Appendix C

Coachella Valley Ozone
Weight of Evidence Analysis

Coachella Valley Weight of Evidence

Introduction

The Coachella Valley Planning Area (Coachella Valley) is currently classified as a severe nonattainment area for the 2015 federal ozone standard of 0.070 parts per million (ppm) with an attainment deadline by 2032. The South Coast Air Quality Management District (District) has included a request for an extreme nonattainment area classification of the Coachella Valley with an attainment deadline of 2037 in their air quality management plan. For areas designated as moderate nonattainment or above, photochemical modeling is a required element of the State Implementation Plan (SIP) to determine whether existing and proposed control strategies provide the reductions needed to meet the federal standard by the attainment deadline.

To address the uncertainties inherent to photochemical modeling assessments, U.S. Environmental Protection Agency (U.S. EPA) guidance, *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze,* recommends that supplemental analyses accompany all model attainment demonstrations. To complement regional photochemical modeling analyses included in the Coachella Valley SIP, the following Weight of Evidence (WOE) demonstration includes detailed analyses of ambient ozone data and trends, precursor emission trends and reductions, population exposure trends, and a discussion of conditions that contribute to exceedances of the 0.070 ppm ozone standard.

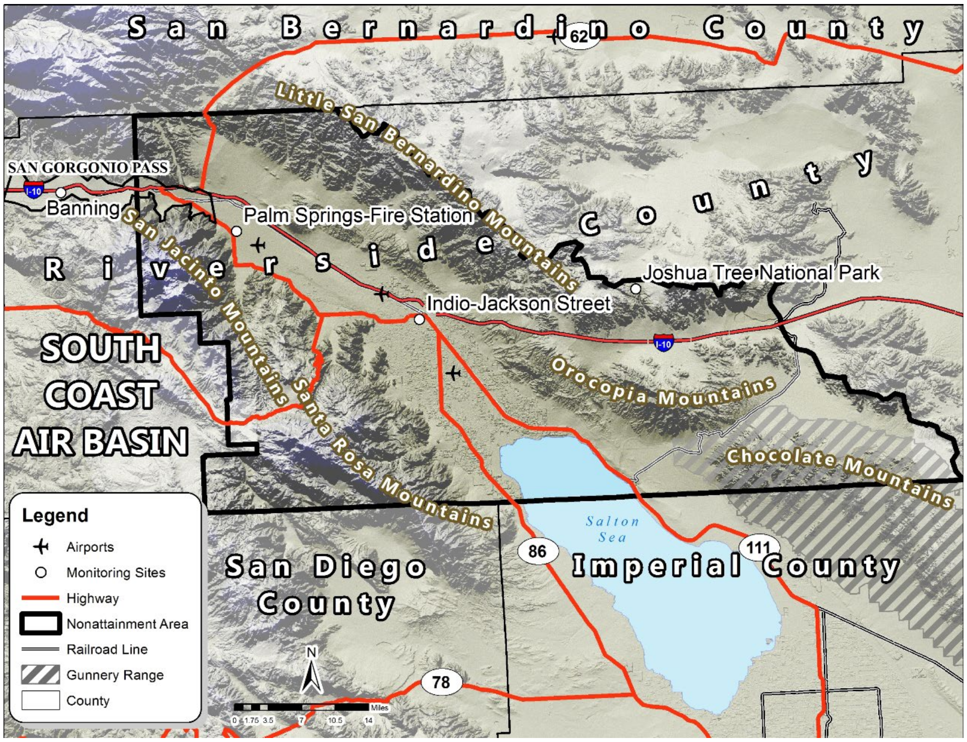
Photochemical modeling analyses for the Coachella Valley indicate that while ozone levels continue to drop, the area will not be able to meet the 0.070 ppm standard by the 2037 attainment deadline with currently adopted regulations. With the inclusion of proposed control measures targeting attainment needs of the upwind South Coast Air Basin (South Coast), the regional modeling analyses project that ozone design values in Coachella Valley will meet the 0.070 ppm ozone standard by 2037.

Area Description

The Coachella Valley is in the Riverside County portion of the Salton Sea Air Basin. It extends approximately 45 miles southeast from the San Gorgonio Pass in the San Bernardino Mountains to the Salton Sea. As shown in Figure 1, the Coachella Valley is bordered by San Bernardino County (Severe nonattainment area) to the north, Imperial and San Diego Counties (Moderate nonattainment areas) to the south, and the western portion of Riverside County (Extreme nonattainment area) to the west.

The Coachella Valley is characterized by widespread complex terrain. The nonattainment area has a northwest-southeast orientation with a low-lying valley floor in its center. The peaks surrounding the valley extend as high as nearly 11,000 feet above sea level. The San Jacinto (10,834 feet) and the Santa Rosa Mountains (8,717 feet) bound the western portion of the Coachella Valley. The Orocopia (3,665 feet) and Chocolate Mountains (2,877 feet) bound the Coachella Valley on the southeast, whereas the Little San Bernardino Mountains (5,814 feet) bound the Coachella Valley in the north and northeast. At the floor, the valley elevation ranges from 500 feet above sea level in the northern part of the valley to nearly 150 feet below sea level near the Salton Sea.

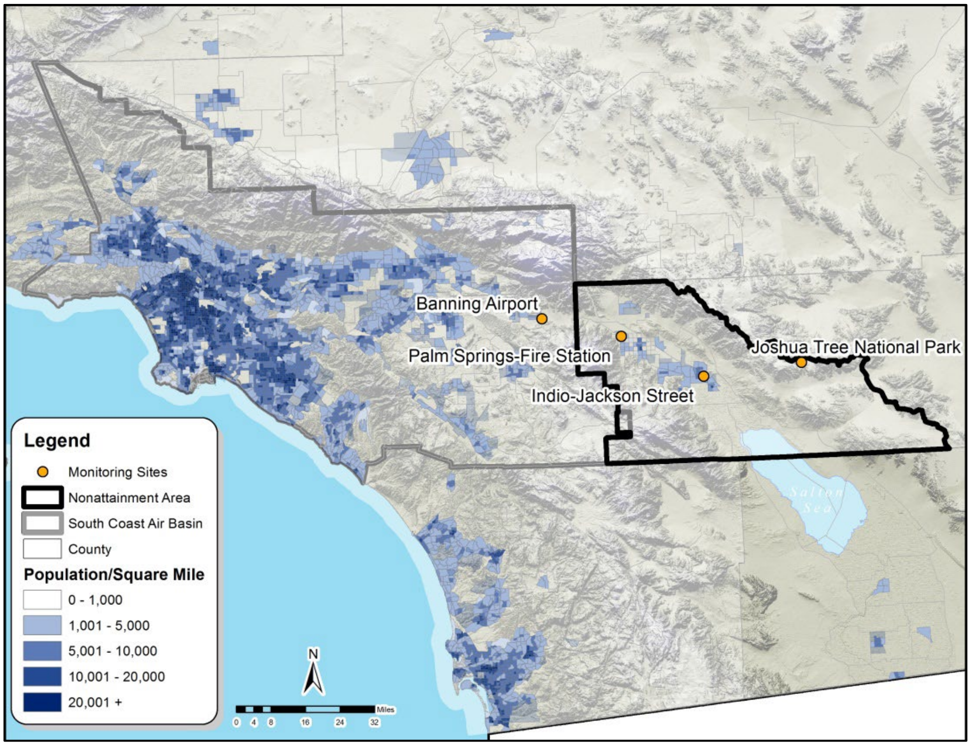
Figure 1: Area Map of the Coachella Valley and Surrounding Areas



The population of the Coachella Valley resides primarily in the northern and central portions of the valley. Indio and Palm Springs are among the largest cities in the Coachella Valley, which has a total population of 448,118 (2020 U.S. Census). As shown in Figure 2, most of the population of the Coachella Valley is clustered in those two major cities. The resident population swells seasonally as the desert climate of the area draws more than 100,000 temporary residents during the winter months. Population growth projections by Southern California Association of Governments indicate that the Coachella Valley will reach a permanent resident population of 884,000 by the year 2035. Despite projections of significant growth, the population of the Coachella Valley is small relative to the population of the adjacent South Coast, which is projected to reach nearly 18.6 million by 2037.

