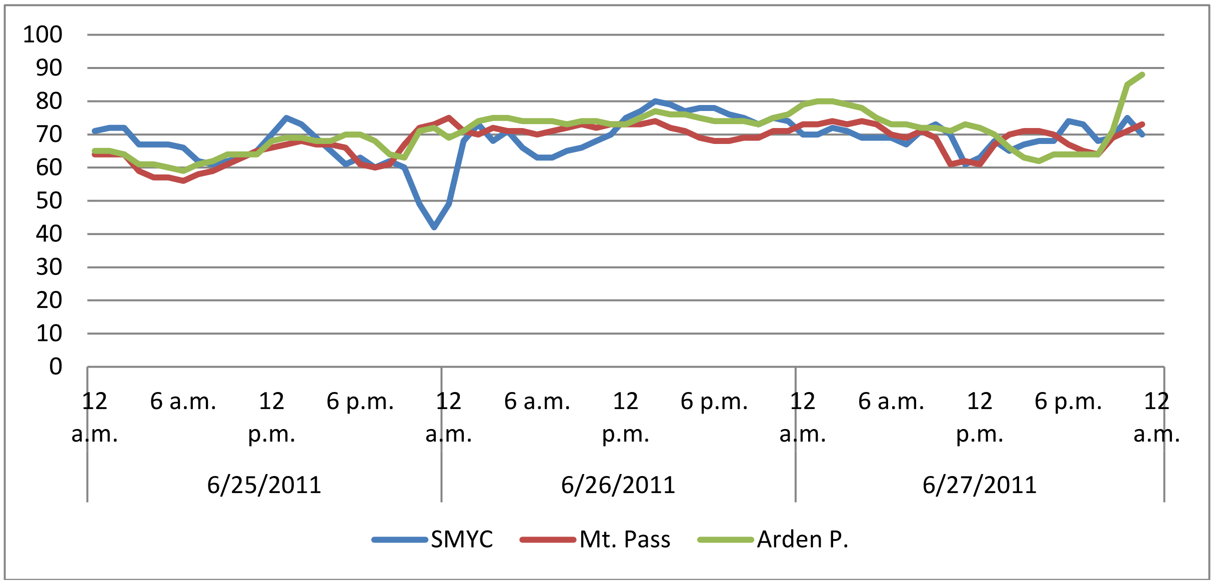


Figure 15. Hourly Ozone Concentrations (ppb) at Seasonal Elevated Sites.

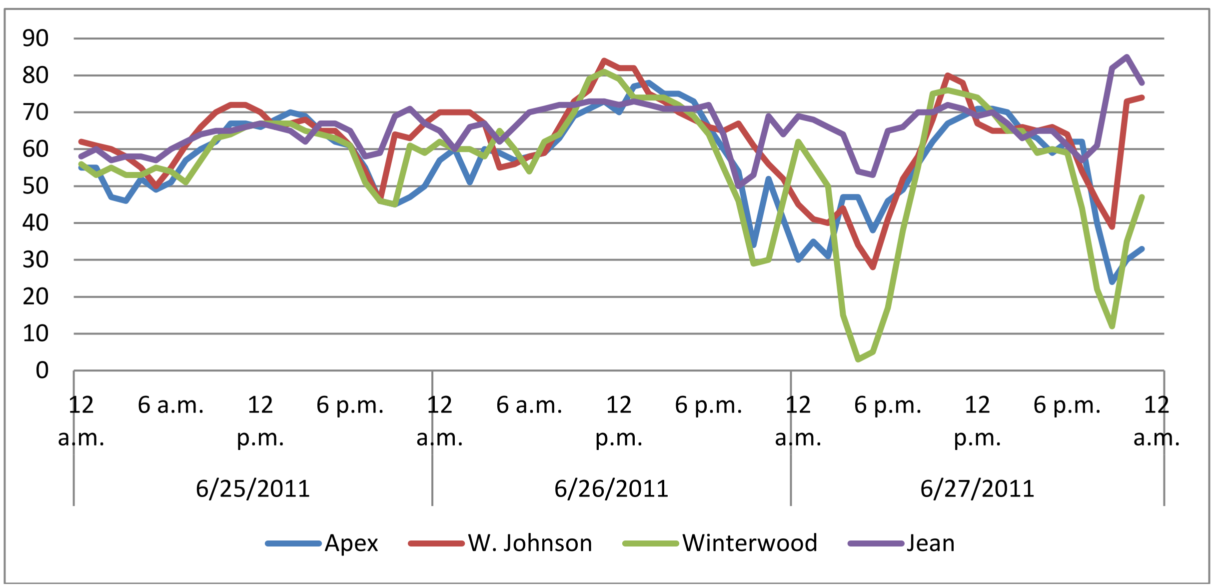


Figure 16. Hourly Ozone Concentrations (ppb) at Selected Permanent Sites.

Hourly concentrations at the seasonal elevated sites (Figure 15) are surprisingly consistent, given the differences in elevation and location. This suggests that the vertical extent of the upper-air ozone reservoir may have been quite deep. The inversion broke at 9 a.m. on June 26; mixing heights rose from 5,380 ft at 9 a.m. to 6,250 ft at 10 a.m., reaching a maximum of 8,790 ft at 3 p.m. The ozone reservoir aloft may have been mixing downward to the surface as a new boundary layer developed on June 26, which could have contributed to the elevated ozone concentrations at the permanent monitoring sites on the valley floor.

2.5.3 Pollutant Transport and Local Emission Impacts on Ozone Concentrations

Figure 17, a HYSPLIT 24-hour back trajectory at 6 p.m. on June 26, shows southwesterly surface winds. These wind patterns, combined with an elevated ozone concentration at the Jean site on June 26, indicate that transport of ozone and ozone precursor pollutants into Clark County was a significant factor in elevated ozone concentrations in urban Las Vegas. Local emissions of ozone precursors exacerbated the problem, particularly in the northwest, where 8-hour average concentrations exceeded 75 ppb.

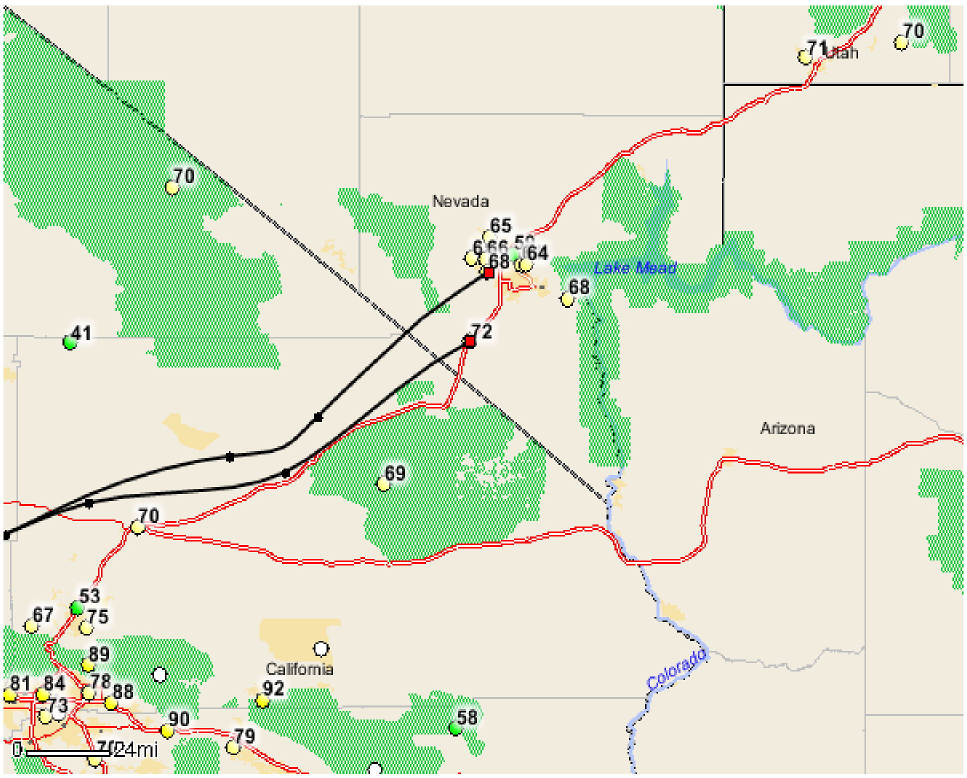


Figure 17. HYSPLIT 24-Back Trajectory (10 m AGL) at 6 p.m. on June 26 from Jean and Paul Meyer Monitoring Sites.

2.6 JULY 1-2 EPISODE

2.6.1 Air Quality and Meteorology

Table 5 shows 8-hour average ozone concentrations for July 1-4, 2011. Ozone concentrations on July 1-2 at some permanent monitoring sites (Paul Meyer, Walter Johnson, Palo Verde, and Joe Neal) were the highest peak 8-hour averages sampled during the 2011 ozone season. High traffic volumes associated with the holiday weekend in the Las Vegas Valley may have been a contributing factor in these elevated ozone concentrations.

Table 5. 8-Hour Average Ozone Concentrations, June 30–July 3, 2011

Sites	Dates			
	Thu (6/30/11)	Fri (7/1/11)	Sat (7/2/11)	Sun 7/3/11
Apex	62	65	64	53
Mesquite	53	53	51	48
Paul Meyer	70	90	82	70
Walter Johnson	71	89	79	69
Palo Verde	67	88	80	70
Joe Neal	75	79	79	67
Winterwood	68	69	69	55
Jerome Mack	70	74	72	58
Boulder City	58	63	65	49
Jean	64	72	66	60
Sandy Valley	55	63	56	55
JD Smith	71	71	70	58
SMYC	68	84	68	63
Mt. Pass	62	82	76	62
Arden Peak	70	83	72	59

An upper-level high-pressure system stayed over the Las Vegas Valley on July 1, with temperatures slightly above normal (104°F at 6 p.m. at McCarran International Airport). Winds throughout the valley were light and variable that day, a situation conducive to elevated pollutant concentrations. As the high-pressure system strengthened, temperatures increased to well above normal, rising to 111°F at McCarran on July 2 at 5 p.m. and 108°F on July 3 at 4 p.m.

2.6.2 Upper-Air Ozone Reservoir and Ground-Level Ozone Concentrations

Figure 18 shows hourly ozone concentrations at the elevated seasonal sites for June 30 through July 3, 2011. Hourly concentrations begin to rise at the three sites during the afternoon of June 30, with the highest concentrations recorded during the afternoon of July 1. The hourly concentrations began to taper off on July 2, and that trend continued through July 3.

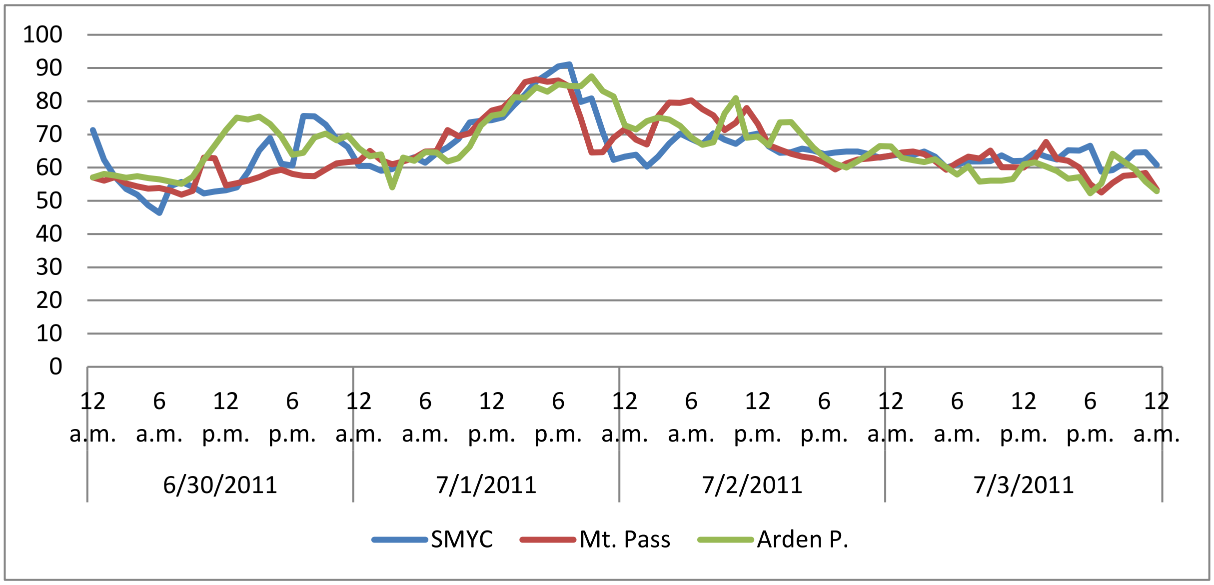


Figure 18. Hourly Ozone Concentrations at Seasonal Elevated Sites (June 30-July3).

Figures 19–21 contain HYSPLIT 24-hour back trajectories at 3,000 m AGL from the SMYC and Arden Peak monitoring sites on June 30, July 1, and July 2, respectively. Figure 19 shows prevailing winds coming from the northwest on June 30. Figure 20 shows more stagnant conditions on July 1 as prevailing winds continued from the northwest, but under an intensifying high-pressure system. Figure 21 shows the prevailing winds originating from the south by July 2.

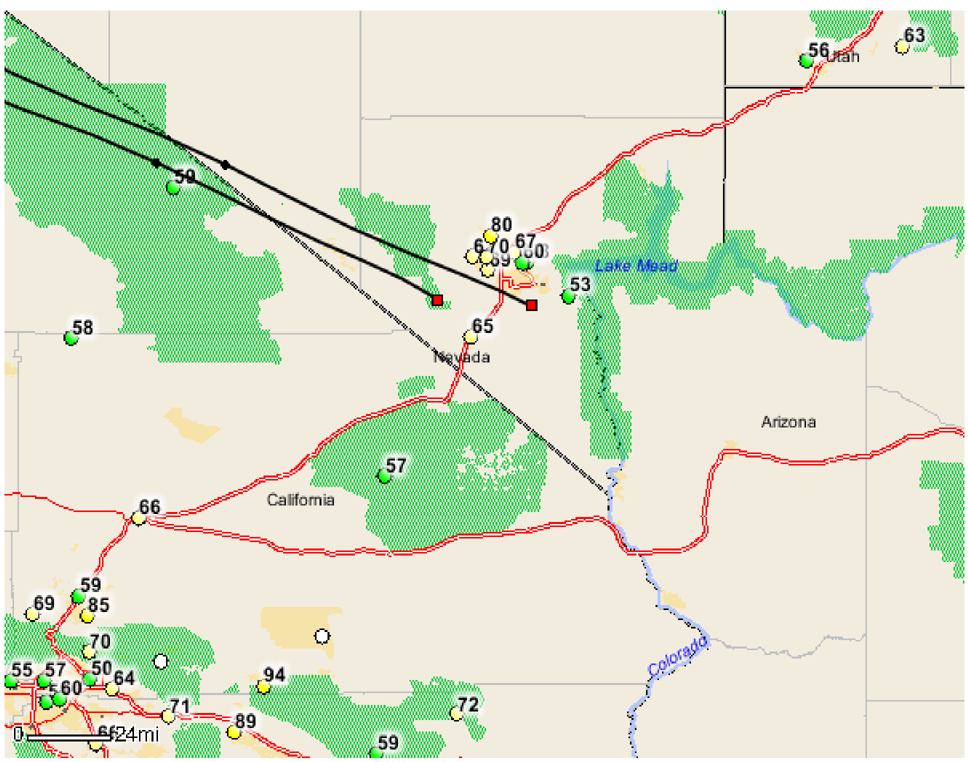


Figure 19. 24-Hour Back Trajectory at 3,000 m AGL at 6 p.m. on June 30 from Arden Peak and SMYC Monitoring Sites.

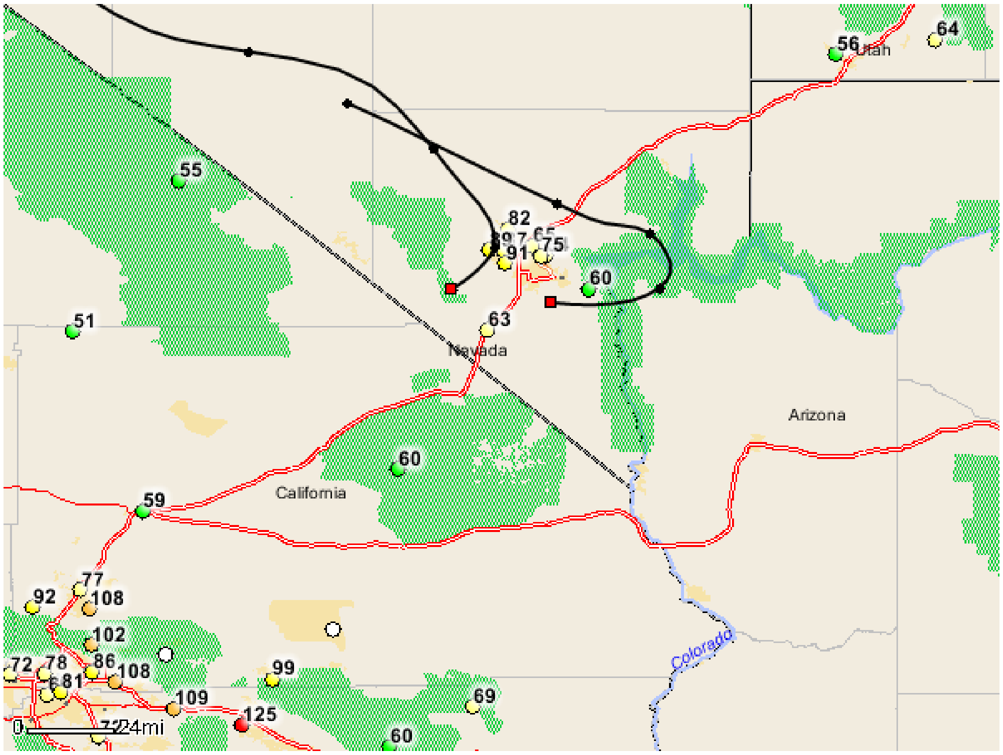


Figure 20. 24-Hour Back Trajectory at 3,000 m AGL at 6 p.m. on July 1 from Arden Peak and SMYC Monitoring Sites.

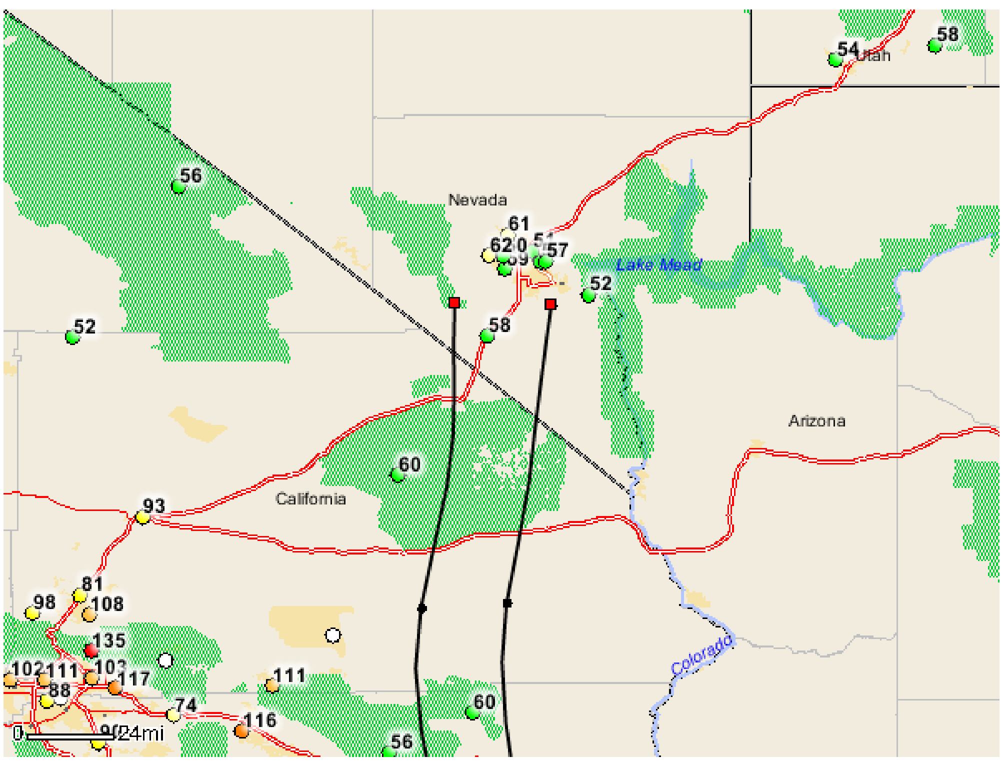


Figure 21. 24-Hour Back Trajectory at 3,000 m AGL at 6 p.m. on July 2 from Arden Peak and SMYC Monitoring Sites.

