Exceptional Event Demonstration for PM_{10} Exceedances in Clark County, Nevada – October 22, 2022

Final Report Prepared for

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San Francisco, CA

June 2024

Sonoma Technology

Exceptional Event Demonstration for PM_{10} Exceedances in Clark County, Nevada – October 22, 2022

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Cover graphic shows images from the M Resort Hotel in Las Vegas on October 22, 2022, at 14:00 PST.

This document contains blank pages to accommodate two-sided printing.

Contents

Figures

Tables

1. Narrative Conceptual Model

In late October 2022, a strong frontal passage traversed south through California and Nevada, driving a windblown dust event that lofted and entrained dust from the Mojave Desert and increased particulate matter (PM) concentrations in Clark County, NV, on October 22, 2022. During this episode, the 2012 24-hour National Ambient Air Quality Standards (NAAQS) threshold was exceeded for particles with a diameter of less than 10 microns (PM_{10}) at 10 monitoring sites in Clark County: Paul Meyer, Mountains Edge, Walter Johnson, Palo Verde, Joe Neal, Green Valley, Liberty High School, Jerome Mack, Sunrise Acres, and Walnut Community Center. Two additional sites also experienced NAAQS exceedances and all other sites throughout Clark County experienced significantly enhanced hourly PM_{10} concentrations but were not regulatorily significant. The widespread impact on PM_{10} concentrations in Clark County indicates a regional dust event. The exceedances at the 10 regulatorily significant sites affected the PM_{10} attainment designation for Clark County during the 2021-2023 design value period.

Due to severe drought conditions in the Mojave Desert in southeastern California, strong winds created by the pressure gradient from the frontal passage lofted, entrained, and transported dust to Clark County, arriving in the afternoon on October 22, 2022. The U.S. Environmental Protection Agency (EPA) Exceptional Event Rule (EER) (U.S. Environmental Protection Agency, 2016) allows air agencies to omit air quality data from the design value calculation if it can be demonstrated that the measurement in question was caused by an exceptional event. In this case, enhanced wind speeds greater than 25 mph in the Mojave Desert source region coincided with the frontal passage and increased PM_{10} concentrations along the transport path, which is consistent with a high-wind dust event as described in the EPA Guidance on High Wind Dust Events (U.S. Environmental Protection Agency, 2019).

Overall, the October 22, 2022, PM_{10} concentrations at the 10 affected sites rank above the 99th percentile for all 2018-2022 PM_{10} events in Clark County, and is clearly exceptional compared to typical PM_{10} conditions. Windblown dust from the Mojave Desert is shown to be entirely from natural, undisturbed lands, and the high concentrations can be considered a natural event that could not be mitigated by anthropogenic actions beyond public warnings. Overall, this report includes detailed analyses that establishes a clear causal relationship between the high-wind event in the Mojave Desert region of southeastern California with the enhanced PM_{10} measured at 10 affected sites in Clark County, NV – designating the October 22, 2022, event as a High Wind Dust Exceptional Event.

Key narrative evidence and timeline elements are shown below and expanded on in this document.

Pre-Event Climatological Context

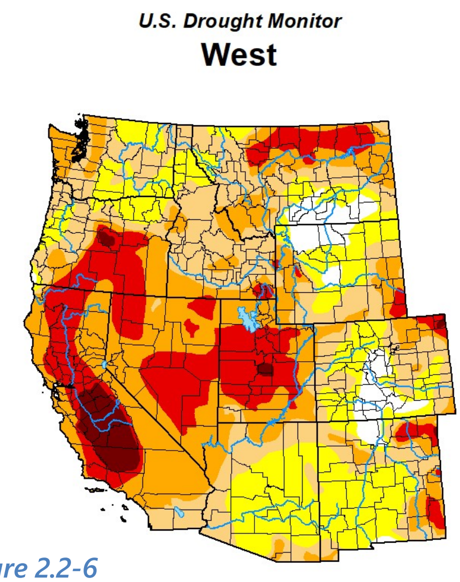

Figure 2.2-6

The Mojave Desert in southeastern California and Clark County, NV, were under severe to extreme drought conditions on and before the October 22, 2022, event. Temperatures were above normal and precipitation below normal compared to climatology. The barren land cover, including the Mojave Desert source region, was primed for significant dust production during the high-wind event.

See Section 2.2.

Inciting High-Wind Event

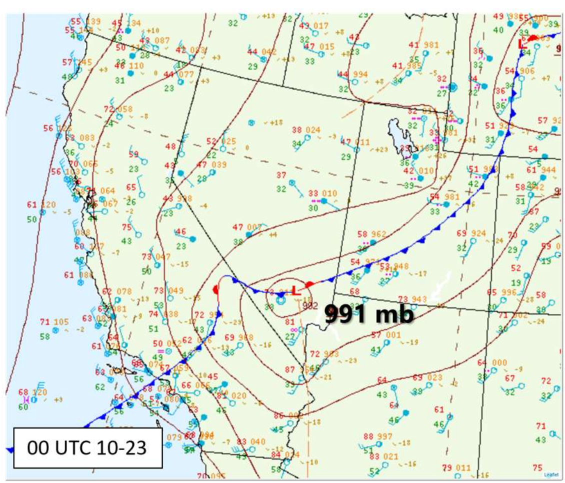

Figure 3.1-3

A frontal passage through California and Nevada precipitated a large pressure gradient across Clark County and the Mojave Desert, culminating in high wind speeds and gusts across the area between 07:00 and 20:00 PST on October 22, 2022. The meteorological analysis and radar images show the frontal passage (and associated dust) entering Clark County, NV, at 12:00 PST on October 22. Wind speeds in the Mojave Desert well exceeded the 25-mph sustained wind threshold over natural undisturbed lands. This caused lofting, entrainment, and transport of PM_{10} from the source region into Clark County.

See Section 3.1.

Transport of PM_{10} from the Source Region to Clark County

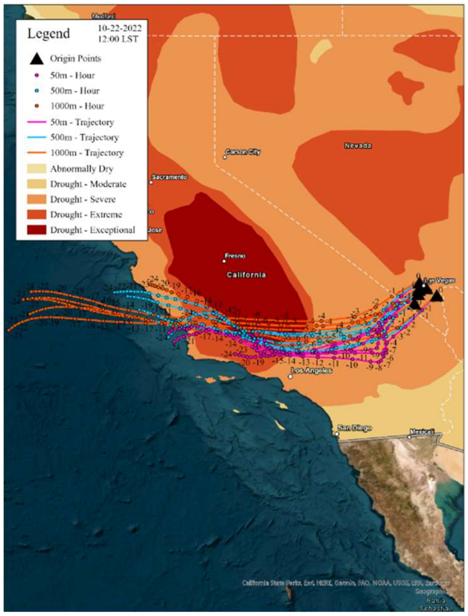

Figure 3.2-2

Back trajectories and meteorological data along the frontal passage confirm the Mojave Desert in southeastern California (located to the southwest of Clark County) as the source region for the high-wind dust event. The frontal passage pushed south through the source region enroute to Clark County, NV, and transported dust quickly to the area (within two to four hours of the exceedance).

See Section 3.2.

Enhanced PM_{10} from High Wind Dust Event Arrives in Clark County

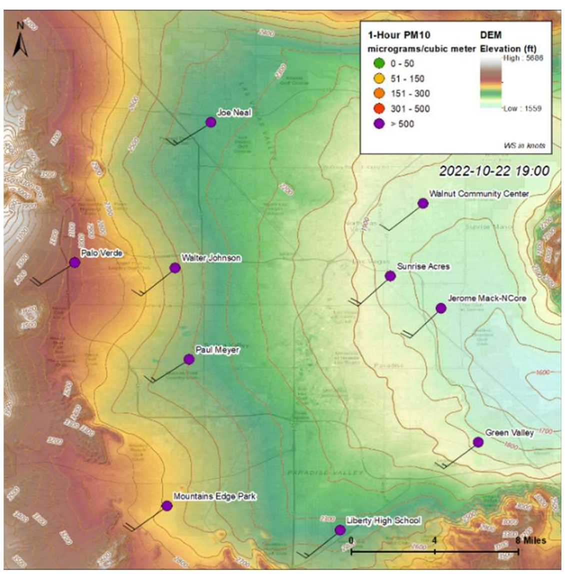

Figure 3.2-12

Enhanced PM_{10} arrived in Clark County beginning at 05:00 PST and increased significantly by 12:00 PST on October 22, with a peak in PM_{10} between 14:00 and 20:00 PST. Concentrations remained enhanced through the remainder of the day. High PM_{10} concentrations at 12 sites across Clark County coincided with the frontal passage and occurred at the same time as high wind speed and gust measurements. Widespread high PM_{10} concentrations at all Clark County sites occurred simultaneously, indicating a regional high-wind event.

See Section 3.2.

Effect of PM_{10} Concentrations in Clark County

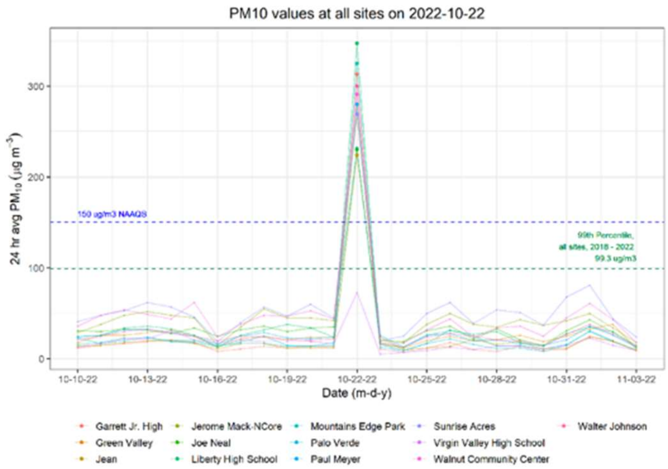

Figure 3.3-6

Twelve PM_{10} monitoring sites exceeded the NAAQS on October 22, 2022 - 10 were regulatorily significant and two were not. All sites throughout the Las Vegas Valley showed peak hourly concentrations of PM_{10} well above 500 µg/m^3. The widespread high PM_{10} concentrations concur with a regional high-wind exceptional event. PM_{10} concentrations at all 12 sites exceeded the 5-year 99th percentile and the NAAQS on October 22, 2022.

See Section 3.3

High Wind or PM_{10} Alerts Issued

News Release

County Commission:
James B. Gibson, Chairman
Justin Jones, Vice Chairman
Marilyn Kirkpatrick
William McCurdy II
Ross Miller
Michael Naft
Tick Segerblom

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For Immediate Release **Thursday, Oct. 20, 2022**

Air Quality Dust Advisory Issued for Saturday

The Clark County Department of Environment and Sustainability has issued a dust advisory for **Saturday, Oct. 22,** to advise residents and local construction sites of the possibility of elevated levels of blowing dust due to the forecast of high winds in our area.

Airborne dust is a form of inhalable air pollution called particulate matter or PM, which aggravates respiratory diseases. Under windy conditions people with heart or lung disease, older adults, and children may feel better staying indoors as much as possible because they could be at greater risk from particulates, especially when they are physically active, according to the U.S. Environmental Protection Agency. Consult your physician if you have a medical condition that makes you sensitive to air pollution.

Figure 3.3-2

The National Weather Service issued a Dust Storm Warning for Clark County on October 22, 2022. Clark County Nevada issued a Dust Advisory in advance of the October 22 event as well, due to forecast high PM_{10} concentrations. They advised residents and local construction sites that enhanced levels of blowing dust were possible due to high winds. Multiple news outlets also reported on high winds, low visibility, and extremely dusty conditions on October 22, 2022.

See Section 3.3

Comparison with Historical Data

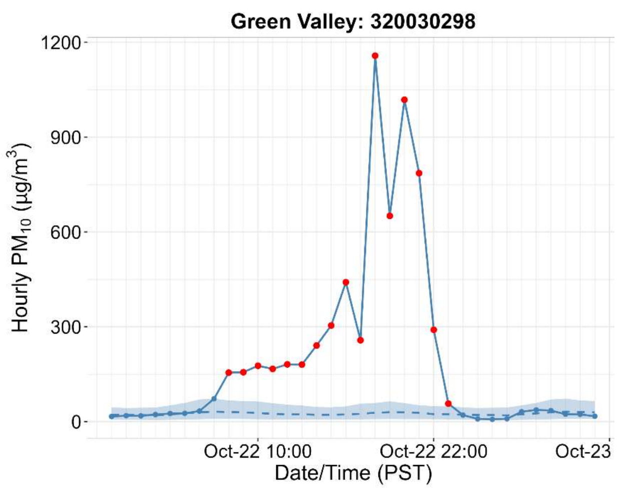


Figure 3.4-27

PM_{10} at all 10 regulatorily significant sites exceeded the 5-year 99th percentile and the NAAQS on October 22, 2022. PM_{10} concentrations are also significantly outside of typical seasonal and monthly ranges. 30-year climatology analyses show that temperatures, wind speeds, and soil moisture in the Mojave Desert source region and Clark County were significantly outside of historical normal on the event date.

See Section 3.4.

Not Reasonably Controllable or Preventable

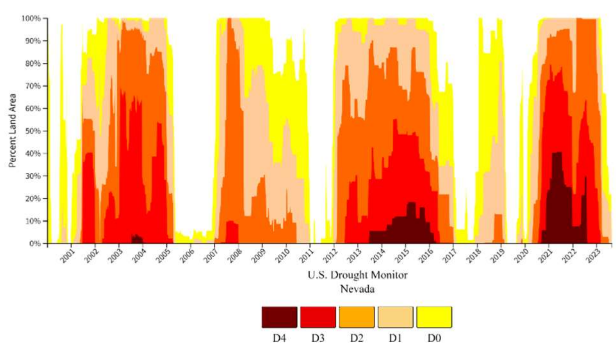


Figure 4.3-3

Based on the severe drought in the source region and the high-wind frontal passage, control measures for PM_{10} within Clark County were quickly overwhelmed and unable to prevent an exceedance event. Significant evidence showing that high winds lofted, entrained, and transported PM_{10} from natural undisturbed lands indicates that this event was natural and not reasonably controllable or preventable (nRCP).

See Sections 4 and 5.

2. Background

2.1 Demonstration Description

2.1.1 PM_{10} Exceptional Event Rule Summary

The U.S. EPA EER (EPA, 2016) allows air agencies to omit air quality data from the design value calculation if it can be demonstrated that the measurement in question was caused by an exceptional event. According to the EER, exceptional events, such as high-wind dust events, which affect PM_{10} concentrations can be excluded from calculations of the NAAQS attainment (i.e., design values) if a clear causal relationship can be established between a specific event and the monitoring exceedance (EPA, 2016). The EER states that an exceptional event demonstration must meet the following six statutory elements:

1. A narrative conceptual model that describes the event(s) causing the exceedance or violation and a discussion of how emissions from the event(s) led to the exceedance or violation at the affected monitor(s),
2. A demonstration that the event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedance or violation,
3. Analyses comparing the claimed-event-influenced concentration(s) to concentrations at the same monitoring site(s) at other times,
4. A demonstration that the event was neither reasonably controllable nor preventable,
5. A demonstration that the event due to human activity that is unlikely to recur at a particular location or was a natural event, and
6. Documentation that the air agency followed the public comment process.

Specifically, a high-wind dust demonstration must show that the dust event is a “natural event,” where windblown dust comes from natural sources or all significant anthropogenic sources of windblown dust have been reasonably controlled using Best Available Control Measures (BACM) (EPA, 2016). Further, air agencies must show that the event met the high-wind threshold of a sustained wind speed of 25 mph or more, or an alternative area-specific, high-wind threshold. The high-wind threshold is the minimum wind speed capable of causing PM emissions from natural undisturbed lands. If the 25-mph wind speed threshold was not met, a more detailed analysis is necessary to support the nRCP criterion. The winds causing the PM_{10} exceedance on October 22, 2022, met the 25-mph sustained wind-speed threshold in the Mojave Desert dust source region and Clark County.

2.1.2 Requirements for Demonstration Based on Tier

The EPA "Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Influenced by High Wind Dust Events Under the 2016 Exceptional Events Rule" (EPA, 2019) describes a three-tier analysis approach to determine a "clear causal relationship" for exceptional events demonstrations from an air agency. A summary of analysis requirements for each tier is listed in **Table 2.1-1**.

- Tier 1 analysis is applicable when the exceptional event is associated with a large-scale dust storm where recorded visibility is ≤0.5 miles, sustained winds are ≥40 mph, and the event is a focus of a Dust Storm Warning.
- Tier 2 analysis is applicable when the impacts of the dust event on PM_{10} levels are less clear and require more supportive documentation than Tier 1 analysis. Tier 2 analysis is warranted when sustained winds are ≥25 mph but the event does not meet the other thresholds required in Tier 1 analysis.
- Tier 3 analysis is necessary when the impacts of the dust event on PM_{10} levels are more complicated than conditions described in the first two Tiers. Tier 3 analysis is needed when sustained winds do not meet the 25-mph threshold and may require additional analysis, such as Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model trajectories from the source area or source-specific emissions inventories.

Table 2.1-1. High-wind PM_{10} exception event guidance requirements by tier.

Tier	Requirements
1	• Referred to as "Large-Scale, High-Energy High Wind Dust Events." • Does not need justification to support the nRCP criterion. • To satisfy the nRCP criterion, the exceedance(s) must be associated with: - A dust storm that is the focus of a Dust Storm Warning, - Sustained winds that are ≥40 mph, - Reduced visibility of ≤0.5 miles. • Must occur over a "large geographic area."
2	• Referred to as "High Wind Dust Events with Sustained Winds at or above the High Wind Threshold." • Does not meet criterion of Tier 1 high-wind dust events. • High-wind threshold: - Default of ≥25 mph for certain states, - Measured as "at least one full hour in which the hourly average wind speed was at or above the area specific high wind threshold." EPA will consider shorter averaging times as part of the weight-of-evidence demonstration, even if the hourly average was not above the threshold. • Must conduct a controls analysis for events where the dust source was anthropogenic: - Identify anthropogenic and natural sources, - Document whether a State Implementation Plan (SIP), Federal Implementation Plan (FIP), or other control measures addressed the event-related pollutant and all sources, - Confirm effective implementation of control measures.
3	• Referred to as "High Wind Dust Events with Sustained Winds less than the High Wind Threshold." • Sustained winds did not meet the threshold (i.e., sustained winds ≤25 mph). • Requirements are the same as Tier 2, except with the addition of the following possible analyses: - HYSPLIT trajectories of source area, - Source-specific emissions inventories, - Meteorological and chemical transport modeling, - PM filter chemical speciation analysis where filter-based monitors are used.

2.1.3 Demonstration Outline

The PM_{10} exceedance on October 22, 2022, qualifies for Tier 2 analysis and may be referred to as a high-wind dust event with sustained winds at or above the high-wind threshold. On October 22, 2022, a resultant hourly average wind speed greater than the 25-mph threshold was observed within the Las Vegas metropolitan region. Additionally, 2-min averaged Automated Surface Observing Systems (ASOS) data from Harry Reid International Airport shows multiple measurements of wind speeds >25 mph throughout the day, and sustained wind speeds in the Mojave Desert source region were significantly higher than the 25-mph threshold.

Table 2.1-2 provides a breakdown by section of all required analyses for the High Wind Exceptional Event. Sections 3.1-3.3 discuss the high-wind event in detail, including a meteorological analysis (Section 3.1), the timeline of the high-wind dust event (Section 3.2), and evidence of the high-wind dust event observed at the surface (Section 3.3). This includes (Sections 3.3.2) media coverage of and (Sections 3.3.5) ground images taken during the event. Guidance for a Tier 2 analysis recommends a controls analysis when the dust source is not anthropogenic. Section 2.2 identifies anthropogenic and natural sources of dust. **Section 2.2.1 and Error! Reference source not found.** discuss the dust source for the October 22, event as natural, undisturbed lands southwest of Las Vegas, including an analysis of climatological factors that fostered prime conditions for lofted dust. Sections 2.2.3 and 4.1 identify regional emissions and other sources of PM_{10}, and Section 4 identifies control measures against PM_{10} emissions that exist in Clark County.

Table 2.1-2. Analysis elements required for Tiers 2 and 3 High Wind Exceptional Events by section in this report.

Tier	Elements	Section of This Report (Analysis Type)
2	High Wind Dust Event	Section 3 (Clear Causal Relationship)
	Sustained Wind Threshold	Sections 3.1.1 (Meteorological Analysis) and 3.2.2 (High Wind Event Timeline)
	Controls Analysis for Dust Source	Sections 2.2.3 (Regional Emissions of PM_{10}), Section 4.1 (Other Possible Source of PM_{10} in Clark County), Section 4.2 (PM_{10} Control Measures in Clark County), Section 4.3 (Reasonableness of Control Measures), and Section 4.4 (Effective Implementation of Control Measures)
3	HYSPLIT Trajectories of Source Area	Section 3.2 (Transport to Clark County)
	Source-Specific Emissions Inventories	Section 2.2.3 (Regional Emissions of PM_{10})
	Meteorological and Chemical Transport Modeling	Section 3.1.1 (Meteorological Analysis)
	PM Filter Chemical Speciation Analysis where Filter-Based Monitors are Used	Section 3.3.4 (Particulate Matter Analysis)

Following the EPA's exceptional event guidance, we performed Tier 2 and Tier 3 analyses to show the "clear causal relationship" between the high-wind dust event and the PM_{10} exceedance event in Clark County, NV, on October 22, 2022. Focusing on the characterization of the meteorology, source region terrain and climatology, transport, and air quality on the days leading up to the event, we conducted the following specific analyses, the results of which are presented in Section 3:

- Performed a top-down meteorological analysis to trace the conditions between the surface and 250 mb that led to the high-wind event in southern Nevada.
- Compiled maps of suspended dust, aerosol optical depth (AOD), and regional wind speed from satellite data.
- Showed the transport patterns via HYSPLIT modeling and identified where the back trajectory air mass intersected with dust sources.
- Compared the timeline of meteorological events, high wind speeds, and enhanced PM_{10} concentrations.
- Tracked surface meteorological conditions along the transport path between the source region and Clark County.
- Compiled media coverage of the high-wind dust event and ground-based visibility imagery during the event.
- Examined speciated PM concentrations during the event.
- Compared diurnal patterns of PM_{10} during the event to historical measurements.
- Performed meteorologically similar day analysis to assess PM_{10} concentrations on days with comparable wind conditions.

2.1.4 Regulatory Significance

The high-wind dust event that occurred on October 22, 2022, caused 24-hour PM_{10} NAAQS exceedances with regulatory significance at the Paul Meyer (Monitor AQS ID 32-003-0043, POC 1), Mountains Edge (Monitor AQS ID 32-003-0044, POC 1), Walter Johnson (Monitor AQS ID 32-003-0071, POC 1), Palo Verde (Monitor AQS ID 32-003-0073, POC 1), Joe Neal (Monitor AQS ID 32-003-0075, POC 1), Green Valley (Monitor AQS ID 32-003-0298, POC 1), Liberty High School (Monitor AQS ID 32-003-0299, POC 1), Jerome Mack (Monitor AQS ID 32-003-0540, POC 1), Sunrise Acres (Monitor AQS ID 32-003-0561 POC 1), and Walnut Community Center (Monitor AQS ID 32-003-2003, POC 1) monitoring sites. Twenty-four-hour PM_{10} exceedance values are listed in **Table 2.1-3**.

Table 2.1-3. Twenty-four-hour PM_{10} concentrations for sites that exceeded the NAAQS October 22, 2022.

Monitor AQS ID	Site Name	24-hour PM_{10} Exceedance Concentration
32-003-0043	Paul Meyer	280 $\mu g/m^3$
32-003-0044	Mountains Edge	326 $\mu g/m^3$
32-003-0071	Walter Johnson	300 $\mu g/m^3$
32-003-0073	Palo Verde	231 $\mu g/m^3$
32-003-0075	Joe Neal	230 $\mu g/m^3$
32-003-0298	Green Valley	269 $\mu g/m^3$
32-003-0299	Liberty High School	351 $\mu g/m^3$
32-003-0540	Jerome Mack	280 $\mu g/m^3$
32-003-0561	Sunrise Acres	269 $\mu g/m^3$
32-003-2003	Walnut Community Center	291 $\mu g/m^3$

A NAAQS exceedance that is approved by the EPA as an exceptional event may be excluded from regulatory examination under the Exceptional Events Rule. Seven additional suspected wind-blown dust events occurred in Clark County between 2021 and 2023. Table 2.1-4 shows the 2021-2023 design values at each of these 10 monitoring sites with and without EPA concurrence on proposed exceptional PM_{10} events between 2021 and 2023.

Table 2.1-4. 2021-2023 design values at monitoring sites in the Las Vegas Valley without and with EPA concurrence that the October 22, 2022, and other suspected events qualify as exceptional events.

Monitor Site Name	Design Value Without EPA Concurrence	Design Value With EPA Concurrence
Paul Meyer	2.0	0.0
Mountains Edge	1.7	0.3
Walter Johnson	2.3	0.3
Palo Verde	1.7	0.0
Joe Neal	2.3	0.3
Green Valley	2.7	0.0
Liberty High School	3.0	0.3
Jerome Mack	3.7	0.3
Sunrise Acres	3.0	0.3
Walnut Community Center	4.0	1.0

Further details on the design values with and without concurrence, as well as data completeness, may be found in the Initial Notification Summary Information (INI) submitted by the Clark County Department of Environment and Sustainability (DES) to EPA Region 9 on February 12, 2024.

We request that the EPA evaluate the following assessment of the wind-blown dust event that occurred in Clark County on October 22, 2022, and agree to exclude the event from regulatory decisions regarding PM_{10} attainment.

2.2 Historical Non-Event Model

2.2.1 Land Type for Source Region and Clark County

Land use and cover type data from both the 2019 National Land Cover Database (NLCD) (Dewitz, 2021) and Sentinel-2 satellite are shown for the approximate source region of Mojave Desert in southeastern California (Figure 2.2-1). The primary land classifications, shown by the Sentinel-2 Land Use/Land Cover map, in this region are bare ground and rangeland, with small pockets of forest and built area. Bare ground is defined as "areas of rock or soil with very sparse to no vegetation for the entire year; large areas of sand and deserts with no to little vegetation." Rangeland is defined as "open areas covered in homogenous grasses with little to no taller vegetation; wild cereals and grasses with no obvious human plotting." The primary classifications shown by the NLCD-2019 map are mostly shrub/scrub, grasslands/herbaceous, and barren land (rock/sand/clay). Classifications from both maps indicate that the source region is primarily land with little to no vegetation cover with natural sources of dust which are predisposed to high-wind events.

Figure 2.2-2 shows the land use and cover of Clark County and the surrounding area. The dominant land cover type in Clark County and the surrounding area is rangeland with pockets of bare ground and built area. Built area is defined as "human made structures; major road and rail networks; large homogenous impervious surfaces including parking structures, office buildings, and residential housing." Central Clark County (i.e., Las Vegas and surrounding communities) is mostly classified as built area with some small areas of bare ground, surrounded by rangeland.

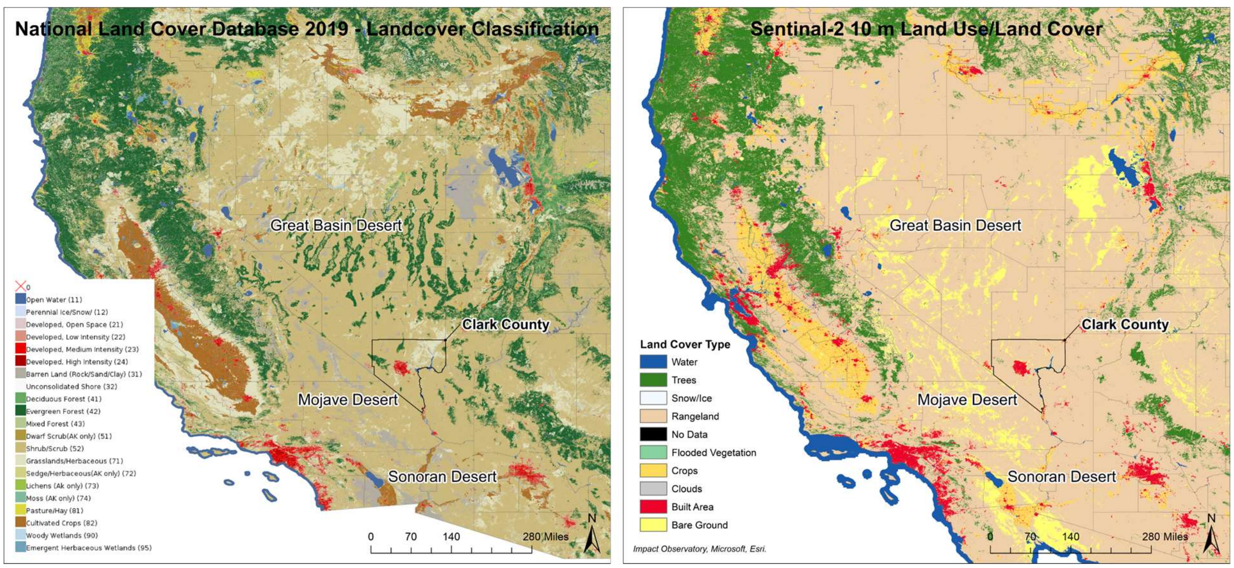


Figure 2.2-1. Land cover type for the western U.S. from (left) the National Land Cover Database-2019 and (right) Sentinel-2 satellite.

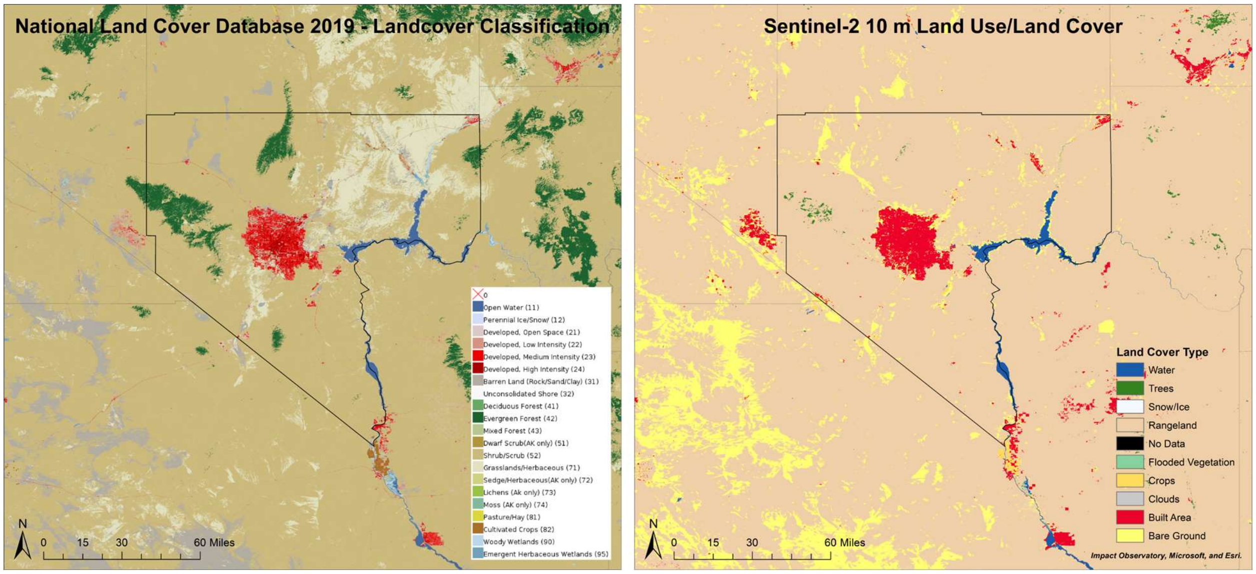


Figure 2.2-2. Land cover type for Clark County, NV, and surrounding area from (left) the National Land Cover Database-2019 and (right) Sentinel-2 satellite.

2.2.2 Climatology for Source Region and Clark County

The source is the Mojave Desert in southeastern California. The Mojave Desert is part of the Mojave Basin and Range Ecoregion, which is located primarily in southern California and southern Nevada (including Clark County), with smaller portions in Arizona and Utah (Sleeter and Raumann, 2012). In general, the Mojave Desert is a roughly 130,000 km^2 ecoregion and composed of broad basins and scattered mountains that are generally lower, warmer, and drier than those of the Central Basin and Range (which border the Mojave Desert to the north and covers the majority of Nevada). The ecoregion climate is characterized by high temperatures during the summer months and very little annual precipitation (50–250 mm in the valleys). In addition to the Mojave Desert, the ecoregion includes other desert areas in southeastern California and southern Nevada. The Mojave Desert is the driest of the deserts that comprise the greater North American Desert. This is due in part to the presence of the Sierra Nevada Mountain range to the west, which produces a rain shadow effect that inhibits significant moisture from reaching the desert. Additionally, heavy use of off-road vehicles and motorcycles in some areas has made the soils susceptible to wind and water erosion (Griffith et al. 2016).[1]

Clark County is located in the southern portion of Nevada and borders California and Arizona. Clark County includes the City of Las Vegas, which is one of the fastest growing metropolitan areas in the United States with a population of approximately 2.2 million (U.S. Census Bureau, 2020). Las Vegas is located in a 1,600-km^2 desert valley basin at 500 to 900 m above sea level (Langford et al., 2015). It is surrounded by the Spring Mountains to the west (3,000 m elevation) and the Sheep Mountain Range

[1] https://pubs.usgs.gov/of/2016/1021/ofr20161021_sheet1.pdf

to the north (2,500 m elevation). Three mountain ranges comprise the southern end of the valley. The valley floor slopes downward from west to east, which influences surface wind, temperature, precipitation, and runoff patterns. The Cajon Pass and I-15 corridor to the east is an important atmospheric transport pathway from the Los Angeles Basin into the Las Vegas Valley (Langford et al., 2015).

The Las Vegas Valley climatology features abundant sunshine and hot summertime temperatures (average summer month high temperatures of 34 °C to 40 °C). Due to mountain barriers that block moisture inflow, the region experiences dry conditions year-round (~107 mm annual precipitation, 22% of which occurs during the summer monsoon season from July through September). The urban heat island effect in Las Vegas during summer leads to large temperature gradients within the valley, with generally cooler temperatures on the eastern side. During the summer season, monsoon moisture brings high humidity and thunderstorms to the region, typically in July and August (National Weather Service Forecast Office, 2020). Winds in the Las Vegas basin tend to be out of the southwest during spring and summer (Los Angeles is upwind), while winds in the fall and winter tend to be out of the northwest, with air transported between the neighboring mountain ranges and along the valley.

Compared to the long-term climate record in the Las Vegas area, the temperature range was above the long-term normal in the weeks and days leading up to the October 22, 2022, exceedance. Concurrently, precipitation accumulation for the Las Vegas area was below normal by late October (**Figure 2.2-3 and Figure 2.2-4**).

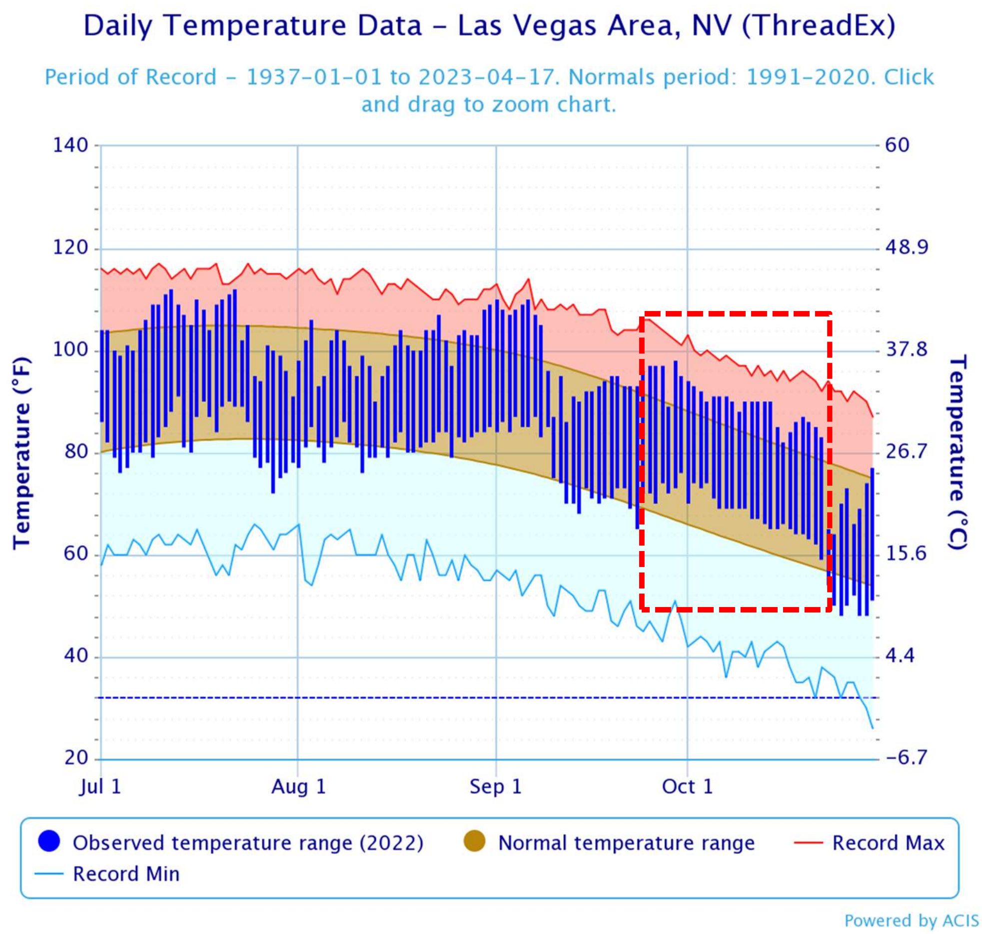


Figure 2.2-3. Las Vegas area, NV, temperature records from January 1, 1937, through October 26, 2022, by day, including (dark blue) observed temperature range 1991-2020, (brown) normal temperature range, (red) record maximum, and (light blue) record minimum. The red box indicates the dates of above-normal heat before the October 22, 2022, event. Data from NWS: https://www.weather.gov/wrh/Climate?wfo=vef.

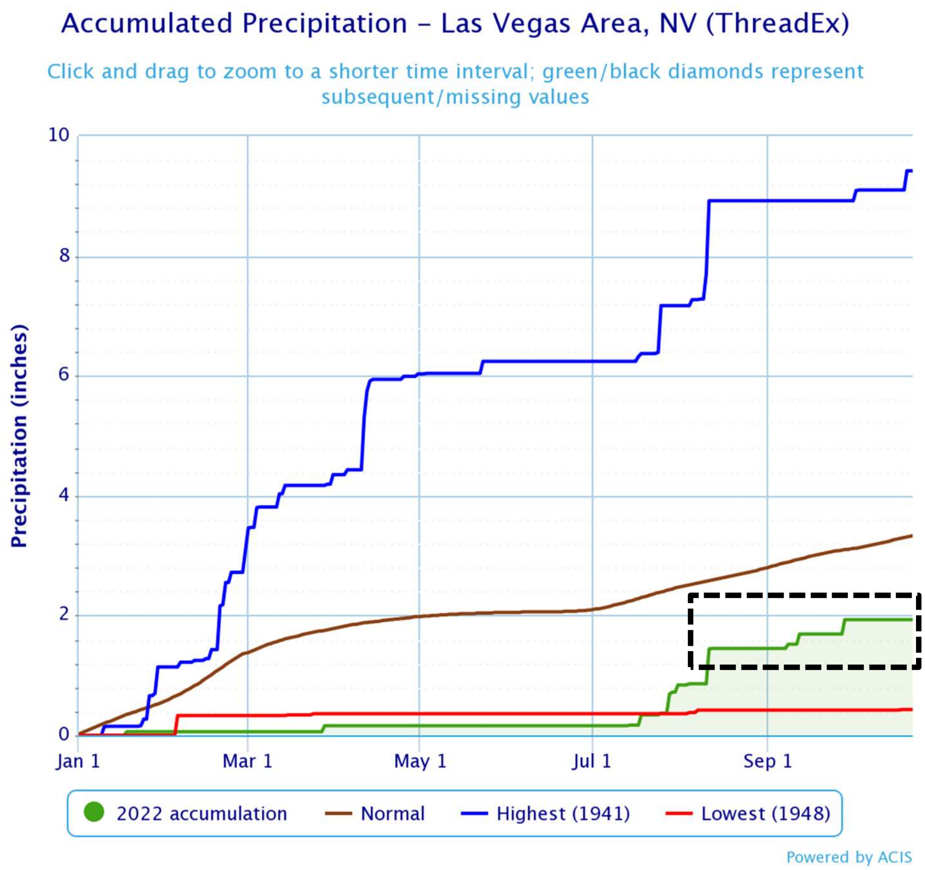


Figure 2.2-4. Las Vegas area, NV, precipitation records by day, including (green) accumulation in 2022, (brown) normal, (blue) record maximum, and (red) record minimum. The black box indicates the period of low accumulated precipitation before the event on October 22, 2022. Data from NWS: **https://www.weather.gov/wrh/Climate?wfo=vef**.

The extreme hot and dry conditions in 2022 are also highlighted by the Palmer Drought Severity Index (PDSI) produced by the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Protection (NCEP). The western U.S. drought conditions progressively increased in area and severity in the months before the PM_{10} exceedance (**Figure 2.2-5**). By October 2022, all counties in California and Nevada were classified as moderate to extreme drought (**Figure 2.2-6** and **Figure 2.2-7**).

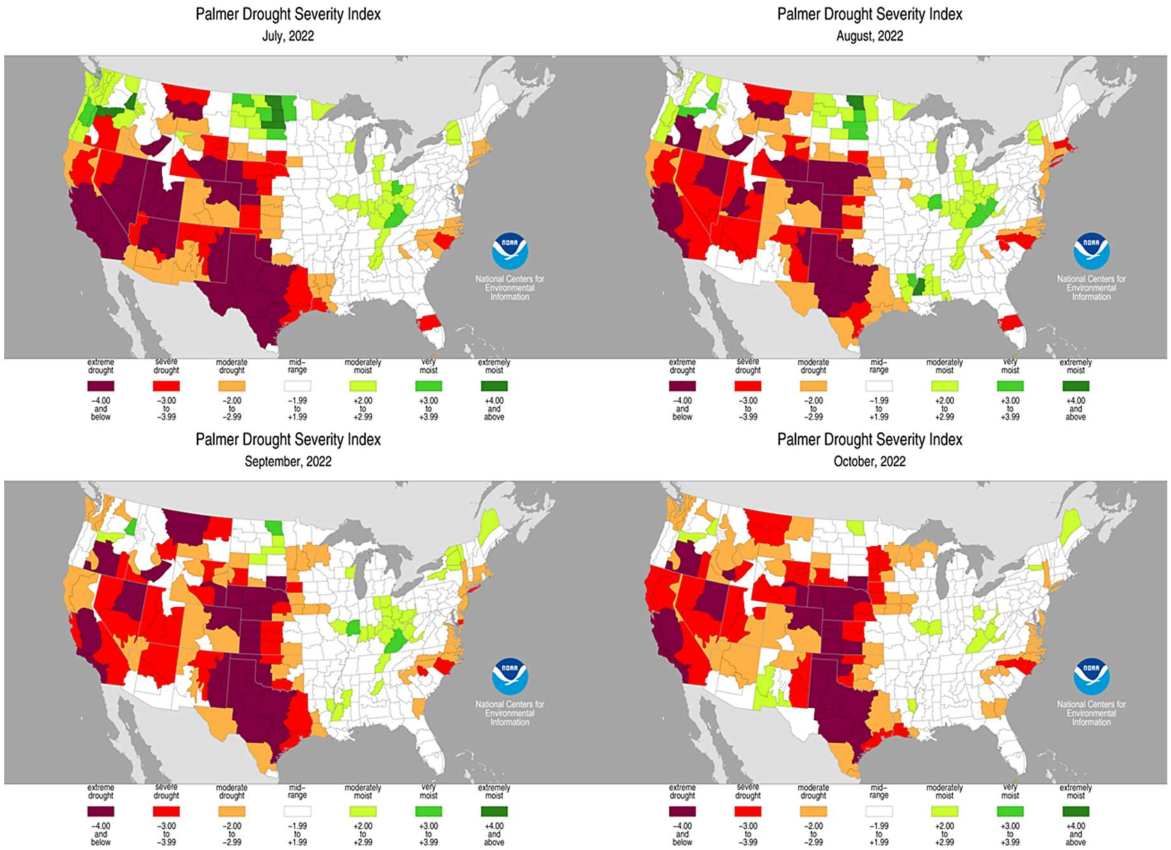


Figure 2.2-5. Palmer Drought Severity Index for July through October 2022.

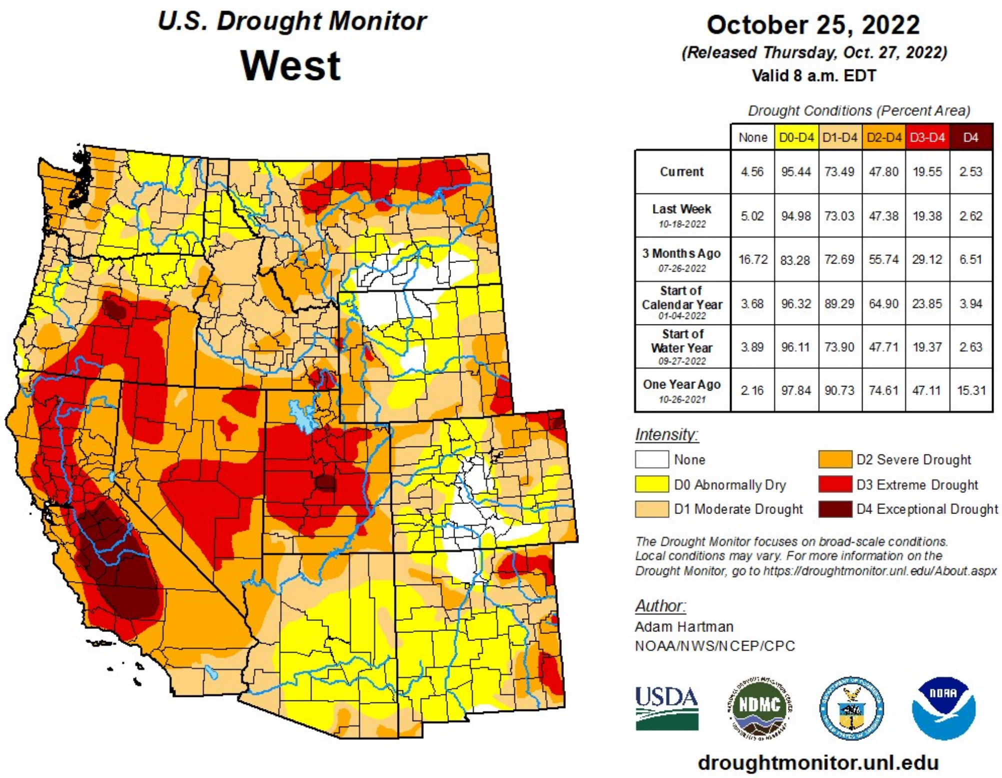


Figure 2.2-6. U.S. Drought Monitor values for the western U.S. on October 25, 2022.

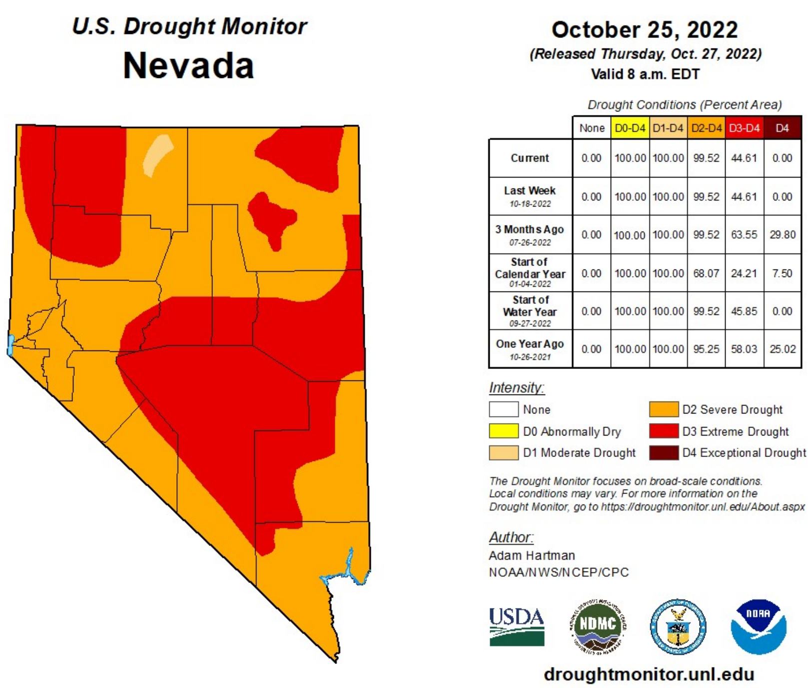


Figure 2.2-7. U.S. Drought Monitor values for Nevada on October 25, 2022.

There are several ASOS weather measurement sites in the wind-blown dust source region with data spanning multiple decades (Figure 2.2-8). Figure 2.2-9 shows the distribution of the maximum daily temperatures at several sites in the wind-blown dust source region on October 21 and 22 (1991 – 2021). The median maximum daily temperatures recorded at all sites on October 21 and 22 (1991 – 2021) are between approximately 74 °F and 83 °F.