Tourism and agriculture are the largest industries in the Coachella Valley. As shown in Figure 1, two major highways, Interstate 10 and State Route 111, run through the Coachella Valley. The area is also served by the Palm Springs International Airport and regular Amtrak routes between the Los Angeles metropolitan area and Palm Springs. Expansion of passenger rail service to the Coachella Valley is being considered in an effort to cater to year-round tourism. The Chocolate Mountain Aerial Gunnery Range lies in the southeast portion of the Coachella Valley, east of the Salton Sea and is closed to the public.

Figure 2: Population Density Comparison of the Coachella Valley and South Coast 2020 Census



The Coachella Valley is under the jurisdiction of the District. Three regulatory monitoring sites are operated within the Coachella Valley. The District operates two sites: Palm Springs-Fire Station and Indio-Jackson Street. The National Park Service operates a site at Joshua Tree National Park, which was established in 2005.

As shown in Table 1, the highest ozone concentrations in the Coachella Valley are typically measured at the Palm Springs monitoring site, which is in the closest proximity to the San Gorgonio Pass, a gap in the mountains that provides a conduit for pollutants transported from the South Coast to the Coachella Valley. On the other end of the spectrum, the lowest ozone concentrations are typically measured at Joshua Tree National Park, which is the site most distant from the San Gorgonio Pass.

Table 1: Ozone Design Values at the Coachella Valley Monitoring Sites

Site Name	AQS ID	2019 Design Value (ppm)	2020 Design Value (ppm)	% Above Standard in 2020
Palm Springs-Fire Station	060655001	0.089	0.088	25.7%

Indio-Jackson Street	060652002	0.086	0.084	20.0%
Joshua Tree National Park	060650010	Not Available	0.071	1.4%

Conceptual Model

The Coachella Valley has over 300 sunny days (NOAA) each year and summertime temperatures peak at 100 to 115°F, creating conditions that are highly conducive to ozone formation. However, transport of pollution from the South Coast is the predominant factor in the Coachella Valley ozone air quality challenge. Local terrain, meteorological conditions, and the regional distribution of emissions yield a favorable setting for routine transport of pollutants from the South Coast to the Coachella Valley.

Terrain and Meteorology

Transport from the South Coast to the Coachella Valley has been a topic of atmospheric research for decades. Studies in the 1970s and 1980s identified the San Gorgonio Pass, in northwest portion of the Coachella Valley, as one of the major outlets for South Coast air pollution. Smith et al. (1983) observed pollution transport at a range of altitudes through the San Gorgonio Pass. Pollutants transported in low level; terrain--following air masses directly affect air quality in areas immediately downwind. Other filamentous layers of pollutants were routinely transported aloft and tended to exit the South Coast following the shoulders of the terrain as well as at higher altitudes through the passes. Layers of pollution transported aloft can readily become entrained in near surface air on the eastern side of the pass through the action of mountain lee waves (Smith et al., 1983).

On most summer days, prevailing winds transport aged air masses from the South Coast into the Coachella Valley. Reflecting the strength and persistence of the winds in this area, the eastern side of the San Gorgonio Pass is the site of one of California's major wind farms.

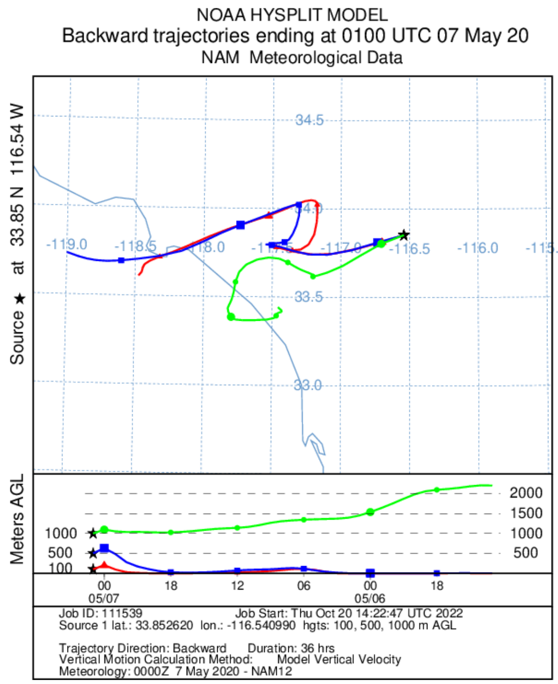
Regional Transport

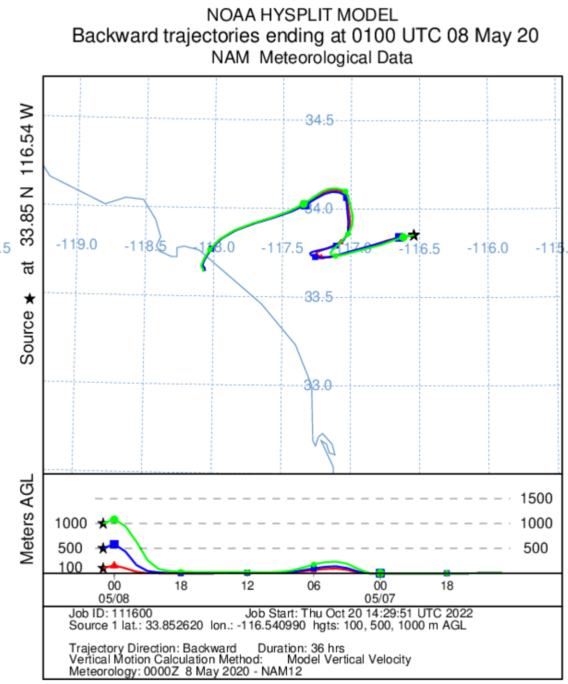
Evaluation of meteorological data helps to assess the transport of emissions contributing to ozone concentrations and to identify areas potentially contributing to the monitored violations.

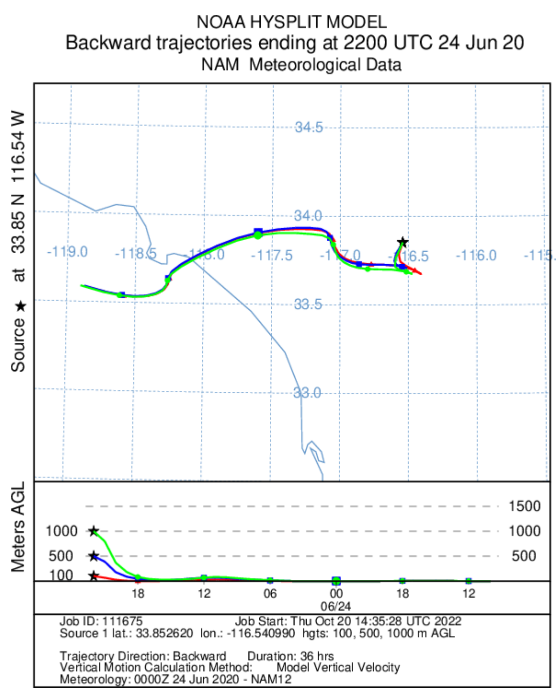
CARB staff used the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model to calculate the 36 hour back trajectories. This analysis was applied to the high ozone days at each of the three Coachella Valley sites. As examples, the regional transport of ozone pollution from the South Coast to the Coachella Valley is evident in Figure 3. At the Palm Springs monitoring site where the highest ozone design values were reported, the back trajectories show that ozone pollution is coming from the direction of Banning in the South Coast, giving a clear indication that it is being transported from the South Coast to the Coachella Valley through the San Gorgonio Pass.

