ENCLOSURE: TECHNICAL SUPPORT DOCUMENT FOR EPA CONCURRENCE ON O_3 EXCEEDANCES MEASURED IN WASHOE COUNTY ON JULY 2-4, 2016, AS EXCEPTIONAL EVENTS

EXCEPTIONAL EVENTS RULE REQUIREMENTS

EPA promulgated the Exceptional Events Rule (EER) in 2007, pursuant to the 2005 amendment of Clean Air Act (CAA) Section 319. In 2016, EPA finalized revisions to the EER. The 2007 EER and the 2016 revisions added 40 CFR §50.1(j)-(r); §50.14; and §51.930 to the Code of Federal Regulations (CFR). These sections contain definitions, criteria for EPA approval, procedural requirements, and requirements for air agency demonstrations. EPA reviews the information and analyses in the air agency's demonstration package using a weight of evidence approach and decides to concur or not concur. The demonstration must satisfy all of the EER criteria for the EPA to concur with excluding the air quality data from regulatory decisions.

Under 40 CFR §50.14(c)(3)(iv), the air agency demonstration to justify data exclusion must include:

A. "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);"

B. "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;"

C. "Analyses comparing the claimed event-influenced concentration(s) to concentrations at the same monitoring site at other times" to support requirement (B) above;

D. "A demonstration that the event was both not reasonably controllable and not reasonably preventable;" and

E. "A demonstration that the event was a human activity that is unlikely to recur at a particular location or was a natural event."[1]

In addition, the air agency must meet several procedural requirements, including:

1. submission of an Initial Notification of Potential Exceptional Event and flagging of the affected data in the EPA's Air Quality System (AQS) as described in 40 CFR §50.14(c)(2)(i),

2. completion and documentation of the public comment process described in 40 CFR

[1] A natural event is further described in 40 CFR §50.1(k) as "an event and its resulting emissions, which may recur at the same location, in which human activity plays little or no direct causal role. For purposes of the definition of a natural event, anthropogenic sources that are reasonably controlled shall be considered to not play a direct role in causing emissions."

§50.14(c)(3)(v), and

3. implementation of any applicable mitigation requirements as described in 40 CFR §51.930.

For data influenced by exceptional events to be used in initial area designations, air agencies must also meet the initial notification and demonstration submission deadlines specified in Table 2 to 40 CFR §50.14.

Narrative Conceptual Model

EPA expects that a narrative conceptual model of the event will describe and summarize the event in question and provide context for analyzing the required statutory and regulatory technical criteria. Air agencies may support the narrative conceptual model with summary tables or maps. For wildfire ozone (O_3) events, the EPA recommends that the narrative conceptual model also discuss the interaction of emissions, meteorology, and chemistry of event and non-event O_3 formation in the area, and, under 40 CFR §50.14(a)(1)(i), the regulatory significance of the requested data exclusion.

Clear Causal Relationship (CCR) and Supporting Analyses

EPA considers a variety of evidence when evaluating whether there is a clear causal relationship between the specific event and the monitored exceedance or violation. For wildfire O_3 events, air agencies should compare the O_3 data requested for exclusion with historical concentrations at the air quality monitor to establish a clear causal relationship between the event and the monitored data. In addition to providing this information on the historical context for the event-influenced data, air agencies should further support the clear causal relationship criterion by providing evidence that the wildfire's emissions were transported to the monitor, that the emissions from the wildfire influenced the monitored concentrations, and, in some cases, air agencies may need to provide evidence of the contribution of the wildfire's emissions to the monitored O_3 exceedance or violation.

For wildfire O_3 events, EPA has published a guidance document[2] that provides three different tiers of analyses that apply to the "clear causal relationship" criterion within an air agency's exceptional events demonstration. This tiered approach recognizes that some wildfire events may be more clear and/or extreme and, therefore, require relatively less evidence to satisfy the rule requirements. If a wildfire O_3 event satisfies the key factors for either Tier 1 or Tier 2 clear causal analyses, then those analyses are the only analyses generally necessary to support the clear causal relationship criterion within an air agency's demonstration for that particular event. Other wildfire/O_3 events will be considered based on Tier 3 analyses.

- Tier 1: Wildfires that clearly influence monitored O_3 exceedances or violations when they occur in an area that typically experiences lower O_3 concentrations.

[2] "Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations," dated September 16, 2016 ("EPA's wildfire O_3 guidance document").

- *Key Factor*: seasonality and/or distinctive level of the monitored O_3 concentration. The event-related exceedance occurs during a time of year that typically has no exceedances, or is clearly distinguishable (*e.g.*, 5-10 ppb higher) from non-event exceedances.
- In these situations, O_3 impacts should be accompanied by clear evidence that the wildfire's emissions were transported to the location of the monitor.