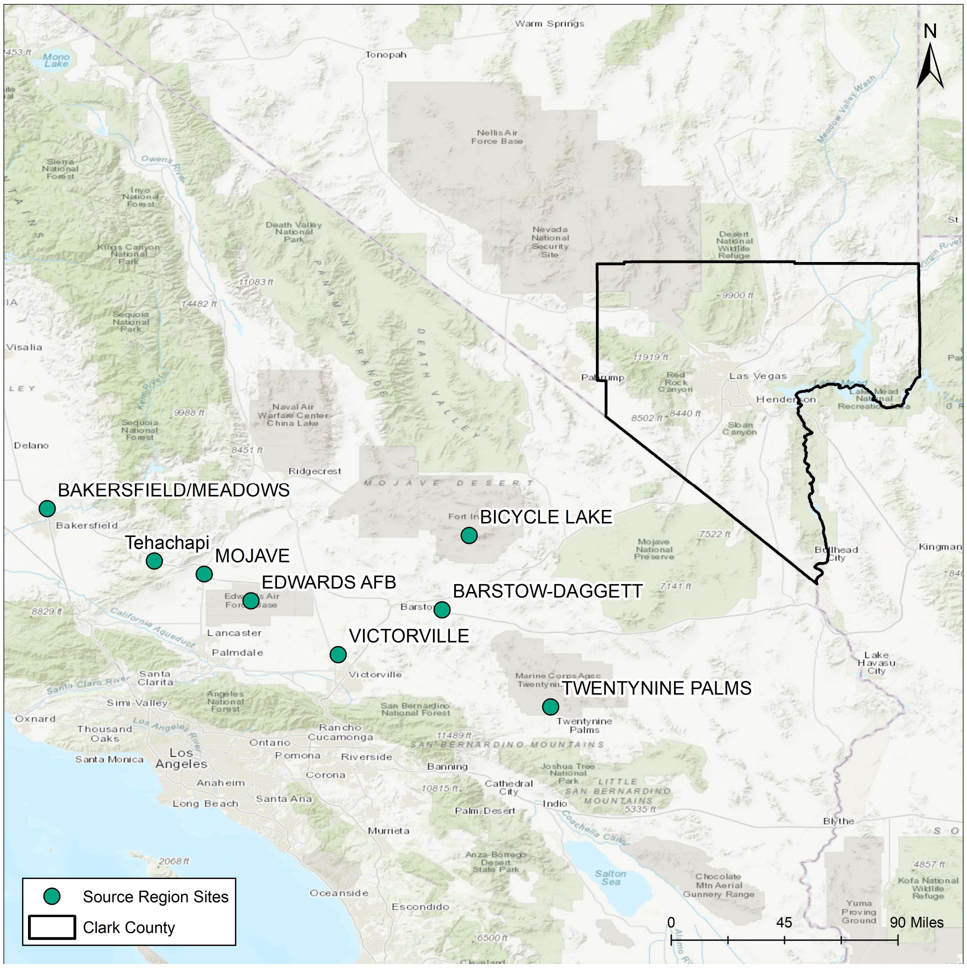


Figure 2.2-8. Location of ASOS measurement sites in the wind-blown dust source region.

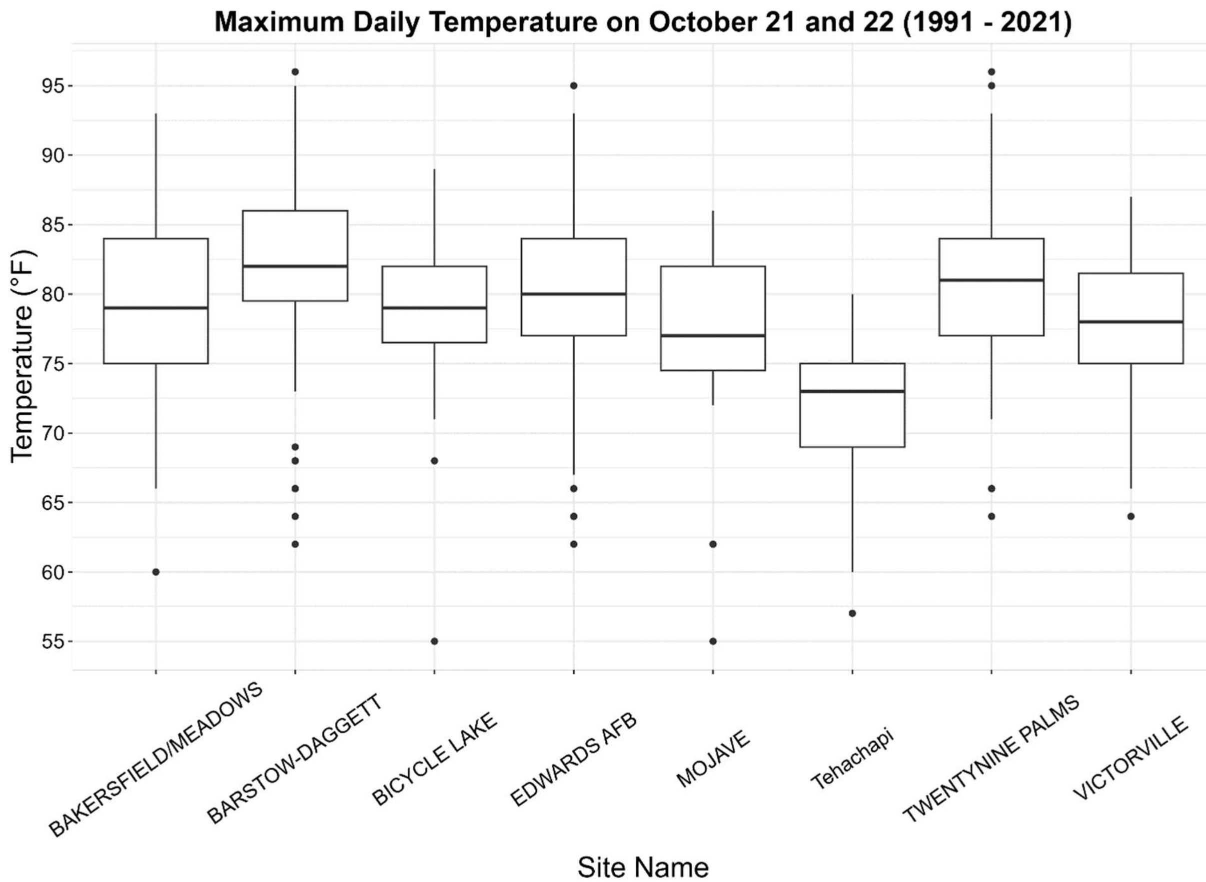


Figure 2.2-9. Maximum daily temperature on October 21 and 22, between 1991 and 2021.

2.2.3 Regional Emissions of PM_{10}

Open lands account for approximately 86% of the total area of Clark County (~4.3 million acres), followed by incorporated lands at 8% (~400,000 acres), tribal lands at 1.5% (~80,000 acres), and the remaining planned land use categories at a combined 4.5% (~242,000 acres) (Figure 2.2-10). Open lands and incorporated Clark County largely align with bare ground and rangeland (Figure 2.2-2), suggesting that dust may have been picked up in Clark County during the high-wind event.

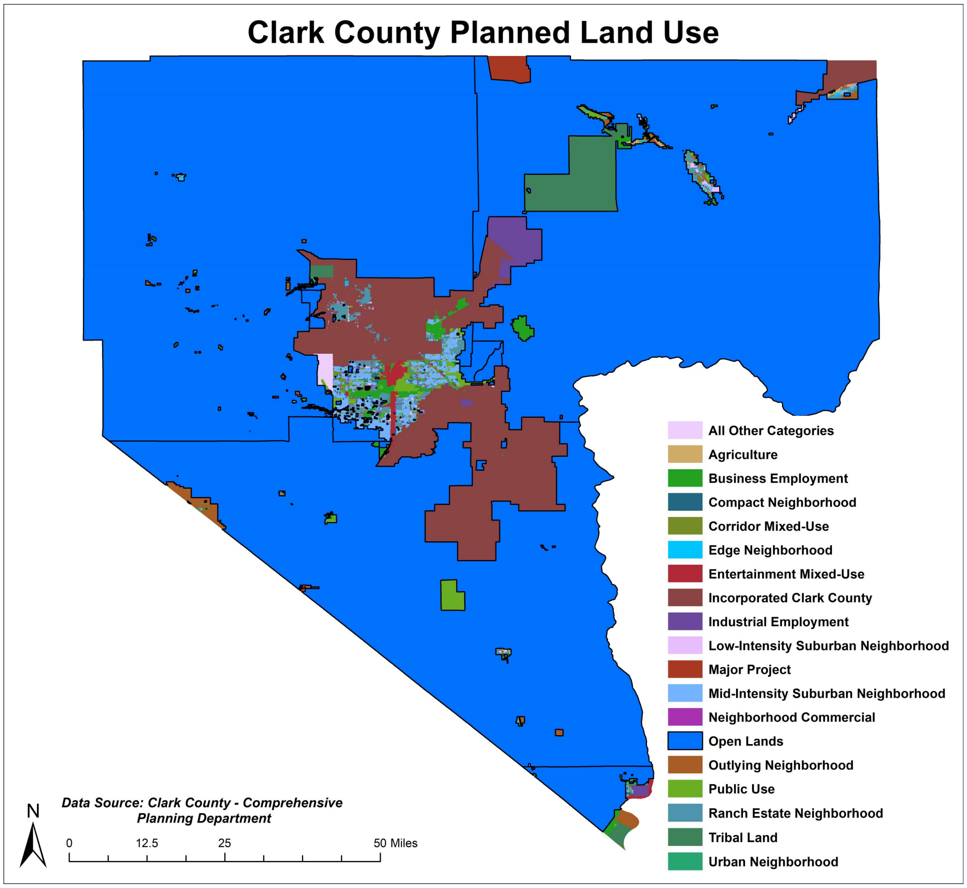


Figure 2.2-10. Planned land use boundaries of Clark County.

Planned land use around the Green Valley site is comprised entirely of incorporated land (Figure 2.2-11). The site is situated at the north, central end of a recreational sports complex. Much of the surrounding area to the north and west of the site is buildings, including baseball fields and single-family homes, and paved surfaces, consisting of parking lots and roads, with little exposed dirt or gravel. The sports complex consists of a mixture of dirt and grassy fields, paved surfaces, and patches of trees.

Figure 2.2-11. Planned land use boundaries around the Green Valley monitoring station.

Planned land use around the Jerome Mack site is comprised of public use to the west (Jerome Mack Middle School campus), mid-intensity suburban neighborhood to the south, urban neighborhood to the southeast, compact neighborhood to the northeast, and business employment to the north and northwest. An aqueduct borders Jerome Mack immediately to the north (**Figure 2.2-12**). Much of the surrounding area is comprised of buildings and paved surfaces that include parking lots and roads, with little exposed dirt or gravel.

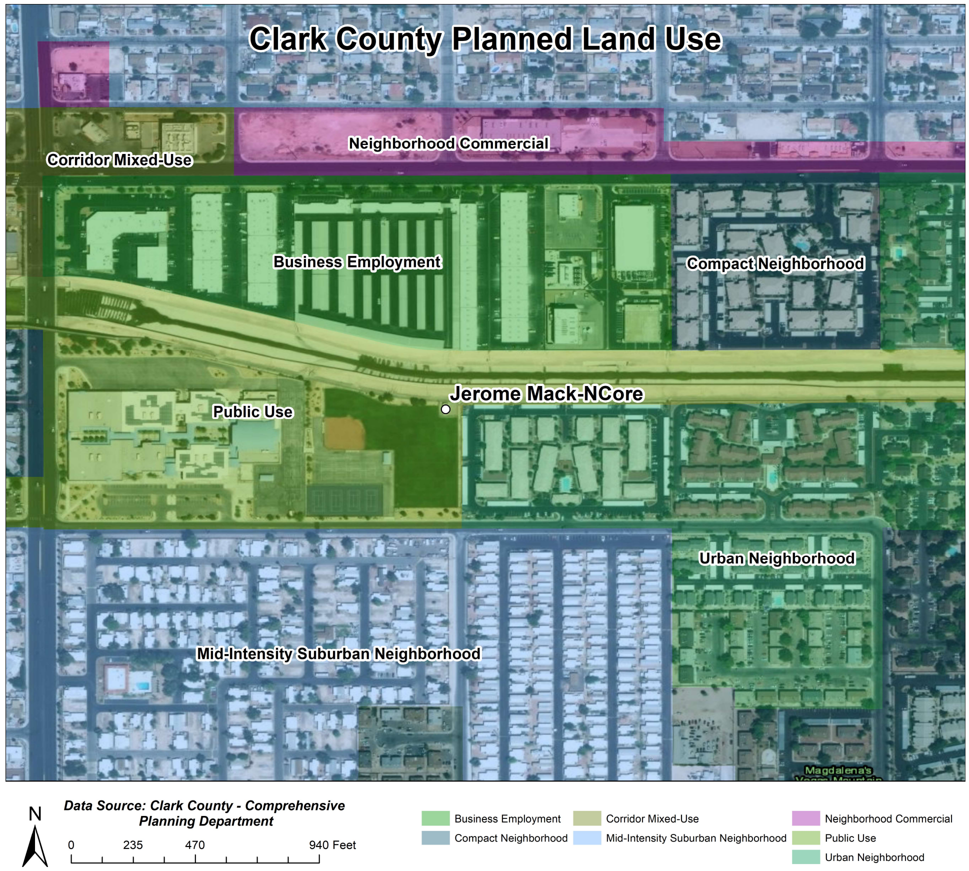


Figure 2.2-12. Planned land use boundaries around the Jerome Mack monitoring station.

Planned land use around the Joe Neal site is largely incorporated Clark County, as well as Ranch Estate Neighborhood to the west (**Figure 2.2-13**). Both of these uses are largely residential, with little exposed dirt or gravel, however vacant lots are visible to the east and southeast of the monitor.

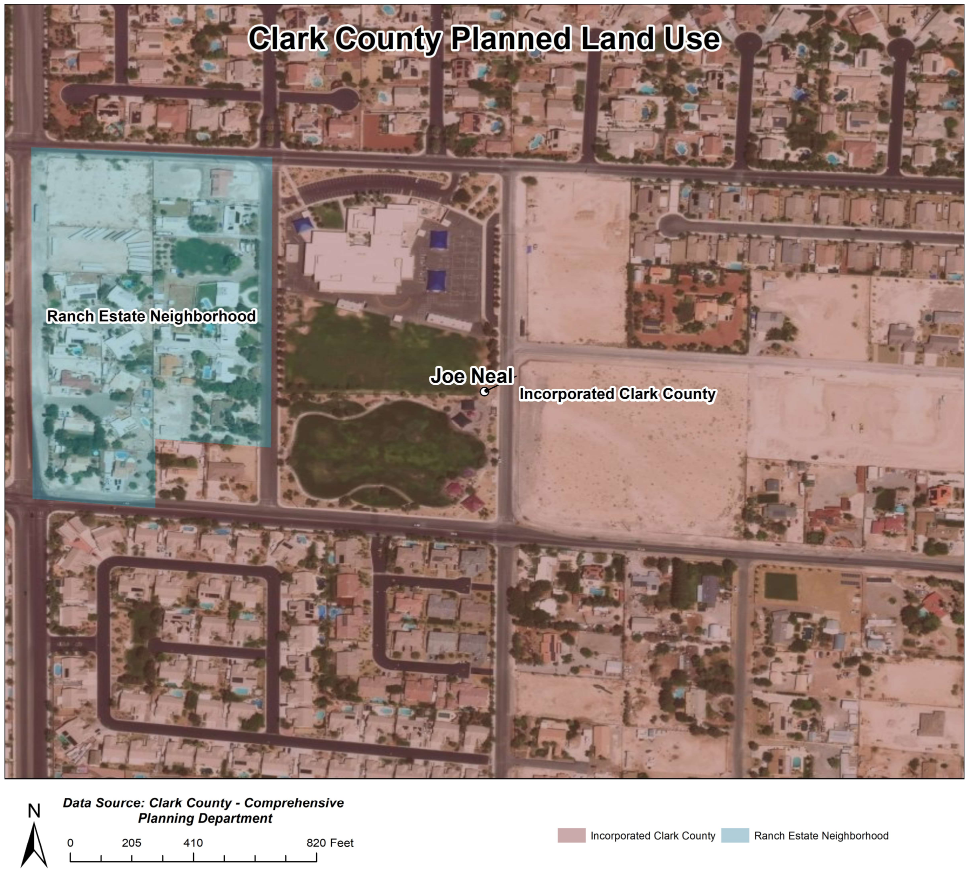


Figure 2.2-13. Planned land use boundaries around the Joe Neal monitoring station.

Planned land use around the Liberty High School site is comprised of incorporated Clark County, Ranch Estate neighborhood, neighborhood commercial, and mid-intensity suburban neighborhood to the west, and mid-intensity suburban neighborhood and corridor mixed-use to the east (Figure 2.2-14). The Liberty High School site is at the southeastern edge of the Liberty High School campus near a baseball field and bordering a road. With the exception of the baseball field and a small strip of shrubs, grass, dirt, and gravel to the east, the immediate surroundings of the Liberty High School site are mostly paved surfaces with little exposed dirt and gravel.

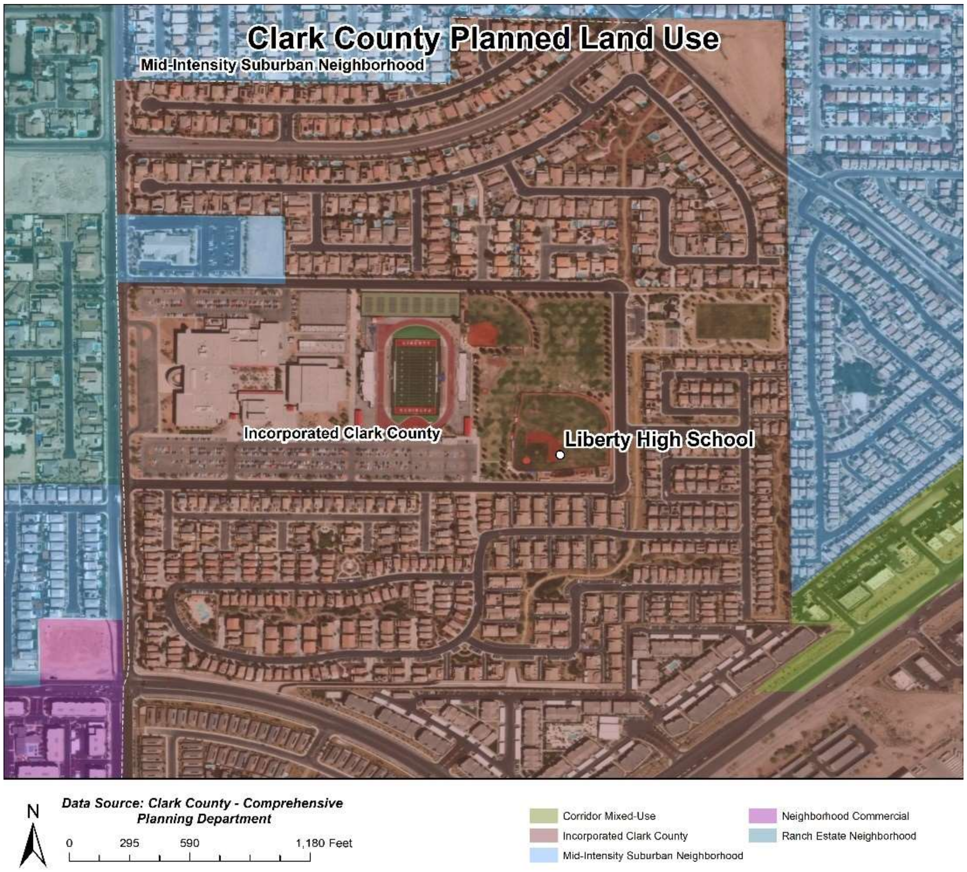


Figure 2.2-14. Planned land use boundaries around the Liberty High School monitoring station.

Planned land use around the Mountains Edge Park site is comprised of open lands to the south and mid-intensity suburban neighborhood to the north (**Figure 2.2-15**). Corridor mixed-use land exists to the east of the site, but it is largely residential. The Mountains Edge Park site is at the north end of Mountains Edge Regional Park, which consists of open grassy fields, baseball fields, parking lots, and short trees. Open lands outside of the park boundary are undeveloped and mostly dirt and gravel, which may contribute to local dust during high-wind events.

Figure 2.2-15. Planned land use boundaries around the Mountains Edge monitoring station.

Planned land use around the Palo Verde site is comprised entirely of incorporated land (**Figure 2.2-16**). Much of the surrounding area is comprised of buildings and paved surfaces, including parking lots and roads. The site is approximately one mile east of the 215 highway and has an aqueduct on its southern border. With the exception of baseball fields to the west, there is virtually no area with exposed dirt or gravel.

Figure 2.2-16. Planned land use boundaries around the Palo Verde monitoring station.

Planned land use around the Paul Meyer site is comprised entirely of public use and mid-intensity suburban neighborhood (Figure 2.2-17). The site is highly residential. With the exception of a neighboring baseball field, there is virtually no area with exposed dirt or gravel.

Figure 2.2-17. Planned land use boundaries around the Paul Meyer monitoring station.

Planned land use around the Sunrise Acres site is comprised mostly of incorporated land (Figure 2.2-18). Residential areas are also present to the south, including compact neighborhood, mid-intensity suburban neighborhood, and commercial neighborhood. Much of the surrounding area is comprised of buildings and paved surfaces, including parking lots and roads, with little exposed dirt or gravel. A vacant, undeveloped lot and a baseball field are present nearby, which may contribute to local dust during high-wind events.

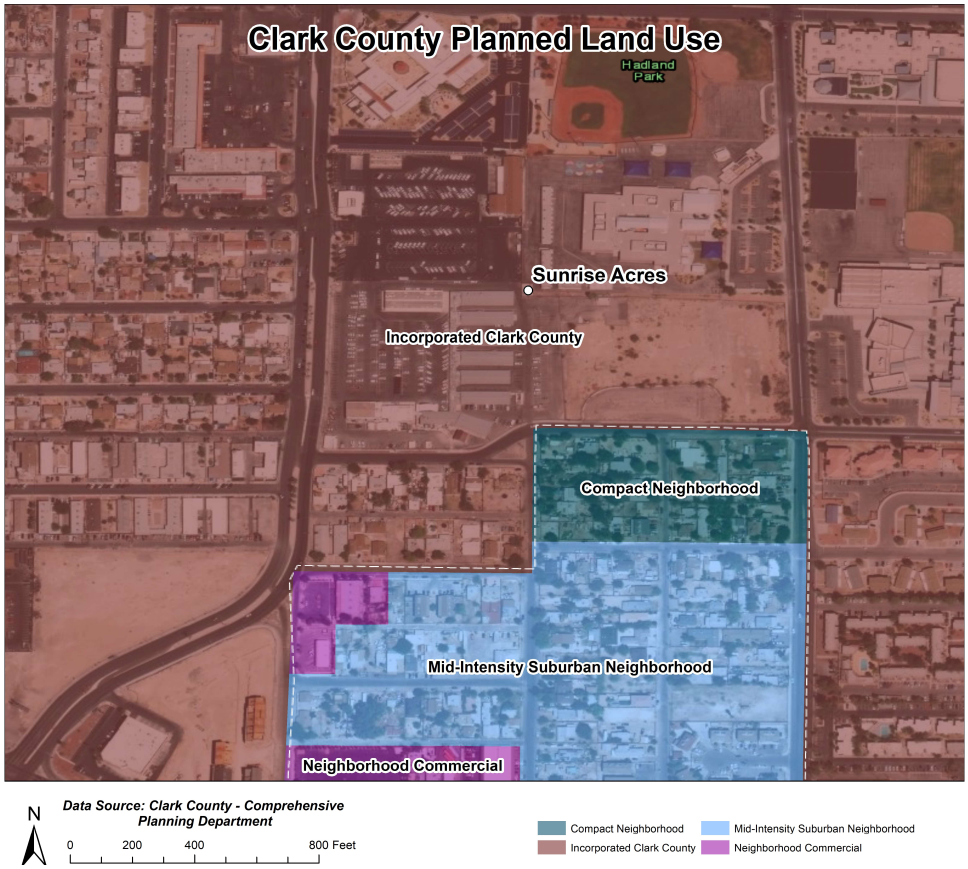


Figure 2.2-18. Planned land use boundaries around the Sunrise Acres monitoring station.

Planned land use around the Walnut Community Center site is comprised of public use (Walnut Park) and business employment to the south (Figure 2.2-19). With the exception of grass fields to the west and east, there is virtually no area with grass or exposed dirt or gravel.

Figure 2.2-19. Planned land use boundaries around the Walnut Community Center monitoring station.

Planned land use around the Walter Johnson site is comprised entirely of incorporated Clark County (Figure 2.2-20). The site is highly residential with little exposed dirt or gravel. The site also neighbors a city park that contains some bare ground.

Figure 2.2-20. Planned land use boundaries around the Walter Johnson monitoring station.

Figure 2.2-21 shows the 2020 National Emissions Inventory (NEI) PM_{10} point sources around the affected sites. The size of the point source marker is proportional to total annual PM_{10} emissions, and the map shows that most sites are not near major point sources. For example, there are no PM_{10} point sources within approximately 2 miles of the Jerome Mack site, and the closest point sources emit less than 3 tons of PM_{10} annually. The Green Valley site is approximately 3 miles from the nearest point sources, which includes three sites to the east emitting between 8 and 18 tons of PM_{10} annually, and one site to the north that emits between 4 and 7 tons of PM_{10} annually.

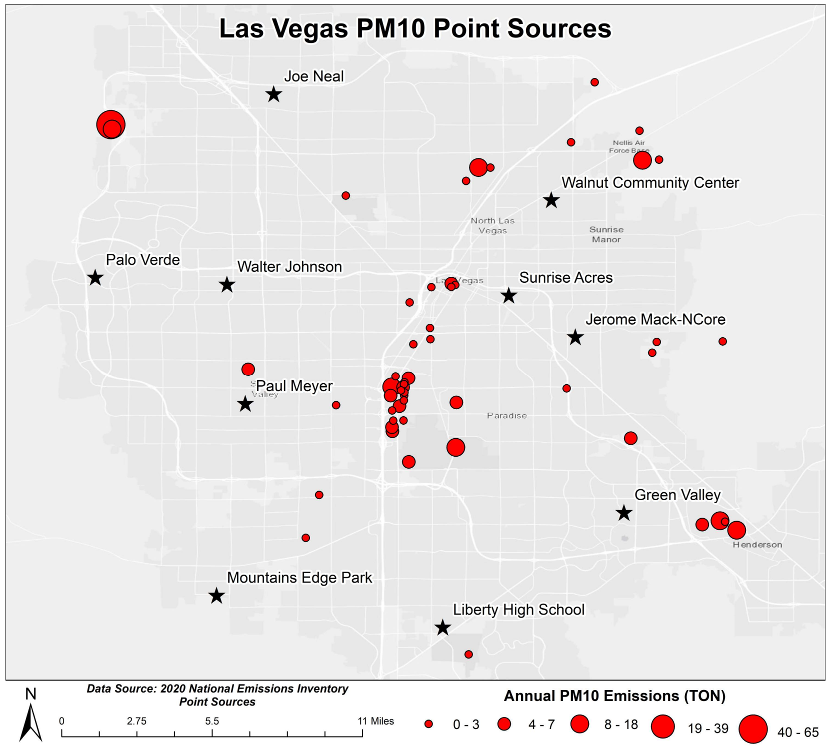


Figure 2.2-21. 2020 NEI point sources of PM_{10}.

Clark County, NV, provided information on all PM_{10} emissions in the 2012 document titled "Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10})." Point sources contributed 0.31% of PM_{10} emissions in 2008, and are projected to contribute 0.59% of PM_{10} emissions in 2023. Given the small contribution of point sources to total PM_{10} emissions and the lack of significant point sources near the sites, it is unlikely that point sources contributed to the exceedance on October 22, 2022. Nonpoint sources, however, contribute greater than 98% of PM_{10} emissions. The assessment shows a 31% reduction in total PM_{10} emissions between 2008 and 2023, with notable decreases in wind erosion (vacant lands) contributions to total PM_{10} emissions between 2008 and 2023 (Figure 2.2-22). Increasing contributions from construction-related emissions are due to increasing conversion of vacant lands to built area. Therefore, wind erosion from construction, paved roads, construction, and other sources has made an increasingly significant contribution to total emissions. As shown in Figure 2.2-11 through Figure 2.2-20, many sites are not near major paved roads. For example, the Jerome Mack site is approximately a quarter of a mile away from a major paved road source (S Lamb Blvd), as is the Green Valley site (N Stephanie St). Thus, paved roads and on-road emissions likely did not contribute to the October 22, 2022, exceedance. The Sunrise Acres site is approximately 530 feet from the nearest major paved road source (N Eastern Ave), so these emissions may have been more likely to impact this site.

A Dust Advisory was issued on Thursday, October 20, for Saturday, October 22, 2022, due to blowing dust via southwesterly winds from the Mojave Desert. Additionally, a Dust Storm Warning was issued by the National Weather Service on October 22 associated with this event. A Dust Advisory requires construction sites to immediately conduct an inspection, implement BACM, and avoid blasting activity at threshold wind speeds to mitigate windblown dust. Additionally, during a Dust Advisory, compliance officers will inspect construction and stationary source sites during the dust event to ensure BACM are being implemented, and any violations will receive a Notice of Violation.

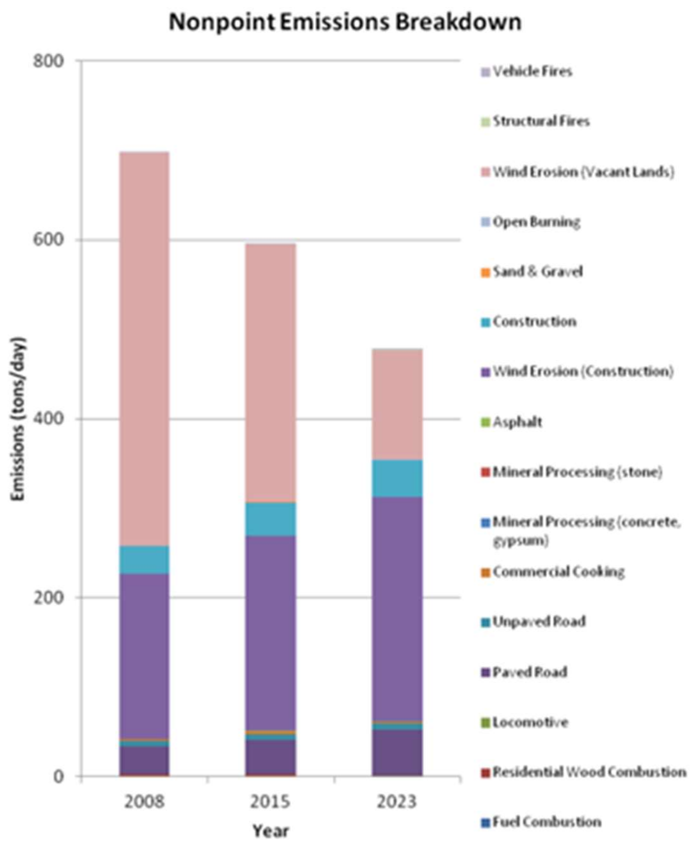


Figure 2.2-22. Nonpoint emissions inventory breakdown from the 2012 document titled "Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10})."

2.2.4 Historical Analysis of PM_{10} in Clark County

Table 2.2-1 displays a statistical summary of 24-hour average PM_{10} concentrations from the five years preceding the event (2018-2022) at all sites which exceeded the 24-hour PM_{10} NAAQS in Clark County, including Garrett Jr. High, Green Valley, Jean, Jerome Mack, Joe Neal, Liberty High School, Mountains Edge Park, Palo Verde, Paul Meyer, Sunrise Acres, Walnut Community Center, and Walter Johnson. Although not regulatorily significant, the table also includes statistics for the Garrett Jr. High and Jean monitoring sites to examine the regional effects of the high-wind dust event. Note that data collection at four sites began less than five years ago, thus summary statistics are shown for the data available through December 2022 for these sites. Mean concentrations range from 20 to 42 µg/m^3 and medians range from 16 to 37 µg/m^3.

Table 2.2-1. Five-year (2018 – 2022) statistical summary of 24-hour average PM_{10} concentration at affected sites. Sites that began data collection less than five years ago are indicated with an asterisk (*), and statistics cover when data collection began until December 2022, as indicated by the value in the 'count' row.

Statistic ($\mu g/m^3$)	Garrett Jr. High*	Green Valley	Jean	Jerome Mack	Joe Neal	Liberty High School*	Mountains Edge Park*	Palo Verde	Paul Meyer	Sunrise Acres	Walnut Community Center*	Walter Johnson
Mean	23	25	20	35	28	31	23	20	24	36	42	23
Median	17	21	16	31	25	26	18	17	21	32	37	20
Mode	11	20	17	31	26	18	16	15	18	25	36	17
St. Dev	27	24	18	25	23	32	22	16	19	25	35	19
Minimum	3	2	1	4	2	2	1	2	3	4	7	3
95th Percentile	52	49	47	66	52	62	47	40	47	72	76	44
99th Percentile	145	108	89	116	85	201	104	67	88	105	181	78
Maximum	350	586	236	445	513	365	325	333	335	468	470	341
Range	347	584	235	441	511	363	324	331	332	464	463	338
Count	635	1820	1795	1790	1813	610	819	1796	1814	1796	579	1822
Exceedances (>150 $\mu g/m^3$)	5	9	7	13	7	8	5	4	6	11	10	7

Seasonal and monthly trends in the 24-hour average PM_{10} data for the five years preceding the event (2018-2022) are shown in boxplots in Figure 2.2-23 and Figure 2.2-24. The interquartile range is represented by the lower (25th percentile) and upper (75th percentile) edges of the box, and the middle bar is the median value. The whiskers extend to the smallest and largest value within 1.5 times the interquartile range. Points beyond this range are considered outlying and have been removed for monthly and seasonal trend clarity (see Section 3.4.2 for trends including outliers). Interquartile ranges for 24-hour average PM_{10} values have high overlap across seasons, ranging from 11 to 35 µg/m^3, with median values ranging from 17 µg/m^3 in winter to 26 µg/m^3 in summer. In autumn, the median value is 24 µg/m^3 and the interquartile range is 17-35 µg/m^3. In October, the interquartile range is 17 – 34 µg/m^3 and the median value is 24 µg/m^3.

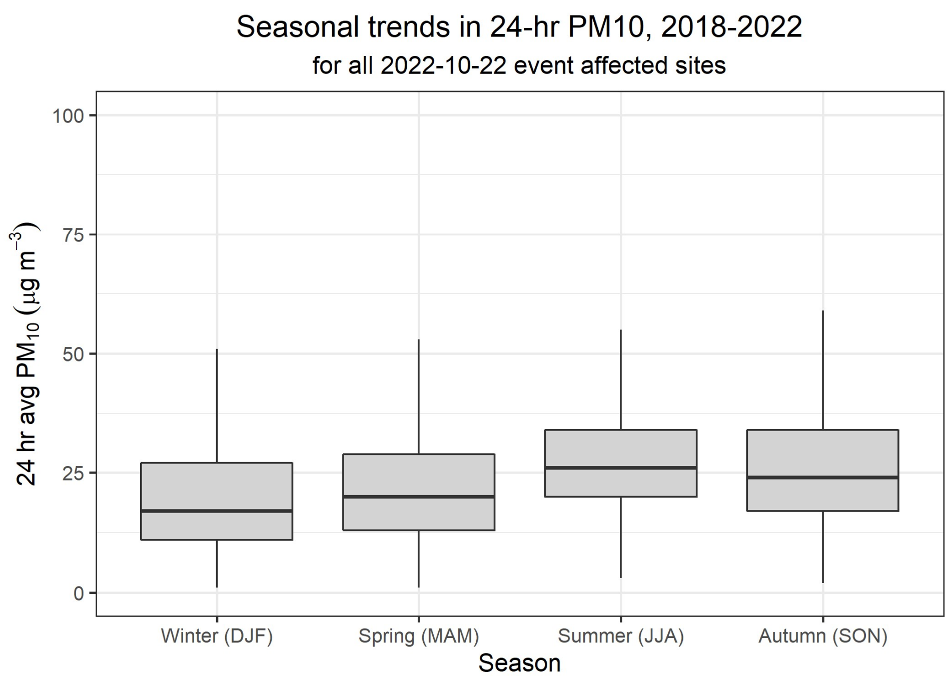


Figure 2.2-23. Seasonal PM_{10} value trends from 2018-2022 (outliers have been removed for clarity).

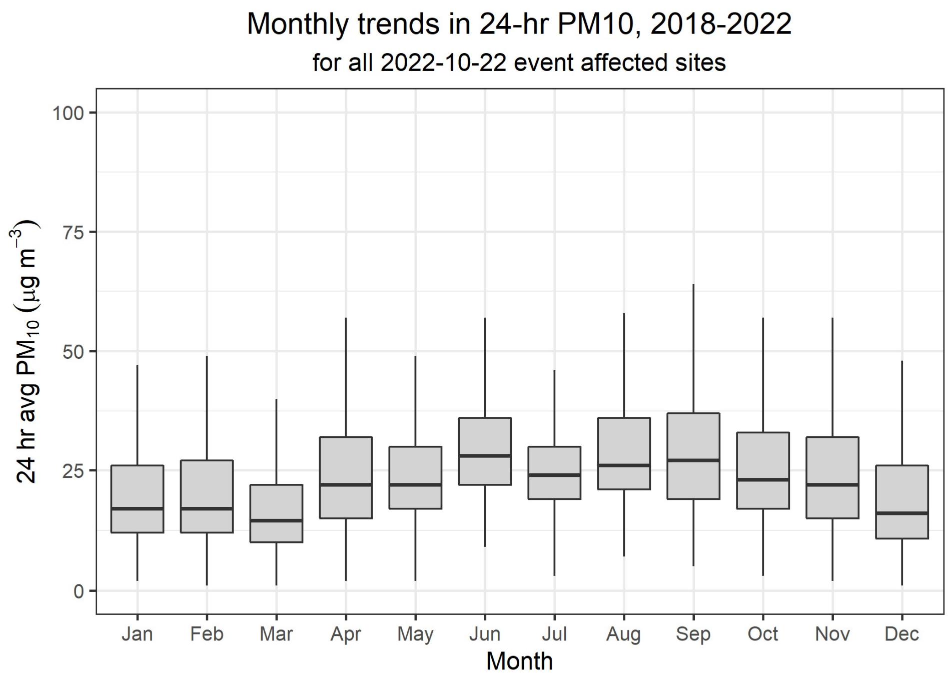


Figure 2.2-24. Monthly PM_{10} value trends from 2018-2022 (outliers have been removed for clarity).

3. Clear Causal Relationship

During late October 2022, a frontal passage through California drove a windblown dust event that increased PM_{10} concentrations in Clark County, NV, on October 22, 2022. Strong sustained winds in the Mojave Desert source region were well above 25 mph (>40 mph). The frontal passage lofted, entrained, and transported dust from the source region into Clark County, where significantly enhanced concentrations started at 12:00 PST on October 22 and lasted through the end of the day. The severe drought conditions affecting the Mojave Desert in southeastern California (**Section 2.2**), created an ample source of dust from friable soils. Enhanced hourly average wind speeds exceeded 25 mph within Clark County, and multiple hours of 2-minute averaged data from Harry Reid International Airport in Las Vegas (code: KLAS) coincided with increased PM_{10} concentrations on October 22. The Mojave Desert source region experienced sustained wind speeds above 40 mph, and (1) transport from the Mojave Desert to Clark County is clearly evident via HYSPLIT, meteorological analyses, and radar images; (2) visibility was greatly reduced in Clark County during the high PM_{10} concentrations; and (3) PM_{10} concentrations were exceptionally outside of typical ranges. In this section, we provide meteorological evidence of lofting, entrainment, and transport of dust from the dust source region (the Mojave Desert) with the frontal passage; evidence of transport from the source region to Clark County via HYSPLIT trajectory modeling; and a discussion of the impacts of the high-wind dust event at the surface in Clark County. We also provide additional evidence using statistical and meteorologically similar event analysis to compare this dust event with other high PM_{10} days in Clark County.

3.1 High-Wind Event Origin

3.1.1 Meteorological Analysis

On October 22, 2022, dust from the Mojave Desert impacted the Las Vegas region, which led to 24-hour average PM_{10} concentrations above the NAAQS threshold at 12 sites in the area (10 regulatorily significant and two not). Strong winds in the Mojave Desert region of southeastern California produced dense blowing dust that was transported to the Las Vegas metropolitan area, significantly increasing PM_{10} concentrations by 12:00 PST on October 22, which peaked between 14:00 and 20:00 PST, and lasted through the end of the day. All other sites within the Las Vegas Valley experienced enhanced PM_{10} concentrations concurrent with sites exceedances. Several synoptic and mesoscale meteorological factors led to favorable conditions for blowing dust on this day. To account for these meteorological factors, observation data were analyzed leading up to and during the dust event. The following narrative will discuss the meteorological factors that led to this blowing dust event. To assess the meteorological conditions that led to poor air quality during this period, observational data were analyzed from the following sources.

- 300-mb heights and winds (approximately 30,000 feet above sea level [ASL])
- Surface pressure readings, wind measurements, fronts, and visibility
- Skew-T diagrams
- Drought conditions

This meteorological analysis will take a “top-down” approach, linking upper-level observations to corresponding lower-level and surface weather patterns. This analysis will focus on the period between 12:00 UTC on October 22, 2022 (04:00 PST on October 22, 2022), and 09:00 UTC on October 23, 2022 (01:00 PST on October 23, 2022).

Top-down Analysis

Upper-level jets are narrow bands of strong winds in the upper troposphere. In the left-exit region (LER) of a jet, divergence aloft induces upward vertical motion with corresponding decreases in pressure at the surface (Bluestein, 1993). These jet dynamics were a key factor in the blowing dust event that occurred on October 22, 2022, in the Las Vegas region.

Upper-level weather maps at 300 mb on the morning of October 22 show the LER of a jet moving into southwestern Oregon and northern California, with wind speeds of 90 knots over Medford, OR; 50 knots over Reno, NV; and 55 knots over Oakland, CA. By 00:00 UTC on October 23, 2022 (16:00 PST on October 22, 2022), the LER of the upper-level jet had progressed south to east-central California and southwestern Nevada, with 300-mb winds above Medford at 155 knots, while winds increased to 100 knots over Oakland and 80 knots over Reno.

As shown in **Figure 3.1-1 and Figure 3.1-2**, the LER moved rapidly from northeastern California to a position just northwest of Las Vegas. From the discussion of jet dynamics above, upward vertical motion and decreasing surface pressure would be expected near the path of this LER. The surface pressure analyses from NOAA’s Weather Prediction Center from 12:00 UTC on October 22 (04:00 PST on October 22) to 03:00 UTC on October 23 (19:00 PST on October 22) in **Figure 3.1-3** confirm these theoretical predictions, with a deepening surface low pressure system and associated fronts developing southeast from northeastern California to the Las Vegas area.

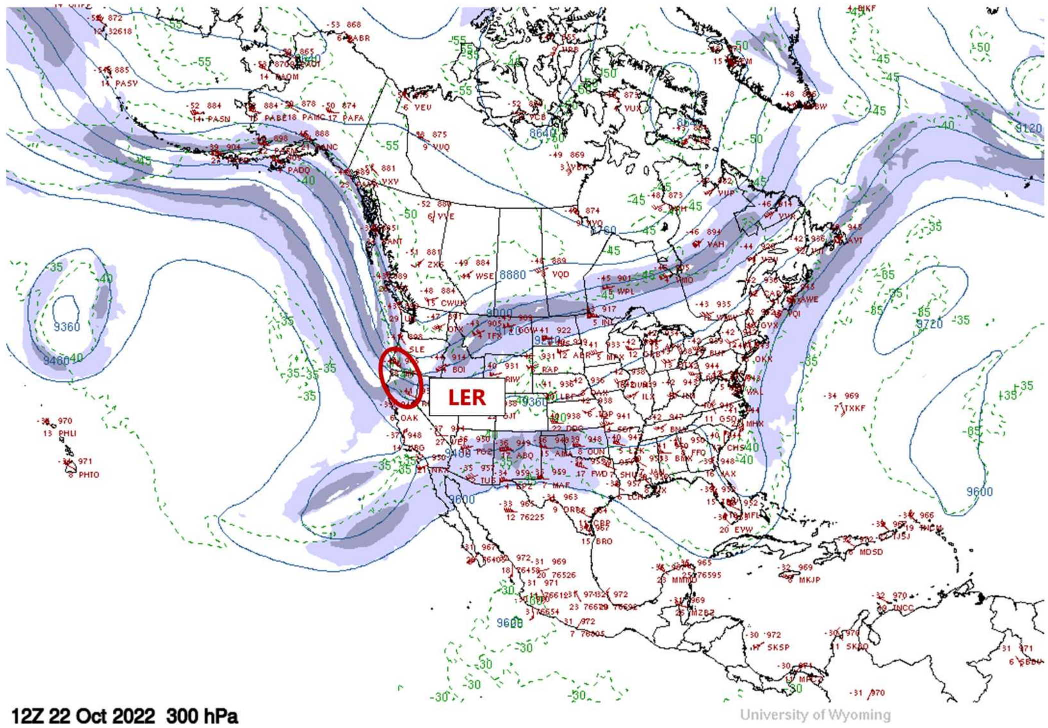


Figure 3.1-1. 300-mb map from 12:00 UTC on October 22, 2022 (04:00 PST on October 22, 2022). Source: University of Wyoming.

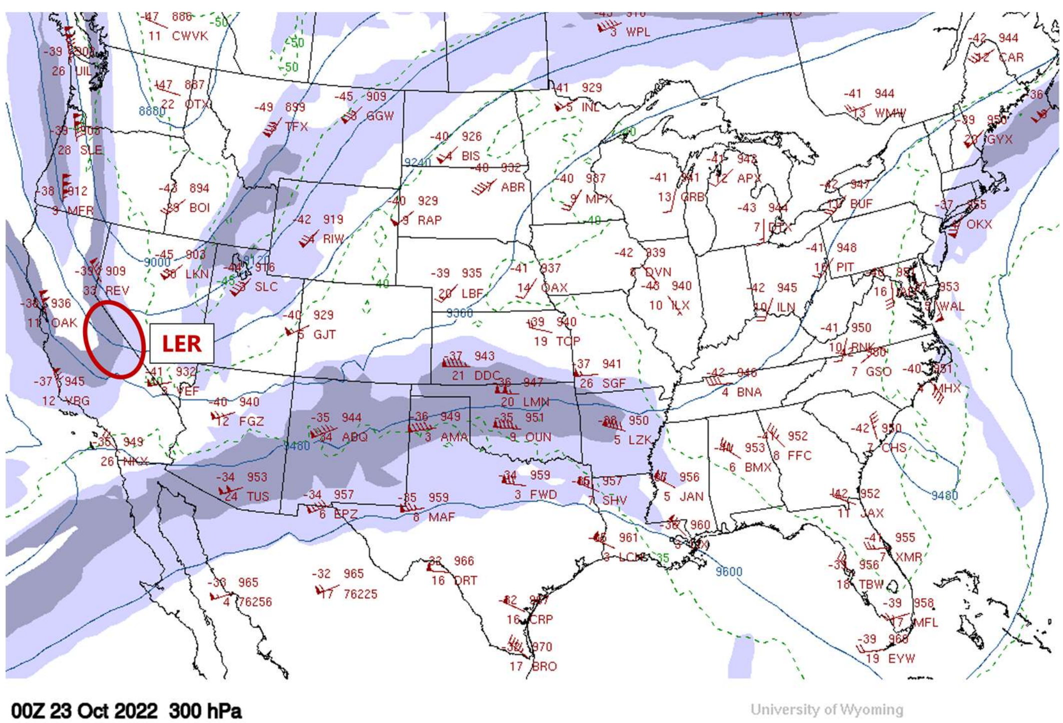


Figure 3.1-2. 300-mb map from 00:00 UTC on October 23, 2022 (16:00 PST on October 22, 2022). Source: University of Wyoming.

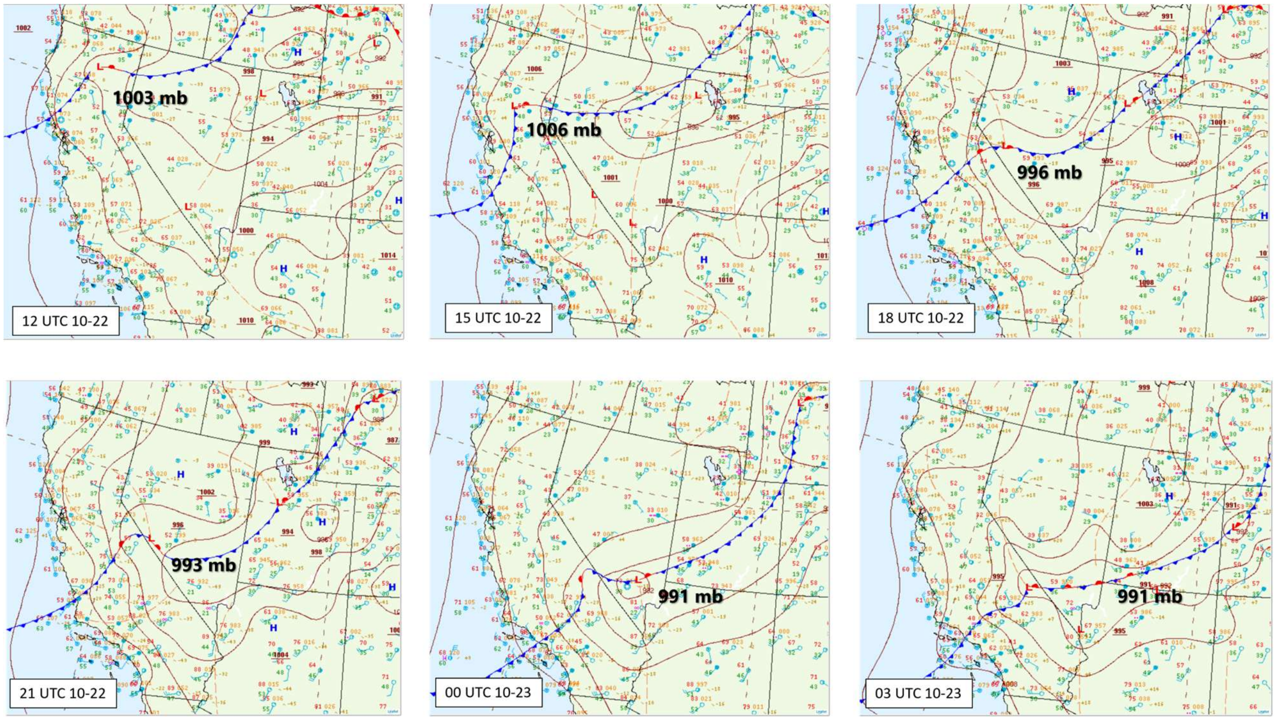


Figure 3.1-3. Progression of the surface low pressure system and associated fronts from 12 UTC October 22 (04:00 PST October 22) to 03 UTC October 23 (19:00 PST October 22). Source: NOAA's Weather Prediction Center.