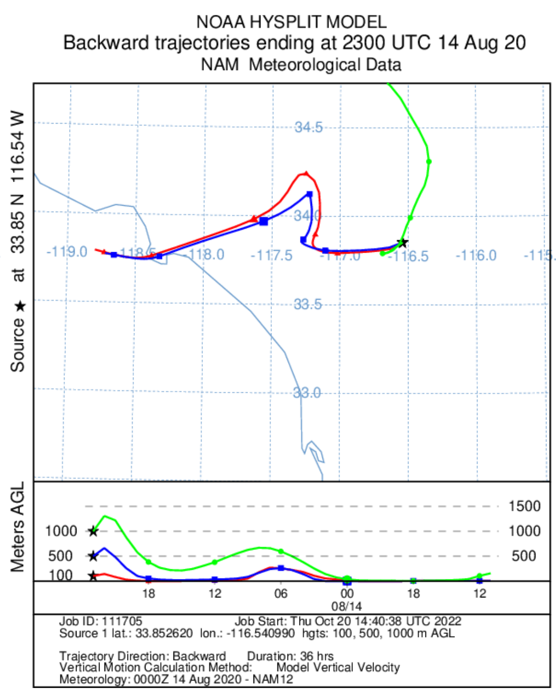
Figure 3. 36-hour Back Trajectories at Time of Maximum Ozone Concentration for the 2020 Top 4 High Ozone Days (>0.070 ppm) at Coachella Valley Sites

