SCOPE OF REPORT

The purpose of this report is to provide additional documentation regarding the impacts of wild fires burning throughout northern California in June and July of 2008 on exceedances of the revised federal 8-hour ozone standard in Shasta County. This document supplements material prepared by the Shasta County Air Quality Management District (AQMD) which is provided in Attachment 1. These documents demonstrate that ozone concentrations on specific days during this period meet the requirements for having been influenced by an exceptional event as stipulated in the U.S. Environmental Protection Agency’s (U.S. EPA) Exceptional Events Rule published on March 22, 2007.

The Shasta County AQMD has flagged the appropriate data affected by these fires in the U.S. EPA Air Quality System. Data has been flagged for the following 2008 days: June 14, 15, 24, 25, 28, 29, 30, and July 2, 13, 17, 18, 19, 23, 24, 25, and 26. This supplemental documentation is focused on supporting the exclusion of the subset of days identified as affecting Shasta County’s federal 8-hour ozone designation status. This subset of days is June 14, 25, 28, and 29 at Lassen Volcanic National Park-Manzanita Lake (Lassen) and June 29 at Anderson-North Street (Anderson).

EXCEPTIONAL EVENT DEFINITION

The Exceptional Events Rule defines an exceptional event as an event that affects air quality, is not reasonably controllable or preventable, and is an event caused by human activity that is unlikely to recur at a particular location or is a natural event.

The following analysis will address this definition and provide documentation to establish that the summer 2008 wildfires met the criteria as set forth in this Rule. Specifically, that a clear causal relationship between the concentration and the event existed; the event was above normal historical fluctuations (including background); and the concentration at the monitoring site(s) would not have exceeded the standards but for the event. In addition, documentation regarding reasonable and appropriate actions taken to protect public health and to provide the public with an opportunity to review this analysis is attached.
FIRES DESCRIPTION

California experienced an unprecedented wildfire season in 2008 fueled by unusually dry landscapes and early season thunderstorms. Statewide rainfall was below normal in 2007 and 2008. Northern California experienced the driest spring on record in 2008 with most communities receiving less than 20 percent of normal rainfall from March to May. The critical dry water conditions prompted Governor Arnold Schwarzenegger to proclaim a statewide drought, the first in over a century.

Under extreme drought conditions, fire was inevitable. The first major fire began on May 22, 2008 in the Santa Cruz Mountains and became known as the Summit Fire. The next major fire to start was the Indians Fire on June 8, 2008 and would be followed by the Basin Complex fire on June 21, 2008. Together, the two fires would burn nearly 215,000 acres in Monterey County. The Humboldt fire in Butte County began on June 11 and was contained by June 21. It was caused by arson and ultimately consumed over 23,000 acres. The Whiskey/Paskenta fire began on June 12 in Tehama County. The fire was contained on June 19, after consuming 7,783 acres. The BTU Lightning Complex Fire in Butte County began June 21, 2008 and burned over 59,000 acres. During the weekend on June 20-21, a dry low-pressure system crossed through California producing dry lightning and igniting nearly 200 fires across 17 counties, ultimately burning over 700,000 acres.

Three major fires in Humboldt County began on June 20 – the SRF Lightning Complex, the Mad Complex, and Hells Half Complex. These fires burned a combined total of approximately 49,000 acres. Seven lightning strike fires were ignited in Mendocino County between June 20-22 and 11 more fires began July 4 through July 7. Over 170,000 acres burned in Mendocino County. In Shasta County, the SHU Lightning Complex fire grew increasingly over time to eventually burn over 75,000 acres.

Due to the wild fires, Governor Schwarzenegger issued States of Emergency in several California counties including Santa Cruz, Santa Clara, Placer, El Dorado, Butte, Monterey, Trinity, Mendocino, and Shasta. In addition, the U.S. Federal Emergency Management Agency (FEMA) declared emergencies in Santa Cruz, Santa Clara, Monterey, Santa Barbara, Kern, Mariposa, Mendocino, Butte, Plumas, Trinity and Shasta counties. By the end of summer, over 1.2 million acres burned statewide.

Figures 1 and 2 depict the locations of the Whiskey/Paskenta and Humboldt fires. A map of the subsequent June 20-21 lightening sparked fire locations is provided in Figure 3. The Humboldt and Whiskey/Paskenta fires were the cause of smoke impacts in Shasta County on June 14 and 15. These fires were located to the south and southeast of Anderson and Lassen. The confluence of all of the
Lightening strike fires that began on June 20 and 21 were the cause of the later impacts in June and July. This massive complex of fires broke out in multiple locations in and surrounding Shasta County. Satellite pictures of the extent of the smoke impacts for each of the impacted days are provided in Attachment 1. The magnitude of the fires resulted in extensive news coverage, both locally and nationally. Shasta County AQMD’s documentation package provides a number of examples of local new coverage, as well as public health alerts that were issued by the District throughout the fire period.
Figure 1: Whiskey/Paskenta Fire Location and Perimeter

Figure 2: Humboldt Fire Location and Perimeter.
Figure 3: California Wildfire Incidences June 22 through August 11, 2008
PREVIOUS RESEARCH

The impact of wildfires on ozone concentrations at both the local and regional level has been extensively evaluated in recent years. Nikolov et al provide an excellent summary of a number of past studies, as well as a conceptual discussion of the physical and chemical mechanisms contributing to the observed impacts. Nicolov concludes that on a regional scale, biomass burning can significantly increase background surface ozone concentrations resulting in exceedances of regulatory standards. Moreover, these impacts can be observed in areas that may be hundreds of miles away from the fire locations.