As the surface low pressure system approached the Las Vegas region, a rapid drop in pressure occurred at KLAS. Here, the pressure decreased from 1,002 mb at 12:00 UTC on October 22 (04:00 PST on October 22) to 990 mb at 00:00 UTC on October 23 (16:00 PST on October 22), which is a 12-mb decrease in 12 hours. Together with a surface high pressure system over the eastern Pacific, this created a west-to-east pressure gradient across the deserts of eastern California and southern Nevada (Figure 3.1-3). Strong southwesterly winds developed in response to the increasing pressure gradient. In addition, the skew-T diagram (Figure 3.1-4) from the radiosonde launched from Las Vegas at 00:00 UTC on October 23 (16:00 PST on October 22) showed dry adiabatic lapse rates from the surface up to approximately 2,270 m above ground level (AGL) (roughly 7,400 feet AGL), which indicated enhanced vertical motion and mixing processes. This deeply mixed boundary layer promoted momentum transfer from stronger winds aloft down to the surface, resulting in surface gusts over 50 mph during the peak of this event.

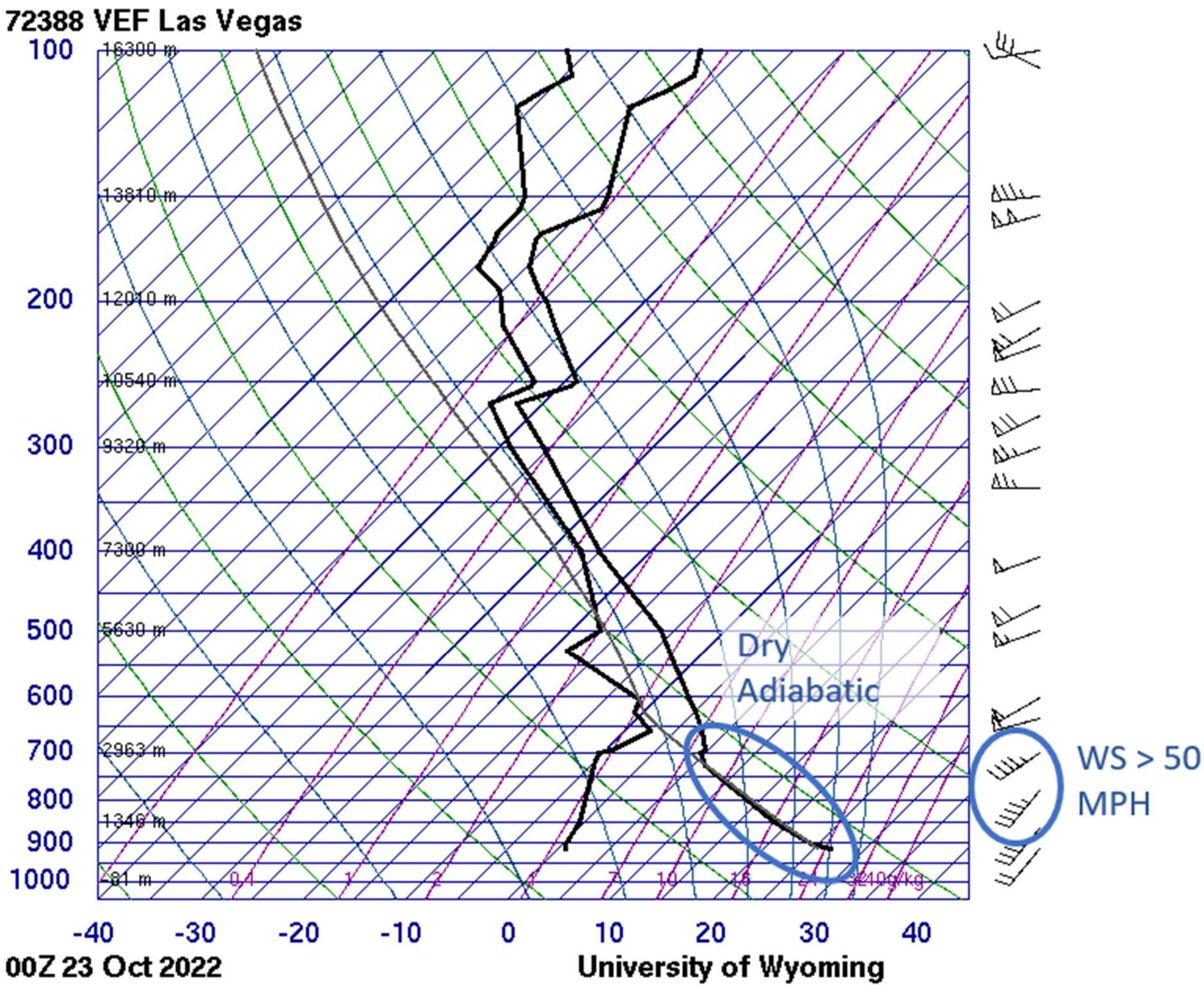


Figure 3.1-4. Skew-T profile of radiosonde data from Las Vegas at 00:00 UTC on October 23, 2022 (16:00 PST on October 22, 2022). The well-mixed boundary layer supported wind gusts >50 mph. Source: University of Wyoming.

Periods of sustained winds greater than 25 mph were observed at Harry Reid Int'l airport (KLAS) from 18:00 UTC on October 22 (10:00 PST on October 22) to 07:30 UTC on October 23 (23:30 PST on October 22), with peak wind gusts >50 mph (**Figure 3.1-5**). The KLAS Meteorological Aerodrome Reports (METARs) also reported reduced visibility and blowing dust from 20:05 UTC on October 22 (12:05 PST on October 22), until 07:50 on UTC October 23 (23:50 PST on October 22).

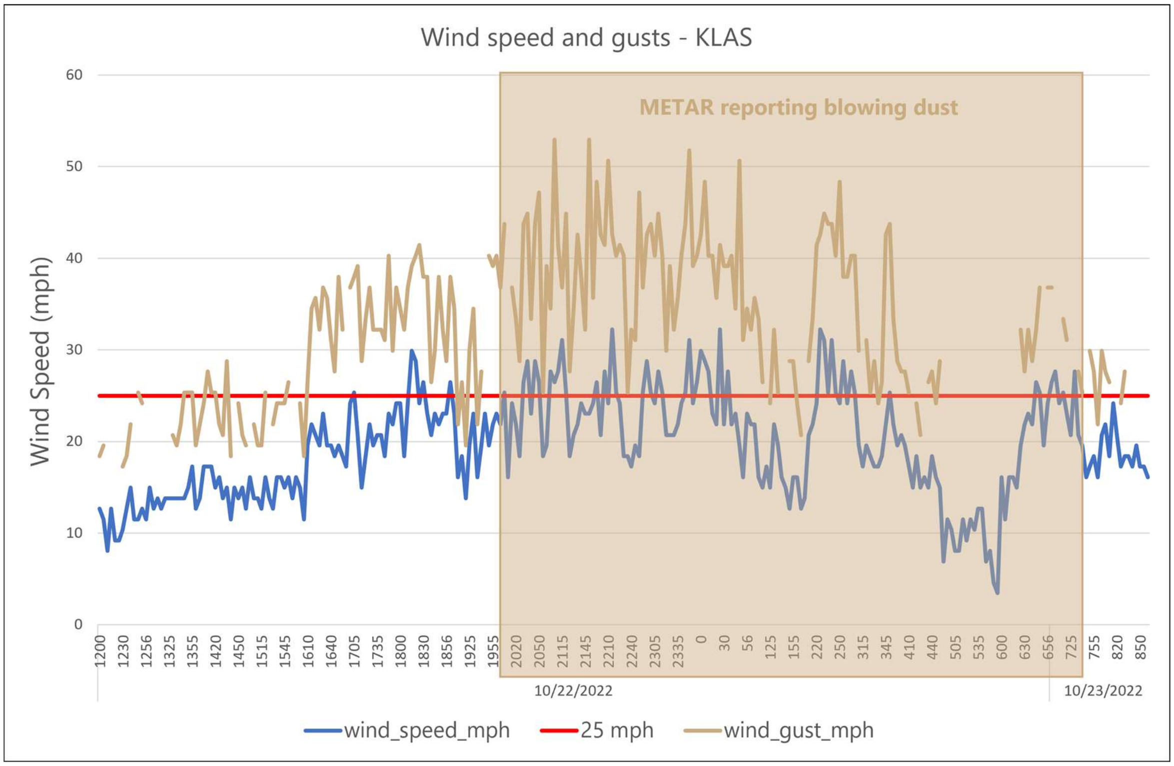


Figure 3.1-5. Wind speeds, gusts, and blowing dust reported on Harry Reid Int'l Airport (KLAS) METARs. The red line indicates the 25-mph windblown dust threshold for the southwest U.S.

Strong and gusty winds and reduced visibility were reported region-wide as this low pressure system moved through southern Nevada (Figure 3.1-6 and Figure 3.1-7). During peak winds of this event, sustained wind speeds >40 mph were observed across the Las Vegas area and extended westward (upwind) into the Mojave Desert. This broader area of high winds likely added a regional dust component to blowing dust that was being produced locally in the Las Vegas area.

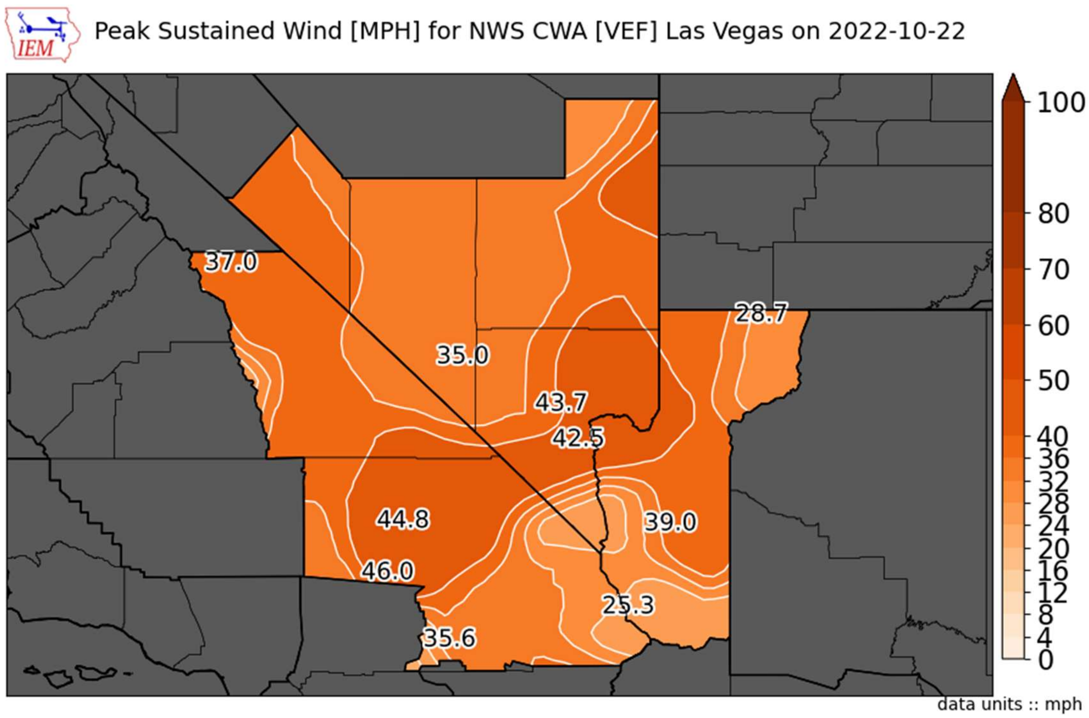


Figure 3.1-6. Peak sustained wind speeds >40 mph observed across Las Vegas and west to Fort Irwin and China Lake in the Mojave Desert. Source: Iowa State University.

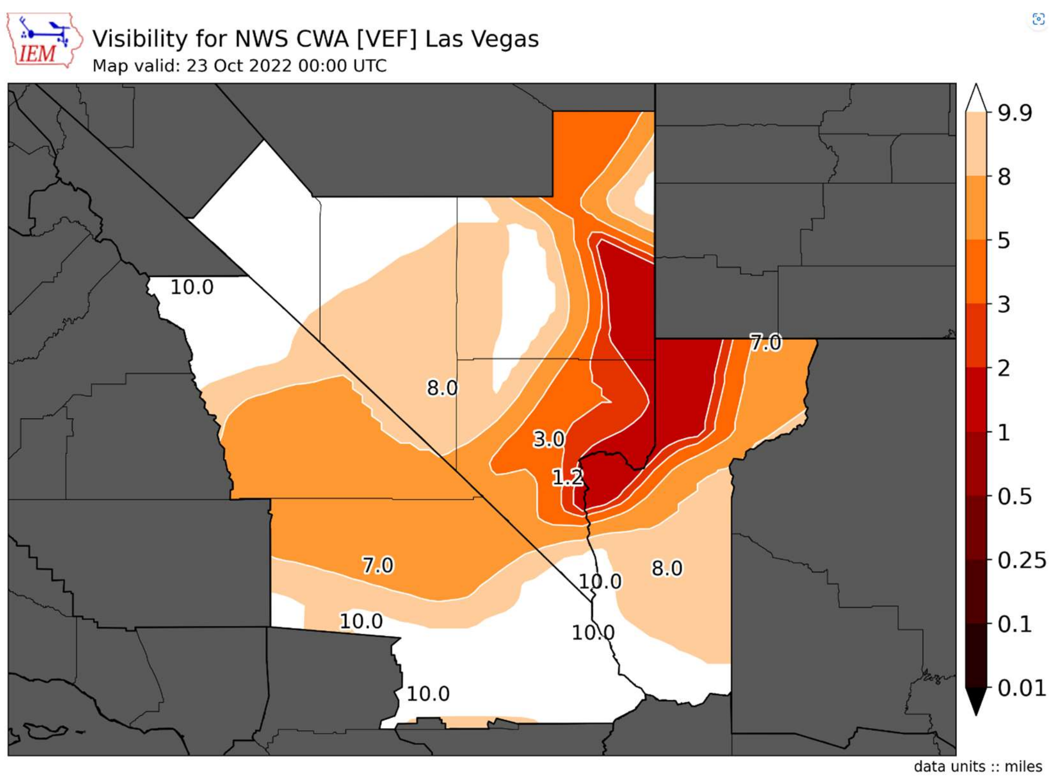


Figure 3.1-7. Region-wide reductions to visibility (miles) as a result of the blowing dust, 00:00 UTC on October 23, 2022 (16:00 PST on October 22, 2022). Source: Iowa State University.

Exceedances of the 24-hour NAAQS PM_{10} standard were observed across the same region where the widespread strong winds and reductions to visibility were observed, with Unhealthy for Sensitive Groups (USG) to Unhealthy Air Quality Index (AQI) levels observed from Las Vegas to the Mojave Desert (Figure 3.1-8).

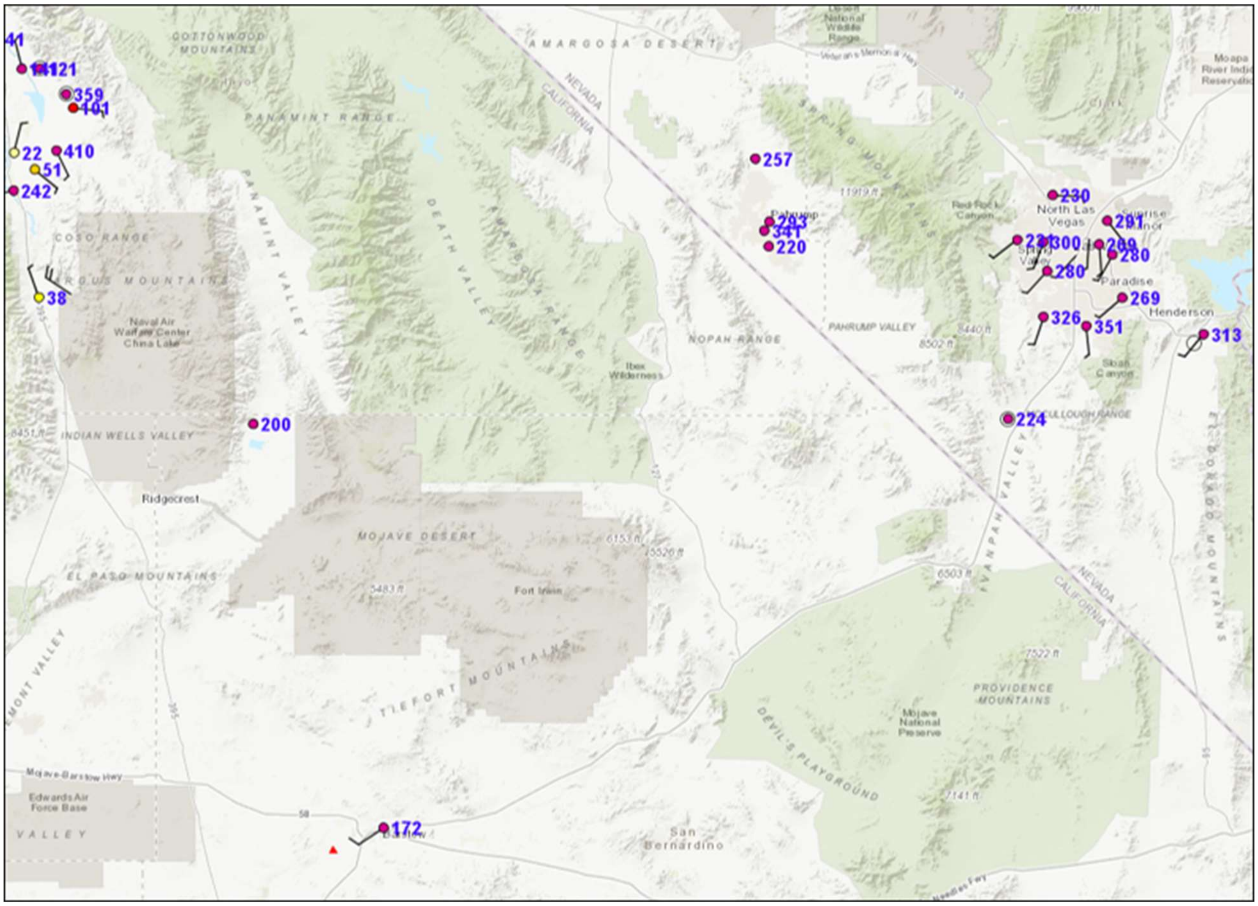


Figure 3.1-8. Twenty-four-hour average PM_{10} concentrations (µg/m^3) for October 22, 2022. Source: AirNow-Tech.

A final factor that worsened this windblown dust event was the existence of severe drought conditions across all of eastern California and southern Nevada (Section 2.2.2 and Figure 2.2-6). While soil moisture in this desert region is low on average, soil moisture was below normal due to the drought, allowing additional loose soil to be lofted into the atmosphere by strong winds.

3.1.2 Satellite Images and Analysis

Satellite imagery and reanalysis products also provide evidence of dust that corresponds with the low-pressure system moving through southern Nevada. Aerosol Optical Depth (AOD) data is retrieved from Moderate Resolution Imaging Spectroradiometer (MODIS) Terra and Aqua satellites using the Multi-Angle Implementation of Atmospheric Correction (MAIAC) algorithm. Before the frontal passage, we see a widespread area of low AOD across southern California and Nevada (Figure 3.1-9 and Figure 3.1-10). Figure 3.1-10 is considered to be before the dust event because MAIAC merges the images from Terra at 10:30 local time (before the dust event) and Aqua at 13:30 local time (at the start of the dust event). The AOD values from the following day capture the aftermath of the event on October 23, 2022 (Figure 3.1-11), showing enhanced AOD compared to the previous days due to windblown dust in southern California and Nevada. Unfortunately, visible imagery does not capture the dust event due to heavy cloud cover in the region.

The Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) reanalysis data show high hourly average and hourly peak wind speeds in the source region and the Las Vegas area during the dust event (Figure 3.1-12 and Figure 3.1-13). The surface high pressure system over the eastern Pacific created an increasing west-to-east pressure gradient over eastern California and southern Nevada. Strong southwesterly winds developed from this increasing pressure gradient. These winds in the Las Vegas area are at or above 15 m/s, which corresponds to around 34 mph.

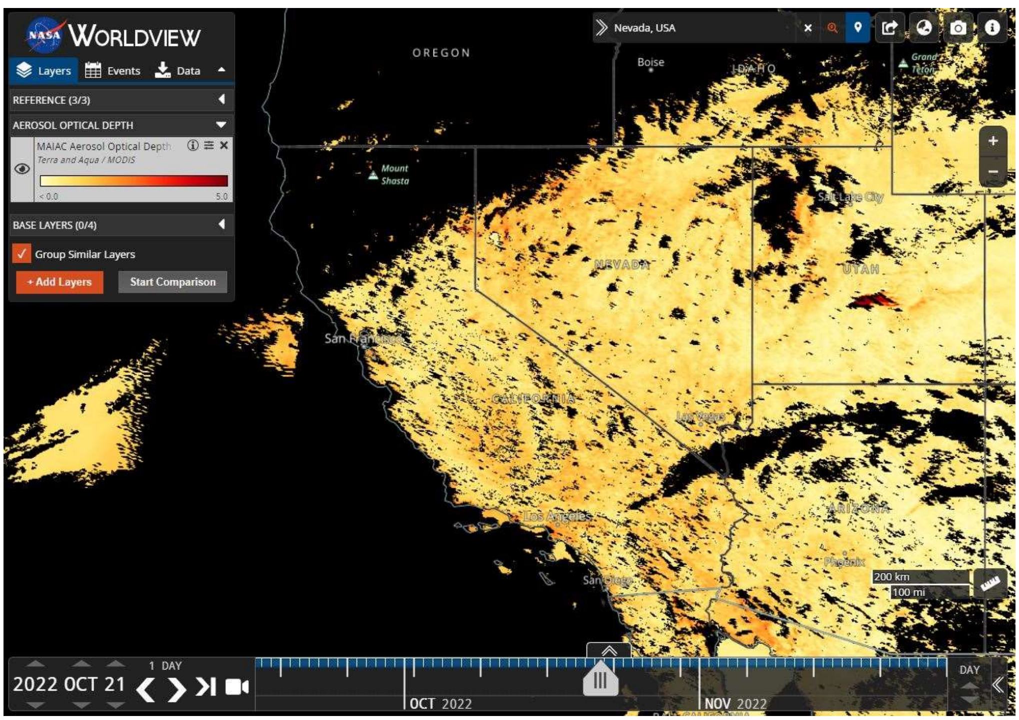


Figure 3.1-9. Satellite AOD from MAIAC Aqua and Terra combined. Terra imagery at 10:30 local time and Aqua imagery at 13:30 local time on October 21, 2022.

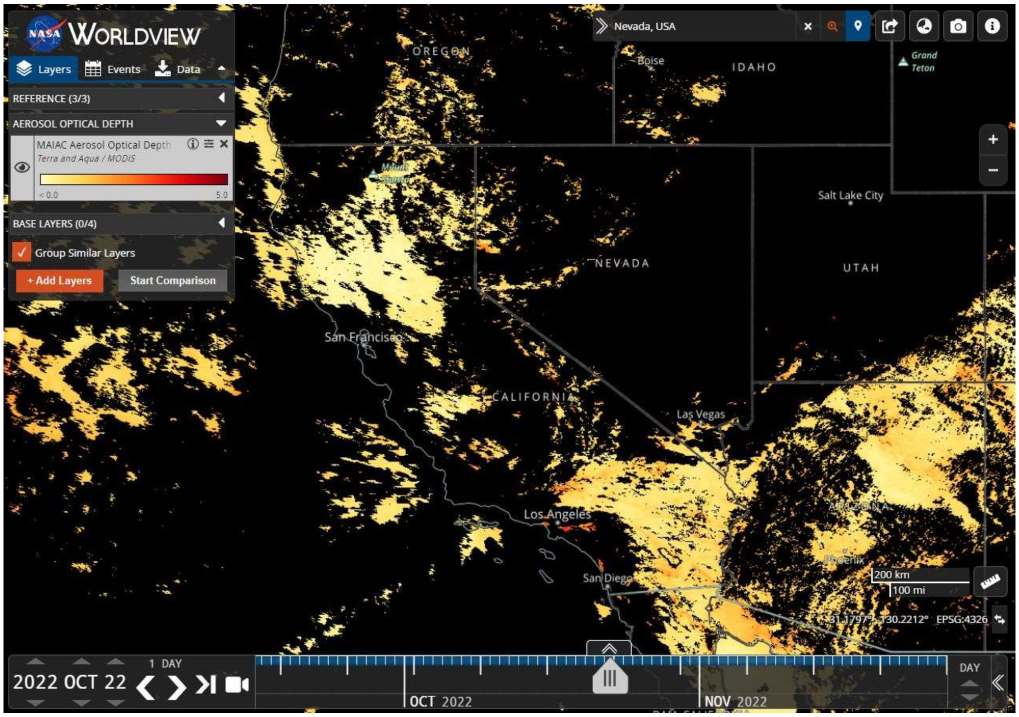


Figure 3.1-10. Satellite AOD from MAIAC Aqua and Terra combined. Terra imagery at 10:30 local time and Aqua imagery at 13:30 local time on October 22, 2022.

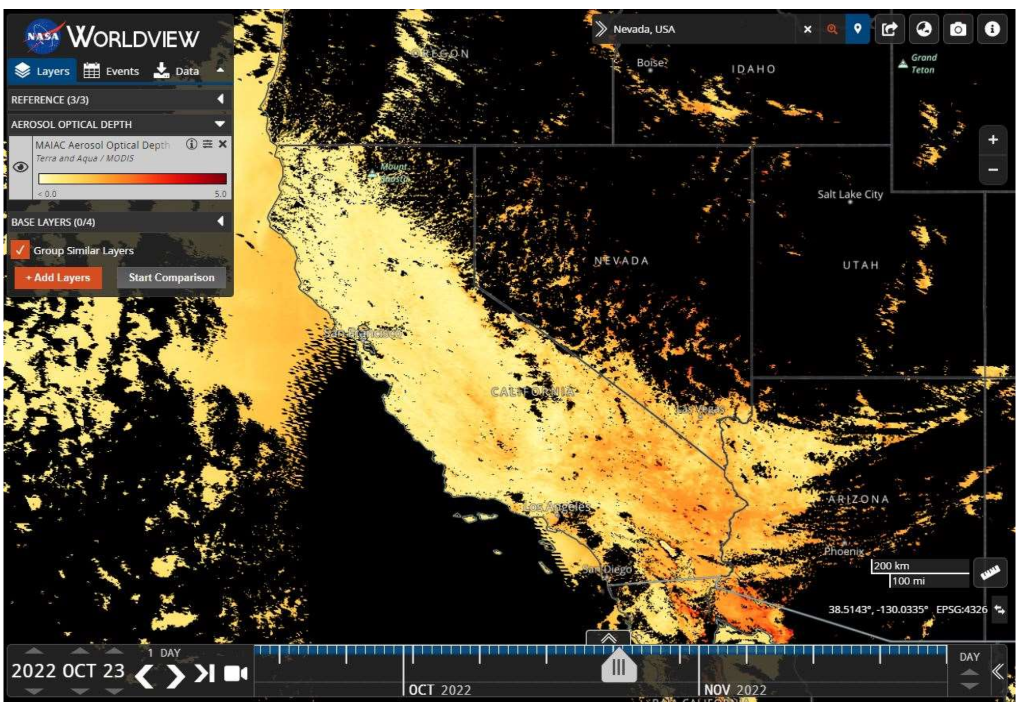


Figure 3.1-11. Satellite AOD from MAIAC Aqua and Terra combined. Terra imagery at 10:30 local time and Aqua imagery at 13:30 local time on October 23, 2022.

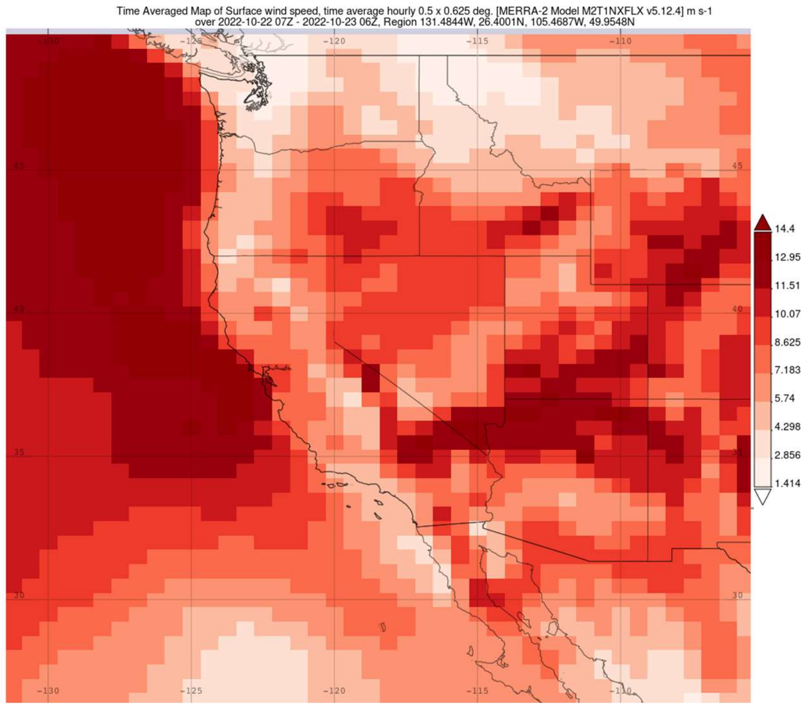


Figure 3.1-12. MERRA-2 reanalysis data hourly averaged surface wind speed (m/s) over October 22, 2022, at 07:00 UTC (October 21, 2022, at 23:00 PST) – October 23, 2022, at 06:00 UTC (October 22, 2022, at 22:00 PST).

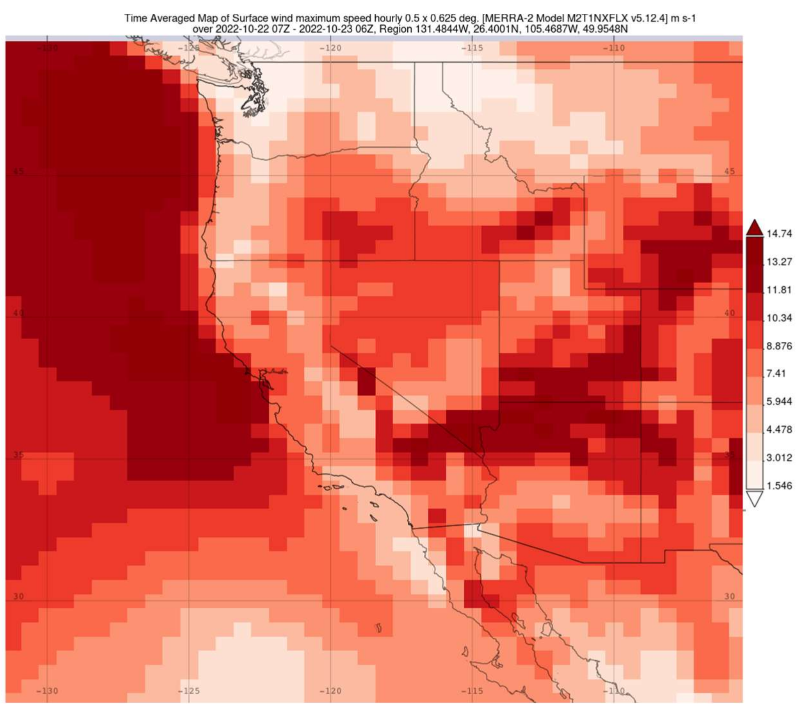


Figure 3.1-13. MERRA-2 reanalysis data hourly maximum surface wind speed (m/s) over October 22, 2022, at 07:00 UTC (October 21, 2022, at 23:00 PST) – October 23, 2022, at 06:00 UTC (October 22, 2022, at 22:00 PST).

3.1.3 Supporting Ground-Based Data

We were unable to find ground-based images in the source region due to the remote location. Satellite imagery was highlighted in the previous section as a substitute.

Peak sustained winds in the Mojave Desert (southeastern California) were developed via the Iowa State University Mesonet Automated Data Plotter. This tool aggregates automated weather data records from the selected region. Figure 3.1-14 shows that peak sustained wind speeds in southeastern California and the Mojave Desert peaked at 45 mph on October 22, 2022. These peak sustained wind speeds were well above the 25-mph threshold in the source region and could easily loft, entrain, and transport PM_{10} downwind quickly to Clark County.

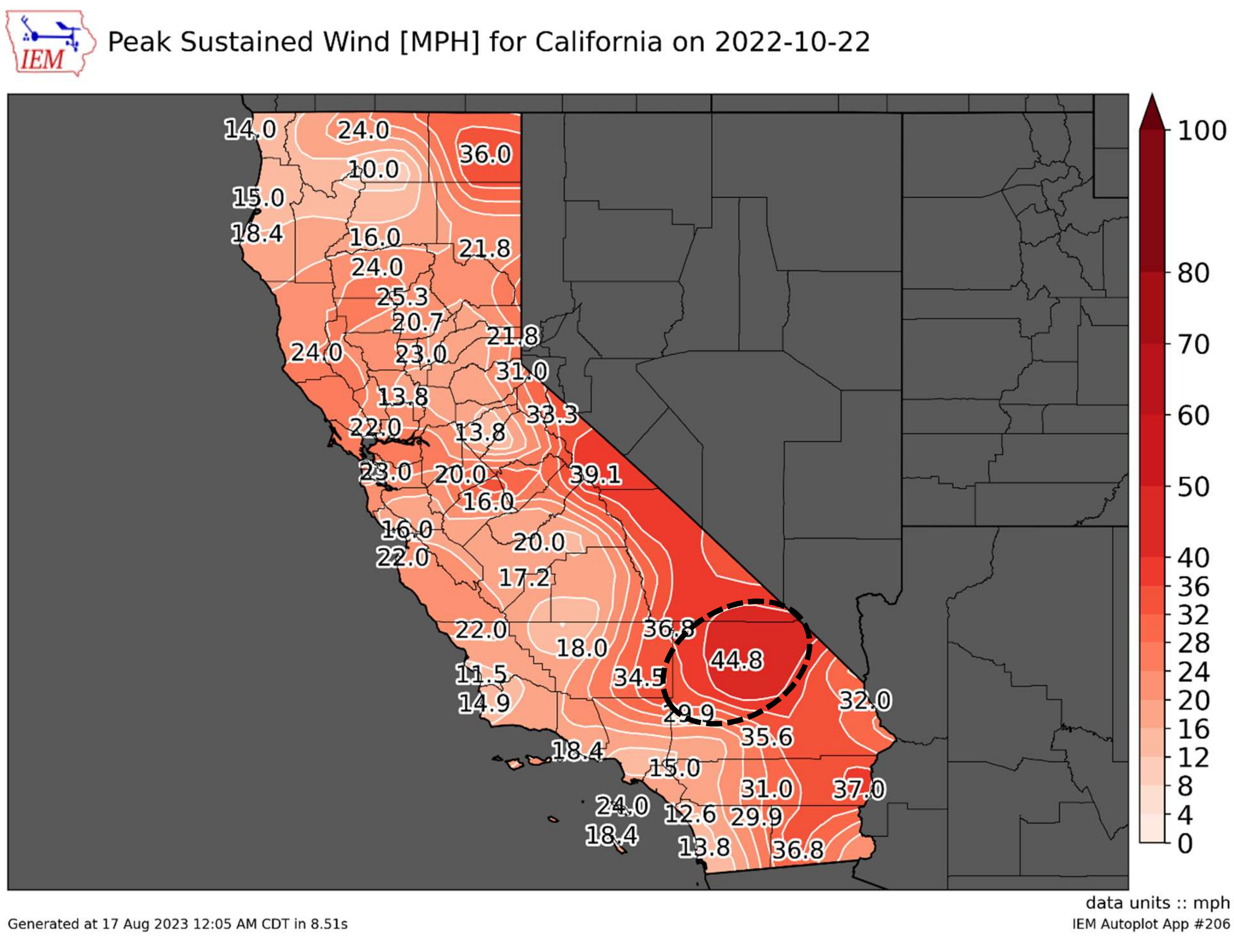


Figure 3.1-14. Peak sustained winds for California on October 22, 2022. The source region is located in southeastern California (the Mojave Desert region). The black dashed line shows the approximate source region. Data source: **https://mesonet.agron.iastate.edu/plotting/auto/**.

Figure 3.1-15 shows the distribution of maximum daily temperatures recorded at several sites in the wind-blown source region on October 21 and 22 (1991 – 2021), and the maximum daily temperatures recorded on October 21 and 22, 2022. The site locations are shown in Figure 2.2-8. Maximum daily temperatures recorded at all sites were at or above the 75th percentile in the dust region and along the transport path compared to maximum daily temperatures from 1991 – 2021. Maximum daily temperatures recorded at all sites on October 22, 2022, during the PM_{10} exceedance were slightly lower than October 21 due to blowing dust reducing incoming solar radiation. The maximum daily temperatures recorded on October 21 provide evidence that the wind-blown dust source regions in the Mojave Desert were unusually hot the day before the PM_{10} exceedance.

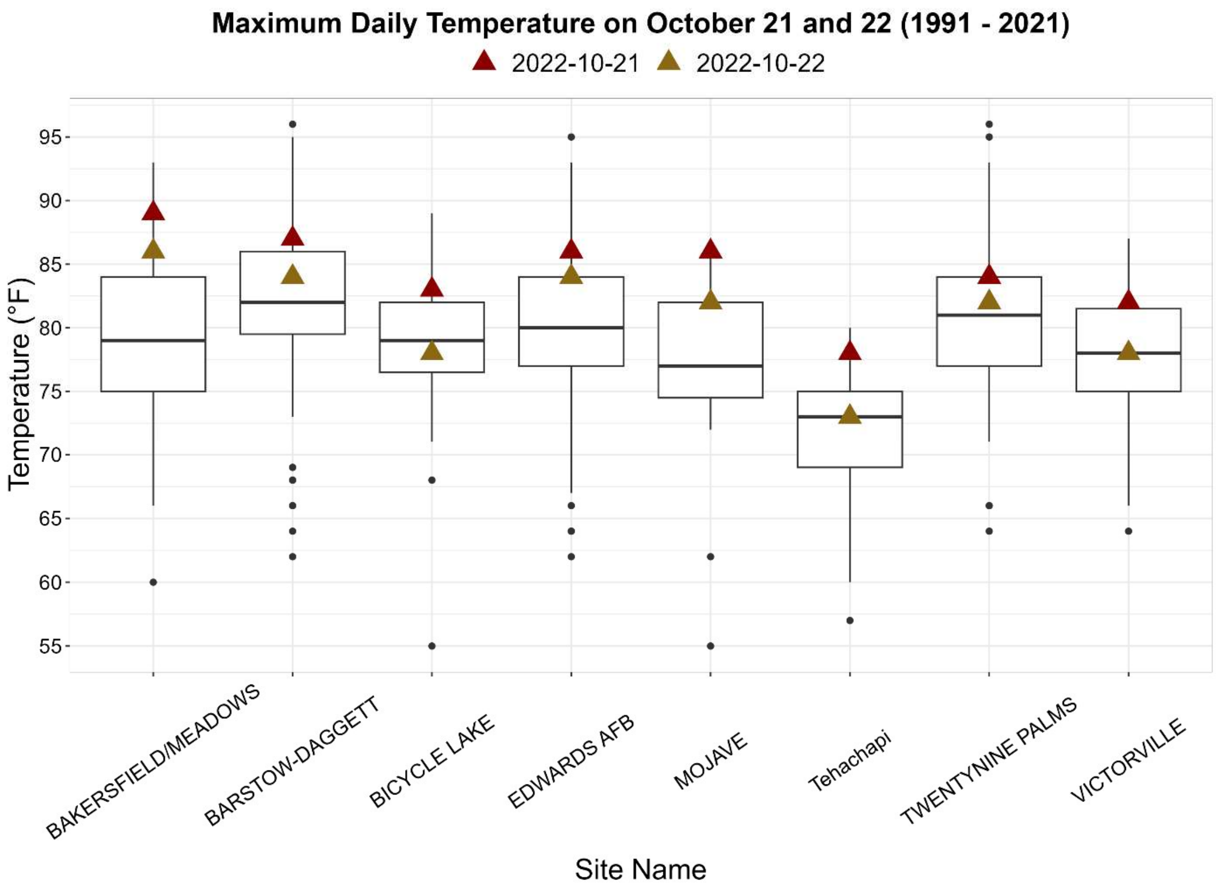


Figure 3.1-15. Maximum daily temperature on October 21 and 22, 2022, compared to the 1991 – 2021 distribution at each site.

Overall, we find overwhelming evidence that PM_{10} was very likely lofted, entrained, and transported from the Mojave Desert region in southeastern California in the afternoon and evening on October 22, 2022, associated with a frontal passage. The evidence corroborating this assertion includes (1) the meteorological analysis that shows conditions were consistent with a high-wind event in the Mojave Desert; (2) radar images from Las Vegas showing the progression of dust moving from the Mojave Desert in southeastern California into the Clark County area; (3) satellite retrievals showing high AOD and winds in the Mojave Desert and Clark County; (4) ground-based measurements of high temperatures in the Mojave Desert region before and on the day of the event (October 21-22, 2022); and (5) aggregated measurements of high winds in the Mojave Desert source region on October 22, 2022.

3.2 Transport to Clark County

3.2.1 HYSPLIT Analysis

Backwards trajectories were modeled from Jerome Mack, Jean, Joe Neal, Mountains Edge, Garrett Jr. High School, and Paul Meyer at the start of the high PM_{10} concentrations (hourly concentration >150 µg/m^3), 12:00 PST at 50, 500, and 1,000-m heights (**Figure 3.2-1**). Archived North American Mesoscale Forecast System (NAM) data with a resolution of 12 km was used as meteorologic input. Temporal resolution of the NAM-12 km is three hours and is run by NCEP.

At all heights, the trajectories converge as they approach the Las Vegas region from the west-southwest and pass over the Mojave National Preserve, which is the primary source region (**Figure 3.2-2**). The Mojave National Preserve is located just east-southeast of the Sierra Nevada Mountain range within its rain shadow and is characterized by barren and scrub/shrub landcover (Figure 3.2-2, left). The region was experiencing severe drought conditions (Figure 3.2-2, right).

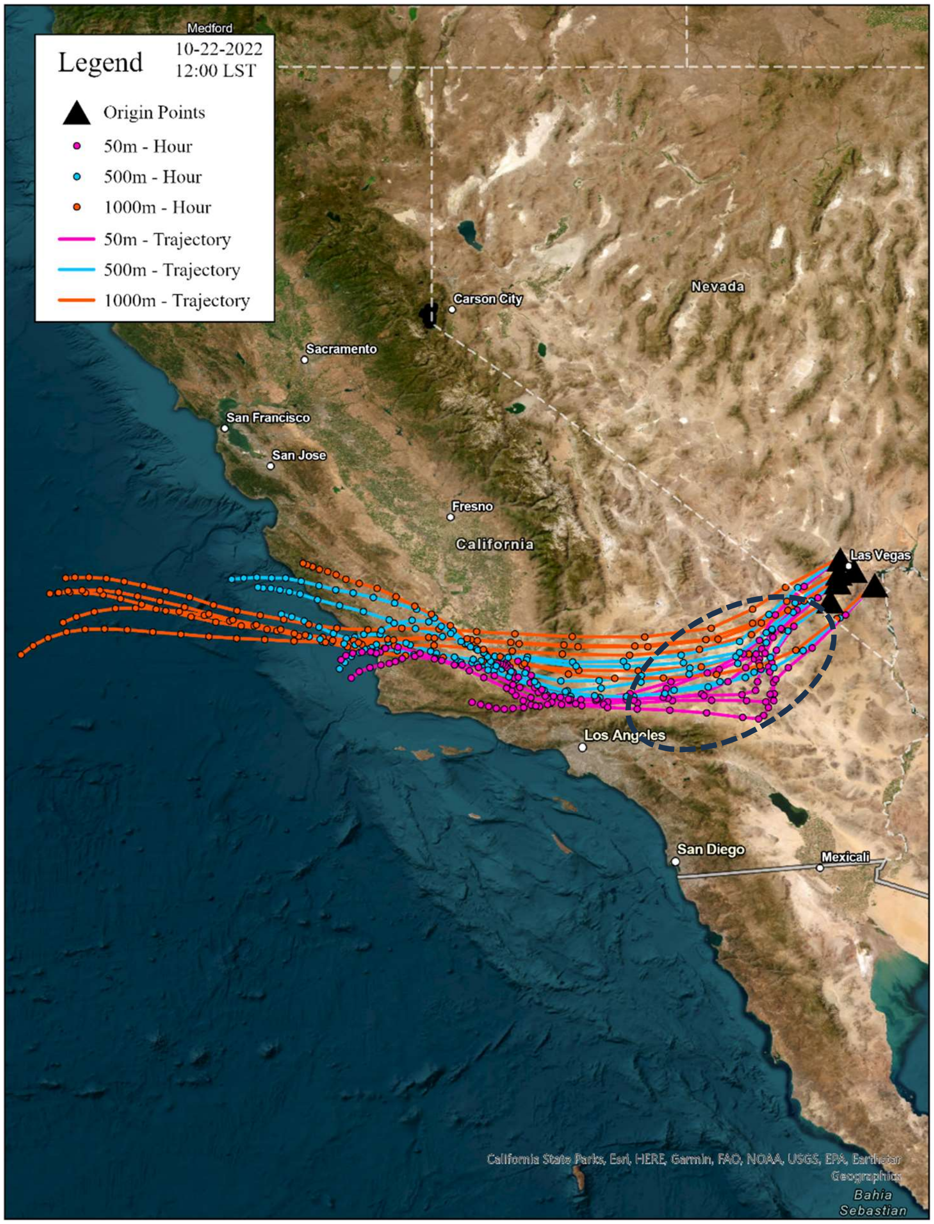


Figure 3.2-1. HYSPLIT 24-hour back trajectories with hourly points from Jerome Mack, Jean, Paul Meyer, Joe Neal, Mountains Edge, and Garrett Jr. High on October 22, 2022, at 12:00 PST, originating at (maroon) 50-m, (green) 500-m, and (blue) 1,000-m. The approximate location of the Mojave Desert source region is shown by a black, dashed oval.

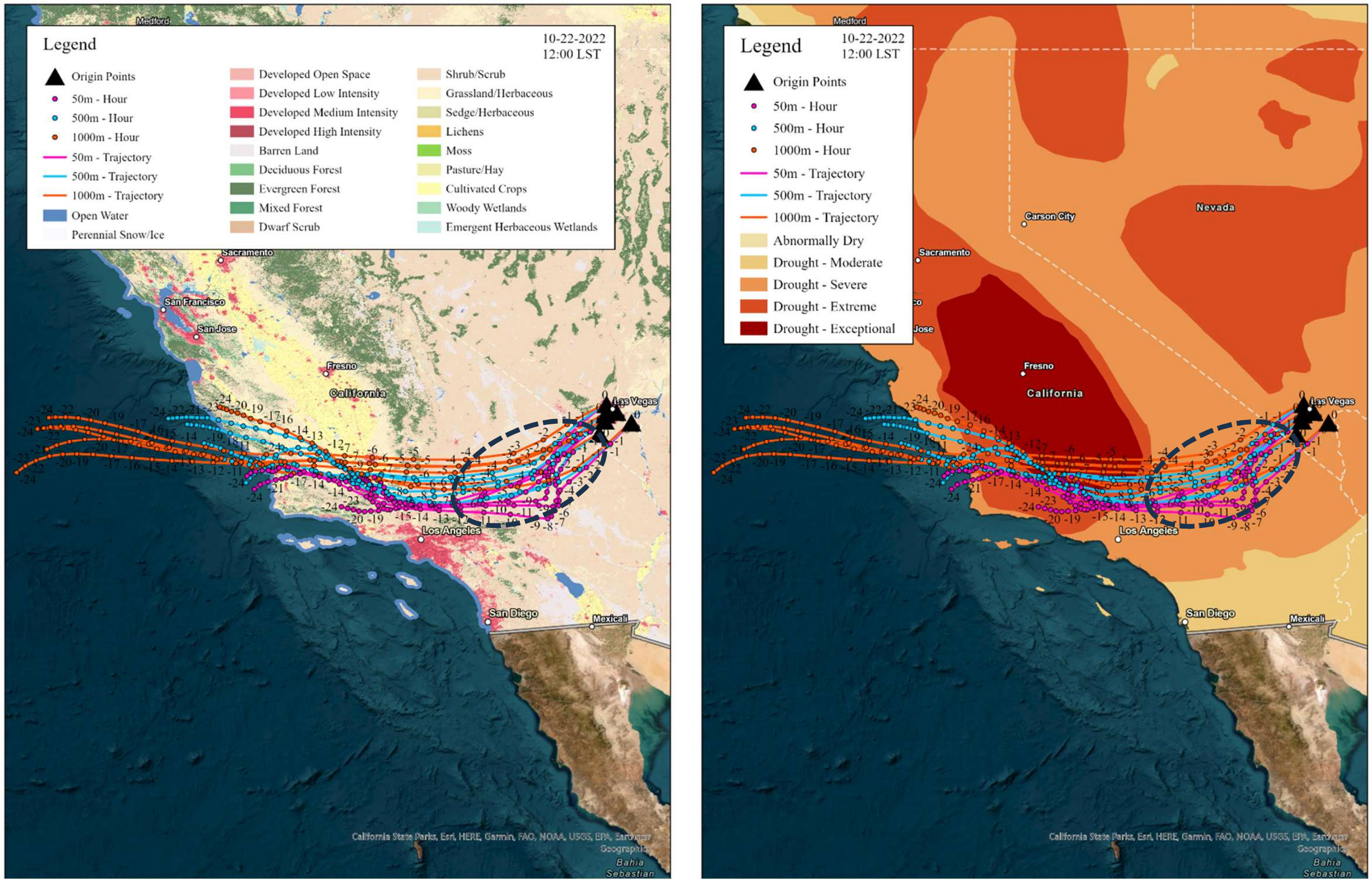


Figure 3.2-2. HYSPLIT 24-hour back trajectories from Jerome Mack, Jean, Paul Meyer, Joe Neal, Mountains Edge, and Garrett Jr. High on October 22, 2022, at 12:00 PST, overlayed on (left) national land type database and (right) drought monitor class. The approximate location of the Mojave Desert source region is shown by a black, dashed oval.