Figure 22 shows hourly ozone averages at four monitoring sites from June 30 through July 3, with a distinct diurnal pattern on all four days. Hourly concentrations are the highest at the Paul Meyer and Walter Johnson sites on July 1–2, exceeding 100 ppb on July 1.

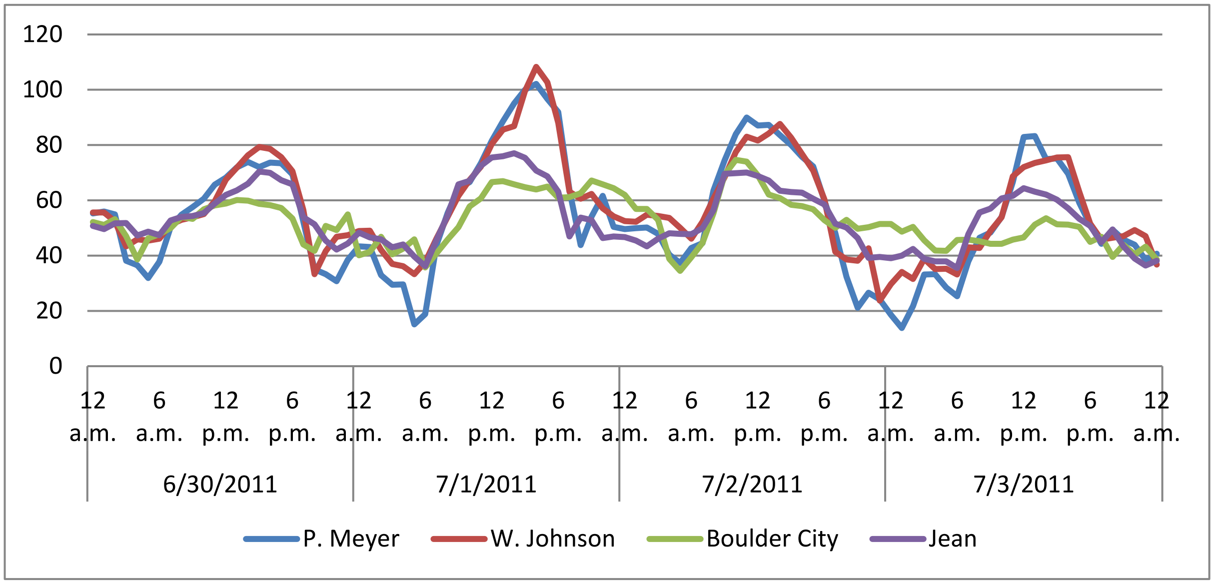


Figure 22. Hourly Ozone Concentrations (ppb) at Selected Permanent Sites.

The inversion broke at approximately 9 a.m. on July 1, with a mixing height of 6,070 ft at 11 a.m. and a maximum mixing height of 7,800 ft at 2 p.m. Mixing heights and hourly ozone concentrations at Arden Peak and Mt. Pass suggest that the upper-air ozone reservoir may have affected monitoring sites at the valley floor. Ozone concentrations at elevated sites began to equalize after 9 a.m., when the inversion broke and mixing began.

Upper-air ozone trapped above the inversion layer the night before carried over into the morning hours on July 2. The inversion broke at approximately 9 a.m., with a mixing height of 5,680 ft at 9 a.m. and a maximum mixing height of 9,270 ft at 4 p.m. As with the previous day, monitoring data from Arden Peak and Mt. Pass, combined with the timing of ozone concentrations at the valley floor, suggest that the upper-air ozone reservoir may have increased ozone concentrations at valley floor sites. Lower concentrations at SMYC were probably due to the increasing mixing height and corresponding pollutant dispersion. A brief period of gusty winds between 1 p.m. and 4 p.m. helped disperse ozone during the afternoon hours.

2.6.3 Pollutant Transport and Local Emission Impacts on Ozone Concentrations

High-pressure systems in the northern hemisphere have regional-scale winds that flow in a clockwise direction, and this flow caused the Las Vegas Valley plume to affect even the Jean site on July 1. This assessment is supported by the HYSPLIT 24-hour back trajectory shown in Figure 23. The trajectory begins at 6 p.m. on July 1 from the Jean and Paul Meyer monitoring sites; the values shown are hourly ozone concentrations at that time. Local emissions of ozone precursor pollutants appear to have been a significant factor in elevated concentrations on July 1, with transport of pollutants into Clark County playing a lesser role.

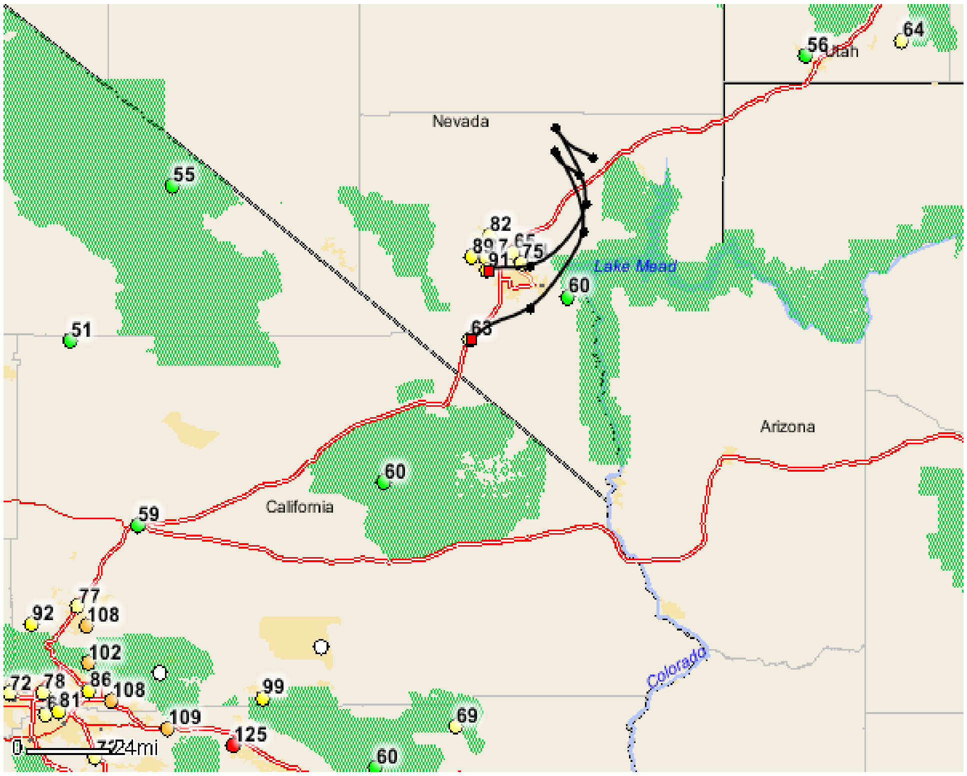


Figure 23. HYSPLIT 24-Hour Back Trajectory (10 m AGL) at 6 p.m. on July 1 from Jean and Paul Meyer Monitoring Sites.

Figure 24 shows a HYSPLIT 24-hour back trajectory at a 10-m height at 6 p.m. on July 2 from the Jean and Paul Meyer monitoring sites. The high-pressure system was strengthening on July 2, and although conditions remained stagnant, the prevailing near-surface wind flow had shifted to the south by then, enhancing the role of pollutant transport into Clark County.

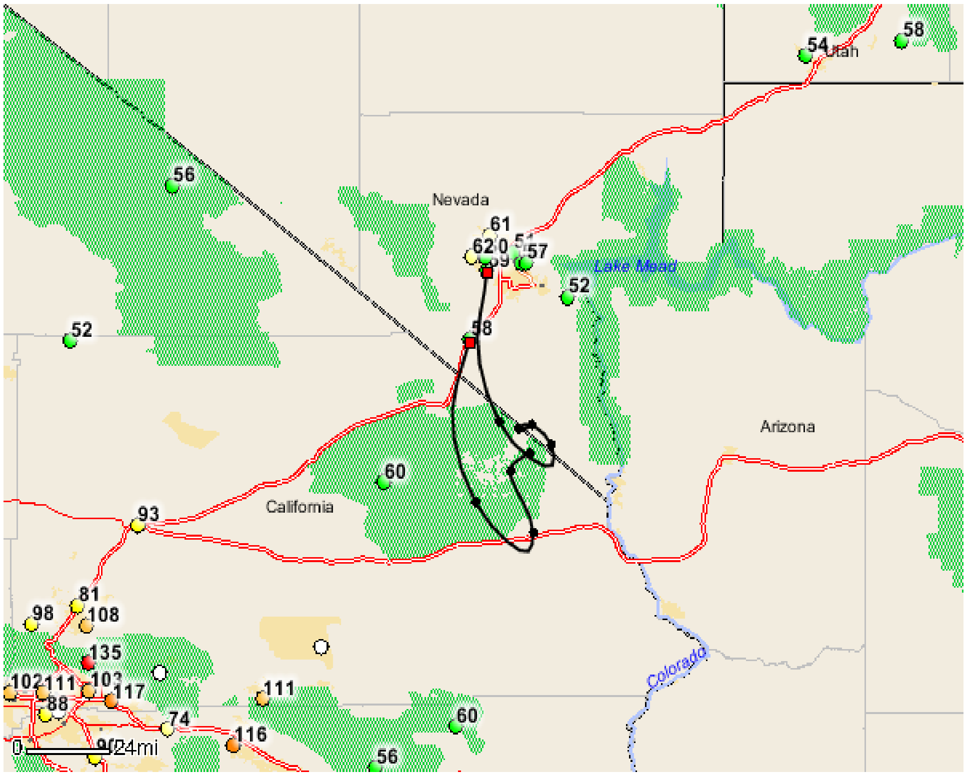


Figure 24. HYSPLIT 24-Hour Back Trajectory (10 m AGL) at 6 p.m. on July 2 from Jean and Paul Meyer Monitoring Sites.

Local emissions of ozone precursors appear to be the dominating variable in elevated ozone concentrations on July 1, with transport playing a smaller role. On July 2, with prevailing winds originating from the south and stagnant conditions continuing under the high-pressure system, pollutant transport was becoming a significant, if not dominating, variable. Local emissions were a significant factor on both days in high ozone concentrations at monitoring sites in the northwest.

2.7 JULY 21 EPISODE

2.7.1 Air Quality and Meteorology

Table 6 shows 8-hour average ozone concentrations for July 20—22, 2011. July 21 was characterized by clear skies and normal temperatures, but five permanent monitoring sites exceeded 75 ppb that day: Paul Meyer, Walter Johnson, Palo Verde, Joe Neal, and Jean. The high temperature recorded at McCarran International Airport on that date was 103°F at 4 p.m. Meteorological conditions produced dry southwesterly winds at the surface and aloft, which are conducive to pollutant transport into southern Nevada. These flows were caused by a trough moving southward over the Pacific Northwest.

Table 6. 8-Hour Average Ozone Concentrations, July 20-22, 2011

Sites	Dates		
	Wed (7/20/11)	Thu (7/21/11)	Fri (7/22/11)
Apex	63	70	63
Mesquite	46	53	54
Paul Meyer	67	77	61
Walter Johnson	65	73	60
Palo Verde	68	81	63
Joe Neal	65	77	64
Winterwood	62	70	64
Jerome Mack	63	70	63
Boulder City	57	65	64
Jean	69	80	70
Sandy Valley	58	70	57
J.D. Smith	63	71	61
SMYC	70	83	81
Mt. Pass	70	82	72
Arden Peak	68	83	75

2.7.2 Upper-Air Ozone Reservoir and Ground-Level Ozone Concentrations

Figure 25 is a time-series plot of hourly ozone concentrations at the seasonal elevated sites for July 20–22. Westerly to southwesterly wind patterns prevailed in the upper air on July 21 (Figure 26).

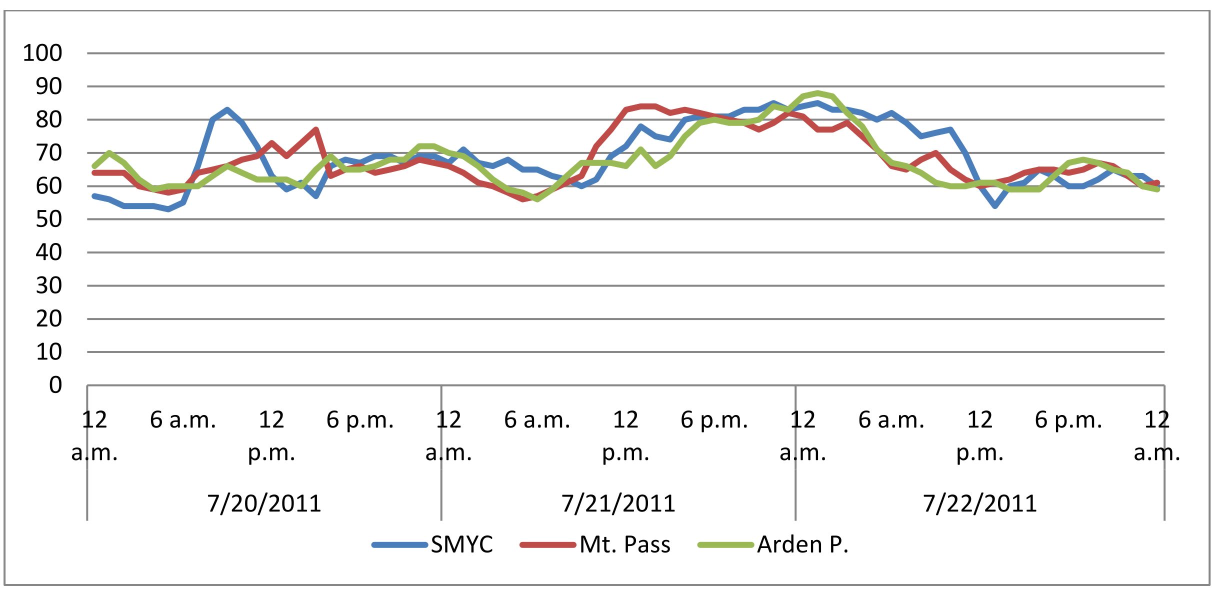


Figure 25. Hourly Ozone Concentrations (ppb) at Seasonal Elevated Sites.

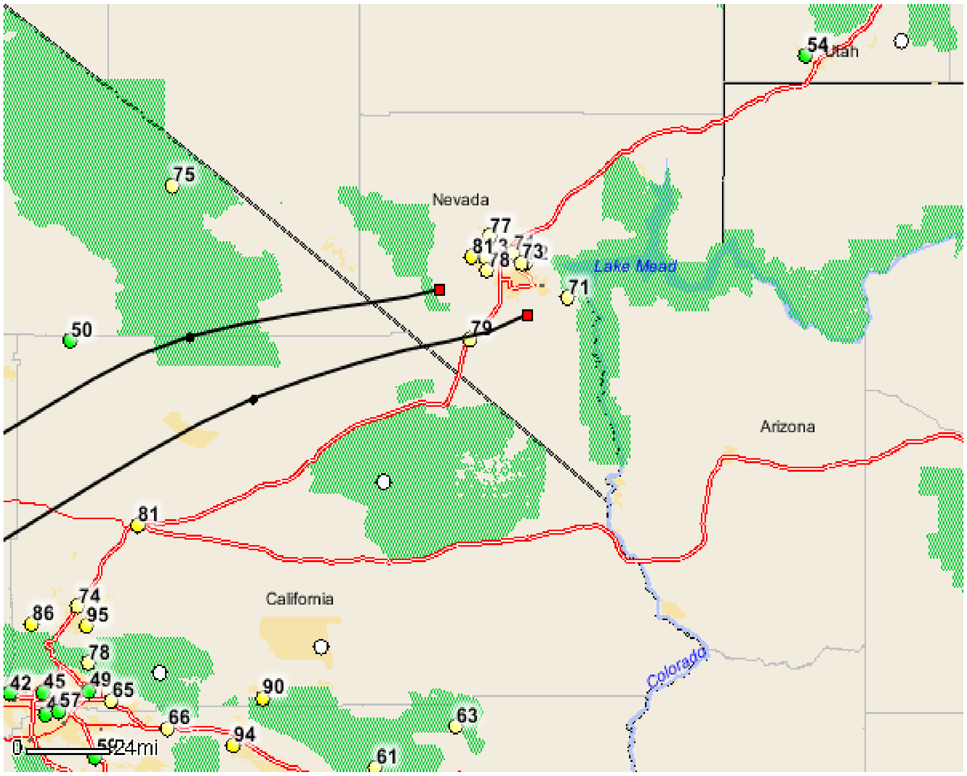


Figure 26. **HYSPLIT 24-Hour Back Trajectory (3,000 m AGL) at 6 p.m. on July 21 from Vicinity of Arden Peak and SMYC Monitoring Sites.**

Figure 27 is a time-series plot of hourly ozone concentrations for select permanent monitoring site during the same time frame. On July 21, Palo Verde recorded its highest hourly peak (86 ppb) at 2 p.m. The highest hourly peak at Jean (84 ppb) occurred at 4 p.m., and the highest hourly peak at Winterwood (78 ppb) occurred at 5 p.m.

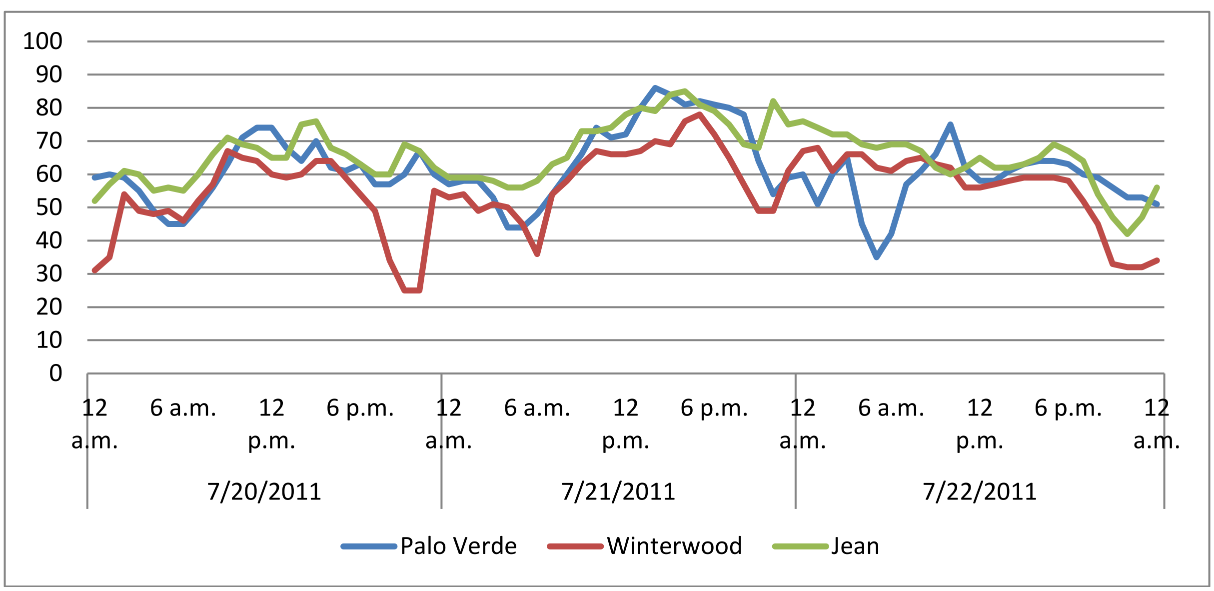


Figure 27. **Hourly Ozone Concentrations (ppb) at Selected Permanent Monitoring Sites.**

The inversion broke at approximately 9 a.m. on July 21, and by 11 a.m. the mixing height had reached 5,559 ft. The height increased to 6,596 by 12 p.m. and reached a maximum of 9,886 ft at 3 p.m. Air quality and meteorological data show no evidence of upper-air ozone reservoir impacts on the valley floor; the rising ozone levels at valley floor monitoring sites seem due primarily to increasing southwesterly wind speeds and pollutant transport.