1) Palm Springs-Fire Station

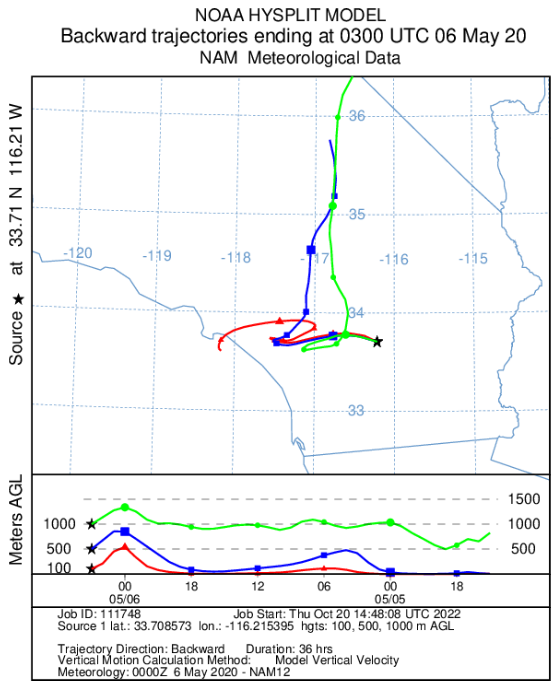


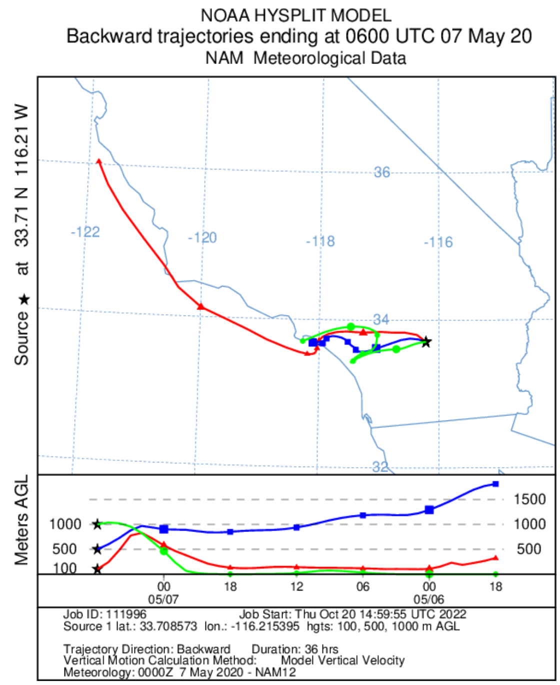


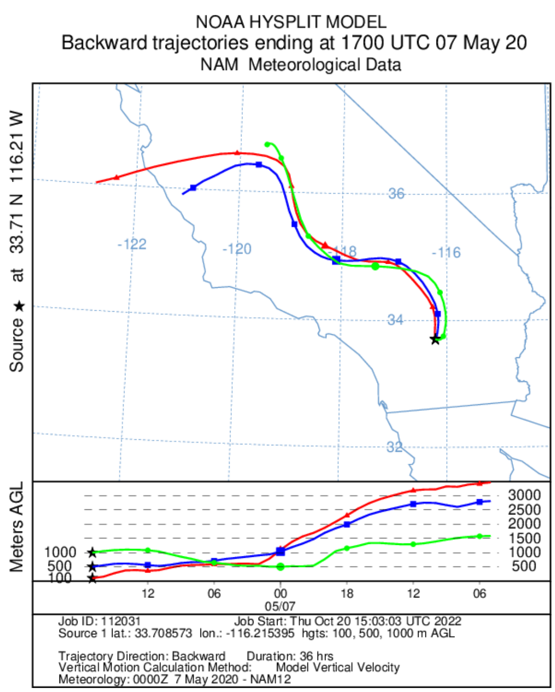


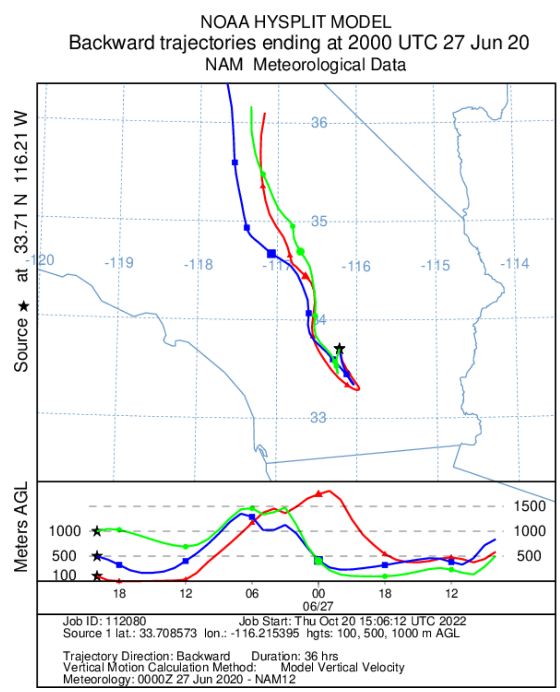


2) Indio-Jackson Street

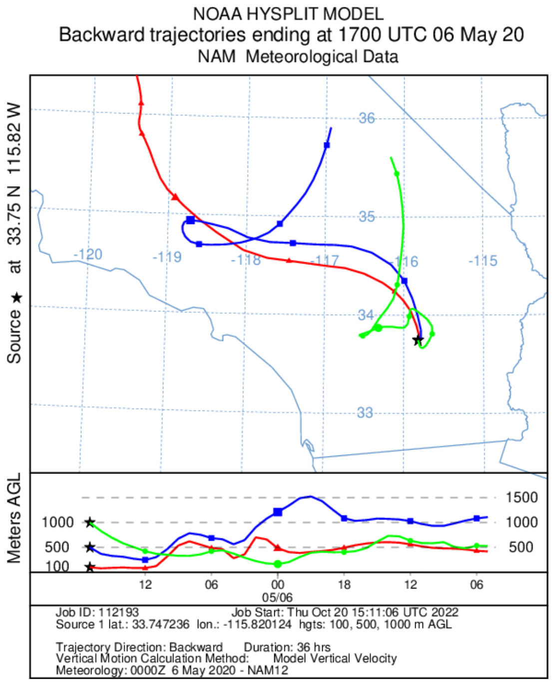


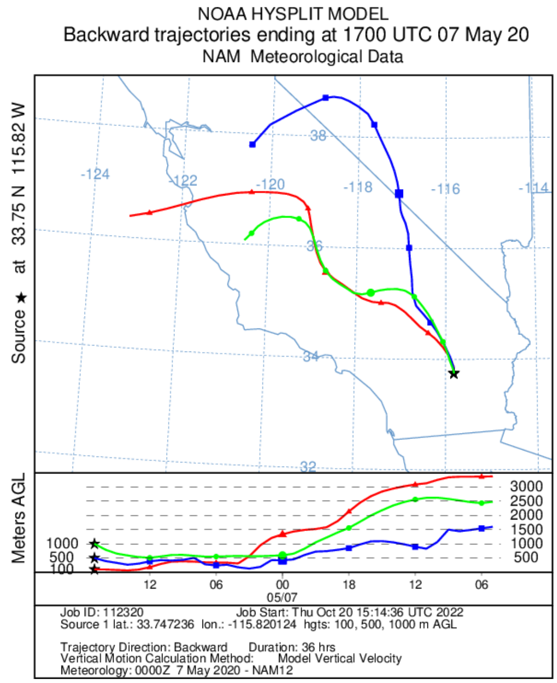


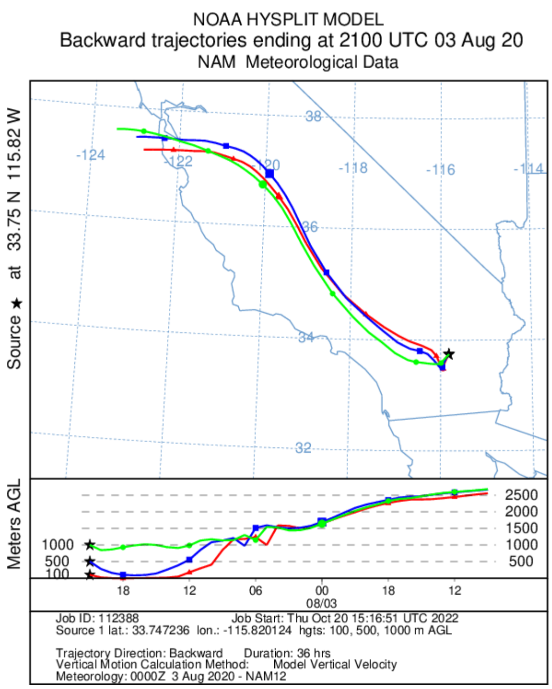


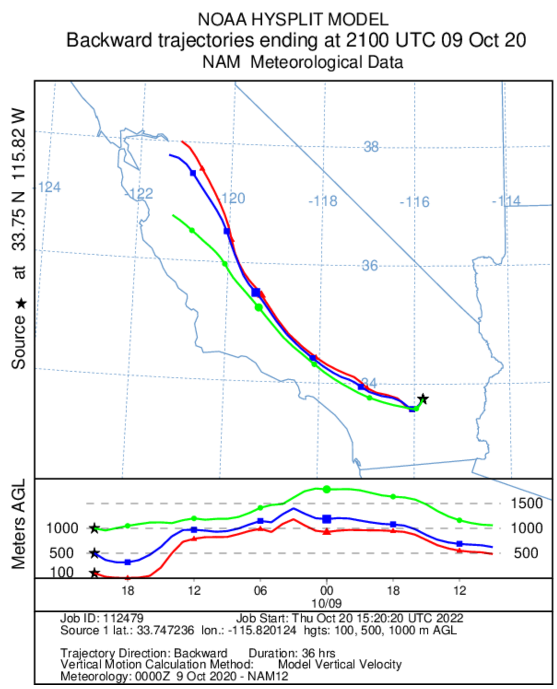


3) Joshua Tree National Park



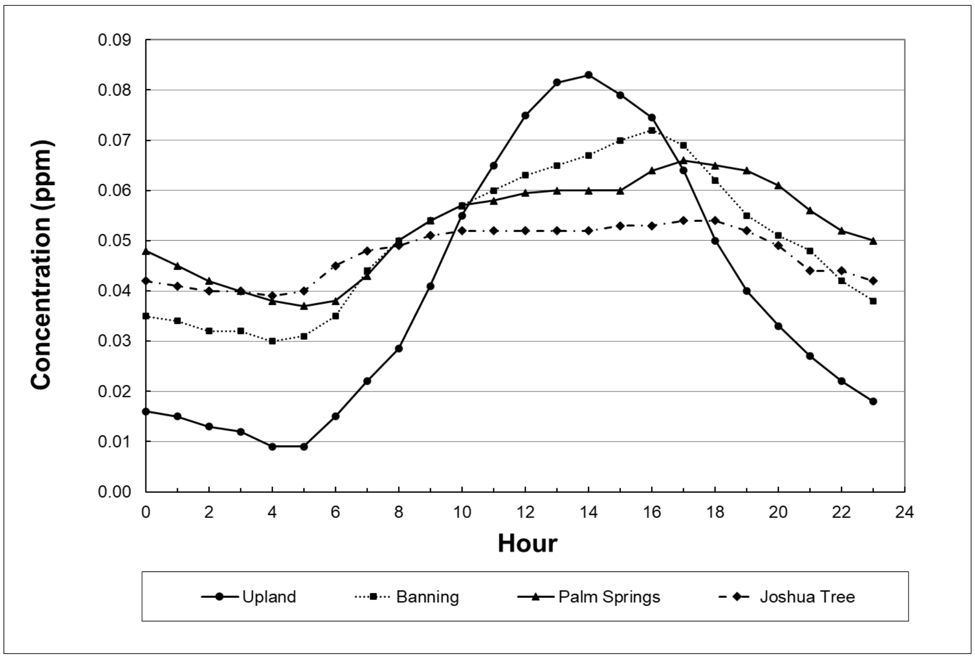






Air masses traversing the San Gorgonio Pass include ozone and precursors derived from the emission source areas throughout the South Coast. Past CARB analyses have documented a progression of maximum ozone concentrations which starts in the South Coast early in the afternoon and follows westerly winds as the afternoon progresses (CARB, 1996). Peak ozone concentrations increase with transport through the South Coast as the transported air masses age and fresh emissions are entrained (CARB, 1996). When the air mass reaches the east side of the San Gorgonio Pass, depositional processes outcompete entrainment of fresh emissions and peak concentrations are lower than at sites on the western side of the Pass.