- Tier 2: The wildfire event's O_3 influences are higher than non-event related concentrations, and fire emissions compared to the fire's distance from the affected monitor indicate a clear causal relationship.
  - *Key Factor 1*: fire emissions and distance of fire(s) to affected monitoring station location(s). Calculated fire emissions of nitrogen oxides (NO_x) and reactive-volatile organic compounds (VOC) in tons per day (Q) divided by the distance from the fire to the monitoring station (D) should be equal to or greater than 100 tons per day/kilometers ($Q/D \geq 100$ tpd/km). EPA's wildfire O_3 guidance document provides additional information on the calculation of Q/D.
  - *Key Factor 2*: comparison of the event-related O_3 concentration with non-event related high O_3 concentrations. The exceedance due to the exceptional event:
    - is in the 99_{th} or higher percentile of the 5-year distribution of O_3 monitoring data, OR
    - is one of the four highest O_3 concentrations within 1 year (among those concentrations that have not already been excluded under the Exceptional Events Rule, if any).
  - In addition to the analysis required for Tier 1, the air agency should supply additional evidence to support the weight of evidence that emissions from the wildfire affected the monitored O_3 concentration.

- Tier 3: The wildfire does not fall into the specific scenarios (i.e. does not meet the key factors) that qualify for Tier 1 or Tier 2, but the clear causal relationship criterion can still be satisfied by a weight of evidence showing.
  - In addition to the analyses required for Tier 1 and Tier 2, an air agency may further support the clear causal relationship with additional evidence that the fire emissions caused the O_3 exceedance.

Not Reasonably Controllable or Preventable (nRCP)

The EPA requires that air agencies establish that the event be both not reasonably controllable and not reasonably preventable at the time the event occurred. This requirement applies to both natural events and events caused by human activities; however, it is presumed that wildfires on wildland will satisfy both factors of the "not reasonably controllable or preventable" element unless evidence in the record clearly demonstrates otherwise.[3]

[3] A wildfire is defined in 40 CFR §50.1(n) as "any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire. A wildfire that predominantly occurs on wildland is a natural event." Wildland is defined in 40 CFR 50.1(o) as "an area in which human activity and development are essentially non-existent, except for roads, railroads, power lines, and similar transportation facilities. Structures, if any, are widely scattered."

Natural Event or Event Caused by Human Activity That is Unlikely to Recur

According to the CAA and the Exceptional Events Rule, an exceptional event must be "an event caused by human activity that is unlikely to recur at a particular location *or* a natural event" (emphasis added). The 2016 EER includes in the definition of wildfire that "[a] wildfire that predominantly occurs on wildland is a natural event." Once an agency provides evidence that a wildfire on wildland occurred and demonstrates that there is a clear causal relationship between the measurement under consideration and the event, the EPA expects minimal documentation to satisfy the "human activity that is unlikely to recur at a particular location or a natural event" element. The EPA will address wildfires on other lands on a case-by-case basis.

OVERVIEW OF EVENTS

On November 10, 2016, Washoe County Health District (WCHD) submitted an Initial Notification of Potential Exceptional Event for four exceedances of the 2015 8-hour O_3 National Ambient Air Quality Standard (NAAQS) that occurred at the Reno3 monitoring station within Washoe County, Nevada on July 2-4, 2016, and July 21, 2016.[4] EPA determined at the time that data exclusion of some of the exceedances may have a regulatory significance for initial area designations for the 2015 8-hour O_3 NAAQS, and worked with WCHD to identify the relevant exceedances.[5]

On April 14, 2017, WCHD submitted an exceptional events demonstration for three exceedances of the 2015 8-hour O_3 NAAQS that occurred at the Reno3 monitoring station within Washoe County, NV on July 2-4, 2016.[6] Table 1 summarizes these exceedances.

In their demonstration, WCHD stated that the three O_3 exceedances measured on July 2, July 3, and July 4, 2016, were caused by emissions from wildfires. Specifically, WCHD stated that the three exceedances were "due to wildfire smoke plume impacts from the Trailhead Fire in California." [7]

Table 1: EPA 8-hour O_3 Exceedance Summary

Exceedance Date	Monitor/Station Name	AQS ID	Max. 8-hour Avg. (ppm)
July 2, 2016	Reno3	32-031-0016	0.073
July 3, 2016	Reno3	32-031-0016	0.073
July 4, 2016	Reno3	32-031-0016	0.073

[4] "Initial Notification of Potential Exceptional Event Information Summary," dated November 10, 2016 ("initial notification").
[5] See email, "Response to Washoe County 2016 Wildfire Ozone Initial Notification Exceptional Events," from Gwen Yoshimura, U.S. EPA Region 9 Air Division, to Daniel Inouye, WCHD Air Quality Management Division, dated February 17, 2017.
[6] "Exceptional Events Demonstration for Ozone Exceedance in Washoe County from the Trailhead Fire on July 2 through July 4, 2016," ("demonstration").
[7] See demonstration, p. 9.

Narrative Conceptual Model

WCHD's demonstration provided a narrative conceptual model to describe how emissions from the Trailhead Fire, a wildfire near Volcanoville, California and approximately 100 km southwest of the Reno/Sparks area, caused O_3 exceedances at the Reno3 monitoring station. Section 1 of the demonstration included non-event characteristics of Washoe County and the Reno/Sparks area, such as general descriptions of the geography, topography, and meteorology; a description of the ambient air quality monitoring network; and a summary of typical non-event O_3 formation in the Reno/Sparks area, including discussion of O_3 precursor emissions, seasonal patterns, and meteorology associated with typical exceedances. WCHD also included a general description of how wildfires in the western U.S. affect air quality in the Reno/Sparks area and a summary of analyses that generally indicate or support the presence of smoke affecting air quality in the area.