2.7.3 Pollutant Transport and Local Emission Impacts on Ozone Concentrations

Southwesterly wind patterns at the surface and aloft, combined with the 80 ppb 8-hour average ozone concentration at the Jean site, indicate that transport of ozone and precursors into Clark County caused high ozone concentrations. Figure 28, a 24-hour HYSPLIT back trajectory from the Jean and Paul Meyer monitoring sites, illustrates southwesterly wind patterns at the surface. A wildfire southeast of Fresno on July 20 may have impacted ozone concentrations in the Las Vegas Valley. This issue is discussed in more detail in Section 4 Regression Modeling.

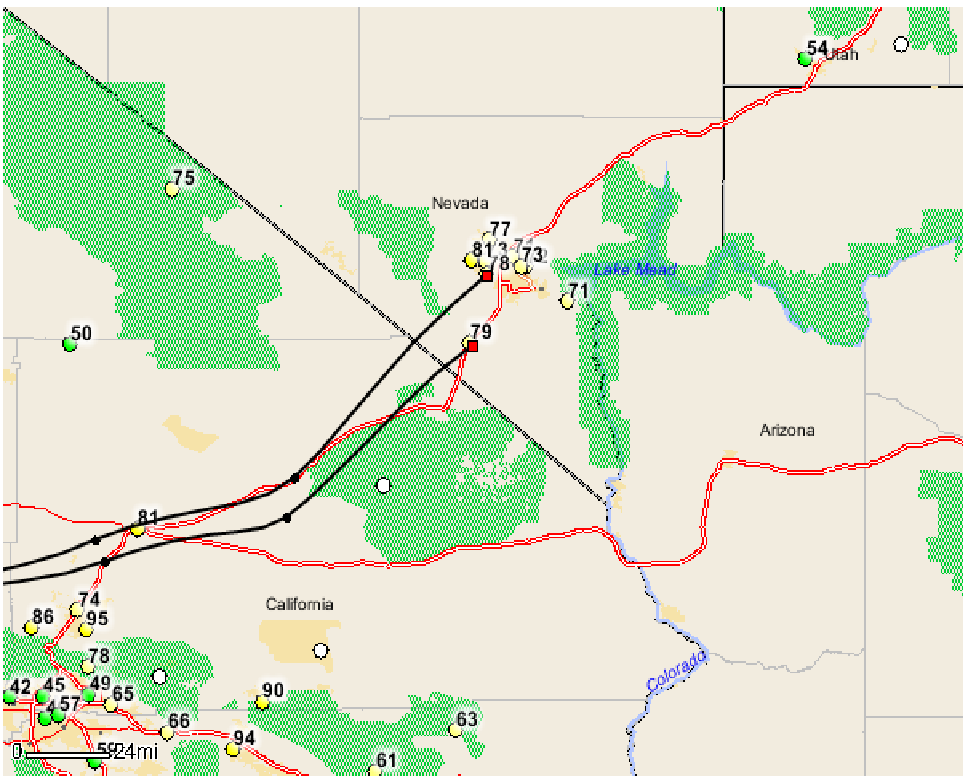


Figure 28. HYSPLIT 24-Hour Back Trajectory (10 m AGL) at 5 p.m. on July 21 from Jean and Paul Meyer Monitoring Sites.

2.8 AUGUST 28 EPISODE

2.8.1 Air Quality and Meteorology

Table 7 shows 8-hour average ozone concentrations for August 27–29, 2011. Ozone readings at three sites exceeded 75 ppb on August 28: Walter Johnson, Palo Verde, and Joe Neal. An upper-air trough over the Pacific Northwest on August 28 maintained a dry southwesterly wind pattern over the Las Vegas Valley, with clear skies and a high temperature of 103°F recorded at 4 p.m. at McCarran International Airport.

Table 7. 8-Hour Average Ozone Concentrations, August 27-29, 2011

Sites	Dates		
	Sat (8/27/11)	Sun (8/28/11)	Mon (8/29/11)
Apex	59	65	61
Mesquite	51	49	50
Paul Meyer	61	72	60
Walter Johnson	60	76	59
Palo Verde	66	77	64
Joe Neal	63	77	66
Winterwood	54	65	58
Jerome Mack	57	67	60
Boulder City	55	59	56
Jean	56	67	61
Sandy Valley	51	57	49
JD Smith	57	69	60
SMYC	64	66	67
Mt. Pass	61	65	61
Arden Peak	66	64	61

2.8.2 Upper-Air Ozone Reservoir and Ground-Level Ozone Concentrations

Figure 29 is a time-series plot of hourly ozone concentrations at the seasonal elevated sites for August 27–29. Minimal diurnal variation occurred in hourly ozone concentrations on August 28 at all sites except Arden Peak. The highest hourly peak for the three sites occurred between 4 p.m. and 6 p.m. on August 28.

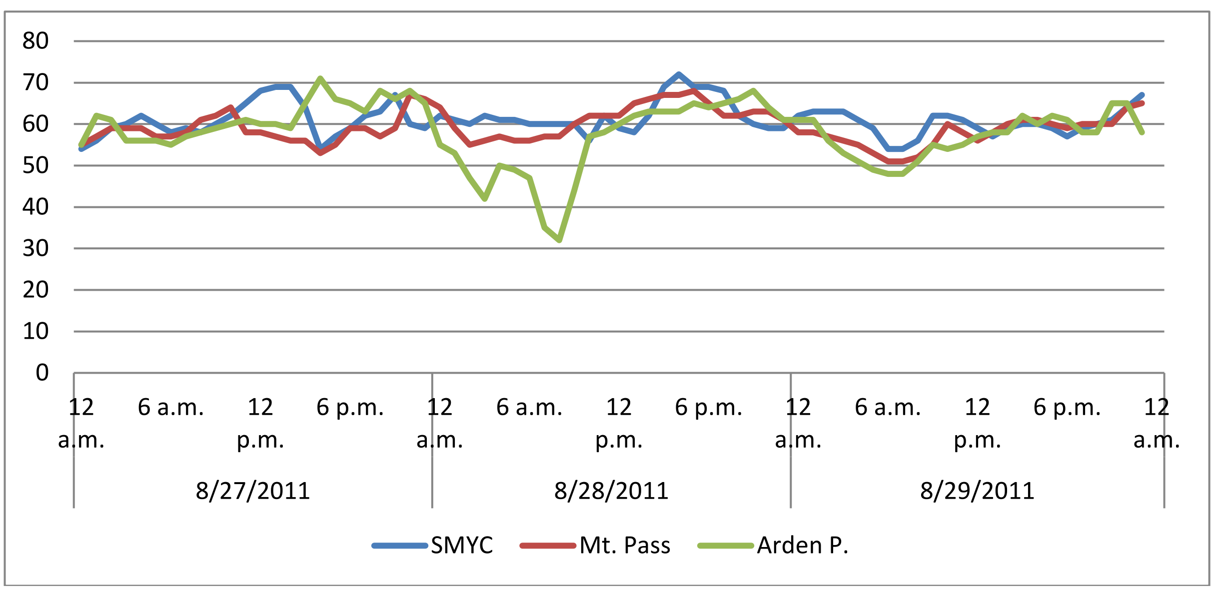


Figure 29. Hourly Ozone Concentrations (ppb) at Seasonal Elevated Sites.

Figure 30, a HYSPLIT 24-hour back trajectory from the Arden Peak and SMYC sites, shows that winds aloft were south-to-southwest.

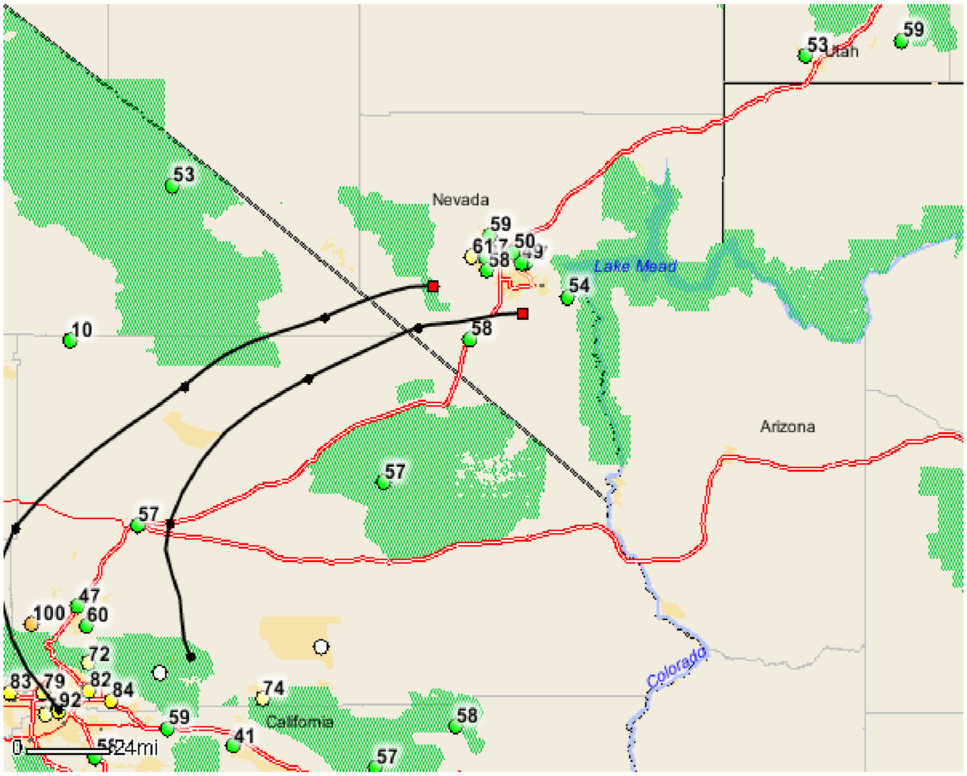


Figure 30. HYSPLIT 24-Hour Back Trajectory (3,000 m AGL) on August 28 at 6 p.m. from Arden Peak and SMYC Monitoring Sites.

Figure 31 provides time-series plots of hourly ozone concentrations at four permanent sites for the same time frame. The highest hourly concentrations at the Jean site were slightly above 60 ppb on August 27, increasing to approximately 69 ppb at 2 p.m. and 4 p.m. on August 28. On August 29, hourly ozone concentrations at the four sites exhibited a pattern similar to that on August 27, with the highest hourly concentrations at the Jean site again just above 60 ppb. All four sites sampled their highest hourly ozone concentrations on August 28, with Walter Johnson, Palo Verde, and Joe Neal approaching or exceeding 90 ppb.

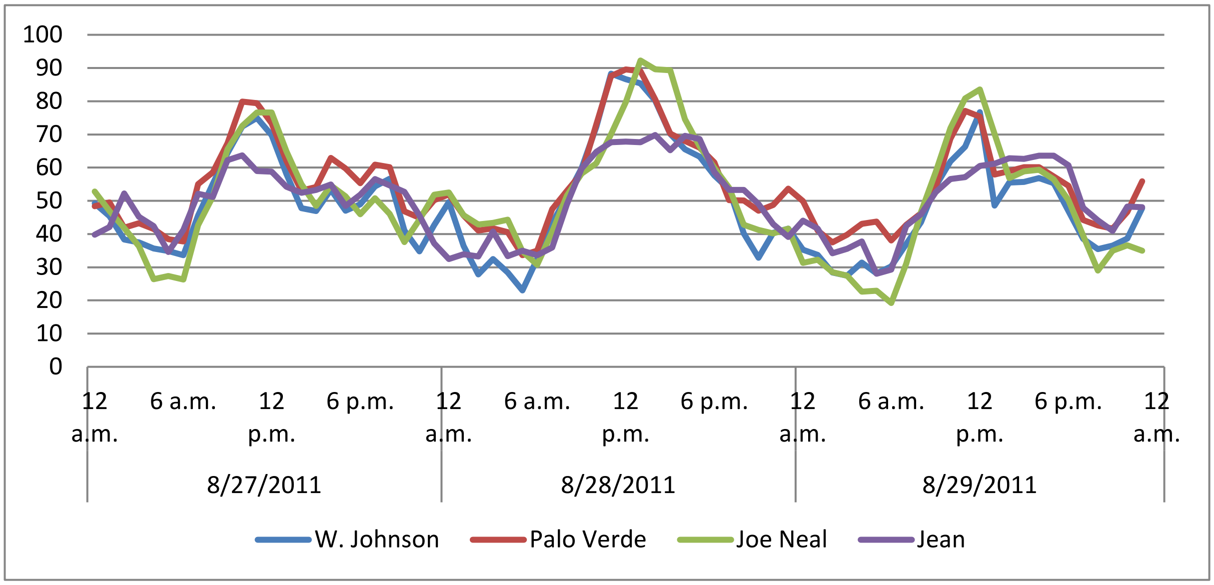


Figure 31. Hourly Ozone Concentrations (ppb) at Selected Permanent Sites

The inversion broke at approximately 9:00 a.m. on August 29, with a maximum mixing height of 6,120 ft at 3:00 p.m. Ozone concentrations at the elevated sites (Figure 29) equalized about this time due to pollutant dispersion within the mixing layer. Air quality and meteorological data offer little evidence that the upper-air reservoir affected monitoring sites at the valley floor.

2.8.3 Pollutant Transport and Local Emission Impacts on Ozone Concentrations

Figure 32, a HYSPLIT 24-hour back trajectory from the Jean and Paul Meyer sites, illustrates southwesterly wind patterns near the ground surface at 6:00 p.m. on August 28. A wildfire in the Mohave National Preserve, called the Wells wildfire (Figure 33), was in progress on August 28 and was not fully contained until August 31. A total of 1,723 acres burned prior to containment. Air quality data and wind trajectories suggest that the smoke plume missed the Jean monitoring site, but parts of the Las Vegas Valley appear to have been affected; $PM_{2.5}$ concentrations rose at the J.D. Smith monitoring site in North Las Vegas and other particulate matter monitoring sites in Las Vegas and Henderson, but the evidence is inconclusive.

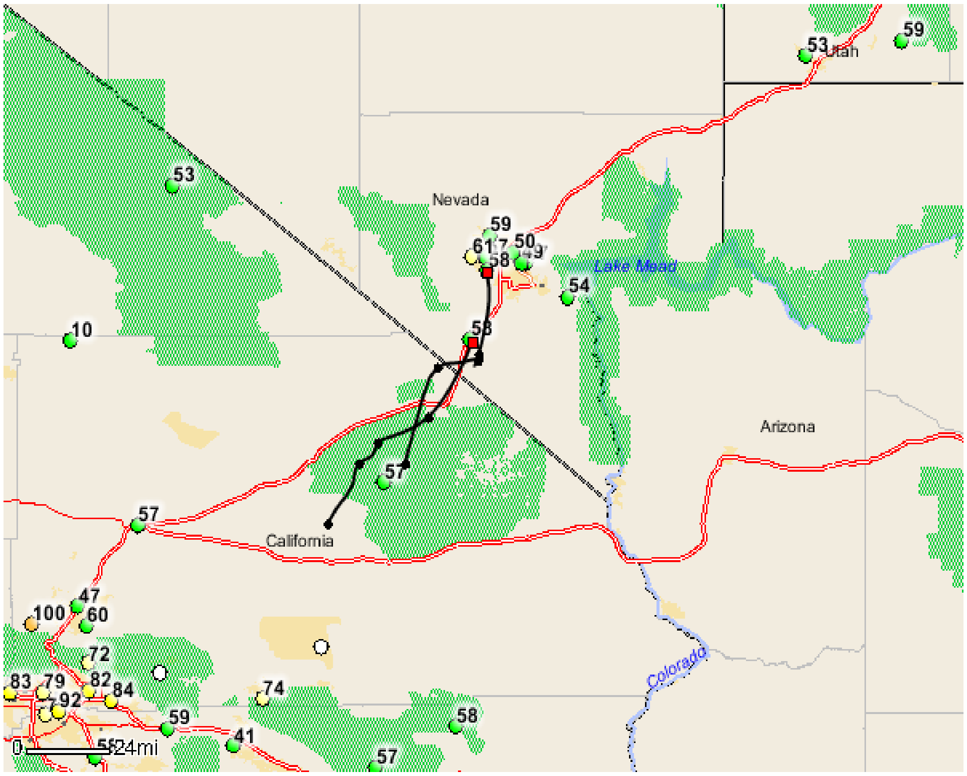
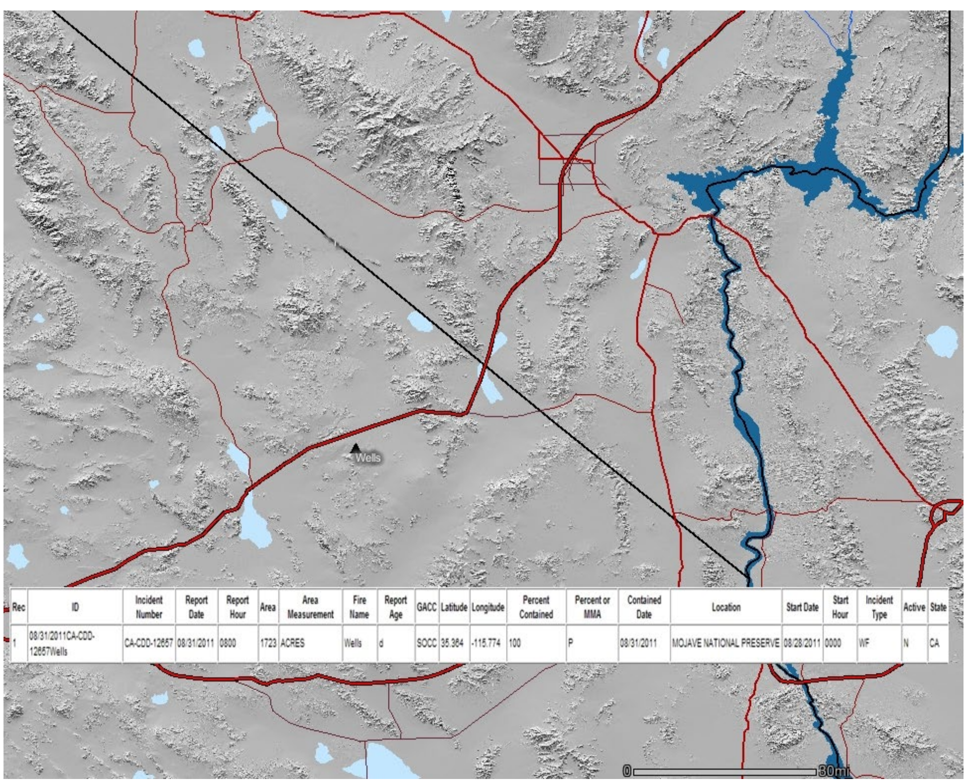


Figure 32. HYSPLIT 24-Hour Back Trajectory (10 m AGL) on August 28 at 6 p.m. from Jean and Paul Meyer Monitoring Sites.



Rec	ID	Incident Number	Report Date	Report Hour	Area	Area Measurement	Fire Name	Report Age	GACC	Latitude	Longitude	Percent Contained	Percent or MMA	Contained Date	Location	Start Date	Start Hour	Incident Type	Active	State
1	08/31/2011CA-CDD-12657Wells	CA-CDD-12657	08/31/2011	0800	1723	ACRES	Wells	d	SOCC	35.384	-115.774	100	P	08/31/2011	MOJAVE NATIONAL PRESERVE	08/28/2011	0000	WF	N	CA

Figure 33. Wells Wildfire Location.

It appears that elevated ozone concentrations on August 28 were caused by a combination of pollutant transport and local emissions, with local emissions the dominant variable. Ozone transported into Clark County was a combination of anthropogenic sources, precursor pollutants, and perhaps smoke plume impacts from the Wells wildfire. Local emissions had a significant impact on elevated ozone levels at monitoring sites in the northwest; high concentrations at the Walter Johnson, Palo Verde, and Joe Neal sites exhibit a typical diurnal pattern where, due to solar-induced terrain heating, drainage flows toward Lake Mead cease and an upslope flow to the west and northwest begins. This flow towards the west and northwest, which includes transported pollutants and local emissions, exacerbates ozone concentrations in the northwest.

3.0 CONFIRMATION OF AIR QUALITY MODELING FOR OZONE

DAQEM uses the Community Multi-scale Air Quality (CMAQ) modeling system to simulate ozone pollution in Clark County. CMAQ is supported by the Community Modeling and Analysis System (CMAS) Center, and is one of the models EPA recommends. It includes state-of-the-art capabilities for conducting urban- to regional-scale simulations of multiple air quality issues, including tropospheric ozone. The model is used to evaluate control measure impacts on air quality, a critical component of the ozone SIP.