Figure 4. South Coast Progression of Peak Ozone Values to Coachella Valley



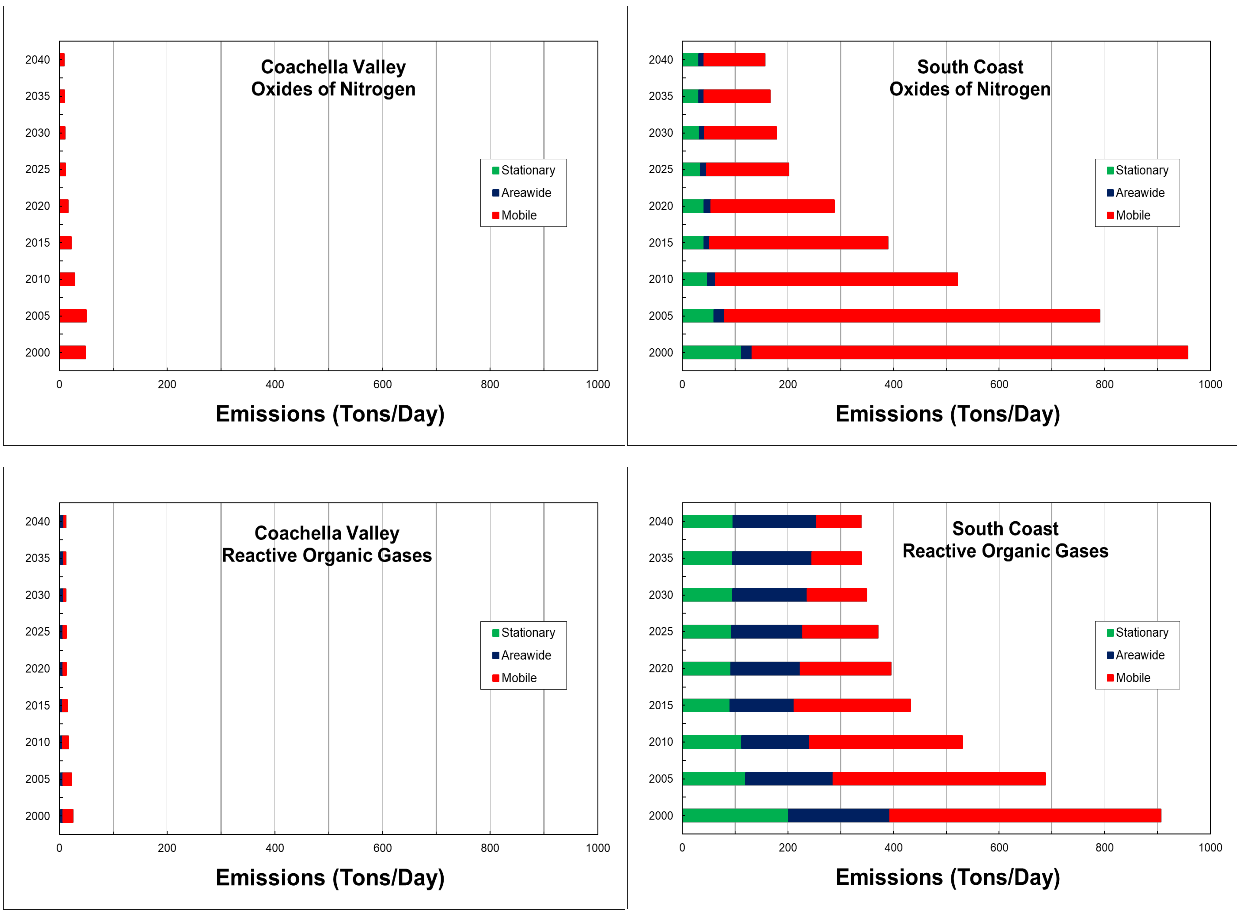
Areas impacted by transport generally show ozone concentrations peaking in the late afternoon or early evening hours. Figure 4 shows 24--hour diurnal profiles plotted for sites from Upland in the South Coast to Joshua Tree in the Coachella Valley during 2020. Plotted values include the median value for every hour of each day from May through August. As shown in Figure 4, the daily peak ozone concentration occurs at a progressively later hour the further downwind the receptor site is located. The first peak occurs in Upland, the furthest western site plotted; it is followed by Banning and Palm Springs, and then lastly by Joshua Tree, the furthest eastern site plotted. This movement of the peak ozone concentration reflects a general west to east transport of emissions and pollutants.

Surrounding terrain can limit ventilation and trap emissions overnight in the Coachella Valley (Edinger, 1973). Coupled with limited available NOx emissions, a significant concentration of ozone may carry over from one day to the next.

Regional Distribution of Precursor Emissions

From a regional perspective, emissions in the Coachella Valley are much lower than emissions in the South Coast. The 2022 summer emissions inventory based on data from the CARB's 2022 Ozone SIP Inventory (Version 1.01 with approved external adjustments and include SCC, OC1, OC2 out to 100 nautical miles), shown in Figure 5, indicates that the Coachella Valley oxides of nitrogen (NOx) and reactive organic gas (ROG) emissions are minimal compared to the South Coast, amounting to only five and three percent of South Coast emissions, respectively. This difference in emissions between the two areas points to the fundamental role of transport in the Coachella Valley's ozone air quality problem.

Figure 5: Inventory of the Coachella Valley and South Coast Summer Emissions by Source Category



Data source: ARB CEPAM 2022 SIP Planning Tool v1.01 with approved external adjustments.

The connection between ozone, a secondary pollutant, and emissions of ozone precursor compounds is characterized by considerable temporal and spatial variability. In general, as air masses travel downwind, entrainment of fresh emissions, atmospheric reactions, depositional processes, and dilution increase the VOC/NOx ratio. As a result, ozone formation in suburban and rural areas downwind of major urban areas is generally regarded as NOx limited (cf. Finlayson-Pitts and Pitts, 1993; Finlayson-Pitts and Pitts, 2000). Given the Coachella Valley's location, downwind of the South Coast extreme nonattainment area, ozone formation would be expected to be NOx limited.

The San Gorgonio Pass is the primary transport route from the South Coast to the Coachella Valley. The transport of ozone and ozone precursors from the South Coast to the Coachella Valley has been well established by peer reviewed studies for over 50 years. Additional analyses presented in the conceptual model support these research findings. As shown by the trajectory analyses for Coachella Valley exceedance days, in Figure 3, persistent surface winds transport emissions originating in the South Coast into the Coachella Valley. Diurnal profiles at Palm Springs show the typical characteristics of a transport site, with the highest peak occurring in the late afternoon or evening. There is a progression of timing of peak ozone from the upwind sites in the South Coast to the Coachella Valley, as shown in Figure 4. Finally, emissions in the Coachella Valley are significantly lower than emissions in the South Coast. Thus, attainment in the Coachella Valley is directly linked to emission reduction strategies upwind, in the South Coast.

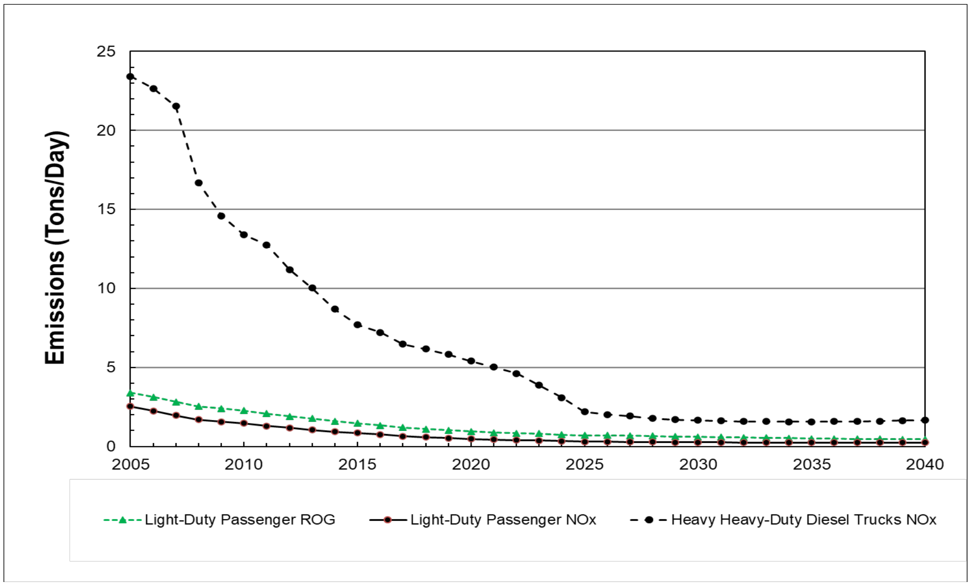
Anthropogenic Emission Trends

Emissions in the Coachella Valley are significantly lower than those in the South Coast, as seen in Figure 5 in the previous section. However, the Coachella Valley continues to make progress in reducing local emissions. In 2020, NOx emissions within the Coachella Valley were dominated by mobiles sources including medium -heavy--duty diesel trucks, heavy -heavy--duty diesel trucks, trains, off-road equipment, light--duty passenger vehicles, and medium--duty trucks. The largest sources of ROG emissions were mobile sources (light-duty passenger vehicles, light--duty trucks, off---road equipment) and areawide sources (consumer products). As shown in Figure 5, statewide and regional control measures resulted in significant reductions of ozone precursor emissions in Coachella Valley between 2000 and 2020:

- Total NOx emissions declined by 67 percent, and
- Total ROG emissions declined by 48 percent.