Section 2 of the demonstration described event-related characteristics, and included WCHD's claims that the exceedances observed were caused by emissions from the Trailhead wildfire in California, and that these exceedances qualify as an exceptional event under the EER. WCHD also stated that the proposed data exclusion has regulatory significance for initial area designations for the 2015 8-hour O_3 NAAQS. WCHD summarized the event, asserting that wildfire emissions from the Trailhead Fire began to impact the Reno/Sparks area on June 29, 2016, and continued to impact the region through July 4, 2016. WCHD provided maps of the Trailhead Fire perimeter on June 29, July 2, and July 4; satellite imagery of the area on June 29 through July 4; and Hazard Mapping System (HMS) smoke contours showing light to moderate density smoke associated with the Trailhead Fire in or near the Reno/Sparks area and the Reno3 monitoring station.

WCHD presented 8-hour maximum O_3 concentrations for all O_3 monitoring stations in the WCHD network between June 25 and July 11, 2016. WCHD also plotted an hourly time series of O_3, NO_x, and $PM_{2.5}$ concentrations at the Reno3 monitoring station, along with an hourly time series of O_3 and $PM_{2.5}$ concentrations at the other stations in the WCHD network covering the same period. WCHD stated that elevated concentrations of O_3 and $PM_{2.5}$ throughout the network demonstrate that the impacts from wildfire emissions were regional and consistent with dispersion from a fire 100 km away.

WCHD used daily weather maps from June 29 through July 5, 2016 to analyze large-scale meteorological features during the event, and compared meteorology (temperature and wind speeds) in the Reno/Sparks area during the event days (July 2-4, 2016) and other days affected by the Trailhead Fire (June 29-July 1, 2016) with meteorology on days before and after the event. WCHD also used visibility data from nearby airports to identify effects from wildfire emissions on visibility measurements in the Reno area on July 2 and July 3. WCHD included media reports of smoke in the area between June 29 and July 3, 2016, including one image from a BlueSky smoke forecasting run showing heavy smoke forecast to be present in the

Reno/Sparks area, and described their public notification process for alerting the public of pollution episodes such as this event.

Based on the information described above, WCHD's demonstration meets the narrative conceptual model criterion of the EER.

Table 2: Documentation of Narrative Conceptual Model

Exceedance Date	Demonstration Citation	Quality of Evidence	Criterion Met?
July 2, 2016	Section 1: p 1-8 Section 2: p 9-49	Sufficient	Yes
July 3, 2016	Section 1: p 1-8 Section 2: p 9-49	Sufficient	Yes
July 4, 2016	Section 1: p 1-8 Section 2: p 9-49	Sufficient	Yes

Clear Causal Relationship (CCR)

WCHD's demonstration included several analyses to support a clear causal relationship between the wildfire event and the monitored exceedances. These analyses are presented in Section 3 of WCHD's demonstration, or in some cases, within the conceptual model (Section 2).

Comparison with historical concentrations

WCHD included a comparison with historical concentrations, as required by 40 CFR §50.14(c)(3)(iv)(C). WCHD compared the event-related O_3 concentrations with all summertime (June through August) concentrations from 2011-2016 (Section 3.2). The plots provided show that 8-hour maximum O_3 concentrations for all three days are at the 99^{th} percentile value (0.073 ppm) for the O_3 season, calculated using 2011-2016 data. The historical concentration plots also show that this monitor has observed concentrations at or above 0.073 ppm on twelve other occasions during the summertime (June through August), including three exceedances in August 2015 that are the subject of another exceptional events demonstration, and that exceedances, including those at or above 0.073 ppm, have been observed throughout the summertime.

Tier 1: Key Factor

To meet the key factor for a Tier 1 analysis, exceedances should be clearly higher than other, non-event related exceedances, or occur during a time of year that typically experiences no exceedances. The event-related exceedances identified in this demonstration occurred during the regular O_3 season, during times when other exceedances similar in magnitude were measured. Therefore, the event exceedances do not meet the Tier 1 Key Factor, and additional evidence beyond a Tier 1 analysis is needed to support the clear causal relationship.

Tier 2: Key Factors

WCHD evaluated the Tier 2 Key Factors in Section 3.3 of the demonstration. For Tier 2 Key Factor 1, WCHD provided an analysis of fire emissions (Q) and distance (D) of the wildfires to the affected monitoring station location.[8] WCHD calculated Q/D for the Trailhead Fire

[8] See demonstration, p. 50-51.

separately for each day between June 28 and July 4, using BlueSky Playground.[9] WCHD also stated that emissions from the smoke plume that began to impact the area on June 29, 2016 did not fully dissipate each day, and thus a multi-day Q/D was calculated. WCHD included a column with an aggregation of the individual Q/D calculations for the wildfire up to that date (e.g., aggregated Q/D for June 30 was the sum of Q/D calculated for June 28, June 29, and June 30). The daily Q/D values for the exceedance days range from 0.35 to 4.34 tpd/km, and the cumulative Q/D values range from 11.31 to 16.00 tpd/km. EPA agrees that aggregation of Q/D from multiple days may be appropriate for this event based on evidence presented later in this section; however, all values are well below the Tier 2 Key Factor 1 screening value of 100 tpd/km. Therefore, the event exceedances do not meet Tier 2 Key Factor 1.