The CMAQ model was used to generate daily maximum 8-hour average ozone concentrations for May 27, 2003 (Figure 34). Areas in red are modeled 8-hour average ozone concentrations near ground level that range from 90–100 ppb. The modeling run indicated high ozone concentrations in elevated areas northwest and south of the Las Vegas Valley, where two of the seasonal elevated sites (SMYC and Arden Peak) lie. Mt. Pass lies within the tan area, where modeled 8-hour average ozone concentrations range from 85–90 ppb.

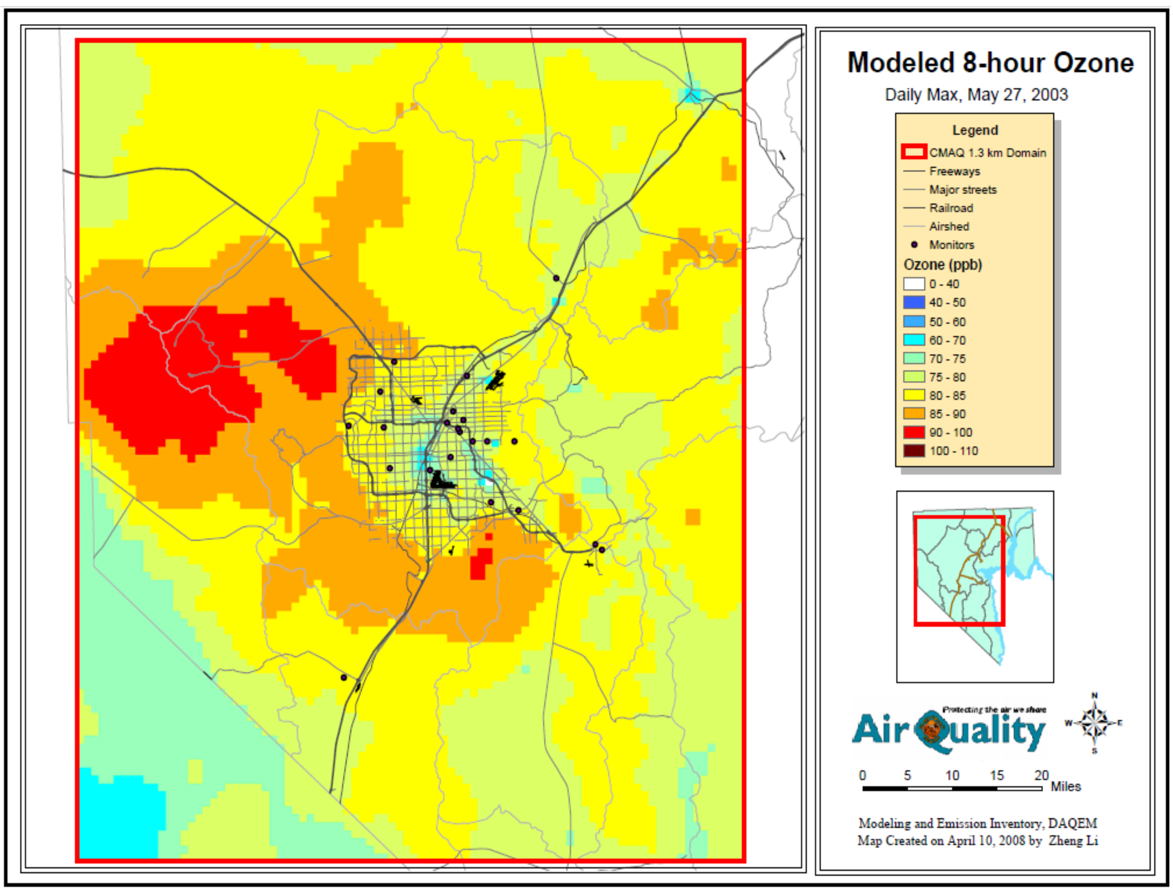


Figure 34. CMAQ Model of Maximum 8-Hour Average Ozone Concentrations on May 27, 2003.

There were 10 days in the 2011 ozone season where 8-hour average ozone concentrations at a permanent monitoring site equaled or exceeded 75 ppb. Table 8 shows concentrations at the seasonal elevated sites on those days, which were generally lower than modeled concentrations for

May 27, 2003. This result is not surprising, given the improvements in ozone air quality across the Southwest in the last few years after the implementation of control measures to reduce emissions of ozone precursor pollutants. However, the modeling results for 2003 also indicated elevated ozone concentrations in areas well above the valley floor, and readings at the seasonal elevated sites confirmed these predictions.

Table 8. 8-Hour Average Ozone Concentrations at Seasonal Elevated Sites on High Pollution Days

Elevated Sites	Days Where 8-Hour Average Ozone Concentrations ≥ 75 ppb at Permanent Monitoring Site									
	6/14	6/15	6/16	6/18	6/21	6/26	7/1	7/2	7/21	8/28
SMYC	70	75	79	70	66	77	84	68	83	66
Mt. Pass	67	76	80	72	80	72	82	76	82	65
Arden P.		84	86	78	77	77	83	72	83	64

4.0 REGRESSION MODELING

4.1 DEVELOPMENT OF THE REGRESSION MODEL

The U.S. EPA's "Omnibus Meteorological Data Set" (OMD) and daily peak 8-hour average ozone concentrations (≥ 75 ppb) of local and upwind areas of the Las Vegas Valley were used to develop a statistical model to identify wildfire events and study their relationships to high ozone episodes. The summer season data collected for development of the statistical model was from calendar years 2004 through 2008 when wildfire impacts were not suspected.

In general, trajectories should not be interpreted as precise tracks of air parcels entering the specific area. Patterns that emerge when analyzing a relatively large number of trajectories provide a good indication of potential transport due to the prevailing large-scale flow regime. Utilizing back-trajectories calculated from the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model for the Las Vegas Valley, combined with a cluster analysis methodology, seven clusters are calculated and shown in Figure 35. A statistical model was then developed for each cluster by using polynomial regression equations with meteorological predictors and observed peak ozone mixing ratios. The means for observed concentrations and model predictions are both ~64.5 ppb and the standard deviations are ~9.6 and ~8.5 ppb, respectively. The correlation of the model's result is 0.88.

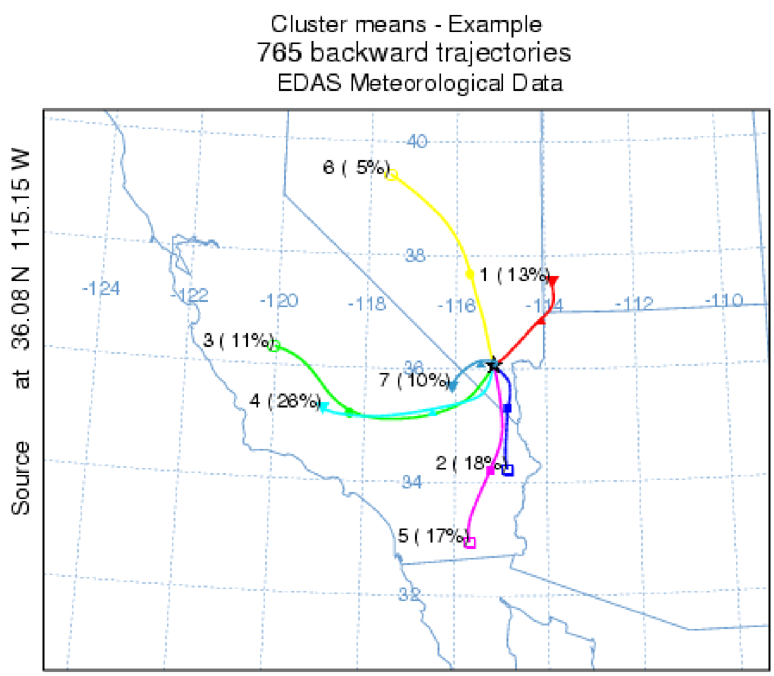


Figure 35. Mean Trajectory Path for Each Cluster.

Figure 36 shows observed peak 8-hour average ozone concentrations and model predicted values on wildfire days for the calendar year 2004-2008 timeframe. Model predicted values are based on their assigned clusters to examine the impact of wildfire events. For example, model predicted values reflect expected peak 8-hour average ozone concentrations without wildfire impacts. This modeling tool is used in exceptional event demonstrations, as a part of the weight of evidence, to show that ozone concentrations would not have exceeded NAAQS in the absence of wildfire impacts.

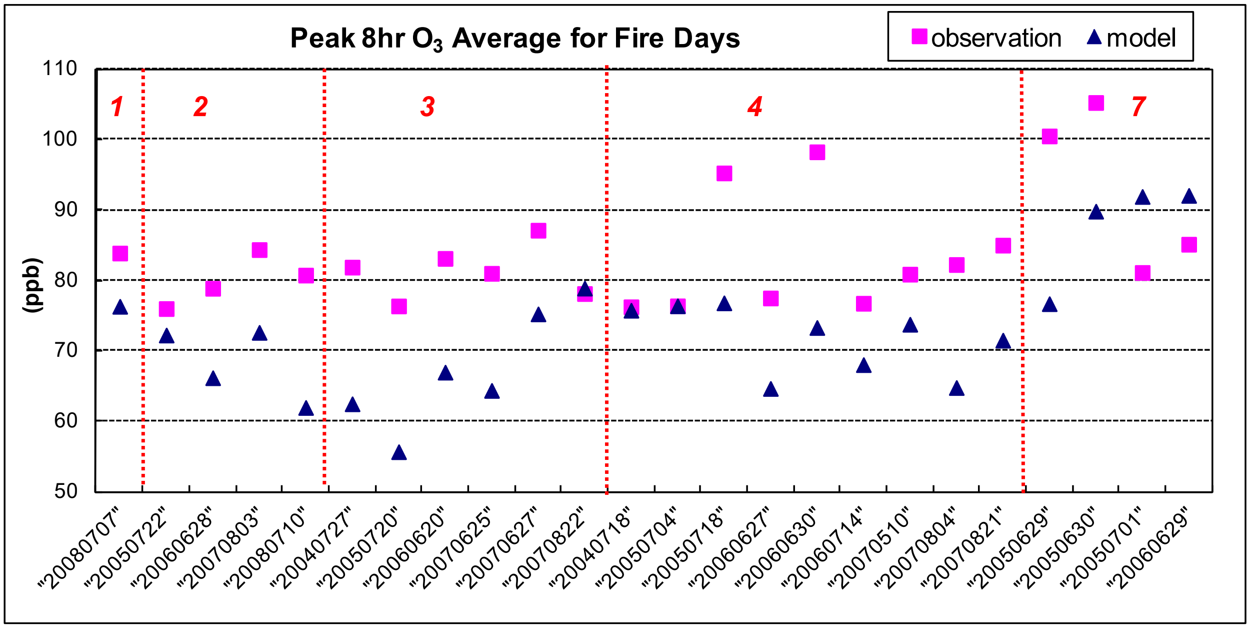


Figure 36. **Model Predictions and Observed Concentrations on Wildfire Days (2004-2008).**

4.2 APPLICATION OF THE REGRESSION MODEL TO 2011 SUMMER DATA

The appropriate cluster number was assigned to each day in June, July, and August. The regression model was then applied to generate model predictions. Figure 37 shows the time series of peak 8-hour average ozone concentrations for observed concentrations and model predicted concentrations during the 2011 summer season. Model predicted concentrations capture the trend of observed concentrations.

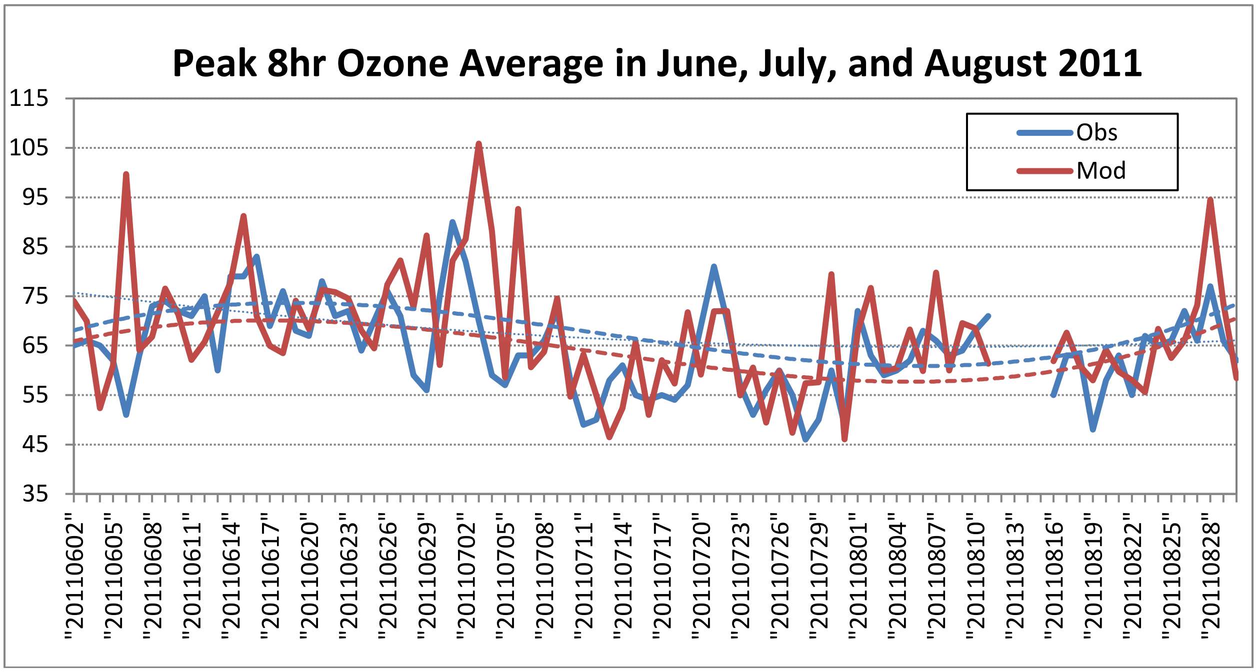


Figure 37. Time Series of Peak 8-Hour Average Ozone Concentrations the 2011 Ozone Season.

Table 9 shows both observed concentrations and model predicted concentrations for the ten ozone episode days during the 2011 summer season. There are three episode days (June 16 and 18, and July 21) where model predictions are lower than the NAAQS of 75 ppb. Model predictions that are lower than observed concentrations may relate to upper air ozone impacts on valley floor ozone concentrations which the regression modeling fails to reflect.

Table 9. Observed and Model Predicted Peak 8-hour Average Ozone Concentrations for the10 Episode Days

Cluster	Date	Observed	Model Predicted
7	"20110614"	79	77.76
7	"20110615"	79	91.25
3	"20110616"	83	70.94
4	"20110618"	76	63.46
1	"20110621"	78	76.29
4	"20110626"	76	77.31
1	"20110701"	90	82.14
7	"20110702"	82	86.56
3	"20110721"	81	71.93
7	"20110828"	77	94.51

On June 16 and June 18, for example, elevated monitoring sites were sampling hourly ozone concentrations considerably greater than seasonal averages for these sites. On June 16, average hourly ozone concentrations at SMCY, Mt. Pass, and Arden Peak were 73, 74, and 80 ppb, respectively. The June mean hourly average was 65 ppb for SMYC and Mt. Pass and 65 ppb for Arden Peak. The observed peak 8-hour average ozone concentration on July 21 (81 ppb) may have been related to a wildfire located in California southeast of Fresno. Figure 38 shows the location of that fire and the associated smoke plume. Figure 39 depicts a 24-hour back trajectory on July 21 which suggests that the smoke plume impacted the Las Vegas Valley exacerbating ozone concentrations.

Figure 38. Wildfire and Smoke Plume on July 20, 2011.

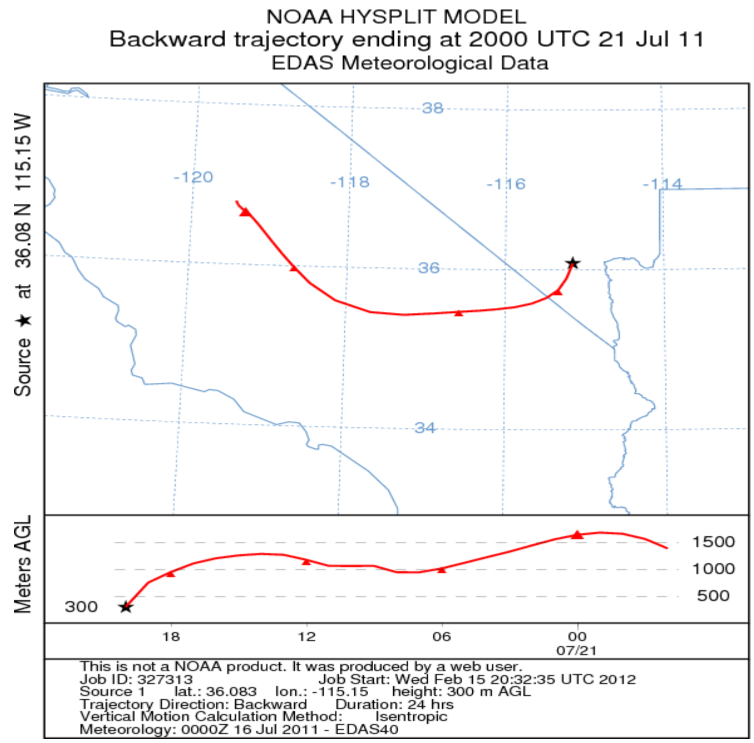


Figure 39. 24-Hour Back Trajectory on July 21, 2011.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Meteorological patterns during the 2011 season were not consistent with those that occurred during previous technical studies. The passage of low-level troughs which initiate southwesterly winds and pollutant transport from population centers in California occurred in 2011, but the predominating high pressure systems preceding trough passages were largely absent. HYSPLIT Model back trajectories for trough passages in 2011, as in previous technical studies, show source areas that include the Los Angeles Basin, the western Mojave Desert, and central California.

Elevated ozone concentrations occur more often in June and July, before the onset of the monsoonal season, with the highest concentrations in the northwest quadrant of Clark County. Local emissions of precursor pollutants can be a significant factor in high ozone concentrations, particularly under stagnant conditions. Previous technical studies deployed ozone analyzers at supplemental sites further north (e.g., Indian Springs, Paiute Reservation), and these sites often recorded the highest ozone concentrations in the study.

Ozone sampling was carried out in the Sandy Valley area this summer to test whether it was a potential transport pathway into Clark County. However, the Jean site consistently recorded higher ozone concentrations. Although concentrations recorded at the Sandy Valley site illustrate the regional nature of ozone, the Jean site is better located for characterizing pollutant transport into Clark County and future sampling is unnecessary.

Ozone concentrations recorded at the three seasonal elevated monitoring sites demonstrate that there is a significant reservoir of ozone aloft. The upper-air data collected during this study confirmed air quality modeling completed in 2003. DAQEM is currently developing new modeling applications based on more recent data and information from the three elevated sites is useful in these work activities. The data from these three sites are surprisingly consistent, despite differences in location and elevation, indicating a widespread upper-air reservoir with deep vertical dimensions. Table 10 compares the mean and maximum hourly ozone concentrations at these three sites during the 2011 study.

Table 10. Mean and Maximum Hourly Ozone Concentrations at Seasonal Elevated Sites

Sites	June		July		August	
	Mean	*Maximum*	*Mean*	*Maximum*	*Mean*	*Maximum*
SMYC	62	86	55	91	60	76
Mt. Pass	62	86	54	86	59	74
Arden Peak	65	90	54	88	59	76

There were 10 episode days when 8-hour average ozone concentrations at one or more permanent monitoring sites exceeded 75 ppb during the 2011 ozone season. Average hourly ozone concentrations at elevated sites on episode days were generally higher than their monthly seasonal averages. For example, on June 15, average hourly ozone concentrations at the SMYC and Mt. Pass elevated sites were 71 and 67 ppb, respectively. Mean hourly concentrations at SMYC and Mt. Pass for the month of June was 62 ppb. On June 16, average hourly ozone concentrations at SMCY, Mt. Pass, and Arden Peak were 73, 74, and 80 ppb, respectively. Arden Peak was offline on June 14 and June 15. This pattern was seen throughout the summer season with few exceptions. The exceptions were limited to June 14, June 21, and August 28 where hourly concentrations were comparable to the monthly seasonal average.

Air quality and meteorological data were evaluated to assess whether the reservoir of ozone aloft had affected ozone concentrations at monitoring sites on the valley floor. Ozone air pollution is a complex process; data limitations relating to both ozone air quality and meteorology did not allow for a quantitative assessment, but simply a qualitative judgment on the potential for impacts. Table 11 lists those high-episode days and provides a qualitative assessment on whether ozone aloft affected the valley floor.