3.2.2 High-Wind Event Timeline

The wind-blown dust event that occurred on October 22, 2022, affected 10 monitoring sites with regulatory significance in Clark County and caused a maximum 24-hour PM_{10} concentration of 351 μg/m^3 at Liberty High School. Concentrations of PM_{10} began to rise at around 05:00 PST, and concentrations peaked between 13:00 and 20:00 PST at measurement sites throughout Clark County. PM_{10} concentrations remained enhanced through midnight.

In addition to the meteorological evidence of the frontal system approach, PM_{10} concentrations and hourly average wind speeds in the source region are provided in **Figure 3.2-3 and Figure 3.2-4**. As stated in the meteorological analysis in Section 3.1.1, a frontal system approached on October 22 and created a pressure gradient across southeastern California and southern Nevada, producing strong gusty winds. This is reflected in the enhanced PM_{10} concentrations throughout the region that started at 07:00 PST and increased into the afternoon (Figure 3.2-3). Hourly average wind speeds measured at several AQS sites in the source region mirror the rise in PM10 concentrations (Figure 3.2-4). Four sites in the Mojave Desert region (Ridgecrest-Ward, Olancha-Well 404, Shell Cut, and Trona) measured hourly average wind speeds greater than 25 mph during peak PM_{10} concentrations, fulfilling a key factor for a Tier 2 high-wind dust event as defined by EPA guidance (i.e., sustained winds above 25 mph in a natural undisturbed desert source region). Wind speeds in the Las Vegas Valley are less intense than the peak winds observed in the source region and occur later in the day, mostly after 13:00. Correspondingly, PM_{10} concentrations in all labeled regions show a near-concurrent rise, although the increase in the Las Vegas region (region five in Figure 3.2-3) occurred much more slowly with peak concentrations later in the day, likely due to some shielding by the Spring Mountains to the west of the Las Vegas Valley. This provides significant evidence of windblown dust lofting and transport from the source region in the Mojave Desert to Clark County, fueled by high winds along the steep pressure gradient created by the frontal system moving through the area.

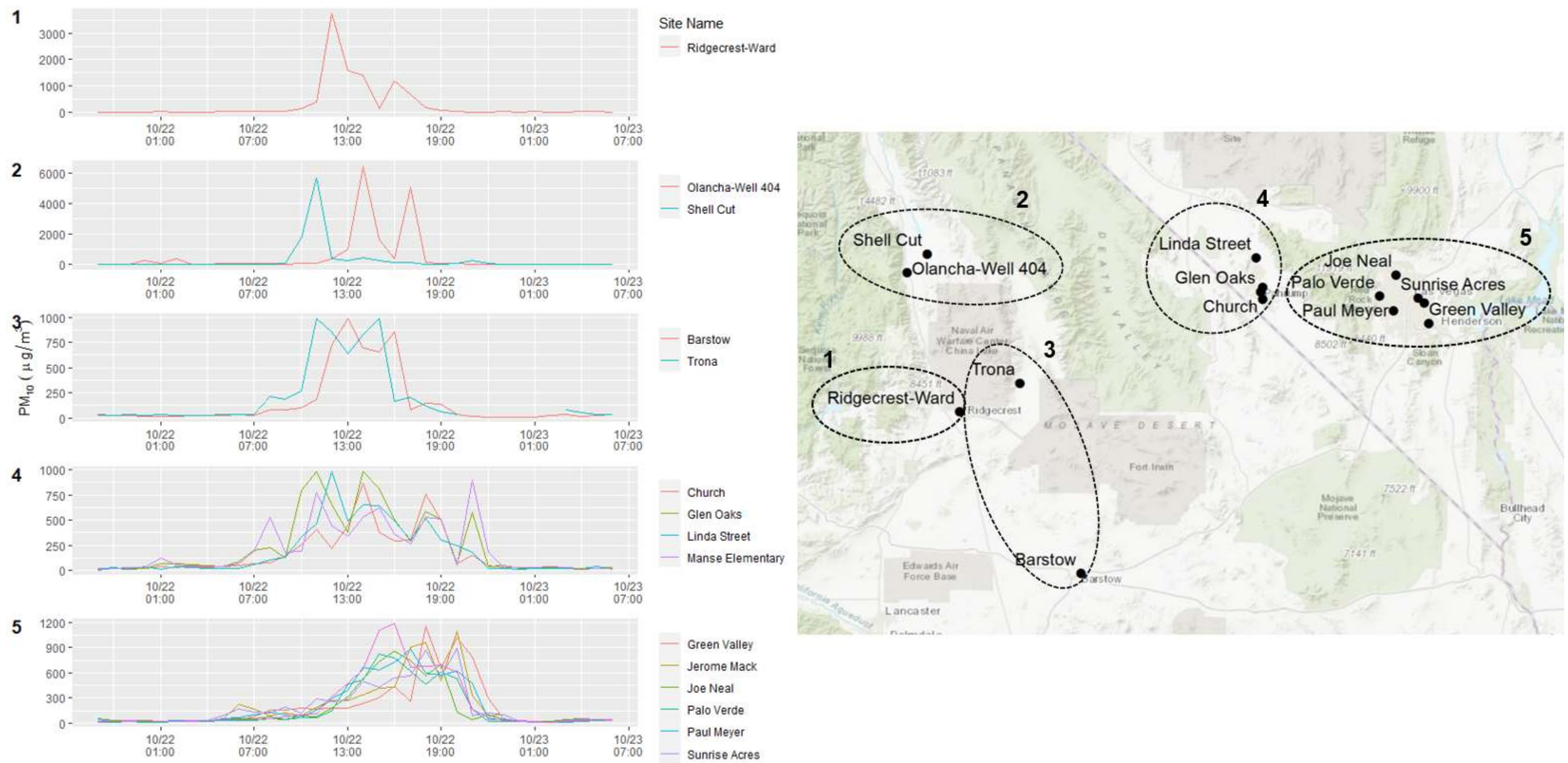


Figure 3.2-3. Timeseries of PM_{10} (left) along the strong pressure gradient associated with an approaching cold front. Data is included from Kern County (Panel 1), Inyo County (Panel 2), San Bernardino County (Panel 3), the Pahrump area of Nevada (panel 4), and the Las Vegas area (Panel 5). Site locations are mapped and circled by region (right). Numbering in the map corresponds to numbering in the time series figures on the left.

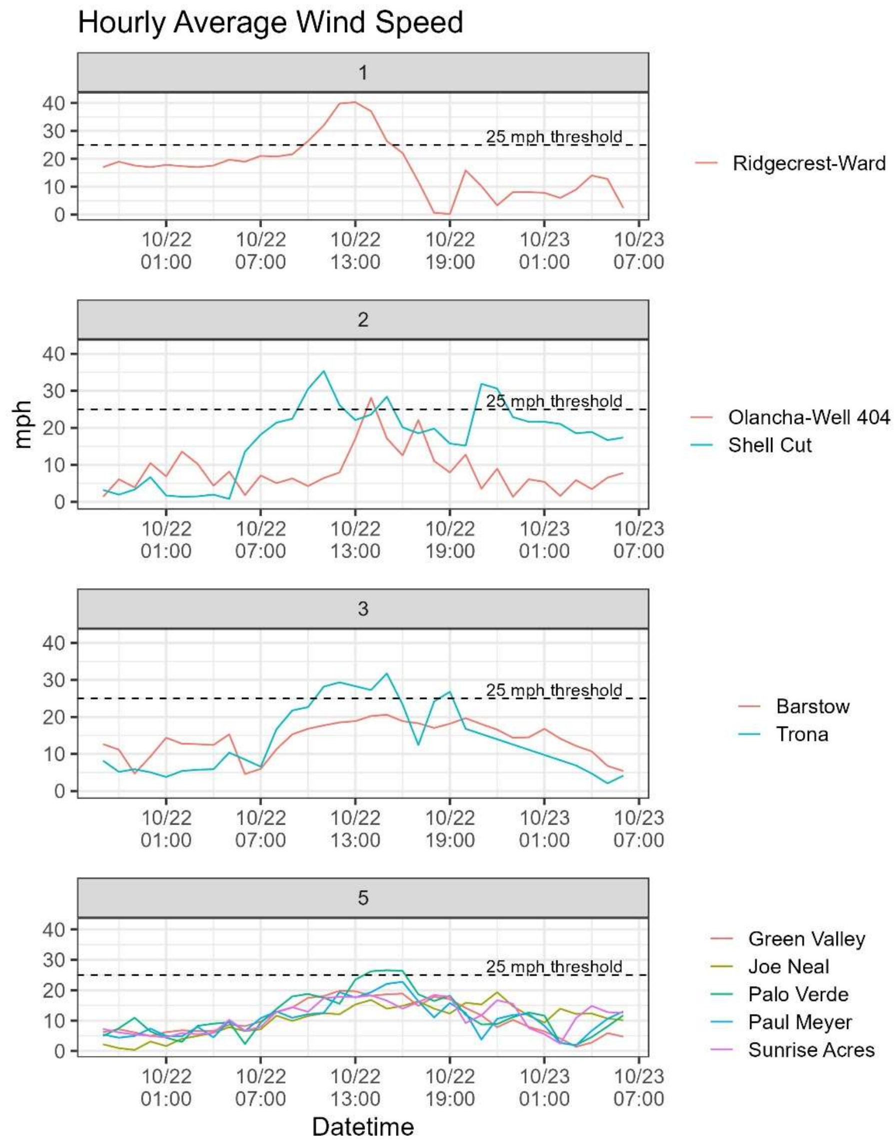


Figure 3.2-4. Timeseries of hourly average wind speed measured at AQS sites displayed in Figure 3.2-3. Numbers that label each panel correspond to labels on the timeseries and in the map of Figure 3.2-3. Meteorology data are not reported from any sites in region 4.

Figure 3.2-5 shows the distribution of five-minute wind speed and direction observations on October 22 measured at Harry Reid Int'l Airport (KLAS). The strongest winds, peaking at 32 mph, came from the southwest which corroborates the approach of a cold front.

Wind speed, direction, and PM_{10} concentrations across Clark County, NV, were consistent with a frontal passage (Figure 3.2-6 to Figure 3.2-13). Starting at 06:00 PST, winds start to shift southwesterly starting in the southern part of the Las Vegas Valley due to the influx of winds through the mountain pass between the Spring Mountains and the McCullough Range, a major wind and transport corridor into the Valley. The shift in winds, starting with the southern sites and moving up to the northern sites, occurred between 06:00 and 08:00 PST as the pressure gradient from the low-pressure system and frontal movement started to affect the Las Vegas Valley. Concentrations of PM_{10} start to increase in the southern part of the Valley first, directly in line with the mountain pass. As dust pushes northward into the Valley, the northern sites are subsequently affected. This gradient in concentration between southern and northern sites is apparent between 08:00 and 13:00 PST. As the pressure gradient increases due to the frontal passage, the western Valley sites become more affected by winds passing over the Spring Mountains. By 14:00 to 20:00 PST all sites in the Las Vegas Valley experience hourly concentrations of PM_{10} > 500 $\mu g/m^3$ for multiple hours with winds consistently out of the southwest. By 21:00 PST, wind speeds start to decline and PM_{10} concentrations also begin to fall. The consistent wind direction coupled with a steady influx of PM_{10} through the mountain pass and over the Spring Mountains as well as extremely high concentrations of PM_{10} for a majority of the day indicates that this was an exceptional event from an upwind source region.

Enhanced PM_{10} concentrations at the affected sites were likely caused by a high wind event in the source region rather than by local emissions, in part because planned land use around these sites, which can be generally described as developed with little exposed dirt or gravel, is not conducive to elevated PM_{10} concentrations. Further, enhanced PM_{10} concentrations at all sites in the Las Vegas Valley are indicative of a regional high-wind dust event. While it is possible that some portions of planned land use, such as the undeveloped lot to the east of the Joe Neal site, may have contributed to local dust during the high wind event, evidence of high winds over a natural, undisturbed desert region upwind of Clark County is clearly the main driver of this dust event. As shown by the timeline of events, high winds from a frontal passage lofted PM_{10} in the Mojave Desert source region and caused a regional dust event across southern California extending into Clark County. Even if there were some contributions from local dust sources due to high winds, the regional dust event is the main source of the extreme PM_{10} concentrations experienced on October 22, 2022.

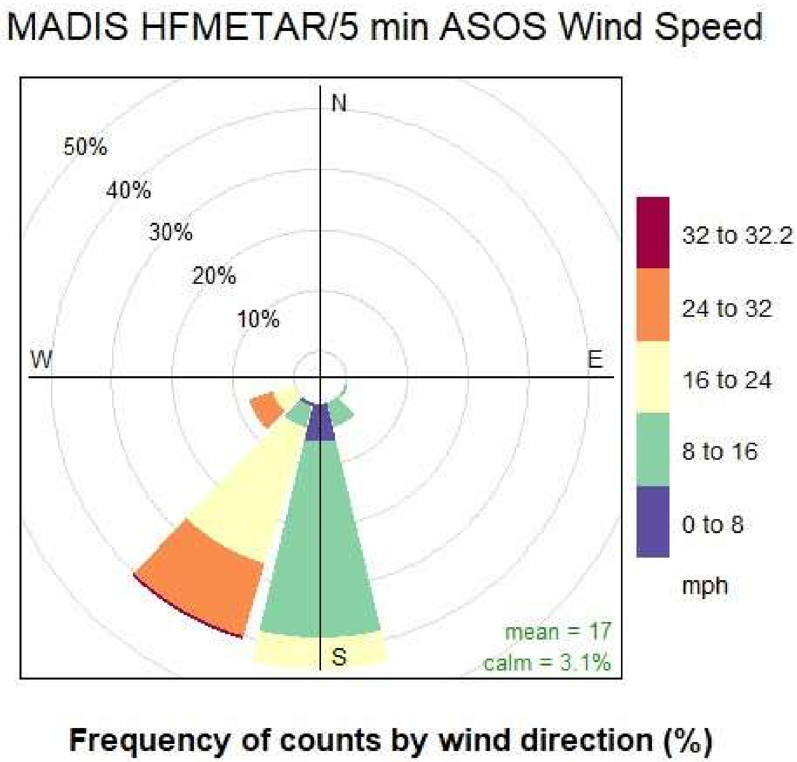


Figure 3.2-5. Wind rose including both wind speed and direction for October 22, 2022, at Harry Reid Int'l Airport (LAS). Wind data was sourced from the Iowa Environmental Mesonet (https://mesonet.agron.iastate.edu/).

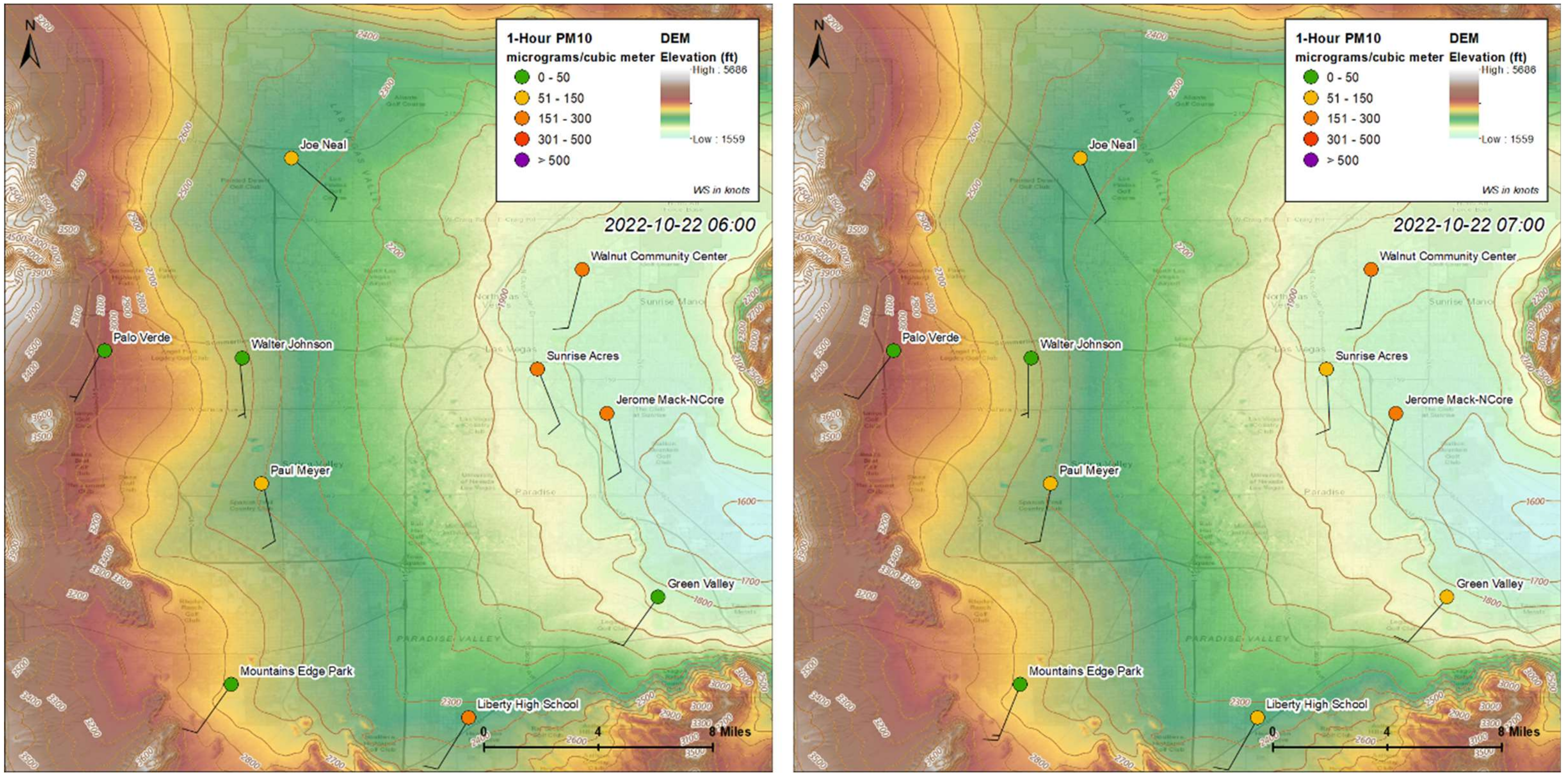


Figure 3.2-6. Surface observations of wind speed, wind direction, and hourly PM_{10} from each measurement site in Clark County, NV, as well as ground elevation for October 22, 2022, from 06:00 to 07:00 PST.

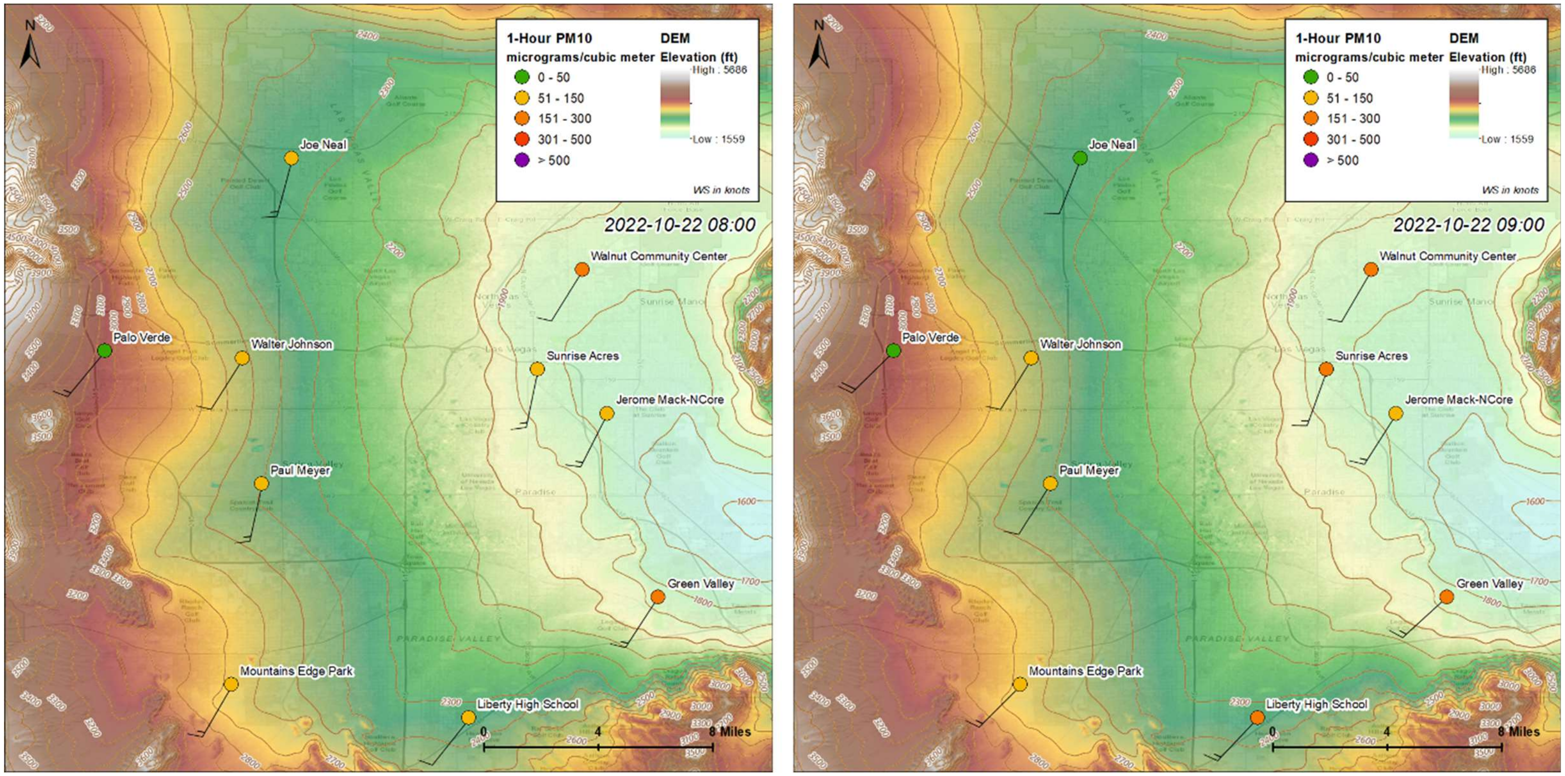


Figure 3.2-7. Surface observations of wind speed, wind direction, and hourly PM_{10} from each measurement site in Clark County, NV, as well as ground elevation for October 22, 2022, from 08:00 to 09:00 PST.

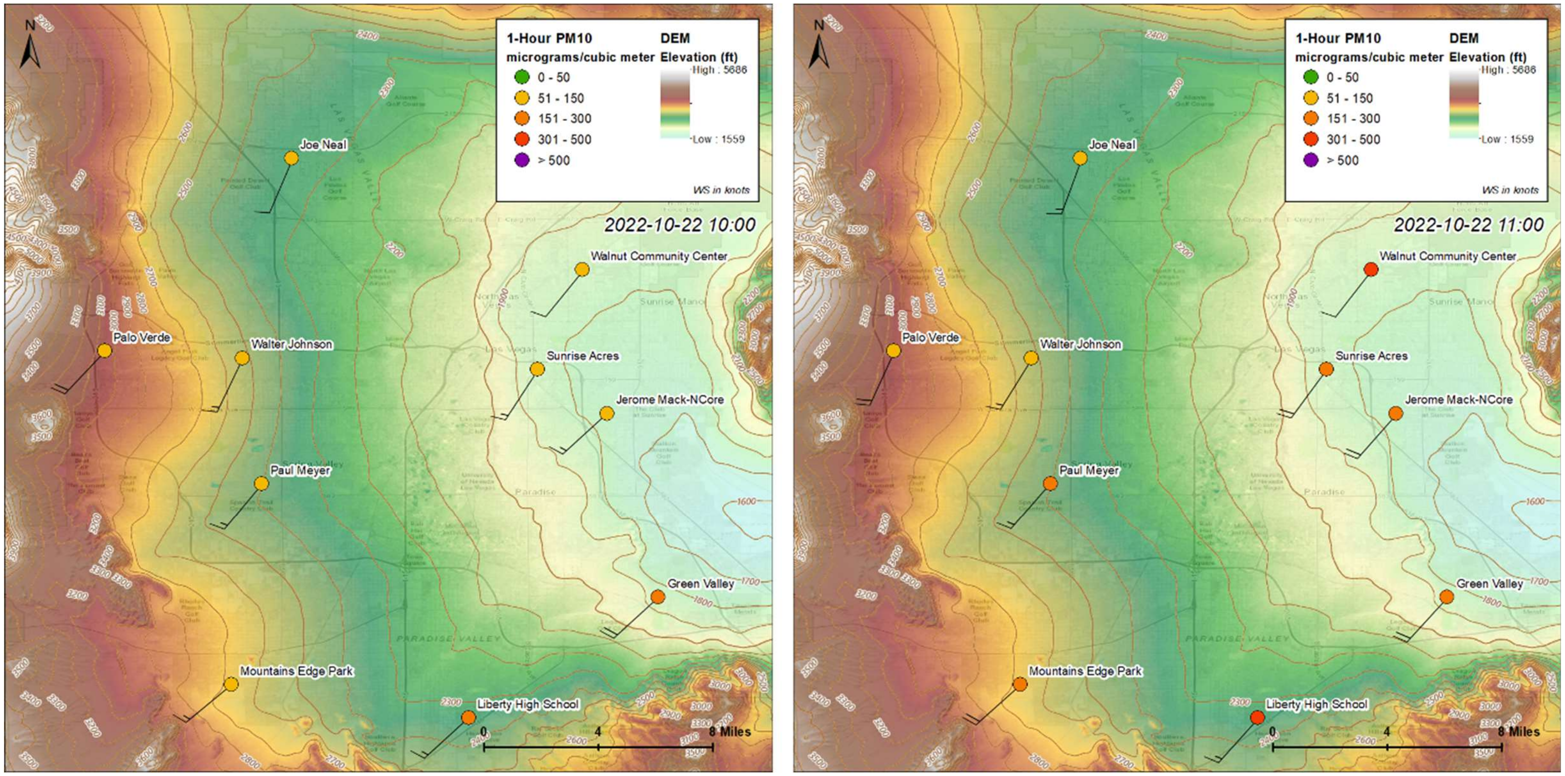


Figure 3.2-8. Surface observations of wind speed, wind direction, and hourly PM_{10} from each measurement site in Clark County, NV, as well as ground elevation for October 22, 2022, from 10:00 to 11:00 PST.

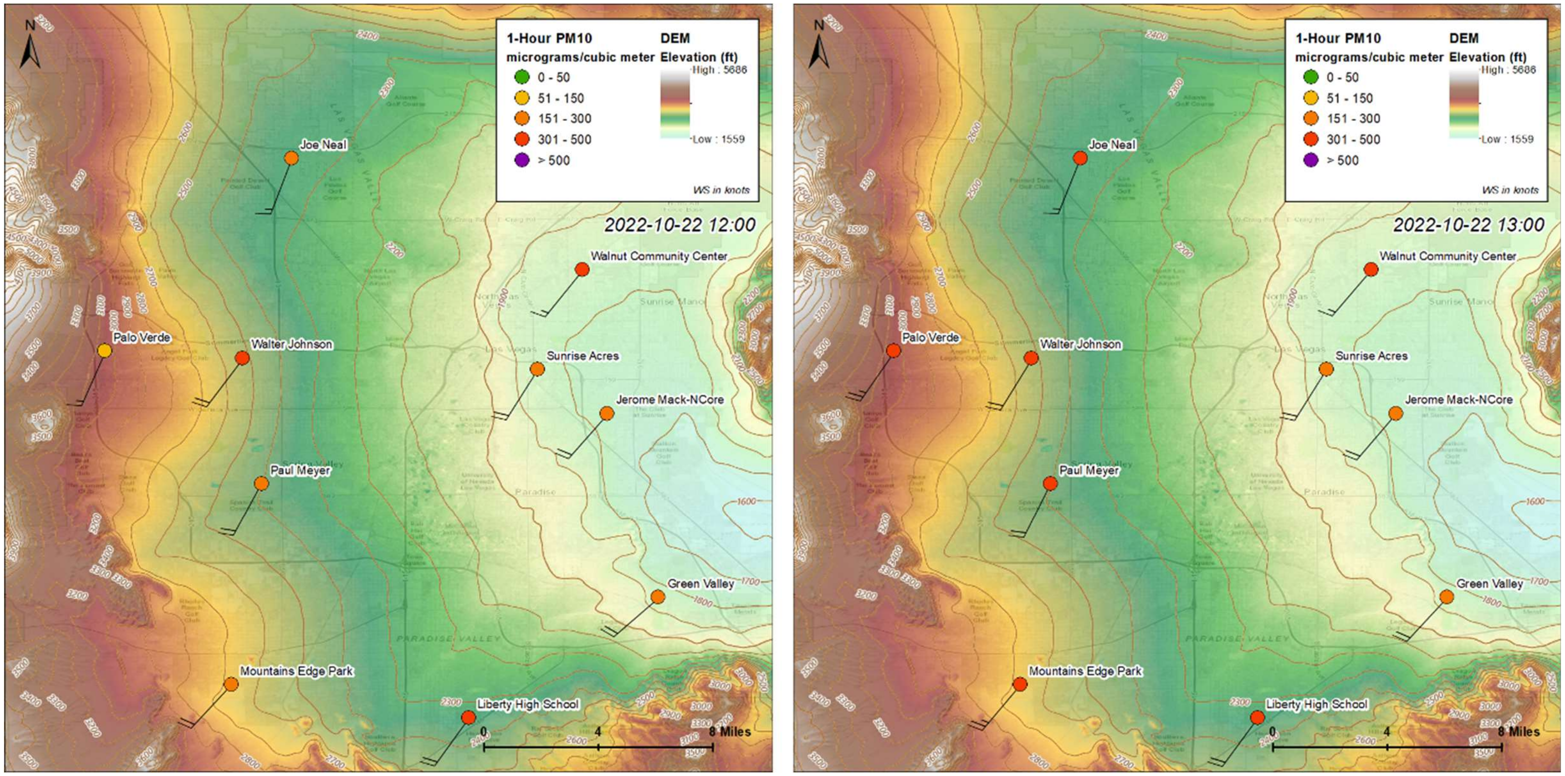


Figure 3.2-9. Surface observations of wind speed, wind direction, and hourly PM_{10} from each measurement site in Clark County, NV, as well as ground elevation for October 22, 2022, from 12:00 to 13:00 PST.

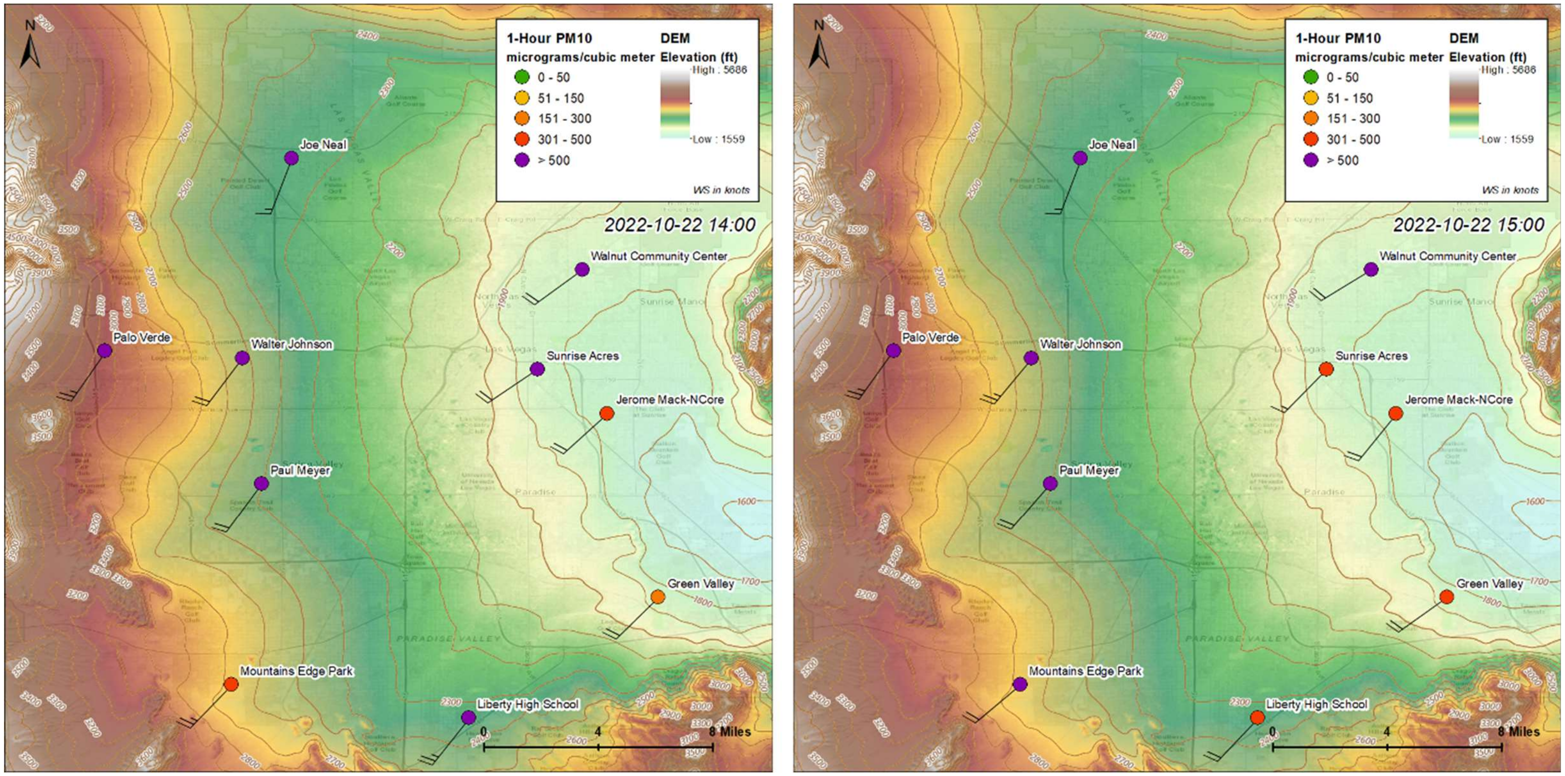


Figure 3.2-10. Surface observations of wind speed, wind direction, and hourly PM_{10} from each measurement site in Clark County, NV, as well as ground elevation for October 22, 2022, from 14:00 to 15:00 PST.

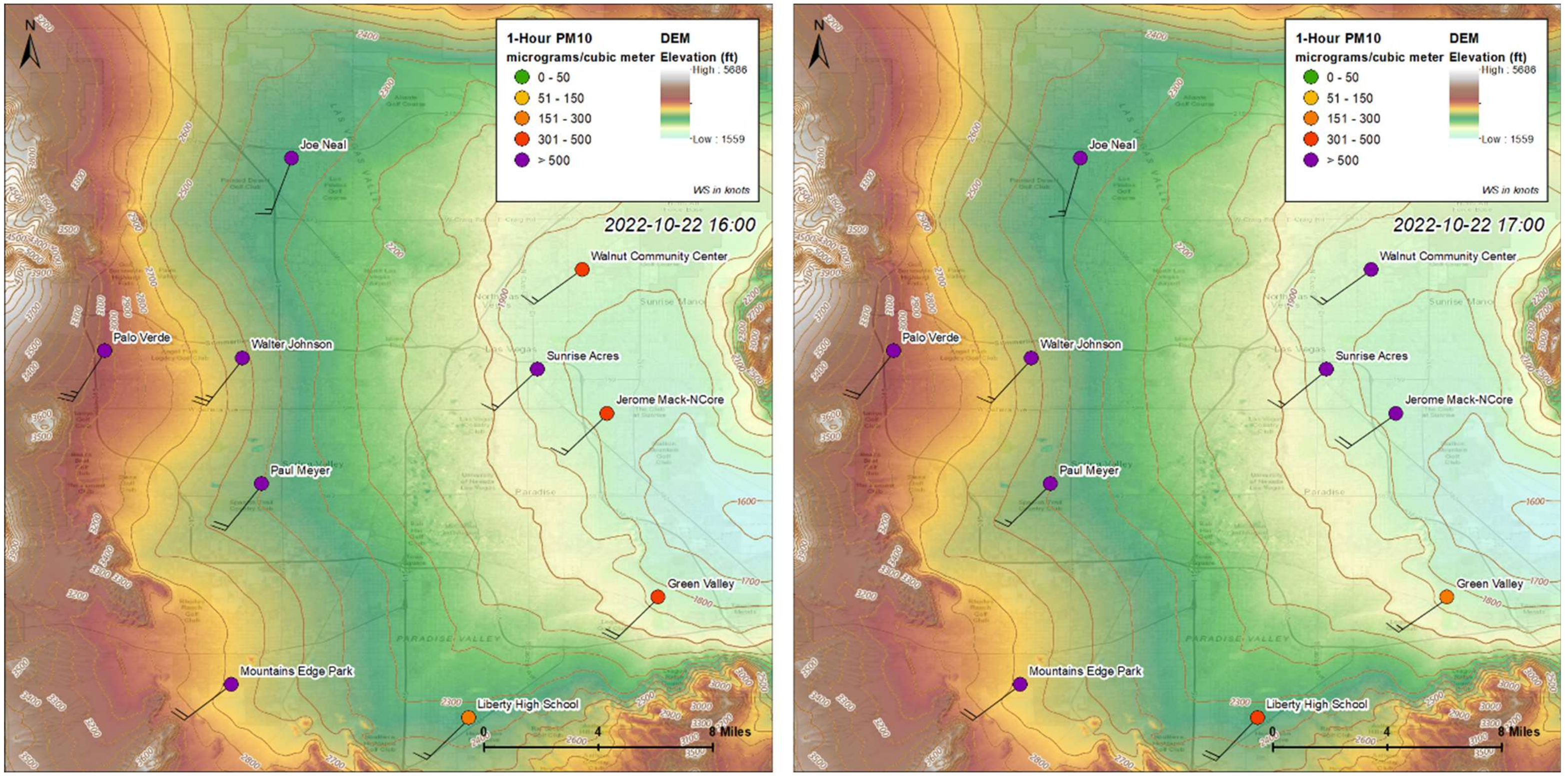


Figure 3.2-11. Surface observations of wind speed, wind direction, and hourly PM_{10} from each measurement site in Clark County, NV, as well as ground elevation for October 22, 2022, from 16:00 to 17:00 PST.

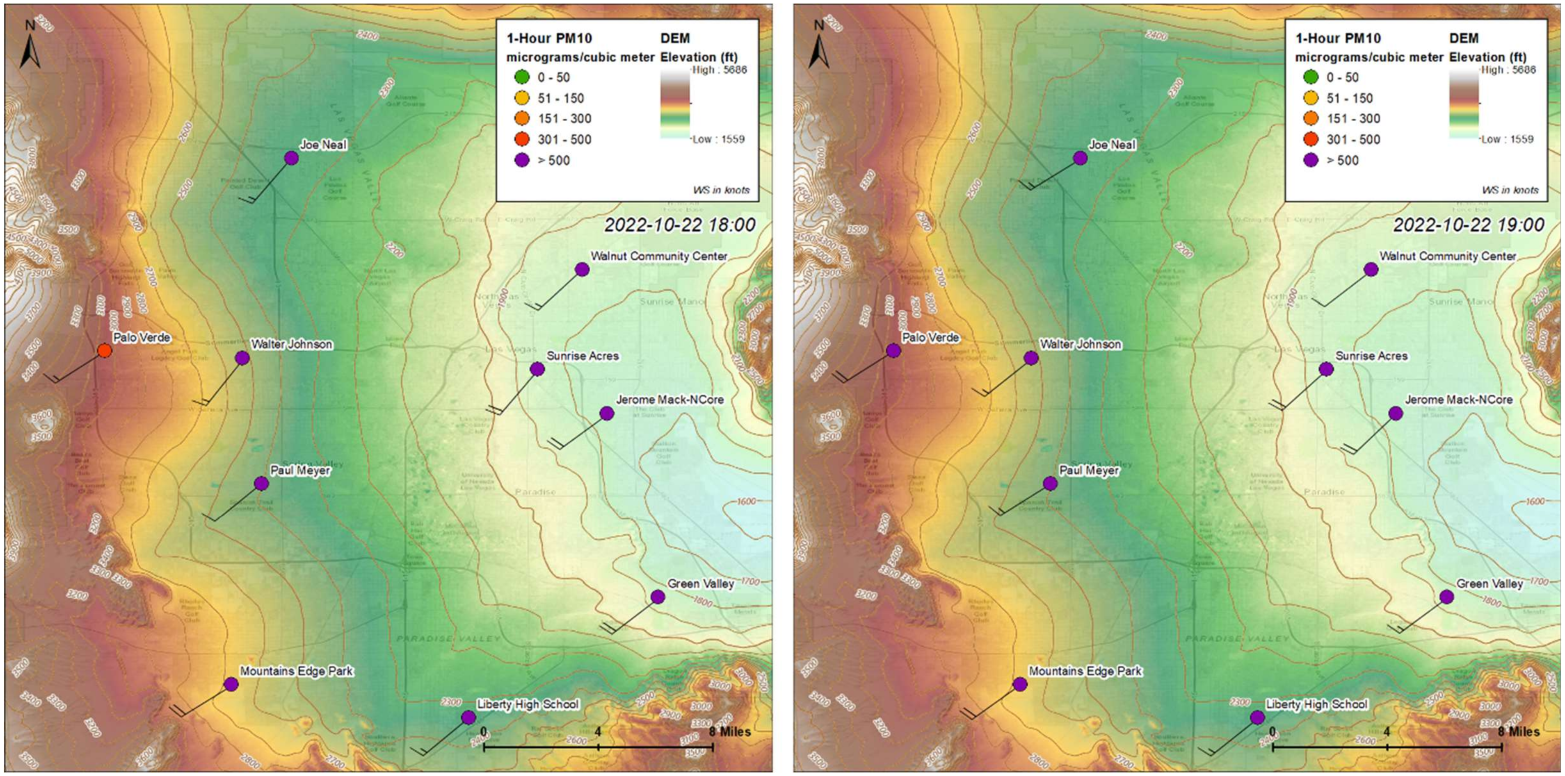


Figure 3.2-12. Surface observations of wind speed, wind direction, and hourly PM_{10} from each measurement site in Clark County, NV, as well as ground elevation for October 22, 2022, from 18:00 to 19:00 PST.

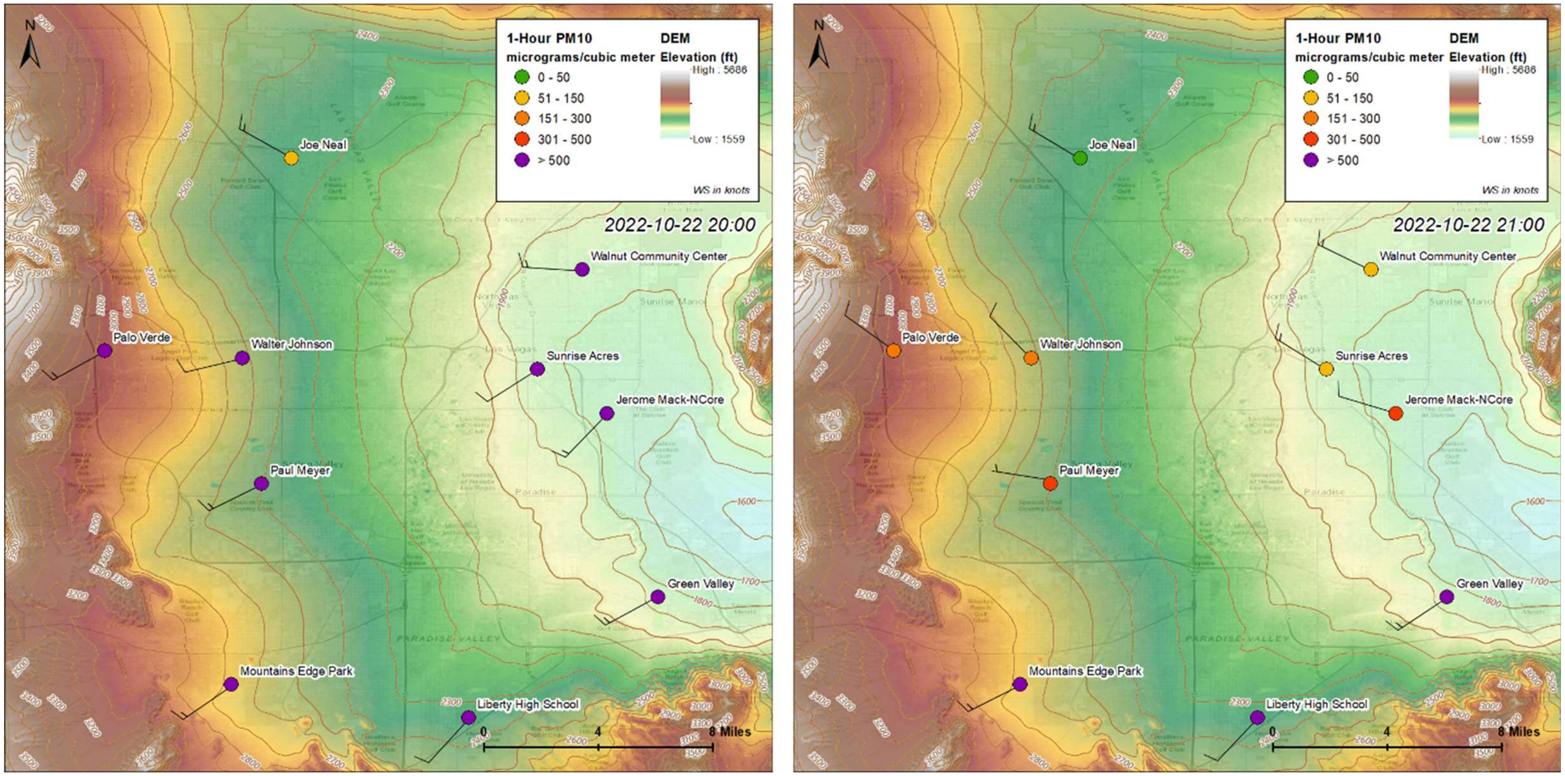


Figure 3.2-13. Surface observations of wind speed, wind direction, and hourly PM_{10} from each measurement site in Clark County, NV, as well as ground elevation for October 22, 2022, from 20:00 to 21:00 PST.

Overall, we found overwhelming evidence that PM_{10} was transported starting in the morning from the Mojave Desert and peaking in the afternoon through evening on October 22, 2022, with a strong frontal passage. Wind speeds in the source region and along the transport path showed sustained speeds above the 25-mph high-wind threshold. PM_{10} concentrations from monitors along the frontal passage also showed the lofted dust from the Mojave Desert in southeastern California. The evidence corroborating this assertion includes (1) HYSPLIT analyses showing transport from the Mojave Desert in southeastern California to Clark County in two to four hours; (2) simultaneous increases in wind speed along the transport path; (3) enhanced PM_{10} evidence from monitoring sites along the transport path; and (4) ground-based observation of PM_{10} and wind speed/direction in Clark County that corroborate the PM_{10} event time of arrival.

3.3 Impacts of Wind-Blown PM_{10} Dust at the Surface

3.3.1 Clark County Alerts

On Thursday, October 20, 2022, Clark County issued a Dust Advisory to all dust control permit holders, contractors, and stationary sources to immediately inspect their sites and employ BACM to control and stabilize soil in advance of the dust event forecast for Saturday, October 22, 2022 (**Figure 3.3-1**). During a Dust Advisory, compliance officers will inspect construction and stationary source sites during the dust event to ensure BACM are being implemented, and violations will receive a Notice of Violation.

Clark County Nevada created a news release on October 20, 2022, indicating an air quality dust advisory that was issued for October 22, 2022 (**Figure 3.3-2**). They advised residents of possible high levels of blowing dust due to high winds. During windy conditions, people with respiratory diseases, older adults, and children may feel better staying indoors since they are at a greater risk. Airborne dust is described as a form of PM pollution that aggravates respiratory diseases. The article includes recommendations such as limiting outdoor exertion when dust is in the air and keeping doors and windows closed to reduce exposure to the dust.

Clark County Department of Environment and Sustainability

Division of Air Quality

DUST ADVISORY

for Saturday, October 22, 2022

Attention Dust Control Permit Holders, Contractors, and Stationary Sources

National Weather Service reports and the weather models used by the Division of Air Quality (DAQ) predict **sustained winds 25 mph**, with **gusts of 40 mph**, beginning Saturday morning and lasting throughout the evening.

DAQ directs all permittees to immediately inspect their site(s) and employ Best Available Control Measures to stabilize all disturbed soils and reduce blowing dust. Permittees with multiple sites should contact each site superintendent to ensure compliance with the Clark County Air Quality Regulations.

BLASTING: This forecast is for wind gusts 40 mph or more. Project operators should not load blasting materials or perform any blasting operations. You are required to monitor National Weather Service reports for wind speeds; if wind gusts above 25 mph are forecast, discontinue charging additional blast holes. Limit the blast to holes charged at the time the wind report is made.

Compliance officers will inspect construction and stationary source sites during this episode to ensure Best Available Control Measures are being implemented. Any observed violation may receive a Notice of Violation.

It is important this Dust Advisory be sent to all supervisors, foremen, and subcontractors working on your construction projects and at PM_{10} stationary sources.

Please direct questions about this Dust Advisory to a DAQ compliance supervisor at (702) 455-5942.

Issued: 10/20/2022

You are receiving this notice because you have asked to be on our mailing list or your e-mail address is listed as the point of contact on an active Dust Control Permit.

Figure 3.3-1. News release to dust control permit holders from Clark County Nevada on Thursday, October 20, 2022, for Saturday, October 22, 2022, indicating dust would be present and issuing an air quality advisory.