For Tier 2 Key Factor 2, WCHD provided evidence that the exceedances are at or above the 99th percentile of the past six years of data from the O_3 season (June through August).[10] WCHD's analysis calculated the percentile for summertime O_3 data only rather than the full year, which acts to increase the 99th percentile value and is a more stringent metric. Also, WCHD provided evidence that the exceedances were three of the four highest concentrations in 2016. Therefore, WCHD has demonstrated that the event exceedances meet Tier 2 Key Factor 2.

Based on the analysis of the Key Factors for Tier 2, EPA's wildfire O_3 guidance document indicates that a Tier 3 analysis is appropriate for this event. As described below, WCHD's demonstration included the required elements for a Tier 3 clear causal relationship analysis, based on EPA's wildfire O_3 guidance document. This includes evidence to support that (1) wildfire emissions were transported from the wildfire to the monitor; (2) wildfire emissions affected the monitor; and (3) wildfire emissions caused the O_3 exceedances.

Evidence of transport of wildfire emissions from the wildfire to the monitor

WCHD presented a trajectory analysis using the HYSPLIT model, along with HMS smoke contours for light, medium, and heavy smoke.[11] WCHD included 24-hour back trajectories from the Reno3 monitoring station at 1000 and 1500 meter (m) altitudes for June 28 through July 5, 2016 at 1500 PST, to show transport of wildfire emissions affecting the Reno/Sparks area June 29 through July 4. The trajectories are consistent with transport from the Trailhead Fire and surrounding areas containing medium or light density smoke from the same fire, as indicated by HMS smoke contours and descriptive text product, throughout the June 29 through July 4 period. The trajectories clearly indicate transport from the wildfire and surrounding areas of smoke to the Reno3 monitoring station on the three O_3 exceedance days. WCHD also included 24-hour forward trajectories from the Trailhead Fire in Appendix F, which are also consistent with transport from the wildfire to the Reno/Sparks area and the Reno3 monitoring station.

In addition to the trajectory analysis, WCHD provided an analysis of synoptic scale meteorological features using weather maps from June 29 through July 5.[12] The analysis was generally consistent with the transport of wildfire emissions from the Trailhead Fire to the Reno/Sparks area and the Reno3 monitoring station. WCHD also included satellite imagery, as

[9] U.S. Forest Service's Bluesky Playground, available at https://tools.airfire.org/playground/.
[10] See demonstration, p. 33 and p. 51-53.
[11] See demonstration, p. 63-71.
[12] See demonstration, p. 36-44.

well as the HMS smoke contours previously described, that show areas of light to moderate smoke density in or near the Reno/Sparks area and the Reno3 monitoring station each day from June 29 through July 4.[13]

EPA's wildfire O_3 guidance document suggests that to show transport, satellite imagery should be accompanied by evidence of the plume reaching the ground.[14] WCHD provided media reports of smoke presence in the area, elevated hourly $PM_{2.5}$ measurements, visibility data from nearby airports, and 24-hour $PM_{2.5}$ concentrations to support that the plume reached the ground during the wildfire-affected period (June 29 through July 4), including all three exceedance days.[15]

Overall, the trajectory analysis, satellite imagery, and evidence of smoke reaching the ground show that emissions from the Trailhead Fire in northern California were transported to the Reno/Sparks area and the Reno3 monitoring station on all three exceedance days.

Evidence that the wildfire emissions affected the monitor

WCHD provided several forms of evidence that the wildfire emissions reached the ground and affected the Reno3 monitoring station. As described above, WCHD included media reports of smoke presence in the Reno/Sparks area and visibility data from nearby airports to support that smoke reached the ground from June 29 through July 4.[16] On p. 87 of the demonstration and in Appendix G, WCHD also included Area Forecast Discussions from the National Weather Service (NWS) in Reno that describe high westerly winds transporting smoke from the Trailhead Fire to the Reno/Sparks area and affecting ground level air quality in the region. These documents support the weight of evidence that smoke was observed at ground level and affected air quality in the greater Reno/Sparks area.