Table 11. Upper-Air Ozone Impacts on Valley Floor Monitoring Sites

Episode Days	Upper Air Ozone Impacts on Valley Floor Monitoring Sites
June 14	Little or no impact based on available data.
June 15	Probable impact based on timing of mixing heights and hourly ozone concentrations.
June 16	Probable impact based on timing of mixing heights and hourly ozone concentrations.
June 18	Little or no impact based on available data.
June 21	No assessment; upper-air instrumentation was offline.
June 26	Probable impact based on timing of mixing heights and hourly ozone concentrations.
July 1	Probable impact based on timing of mixing heights and hourly ozone concentrations.
July 2	Probable impact based on timing of mixing heights and hourly ozone concentrations.
July 21	Little or no impact based on available data.
August 28	Little or no impact based on available data.

Ozone air quality and meteorological data were also evaluated to determine the respective roles of pollutant transport and local emissions on each episode day. All days will have some transport and local emission impacts, but there are some days where either local emissions or pollutant transport are the dominating variable. Table 12 summarizes these impacts on the 10 high-ozone days. The second column includes both permanent monitoring sites and the six seasonal monitoring sites deployed for this study. Local emissions appear to be the dominating variable in 5 of the 10 episode days, whereas pollutant transport into Clark County is the dominating variable in 4 of the 10 ozone episode days. On one day, July 2, both pollutant transport and local emissions were significant factors in elevated ozone concentrations.

Table 12. Pollutant Transport and Local Emission Impacts on Elevated Ozone Concentrations

Episode Days	No. Sites ≥ 75 ppb	Pollutant Transport/Local Emissions
June 14	3	Local emissions were the dominating influence.
June 15	4	Pollutant transport was the dominating influence.
June 16	14	Pollutant transport was the dominating influence.

June 18	2	Pollutant transport was the dominating influence.
June 21	3	Local emissions were the dominating influence.
June 26	7	Pollutant transport was the dominating influence.
July 1	7	Local emissions were the dominating influence.
July 2	5	Both local emissions and pollutant transport were significant contributors.
July 21	7	Local emissions were the dominating influence.
August 28	3	Local emissions were the dominating influence.

5.2 RECOMMENDATIONS

The development of a conceptual description of ozone air pollution in the Clark County nonattainment area is an important first step in guiding modeling analyses in future attainment demonstrations. Observed data on air quality and meteorology collected during ozone episodes enhances operational and diagnostic analyses on model performance. Characterizing elevated ozone episodes with respect to the role of pollutant transport versus local emissions, surface and upper air meteorology, and ozone concentrations at the surface and aloft also provides useful information in the development of a weight of evidence in support of modeling and attainment demonstrations.

The Laughlin area may be a transport pathway into the Las Vegas Valley where ozone sampling has yet to be carried out. Deployment of a seasonal ozone analyzer in this area is recommended for the 2012 summer season. Drought conditions in California and limited snowfall in mountain areas this winter season may also lead to an active wildfire season in 2012. Air quality monitoring in Laughlin may also provide useful data for exceptional event demonstrations if needed. Inspections of a potential site were conducted in 2011, and there is sufficient space for monitoring equipment at the Laughlin Government Center.

Elevated ozone concentrations occur most frequently in the northwest part of the Las Vegas Valley, but past research indicates the existing network may not be measuring the highest concentrations. For the 2012 ozone season, provided resources are available, ozone analyzers should be located at the extreme northwest end of the valley (e.g., Indian Springs and/or the Paiute Indian Reservation).

Previous technical studies and monitoring during the 2011 ozone season clearly demonstrate that ozone aloft is widespread, with deep vertical dimensions. Seasonal elevated sites for ozone sampling have so far been limited to the west and south sides of the Las Vegas Valley; candidate sites on the east and north side of the Las Vegas Valley should be identified for potential seasonal sampling during the 2012 summer season to further characterize the ozone reservoir in the upper atmosphere.

The department should also pursue a cooperative relationship with an appropriate entity (e.g., National Weather Service, Desert Research Institute) to measure ozone aloft when high-ozone episodes are anticipated. Balloon-borne measurements of temperature, relative humidity, winds (rawinsonde), and ozone (ozonesonde) would complement ozone measurements at the valley floor and elevated locations. Hourly measurements during those periods when elevated ozone concentrations are anticipated would permit improved characterization of ozone aloft and the research could be structured to allow for the impacts of ozone aloft on the valley floor monitoring network to be quantified.

The last comprehensive effort to model an ozone episode was in 2003. Several technical studies have been implemented since then to more fully characterize ozone air pollution in terms of the adequacy of the monitoring network, the roles of pollutant transport and local emissions, the upper-air ozone reservoir, wildfire-related impacts, and meteorological conditions. With continuing improvements to the CMAQ modeling system, DAQEM should undertake a simulation of more recent ozone episodes, perhaps after the 2012 summer season, to validate model performance. Future year modeling is not necessary for this effort. The focus should be on selecting meteorological episodes to model and generation of the appropriate air quality, meteorological, and emission inventory inputs. Model performance, could be then be evaluated with respect to actual observations with diagnostic tests as necessary. This effort would highlight problem areas and support future attainment demonstrations when control measure impacts on future air quality are assessed.

6.0 APPENDIX A. WEEKLY AIR QUALITY REPORTS

6.1 MAY 16-22, 2011

The highest 8-hour ozone concentration sampled at all ozone monitoring sites (permanent and seasonal sites) was 75 ppb at SMYC on May 22nd (Sunday). On the same date, the Arden Peak and Mt. Pass sites showed 8-hour ozone concentrations of 71 ppb and 69 ppb, respectively. The highest 8-hour ozone concentration sampled at our permanent sites also occurred on May 22nd (Jean, 69 ppb) with Walter Johnson, Palo Verde, and the Joe Neal monitoring sites recording 68 ppb on this date. The highest 8-hour concentrations sampled at key sites for the week (May 16-22, 2011) are presented below in Table 1.

Table 1. Highest 8-Hour Ozone Concentrations (ppb) at Selected Monitoring Sites (May 16-22, 2011)

Site	May 16	May 17	May 18	May 19	May 20	May 21	May 22
Walter Johnson	61	61	59	49	54	63	68
Palo Verde	57	60	55	47	50	62	68
Joe Neal	61	60	57	46	52	66	68
Jean	59	60	58	49	54	66	69
Sandy Valley	52	57	56	46	50	60	61
SMYC	65	67	65	52	55	65	75
Arden Peak	63	61	54	54	60	69	71
Mt. Pass	58	61	57	48	54	67	69

Throughout the week, ozone concentrations at the Sandy Valley site generally tracked significantly lower than values recorded at the Jean site. Figure 1 shows hourly concentrations for both sites during the seven day period May 16-22, 2011.

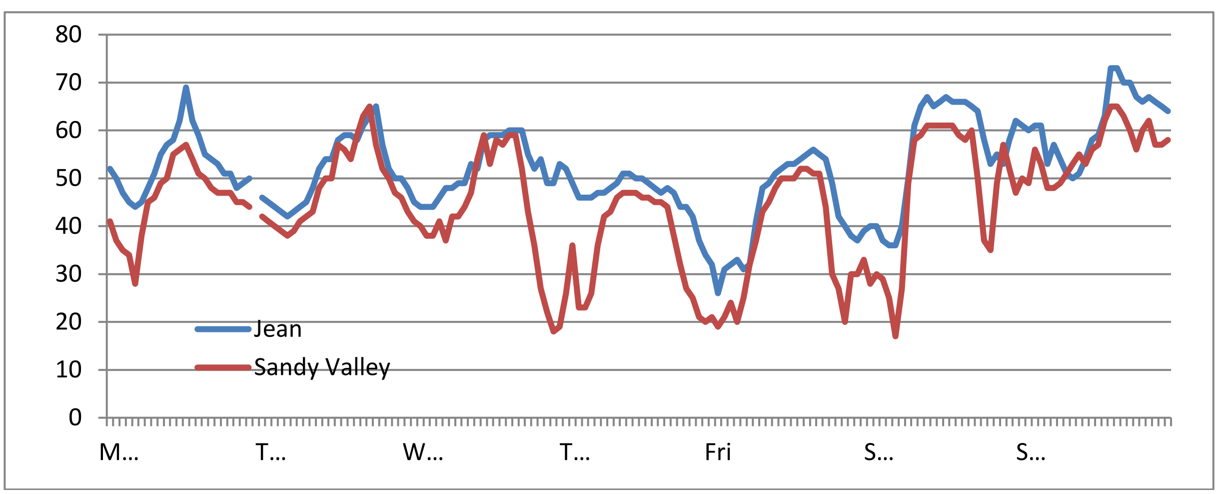


Figure 1. Hourly Ozone Concentrations (ppb) at the Jean and Sandy Valley Monitoring Sites (May 16-22, 2011)

6.2 MAY 23-29, 2011

With respect to our permanent sites, the highest 8-hour ozone concentration recorded for this week occurred on May 24th (Tuesday) at Paul Meyer (72 ppb). SMYC and Arden Peak, two of our three elevated sites, also recorded 8-hour ozone concentrations of 72 ppb on this date. The highest 8-hour ozone concentration for the week was sampled at the SMYC elevated site (79 ppb) on May 28th (Saturday) and is unusually high relative to sampled concentrations at other sites. This high value may be due to instrument error or other site issues (e.g., probe location relative to adjacent structures). An alternative explanation, if the sampled concentration is valid, may relate to wood smoke (i.e., fireplaces and barbecues) and biogenic emissions. Table 1 shows high 8-hour ozone concentrations for the week (May 23-29) at selected sites.

Table 1. Highest 8-Hour Ozone Concentrations (ppb) at Selected Monitoring Sites (May 16-22, 2011)

Site	May 23	May 24	May 25	May 26	May 27	May 28	May 29
Walter Johnson	66	70	65	60	50	54	59
Joe Neal	67	70	66	61	58	53	57
Paul Meyer	66	72	66	59	49	53	58
Jean	69	69	67	56	51	57	57
SMYC	69	72	69	56	58	79	63
Arden Peak	75	72	67	59	52	59	60
Mt. Pass	68	69	67	54	49	54	56

Figure 1 depicts hourly ozone concentrations (ppb) for the three elevated sites and Paul Meyer for the week (May 23-29, 2011). The highest 1-hour ozone concentration (88 ppb) occurred at 10 p.m. on Saturday (5/28) at the SMYC site.

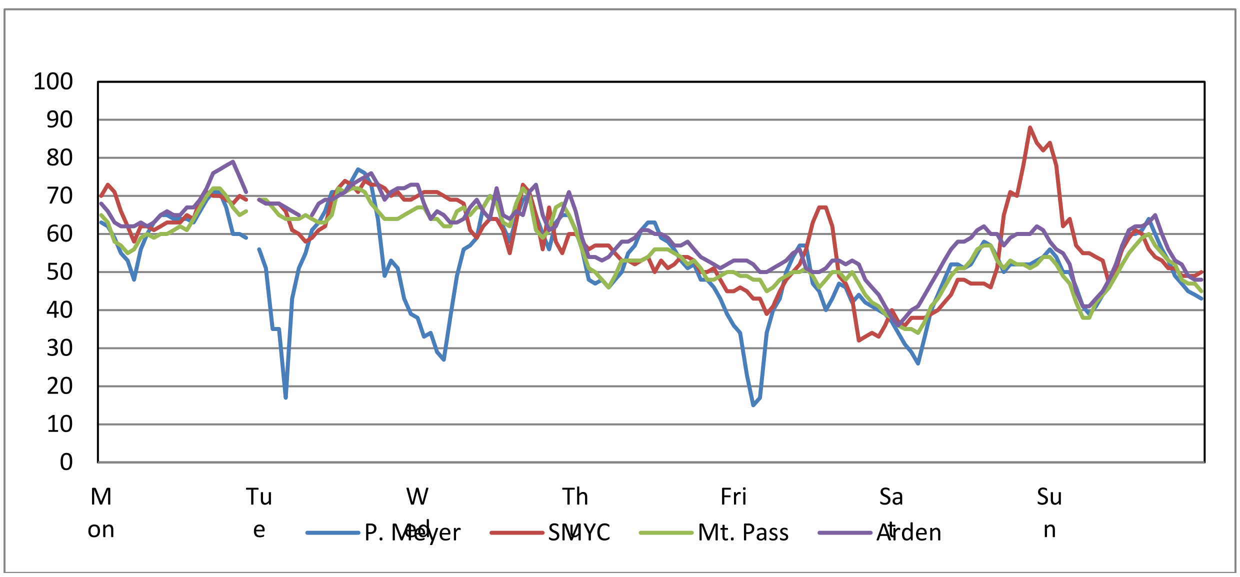


Figure 1. Hourly Ozone Concentrations (ppb) May 23-29, 2011

6.3 MAY 30-JUNE 5, 2011

With respect to our permanent sites, the highest 8-hour ozone concentration recorded for this week occurred on May 31st (Tuesday) at Palo Verde (70 ppb). SMYC, Arden Peak and Mountain Pass, our three elevated sites, also recorded 8-hour ozone concentrations of 77, 76, and 74 ppb respectively, on this date. The highest 8-hour ozone concentration for the week was sampled at the SMYC elevated site (77 ppb) on May 31st (Tuesday) and is much higher as compared to sampled concentrations at the other sites. Additionally, SMYC and Arden Peak sampled high for the majority of the week. Table 1 shows high 8-hour ozone concentrations for the week (May 30-June 5) at selected sites.

Table 1. Highest 8-Hour Ozone Concentrations (ppb) at Selected Monitoring Sites (May 30 – June 5, 2011)

Site	May 30	May 31	June 1	June 2	June 3	June 4	June 5
Walter Johnson	55	68	65	64	65	63	60
Joe Neal	54	63	63	65	66	62	60
Paul Meyer	54	65	65	63	64	61	60
Jean	53	69	69	62	66	65	62
Palo Verde	51	70	64	60	61	63	57
SMYC	65	77	70	67	73	72	57
Arden Peak	60	76	76	67	76	76	67
Mt. Pass	58	74	68	63	70	71	60

Figure 1 depicts hourly ozone concentrations (ppb) for the three elevated sites and Palo Verde for the week (May 30 – June 5, 2011). The highest 1-hour ozone concentrations (81 ppb) occurred at 5 p.m. and 11, p.m. on Tuesday (5/31) and 12 a.m. and 6 a.m. on Wednesday (6/1) at the SMYC site. Arden Peak's highest 1-hour ozone concentrations (81 ppb) occurred at 11 a.m. on Wednesday (6/1).

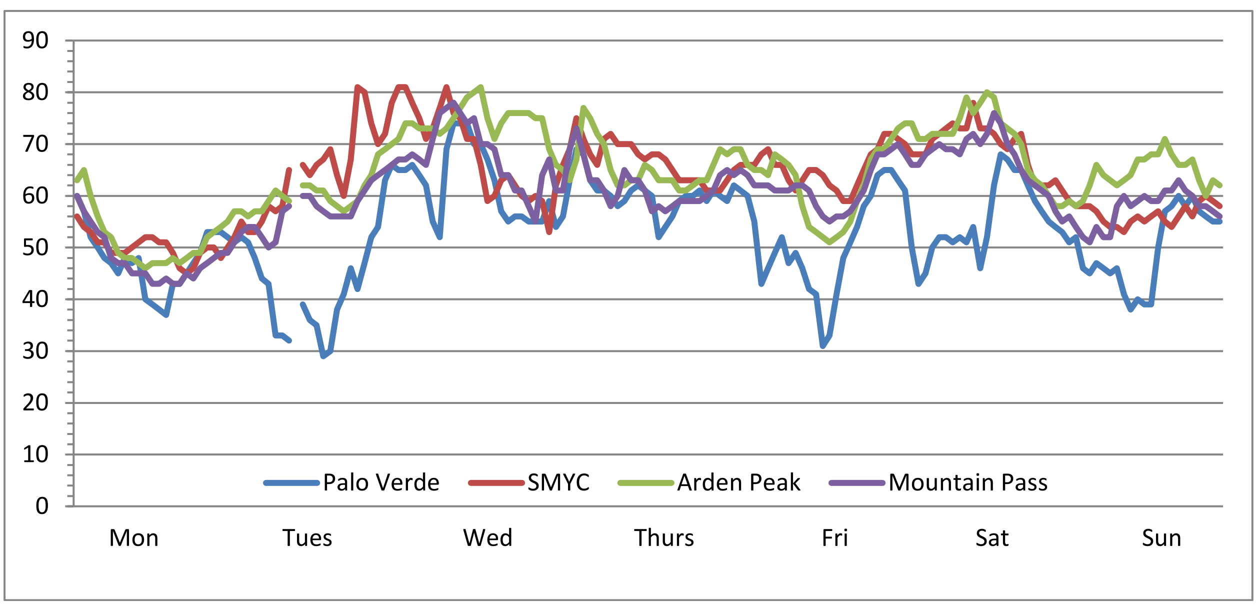


Figure 1. Hourly Ozone Concentrations (ppb) May 30 – June 5, 2011

6.4 JUNE 6 - 12, 2011

At our permanent sites, the highest 8-hour ozone concentration recorded for this week occurred on June 12th (Sunday) at Walter Johnson (75 ppb) and Joe Neal (75 ppb) and represent the highest sampled to date for this ozone season. Our three elevated sites (SMYC, Arden Peak, and Mountain Pass) recorded 8-hour ozone concentrations of 77 ppb on June 10th (Friday). The highest 8-hour ozone concentration for the week was sampled at SMYC (79 ppb) on June 11th (Saturday). SMYC, Mountain Pass and Arden Peak sampled high for the entire weekend. Table 1 shows high 8-hour ozone concentrations for the week (June 6 – 12, 2011) at selected sites.

Table 1. Highest 8-Hour Ozone Concentrations (ppb) at Selected Sites (June 6 - 12, 2011)

Site	Jun 6	Jun 7	Jun 8	Jun 9	Jun 10	Jun 11	Jun 12
Walter Johnson	46	62	66	72	71	67	75
Joe Neal	49	63	68	74	71	67	75
Paul Meyer	46	62	67	69	71	66	73
Jean	51	62	63	66	72	68	74
Jerome Mack	45	61	72	72	67	70	72
SMYC	64	65	60	66	77	79	76
Arden Peak	59	60	70	71	77	76	77
Mt. Pass	47	59	63	65	77	73	73

Figure 1 depicts hourly ozone concentrations (ppb) for the three elevated sites and two permanent sites for the week (June 6 - 12, 2011). The highest 1-hour ozone concentrations (86 ppb) occurred at 2 a.m. on Sunday (6/12/2011) at the SMYC site. Arden Peak's highest 1-hour ozone concentrations (81 ppb) occurred at 12 noon on June 12th (Sunday). The two permanent sites recorded high 1-hour ozone concentrations (80 ppb) at Joe Neal on June 9th (Thursday) at both 2 p.m. and 3p.m. Walter Johnson recorded high 1-hr ozone concentrations (79 ppb) on June 9th (Thursday) at 12 noon. and 1 p.m.

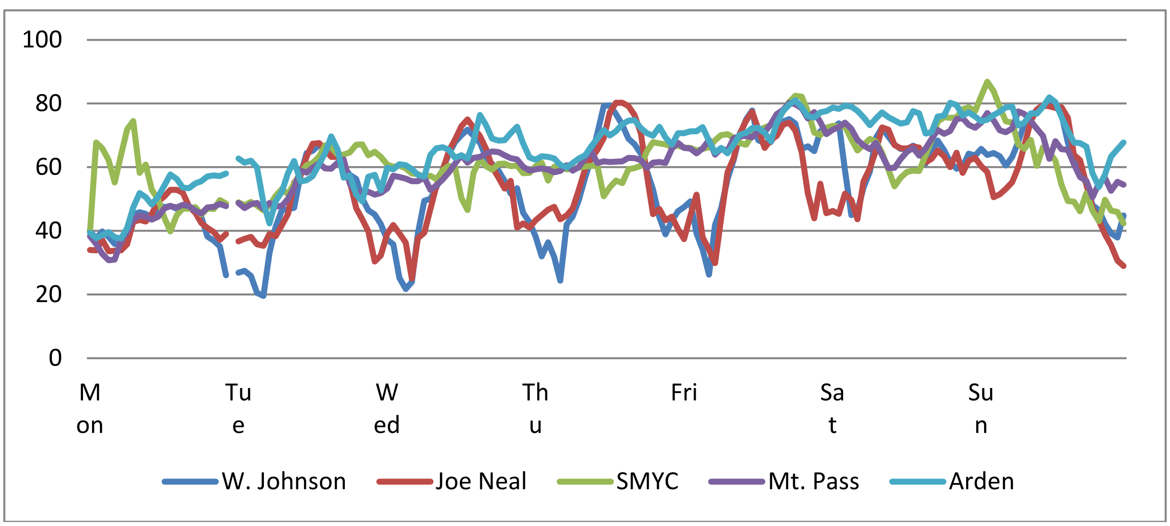


Figure 1. Hourly Ozone Concentrations (ppb) at Selected Sites (June 6-12, 2011)

6.5 JUNE 13-19, 2011

The highest 8-hour ozone concentration recorded for this week among permanent sites occurred on June 16 (Thursday) at Jean (83 ppb). Walter Johnson recorded a high 8-hour ozone concentration (79 ppb) on June 14 (Tuesday) and Paul Meyer (79 ppb) on June 16 (Thursday). SMYC, Arden Peak, and Mountain Pass, the three elevated sites, all recorded 8-hour ozone concentrations of 79, 86, 80 ppb, respectively, on June 16 (Thursday). Table 1 shows high 8-hour ozone concentrations for the week (June 13–19, 2011) at the identified sites.