News Release

County Commission:
James B. Gibson, Chairman
Justin Jones, Vice Chairman
Marilyn Kirkpatrick
William McCurdy II
Ross Miller
Michael Naft
Tick Segerblom

Yolanda King, County Manager

Office of Public Communications • (702) 455-3546 • FAX (702) 455-3558 • www.ClarkCountyNV.gov

Contact: Kevin J. MacDonald
Public Information Officer

Mobile: (702) 232-0931
E-mail: KevMac@ClarkCountyNV.gov

For Immediate Release **Thursday, Oct. 20, 2022**

Air Quality Dust Advisory Issued for Saturday

The Clark County Department of Environment and Sustainability has issued a dust advisory for **Saturday, Oct. 22,** to advise residents and local construction sites of the possibility of elevated levels of blowing dust due to the forecast of high winds in our area.

Airborne dust is a form of inhalable air pollution called particulate matter or PM, which aggravates respiratory diseases. Under windy conditions people with heart or lung disease, older adults, and children may feel better staying indoors as much as possible because they could be at greater risk from particulates, especially when they are physically active, according to the U.S. Environmental Protection Agency. Consult your physician if you have a medical condition that makes you sensitive to air pollution.

Figure 3.3-2. News release by Clark County Nevada issued on October 20, 2022, for October 22, 2022, indicating possible high levels of dust and issuing an air quality advisory.

3.3.2 Media Coverage

Many news sources including KTNV Las Vegas, Las Vegas Review-Journal, Fox 5, New 3, 8 News Now and The Rolling Stone reported on the windy conditions and dust on October 22, 2022. Screenshots of news articles referenced in this section are included in Appendix A.

KTNV Las Vegas reported that strong southwest winds were coming on the weekend, with gusts increasing from 30 mph to 50 mph by the afternoon. A high wind warning was in effect for Las Vegas from 05:00 PDT Saturday through 05:00 PDT on Sunday. There were concerns of blowing dust, downed tree limbs, and strong crosswinds (https://www.ktnv.com/weather/13-first-alert-weather-forecast-saturday-morning-october-22-2022#:~:text=A%20High%20Wind%20Warning%20is,dust%20and%20downed%20tree%20limbs).

The Las Vegas Review-Journal reported gusty winds reached 65 mph at Red Rock Canyon in the afternoon on October 22, 2022. There were sustained winds between 25 and 35 mph throughout the valley, and arrival delays at the airport. The first day of the When We Were Young music festival in Las Vegas was cancelled. Motorists were advised to use caution when driving, especially when driving a high-profile vehicle (https://www.reviewjournal.com/local/weather/cold-front-rattles-valley-into-evening-airport-delays-top-2-5-hours-2662330/).

Fox 5 reported that the Clark County Department of Environment and Sustainability issued a dust advisory for the Las Vegas Valley on October 22, 2022, due to high levels of blowing dust from high winds. They advise that there would be unhealthy levels of dust for sensitive groups of people. It was recommended that people with heart or lung disease, older adults, and children might feel better if they stayed indoors as much as possible (https://www.fox5vegas.com/2022/10/21/clark-county-issues-air-quality-dust-advisory-las-vegas-valley-saturday/).

News 3 reported that an air quality warning was issued to prepare for the high winds in the valley over the weekend. The Clark County Department of Environment and Sustainability issued the warning for October 22, 2022, and noted it could be extended if the high winds continued. Recommendations to limit exposure to dust, including limiting outdoor exertion and keeping windows and doors closed, were included in the article (https://news3lv.com/news/local/dust-advisory-issued-for-clark-county-as-high-wind-warnings-begin-saturday).

8 News Now reported that the strong storm was making it difficult for vehicles to stay in their lanes. There were trees down and debris on the streets and sidewalks. The National Weather Service issued a high wind warning for the valley from 11:00 PDT on October 22, 2022, to 05:00 PDT on October 23, 2022, and it expanded to California in the early afternoon. A high wind warning graphic from the National Weather Service is shown in Figure 3.3-3. The highest recorded wind speed in Clark County on October 22, 2022, was 82 mph at Angel Peak (https://www.8newsnow.com/news/local-news/viewers-share-video-photos-as-las-vegas-valley-finds-itself-twisting-in-the-wind/).

8 News Now reported that the National Weather Service issued a high wind warning, and that wind gusts from the south-southeast were approximately 40-60 mph and higher in the Red Rock Canyon and Spring Mountains. The weather service stated that winds could be dangerous and blow down trees and power lines leading to widespread power outages. They also warned drivers to be prepared for difficult conditions (https://www.8newsnow.com/news/local-news/high-wind-warning-issued-for-las-vegas-saturday/).

The Rolling Stone reported that the Las Vegas When We Were Young Fest cancelled the opening day due to a high wind warning. The National Weather Service upgraded the forecast for October 22, 2022, to a High Wind Warning with dangerous 30-40 mph winds and 60 mph gusts. With advisement from the National Weather Service and Las Vegas Metropolitan Police Department, they had no option but to cancel the festival (https://www.rollingstone.com/music/music-news/when-we-were-young-fest-cancels-opening-day-high-wind-warning-las-vegas-1234616495/).

Fox 5 reported that wind gusts were over 50 mph when the wind picked up late in the morning and throughout the day on October 22, 2022. (https://www.fox5vegas.com/2022/10/23/forecast-outlook-102222/).

3 News reported that the When Were Young Fest was cancelled on October 22, 2022, due to winds. The National Weather Service upgraded the forecast for October 22, 2022, to a High Wind Warning with dangerous 30-40 mph winds (https://news3lv.com/news/local/when-we-were-young-fest-canceled-saturday-due-to-high-winds).

Figure 3.3-3. High wind warning graphic issued by the National Weather Service on October 22, 2022.

Table 3.3-1 includes all urgent weather messages (include wind advisories) and dust storm warnings for Clark County, the Mojave source region, and surrounding counties also affected by the dust event. Text associated with each of these warnings and messages is included in Appendix A.

Table 3.3-1. National Weather Service Las Vegas, NV, warnings issues on October 22, 2022.

Warning	Time (PDT)	Location
Dust Storm Warning	15:48	Southeastern Clark County in southern Nevada
Dust Storm Warning	16:24	Southeastern Clark County
Dust Storm Warning	16:44	Southeastern Clark County
Urgent Weather Message	04:25	Owens Valley, Esmeralda and Central Nye County-Lincoln County, Eastern Sierra Slopes, Spring Mountains-Red Rock Canyon-Las Vegas Valley, Western Mojave Desert, Northwest Plateau-Northwest Deserts- Lake Mead National Recreation Area-Death Valley National Park- Eastern Mojave Desert-Morongo Basin-Northeast Clark County- Western Clark and Southern Nye County-Sheep Range- Southern Clark County, White Mountains of Inyo County
Urgent Weather Message	10:55	Eastern Mojave Desert-Southern Clark County, Owens Valley, Esmeralda and Central Nye County-Lincoln County, Eastern Sierra Slopes, Spring Mountains-Red Rock Canyon-Las Vegas Valley, Western Mojave Desert, Northwest Plateau-Northwest Deserts- Lake Mead National Recreation Area-Death Valley National Park- Morongo Basin-Northeast Clark County-Western Clark and Southern Nye County-Sheep Range, White Mountains of Inyo County
Urgent Weather Message	13:01	Northwest Plateau, Owens Valley, Esmeralda and Central Nye County-Lincoln County, Eastern Sierra Slopes, Eastern Mojave Desert-Spring Mountains-Red Rock Canyon- Las Vegas Valley-Southern Clark County, Western Mojave Desert, Northwest Deserts-Lake Mead National Recreation Area-Death Valley National Park-Morongo Basin-Northeast Clark County- Western Clark and Southern Nye County-Sheep Range, White Mountains of Inyo County

3.3.3 Pollutant and Diurnal Analysis

As discussed in Section 3.2, PM_{10} concentrations in the Las Vegas Valley start to increase at around 05:00 PST on October 22, 2022, which coincides with the approach of a frontal system. Figure 3.3-4 show hourly PM_{10} concentrations at monitoring sites throughout Clark County. By 12:00 PST, most monitoring sites show a rapid increase in PM_{10} concentration with multiple sites exceeding an hourly concentration of 1,000 $\mu g/m^3$ between 14:00 and 20:00 PST. A peak hourly concentration of 1,451 $\mu g/m^3$ is measured at Liberty High School. Enhanced PM_{10} concentrations persist through 23:00 PST on October 22 at several sites. The concurrent rise in PM_{10} at a majority of monitoring sites in the Las Vegas Valley is indicative of a regional dust event.

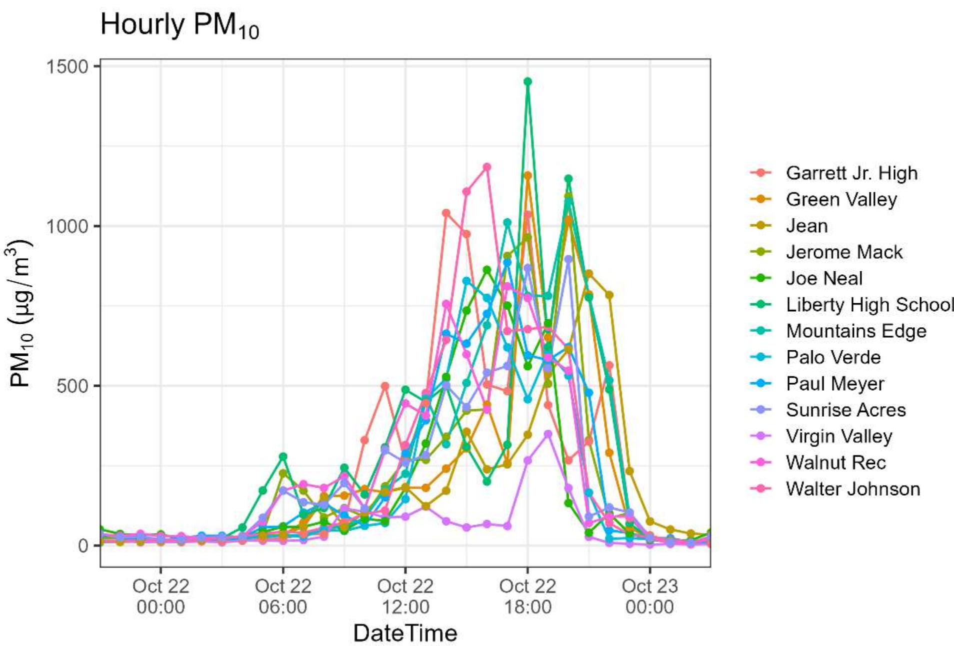


Figure 3.3-4. Hourly PM_{10} observations from all Clark County measurement sites on the event date, including the regulatorily significant sites: Paul Meyer, Mountains Edge, Walter Johnson, Palo Verde, Joe Neal, Green Valley, Liberty High School, Jerome Mack, Sunrise Acres, and Walnut Community Center.

Figure 3.3-5 shows the measured hourly PM_{10} concentrations on October 22, 2022, together with the diurnal profile of the historical hourly data from 2018-2022. Measurements above the 5-year 95th percentile are shown in red. Measurements began surpassing the 95th percentile near 06:00 PST and reached peaks near 1,200 µg/m^3 leading up to 20:00 PST. Values returned to within the 95th percentile near midnight.

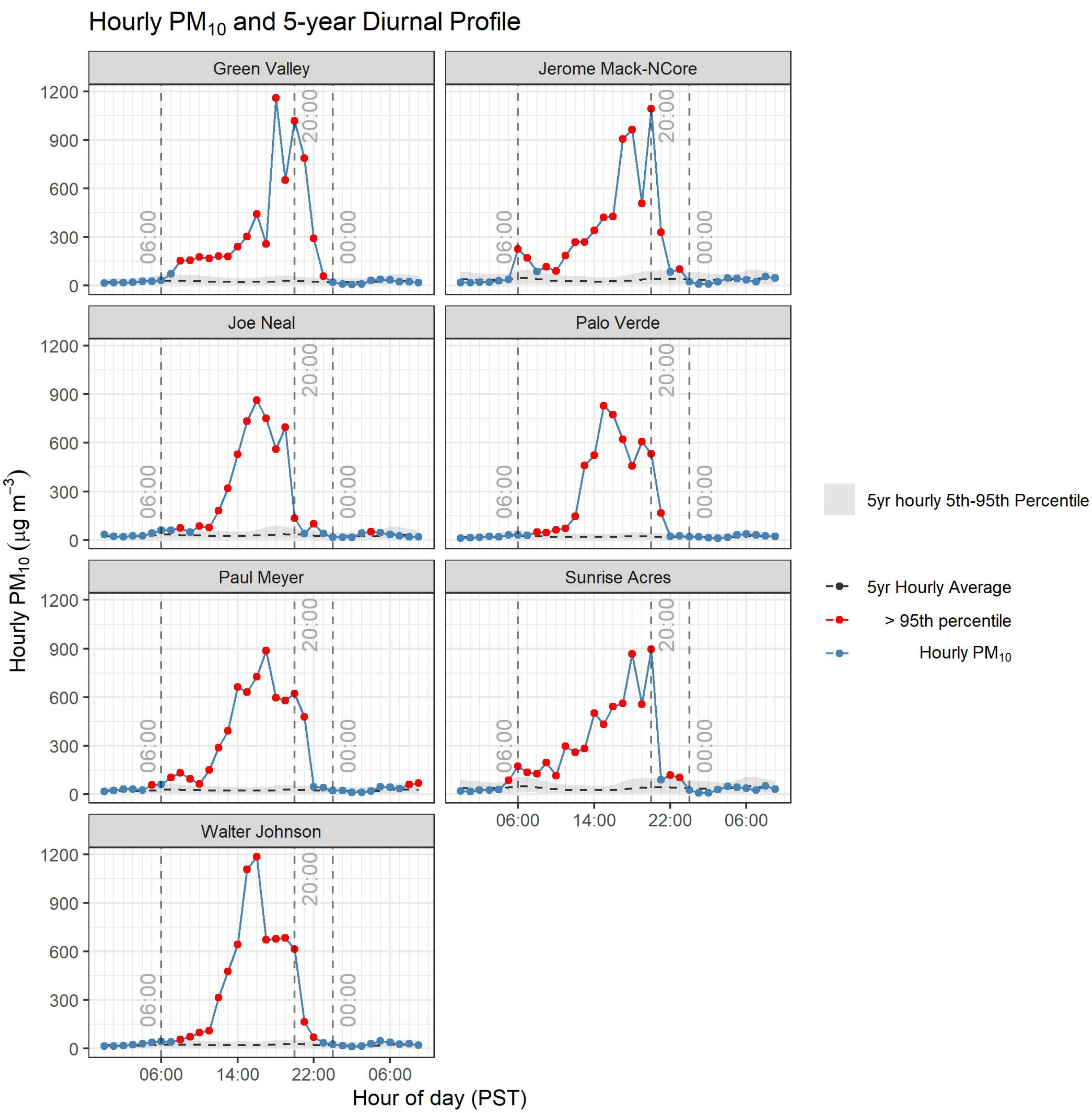


Figure 3.3-5. Measured hourly PM_{10} values on October 22, 2022, compared to 5-year diurnal pattern. The dotted solid line represents the hourly PM_{10} values measured on the event day. The dashed line represents the mean hourly PM_{10} for each hour of the day from 2018-2022 at each site and the shaded area indicates the 5th - 95th percentile.

The 24-hour average PM_{10} values at all sites in Clark County before and after the exceedance event on October 22, 2022, remained below the 99th percentile of the 5-year (2018-2022) historical values (Figure 3.3-6). On October 21, 2022, the 24-hour average PM_{10} values at all sites were below 50 µg/m^3. On October 22, 2022, the day of the exceedance, the 24-hour average PM_{10} values at all sites in the Las Vegas Valley exceeded the 99th percentile and the NAAQS value of 150 µg/m^3. The simultaneous increase in PM_{10} concentrations at all sites, with all but one exceeding the 99th percentile threshold, provides further evidence of a regional wind-blown dust event.

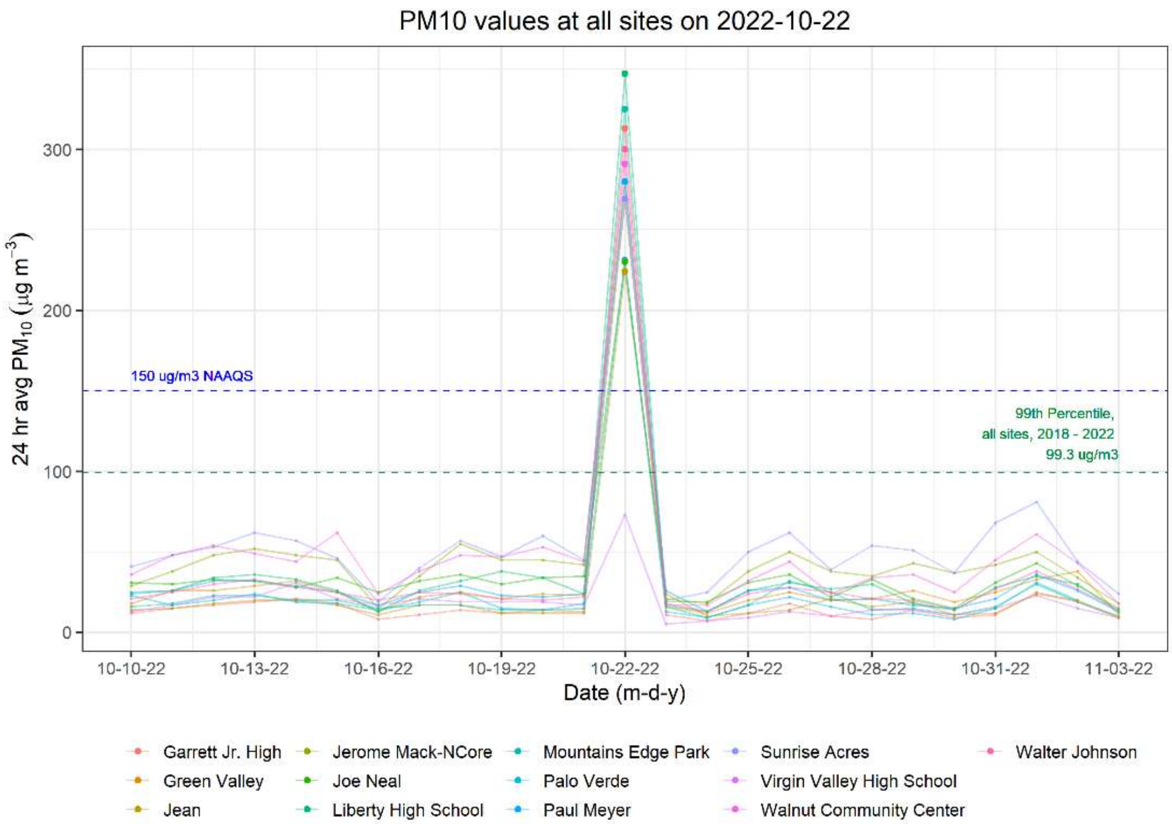


Figure 3.3-6. PM_{10} values at all Clark County, NV measurement sites from October 10, 2022, to November 3, 2022, with NAAQS (blue dash) indicated. The green dashed line indicates the 99th percentile of 99.3 µg/m^3 of the 5-year historical values at these sites. Virgin Valley High School is located in Mesquite, NV (not in the Las Vegas Valley) near the northeast border of Clark County.

3.3.4 Particulate Matter Analysis

Before the high-wind dust event on October 22, 2022, the hourly $PM_{2.5}$ to PM_{10} ratio is slightly below average at all sites except Jean based on the 2018 – 2022 ratio data (**Figure 3.3-7**). Late in the morning on October 22, the hourly $PM_{2.5}/PM_{10}$ ratio at all sites dropped below the 5th percentile and stayed below the 5th percentile for the rest of the day. The low value of less than 0.1 is consistent with values from dust events reported in studies (Jiang et al., 2018). The decrease in the $PM_{2.5}/PM_{10}$ ratio observed during midday is also consistent with the increase in hourly PM_{10} concentrations as described in **Section 3.2.2**. $PM_{2.5}/PM_{10}$ ratios rise early in the morning on October 23, then continue to rise to less than normal levels throughout the day following the high-wind dust event.

No chemical speciation data are available on October 22, 2022 since speciated $PM_{2.5}$ measurements are collected on a three-day cadence in Clark County. Measurements were not taken on the event date, and the observations from surrounding days, October 20 and October 23, do not reflect conditions on October 22.

Figure 3.3-7. Ratio of $PM_{2.5}/PM_{10}$ concentrations at the Green Valley, Jean, Jerome Mack, Paul Meyer, and Sunrise Acres sites before, during, and after the October 22, 2022, PM_{10} exceedance. The 5-year average $PM_{2.5}/PM_{10}$ diurnal ratio is displayed as a dotted line, and the 5th to 95th percentile range is shown as a shaded ribbon. The average and 5th to 95th percentile ratio is calculated across September – November of 2018 – 2022.

3.3.5 Visibility/Ground-Based Images

Visibility data is available from airport monitoring sites through the NWS Weather and Hazards Data Viewer. Figure 3.3-8 shows visibility observations on October 22, 2022, at Harry Reid International Airport (LAS) in Las Vegas. Concurrent with the increasing wind speeds, visibility decreases between 09:00-11:00 PST, and remains below the 10-mile maximum measurement through 23:00 PST. This is confirmed by camera images in the Las Vegas Valley (Figure 3.3-9 through Figure 3.3-15), which show intensification of dusty conditions and low visibility between 09:00 and 15:00 PST on October 22, 2022.

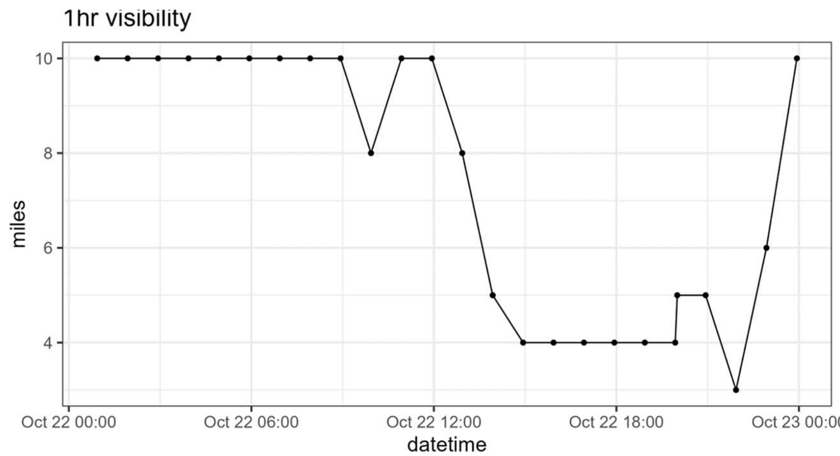


Figure 3.3-8. Visibility in miles on October 22, 2022, recorded as Harry Reid International Airport. Visibility data is from the Iowa Environmental Mesonet (https://mesonet.agron.iastate.edu/).

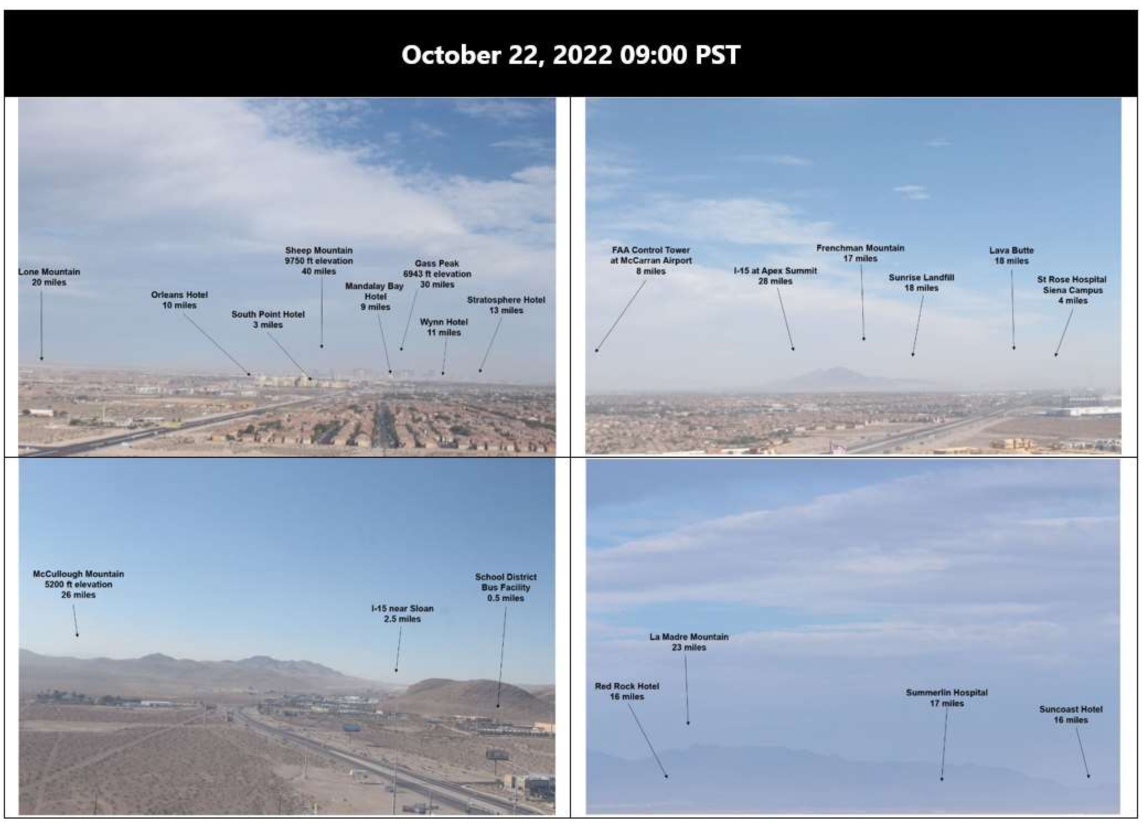


Figure 3.3-9. Camera images for north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on October 22, 2022, at 09:00 PST.

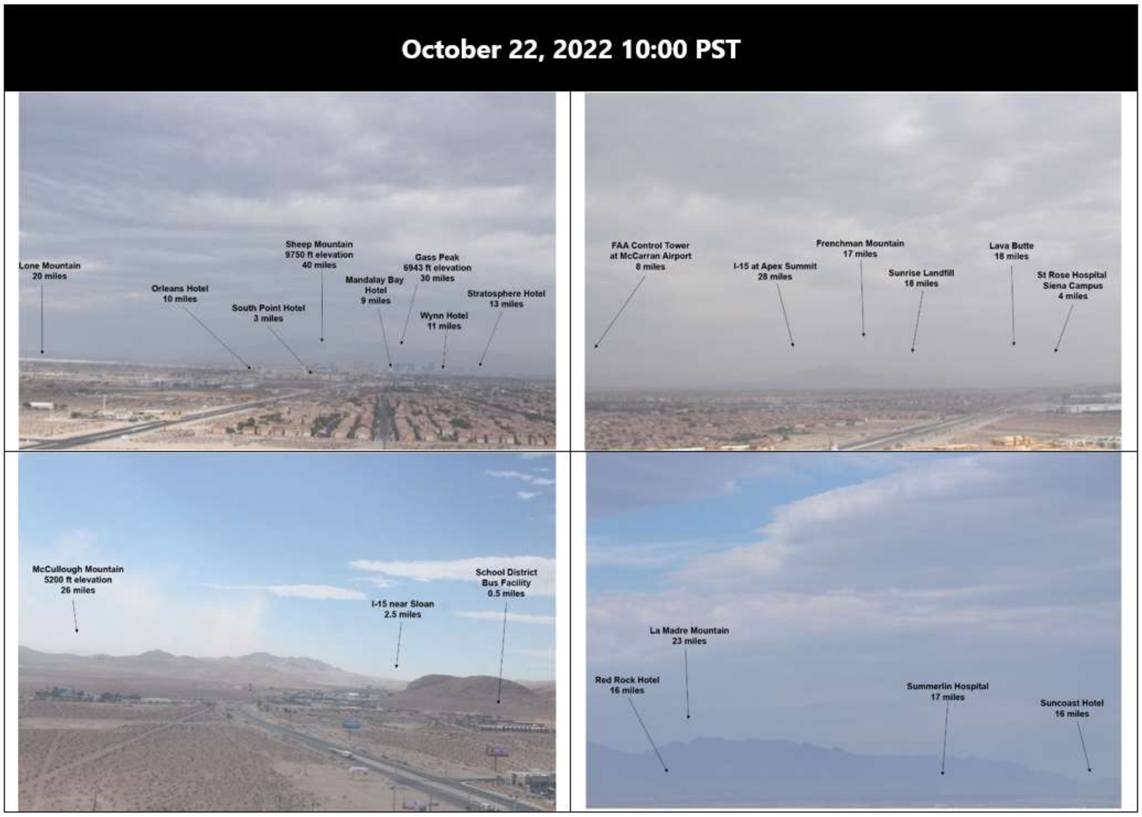


Figure 3.3-10. Camera images for north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on October 22, 2022, at 10:00 PST.

Figure 3.3-11. Camera images for north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on October 22, 2022, at 11:00 PST.

Figure 3.3-12. Camera images for north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on October 22, 2022, at 12:00 PST.

Figure 3.3-13. Camera images for north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on October 22, 2022, at 13:00 PST.

Figure 3.3-14. Camera images for north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on October 22, 2022, at 14:00 PST.

Figure 3.3-15. Camera images for north (top left), south (bottom left), northeast (top right), and northwest (bottom right) coordinal directions from Clark County, Nevada, on October 22, 2022, at 15:00 PST.

Overall, we find overwhelming evidence that PM_{10} was transported from the Mojave Desert in southeastern California to Clark County with large enhancements in PM_{10} from 12:00 PST through the end of the day on October 22, 2022. PM_{10} concentrations increased along with the frontal passage and peaked between 14:00-20:00 PST on October 22. This suggests that Clark County was impacted by a regional high-wind dust event originating in the Mojave Desert. The evidence corroborating this assertion includes (1) forecast alerts and media coverage in Clark County and the surrounding areas, (2) an abrupt, concurrent increase at all PM_{10} monitoring sites in Clark County, (3) a drop in $PM_{2.5}/PM_{10}$ values indicating windblown dust sources, (4) decreased visibility at the Las Vegas airport corresponding with the PM_{10} event arrival, and (5) extremely dusty ground-based images from the M Resort Hotel in Las Vegas on October 22, 2022. All pieces of evidence suggest a significant impact of windblown dust at the surface in Clark County on the event date.

3.4 Comparison of Exceptional Event with Historical Data

3.4.1 Percentile Ranking

The 24-hour average PM_{10} concentration observed on October 22, 2022, ranked above the 99.6 percentile of all concentrations observed in the 5-year period from 2018-2022 at all sites (Table 3.4-1).

Table 3.4-1. Five-year (2018-2022) PM_{10} value rank and percentile on October 22, 2022, at affected sites. Sites where data collection began less than five years ago are indicated with an asterisk (*).

Date	Site	Rank	Percentile	24-hour PM_{10} ($\mu g/m^3$)
10/22/2022	Garrett Jr. High*	2	99.84	313
10/22/2022	Green Valley	3	99.89	269
10/22/2022	Jean	2	99.94	224
10/22/2022	Jerome Mack	5	99.78	280
10/22/2022	Joe Neal	4	99.83	230
10/22/2022	Liberty High School*	2	99.84	347
10/22/2022	Mountains Edge Park*	1	100	325
10/22/2022	Palo Verde	2	99.94	231
10/22/2022	Paul Meyer	2	99.94	280
10/22/2022	Sunrise Acres	4	99.83	269
10/22/2022	Walnut Community Center*	3	99.65	291
10/22/2022	Walter Johnson	3	99.89	300

An annual time series of 24-hour average PM_{10} concentrations for each affected site is provided in Figure 3.4-1 through Figure 3.4-12. October 22, 2022, is marked by a red point for comparison to the 150 $\mu g/m^3$ NAAQS threshold (blue line) and the 5-year (2018-2022) 99th percentile (green line) described in Table 2.2-1. At all sites, observations on October 22, 2022, were above the 5-year 99th percentile.

A 5-year time series of 24-hour average PM_{10} concentrations for each affected site is provided in Figure 3.4-13 through Figure 3.4-24 to compare the event day to a range of normal values. Other exceedances of the 150 $\mu g/m^3$ NAAQS threshold (blue dashed line) were further investigated for potential dust event evidence based on meteorological data and visibility camera images to compare to October 22, 2022. Days that showed preliminary evidence of being a high-wind dust event or for which other exceptional event narratives have been prepared are also marked in the annual and 5-year time series figures at all sites.

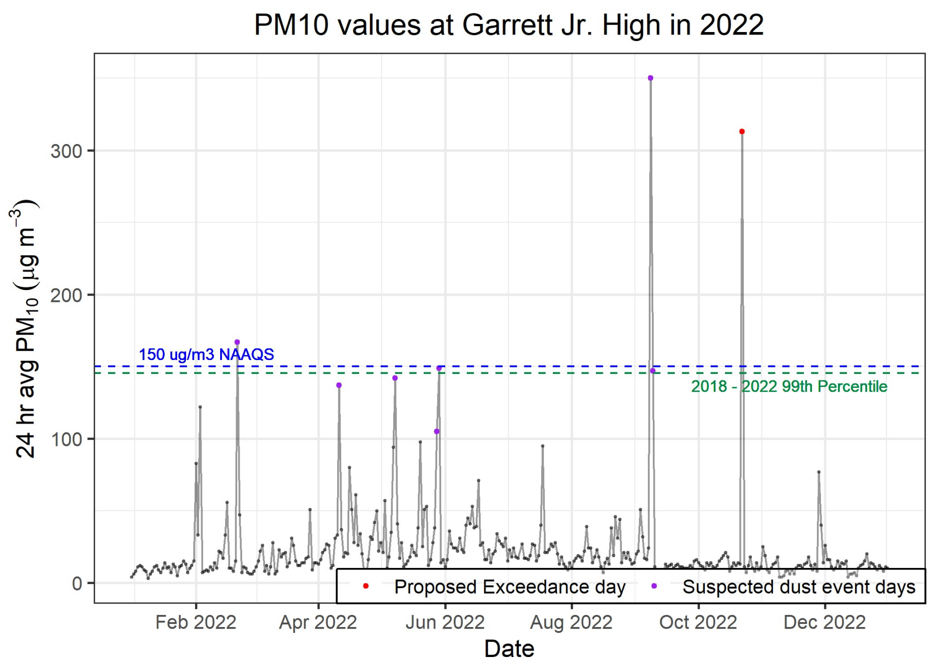


Figure 3.4-1. Garrett Jr. High 24-hour PM_{10} measurement in µg/m^3 for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

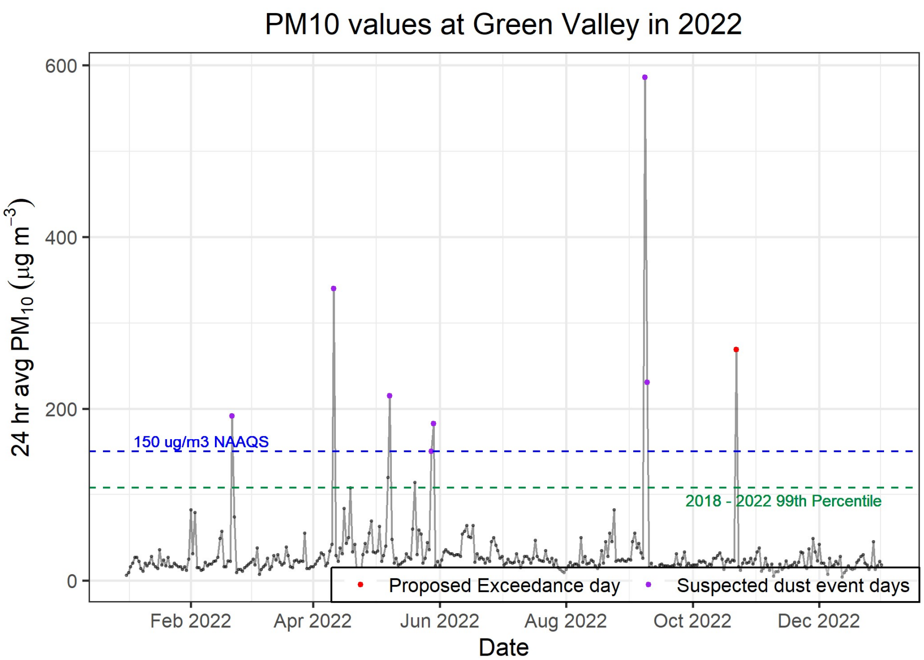


Figure 3.4-2. Green Valley 24-hour PM_{10} measurement in μg/m^3 for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

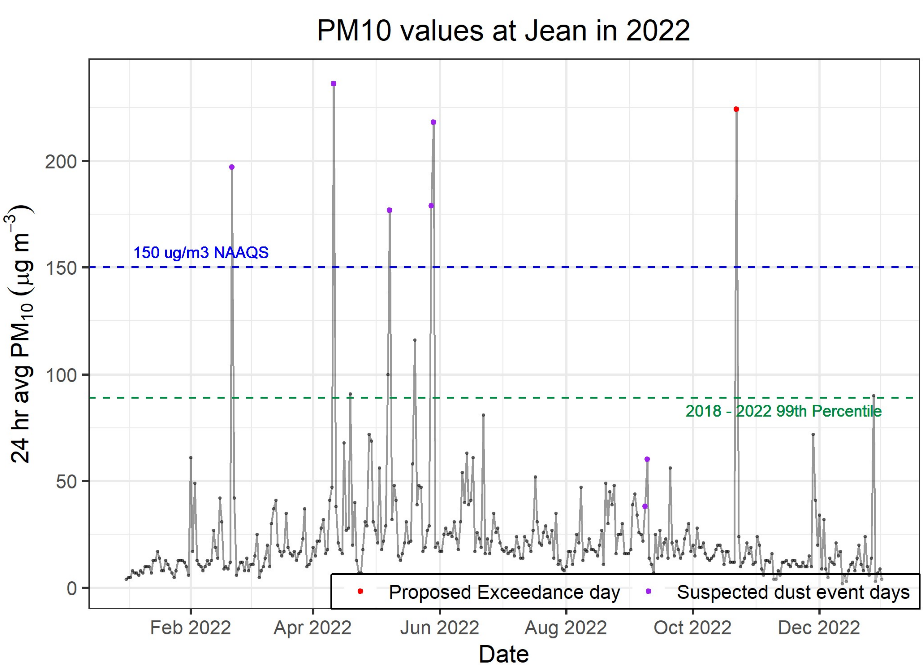


Figure 3.4-3. Jean 24-hour PM_{10} measurement in μg/m^3 for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

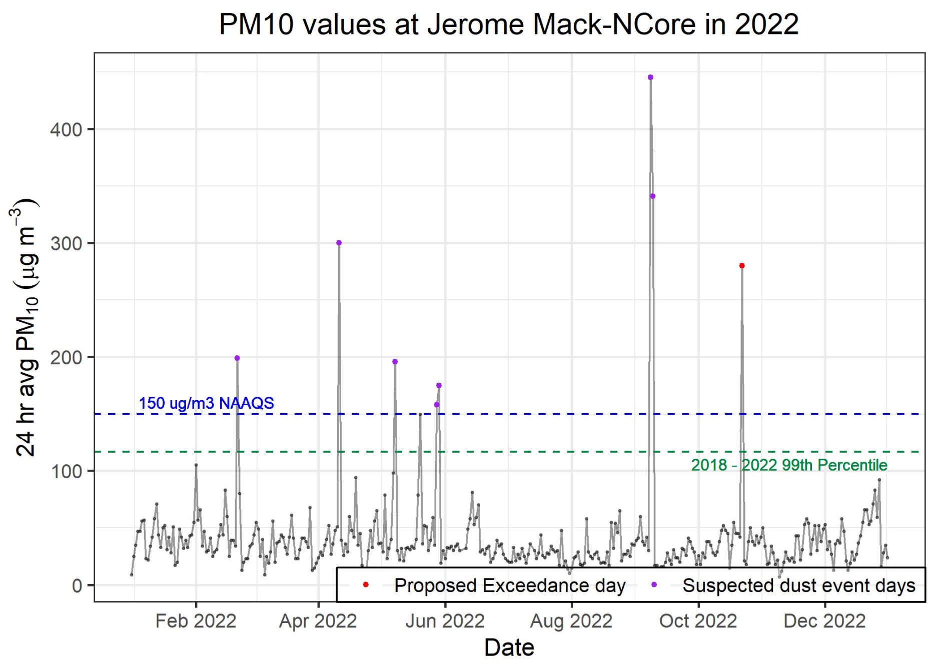


Figure 3.4-4. Jerome Mack 24-hour PM_{10} measurement in μg/m^3 for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

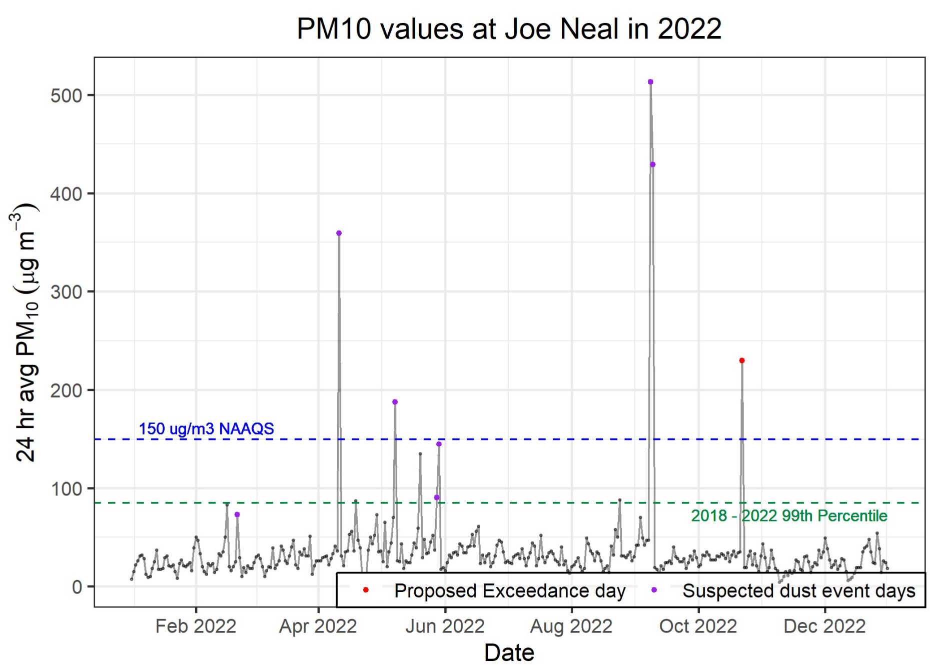


Figure 3.4-5. Joe Neal 24-hour PM_{10} measurement in μg/m^3 for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

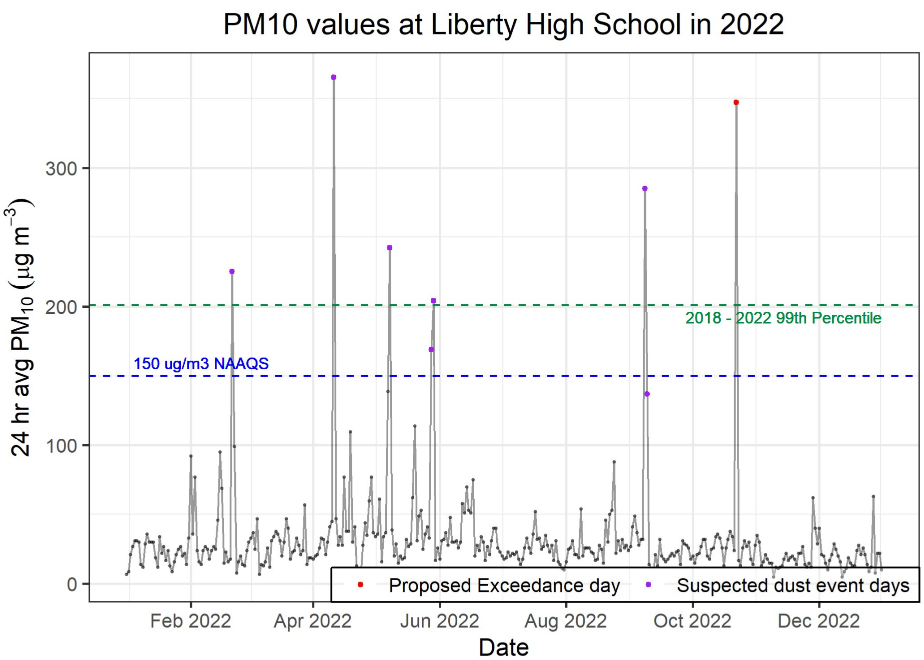


Figure 3.4-6. Liberty High School 24-hour PM_{10} measurement in µg/m³ for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

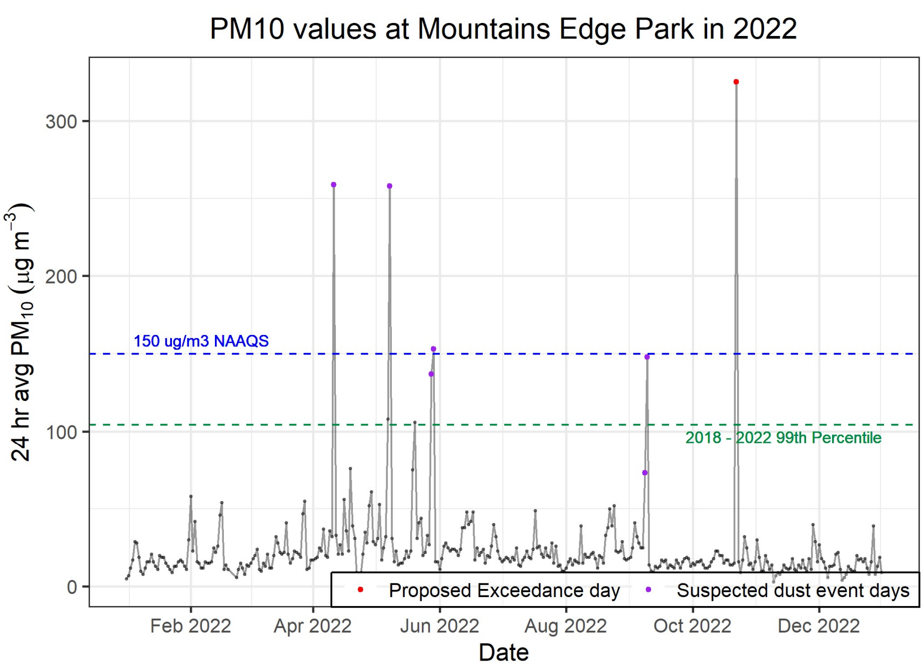


Figure 3.4-7. Mountains Edge Park 24-hour PM_{10} measurement in µg/m³ for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

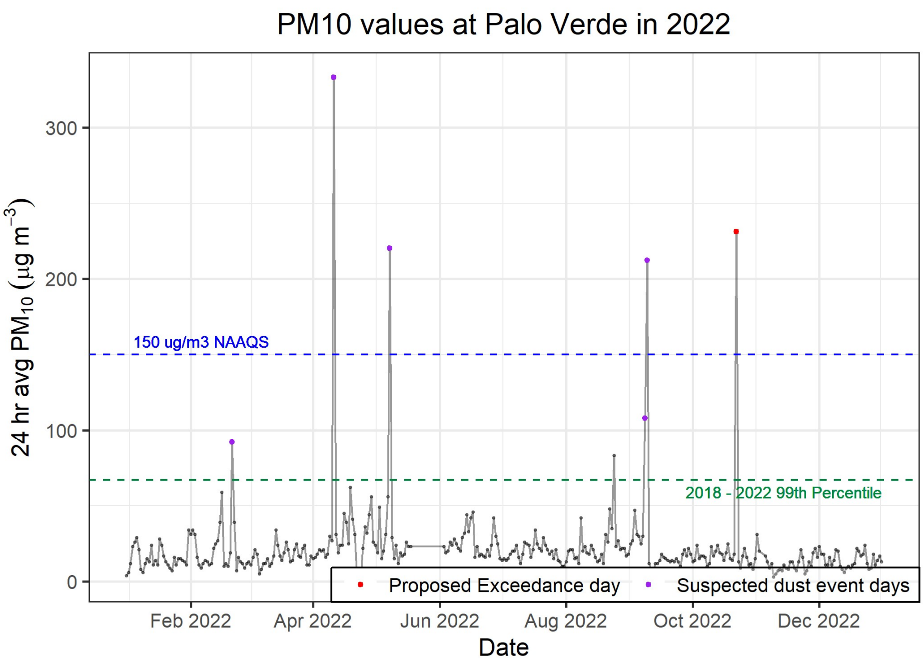


Figure 3.4-8. Palo Verde 24-hour PM_{10} measurement in µg/m^3 for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

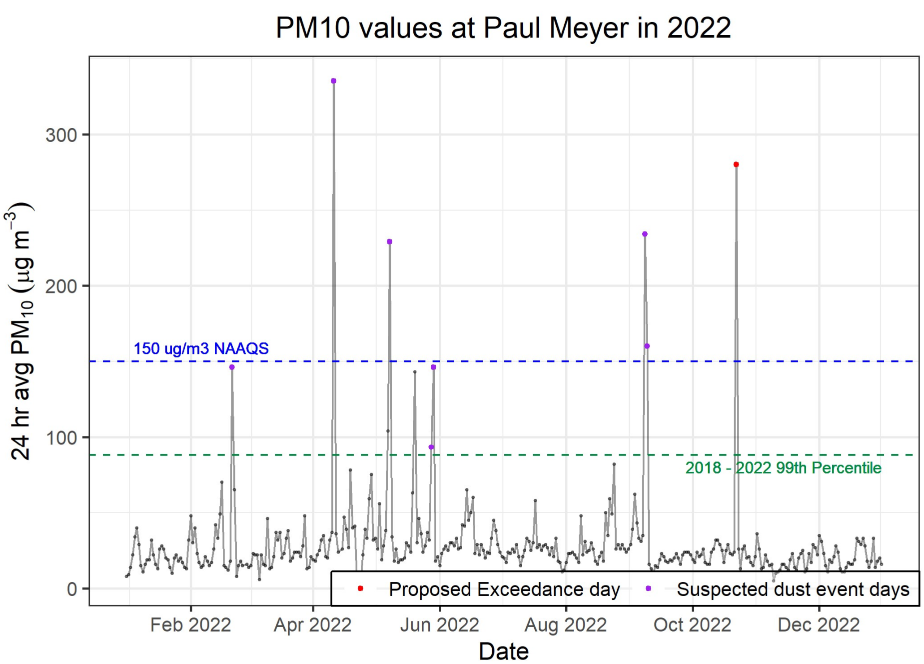


Figure 3.4-9. Paul Meyer 24-hour PM_{10} measurement in µg/m^3 for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

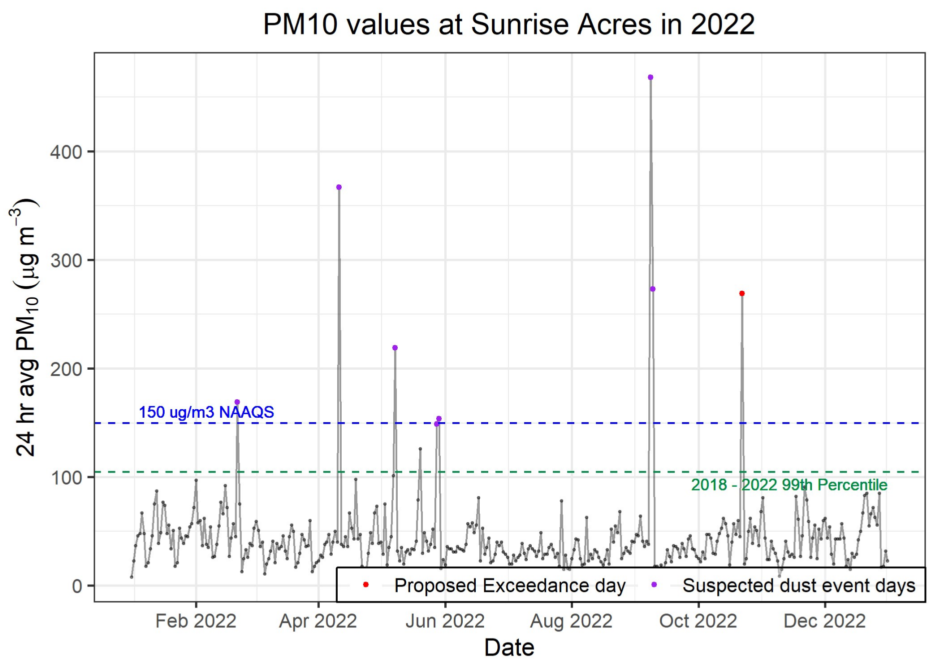


Figure 3.4-10. Sunrise Acres 24-hour PM_{10} measurement in µg/m^3 for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

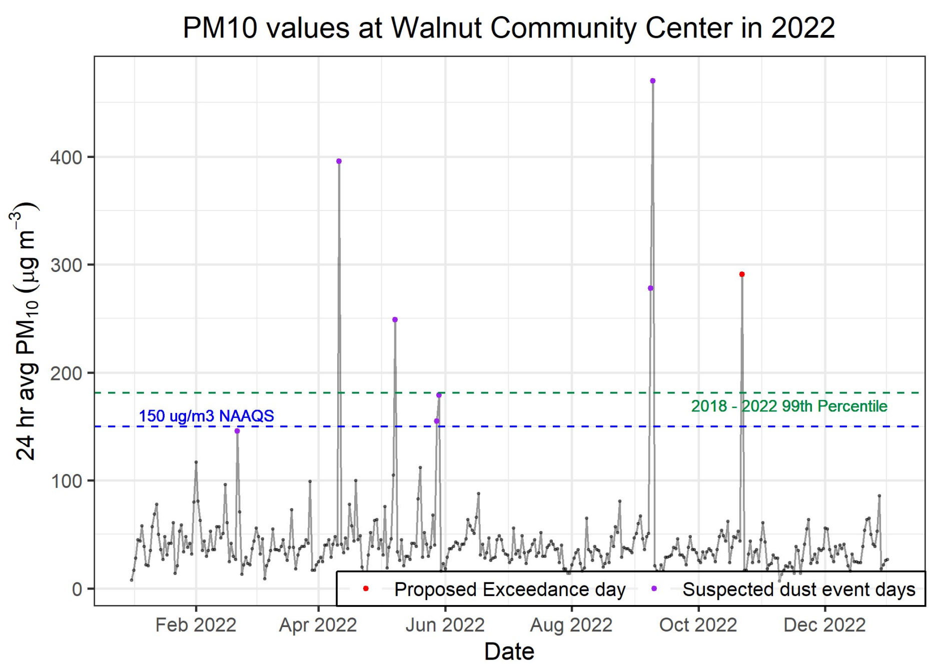


Figure 3.4-11. Walnut Community Center 24-hour PM_{10} measurement in µg/m^3 for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

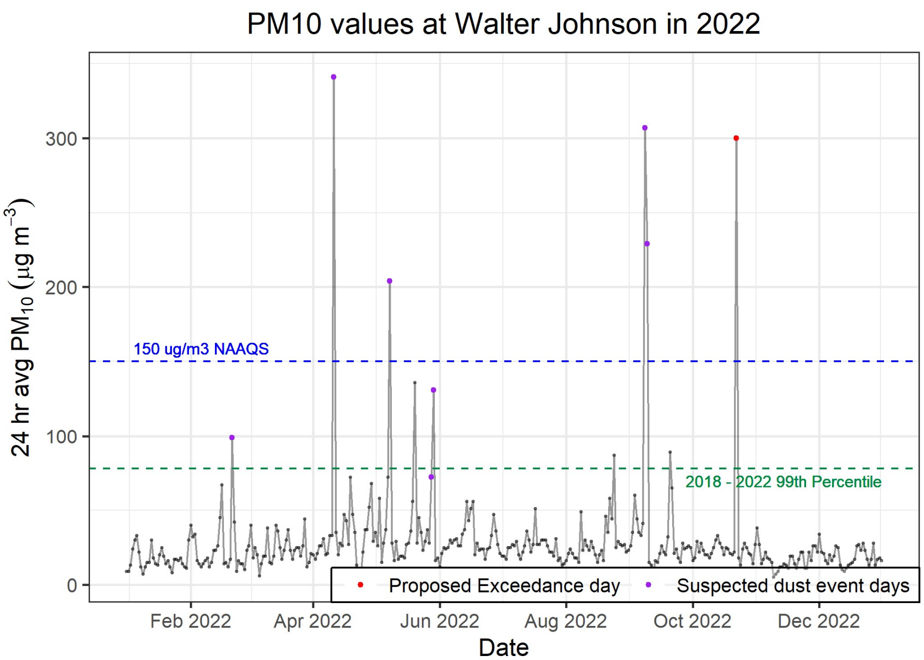


Figure 3.4-12. Walter Johnson 24-hour PM_{10} measurement in μg/m^3 for 2022 with (green dash) 2018-2022 99th percentile, (blue dash) NAAQS, (purple points) suspected dust event days, and (red point) proposed exceedance day indicated.