WCHD also provided hourly pollutant concentrations for $PM_{2.5}$, NO_x, and O_3 at the Reno3 monitoring station, and for O_3 and $PM_{2.5}$ at other stations within the WCHD monitoring network.[17] $PM_{2.5}$ in particular is a good indicator for wildfire emissions during summer months in the Reno/Sparks area; the area typically experiences low $PM_{2.5}$ unless affected by wildfire smoke, or by dust events tied to thunderstorms (which did not occur prior to or during the event period). The hourly pollutant data clearly show elevated concentrations for $PM_{2.5}$ and O_3 throughout the wildfire-affected period (June 29 through July 4) as compared to the several days prior to and following the wildfire. WCHD also compared 24-hour average $PM_{2.5}$ concentrations for June 29 through July 4 to historical data for June 15 through July 15 in 2012-2016, excluding data that WCHD had flagged for wildfire impact.[18] The 24-hour average $PM_{2.5}$ concentrations from June 29 through July 4 were several $\mu g/m^3$ above the 98^{th} percentile value for non-flagged 2012-2016 data. The first two exceedance days (July 2 and July 3) were particularly high - over two times the 98^{th} percentile value. These analyses further support that wildfire emissions reached the ground and affected air quality at the Reno3 monitoring station.

[13] See demonstration, p. 10-31
[14] See EPA's wildfire O_3 guidance document, p. 14-15.
[15] See demonstration, p. 32-37, p. 47-49, p. 72-82, and Appendix E.
[16] See demonstration, p. 36-37, p. 47-49, and Appendix E.
[17] See demonstration, p. 32-35.
[18] See demonstration, p. 72-73.

WCHD examined speciation data from the Chemical Speciation Network (CSN) available at the Reno3 monitoring station for elemental carbon (EC) and organic carbon (OC).[19] WCHD presented EC and OC concentrations for every three days between June 23 and July 11, 2016, corresponding with the CSN operating schedule. WCHD also compared these concentrations to the median and 98th percentile concentration for each species from June through August of 2011-2015, excluding flagged data as described previously. Concentrations for both EC and OC were near the median for each value on sample days prior to and after the wildfire (June 23, June 26, July 8, and July 11). Concentrations of OC on June 29, when smoke began to affect the Reno/Sparks area, were between 7 and 8 µg/m^3 (approximately 4.5 times the median), and on July 2, the first O_3 exceedance day, were 9.48 µg/m^3 (approximately 6 times the median). Both concentrations were also well above the 98th percentile value for OC. Concentrations of EC were similarly elevated on June 29 and July 2, although at a smaller magnitude, with concentrations on both days approximately at the 98th percentile value. On July 5, the EC concentration was near the median, and OC was just under 3 µg/m^3 (above the median but below the 98th percentile), consistent with a possible small residual smoke effect from the previous day. The EC and OC concentrations, particularly OC, strongly support that wildfire emissions were present and affected air quality at the Reno3 monitoring station on June 29, and even more strongly on the July 2 exceedance day, with a reduced effect by July 5. These observations also support that wildfire emissions were very likely present at the monitor on the other exceedance days (July 3 and July 4), although observations were not collected on those dates due to the sampling schedule.

WCHD's narrative conceptual model asserted that wildfire smoke increases the ratio of $PM_{2.5}$ to PM_{10} in the Reno/Sparks area.[20] Accordingly, WCHD evaluated the ratio of 24-hour average $PM_{2.5}$ and PM_{10} concentrations for June 28 through July 5.[21] Ratios from before and after the wildfire, on June 28 and July 5, were 0.49 and 0.47, respectively. Ratios calculated for days during the wildfire period ranged from 0.58 to 0.62, a clear increase. This further supports that smoke reached the Reno3 monitoring station and affected air quality.

Finally, WCHD evaluated $PM_{2.5}$/carbon monoxide (CO) enhancement ratios.[22] This more detailed analysis of ozone precursors adds to the weight of evidence that smoke affected the Reno3 monitoring station. As explained by Laing, et al.,[23] $PM_{2.5}$/CO enhancement ratios can be calculated by determining the regression slope of CO versus $PM_{2.5}$ during a smoke or pollution event, and can be used as an indicator of smoke impact. Mobile emission and urban background $PM_{2.5}$/CO ratios are much lower than typical wildfire smoke ratios; typical urban measurements are on the order of 20-45 µg/m^3 ppmv^{-1}, while wildfire smoke ratios are typically well-correlated and above 100 µg/m^3 ppmv^{-1}. For each of the three exceedance days (July 2-4), WCHD calculated slopes based on hourly $PM_{2.5}$ and CO values, and compared these to a slope calculated on a non-event day (June 26, 2016). WCHD's non-event slope was approximately -2 µg/m^3 ppmv^{-1}, with a very low R^2 (0.0002). On July 2 and July 3, the slopes (~132 and 112 µg/m^3 ppmv^{-1}, respectively) and R^2 (0.8641 and 0.7503) clearly indicate the influence of wildfire

[19] See demonstration, p. 83-84.
[20] See demonstration, p. 7.
[21] See demonstration, p. 85.
[22] See demonstration, p. 85-87.
[23] Laing J.R., Jaffe D.A., Slavens A.P., Li W., Wang, W. Using ΔPM2.5/ΔCO and ΔNOy/ΔCO Enhancement Ratios to Identify Wildfire Smoke in Urban Areas. Submitted to Aerosol and Air Quality Research, Feb. 2017.

emissions. On July 4, the slope (~80 µg/m^3 $ppmv^{-1}$) is larger than the non-event slope, and is also well above the range of normal urban ratios, suggesting mixing of the smoke-related $PM_{2.5}$ and CO signal with ambient urban air. The increase in R^2 (0.5897) when compared to the non-event day also supports that concentrations of these pollutants on July 4 were affected by wildfire emissions. This analysis strongly adds to the weight of evidence that wildfire emissions reached the ground and affected air quality within the Reno/Sparks area and specifically at the Reno3 monitoring station.