Table 1. Highest 8-Hour Ozone Concentrations (ppb) at Selected Sites (June 13-19, 2011)

Site	Jun 13	Jun 14	Jun 15	Jun 16	Jun 17	Jun 18	Jun 19
Walter Johnson	58	79	72	77	67	70	57
Joe Neal	60	76	73	76	69	76	56
Paul Meyer	56	78	74	79	65	69	57
Palo Verde	54	74	71	75	63	68	54
Jean	57	74	79	83	66	74	68
Jerome Mack	53	73	70	75	64	71	55
SMYC	61	70	75	79	72	72	58
Arden Peak	60	N/A	84	86	73	78	66
Mountain Pass	56	67	76	80	65	70	68

Figure 1 below depicts hourly ozone concentrations for the three elevated sites and three permanent sites for the week (June 13-19, 2011). The highest 1-hour ozone concentration for the three elevated sites (88 ppb) occurred at 2 p.m. and 3 pm on Thursday (June 16, 2011) at the Arden Peak site. The highest 1 hour concentration sampled at our permanent sites (Walter Johnson) was 88 ppb at 10 am. on June 16th.

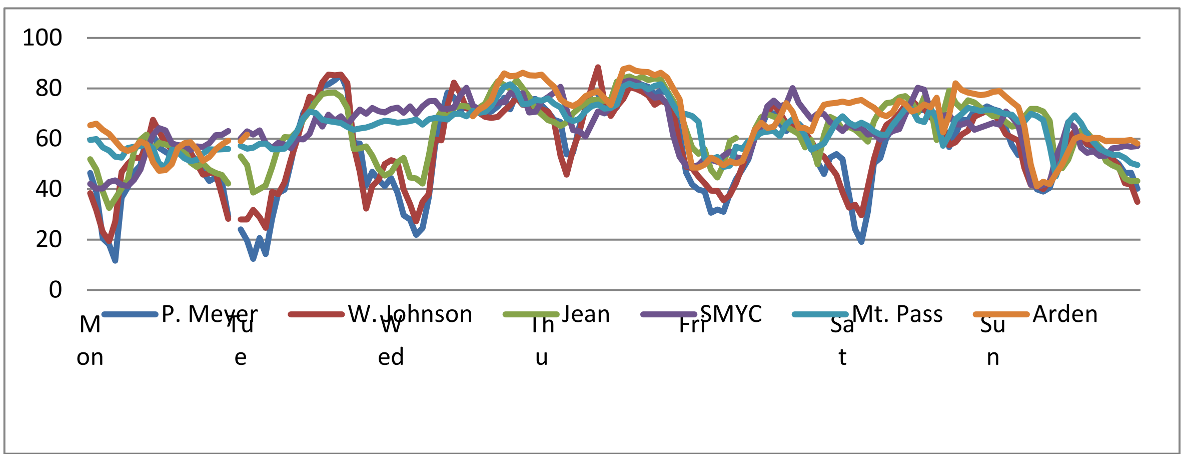


Figure 1. Hourly Ozone Concentrations (ppb) June 13-19, 2011

6.6 JUNE 20-26, 2011

Table 1 below shows maximum 8-hour ozone concentrations at selected sites within Clark County for the week ending Sunday (June 26th). The highest concentration sampled among our permanent sites occurred on Tuesday (78 ppb) at the Paul Meyer site. Mountain Pass, one of three high elevation seasonal sites, also recorded the highest 8-hour ozone concentration (80 ppb) on Tuesday.

Table 1. Highest 8-Hour Ozone Concentrations (ppb) at Selected Sites (June 20-26, 2011)

Site	Mon 6/20	Tues 6/21	Wed 6/22	Thu 6/23	Fri 6/24	Sa 6/25t	Sun 6/26
Walter Johnson	65	72	70	71	62	68	76
Joe Neal	60	65	71	70	64	70	76
Paul Meyer	66	78	71	72	60	66	75
Palo Verde	59	70	69	67	61	65	74
Jean	67	68	68	69	60	65	72
SMYC	58	66	70	62	69	67	77
Arden Peak	69	77	78	78	64	73	77
Mountain Pass	60	80	76	73	64	71	72

Figure 1 shows hourly ozone concentrations for the selected permanent sites. The Paul Meyer site shows significant variability in hourly concentrations early in the week with a high of 91 ppb at-5 pm. on Tuesday (June 21st) to a low of 9 ppb at 5 am on Wednesday. Less variability in hourly concentrations is apparent at all sites for Friday, Saturday, and Sunday. Figure 2 shows hourly ozone concentrations at the three elevated sites for the week. It is interesting to note the highest one hour ozone concentration was sampled at the Arden site at 6pm. on Tuesday (June21, 2011).

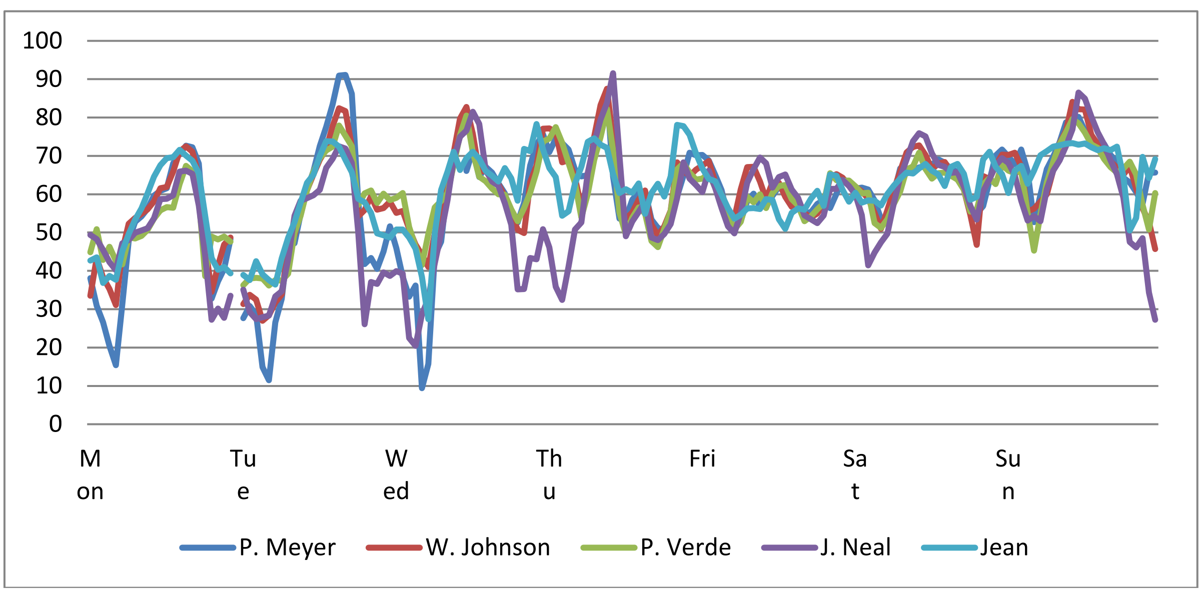


Figure 1. Hourly Ozone Concentrations (ppb) for the Week (June 20-26, 2011)

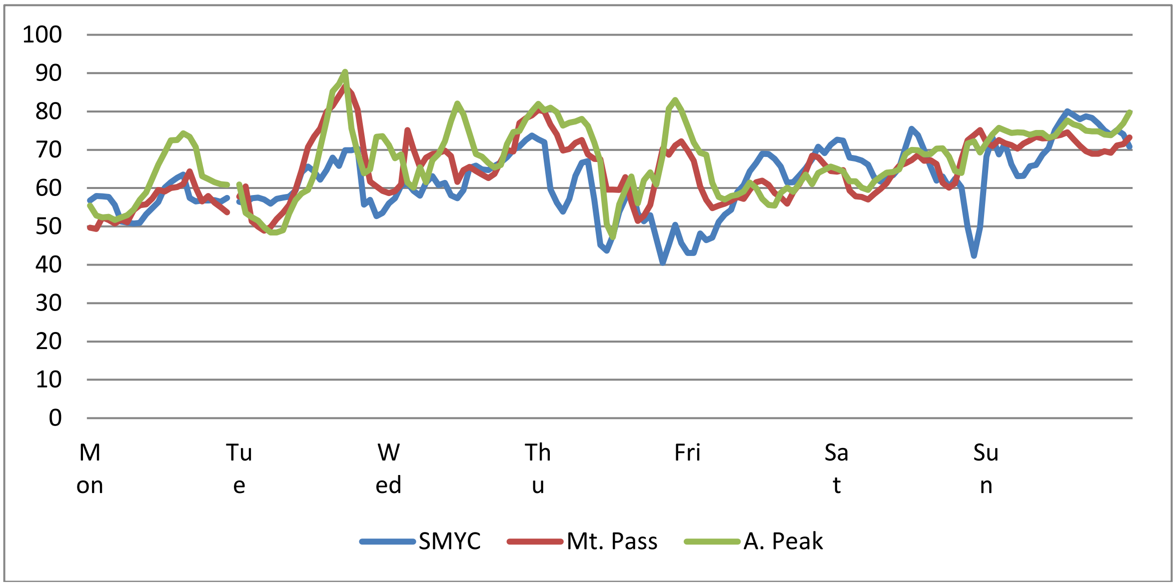


Figure 2. Hourly Ozone Concentration (ppb) at Elevated Sites for the Week (June 20-26, 2011)

6.7 JUNE 27-JULY 3, 2011

This week was an unusual one for air quality. Table 1 below shows maximum 8-hour ozone concentrations at selected sites within Clark County for the week ending Sunday (July 3rd). The highest concentrations were sampled at our permanent sites on July 1st (Friday). These 8-hour concentrations are the highest to date for our permanent sites and suggest local impacts are significant given relatively low concentrations at Jean.

Table 1. Highest 8-Hour Ozone Concentrations (ppb) at Selected Monitoring Sites (June 20-26, 2011)

Site	Mon 6/27	Tues 6/28	Wed 6/29	Thu 6/30	Fri 7/1	Sa 7/2t	Sun 7/3
Walter Johnson	69	58	56	71	89	**79**	69
Joe Neal	71	57	55	75	79	79	67
Paul Meyer	68	58	56	70	90	82	70
Palo Verde	66	59	55	67	88	80	70
Jean	70	58	56	64	72	66	60
SMYC	71	60	69	68	84	68	63
Arden Peak	69	67	58	70	83	72	59
Mountain Pass	76	61	56	62	82	76	62

Figure 1 displays hourly ozone concentrations for three permanent sites and Arden, one of three elevated seasonal sites. Paul Meyer had hourly concentrations (ppb) of 95, 100, and 102 at 2pm, 3pm and 4pm, respectively, Friday afternoon (July 1st). Walter Johnson experienced hourly concentrations of 86, 99, and 108 over the same timeframe. Figure 2 displays hour concentrations during the week for the three seasonal elevated sites.

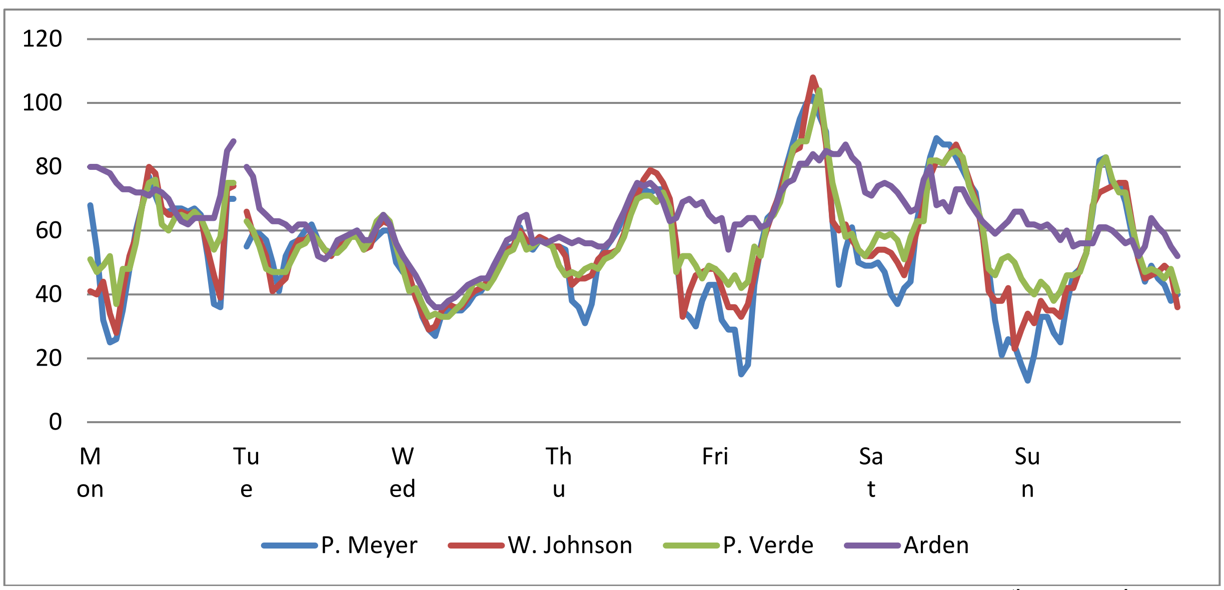


Figure 1. Hourly Ozone Concentrations (ppb) for the Week (June 27th-July 3rd)

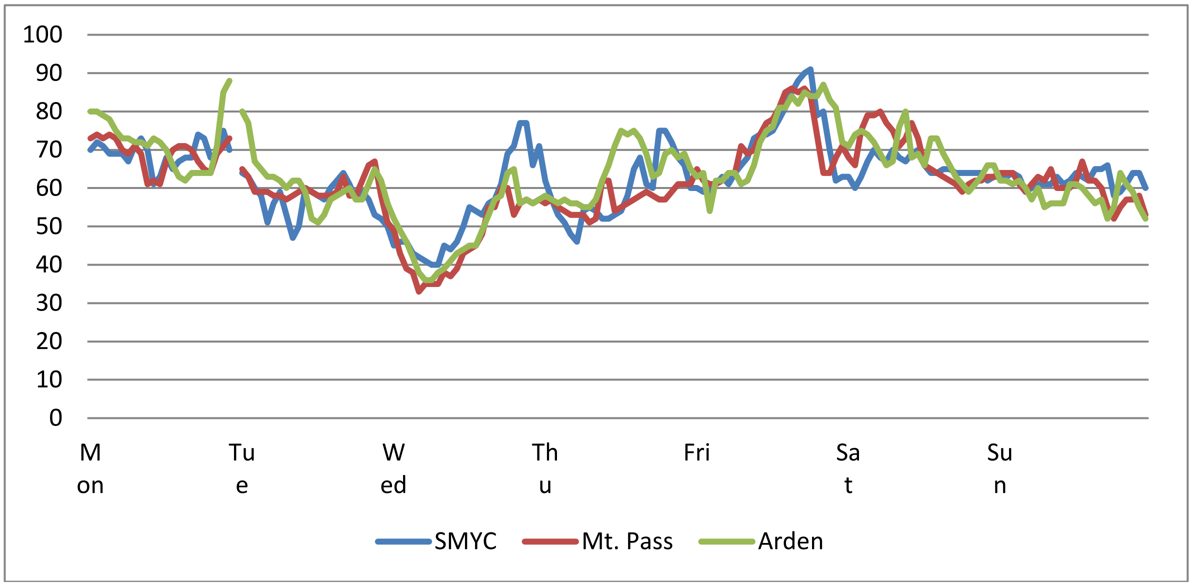


Figure 2. Hourly Ozone Concentrations (ppb) at our Seasonal Elevated Sites for the Week (June 27th-July 3rd)

6.8 JULY 4-10, 2011

This week was relatively clean for ozone given isolated thunderstorms and the absence of stagnant conditions. Table 1 below shows maximum 8-hour ozone concentrations at selected sites within Clark County for the week ending Sunday (July 10, 2011). The highest 8-hour average concentration was sampled at Joe Neal, a permanent site, on July 9 (Saturday).

Table 1. Highest 8-Hour Ozone Concentrations (ppb) at Selected Monitoring Sites (July 4-10, 2011)

Site	Mon 7/4	Tues 7/5	Wed 7/6	Thu 7/7	Fri 7/8	Sat 7/9t	Sun 7/10
Walter Johnson	58	NA	NV	56	57	**66**	51
Joe Neal	59	57	61	56	62	72	54
Paul Meyer	58	53	63	62	60	65	53
Palo Verde	55	NV	63	58	56	69	58
Jean	53	44	55	56	65	65	54
SMYC	55	53	60	53	56	66	61
Arden Peak	57	55	61	60	63	68	58
Mountain Pass	52	50	61	57	65	67	58

Figure 1 depicts hourly ozone concentrations (ppb) at Joe Neal and Jean (transport site) and Figure 2 depicts hourly ozone concentrations (ppb) at our three elevated sites for the week ending Sunday (July 10). Joe Neal recorded the highest hourly ozone concentration (88 ppb) at 12 noon on Saturday (July 9, 2011).