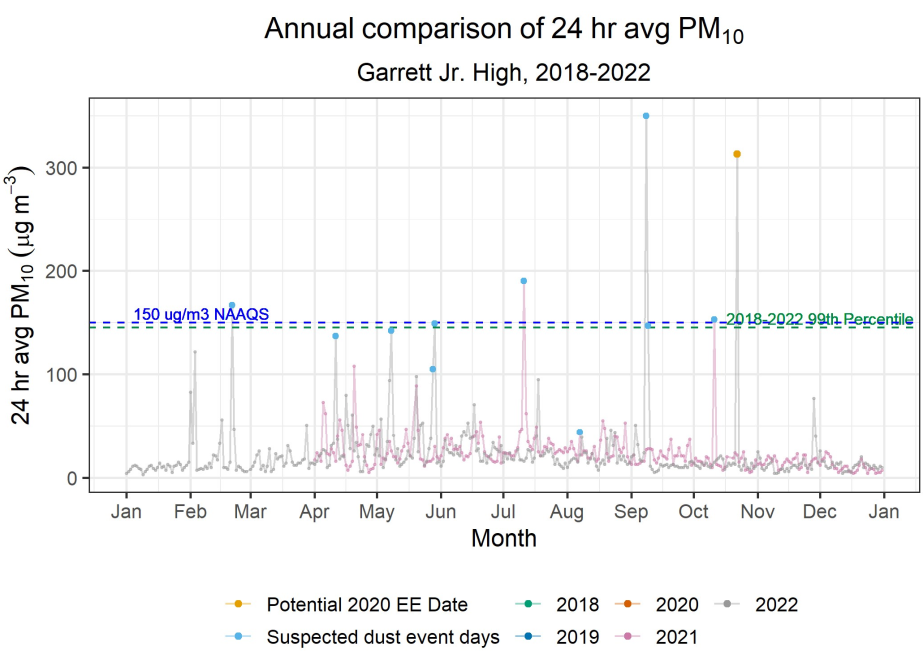


Figure 3.4-13. Garrett Jr. High 24-hour PM_{10} measurements in μg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

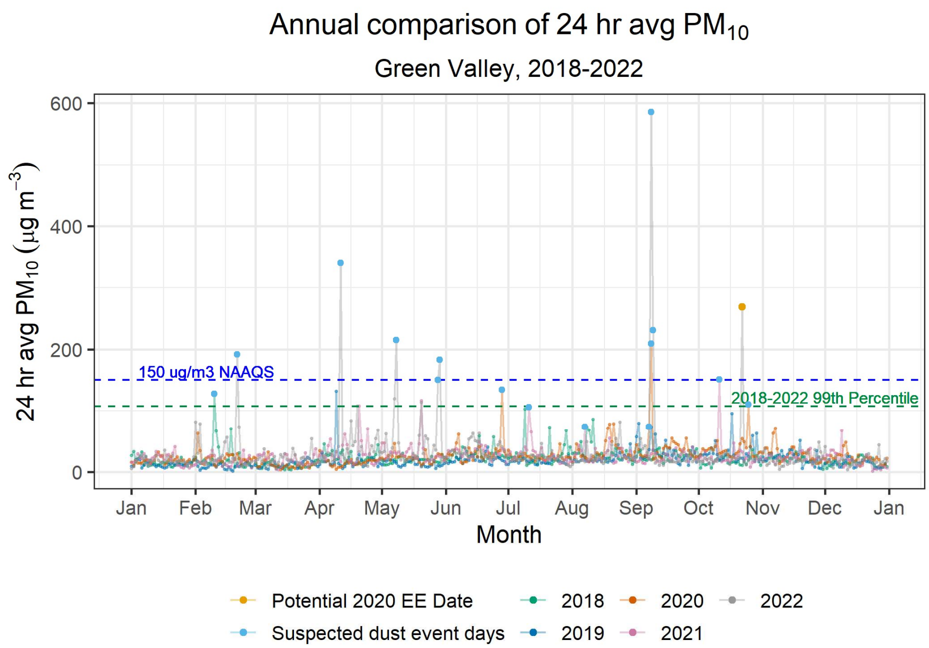


Figure 3.4-14. Green Valley 24-hour PM_{10} measurements in µg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

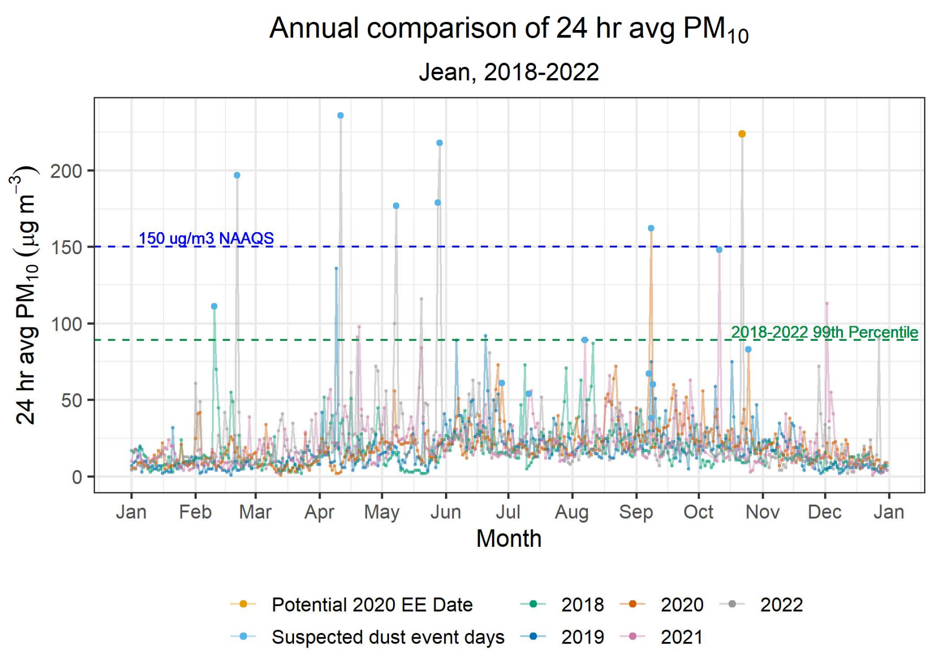


Figure 3.4-15. Jean 24-hour PM_{10} measurements in µg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

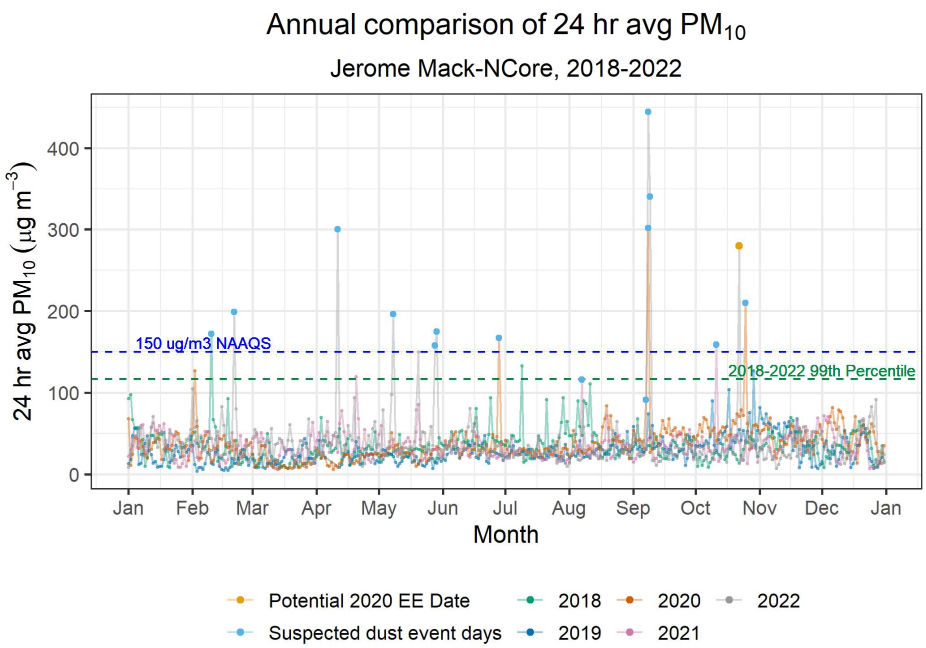


Figure 3.4-16. Jerome Mack 24-hour PM_{10} measurements in µg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

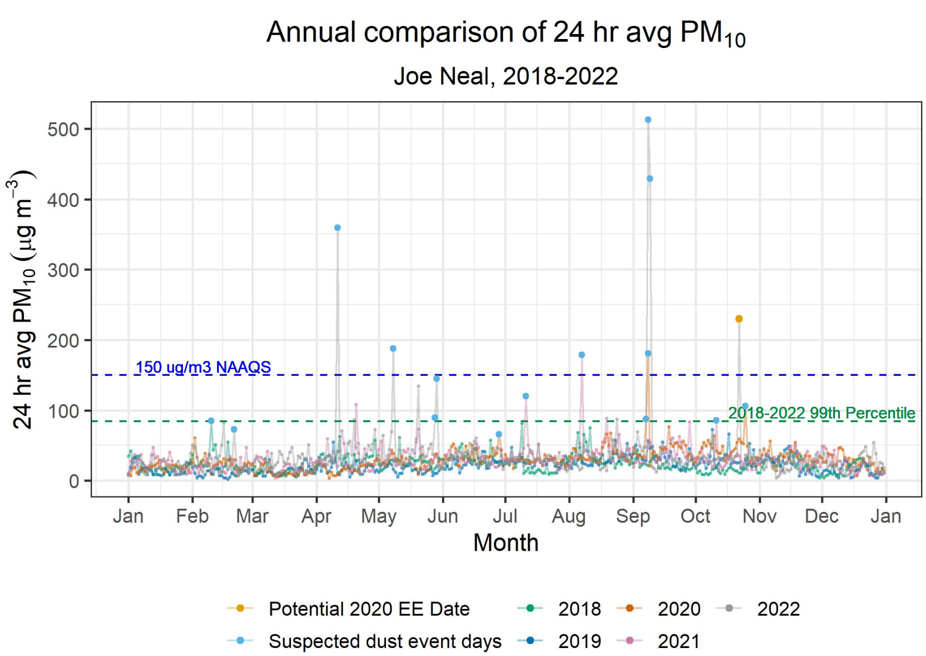


Figure 3.4-17. Joe Neal 24-hour PM_{10} measurements in µg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

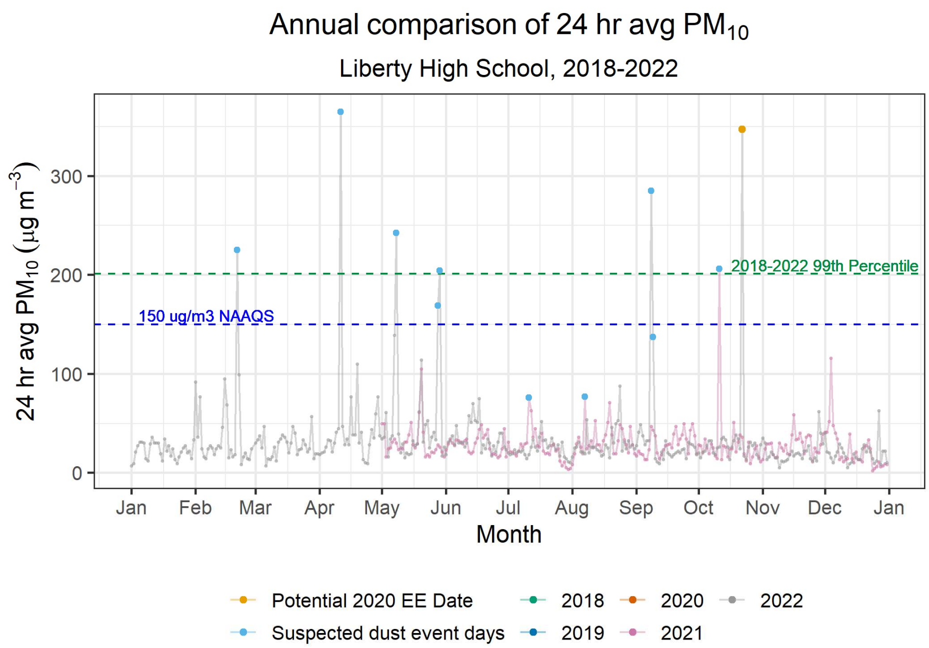


Figure 3.4-18. Liberty High School 24-hour PM_{10} measurements in µg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

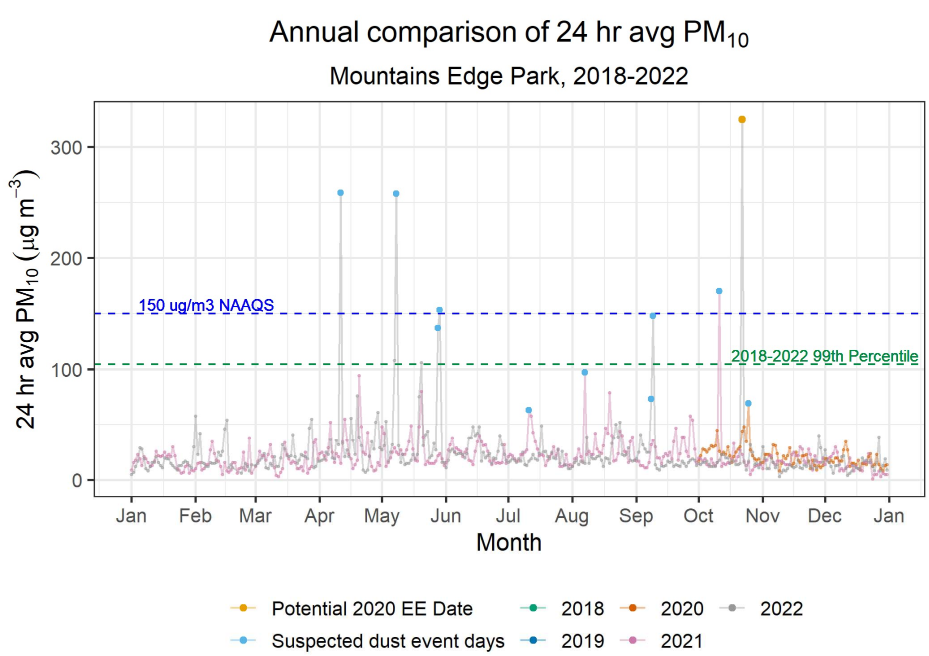


Figure 3.4-19. Mountains Edge Park 24-hour PM_{10} measurements in µg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

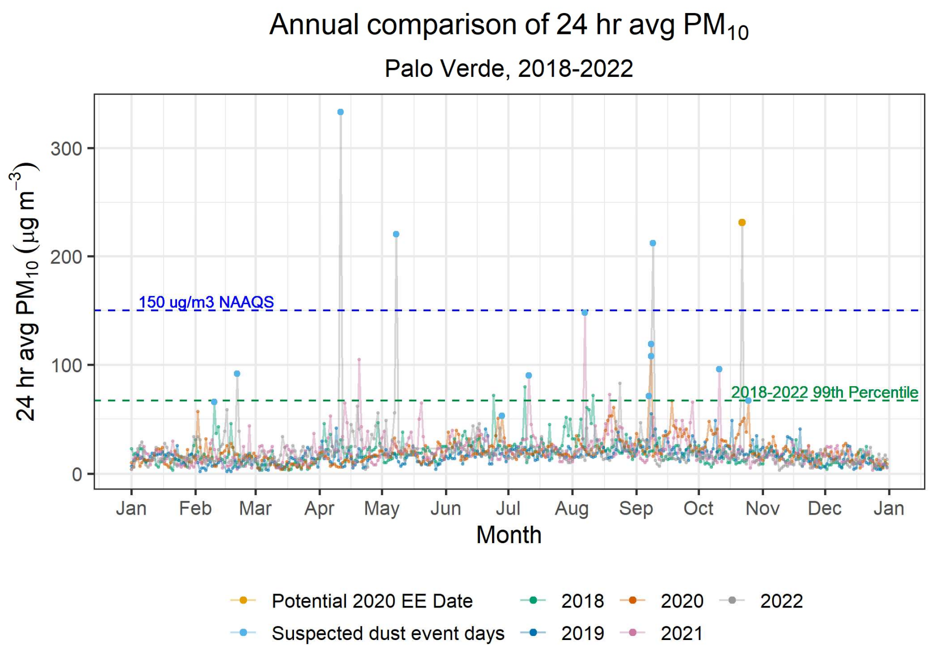


Figure 3.4-20. Palo Verde 24-hour PM_{10} measurements in μg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

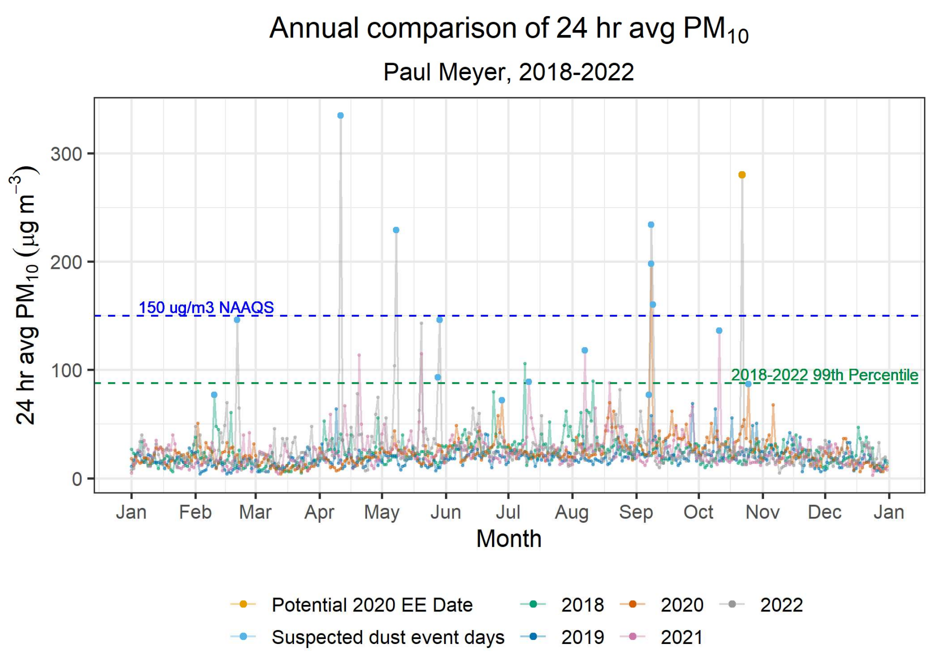


Figure 3.4-21. Paul Meyer 24-hour PM_{10} measurements in μg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

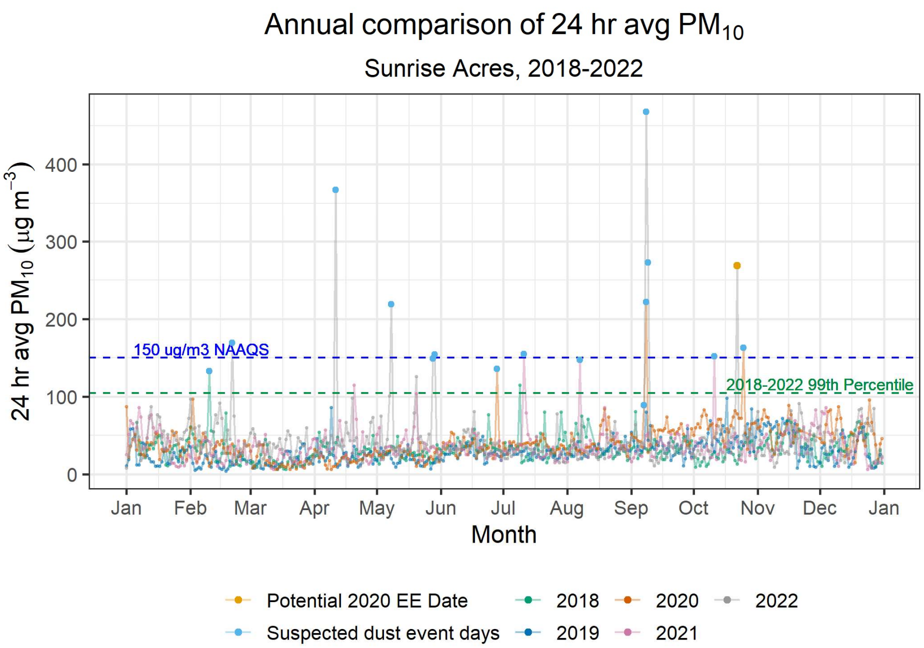


Figure 3.4-22. Sunrise Acres 24-hour PM_{10} measurements in µg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

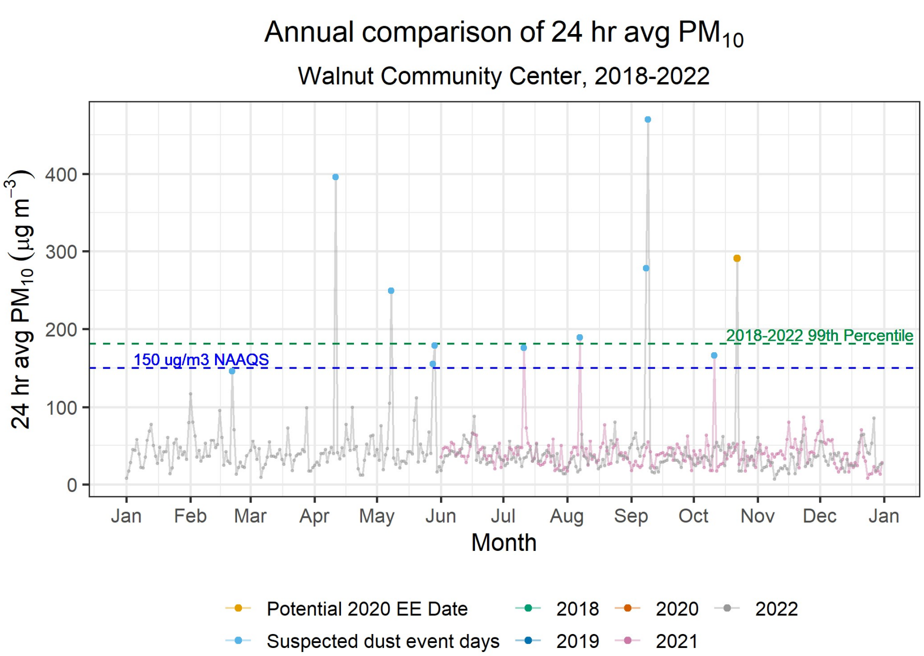


Figure 3.4-23. Walnut Community Center 24-hour PM_{10} measurements in µg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

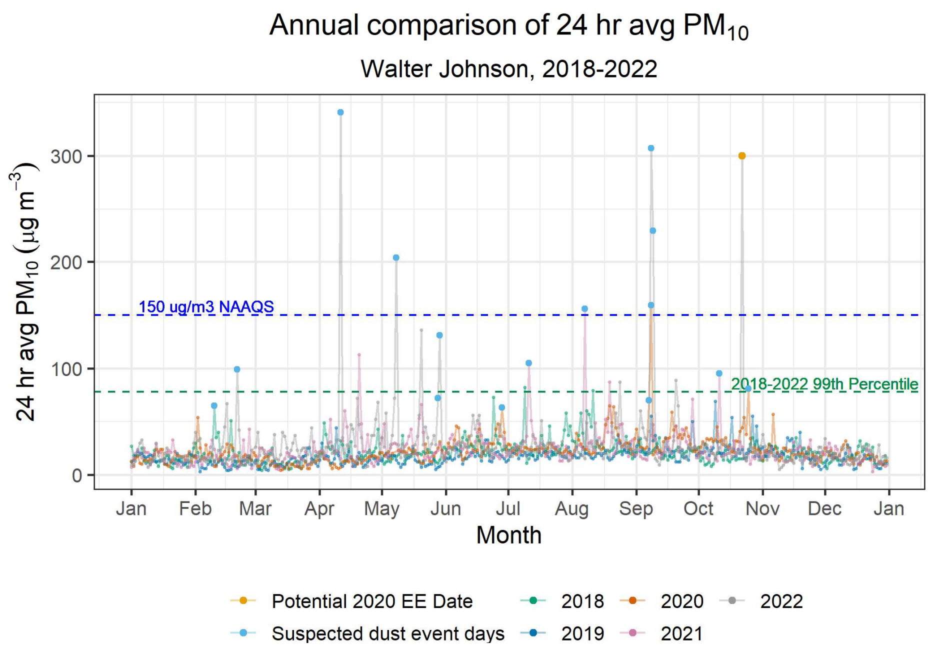


Figure 3.4-24. Walter Johnson 24-hour PM_{10} measurements in µg/m^3 from 2018-2022 by month with 99th percentile (green dash) and NAAQS (grey dash) indicated.

3.4.2 Event Comparison with Diurnal/Seasonal Patterns

The 24-hour average PM_{10} concentrations were compared to 5-year (2018-2022) monthly and seasonal averages are shown in boxplots in **Figure 3.4-25 and Figure 3.4-26.** The interquartile range is represented by the lower (25th percentile) and upper (75th percentile) edges of the boxes, and the middle bar is the median value. The whiskers extend to the smallest and largest value within 1.5 times the interquartile range. Points beyond this range are considered outliers. The concentrations recorded on October 22, 2022, are shown to be the highest recorded outliers for October and second highest outliers in autumn (behind September 8-9, 2022) during the entire 5-year period.

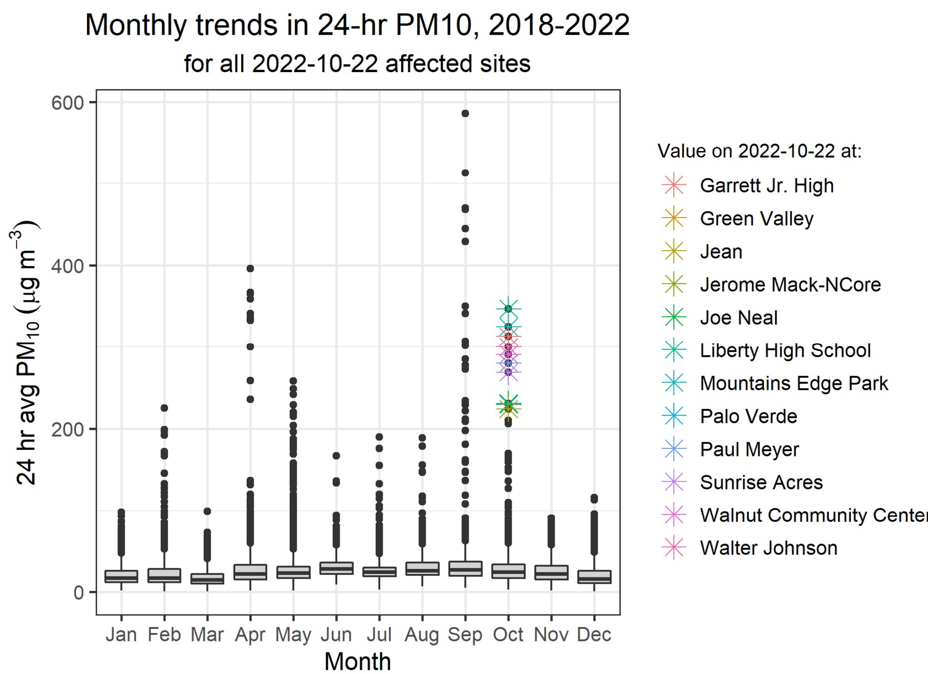


Figure 3.4-25. Monthly trend in 24-hour PM_{10} for 2018-2022, including outliers, with the potential exceedance day highlighted.

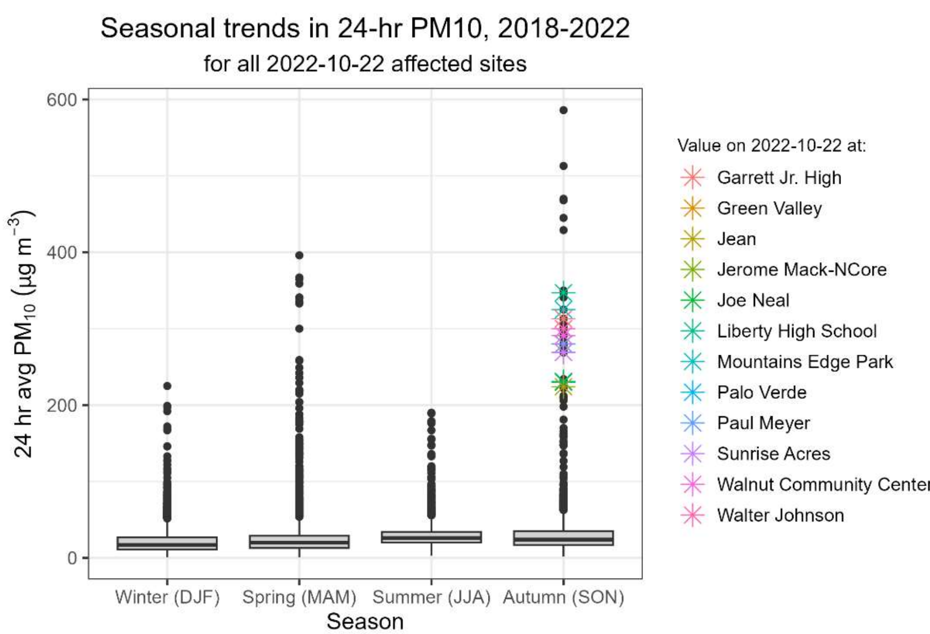


Figure 3.4-26. Seasonal trend in 24-hour PM_{10} for 2018-2022, including outliers, with the potential exceedance event day highlighted.

The hourly PM_{10} concentrations were also compared to 5-year (2018-2022) hourly averages. A summary of the maximum value observed compared to the 5-year (2018-2022) 95th percentile is shown in Table 3.4-2, and time series are shown in Figure 3.4-27 through Figure 3.4-35. At the

Walter Johnson site, for example, hourly PM_{10} concentrations reached a maximum of 1,184 µg/m^3 at 16:00 PST, 28 times the 5-year 95th percentile of 42.8 µg/m^3. Similar trends were seen at other sites.

Table 3.4-2. Summary of max hourly PM_{10} measurements compared to 5-year hourly PM_{10} 95th percentile. Sites that began data collection less than five years ago are indicated with an asterisk (*). Insufficient hourly data was available from Garrett Jr. High to create statistics here.

Site Name	Time of hourly PM_{10} max (PST)	Hourly PM_{10} (µg/m^3)	5-year hourly PM_{10} 95th percentile (µg/m^3)	Hourly/5-year 95th percentile
Green Valley	10/22/2022 18:00	1,158	59.3	20
Jean	10/22/2022 21:00	851	62.6	14
Jerome Mack	10/22/2022 20:00	1,093	94.1	12
Joe Neal	10/22/2022 16:00	863	63.1	14
Liberty High School*	10/22/2022 18:00	1,452	65.6	22
Mountains Edge Park*	10/22/2022 20:00	1,077	58.1	19
Palo Verde	10/22/2022 15:00	828	37.7	22
Paul Meyer	10/22/2022 17:00	886	47.6	19
Sunrise Acres	10/22/2022 20:00	896	102	9
Walnut Community Center*	10/22/2022 17:00	811	93.3	9
Walter Johnson	10/22/2022 16:00	1,184	42.8	28

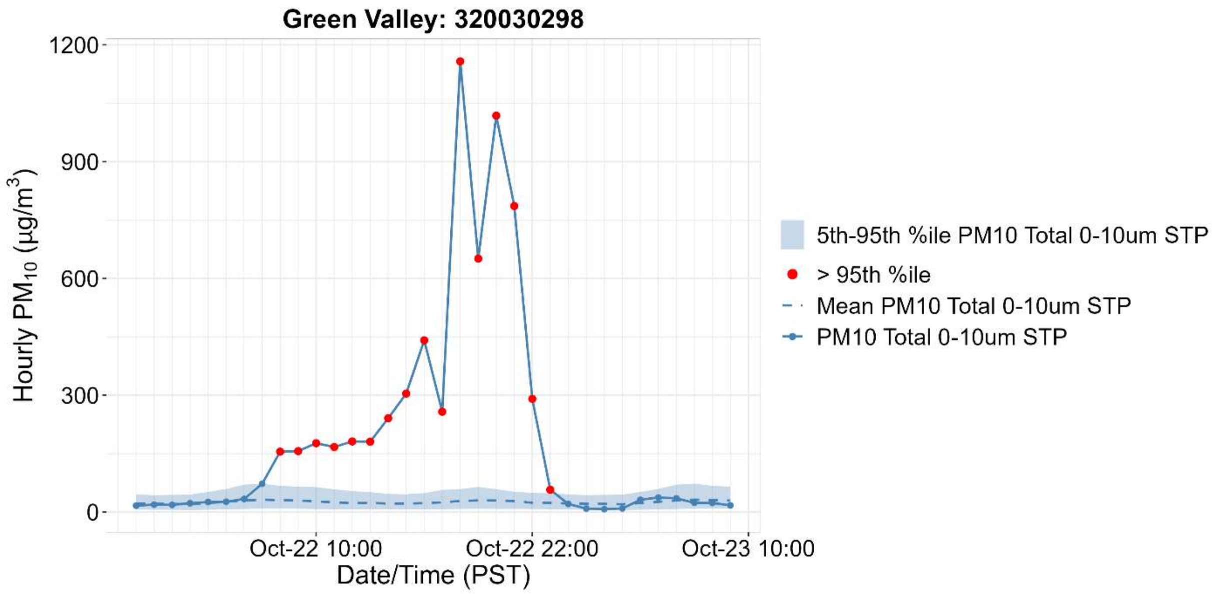


Figure 3.4-27. Hourly PM_{10} concentrations compared to the seasonal average (dashed line) and 5th - 95th percentile (shaded area) at Green Valley from 2018-2022.

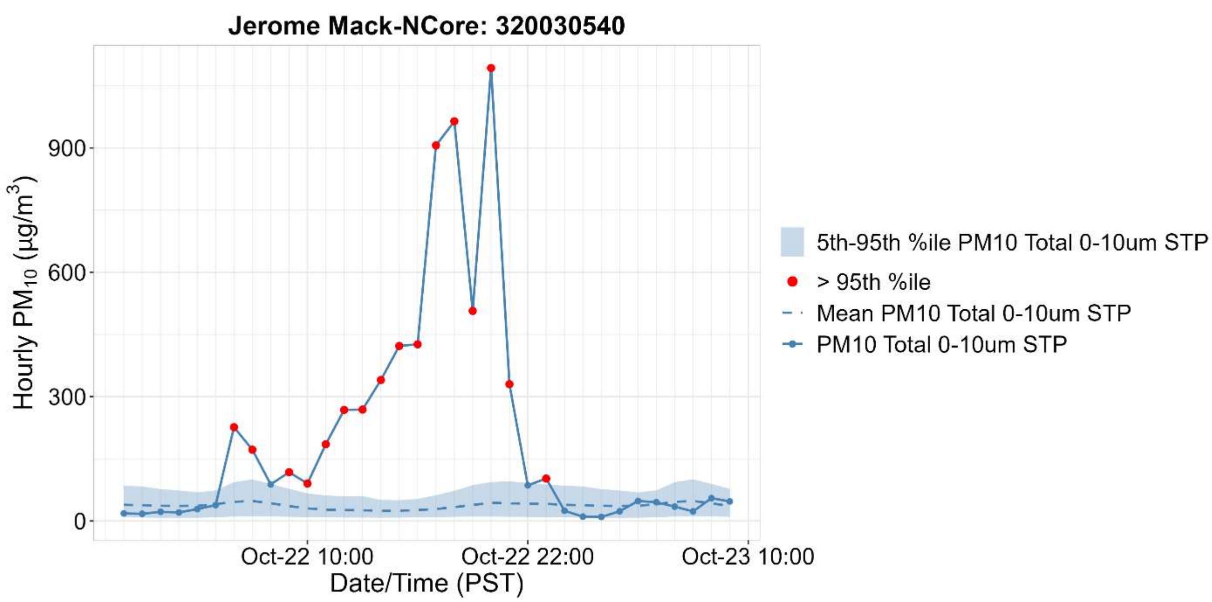


Figure 3.4-28. Hourly PM_{10} concentrations compared to the seasonal average (dashed line) and 5th - 95th percentile (shaded area) at Jerome Mack from 2018-2022.

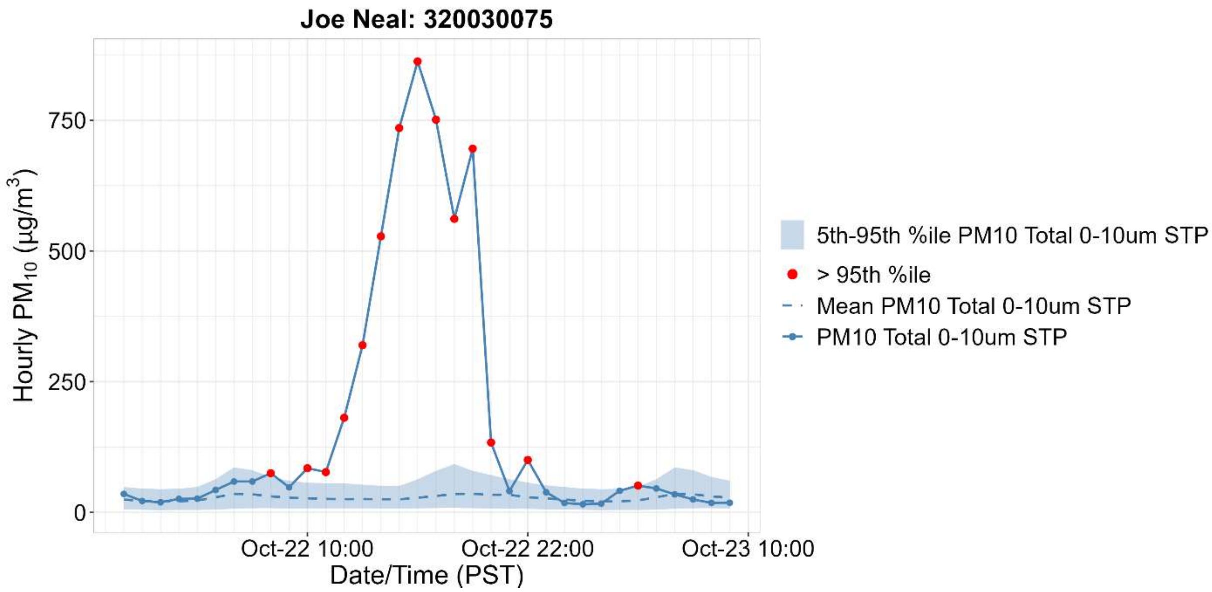


Figure 3.4-29. Hourly PM_{10} concentrations compared to the seasonal average (dashed line) and 5th - 95th percentile (shaded area) at Joe Neal from 2018-2022.

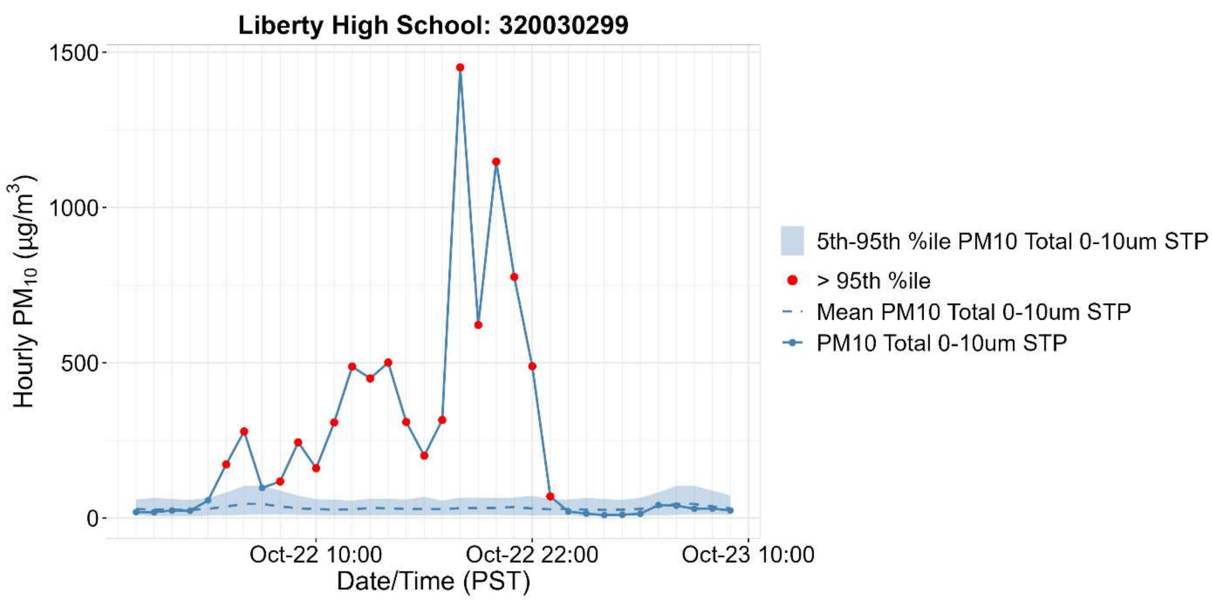


Figure 3.4-30. Hourly PM_{10} concentrations compared to the seasonal average (dashed line) and 5th - 95th percentile (shaded area) at Liberty High School from 2018-2022. *Data collection began less than five years ago at this site.

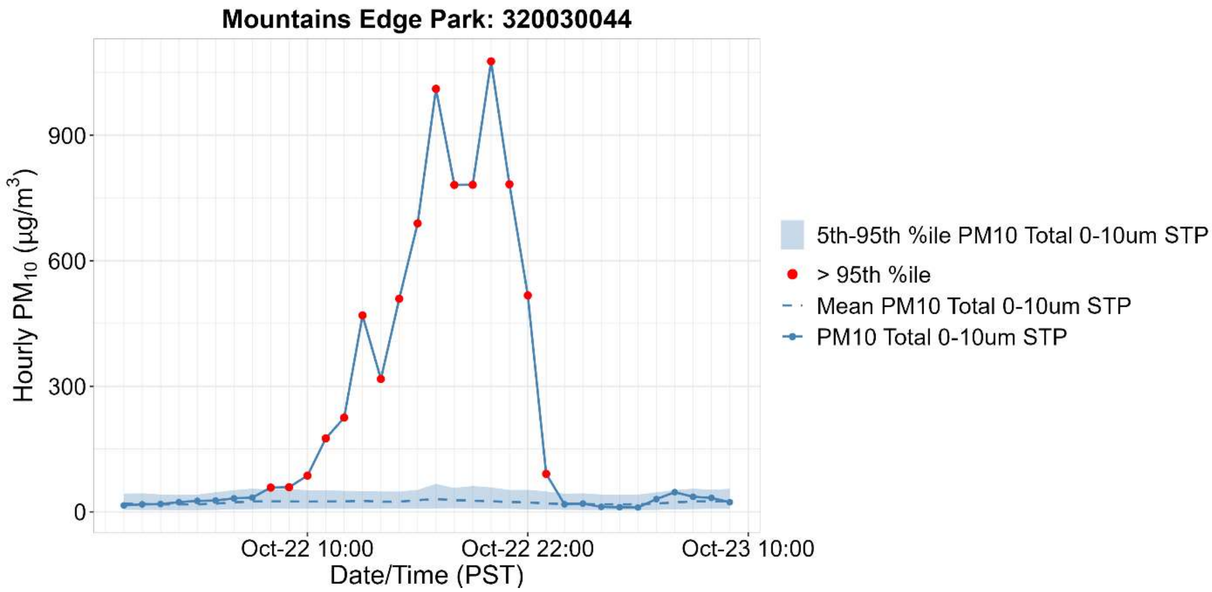


Figure 3.4-31. Hourly PM_{10} concentrations compared to the seasonal average (dashed line) and 5th - 95th percentile (shaded area) at Mountains Edge Park from 2018-2022. *Data collection began less than five years ago at this site.