Overall, the media reports and airport visibility data, elevated hourly $PM_{2.5}$ and O_3 concentrations and 24-hour $PM_{2.5}$ concentrations, elevated OC and EC concentrations, increase in $PM_{2.5}/PM_{10}$ ratio, and elevated $PM_{2.5}$/CO ratios and correlation coefficients clearly support that wildfire emissions reached the ground and affected measurements at the Reno3 monitoring station between June 29 and July 4, including on the three exceedance days (July 2-4).

Additional evidence that the wildfire emissions caused the O_3 exceedance

WCHD provided additional evidence to support that the wildfire emissions specifically affected O_3 concentrations at the Reno3 monitoring station and caused the O_3 exceedances. WCHD assessed diurnal patterns in O_3 concentrations by comparing hourly O_3 concentrations for June 28 through July 5 with the 5^{th}, 50^{th}, and 95^{th} percentile O_3 concentrations for each hour, based on 2011-2015 data.[24] The three percentile hourly profiles show a similar pattern to one another, with the lowest O_3 concentrations typically observed around 6am, steeply increasing to a peak around 12pm (consistent with photochemical production of O_3 caused by increasing light intensity and precursor concentrations), and then slowly decreasing throughout the afternoon, evening, and night. On June 28, prior to start of wildfire emissions affecting the Reno3 monitoring station, the diurnal profile was fairly similar to the percentile profiles.

Beginning on June 29, however, a unique feature appeared in the diurnal profile: after reaching the earlier, typical late morning/early afternoon peak and beginning to decrease, O_3 concentrations began to increase again at approximately 1500 PST, with a total increase of over 10 ppb resulting in a second peak around 2000 PST. This second afternoon peak is clearly atypical for the region based on the percentile profiles. As the increase occurred while light intensity was decreasing and wind speeds were increasing, which normally acts to reduce O_3 concentrations, the peak suggests transport of O_3 and/or high concentrations of O_3 precursors into the area. On June 30, the same late afternoon peaking feature occurred, and additionally, the initial morning O_3 concentrations were higher (following approximately the 95^{th} percentile line) due to effects from high concentrations in the late afternoon and evening carrying over to the next day. In mid-day, concentrations dropped relative to the percentile lines, possibly due to partial clearing out of the smoke from the previous day. Similarly, high baseline morning O_3 and unusual late afternoon increases in O_3 were observed on July 1-4. The patterns indicate that the wildfire caused higher-than-usual O_3 concentrations throughout the wildfire-affected period, but did not cause exceedances on the first few days. On the exceedance days (July 2-4), morning baseline O_3 was even higher than on the previous wildfire-affected days, possibly due to cumulative carryover from multiple days and/or higher smoke density. Also, during the exceedance days, while mid-day concentrations still decreased relative to percentile lines, the magnitude was smaller than on the previous three days, suggesting that less of the previous day's

[24] See demonstration, p. 54-62.

smoke was cleared out during this time. The 8-hour average O_3 concentrations that exceed the standard on each day correspond with both the abnormally high morning peak (due to wildfire emissions and resulting high O_3 carried over from the previous afternoon), as well as the secondary afternoon O_3 increase (which reflects additional transport of emissions to the area). On July 5, carryover effects from high O_3 on the previous days were still observed; however, while late afternoon concentrations remained high, there was no second increase or peak, consistent with the substantial decrease in wildfire emissions and minimal smoke observed on that day. The clearly atypical diurnal features in O_3 concentrations and their magnitude at the Reno3 monitoring station throughout the active wildfire period, and in particular on the exceedance days, strongly indicate that wildfire emissions caused the O_3 exceedances.

To further support this analysis, WCHD provided similar percentile and daily profile plots for $PM_{2.5}$ during the wildfire-affected period, with percentile values calculated by excluding data flagged as affected by wildfires.[25] Since prior analyses demonstrated that the elevated $PM_{2.5}$ during June 29 through July 4 was clearly the result of wildfire emissions (see subsection above, "Evidence that the wildfire emissions affected the monitor"), any abnormally high $PM_{2.5}$ hourly concentrations can show the timing and magnitude of wildfire emission effects. The hourly $PM_{2.5}$ plots are highly consistent with the O_3 features described above. Diurnal behavior of $PM_{2.5}$ concentrations on June 28 was fairly typical. On June 29, a large increase in $PM_{2.5}$ concentration was observed starting at 1500 PST and peaking at 2000 PST, consistent with the timing of the abnormal O_3 peak described previously. The peak $PM_{2.5}$ concentration was five times the hourly 95th percentile value. On June 30, $PM_{2.5}$ concentrations remained high (above the 95th percentile line) until mid-morning, and then decreased to approximately the 50th percentile line, suggesting that smoke cleared out mid-day. This is again consistent with high overnight O_3 concentrations due to residual wildfire emissions present in the area, as well as decreases in mid-day concentrations (relative to percentiles). At approximately 1500 PST, $PM_{2.5}$ concentrations increased to above the 95th percentile line again, consistent with the abnormal late afternoon peak in O_3. This general pattern (increasing late afternoon $PM_{2.5}$ coincident with abnormal increasing O_3, concentrations remaining high through the evening and night consistent with elevated baseline O_3, then decreasing in mid-day for a few hours consistent with drops in O_3) persisted throughout the wildfire-affected period (June 29 through July 4). Concentrations on July 2-4 also showed less of a decrease in mid-day than the previous days, and for fewer hours, consistent with persistent wildfire emissions that did not fully clear out, as also described for O_3 concentrations. This analysis strongly supports the analysis of O_3 profiles above that indicates that 8-hour O_3 exceedances were caused by wildfire emissions. We also note that, as these analyses indicate that smoke did not fully clear out on several of the days, these analyses also support aggregation of multiple days for a Q/D calculation.