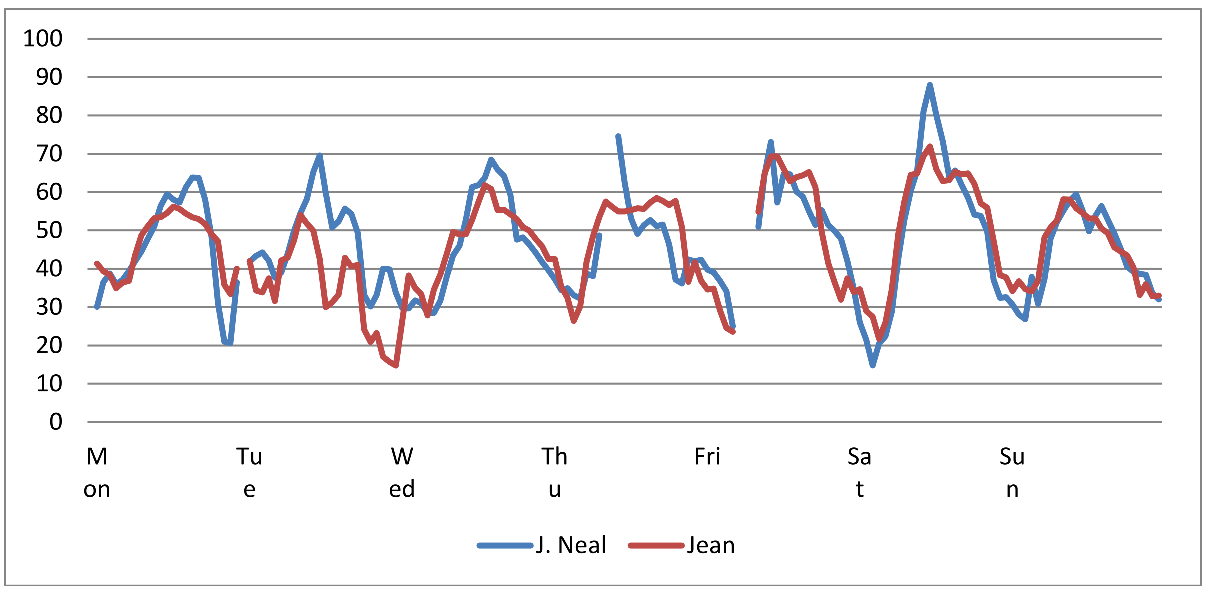


Figure 1. Hourly Ozone Concentrations (ppb) for the Week (July 4-10, 2011)

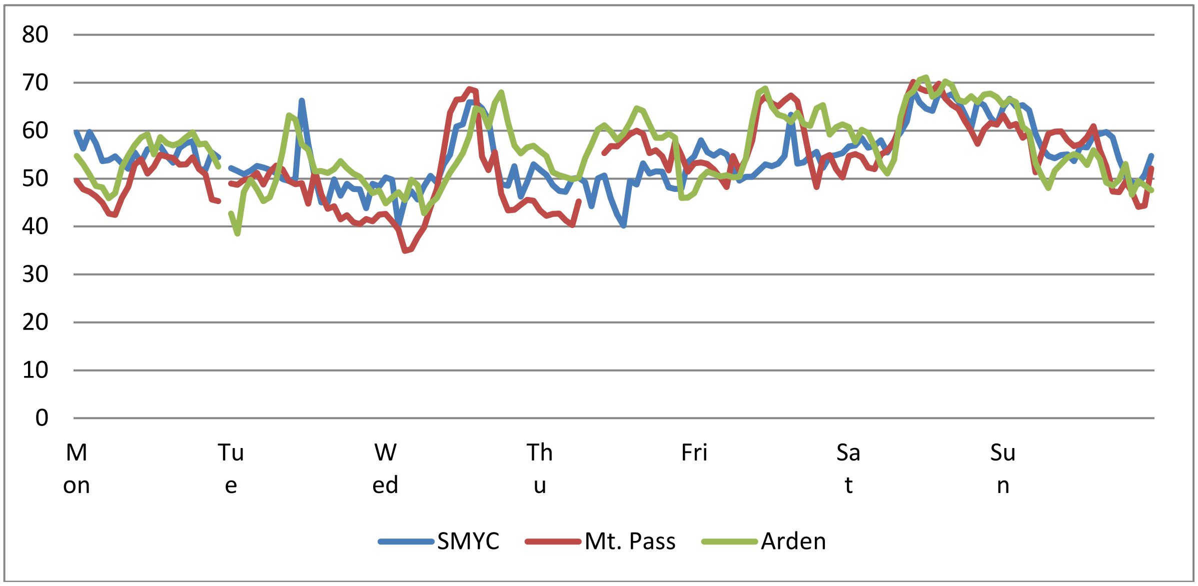


Figure 2. Hourly Ozone Concentrations (ppb) at Elevated Sites for the Week (July 4-10, 2011)

6.9 JULY 11-17, 2011

This week was among the cleanest to date for ozone this season. The highest 8-hour average ozone concentration sampled among our permanent sites was 61 ppb at Joe Neal on July 14th (Thursday). Jean, our transport site, recorded an average of 60 ppb on the same date while SMYC, an elevated seasonal site, recorded an 8-hour average concentration of 62 ppb. Table 1 below shows maximum 8-hour ozone concentrations at selected sites within Clark County for the week ending Sunday (July 17, 2011).

Table 1. Highest 8-Hour Ozone Concentrations (ppb) at Selected Monitoring Sites (July 11-17, 2011)

Site	Mon 7/11	Tues 7/12	Wed 7/13	Thu 7/14	Fri 7/15	Sat 7/16	Sun 7/17
Walter Johnson	46	46	51	56	51	**49**	52
Joe Neal	48	50	54	61	55	54	54
Jean	48	47	55	60	52	53	52
SMYC	53	56	61	62	57	56	56
Arden Peak	49	51	57	58	50	56	56
Mountain Pass	50	56	61	61	NA	NA	NA

The Sandy Valley site continues to sample ozone concentrations at a level that is significantly lower than those sampled at the Jean site, which demonstrates that transport of pollutants is primarily from the southwest. Figure 1 depicts hourly ozone concentrations for two permanent sites (Jean and Joe Neal) and two elevated sites (SMYC and Arden) for the week ending July 17, 2011 (Sunday). Mt. Pass, an elevated site, was excluded from this graph due to instrumentation problems.

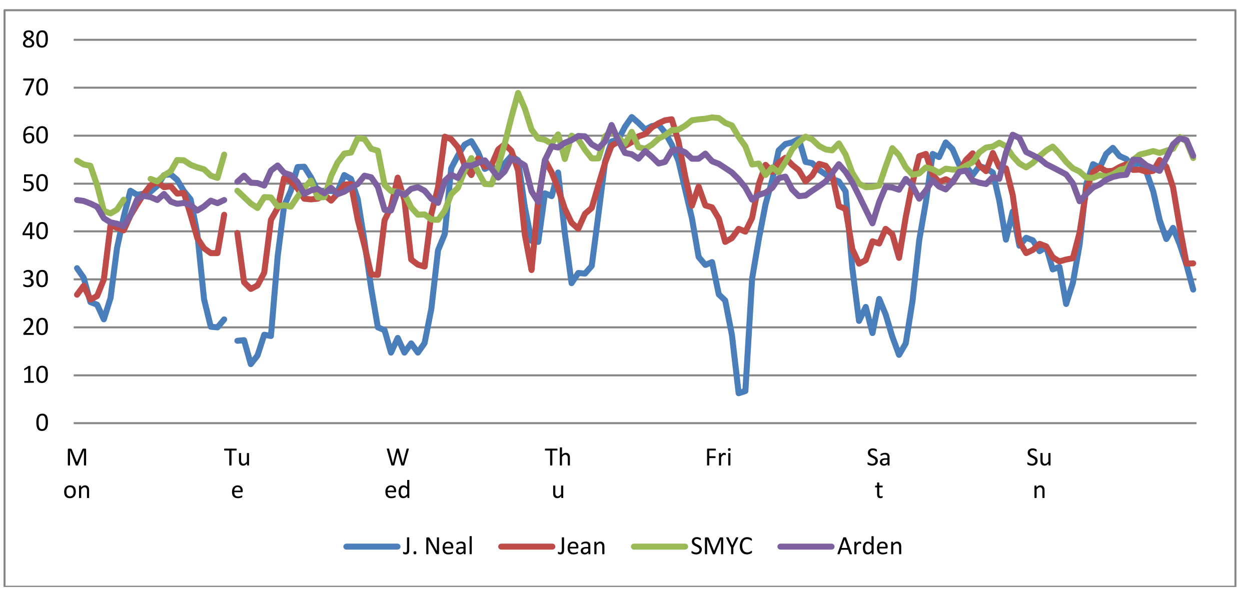


Figure 1. Hourly Ozone Concentrations at Selected Sites for the Week (July 11-17)

6.10 JULY 18-24, 2011

Light winds earlier in the week dispersed pollutants, which maintained relatively low ozone concentrations, but conditions began to change on Wednesday (July 20th). On Thursday (July 21st) the highest 8-hour average concentrations were recorded for the week. At our permanent sites, the highest concentration was 81 ppb at Palo Verde with Jean (transport site) at 80 ppb. Seasonal elevated sites (SMYC, Arden, and Mt. Pass) on Thursday were surprisingly consistent with 83, 83, and 82 ppb, respectively. Transport of pollutants into Clark County appears to be the prevailing variable in the high ozone concentrations recorded on Thursday. Table 1 shows maximum 8-hour ozone concentrations at selected sites within Clark County for the week ending Sunday (July 24 2011).

Table1. Highest 8-Hour Concentrations s(ppb) at Selected Monitoring Sites

Site	Mon 7/18	Tues 7/19	Wed 7/20	Thu 7/21	Fri 7/22	Sat 7/23	Sun 7/24
Walter Johnson	51	50	65	73	60	**52**	47
Paul Meyer	52	54	67	77	61	52	45
Palo Verde	54	54	68	81	63	57	50
Joe Neal	54	54	65	77	64	56	47
Jean	52	57	69	80	70	57	51
SMYC	54	55	70	83	81	57	51
Arden Peak	54	63	68	83	75	56	46
Mountain Pass	NV	62	70	82	72	57	50

Figure 1 shows hourly ozone concentrations for Jean and the three season elevated sites (SMYC, Mt. Pass, and Arden Peak). The highest 1-hour ozone concentration was sampled at Arden Peak (88 ppb) at 1 am on Friday (July 22nd).

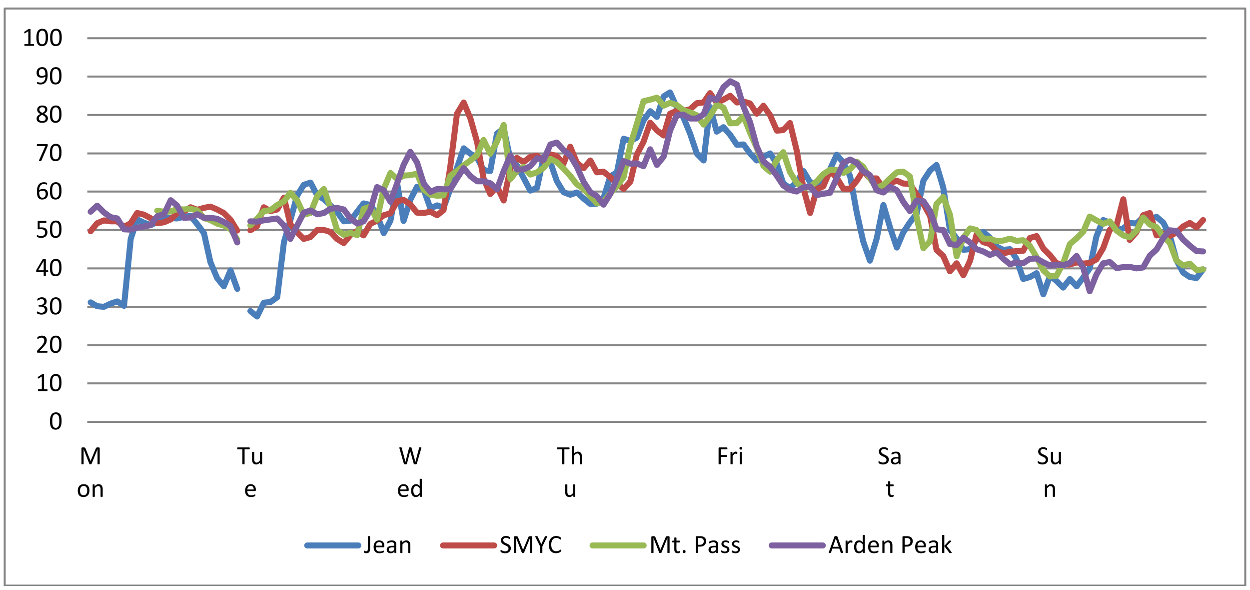


Figure 1. Hourly Ozone Concentrations (ppb) at Selected Sites for the Week (July 18-24, 2011)

6.11 JULY 25-31, 2011

Light winds and moist monsoonal conditions resulted in relatively low ozone concentrations for the week. The highest 8-hour average ozone concentration recorded at our permanent surface sites was 60 ppb on Tuesday (July 26th) at the Jean site and Saturday (July 30th) at the Jerome Mack and JD Smith sites. Arden Peak, one of our three seasonal elevated sites, recorded a high 8-hour average ozone concentration of 59 ppb on Saturday (July 30th). Figure 1 shows hourly ozone concentrations for the week at our elevated sites. SMYC recorded the highest 1-hour concentration (66 ppb) at 1 pm on Monday (July 25th).

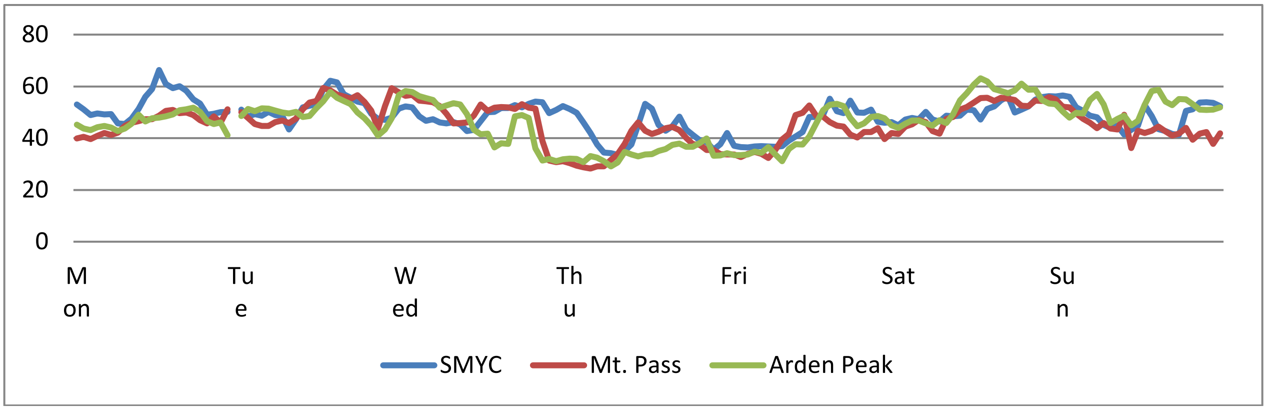


Figure 1. Hourly Ozone Concentrations (ppb) at Seasonal Elevated Sites (July 25-31, 2011)

Although we have a another six weeks in the 2011 ozone season, Table 1 shows the 4th highest ozone average for two three year periods, (2008-2010) and (2009-2011). Ozone concentrations (ppb) highlighted in yellow are the current design values for future planning and modeling purposes.

Table 1. 4th Highest Ozone Concentrations and 3-year Averages (2008-2010) and (2009-2011)

Monitoring Site	2008 (4th Highest)	2009 (4th Highest)	2010 (4th Highest)	2011 (4th Highest)	4th Highest Average (2008-2010)	4th Highest Average (2009-2011)
Apex	71	70	68*	70	69	69
Mesquite	69	62	63*	59**	64	61
Paul Meyer	77	71	70	78	72	73
W. Johnson	76	74	73	77	74	74
Palo Verde	74	72	71	75	72	72
Joe Neal	80	74	74	76	76	74
Winterwood	71*	70	68	73	69	70
Boulder City			69*	70		
Jean	74	72	74	74	73	73
JD Smith	68	72	68	71	69	70

* Does not represent an entire year's worth of data.
** Does not represent a complete set of data for 2011.

6.12 AUGUST 1-7, 2011

The highest 8-hour ozone concentration recorded for this week occurred on Monday, August 1 at J.D. Smith (72 ppb). Arden Peak, one of Clark County's three elevated sites, recorded the second highest 8-hour ozone concentration of 71 ppb on Thursday, August 4. Apex recorded the third highest 8-hour ozone concentration on Monday, August 1 of 70 ppb. The remaining sites, both permanent and temporary, recorded ozone concentrations from 40 ppb to as high as 69 ppb. All sites recorded low- to high-moderate ozone readings for the week. There were no "Unhealthy for Sensitive's" ozone concentrations recorded for the week.

Table 1.Highest 8-Hour Ozone Concentrations (ppb) at Selected Monitoring Sites (August 1-7, 2011)

Site	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
J.D. Smith	72	62	53	58	57	68	62
Joe Neal	67	63	55	58	59	67	64
Winterwood	64	58	54	58	58	57	62
Jerome Mack	67	61	55	59	58	68	63
SMYC	58	60	66	64	63	63	64
Mt. Pass	57	55	60	66	63	65	66
Arden Peak	57	65	61	71	69	67	68
Apex	70	61	57	59	62	62	63

Figure 1 depicts hourly ozone concentrations for the three elevated sites, J.D. Smith, Joe Neal, and Apex, for the week (August 1-7, 2011). The highest 1-hour ozone concentration (82 ppb) occurred at 9 p.m. on Monday, August 1 at the J.D. Smith site.

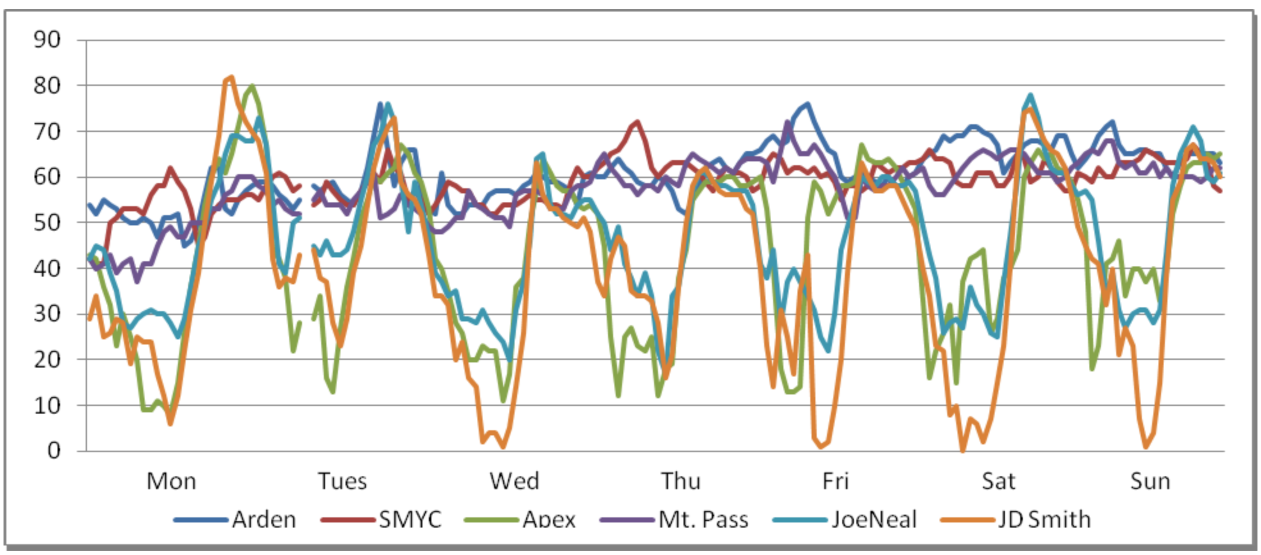


Figure 1. Hourly Ozone Concentrations (ppb) August 1-7, 2011

6.13 AUGUST 8-14, 2011

Generally low ozone concentrations were the norm for the week ending Sunday (August 14th). The highest 8-hour average ozone concentration recorded at our permanent surface sites was 71 ppb on Thursday (August 11th) at Jean. Arden Peak, one of our three seasonal elevated sites, recorded a high 8-hour average ozone concentration of 72 ppb on Monday and Tuesday (August 8th and 9th). Table 1 displays the highest 8-hour ozone concentrations (ppb) at selected sites..

Table 1. Highest 8-Hour Concentrations (ppb) at Selected Monitoring Sites

Site	Mon 8/8	Tues 8/9	Wed 8/10	Thu 8/11	Fri 8/12	Sat 8/13	Sun 8/14
Walter Johnson	55	56	61	59	57	41	50
Paul Meyer	57	58	64	64	58	45	51
Palo Verde	59	60	64	62	64	45	57
Joe Neal	61	63	65	66	64	39	54
Jean	63	64	68	71	62	48	56
SMYC	60	62	66	65	68	60	62
Arden Peak	72	72	71	65	59	58	62
Mountain Pass	65	66	69	67	64	53	62

Hourly ozone concentrations (ppb) for the Arden Peak, Jean, and Joe Neal sites are depicted in Figure 1. Joe Neal sampled the highest hourly concentration (82 ppb) at 11 am on Tuesday. Arden Peak, one of three elevated seasonal sites, generally sampled higher ozone concentrations than the two other elevated sites (Mt. Pass and SMYC) throughout the week.