Statewide emission control programs targeting mobile sources, particularly passenger vehicles and diesel trucks have contributed to these reductions. For example, the 2007 adoption of regulations for heavy-duty engine standards and the 2012 truck and bus rule both led to marked reductions in NOx emissions. As shown in Figure 6, between 2005 and 2020, NOx emissions from heavy heavy-duty diesel truck subcategories declined 77 percent. For the same period, NOx and ROG emissions from the light duty passenger vehicle subcategory declined by 82 and 72 percent respectively.

Figure 6: Summer Emissions for Top Two On-road Mobile Source Subcategories in the Coachella Valley from 2005 to 2040



Emissions inventory projections for the Coachella Valley and South Coast indicate that adopted emission control programs will continue to yield reductions in the coming years. Between 2020 and 2037, in the Coachella Valley, NOx and ROG emissions from light-duty passenger vehicles are both projected to decline an additional 50 percent, respectively. Additionally, NOx emissions from heavy heavy-duty trucks are expected to decline 70 percent during that same period.

Between 2020 and 2037, the Coachella Valley is predicted to see an overall decline in NOx and ROG of 40 and 10 percent respectively under the current adopted emissions control programs. During the same period, the South Coast is expected to see reductions in NOx and ROG of 44 and 14 percent respectively, amounting to a reduction of 126 and 57 tons per day respectively.

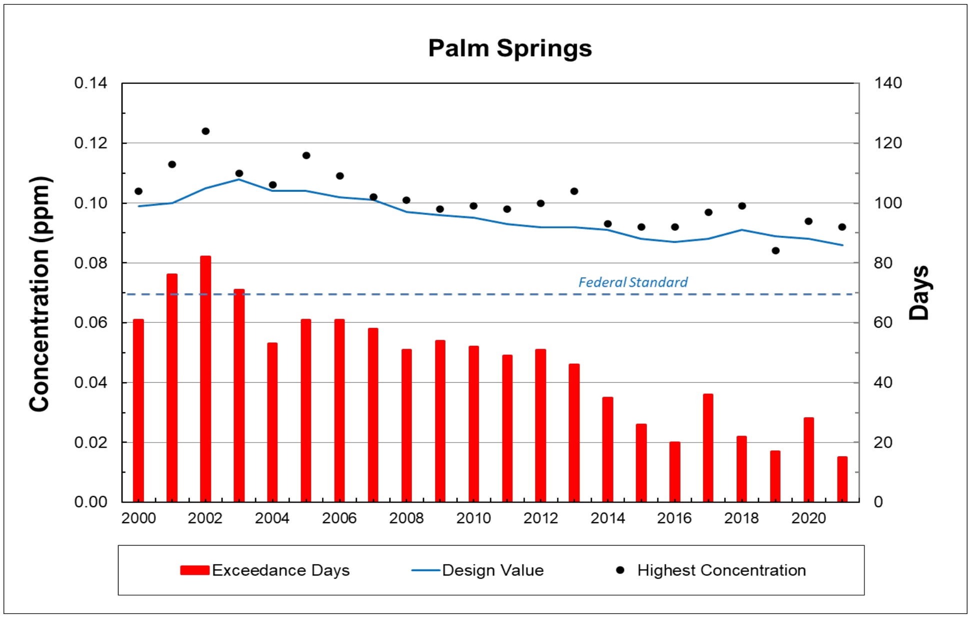
Additional reductions in the South Coast will be necessary to ensure that both the South Coast and Coachella Valley come into attainment by 2037. Future South Coast measures include transitioning to zero or near zero emission technologies for stationary sources and appliances, reductions from non-refinery flares, reducing existing residential building energy use, improved leak detection and repair, and green waste composting. These upcoming emission controls from the South Coast will contribute to attainment in the Coachella Valley.

Ozone Air Quality

In response to declining emissions, ozone air quality has markedly improved over the last two decades. As shown in Figure 7, between 2000 and 2020, the number of ozone exceedance days decreased 54 percent at the Palm Springs monitoring site, from 61 days to 28 days. Over this same period, the highest daily maximum 8--hour ozone concentration decreased 10 percent, from 0.104 to 0.094 ppm. The Coachella Valley's ozone design value also saw a decrease of 11 percent from 0.099 to 0.088 ppm. The 2020 ozone design value at Palm Springs (0.088 ppm) was 26 percent above the

0.070 ppm ozone standard, compared with the design value in 1977 (0.140 ppm), which was 100 percent above this standard.

Figure 7: Coachella Valley Ozone Statistics from 2000 to 2021

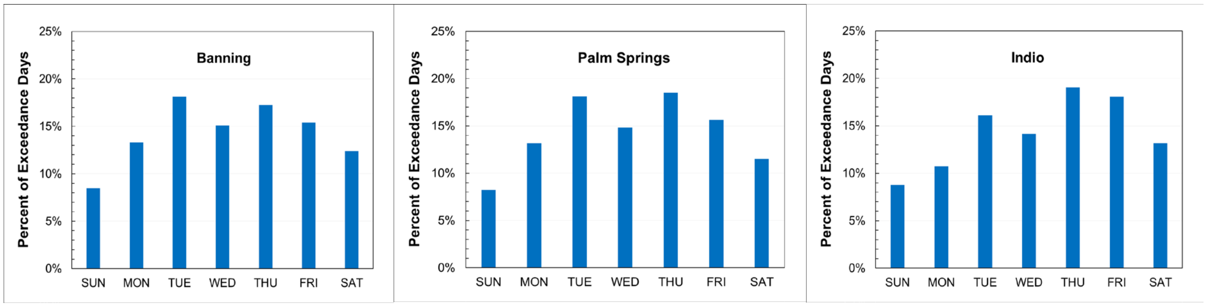


Ozone air quality has also improved at other sites in the Coachella Valley. Between 2000 and 2020, exceedance days have decreased significantly at all sites. After reviewing years with complete data for Joshua Tree National Park, exceedance days dropped from 12 days in 2006 to only one day in 2020, a decrease of 91 percent. Indio had 28 exceedance days in 2006 and 17 days in 2020, a decrease of 39 percent.

Weekend/Weekday Differences

The South Coast has historically shown weekend/weekday differences. Ozone exceedance days on weekends and weekdays were compared to determine if there were any significant differences in the frequency of occurrences in the Coachella Valley. Figure 8 shows the daily percentage of exceedances at each site on each day of the week over the course of five years between 2016 and 2020. The percentage of exceedance days on weekdays was generally higher as compared with the percentage of exceedance days on weekend days for both the two Coachella Valley sites and the Banning site.