The Area Forecast Discussions from the NWS in Reno, discussed previously, further corroborate the timing and magnitude of wildfire emission effects on O_3 concentrations described above. For the wildfire-affected period, these products specifically describe smoke from the Trailhead Fire arriving in the area in the late afternoon, persisting through the evening and into morning, and mixing/clearing out for portions of mid-day, consistent with the O_3 and $PM_{2.5}$ hourly features noted above. The forecast discussions also include descriptions of smoke persisting longer and mixing out more slowly starting on July 2 (the first exceedance day), also consistent with the

[25] See demonstration, p. 74-82.

features observed in O_3 and $PM_{2.5}$. These forecast discussions provide additional evidence that the abnormal O_3 diurnal features and exceeding maximum 8-hour average concentrations were caused by wildfire emissions from the Trailhead Fire.

Finally, WCHD included a comparison of the basic meteorology and maximum 8-hour O_3 concentration on event exceedance days and prior wildfire-affected days with data from non-event days before and after the wildfire-affected period (June 26-28 and July 11), along with historical average wind speeds and temperatures.[26] High temperatures can contribute to high O_3 concentrations during non-event periods; WCHD's conceptual model also described the Washoe Zephyr, or afternoon high-speed westerly winds, as a factor that acts to reduce O_3 in the area. On the exceedance days, while temperatures were above the historical average, wind speeds were also above the historical average, indicating that meteorology was not favorable for non-event exceedances. The comparison with the pre-event days also showed that temperatures were higher and wind speeds were lower in the days leading up to the Trailhead Fire (particularly June 27-28) than during the event exceedance days, even though maximum 8-hour O_3 concentrations were at least 14 ppb lower. The differences in maximum O_3 concentration and in meteorology between the exceedances and non-event days further indicate that the high O_3 concentrations on event days were atypical with respect to normal, non-event high O_3 in the Reno/Sparks area, supporting that wildfire emissions caused the O_3 exceedances at the Reno3 monitoring station on July 2-4.

Overall, the O_3 hourly concentration and percentile profile analysis, $PM_{2.5}$ hourly concentration analysis, NWS Area Forecast Discussions, and meteorological analysis clearly show that wildfire emissions from the Trailhead Fire caused the O_3 exceedances observed on July 2-4.

<u>CCR conclusion</u>
WCHD stated, "The comparisons and statistical analyses provided in Section 3.0 of this demonstration support AQMD's demonstration that the wildfire event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedances on July 2, 3 and 4, 2016. Section 3.0 thus satisfies the clear causal relationship criterion as required by the EER and 40 CFR 50.14(c)(3)(iv)." [27]

The analyses included in the demonstration, specifically, the comparison with historical O_3 8-hour maximum concentrations, HYSPLIT analysis, HMS contours, media reports of smoke and visibility analysis, time series plots of hourly concentrations of O_3 and related pollutants, 24-hour $PM_{2.5}$ concentrations, EC/OC speciation data, $PM_{2.5}/PM_{10}$ ratios, $PM_{2.5}$/CO enhancement ratios, general comparison to non-event days with similar meteorology, O_3 hourly percentile profile analysis, $PM_{2.5}$ hourly percentile profile analysis, and NWS Area Forecast Discussions, sufficiently demonstrate a clear causal relationship between the emissions generated by the Trailhead wildfire in California and the exceedances measured at the Reno3 monitoring station.

[26] See demonstration, p. 45-46.
[27] See demonstration, p. 88.