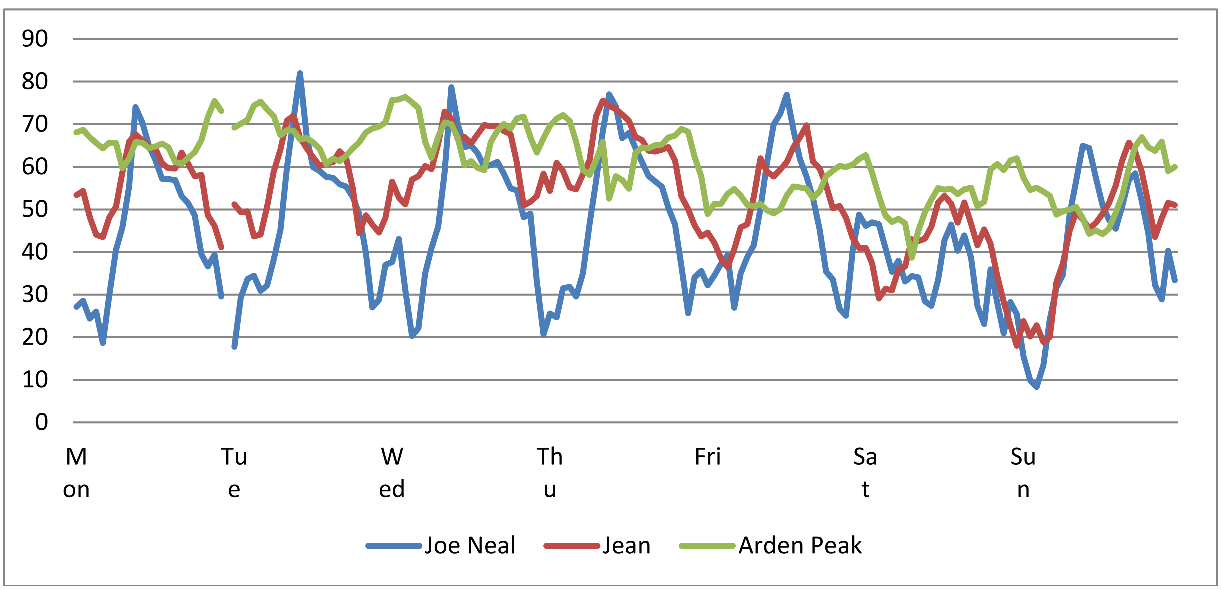


Figure 1. Hourly Ozone Concentrations (ppb) at Selected Sites for the Week (August 8-14, 2011)

6.14 AUGUST 15-21, 2011

Largely due to the absence of stagnant conditions, relatively low ozone concentrations were the norm for the week ending Sunday (August 21st). The highest 8-hour average ozone concentration recorded at our permanent surface sites was 63 ppb on Wednesday and Thursday (August 17th and 18th) at Jean and Sunday (August 21st) at Joe Neal. Mt. Pass, one of our three seasonal elevated sites, recorded a high 8-hour average ozone concentration of 71 ppb on Thursday and Friday (August 18th and 19th). Table 1 displays the highest 8-hour ozone concentrations (ppb) at selected sites.

Table1. Highest 8-Hour Concentrations (ppb) at Selected Monitoring Sites

Site	Mon 8/15	Tues 8/16	Wed 8/17	Thu 8/18	Fri 8/19	Sat 8/20	Sun 8/21
Walter Johnson	50	49	58	58	44	53	59
Palo Verde	55	51	62	61	47	53	59
Joe Neal	54	54	62	62	48	58	63
Jean	57	54	63	63	48	55	59
SMYC	64	63	64	67	65	63	64
Arden Peak	60	60	62	69	56	61	62
Mountain Pass	57	57	62	71	71	65	59

Hourly ozone concentrations (ppb) for the Arden Peak, Mt. Pass, SMYC, Jean, and Joe Neal sites are depicted in Figure 1. Mt. Pass, an elevated seasonal site sampled the highest hourly concentration (74 ppb) at 5 am on Tuesday. Joe Neal, a permanent site, had a high one hour concentration of 72 ppb at 12 noon on Wednesday (August 17th).

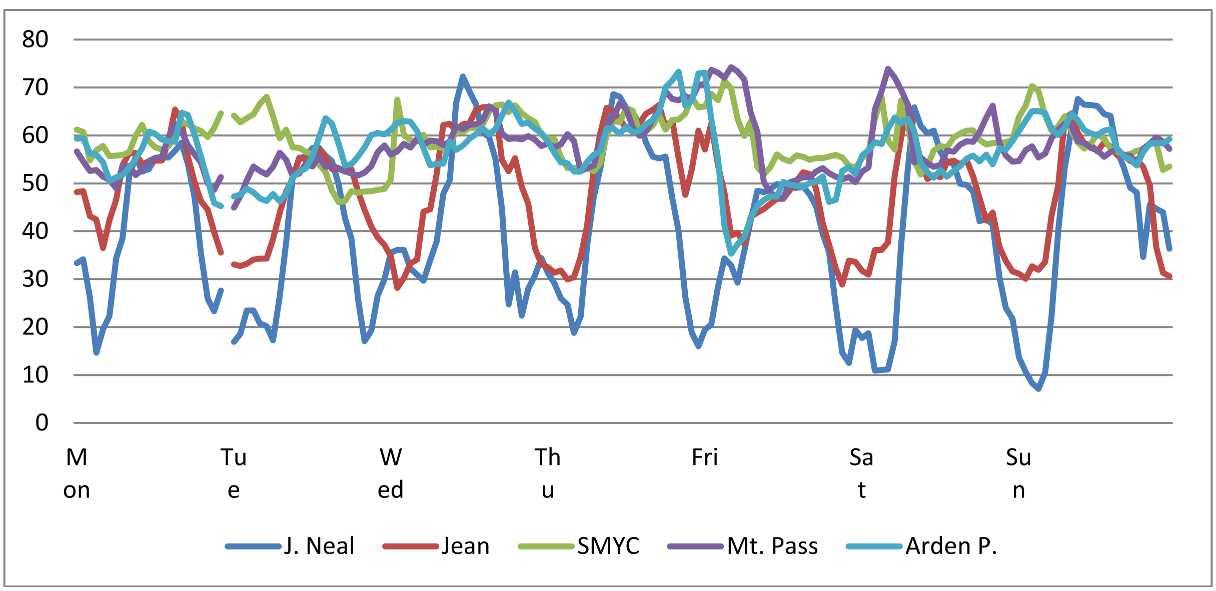


Figure 1. Hourly Ozone Concentrations (ppb) at Selected Sites for the Week (August 15-21, 2011

6.15 AUGUST 22-28, 2011

On Sunday (August 28th), with respect to our permanent sites, we recorded our highest 8-hour average ozone concentrations since July 21st. Ozone concentrations at Jean, our transport site, were relatively low suggesting that the local contribution was significant. Table 1 displays the highest 8-hour ozone concentrations (ppb) at selected sites including our seasonal elevated sites.

Table1. Highest 8-Hour Concentrations (ppb) at Selected Monitoring Sites

Site	Mon 8/22	Tues 8/23	Wed 8/24	Thu 8/24	Fri 8/26	Sat 8/27	Sun 8/28
Walter Johnson	52	60	59	59	61	60	76
Palo Verde	54	63	59	62	**66**	66	77
Joe Neal	55	67	65	66	72	63	77
Jean	54	59	56	59	59	56	67
SMYC	56	70	58	60	65	64	66
Arden Peak	58	58	60	61	63	66	64
Mountain Pass	56	57	57	56	60	61	65

Hourly ozone concentrations (ppb) for selected sites are depicted in Figure 1. Joe Neal, a permanent site, sampled the highest one-hour concentration (92 ppb) at 1 pm on Sunday (August 28th).

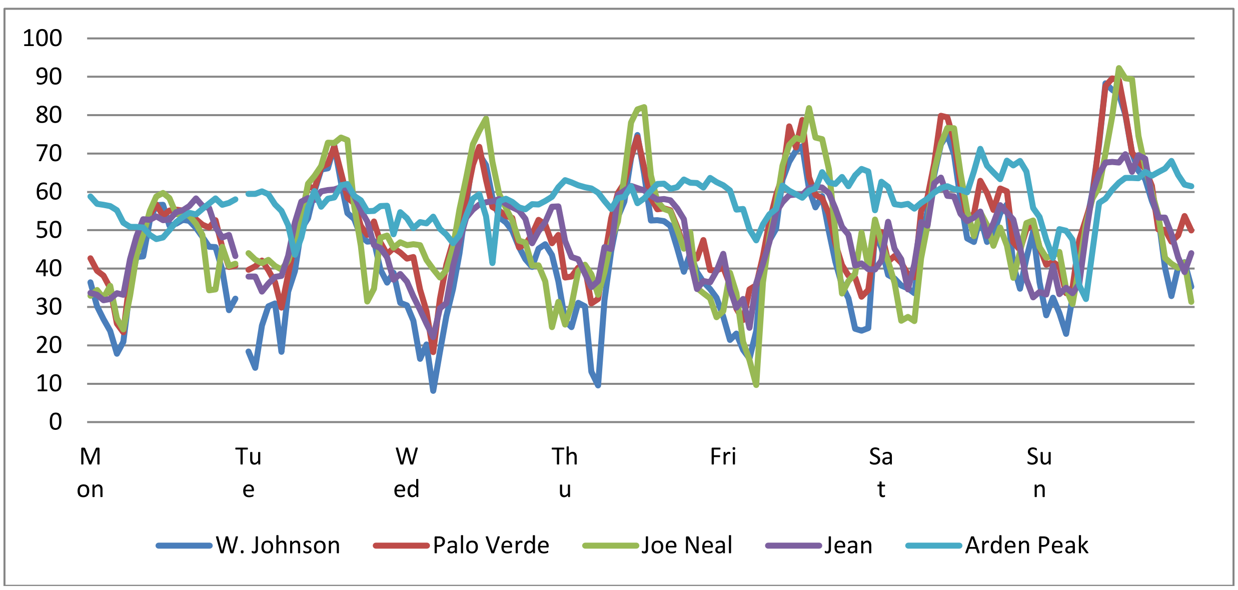


Figure 1.Hourly Ozone Concentrations (ppb) at Selected Sites for the Week (August 22-28, 2011)

6.16 AUGUST 29-SEPTEMBER 4, 2011

Among our permanent sites, Joe Neal recorded the highest 8-hour ozone concentration during this week (70 ppb on Sept. 2nd). SMYC, a seasonal elevated site, recorded the highest 8-hour ozone concentration (72 ppb) on the same date. Table 1 lists the high 8-hour ozone concentrations for selected sites during the week ending Sunday (Sept. 4th).

Table1. Highest 8-Hour Concentrations (ppb) at Selected Monitoring Sites

Site	Mon 8/29	Tues 8/30	Wed 8/31	Thu 9/1	Fri 9/2	Sat 9/3	Sun 9/4
Walter Johnson	59	55	57	58	59	62	62
Palo Verde	64	57	61	63	64	65	65
Joe Neal	66	62	60	62	70	68	64
Jean	61	60	63	66	63	62	61
SMYC	67	66	73	69	72	66	61
Arden Peak	61	60	60	61	60	63	59
Mountain Pass	61	64	66	64	63	60	59

Hourly ozone concentrations (ppb) for selected sites are depicted in Figure 1. Joe Neal, a permanent site, sampled the highest one-hour concentration (84 ppb) at 12 noon on Monday (August 28th) and 81 ppb at 3 pm on Sept. 2nd (Friday). Among the three elevated seasonal sites, SMYC generally recorded higher one hour ozone concentrations throughout the week.

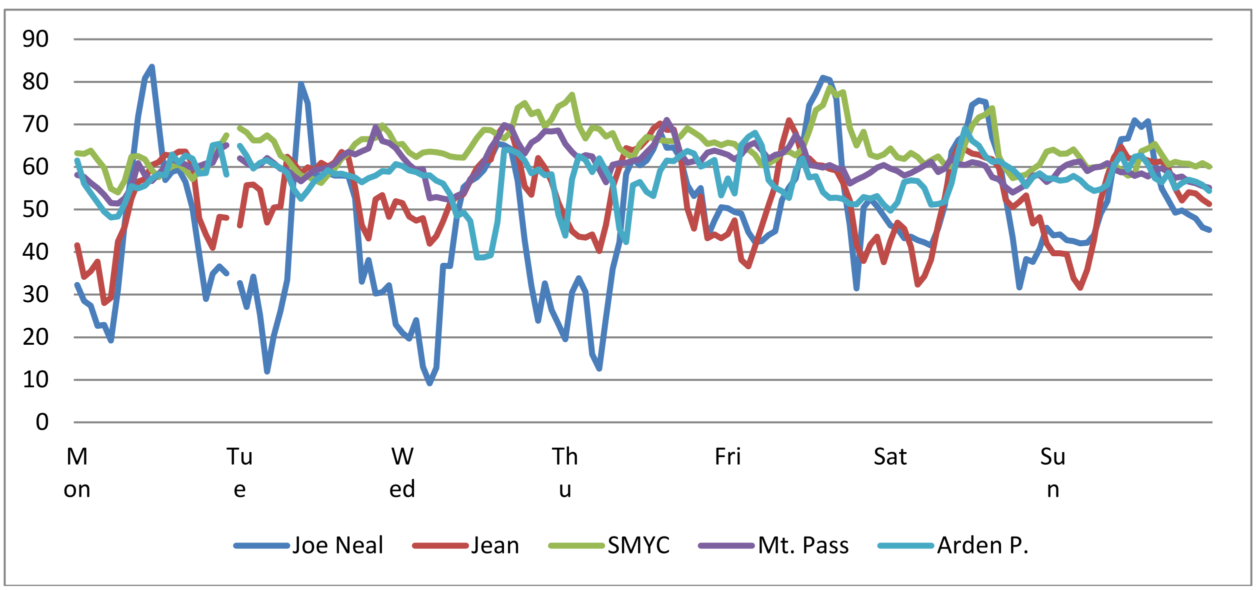


Figure 1. Hourly Ozone Concentrations (ppb) at Selected Sites for the Week (August 29-September 4, 2011)

6.17 SEPTEMBER 5-11, 2011

Moving towards the end of the 2011 ozone season, 8-hour average ozone concentrations were low this week with Jean (transport site) recording the highest concentration (63 ppb) at our permanent sites on September 9th. With respect to our seasonal elevated sites, it is interesting to note that Mountain Pass recorded the highest 8-hour average concentrations for six days this week (Sept. 6th –Sept. 11th). The Sandy Valley site continued to sample ozone concentrations at a significantly lower level than the Jean site. Table 1 shows 8-hour average ozone concentrations for selected sites during the week September 5th -12th, 2011.

Table1. Highest 8-Hour Concentrations (ppb) at Selected Monitoring Sites

Site	Mon 9/5	Tues 9/6	Wed 9/7	Thu 9/8	Fri 9/9	Sat 9/10	Sun 9/11
Walter Johnson	47	59	57	61	59	44	51
Palo Verde	48	62	57	61	60	49	54
Joe Neal	50	60	57	61	59	46	51
Jean	51	62	64	62	63	52	50
SMYC	56	55	59	60	57	54	52
Arden Peak	51	55	58	61	57	55	47
Mountain Pass	52	66	64	67	67	56	54

Hourly ozone concentrations (ppb) for the three seasonal elevated sites are shown in Figure 1. Mt. Pass sampled the highest one-hour concentration (72 ppb) at 3 pm on Friday (September 9th).

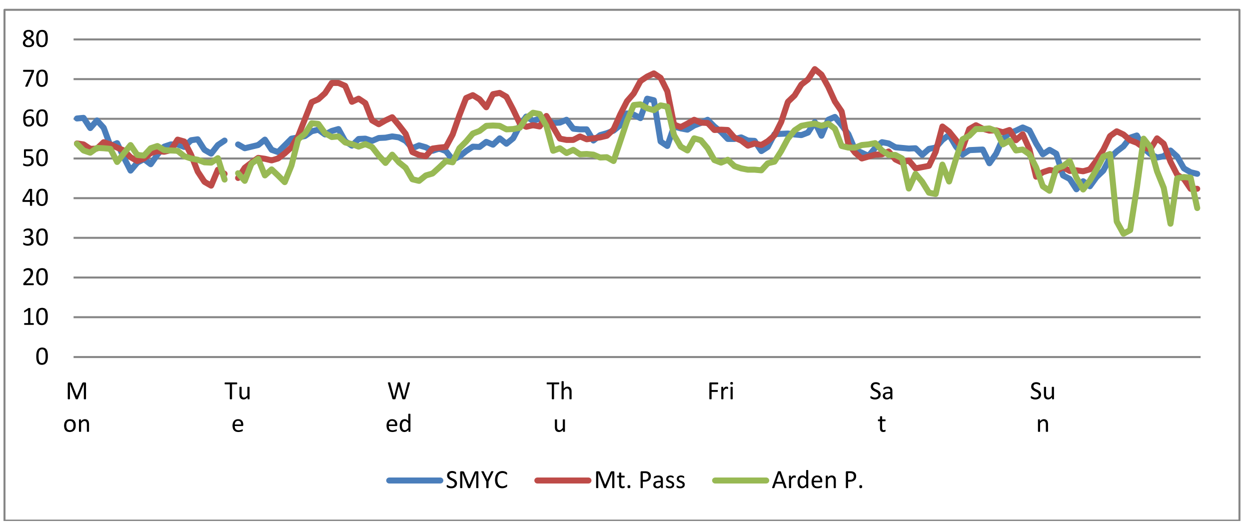


Figure 1. Hourly Ozone Concentrations (ppb) at Elevated Sites for the Week (September 5-11, 2011)

6.18 SEPTEMBER 12 - 18, 2011

This is the last weekly report on air quality for the 2011 ozone season. Dismantling of our seasonal sites is currently underway, but there is data through Sunday (Sept 18). This report will reflect air quality for this last seven day period. At our permanent sites, Jean recorded the highest 8-hour average concentration (70 ppb) on Friday (September 16th). With respect to our seasonal elevated sites, SMYC recorded a high of 72 ppb on the same day. Table 1 shows 8-hour average ozone concentrations for selected sites during the week September 12 -18, 2011.

Table1. Highest 8-Hour Concentrations (ppb) at Selected Monitoring Sites

Site	Mon 9/12	Tues 9/13	Wed 9/14	Thu 9/15	Fri 9/16	Sat 9/17	Sun 9/18
Walter Johnson	51	42	35	55	63	55	56
Palo Verde	52	45	40	56	66	55	NV
Joe Neal	53	44	37	62	67	59	59
Jean	50	45	43	53	70	54	55
SMYC	50	49	49	57	72	59	62
Arden Peak	48	45	41	60	67	56	54
Mountain Pass	53	50	44	65	70	52	61

Hourly ozone concentrations (ppb) for the three seasonal elevated sites and Jean are shown in Figure 1. Jean had 1hour ozone concentrations of 76 ppb at 10am and 11am while SMYC recorded a 1 hour value of 76 ppb at 6 pm on Friday (Sept.16th).

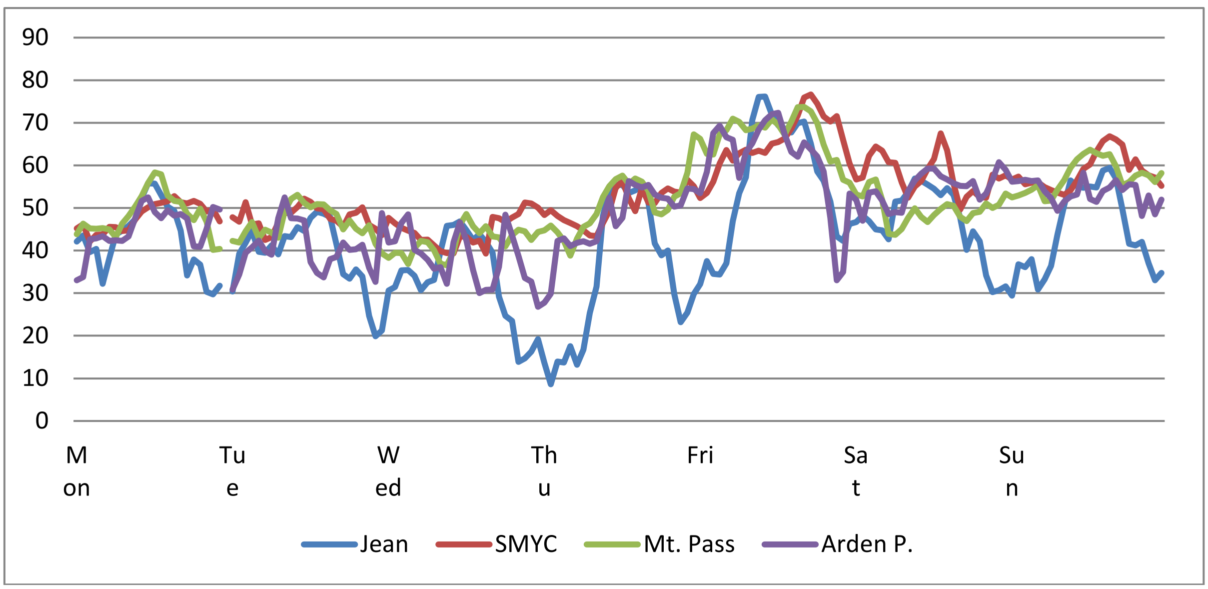


Figure 1. Hourly Ozone Concentrations (ppb) at Elevated Sites and Jean for the Week (September 12 18, 2011)