Figure 8: Weekend/Weekday Differences in the Coachella Valley and South Coast

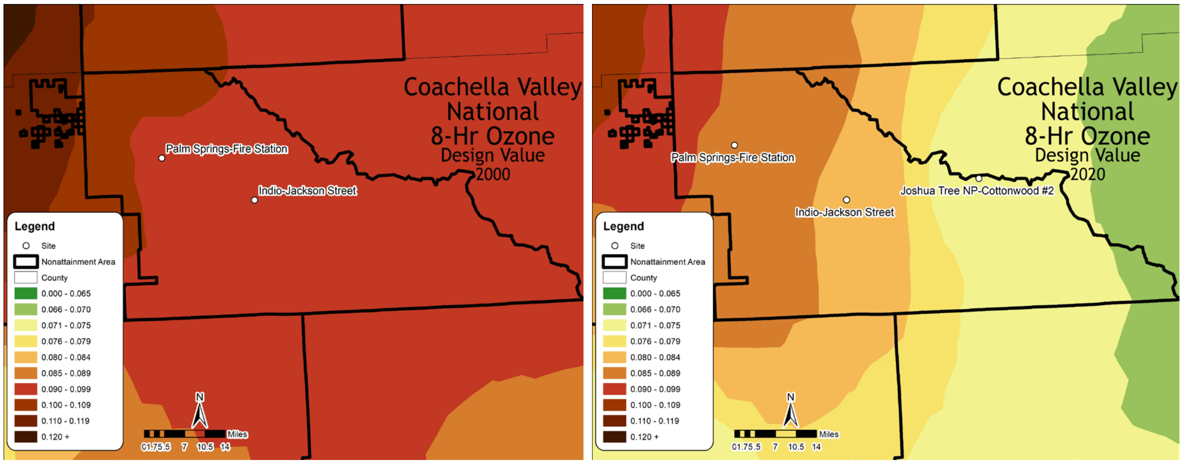


The weekend effect is not observed for the two Coachella Valley sites as well as the Banning site in the South Coast. Ozone formation downwind of large urban areas is generally regarded as NOx limited (as previously discussed in the conceptual model). As such, the lack of notable weekend effect in the Coachella Valley would be expected. This analysis helps corroborate the characterization of the downwind and transport impacted nature of the ozone air quality in the Coachella Valley.

Population Exposure

The contour maps in Figure 9 are a visual representation of design values and their change over time. These values are used to approximate air quality levels over the entire nonattainment area. As shown in the following maps, in 2000 all the Coachella Valley exceeded the 0.070 ppm ozone standard. As the years have progressed, the area to the southeast of the Valley and the population in the most southern part of the nonattainment area are seeing decreasing ozone values.

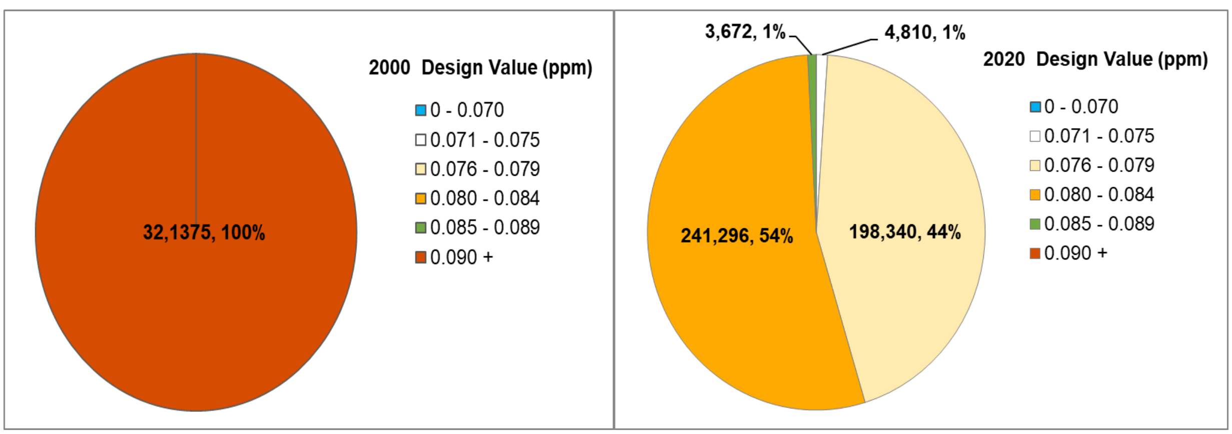
Figure 9: Contour Maps Representing the Spatial Distribution of Ozone Air Quality in the Coachella Valley in 2000 and 2020



To develop the contour maps, ARB staff used inverse distance weighting to spatially interpolate design values calculated from sites throughout the State. Contours extend spatially as far as data is available and may result in gaps due to lack of said data.

To evaluate changes in population exposure, spatial analysis tools were used to overlay county level census data with the design value contour maps. As shown in Figure 10, from 2000 to 2020, the number of people residing in areas with the highest ozone concentrations substantially declined. In 2000, the entire population resided in areas with ozone design values above 0.090 ppm, whereas, in 2020 all areas of the Coachella Valley were below 0.090 ppm. In 2020, 45 percent of the population lived in areas between 0.070 ppm and 0.080 ppm ozone levels, and the remaining 55 percent of the population lived in areas between 0.080 ppm and 0.090 ppm.

Figure 10: Population Distribution by Ozone Design Value in 2000 and 2020

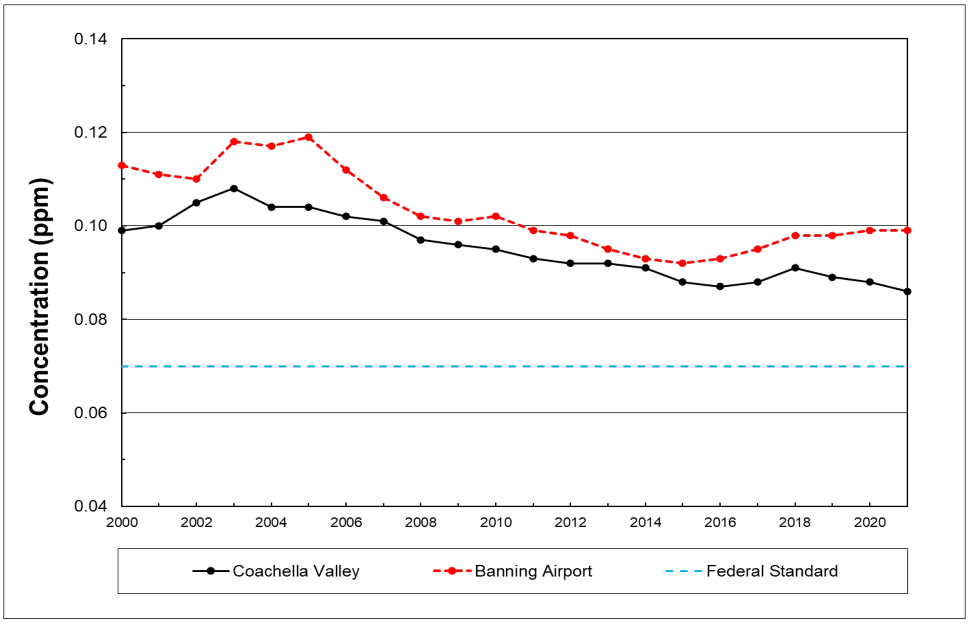


Based on 2000/2020 U.S. Census population and 2000/2020 Design Values.

Upwind and Downwind Trends

Design values were compared between upwind and downwind sites to confirm that progress in the South Coast was translating to similar progress in the Coachella Valley. Figure 11 shows the design value trends for Banning and the Coachella Valley. As shown, the two trends track remarkably well over time, given the complex nature of the ozone problem in both the South Coast and the Coachella Valley. The difference in ozone design values concentrations at the Coachella Valley, which is dominated by Palm Springs site, and South Coast Banning Airport site is quite consistent and ranges from 0.002 to 0.015 ppm from 2000 to 2020, except for the recent poor air quality since 2017 in the South Coast due to poor meteorology and complex photochemistry. As shown, from 2005 to 2020, Palm Springs site had a fifteen percent reduction and Banning Airport had a seventeen percent reduction in ozone design values.