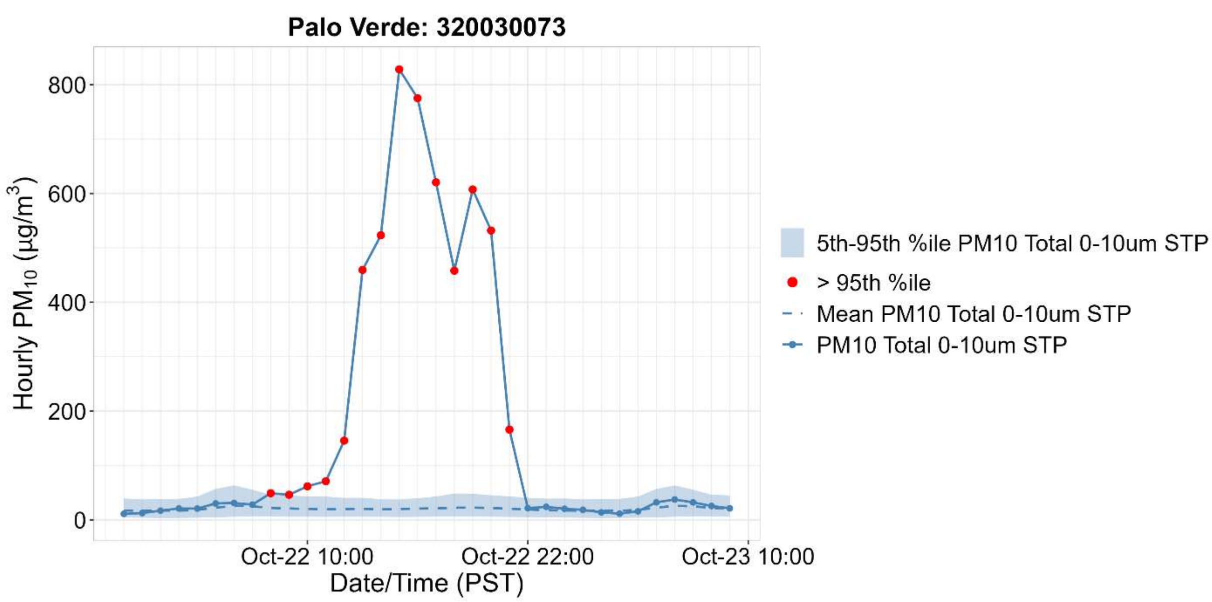


Figure 3.4-32. Hourly PM_{10} concentrations compared to the seasonal average (dashed line) and 5th - 95th percentile (shaded area) at Palo Verde from 2018-2022.

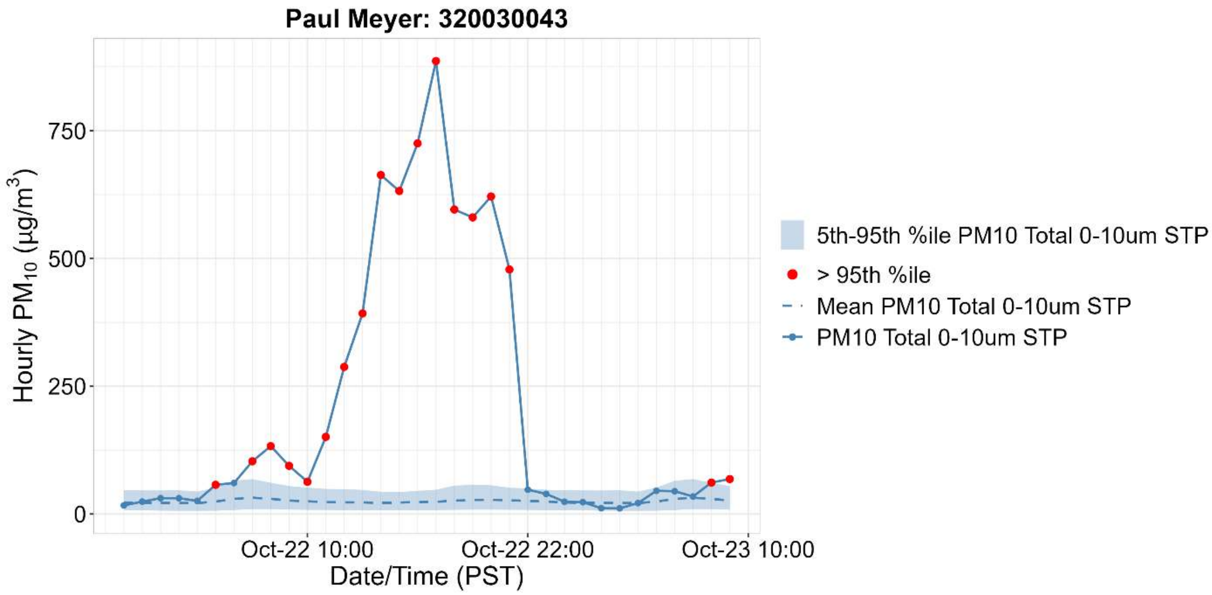


Figure 3.4-33. Hourly PM_{10} concentrations compared to the seasonal average (dashed line) and 5th - 95th percentile (shaded area) at Paul Meyer from 2018-2022.

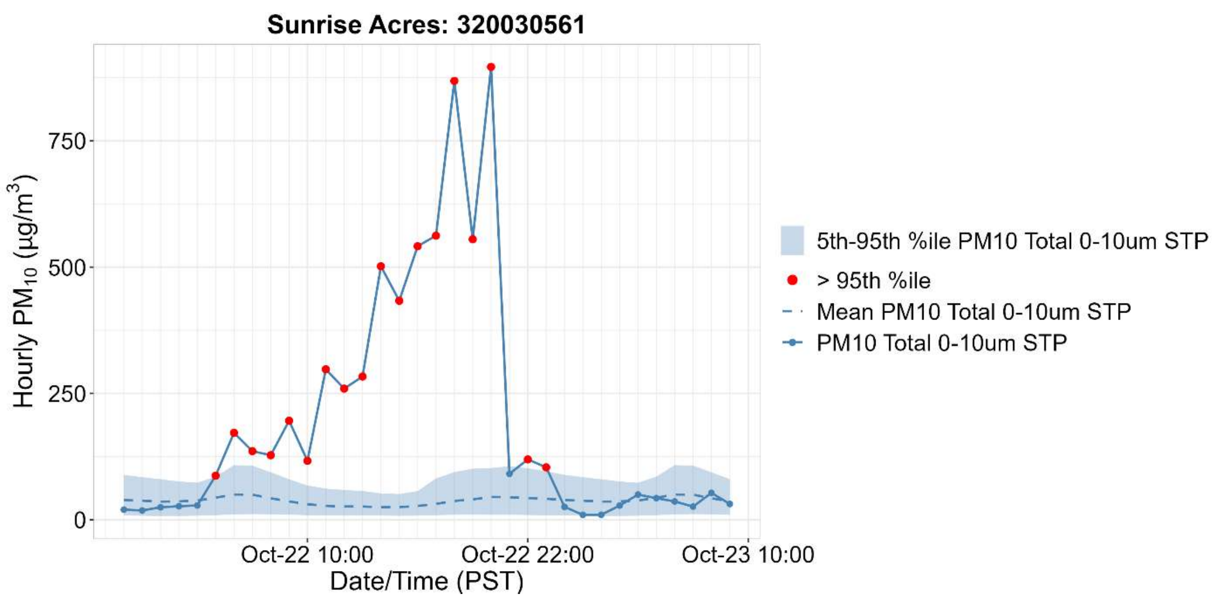


Figure 3.4-34. Hourly PM_{10} concentrations compared to the seasonal average (dashed line) and 5th - 95th percentile (shaded area) at Sunrise Acres from 2018-2022.

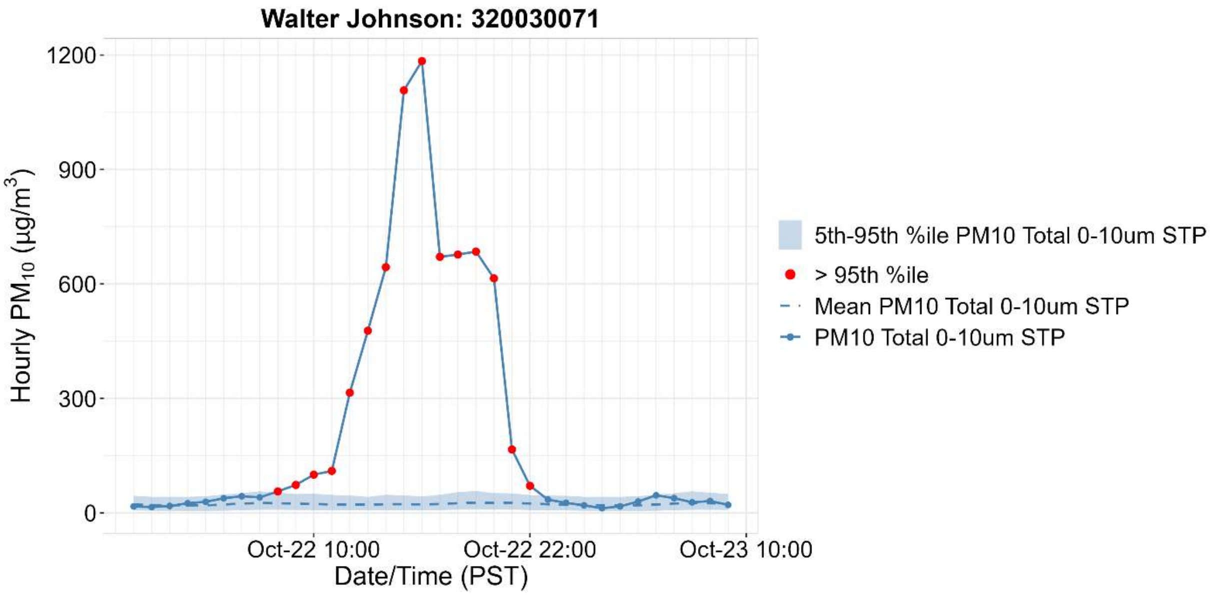


Figure 3.4-35. Hourly PM_{10} concentrations compared to the seasonal average (dashed line) and 5th - 95th percentile (shaded area) at Walter Johnson from 2018-2022.

3.4.3 Event Comparison with Climatology

Thirty-year seasonal climatology was created using European Environment Agency (ERA5) reanalysis at 0.25° x 0.25° horizontal resolution from 1993-2022 for both the source region and Clark County. Temperature, volumetric soil moisture, and maximum winds speed were chosen and modeled as the most likely variables to influence a windblown dust event in both the source region and Clark County. This analysis shows the seasonal September-October-November 30-year average for each variable in the top panel and the event date departure from the seasonal climatology in the bottom panel. Figure 3.4-36 shows the climatology compared with the event date for the source region. On the event date the source region was experiencing ground level temperatures near 10 °F above the long-term average, lower-to-normal soil moisture, and max ground level wind speeds were well above average. Figure 3.4-37 shows the climatology compared with the event date for Clark County. On the event date Clark County was experiencing ground level temperatures slightly above the long-term average, lower-to-normal soil moisture, and max ground level wind speeds >5 m/s (11 mph) above the typical climatological average. This climatological evidence provides proof that the conditions on the event date were abnormal in both the source region and Clark County, leading to a windblown dust event.

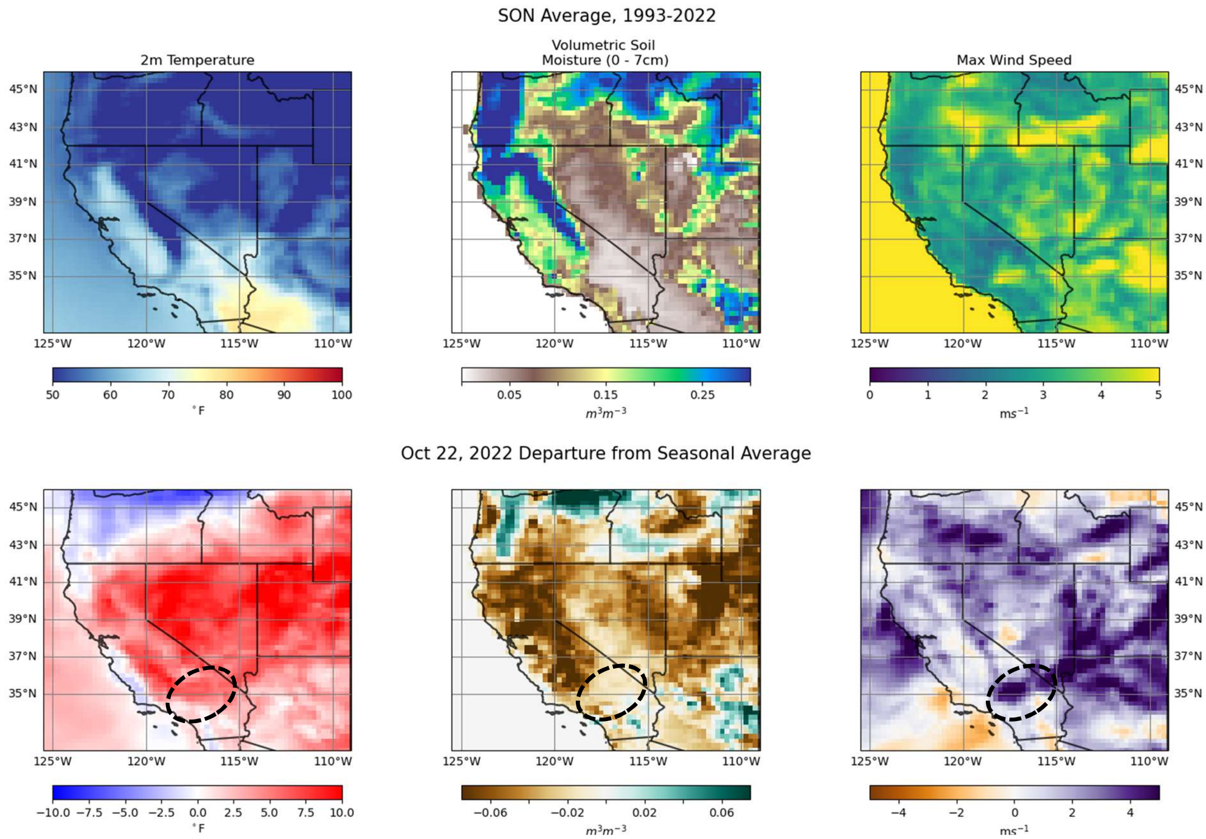


Figure 3.4-36. The 30-year September-November seasonal climatological average based on ERA5 reanalysis for 2-m temperature, volumetric soil moisture of the first 7 cm, and maximum 10-m wind speed (top row), and the daily departure for October 22, 2022, from the 30-year average (bottom row). The source region is circled.

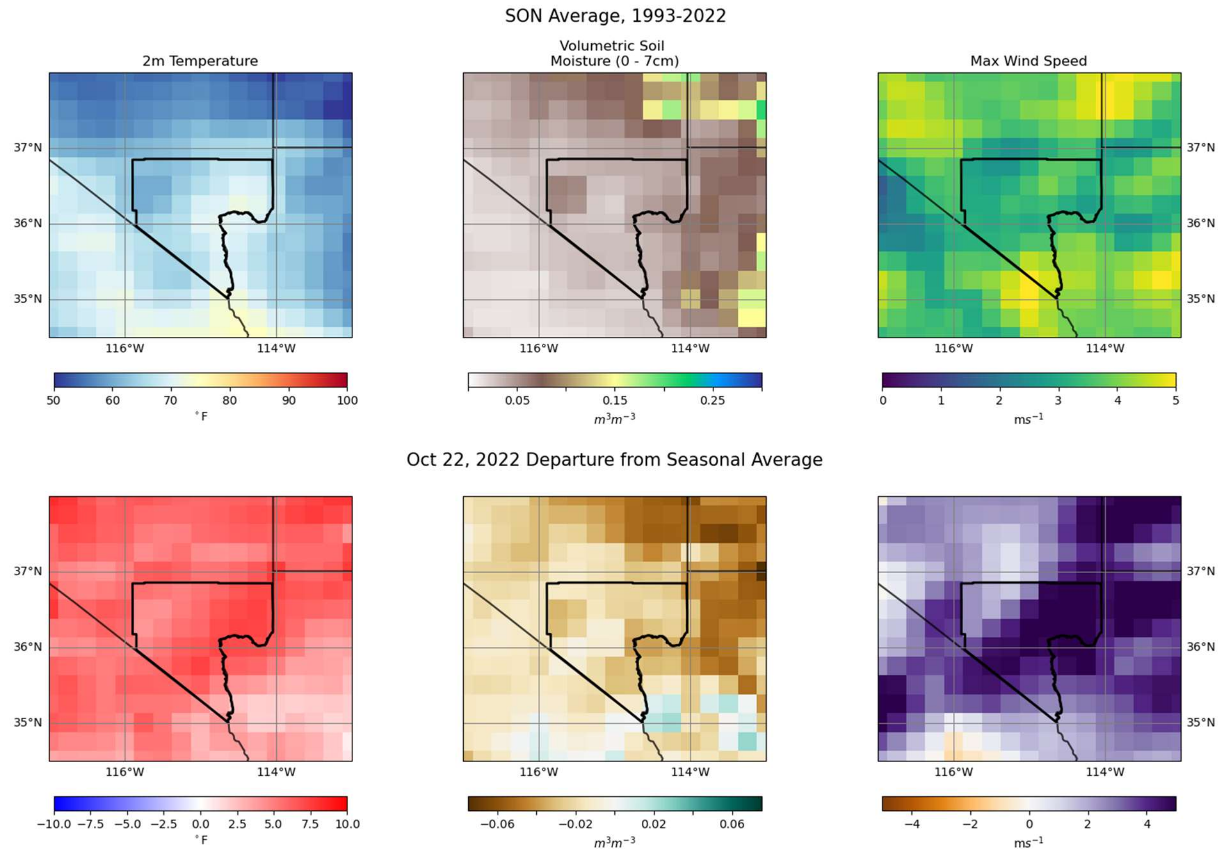


Figure 3.4-37. The 30-year September-November seasonal climatological average for Clark County based on ERA5 reanalysis for 2-m temperature, volumetric soil moisture of the first 7 cm, and maximum 10-m wind speed (top row), and the daily departure for October 22, 2022, from the 30-year average (bottom row). Clark County is outlined in black.

Overall, we find overwhelming evidence that the October 22, 2022, high-wind dust event in Clark County was well outside normal conditions. This suggests that Clark County was impacted by a high-wind dust exceptional event. The evidence corroborating this assertion includes (1) the event rank was at or above the 99th percentile for both regulatorily significant sites and sites that exceeded the NAAQS; (2) the abrupt increase in PM_{10} was well outside the typical diurnal profile; (3) the PM_{10} 24-hour average event concentration was well outside the typical monthly or seasonal norms; and (4) 30-year climatology shows higher temperatures, lower soil moisture and higher winds on the event date in the source region and Clark County than climatological averages.

3.5 Meteorological Similar Analysis

Enhanced surface-level wind speeds and frequent wind gusts on October 22, 2022, created prime conditions to maintain the suspension of fine dust particles in the air in the midst of regional drought. The resultant daily average wind speed was quite high at 15.4 mph, and five wind gusts greater than 50 mph were observed. Sustained wind speed reached a maximum of 31 mph. The maximum gust for the day was 53 mph. The strongest winds came from the southwest direction. The highest wind speeds and gusts aligns with the timing of enhanced PM_{10} concentrations. Visibility at LAS dropped to a minimum of 3 miles during the evening of October 22, 2022.

The following sections compare surface-level wind and visibility on October 22, 2022, to dates that show (1) comparable wind profiles that did not show PM_{10} concentrations above the NAAQS and (2) a PM_{10} concentration above the NAAQS with a lack of notable wind speeds. All wind speed, wind direction, and visibility values in the next two sections were measured at LAS and downloaded from the Iowa Environmental Mesonet data portal. (http://mesonet.agron.iastate.edu/)

3.5.1 Wind Event Days without High Concentration

The comparison of the event date to specific non-event high-wind days without enhanced PM concentrations shows key differences between comparable wind events and the event date. All dates in the years 2016-2020 were considered when identifying days with a wind event comparable to the event date. Four criteria that describe the intensity of the wind event on October 22, 2022, were applied to identify comparable dates: (1) daily average wind speed greater than 15 mph, (2) peak daily wind gust greater than 52 mph, (3) at least nine hourly observations with sustained wind speed greater than 20 mph, and (4) at least five measured wind gusts greater than 50 mph. Additionally, dates were filtered to those without enhanced PM_{10} (<100 µg/m^3) at monitors in Clark County. A single date identified as a comparable wind event without high PM_{10} concentrations, listed in Table 3.5-1.

Table 3.5-1. A similar meteorological event day without enhanced PM_{10} concentrations. PM_{10} concentrations are reported at Jerome Mack (JM), Paul Meyer (PM), Walter Johnson (WJ), Palo Verde (PV), Joe Neal (JN), Green Valley (GV), Jean (J), Sunrise Acres (SA), Mountains Edge (ME), Walnut Rec. (WR), Garrett Jr. High (GJH), and Liberty High School (LHS).

			Daily PM_{10} (µg/m^3)											
Date	Daily Wind Speed (mph)	Peak Wind Gust (mph)	JM	PM	WJ	PV	JN	GV	J	SA	ME	WR	GJH	LHS
2022-10-22 (event date)	15	53	280	280	300	231	230	269	224	269	326	291	313	347
2022-03-20	17	62	41	38	37	21	47	29	19	50	21	38	26	40

A comparison between October 22, 2022, and the comparable date March 20, 2022, is outlined below. **Figure 3.5-1, Figure 3.5-2, and Figure 3.5-3** below compare surface-level wind and visibility conditions on the event date and March 20, 2022. The wind profile on March 20, 2022, exceeds the intensity of the wind event that occurred on the event date with higher-speed wind gusts and a longer period of sustained winds above 20 mph (Figure 3.5-1). Figure 3.5-2 shows that the highest wind speeds, between 20-40 mph, came from the southwest on the event date and from the northwest on March 20. On March 20, visibility remained at the maximum value of 10 miles throughout the day (Figure 3.5-3). The maintenance of high visibility on March 20 confirms that the high-wind event did not dramatically affect levels of suspended dust particles, a claim supported by the fact that daily PM_{10} concentration was relatively low (50 µg/m^3 or less) at all examined sites. In contrast, visibility on the event date reached a minimum of 3 miles during peak winds. A key difference between the event date and March 20, 2022, is displayed in **Figure 3.5-4**, which shows the spatial distribution of peak sustained wind speeds centered on the Las Vegas NWS forecast office (VEF). On October 22, peak sustained winds exceeded 30 mph in most of the area surrounding Las Vegas, and were especially enhanced (>40 mph) towards the southwest along the path of air transport. In contrast, on March 20 some of the highest peak winds occurred within the Las Vegas metropolitan area. Wind speeds in the scrubland/bare-ground regions surrounding Las Vegas were notably lower on March 20, 2022, compared to the event date, particularly to the northwest in the direction of air. Another key difference is the altitude of air transport towards Clark County. **Figure 3.5-5** compares HYSPLIT back-trajectories on the event date ending at 11:00 PST (during the rapid increase in PM_{10} concentrations) and March 20 ending at 14:00 PST (approximate time of maximum PM_{10}). On the event date, near-surface transport (<250 m) occurred in the hours before arrival in Las Vegas. This low-altitude transport facilitated entrainment and transport of dust from the surface of source regions surrounding Las Vegas. March 20, 2022, lacked surface-level transport, as air transport towards Las Vegas occurred >500 m, which hindered transport of dust from surrounding regions. Differences in regional wind speed profiles and altitude of transport to the Las Vegas region may account for the discrepancy in daily PM_{10} concentrations between October 22, 2022, and March 20, 2022, under comparable local wind conditions.

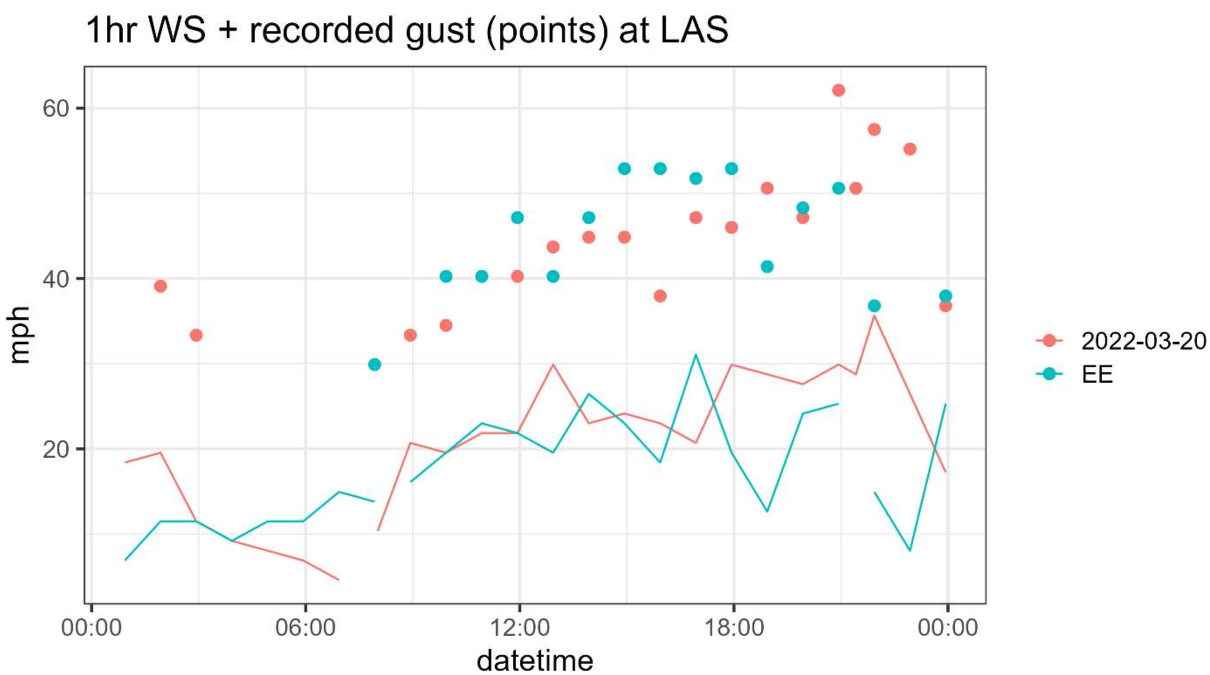
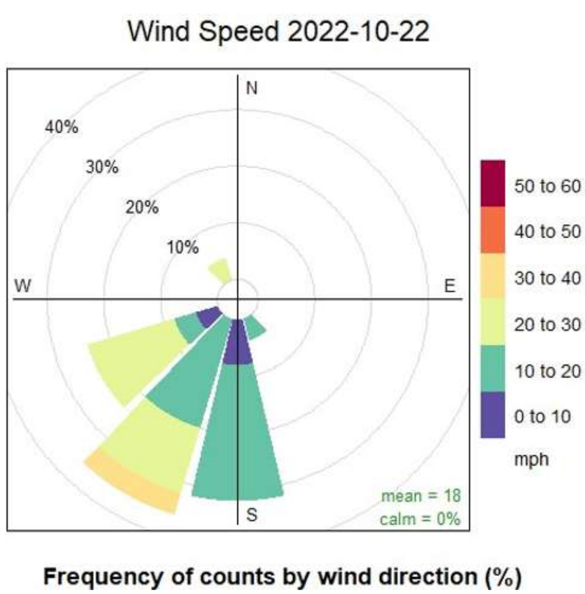


Figure 3.5-1. Wind speed and maximum hourly wind gust in mph at LAS for March 20, 2022 (pink), and the October 22, 2022, suspected exceptional event (EE) day (teal).



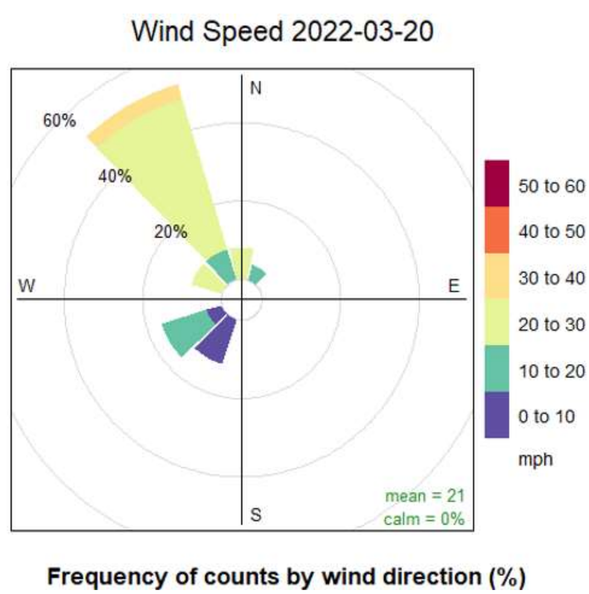


Figure 3.5-2. Wind speed (mph) and direction frequency for (left) October 22, 2022, the suspected exceptional event day (EE), and (right) March 20, 2022.

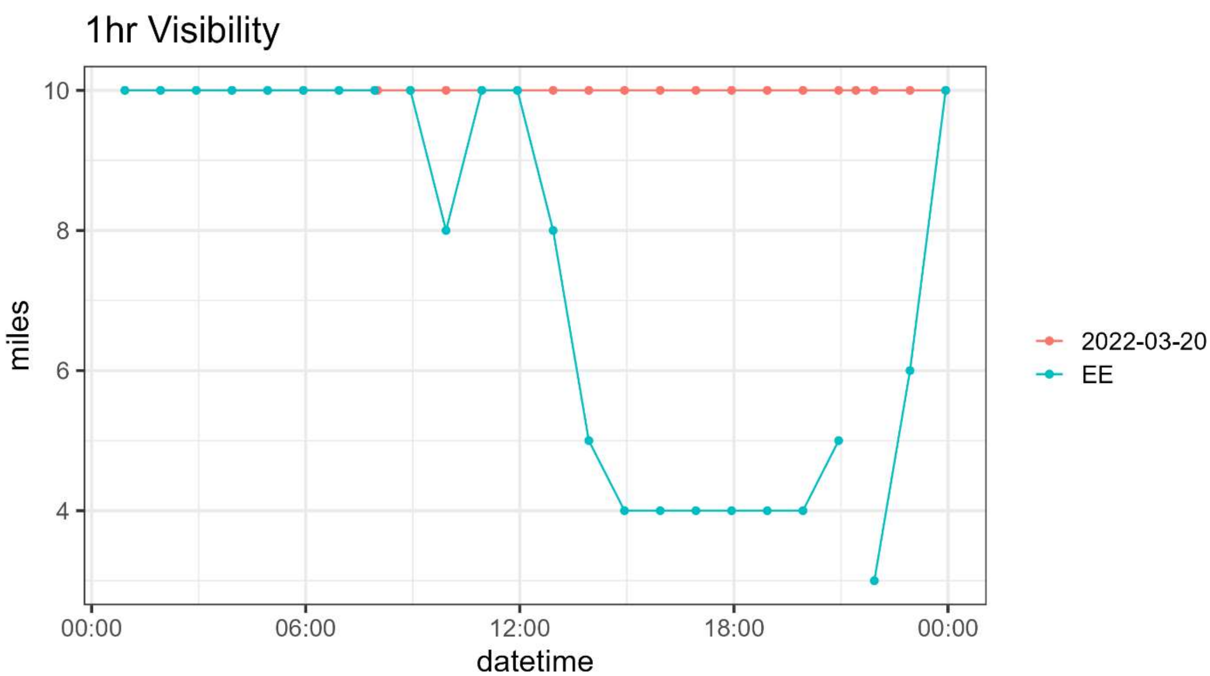


Figure 3.5-3. Hourly-reported visibility in miles at LAS for March 20, 2022 (pink), and the October 22, 2022, suspected exceptional event (EE) day (teal).

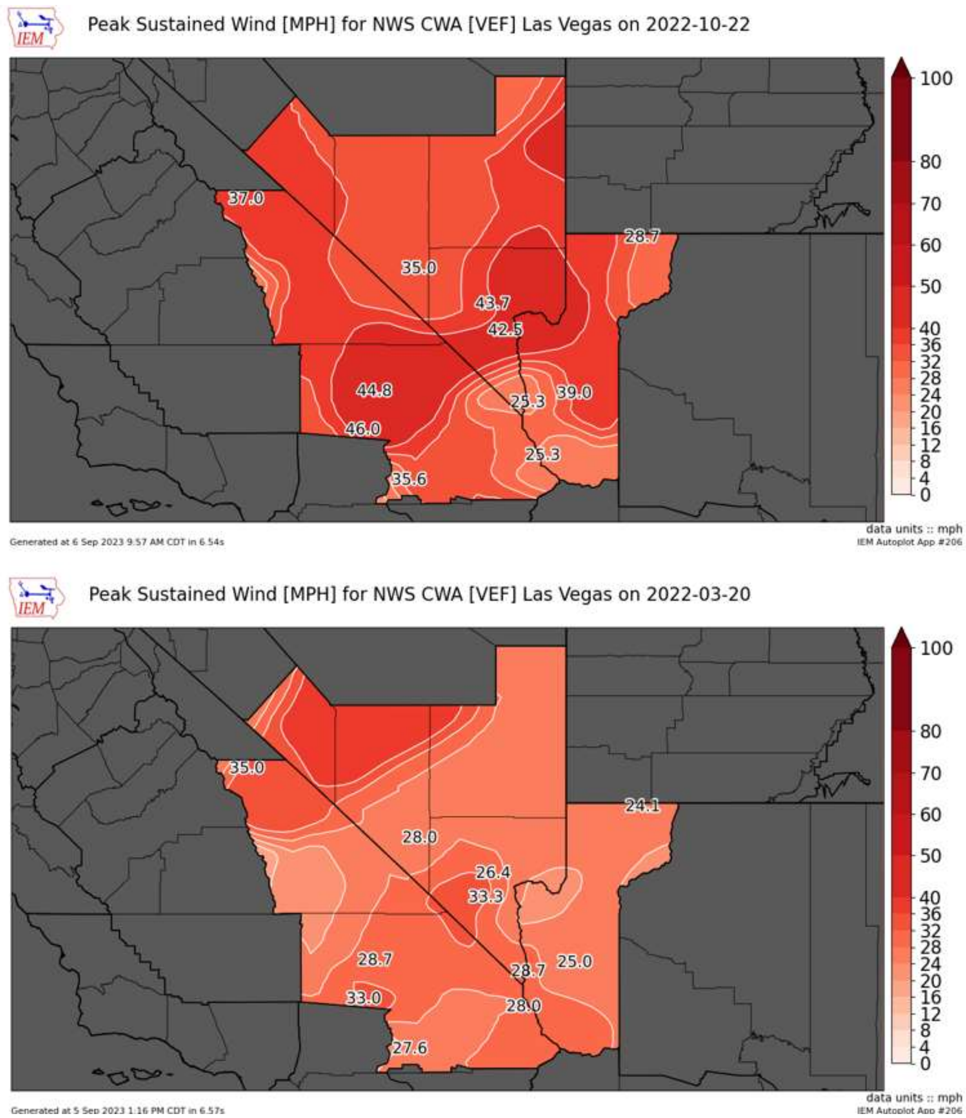


Figure 3.5-4. Spatial distribution of peak sustained wind speeds on October 22, 2022 (top), and March 20, 2022 (bottom), in Clark County and the surrounding regions. Generated from automated ASOS data using the Iowa Environmental Mesonet's plotter tool (**https://mesonet.agron.iastate.edu/plotting/auto**).

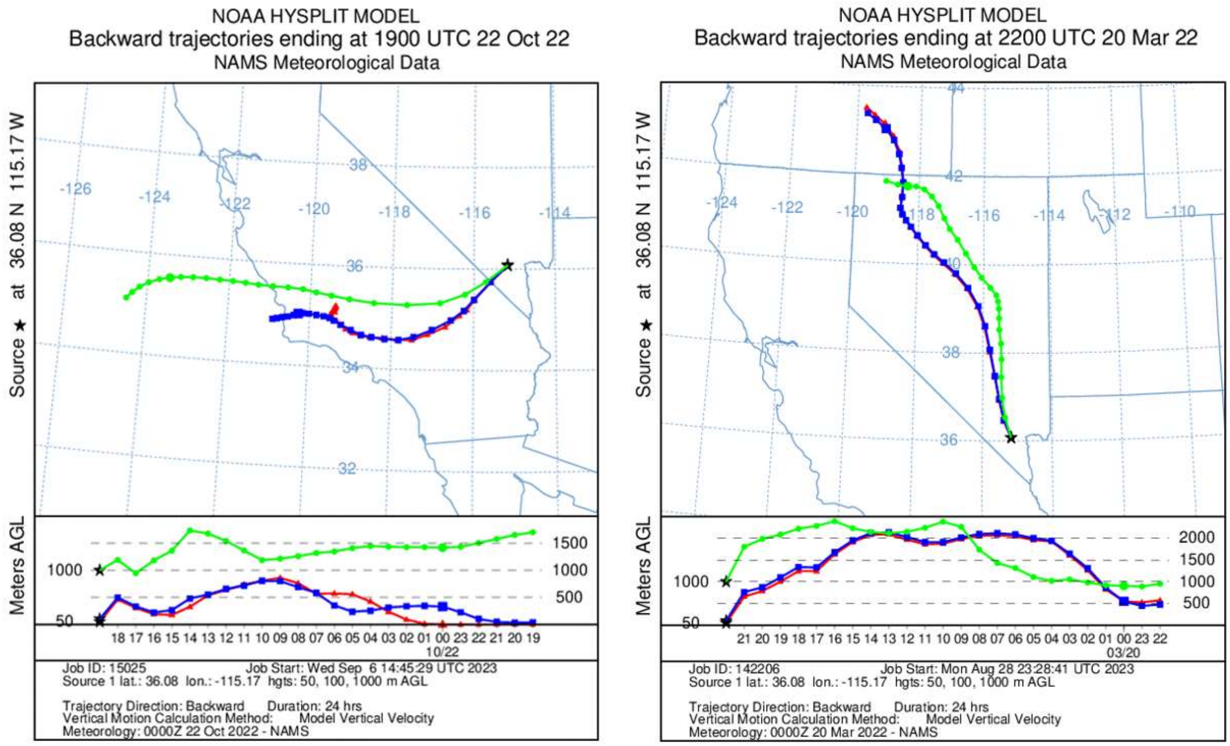


Figure 3.5-5. 24-hour HYSPLIT back-trajectories initiated from Las Vegas at (left) 19:00 UTC (11:00 PST) on October 22, 2022 (event date), and (right) 22:00 UTC on March 20, 2022 (10:00 PST), at 50 m (red), 100 m (blue), and 1,000 m (green).

3.5.2 High Concentration Days in the Same Season

Dates in the same season as the suspected exceptional event were screened by daily PM_{10} concentration to compare surface meteorological conditions with the event date. All dates from mid-summer to fall, between July and December 2022, were screened. The only other days when PM_{10} exceeded the NAAQS during this period were September 8-9, 2022, which is also a suspected high-wind dust event.

4. Not Reasonably Controllable or Preventable

4.1 Other Possible Sources of PM_{10} in Clark County

According to the EPA 2019 High Wind Dust Event Guidance document (and quoted Code of Federal Regulations [CFR] therein), agencies are required to (1) identify natural and anthropogenic sources of emissions contributing to the monitored exceedance, including contributions from local sources; (2) identify a relevant State Implementation Plan (SIP) for sources identified as natural and anthropogenic sources of emissions contributing to the monitored exceedance, including contributions from local sources and the implementation of these controls; and (3) provide evidence of effective implementation to satisfy the nRCP criterion.

Section 2.2.3 provides evidence for natural and anthropogenic sources near the Paul Meyer, Mountains Edge, Walter Johnson, Palo Verde, Joe Neal, Green Valley, Liberty High School, Jerome Mack, Sunrise Acres, and Walnut Community Center monitoring sites of PM_{10} that could have contributed to the October 22, 2022, exceedance. As shown in Section 3.2, however, the main source of PM_{10} is the large bare ground/land area to the southwest of Clark County (identified in the rest of the document as the Mojave Desert source region), which is outside of the jurisdiction of Clark County and, therefore, not subject to control measures. Additional conclusions from this analysis indicate that anthropogenic point sources were unlikely to contribute to a PM_{10} exceedance event and BACM are in place to control fugitive sources such as construction emissions. According to the 2012 "Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10})," the main sources of enhanced PM_{10} emissions in Clark County, Nevada, are (1) wind-blown dust, (2) re-entrained road dust, and (3) construction emissions. These nonpoint emission sources contribute approximately 98% of total annual PM_{10} emissions and are often amplified by dry arid conditions. Control measures have been implemented and enforced to mitigate emissions from the sources listed above within the jurisdiction of Clark County. Therefore, since natural bare ground was identified as the most likely source that contributed to the October 22, 2022, event (fulfilling nRCP part 1), in this section we focus on providing information on control measures used in Clark County to mitigate emissions from construction sites and possible dust sources in both the SIP (fulfilling nRCP part 2), and providing evidence of effective implementation (fulfilling nRCP part 3).

4.2 PM_{10} Control Measures in Clark County

For an air quality episode to qualify as a high-wind exceptional event, Clark County DES must show that all anthropogenic sources of PM_{10} are reasonably controlled (40 CFR 50.14(b)(5)(ii)). The

Exceptional Event rule provides that enforceable control measures that EPA approved into the SIP within five years of the date of the event (40 CFR 50.14(b)(8)(v)) are presumptively reasonable. Controls adopted into the SIP more than five years before the event date may also be reasonable (81 FR 68238), and EPA will also consider other control measures not approved into the SIP if the air pollution control agency is implementing and enforcing the control measures (81 FR 68238-9).

Clark County DES operates one of the most robust fugitive emissions control programs in the country to reduce ambient air concentrations of PM_{10}. The 2001 PM_{10} SIP details emission sources and BACM that have been coded into the Clark County Air Quality Regulation (AQR). These include (1) stabilization of open areas and vacant lands (Section 90); (2) stabilization of unpaved roads and paving of unpaved roads when traffic volume is equal to or greater than 150 vehicles per day (Section 91); (3) stabilization of unpaved parking areas, including material handling and storage yards, and generally prohibiting the construction of new unpaved parking lots in the nonattainment area (Section 92); (4) requirements for paved roads, street sweeping equipment, and other dust-mitigating devices (Section 93); and (5) permitting and dust control requirements for construction activities (Section 94). These BACM are updated and continued in the most recent 2012 Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10}) (2012 Maintenance Plan) document for Clark County, Nevada, which was approved by EPA and extends through 2023. The 2012 updated SIP and AQR document are provided as evidence in **Appendix B**.

The 2012 Maintenance Plan also identified the Natural Events Action Plan for High-Wind Events: Clark County, Nevada (DES 2005) as a control measure. Since submission of the 2012 Maintenance Plan, DES replaced this action plan with the Clark County Mitigation Plan for Exceptional Events (DES 2018). DES developed this revised plan in response to EPA's 2016 EER (81 FR 68216) that required areas with historically documented or known seasonal exceptional events to develop mitigation plans (40 CFR 51.930(b)). EPA does not require this plan to be included in the SIP or be federally enforceable, but did review each plan to assure that the required elements were included. The revised plan includes practices from the first action plan:

- A high-wind event notification system that includes an early warning procedure.
- Education and outreach programs.
- Enhanced enforcement and compliance programs to reduce emissions.
- Submittal of required documentation to EPA in the event of an exceedance.

The new plan includes more sophisticated air quality advisories and alerts, and commits to maintaining an open line of communication with neighboring areas involved in high PM_{10} ambient air concentration events. The new plan also references the Clark County flood control system (Clark County 2018) and street sweeping schedule for Las Vegas Valley, Hydrological Area 212 (HA 212) referenced in Appendix J of the 2001 PM_{10} SIP (DES 2001). This system maintains a robust flood control system that minimizes silt deposition from flood waters onto roads, parking areas, and undeveloped land. The system undergoes continuous expansion to accommodate new development in the Las Vegas Valley, with the following recent plan changes:

- Duck Creek – Gilispie System: March 2023;
- Harry Reid Airport Peaking Basin Outfall and Van Buskirk System: Feb. 2022;
- Monson Channel-Jimmy Durant to Boulder Highway: Apr. 2022;
- Blue Diamond 02 Channel, Decatur-Le Baron to Richmar: July 2020;
- Gowan Outfall Facilities-Simmons to Clayton: May 2021;
- Pittman Wash-Interstate Channel: June 2020.[2]

The Nevada Department of Transportation, Clark County, the City of Las Vegas, the City of North Las Vegas, and the City of Henderson maintain policies requiring rapid removal of silt deposits from paved roads after storm events.

In addition to regulating direct releases of PM_{10} to the atmosphere, DES' control measures includes requirements to reduce precursors, including VOC, NO_x, and SO_x, which can react in the atmosphere to form PM_{10} emissions under certain meteorological conditions. The control measures also regulate mercury emissions. Mercury emissions are a source of PM pollution when emitted in a non-gaseous form or when adsorbed by PM to form particulate mercury. Thus, standards designed to control mercury emissions also reduce PM_{10} ambient air concentrations.

The following section explains the reasonable control measures that collectively assure that all local sources of anthropogenic sources impacting HA 212 were reasonably controlled before and after the event. The measures include controls that are presumptively reasonable because EPA approved the control measure into the SIP within five years of the event, along with other reasonable measures.

4.2.1 Presumptively Reasonable Controls

The following measures are reasonable because EPA approved the control measures into the SIP within five years of the event date:

Section 12.0-12.6 Permitting Programs – Sections 12.0 and 12.1 originally adopted November 3, 2009; last amended February 20, 2024, and awaiting SIP approval. Section 12.2 originally adopted May 18, 2010; last amended March 14, 2014, and SIP-approved October 17, 2014. Sections 12.3 and 12.4 originally adopted May 18, 2010; last amended July 20, 2021, and awaiting SIP-approval. Section 12.5 originally adopted May 18, 2010 and awaiting SIP-approval. Section 12.1 requires all minor stationary sources to obtain a permit to construct and operate if they have the potential to emit 5 tons per year (tpy) or more of a regulated pollutant, or if they are subject to another AQR, such as a control technique guideline (CTG) Reasonable Available Control Technologies (RACT) rule, that requires a minor source to obtain a permit. Some emissions units at these minor stationary sources must comply with RACT requirements when proposing an emissions increase that meet or

[2] The flood plan and updates are available at https://www.regionalflood.org/programs-services/document-library/master-plan-documents.

exceed the significance thresholds. Sections 12.2-12.5 requires all major stationary sources to obtain a permit to construct and operate. Some emissions units must comply with RACT requirements when they are the subject of an emissions increase in PM_{10} or its precursors that meets or exceeds the minor New Source Review (NSR) significance thresholds. In addition, these rules implement the federally mandated NSR Program for attainment, unclassifiable, and nonattainment areas. New major sources and existing major sources undertaking a modification that results in a significant increase in PM_{10} emissions or its precursors must install and operate Best Available Control Technology (BACT) or Lowest Achievable Control Technology (LAER).

Section 26 Emissions of Visible Air Contaminants – Amended April 26, 1983; last amended May 5, 2015; and SIP-approved June 16, 2017. This rule requires all sources to generally maintain an average opacity below 20%, with certain sources subject to a lower 10% average opacity standard.

Section 41 Fugitive Dust – Originally adopted June 25, 1992; last amended January 21, 2020; and SIP-approved May 19, 2022. This rule requires fugitive emissions abatement to prevent airborne PM emissions during construction and deconstruction activities, and during use of unpaved parking lots, agricultural operations, and raceways. The rule includes notice, registration, and permitting requirements.

Section 90 Fugitive Dust from Open Areas and Vacant Lots – Originally adopted June 22, 2000; last amended January 21, 2020; and SIP-approved May 19, 2022. This rule requires certain owners of land to take measures to prevent access of trespassers operating motor vehicles on the land. Owners must also create a stable surface area, including gravel installation that provides a 20% non-erodible cover. Landowners of large parcels must develop and submit a dust mitigation plan.

Section 93: Fugitive Dust from Paved Roads and Street Sweeping Equipment – Originally adopted June 22, 2000; last amended January 21, 2020; and SIP-approved May 19, 2022. This rule requires construction and reconstruction of roads in accordance with road shoulder widths and drivable median stabilization requirements. It also establishes an opacity standard for unpaved shoulders and medians, and for the use of road cleaning equipment. The rule requires road wetting when using rotary brushes and blowers to clean roads and allows only vacuum type crack cleaning seal equipment.

Section 94 Permitting and Dust Control for Construction and Temporary Commercial Activities – Adopted June 22, 2000; amended January 21, 2020; SIP-approved May 19, 2022; last amended August 3, 2021; and awaiting further revision before SIP approval. This rule applies to all construction and temporary commercial activities that disturb or have the potential to disturb soil. It requires a dust control permit and maintenance of a dust mitigation plan.

4.2.2 Other Reasonable Control Measures

The following identifies additional reasonable control measures that assure that all anthropogenic sources of PM_{10} emissions were controlled before and after the event. The controls fall into one of three categories: (1) EPA approved the control measures into the SIP more than five years before the event date; (2) the state submitted revisions that EPA has not yet approved into the SIP; or, (3) the Clean Air Act (CAA) and EPA do not require states to submit the type of control measure for SIP approval. As explained below, these control measures are reasonable because they meet or exceed CAA requirements, enhance enforcement efforts, and are equal or more stringent than control programs found in other state SIPs.