Table 3: Documentation of CCR

Exceedance Date	Demonstration Citation	Quality of Evidence	Criterion Met?
July 2, 2016	Section 2: p 9-49 Section 3: p 50-88 Appendices F and G	Sufficient	Yes
July 3, 2016	Section 2: p 9-49 Section 3: p 50-88 Appendices F and G	Sufficient	Yes
July 4, 2016	Section 2: p 9-49 Section 3: p 50-88 Appendices F and G	Sufficient	Yes

Not Reasonably Controllable or Preventable (nRCP)

The Exceptional Events Rule presumes that wildfire events on wildland are not generally reasonable to control or prevent.[28] WCHD's demonstration provided evidence that the wildfire event meets definition of wildfire. Specifically, WCHD stated that "Although the cause of the fire is still under investigation, '…wildfires on wildland initiated by accident or arson are considered natural events, and on a case-by-case basis this treatment for wildfires may bear on the appropriate treatment of accidental and arson-set structural fires'… The event also meets the definitions of 'Wildfire' predominantly occurring on 'Wildland' as defined in 40 CFR 50.1(n) and (o). The Trailhead Fire predominantly occurred on federal and/or state owned lands." [29] Fire location and perimeter maps provided in Section 2 of WCHD's demonstration indicate that the fires occurred predominantly on wildland.[30] Therefore, the documentation provided sufficiently demonstrates that the event was not reasonably controllable and not reasonably preventable.

Table 4: Documentation of nRCP

Exceedance Date	Demonstration Citation	Quality of Evidence	Criterion Met?
July 2, 2016	Section 5: p 90 Section 4: p 89 Section 2: p 13, 23, 30	Sufficient	Yes
July 3, 2016	Section 5: p 90 Section 4: p 89 Section 2: p 13, 23, 30	Sufficient	Yes
July 4, 2016	Section 5: p 90 Section 4: p 89 Section 2: p 13, 23, 30	Sufficient	Yes

Natural Event

The definition of "wildfire" at 40 CFR §50.1(n) states, "A wildfire that predominantly occurs on wildland is a natural event." WCHD's demonstration included documentation that the event meets the definition of a wildfire and occurred predominantly on wildland. WCHD has therefore shown that the event was a natural event.

[28] See 40 CFR §50.14(b)(4).
[29] See demonstration, p. 89.
[30] See demonstration, p. 12-30.

Table 5: Documentation of Natural Event

Exceedance Date	Demonstration Citation	Quality of Evidence	Criterion Met?
July 2, 2016	Section 4: p 89 Section 2: p 13, 23, 30	Sufficient	Yes
July 3, 2016	Section 4: p 89 Section 2: p 13, 23, 30	Sufficient	Yes
July 4, 2016	Section 4: p 89 Section 2: p 13, 23, 30	Sufficient	Yes

Schedule and Procedural Requirements

In addition to technical demonstration requirements, 40 CFR §50.14(c) and 40 CFR §51.930 specify schedule and procedural requirements an air agency must follow to request data exclusion. Table 6 outlines EPA's evaluation of these requirements.

As these events may impact initial area designations for the 2015 8-hour O_3 NAAQS, the demonstrations are subject to the deadlines found in 40 CFR §50.14 Table 2. WCHD's initial notification was submitted November 10, 2016, prior to the May 31, 2017 deadline. WCHD's demonstration was submitted April 14, 2017, prior to the May 31, 2017 deadline.

Table 6: Schedules and Procedural Criteria

Criterion	Reference	Demonstration Citation	Criterion Met?
Did the agency provide prompt public notification of the event?	40 CFR §50.14 (c)(1)(i)	Section 2: p 47	Yes
Did the agency submit an Initial Notification of Potential Exceptional Event and flag the affected data in the EPA's Air Quality System (AQS)?	40 CFR §50.14 (c)(2)(i)	Section 2: p 10 Appendix C	Yes
Did the initial notification and demonstration submittals meet the deadlines for data influenced by exceptional events for use in initial area designations, if applicable? Or the deadlines established by EPA during the Initial Notification of Potential Exceptional Events process, if applicable?	40 CFR §50.14 Table 2 40 CFR §50.14 (c)(2)(i)(B)	Appendix C April 14, 2017 Letter[31]	Yes

[31] See letter from Charlene Albee, WCHD Air Quality Management Division, to Meredith Kurpius, U.S. EPA Region 9 Air Division, dated April 14, 2017.

Criterion	Reference	Demonstration Citation	Criterion Met?
Was the public comment process followed and documented? • Did the agency document that the comment period was open for a minimum of 30 days? • Did the agency submit to EPA any public comments received? • Did the state address comments disputing or contradicting factual evidence provided in the demonstration?	40 CFR §50.14 (c)(3)(v)	Section 2: p 10 Appendix D May 15, 2017 Letter[32]	Yes
Has the agency met requirements regarding submission of a mitigation plan, if applicable?	40 CFR §51.930 (b)	NA	NA

Conclusion

EPA has reviewed the documentation provided by WCHD to support claims that smoke from a wildfire in California caused exceedances of the 2015 8-hour O_3 NAAQS at the Reno3 monitoring station on July 2, July 3, and July 4, 2016. EPA has determined that the flagged exceedances at this monitoring station on these days meet the definition of an exceptional event: the event affected air quality in such a way that there exists a clear causal relationship between the event and the monitored exceedance, was not reasonably controllable or preventable, and meets the definition of a natural event. EPA has also determined that the WCHD has satisfied the schedule and procedural requirements for data exclusion.

[32] See letter from Charlene Albee, WCHD Air Quality Management Division, to Meredith Kurpius, U.S. EPA Region 9 Air Division, dated May 15, 2017.