Figure 11: Ozone Design Value Trends in the Coachella Valley and Banning 8-hour Ozone Design Values 2000 to 2021



The analyses presented above illustrate the extent of the progress between 2000 and 2020 and the linkage between the upwind South Coast and the Coachella Valley. In 2020, the ozone design values at all three monitoring sites, Palm Springs, Indio, and Joshua Tree National Park, continue to exceed the 0.070 ppm ozone standard. However, ozone air quality has improved throughout the Coachella Valley in response to declining upwind emissions of ozone precursors and analyses of air quality data indicate that the sites are continuing to make progress toward attainment. As air quality improves in the South Coast, transported air pollution and its effects will continue to be reduced on the Coachella Valley.

Attainment Projections

Regional Photochemical Modeling Results

Photochemical modeling was completed by the District in Summer 2022 reflecting both the current and future control programs. The modeling results provide projected 2037 design values for sites throughout the South Coast Air Basin. The modeling results indicate that the Coachella Valley will not meet the 2037 attainment date with the current control measures. However, with the inclusion of proposed more strict control measures targeting attainment needs of the upwind South Coast, District modeling projects that ozone design values at Palm Springs and Indio-Jackson Street will meet the 0.070 ppm ozone standard by the 2037 attainment date. As shown in Table 2, the modeled ozone design value is 0.061 ppm at Palm Springs-Fire Station and 0.066 ppm at Indio-Jackson Street in 2037.

Table 2: Projected Design Values from District Modeling and 2020 Design Values from Monitoring Sites in the Coachella Valley

Site Name	AQS ID	2020 Design Value (ppm)	2037 Projected Design Value (ppm)
Palm Springs-Fire Station	060655001	0.088	0.061
Indio-Jackson Street	060652002	0.084	0.066
Joshua Tree National Park	060650010	0.071	Not Available

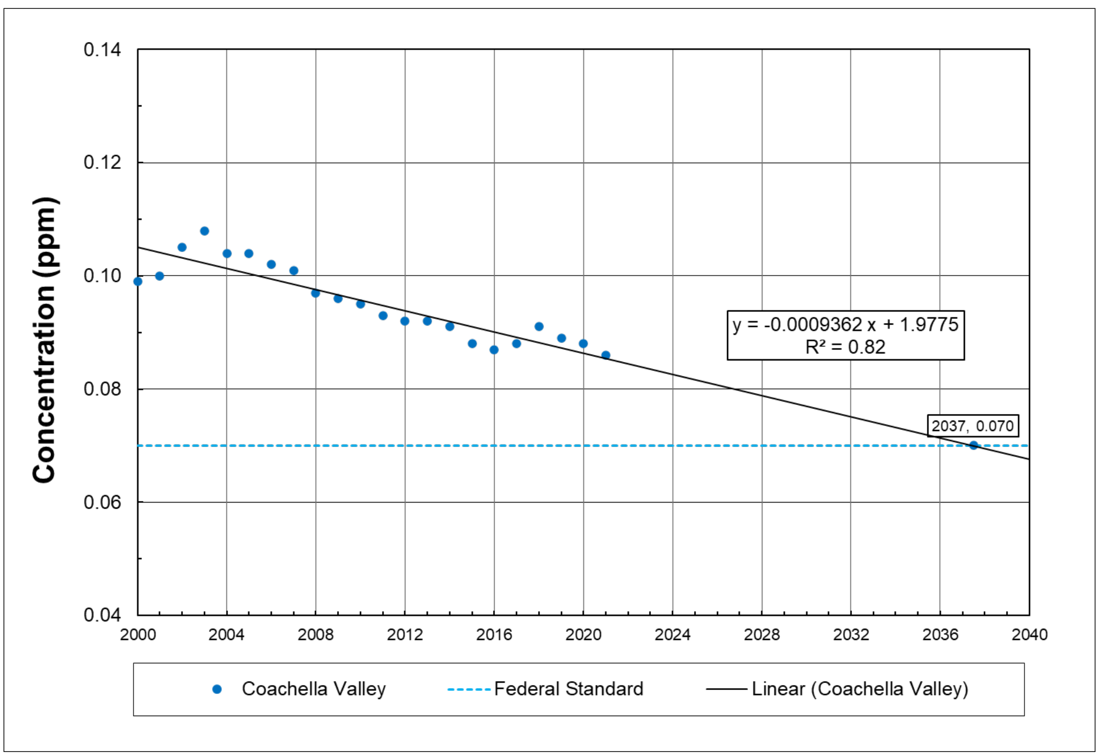
Projection based on Air Quality Trends

As emission controls increase in upwind areas, it is expected that ozone precursors will continue to decrease, and ozone will continue a downward trend in the Coachella Valley. As shown in Table 3, data for 2021 show decreases in the 8-hour ozone design values at all three sites in the Coachella Valley. Figure 12 shows the 8-hour ozone design value trends, extended to the 2037 attainment deadline. It indicates that the Coachella Valley can be expected to attain the 0.070 ppm ozone standard by 2037 approximately, which is generally consistent with the projection based on modeling.

Table 3: Comparison of 2020 Design Values and Preliminary 2021 Design Values in the Coachella Valley

Site Name	AQS ID	2020 Design Value (ppm)	2021 Design Value (ppm)	2020 to 2021 Change (ppm)
Palm Springs-Fire Station	060655001	0.088	0.086	-0.002
Indio-Jackson Street	060652002	0.084	0.080	-0.004
Joshua Tree National Park	060650010	0.071	0.066	-0.005

Figure 12: 8-Hour Ozone Design Value Projection in 2037 based on Design Value Trends in the Coachella Valley



Summary

The Coachella Valley is classified as extreme nonattainment area for the 0.070 ppm ozone standard, with an attainment deadline of 2037. This WOE demonstration evaluated ambient ozone data and trends, precursor emission trends and reductions, population exposure trends to complement the regional photochemical modeling analyses conducted to evaluate Coachella Valley's progress toward meeting the 2037 attainment date.

- Local terrain, persistent surface winds, and the regional distribution of emissions yield a favorable setting for routine transport of pollutants from the South Coast to the Coachella Valley. This WOE has demonstrated the fundamental role of transport on the Coachella Valley ozone problem and attainment strategy. Thus, attainment in the Coachella Valley is directly linked to emission reduction strategies upwind, in the South Coast.
- Local emissions of ozone precursors declined significantly between 2000 and 2020. Total NOx emissions declined by 67 percent whereas total ROG emissions declined by 48 percent. Local emissions, however, are much lower than emissions upwind in the South Coast. NOx and ROG in the Coachella Valley are just five and three percent respectively, of those in the South Coast. During this same period, emissions in the South Coast have declined by 670 and 511 tons per day (70 and 56 percent), respectively for NOx and ROG, which greatly contributes to air quality progress in the Coachella Valley.
- Between 2000 and 2020, exceedance days decreased by 54 percent, and both the daily 8--hour maximum ozone concentration and the design value have decreased by approximately 10 percent. The 2020 ozone design value was 0.088, 26 percent above the 0.070 ppm ozone standard. These design value decreases are consistent with the decrease in the South Coast.
- South Coast emissions will continue to decrease going forward with implementation of the attainment strategy for that upwind region. Currently adopted programs will decrease NOx and ROG by 44 and 14 percent between 2020 and 2037.
- Photochemical modeling completed by the District indicates that the Coachella Valley will not be able to meet the standard by the 2037 attainment deadline with currently adopted regulations. However, with the inclusion of proposed controls the regional modeling analyses projects that ozone design values in Coachella Valley will meet the 0.070 ppm ozone standard by the 2037 attainment date.
- 8-hour ozone design value trends also indicate that the Coachella Valley can be expected to attain the 0.070 ppm ozone standard by 2037 approximately, which is consistent with the projection based on modeling.

Taken together, the results from all these analyses indicate that the Coachella Valley is on track to attain the 2015 federal 8-hour ozone standard of 0.070 ppm by 2037.

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