State Control Measures

Nevada Regional Haze State Implementation Plan – Originally adopted October 2009 and partially SIP approved March 26, 2012, and August 28, 2013, awaiting SIP approval. Prepared by the Nevada Division of Environmental Protection (NDEP) and codified by DES in AQR Section 12.14 on June 7, 2022. This plan requires reductions in visibility impairing pollutants, and thereby reduces the potential for PM_{10} formation. The plan specifically required Reid Gardner (a point source in Clark County) to meet PM control requirements by June 30, 2016, or to shutdown Units 1, 2, 3 by this date. The 2022 revised plan, which should become effective during the second maintenance period, requires the installation of low NO_x burners and selective non-catalytic reduction control equipment to reduce visibility impairing pollution on lime kilns operating in Clark County. This rule is reasonable because the controls imposed met the CAA's Best Available Retrofit Technology (BART) standard.

NAC 445B.737-774, Heavy-Duty Vehicle Program – adopted October 22, 1992; last amended October 18, 2002. The NDEP and Nevada Department of Motor Vehicles (DMV) jointly developed this rule to reduce motor vehicle related pollution by limiting excessive tailpipe or smokestack emissions from any gasoline or diesel-powered vehicle with a manufacturer's gross vehicle weight rating (GVWR) of 14,001 lbs. or more. Enforcement inspectors pull over heavy-duty vehicles for random roadside testing to determine if the exhaust from their vehicle exceeds state opacity standards. Violators must repair and retest the vehicle within 30 days. Fleets may also request opacity testing in their fleet yard. Fleet managers voluntarily repair and re-test vehicles failing the inspection. This regulation is reasonable because it exceeds EPA's inspection and maintenance program requirements, and actively prevents smoking vehicles from operating on roads.

NAC 445B.400-735, Inspection and Maintenance Program – adopted September 28, 1988; subsequently amended and SIP-approved July 3, 2008; last amended October 18, 2022. The NDEP and the Nevada DMV jointly developed this rule, administered by the DMV, to control vehicle emissions. The rule reduces motor vehicle-related NO_x and VOC emissions through the vehicle inspection and emissions-related repairs. Clark County requires annual emissions testing before renewing a vehicle's registration. All gasoline-powered vehicles must be tested, with limited exceptions, as well as diesel-powered vehicles weighing up to 14,000 lbs. gross vehicle weight rating (GVWR). EPA approved the inspection and maintenance program as part of the Carbon Monoxide State Implementation Plan: Las Vegas Valley Nonattainment Area, Clark County, Nevada (CO SIP[3]), in September 2004 (69 FR 56351). This inspection and maintenance program is reasonable because it (1) exceeds EPA's requirements for a basic inspection and maintenance program, and (2) follows a standard that qualifies as a low-enhanced performance standard.

NAC 445B.3611-3689 Nevada Mercury Control Program – Originally adopted May 4, 2006; last revised November 2, 2016. Mercury emissions can also be a source of PM pollution when emitted as in non-gaseous form a particulate or when adsorbed by PM to form particulate mercury. Thus, standards designed to control mercury emissions also reduce PM_{10} ambient air concentrations. The rule requires particulate emissions control technologies to reduce mercury emissions from thermal units located in precious metal mines. The CAA does not require states to submit hazardous air pollutant control measures for SIP approval. These measures are reasonable because they reduce the ambient air concentration of PM_{10} by requiring use of the Maximum Achievable Control Technology (MACT) and apply in addition to the federal standards at 40 CFR Part 63, Subpart E.

County Air Quality Regulations

Section 14 New Source Performance Standards (NSPS) - Originally adopted September 3, 1981; last amended March 15, 2022. Regulations in this section are reasonable because they implement EPA's federal PM and total suspended particulate (TSP) emissions limitations in 40 CFR Part 60 "New Source Performance Standards" (NSPS) that apply to a variety of stationary sources. EPA has delegated implementation and enforcement of the federal standards to DES. The CAA does not require states to submit NSPS control measures for SIP approval.

Section 13 National Emissions Standards for Hazardous Air Pollutants (HAP) – Originally adopted September 3, 1981; last amended March 15, 2022. Regulations in this section are reasonable because they implement federal HAP emissions limitations in 40 CFR Part 63 that apply to a variety of stationary sources that emit particulate emissions in the form of metal HAP. These standards are based on Maximum Achievable Control Technology. EPA has delegated implementation and enforcement of the standards to DES. The CAA does not require states to submit HAP control measures for SIP approval.

Section 27 Particulate Matter from Process Weight Rate – Originally adopted September 3, 1981 (SIP approved June 18, 1982); last amended July 1, 2004. Establishes process weight restrictions for PM emissions for all operations. This regulation is reasonable because it establishes maximum rates for PM emissions from stationary sources that are more stringent than any specific CAA or SIP

[3] https://webfiles.clarkcountynv.gov//Environmental%20Sustainability/SIP%20Related%20Documents/Carbon_Monoxide_State_Implementation_Plan_Revision-without_Appendices.pdf

requirement, and comparable to limits found in other state SIPs. Compare the rule, for example, to Chapter 1200-3-7 "Process Emission Standards" in the Tennessee SIP.[4]

Section 28 Fuel Burning Equipment – Originally adopted December 28, 1978; SIP-approved August 27, 1981; last amended July 1, 2004. This rule applies to fuel burned for the primary purpose of producing heat or power by indirect heat transfer. It regulates the burning of coke, coal, lignite, coke breeze, fuel oil, and wood, but not refuse. The regulation targets reductions in PM_{10} emissions, but by promoting good combustion practices, the rule also produces NO_x and VOC emissions reduction co-benefits that further reduce the potential for PM_{10} formation. The rule establishes PM emissions rates based on heat input. This regulation is reasonable because it establishes maximum rates for PM emissions from stationary sources that are more stringent than any specific CAA or SIP requirement and emissions limitations found in other states. Compare the rule, for example, to Chapter 13 "Emission Standards for Particulate Matter" in the Louisianna SIP.[5]

Section 42 Open Burning – Originally adopted December 28, 1978; SIP-approved August 27, 1981; last amended July 1, 2004. This rule requires preauthorization to burn any combustible material and prohibits open burning during air pollution episodes, which is consistent with the Nevada Emergency Episode Plan. This regulation is reasonable because it allows the Control Officer to assess and prevent any burning that could lead to a PM_{10} NAAQS exceedance. The rule also is comparable to similar control measures found in other SIPs. See, for example, South Coast Air Quality Management District's Rule 444[6].

Section 91 Fugitive Dust from Unpaved Roads, Unpaved Alleys, and Unpaved Easement Roads – Originally adopted June 22, 2000; last amended April 15, 2014; and SIP-approved October 6, 2014. This rule applies to unpaved roads, including unpaved alleys, unpaved road easements, and unpaved access roads for utilities and railroads. It requires PM emissions control measures including paving or application of dust palliatives. This regulation is reasonable because it targets and reduces emissions of event-related fugitive dust emissions using state-of-the-art emissions controls, which are more stringent than the best practices recommended by EPA. See "Fugitive Dust Control Measures and Best Practices," EPA, January 2022[7].

Section 92 Fugitive Dust from Unpaved Parking Lots and Storage Areas – Originally adopted June 22, 2000; amended April 15, 2014; SIP-approved October 6, 2014; last amended August 3, 2021. This rule applies to lot and storage areas greater than 5,000 ft^2. The rule generally requires owners of a lot or storage area to pave the area or cover it in two inches of gravel. It also prohibits visible dust plumes from crossing the property boundary. This regulation is reasonable because it targets and reduces emissions of event-related fugitive dust emissions using state-of-the-art emissions controls, which are more stringent than the best practices recommended by EPA. See "Fugitive Dust Control

[4] https://www.epa.gov/system/files/documents/2021-12/chapter-1200-3-7.pdf
[5] https://www.epa.gov/air-quality-implementation-plans/louisiana-lac-33iii-ch-13-section-1301-emission-standards
[6] https://ww2.arb.ca.gov/sites/default/files/2021-06/SouthCoastSMP.pdf
[7] https://www.epa.gov/system/files/documents/2022-02/fugitive-dust-control-best-practices.pdf

Measures and Best Practices," EPA, January 2022. The rule also regulates sources not typically regulated in other state SIPs.

Section 94 Permitting and Dust Control for Construction and Temporary Commercial Activities – Adopted June 22, 2000; amended January 21, 2020; SIP-approved May 19, 2022; last amended August 3, 2021. This rule applies to all construction and temporary commercial activities that disturb or have the potential to disturb soil. It requires a dust control permit and maintenance of a dust mitigation plan. This regulation is reasonable because it targets and reduces emissions of event-related fugitive dust emissions using state-of-the-art emissions controls, which are more stringent than the best practices recommended by EPA. See "Fugitive Dust Control Measures and Best Practices," EPA, Jan. 2022. The rule also regulates sources not typically regulated in other state SIPs.

Transportation Conformity – Clark County works closely with the Regional Transportation Commission of Southern Nevada (RTC) to assure that regional transportation plans and transportation improvement programs in HA 212 are consistent with and conform to Clark County's air quality program requirements, including the PM_{10} SIP and corresponding motor vehicle emissions budget (MVEB).

In this section (and in Appendix B), we have provided information on adopted presumptively and other reasonable control measures used in Clark County to mitigate emissions from construction sites and other possible dust sources, fulfilling part 2 of the nRCP criterion.

4.3 Reasonableness of Control Measures

Table 2 in the 2019 High-wind Dust Exceptional Event Guidance document provides example factors that an air agency and EPA may consider when assessing the reasonableness of controls as part of the nRCP criterion. This table details example factors, such as (1) control requirements based on area's attainment status, (2) the frequency and severity of past exceedances, (3) the use of widespread measures, and (4) jurisdiction. In this section, we address all the possible factors that evaluate the reasonableness of controls.

4.3.1 Historical Attainment Status

The 2012 Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10}) document for Clark County, Nevada, provides a comprehensive historical analysis of the Clark County nonattainment area. Briefly, after the passage of the 1990 Clean Air Act Amendments, EPA designated all areas previously classified as Group I areas as "moderate" nonattainment areas, including HA 212 (CAA §107(d)(4)(B)). EPA required these moderate nonattainment areas to submit a SIP by November 1991 that would demonstrate attainment of the PM_{10} NAAQS by December 1994. Because of unprecedented regional growth, high-wind events, and other factors, Clark County could not demonstrate attainment by the required date, and EPA reclassified HA 212 as a "serious" nonattainment area on January 8, 1993 (58 FR 3334). In 1997, a PM_{10} SIP revision was submitted. In December 2000, the Clark County Board of County Commissioners (BCC) requested that the state formally withdraw all previously submitted SIPs and addenda because none demonstrated attainment of the NAAQS.

After completing comprehensive research and work programs to address the problems identified in the 1997 PM_{10} SIP revision, Clark County submitted a new SIP to EPA in June 2001 that met federal requirements for remediating serious PM_{10} nonattainment areas. This new SIP demonstrated that the adoption and implementation of BACM for fugitive sources and continuation of controls for stationary sources would result in attainment of the annual average PM_{10} NAAQS by 2001, and attainment of the 24-hour NAAQS by December 31, 2006. Although the CAA required the SIP demonstrate attainment of the PM_{10} NAAQS no later than December 31, 2001, EPA granted Clark County a five-year extension for the 24-hour NAAQS attainment date. Clark County supported its extension request with a "Most Stringent Measure" control analysis that showed the emission control programs proposed for the valley were at least as stringent, if not more so, than control programs implemented in other nonattainment areas.

In June 2004, EPA published final approval of the Clark County PM_{10} SIP (69 FR 32273). In June 2007, Clark County submitted a milestone achievement report that described the county's progress in implementing the SIP. In August 2010, EPA determined HA 212 had attained the PM_{10} NAAQS (75 FR 45485).

In August 2012, the Redesignation Request and Maintenance Plan for Particulate Matter (PM_{10}) (i.e., 2012 Maintenance Plan) was formally approved, and EPA redesignated the Clark County PM_{10} nonattainment area to attainment for the 1987 24-hour NAAQS. To achieve attainment of the 1987 24-hour PM_{10} NAAQS, Clark County DES implemented emissions control measures that lead to a permanent and enforceable improvement in air quality, as required by CAA Section 107(d)(3)(E)(iii) (42 U.S.C. 7407). The 2012 Maintenance Plan explained that Clark County adopted comprehensive fugitive dust controls in the Section 90 series of the AQR, and implemented and enforced SIP and non-SIP regulations to control PM_{10} emissions from stationary and nonpoint sources. The maintenance plan summarized the progress in attaining the PM_{10} standard, demonstrated that all Clean Air Act and Clean Air Act Amendment requirements for attainment had been met, and presented a plan to assure continued maintenance over the next 10 years. The plan became federally enforceable and determined how Clark County maintained the 1987 PM_{10} NAAQS through 2023.

In 2022, Clark County began work on a Second PM_{10} Maintenance Plan. For this plan, Clark County DES must show attainment in the background and assessment design value periods, specified as the 2017-2019 background period and the 2021-2023 assessment period. This exceptional event demonstration and the associated demonstrations for the 2021-2023 design value period will show that Clark County's HA 212 area is in attainment of the PM_{10} NAAQS but for the proven exceptional event dates. Approval and implementation of the Second PM_{10} Maintenance Plan is expected in 2024.

4.3.2 Historical Analysis of Past PM_{10} Exceedances

The 2012 Maintenance Plan document for Clark County, Nevada, provides historical context of regulatory efforts by Clark County to achieve attainment of PM_{10} NAAQS over the past 30 years, and a robust weight-of-evidence trend analysis for PM_{10} concentrations from 2001-2010. With the implementation of the PM_{10} SIP control measures, evidence shows a decreasing trend in PM_{10} design values, especially after BACM implementation (Figure 4.3-1). The decrease in wind erosion from vacant lands has driven the decreasing trend of PM_{10} emissions as construction within the Las Vegas Valley overtakes vacant lands. Given that the Las Vegas Valley was designated as being in "moderate" and later "serious" nonattainment for the PM_{10} NAAQS in the early 1990s, PM_{10} emissions before 1999 were likely high relative to the 2008-2010 period shown in Figure 4.3-1. This confirms that PM_{10} emissions have decreased over the past 30 years since the implementation of BACM from anthropogenic sources.

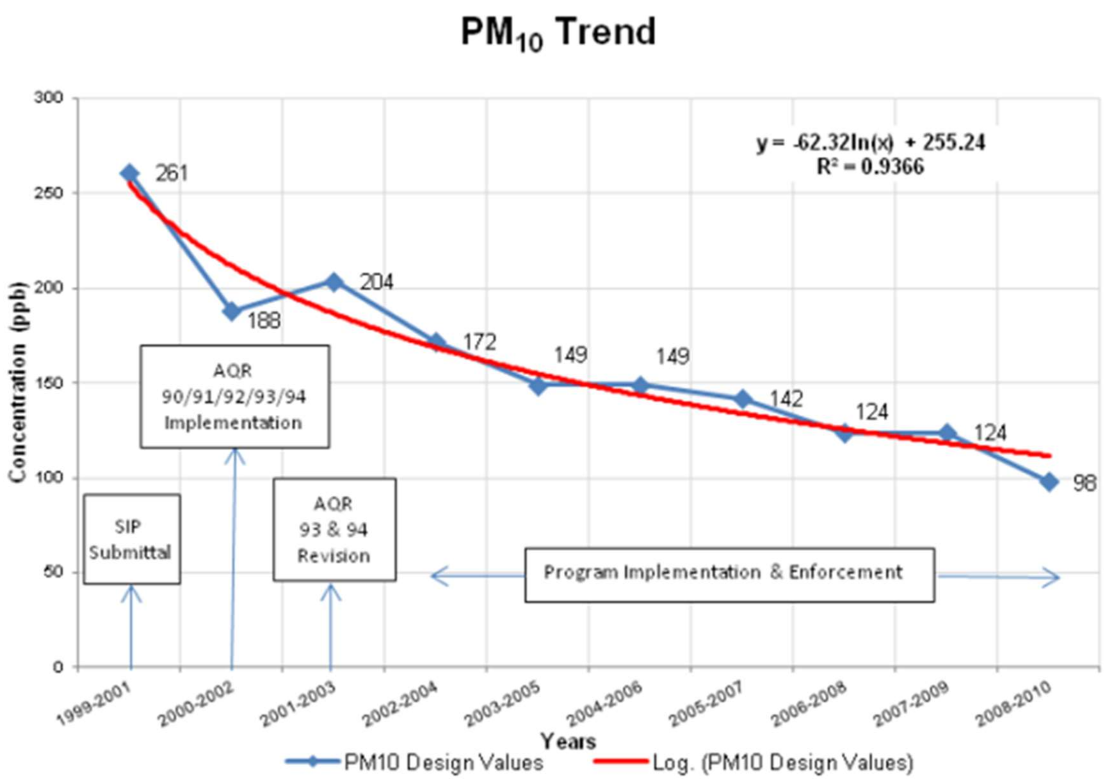


Figure 4.3-1. PM_{10} trends from the 2012 Maintenance Plan.

Continuing this evaluation through 2022, Figure 4.3-2 shows the three-year running average concentration at a long-running PM_{10} monitoring site in Clark County (Paul Meyer: AQS ID 32-003-0043) (orange line), along with the three-year running average of drought conditions in Nevada (blue bars). Drought conditions are categorized on a scale of D0 (abnormally dry) to D4 (exceptional), and Figure 4.3-2 shows the three-year running average of D2 (severe) conditions. We see that the typical five-year cyclical drought pattern in Nevada has increased in magnitude in the most recent years and this has corresponded to an uptick in average PM_{10} concentrations. This suggests that the control measures put in place via the 2012 SIP have been at least partially counterbalanced by increasing drought throughout the state of Nevada, affecting PM_{10} concentrations. Figure 4.3-3 shows the D0 - D4 drought conditions for 2000-2023, highlighting the increase in D3 (extreme) and D4 drought conditions through the most recent years. According to NLCD 2019 data, 87% of Nevada's land cover is bare ground or land that has little vegetation cover. The expansion in magnitude of severe-to-exceptional drought conditions will disproportionately affect natural areas prone to dust lofting, entrainment, and transport, ultimately enhancing PM_{10} concentrations.

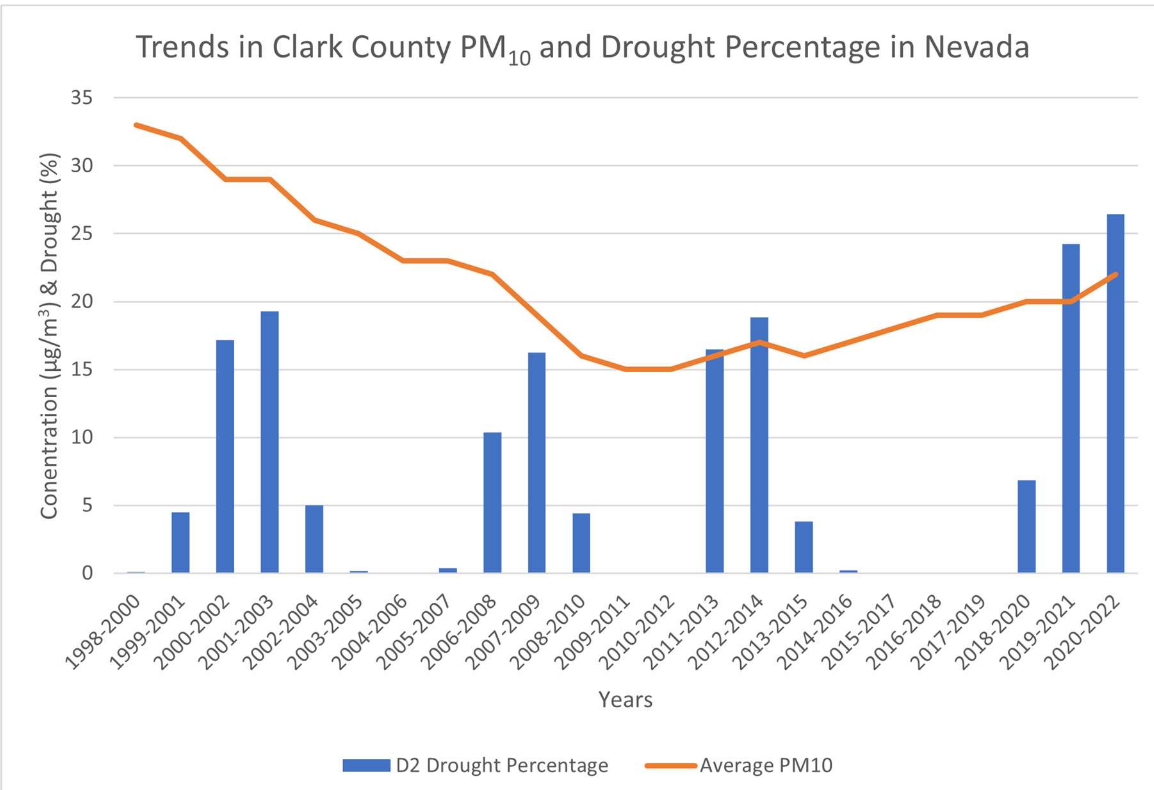


Figure 4.3-2. Three-year running average of PM_{10} concentrations (µg/m^3) at the long-running Paul Meyer monitoring site (AQS: 32-003-0043) (orange line) and the D2 (severe) drought percentage of Nevada (blue bars). Source: https://www.drought.gov/states/nevada.

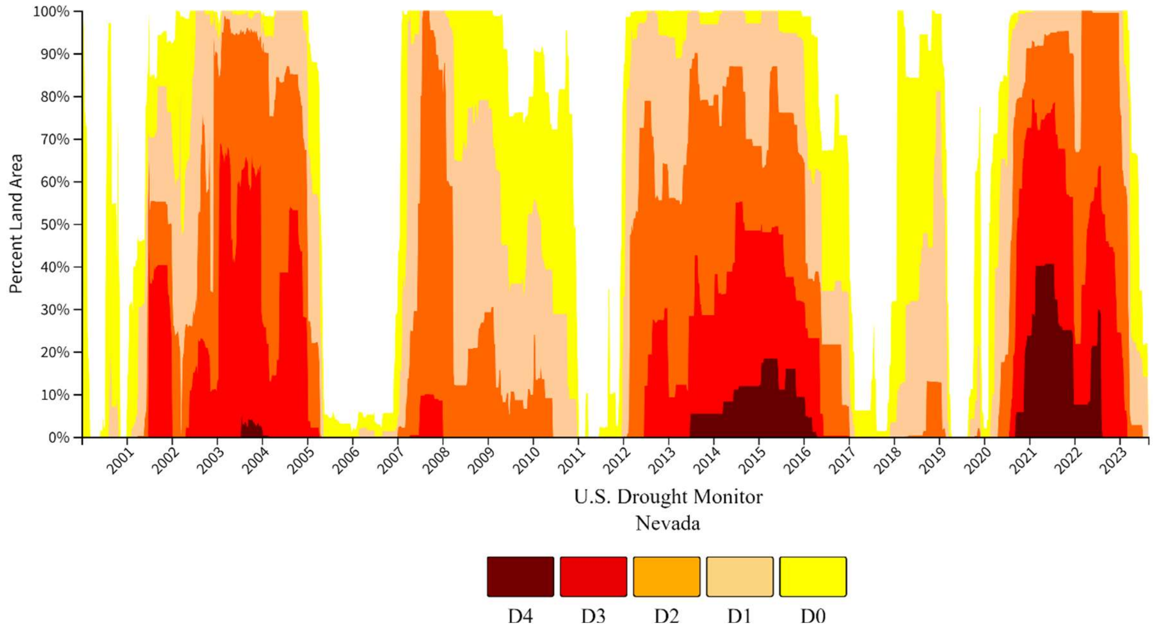


Figure 4.3-3. Drought statistics for Nevada from 2000-2023, colored by drought severity for D0 to D4. Source: **https://www.drought.gov/states/nevada**.

Historical PM_{10} exceedance frequency in Clark County has varied among air quality monitoring sites since the late 1990s and early 2000s. **Figure 4.3-4 and Figure 4.3-5** show historical 24-hour PM_{10} exceedance count and concentration and design values at site in HA212 with at least 20 years of data. PM_{10} exceedances at the Joe Neal and Green Valley sites occurred at a greater frequency (≥1 exceedance per year) in the late 1990s and early 2000s followed by a drop to no exceedances per year in the mid-2000s coinciding with BACM implementation and less severe drought conditions. Other sites show one exceedance every few years before 2022. The number of exceedances per year increased in the 2010s for most long-term sites, coinciding with more widespread and severe drought conditions in Nevada. The number of exceedances rose significantly for all long-term sites in 2022 and 2023 due to the wind-blown dust exceptional events. Without these 2022 and 2023 events, the number of exceedances would more closely align with the mid-2000s period. These observations are consistent with the historical PM_{10} and drought analysis presented in the 2012 Maintenance Plan.

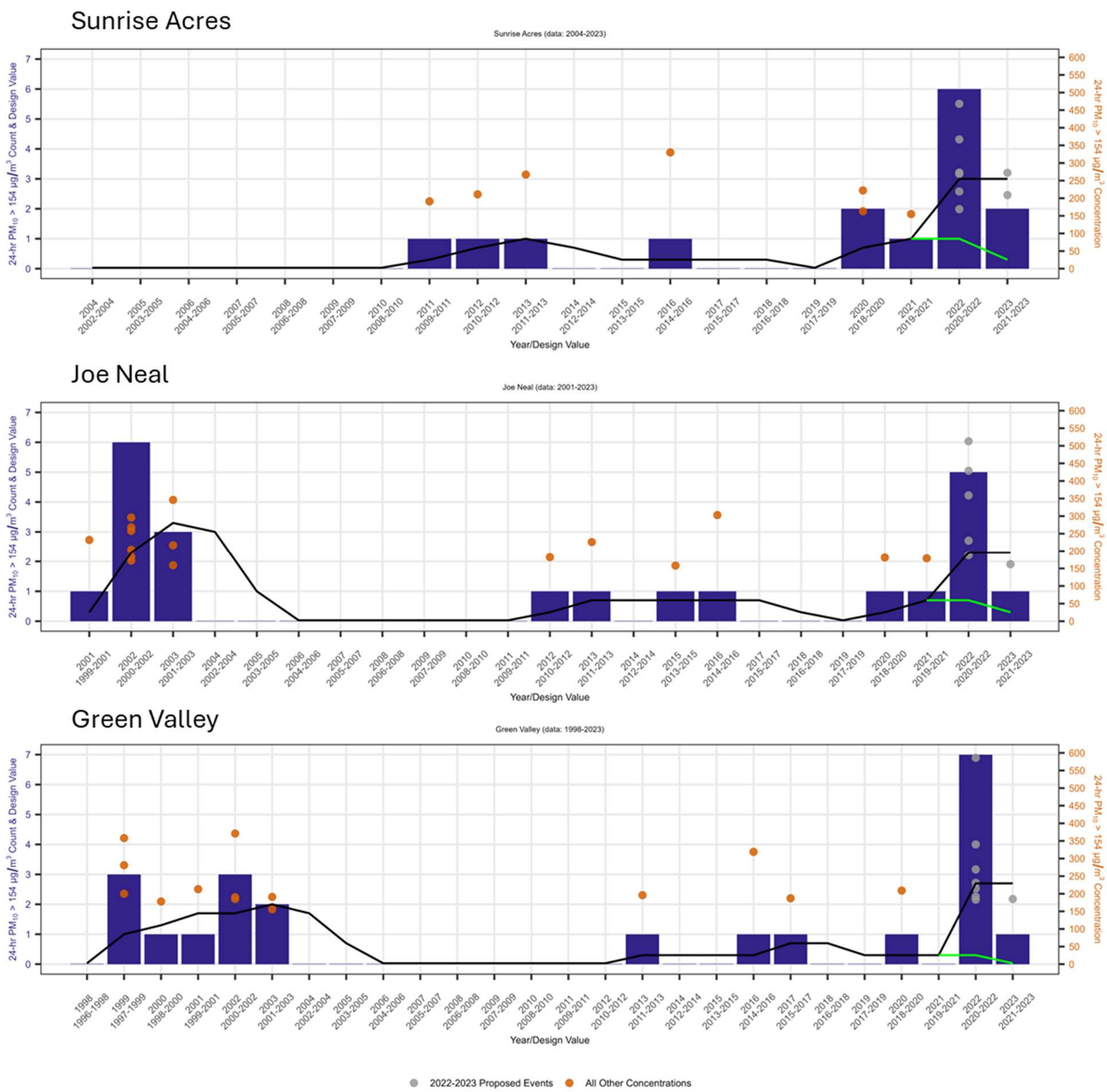


Figure 4.3-4. Historical 24-hour PM_{10} exceedance count (purple bars) and concentration (orange dots) per year/design value period at the Sunrise Acres, Joe Neal, and Green Valley monitoring sites (AQS: 32-003-0561; 32-003-0075; 32-003-0298). The gray dots represent the proposed 2022-2023 PM_{10} exceptional events, the black line represents the design value for all periods with all PM_{10} exceptional events included, and the green line represents the design value for the period with the 2022-2023 PM_{10} exceptional events excluded.

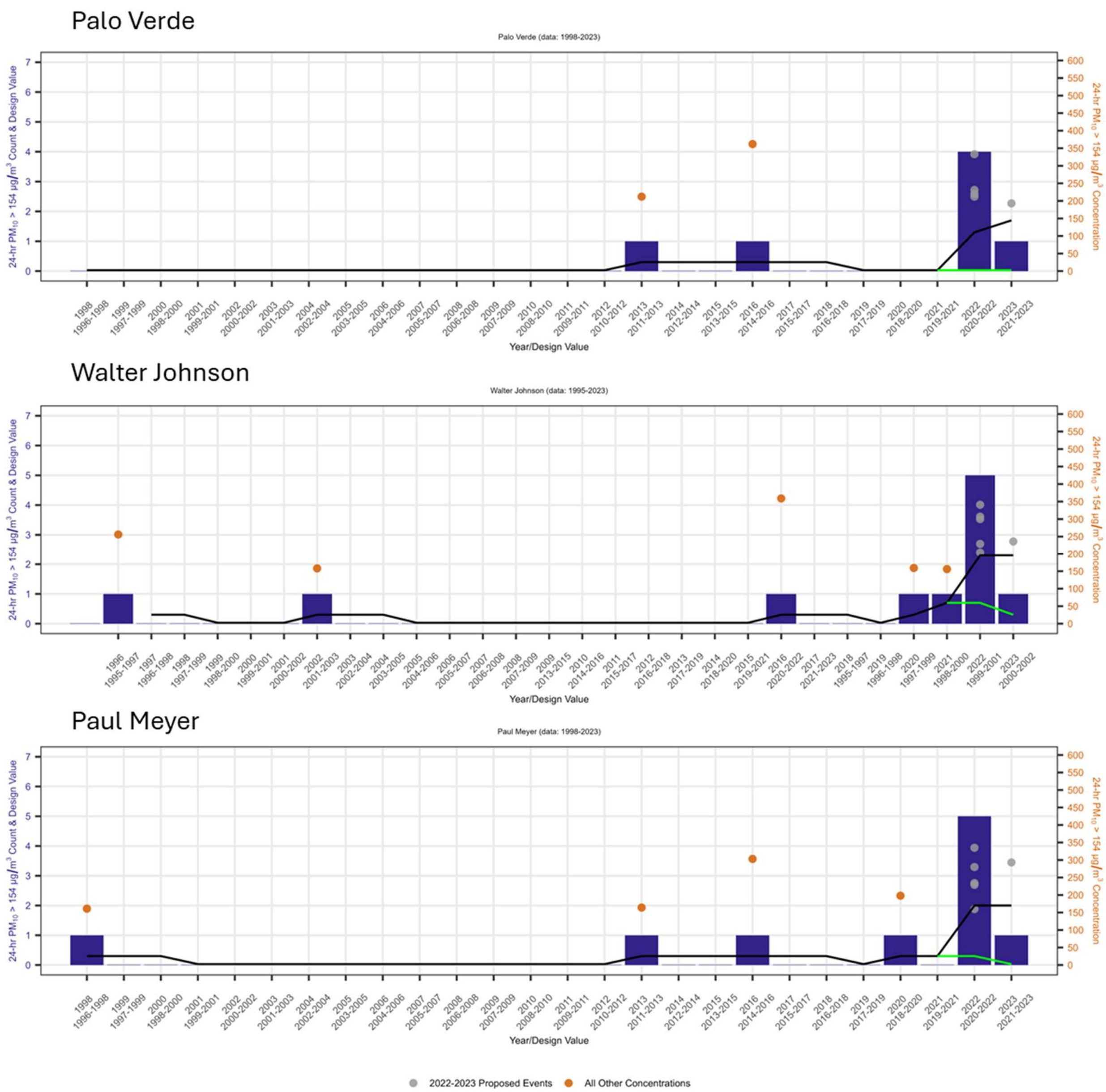


Figure 4.3-5. Historical 24-hour PM_{10} exceedance count (purple bars) and concentration (orange dots) per year/design value period at the Palo Verde, Walter Johnson, and Paul Meyer monitoring sites (AQS: 32-003-0073; 32-003-0071; 32-003-0043). The gray dots represent the proposed 2022-2023 PM_{10} exceptional events, the black line represents the design value for all periods with all PM_{10} exceptional events included, and the green line represents the design value for the period with the 2022-2023 PM_{10} exceptional events excluded.

4.3.3 Widespread Use of Controls

In addition to the similar controls listed per rule in Section 4.2, Clark County's dust control measure regulatory framework is similar to that of nearby jurisdictions. Rule 403 in the Rules and Regulations of the Mojave Desert Air Quality Management District (MDAQMD)[8] and Rule 310 of Maricopa County's (Arizona) Air Pollution Control Regulations[9] describe the regulations and enforcement of fugitive dust control measures. Like the fugitive dust controls outlined in Clark County's AQR, MDAQMD and Maricopa County provide definitions of control measures that dust-producing operations in the air agency's jurisdiction must apply to prevent, reduce, or mitigate fugitive dust. The control measures implemented by Clark County, MDAQMD, and Maricopa County emphasize the stabilization of site surfaces, and have requirements for equipment usage, permitting, and enforcement. The rules of the respective jurisdictions provide differing levels of detail and requirements regarding fugitive dust control measures. Further, the rules of the respective jurisdictions are tailored to fit the specific dust control challenges each jurisdictions faces.

The stabilization of site surfaces is defined similarly across Clark County, MDAQMD, and Maricopa County as the reduction of dust-producing capability of a disturbed surface through the treatment of the surface using methods such as watering, paving, manual compacting, or chemical treatment. Stabilization of site surfaces—where a portion of the earth's surface or material placed on the earth's surface is disturbed and has the potential to produce fugitive dust emissions—is required across all three jurisdictions. Stabilization is a critical component of dust control measures across the three jurisdictions. During high-wind events, all three jurisdictions must ensure that site surfaces are stabilized to prevent wind-blown dust. Maricopa County and Clark County specify in their respective rules that, during high-wind events, certain operations that destabilize surfaces such as blasting must cease, whereas MDAQMD requires that "non-essential" destabilizing operations must be reduced.

Specific rules regarding equipment use vary slightly across the three jurisdictions in requirements and level of detail, but generally include requirements such as speed limits for equipment while on site and limits on hauling vehicles (e.g., covers over dust-producing material). For example, MDAQMD requires that hauling vehicles working at a mining, stone, asphalt, or clay facility maintain at least six inches of freeboard (i.e., the distance between the hauled material and the top of the hauling container) on haul vehicles when transporting material on public roads, whereas Maricopa County requires that hauling vehicles working off-site in areas accessible to the public maintain at least three inches of freeboard on haul vehicles when transporting material. Maricopa County also provides detail on hauling truck operations working under other circumstances, such as on-site and not accessible to the public.

Dust control plans required across the three jurisdictions vary slightly, but are integral parts of the permitting process that detail control measures that will be implemented. All dust control plans require basic information such as site details, control measures, contingency control measures, and a summary of general day-to-day operations. The circumstance under which a dust-generating operation must submit a dust control plan differs between the jurisdictions. For example, there are seven circumstances that would require the submittal of a dust control plan to MDAQMD, such as a

[8] https://www.mdaqmd.ca.gov/home/showpublisheddocument/8482/637393282546170000

[9] https://www.maricopa.gov/DocumentCenter/View/5354/Rule-310---Fugitive-Dust-from-Dust-Generating-Operations-PDF?bidId=

"Residential Construction/Demolition Activity with a Disturbed Surface Area of at least ten (10) acres." Maricopa County, however, requires the submittal of a dust control plan for any potential dust-generating operation that would meet or exceed 0.10 acres. Clark County, under Section 94 of the AQR, requires the submittal of a dust control plan for "Construction and Temporary Commercial Activities" under four circumstances (e.g., Construction Activities that disturb soils 0.25 acres or greater in overall area).

Enforcement of dust control regulations and dust control plan compliance are also similar, but differ in level of detail and stringency between the three jurisdictions. Clark County's enforcement activities are extensive and detailed. For example, per Section 94 of the AQR, Clark County requires that, under certain circumstances, a Dust Control Monitor (i.e., a construction superintendent or other on-site representative) is given power to ensure the dust-generating operation is compliant with dust control regulations and follows the dust control plan. Maricopa County has similar rules regarding an official monitor of dust control regulation and dust control plan compliance. Officials in charge of monitoring dust-producing activities are trained in dust control practices and are generally responsible for managing and enforcing dust control practices at the dust-producing site. Dust-producing operations in violation of regulations and their dust control plan are subject to penalties.

The prevalence of similar standard fugitive dust control practices employed by Clark County, MDAQMD, and Maricopa County provide a benchmark for reasonable dust controls for similar environments in the southwest U.S.

4.3.4 Jurisdiction

As detailed in **Section 3.1.1**, on October 22, 2022, dense blowing dust from the Mojave Desert source region impacted the Las Vegas metropolitan area. Due to the strengthening pressure gradient caused by an associated surface low pressure system, surface wind speeds increased in Clark County and the Mojave Desert, which produced blowing dust in the afternoon on October 22, 2022, in the area southwest of Las Vegas. As detailed in **Section 3.2.2**, strong winds in the Mojave Desert source region were well above 25 mph from the frontal passage, which lofted, entrained, and transported dust from the source region to Clark County. From 14:00 to 20:00 PST, almost all sites in the Las Vegas Valley exceeded 500 $\mu g/m^3$. Ground-based evidence, including particulate matter analysis (**Section 3.3.4**) and visibility monitors (**Section 3.3.5**), provide additional strong evidence that PM_{10} control measures within Clark County were overwhelmed and unable to prevent an exceedance event on October 22, 2022. The timeline shown in this exceptional event demonstration highlights the progression of extremely high concentrations of PM_{10} from the source region into Clark County (and HA 212) within a very short period of time. This progression clearly indicates an upwind source of windblown dust. As the strong winds lofted, entrained, and transported dust from the Mojave Desert in southeastern California and southern Nevada, this source region was outside the jurisdiction of Clark County and the implemented control measures.

4.4 Effective Implementation of Control Measures

In addition to the SIP and AQR documentation previously provided, the Clark County DES is responsible for monitoring and forecasting air quality and enforcing dust mitigation measures before, during, and after an exceptional event. Clark County issues "advisories" and "Construction Notices" when weather conditions are forecast to be favorable for a wind-blown dust event. Advisories consist of health-based notifications disseminated to the public that provide educational materials on how to limit exposure and mitigate emissions for dust, $PM_{2.5}$, seasonal ozone, ozone, and/or smoke. Construction Notices are notifications to stationary sources, dust control permit holders, and contractors that detail mitigation measures. The issuance of Construction Notices may not meet the wind threshold for a potential high-wind dust event, but if weather conditions change to prompt a public advisory or alert, stationary sources are sent a detailed form of the public advisory or an alert with language specific to their operations and dust abatement requirements.

Dust Advisories are issued for forecasts of sustained wind speeds of 25 mph or more, or wind gusts of 40 mph or more. Construction Notices are issued for forecasts of sustained wind speeds of 20 mph or more, or wind gusts of 30-35 mph or more. Upon issuance of either a Construction Notice or an Advisory, the DES directs stationary sources to inspect their site(s), cease blasting operations, and employ BACM to stabilize all disturbed soils and reduce blowing dust. Recipients of a Construction Notice are informed that the DES officials will inspect sites to ensure BACM is being implemented.

Specific construction-related control measures include required dust control classes for construction superintendents or other on-site representatives.[10] Clark County also collects air quality complaints (including dust complaints) submitted online, over the phone, or via email, and responds to all complaints within 24 hours or the next business day.[11] Expansive rules and BACM for dust control at construction and temporary commercial activities are included in AQR Section 94. These include requirements for dust control monitors, soil stabilization standards, testing methods, and rules for non-compliance or violations if a permit or Dust Mitigation Plan has been violated. During high-wind dust periods, Clark County compliance officers inspect construction and stationary source sites to ensure BACM are being implemented, and any observed violation may receive a Notice of Non-Compliance or a Notice of Violation.

On October 20, 2022, a Dust Advisory for Saturday, October 22, 2022, was issued by Clark County to all dust control permit holders, contractors, and stationary sources instructing them to immediately inspect their site(s) and employ BACM to stabilize disturbed soils and reduce blowing dust (see **Appendix D**). In the case of a Dust Advisory, compliance officers inspect construction and stationary source sites during the episode to ensure BACM are being implemented, where any observed violation may receive a Notice of Violation. This and other Clark County public-facing alerts shown in

[10] https://www.clarkcountynv.gov/government/departments/environment_and_sustainability/compliance/dust_classes.php
[11] https://www.clarkcountynv.gov/government/departments/environment_and_sustainability/division_of_air_quality/air_quality_complaints.php

Section 3.3.1 indicated the implementation of BACM and enforcement procedures. Appendix C also provides all inspection information and notices of violation from the October 22, 2022, event.

The Clark County DES is comprised of Monitoring, Compliance and Enforcement, and Planning divisions. The Monitoring Division is primarily responsible for weather and air quality monitoring, forecasting Air Quality Index (AQI) levels and coordinating with other divisions and Clark County more broadly on the issuance of Construction Notices or Advisories. The Compliance and Enforcement Division is responsible for disseminating Construction Notices to appropriate stationary sources, dust control permit holders, and contractors. This department also disseminates Advisories to the public, conducts field inspections of sources before and during a dust event, alerts alleged violators of compliance statuses, and documents observations made in the field of enforcement actions. The Planning Division is responsible for coordinating with the other divisions to prepare exceptional event packages. Full details on these procedures can be found in Appendix D. Based on the implementation of increased control measures, as well as compliance and the enforcement of advisories for windblown dust, part 3 of the nRCP requirement is fulfilled.

The documentation and analysis presented in this demonstration and appendices demonstrate that all identified sources that caused or contributed to the exceedance were reasonably controlled, effectively implemented, and enforced at the time of the event; therefore, emissions associated with the October 22, 2022, PM_{10} event were not reasonably controllable or preventable.

5. Natural Event

The October 22, 2022, event is the result of a frontal passage and associated pressure gradient that caused high winds over the Mojave Desert source regions which lofted, entrained, and transported dust into Clark County, NV. In the case when high-wind events pass over natural undisturbed lands, the EPA considers high-wind dust events natural. In addition, there were controls in place for anthropogenic sources (**Section 4.2**) during the high-wind dust event. Therefore, we conclude this event meets the EPA criteria for a natural event.

6. Conclusions

The evidence provided within this report demonstrates that the PM_{10} exceedance on October 22, 2022, was caused by a High Wind Dust Event where dust was lofted, entrained, and transported from the extremely dry Mojave Desert in southeastern California. Key elements and evidence associated with the event timeline include:

1. A low-pressure system and associated frontal passage north of Clark County caused a pressure gradient to develop across southern California and Nevada starting at 04:00 PST on October 22, 2022. This pressure gradient caused a sharp rise in southwesterly wind speeds across an extremely dry desert source region in the Mojave Desert to the southwest of Clark County. With this frontal passage, dust from the Mojave was lofted, entrained, and transported to Clark County starting around 07:00 PST on October 22. Meteorological measurements in the source region and along the transport path show winds greater than the 25-mph threshold.

2. Back trajectories and meteorological data along the frontal passage confirm the Mojave Desert as the source region for the high-wind dust event. The frontal passage pushed south, strengthening the pressure gradient between Clark County and the source region and causing high winds to bring dust from the Mojave Desert within two to four hours of the exceedance. Satellite data, meteorological data, and visibility measurements all align to confirm event transport from the Mojave Desert. PM_{10} concentrations along the frontal passage increased as winds pushed through Kern, Inyo, and San Bernardino counties in California then Nye and Clark counties in Nevada, confirming high PM_{10} along the timeline and trajectories established.

3. A frontal passage entered Clark County by approximately 12:00 PST on October 22, 2022. Along with the frontal passage, PM_{10} was extremely enhanced, dust and weather alerts were issued, visibility measurements indicated dusty conditions, and $PM_{2.5}/PM_{10}$ ratios dropped (indicating windblown dust). Enhanced PM_{10} concentrations and low visibility due to the dust storm continued through the end of the day.

4. PM_{10} concentrations increased at the same time as the frontal passage pushed into Clark County, starting at approximately 12:00 PST and peaked in intensity between 14:00-20:00 PST on October 22, 2022. Twenty-four-hour PM_{10} concentrations were above the NAAQS threshold of 150 µg/m^3 at 12 sites (regulatory significance at 10 sites: Green Valley at 269 µg/m^3, Mountains Edge at 326 µg/m^3, Liberty High School at 351 µg/m^3, Jerome Mack at 280 µg/m^3, Joe Neal at 230 µg/m^3, Palo Verde at 231 µg/m^3, Paul Meyer at 280 µg/m^3, Sunrise Acres at 269 µg/m^3, Walnut Community Center at 291 µg/m^3, and Walter Johnson at 300 µg/m^3). The other two sites exceeding the 24-hour PM_{10} NAAQS recorded concentrations above the 99th percentile but were not regulatorily significant in this case. Hourly PM_{10} concentrations at all sites in Clark County peaked well above 500 µg/m^3 through the event

on October 22. The concurrent rise in PM_{10} at all sites around Clark County indicates a regional dust event.

5. All sites of regulatory significance exceeded the 5-year 99th percentile and the NAAQS on October 22, 2022. Hourly PM_{10} concentrations are also significantly outside typical diurnal, monthly, and seasonal ranges.
6. Clark County, NV, and the surrounding source region was under increasingly severe drought conditions on and before the October 22, 2022, event. The 30-year climatology shows that temperatures and wind speeds were above normal, while soil moisture was below normal. The barren land cover in the Mojave Desert source region was primed for significant dust production during the high-wind event. PM_{10} control measures within Clark County were quickly overwhelmed and unable to prevent an exceedance event on October 22, 2022. Dust lofted and transported from this natural, undisturbed area experiencing severe drought is considered to be a natural and not reasonable or controllable event.
7. Analysis comparing another date similar to October 22, 2022, includes dates with comparable wind profiles that did not show PM_{10} concentrations above the NAAQS. This analysis indicates that in the absence of an extremely dry source region and high surface winds, PM_{10} concentrations would not have been exceptionally high.

Within this document the following requirements for the EER have been met:

1. A narrative conceptual model that describes the event(s) causing the exceedance or violation and a discussion of how emissions from the event(s) led to the exceedance or violation at the affected monitor(s);
2. A demonstration that the event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedance or violation;
3. Analyses comparing the claimed event-influenced concentration(s) to concentrations at the same monitoring site at other times;
4. A demonstration that the event was both not reasonably controllable and not reasonably preventable;
5. A demonstration that the event was a human activity that is unlikely to recur at a particular location or was a natural event; and
6. Documentation that the air agency followed the public comment process (included in **Appendix E**).

The high-wind dust event that occurred on October 22, 2022, caused 24-hour PM_{10} NAAQS exceedances with regulatory significance at Paul Meyer (Monitor AQS ID 32-003-0043, POC 1), Mountains Edge (Monitor AQS ID 32-003-0044, POC 1), Walter Johnson (Monitor AQS ID 32-003-0071, POC 1), Palo Verde (Monitor AQS ID 32-003-0073, POC 1), Joe Neal (Monitor AQS ID 32-003-0075, POC 1), Green Valley (Monitor AQS ID 32-003-0298, POC 1), Liberty High School (Monitor AQS ID 32-003-0299, POC 1), Jerome Mack (Monitor AQS ID 32-003-0540, POC 1), Sunrise Acres (Monitor

AQS ID 32-003-0561 POC 1), and Walnut Community Center (Monitor AQS ID 32-003-2003, POC 1). On October 22, 2022, the 24-hour PM_{10} at Green Valley was 269 µg/m^3, Liberty High School was 351 µg/m^3, Jerome Mack was 280 µg/m^3, Joe Neal was 230 µg/m^3, Palo Verde was 231 µg/m^3, Paul Meyer was 280 µg/m^3, Mountains Edge at 326 µg/m^3, Sunrise Acres was 269 µg/m^3, Walnut Community Center was 291 µg/m^3, and Walter Johnson was 300 µg/m^3. Seven additional suspected wind-blown dust events occurred between 2021 and 2023. Without EPA concurrence that the wind-blown dust event on October 22, 2022, and the other suspected events qualify as exceptional events, the 2020-2022 design value is 2.0 at Paul Meyer, 1.7 at Mountains Edge, 2.3 at Walter Johnson, 1.7 at Palo Verde, 2.3 at Joe Neal, 2.7 at Green Valley, 3.0 at Liberty High School, 3.7 at Jerome Mack, 3.0 at Sunrise Acres, and 4.0 at Walnut Community Center. This is outside of the attainment standard of 1.0. With EPA concurrence on October 22, 2022, and the other suspected events, the 2021-2023 design value is 0.0 at Paul Meyer, 0.3 at Mountains Edge, 0.3 at Walter Johnson, 0.0 at Palo Verde, 0.3 at Joe Neal, 0.0 at Green Valley, 0.3 at Liberty High School, 0.3 Jerome Mack, 0.3 at Sunrise Acres, and 1.0 at Walnut Community Center, within the attainment standard. Within this demonstration, all elements of the EER have been addressed. Therefore, we request that the EPA consider the overwhelming evidence of windblown dust that occurred in Clark County on October 22, 2022, and agree to exclude the event from regulatory decisions regarding PM_{10} attainment.

7. References

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