Individual studies to evaluate the impacts of wildfires on ozone concentrations include both direct observations such as aircraft flights or ozonesondes, as well as photochemical or smoke plume modeling. Aircraft flights through smoke plumes have demonstrated increased ozone concentrations of 15 to 30 ppb in California (Bush 2008), while ozonsonde measurements in Texas found enhanced ozone aloft of 25 to 100 ppb attributable to long-range transport of smoke plumes from Canada and Alaska (Morris 2006).

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

GEOGRAPHIC REGION

Shasta County (County) is located in the upper central portion of northern California. The County encompasses the northern end of the Sacramento Valley and is ringed by tall mountains, except to the south. The southern extent of the Cascade Range is in the northern and eastern portions of the County with elevations to 10,457 feet at Lassen Peak. The western side of the County has the eastern foothills and mountains of the Coast Range with elevations ranging 2,000 to 4,500 feet. The Sacramento Valley portion of the County is typically 400 to 1,000 feet in elevation.
SHASTA COUNTY AIR QUALITY ANALYSIS

Shasta County has four air quality monitoring sites located in Redding, Anderson, Shasta Lake, and Lassen Volcanic National Park. The Anderson and Lassen sites are equipped to measure ozone and particulate matter. The Redding site is equipped to measure ozone, carbon monoxide, nitrogen dioxide, and particulate matter. The Shasta Lake site is equipped to measure particulate matter. The Redding, Anderson, and Shasta sites are within the Sacramento Valley at elevations of 489 feet, 495 feet, and 807 feet respectively. The Lassen site is located near the West Entrance Station within the Lassen Volcanic National Park and Manzanita Lake at an elevation of 5865 feet.

Violations of the federal 8-hour ozone standard occurred in Lassen Volcanic National Park (Lassen) and Anderson as a result of exceptional events due to wildfires. The exceptional events occurred on June 14, June 25, June 28 and June 29 at Lassen, and on June 29 at Anderson.

Meteorological Conditions June – July 2008
On June 10, 2008 a Fire Weather Watch for high fire danger was issued for the Sacramento Valley and surrounding foothills. The watch was for relatively dry conditions and gusty winds from the north. The gusty winds were the result of strong surface high pressure building into the Pacific Northwest including northern California.

Three fires in northern California broke out under the windy and dry conditions, in addition to the Indians Fire that was already burning in southern Monterey County. The first of these fires was the Ophir Fire beginning on June 10 just southwest of Oroville. The Humboldt Fire began June 11 and was located between Chico and Paradise. The Whiskey Fire began June 12 in western Tehama County. By June 13, the strong winds had subsided in the Sacramento Valley. The lighter winds on June 13 resulted in smoke from the fires dispersing mostly within the Sacramento Valley, as seen in a NASA satellite image. On June 14, light winds aloft from the southwest blew smoke and emissions from the Whiskey Fire across the Sacramento Valley, impacting the monitor at Lassen National Park.

On June 20 and 21, 2008, a storm system moved through northern and central California. This storm was associated with a nearly stationary Gulf of Alaska low pressure area. The storm brought thunderstorms, some severe, and cloud to ground lightning. This deluge of lightning strikes – over 6000 in more than 26 counties – along with record dry conditions started over 2000 lightning fires in the California Coastal Ranges and Sierra Nevada Mountains.

Following the storms’ passage, air over California stabilized and winds subsided. Over the next several days, smoke began to spread locally in northern California from the many lightning caused wildfires ringing the Sacramento Valley, as seen
in NASA satellite images. Two major factors caused smoke to spread over the Sacramento Valley and into the San Joaquin Valley – 1) air movement controlled by localized upslope and down slope winds in the foothills and mountains, and 2) weak winds from the north due to surface high pressure building into the Pacific Northwest.

This weather and smoke pattern persisted until June 28 when a weak low pressure area formed off the coast of California and a ridge of high pressure expanded over the Great Basin and into the Pacific Northwest. This new weather pattern resulted in moderate winds from the south. Consistent with this new wind pattern and observed in satellite images, smoke plumes from the wildfires traveled northward into the upper portion of northern California, and as far north as Oregon by June 29.

**Clear Causal Relationship**

This document clearly establishes a causal relationship between the wildfires and measured air quality in Shasta County. One important indication of the impact of the wildfire is the elevated PM2.5 levels. PM2.5 is directly emitted during combustion, and elevated concentrations are an important indicator that emissions from the wildfires reached Shasta County and directly affected ozone air quality measurements. Anderson, which is the closest BAM monitor to Lassen and was downwind of the Whiskey Fire, measured elevated PM2.5 concentrations. Hourly PM2.5 concentrations on June 13 and 14, 2008 reached 34 ug/m³, which is much higher than is typical for the Northern Sacramento Valley. Historical PM2.5 data for Anderson is not available. However, PM2.5 concentrations during June and July at Colusa typically average between 6 to 10 ug/m³, with the maximum not exceeding 18 ug/m³ in the most recent nine years. The satellite images also provide compelling evidence for the intrusion of smoke from the wildfire. During the last week in June, PM2.5 concentrations reached even higher levels. As can be seen in Table 1 below, the maximum 24-hour average PM2.5 concentration in 2008 is approximately 10 times greater than the previous three years.

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak 24-hour average* PM2.5 concentration (ug/m³)</td>
<td>20.0</td>
<td>31.0</td>
<td>18.6</td>
<td>200.2</td>
</tr>
</tbody>
</table>

*Highest National 24-hour Average, as measured at Redding, California

Table 2 below lists the highest hourly PM2.5 concentrations in Anderson on the days impacted by the wildfires. As can be seen, PM2.5 concentrations reached hazardous levels. This data, along with the graphs supplied by the District, and numerous health advisories and media stories, clearly demonstrates the
unprecedented levels of PM2.5 produced from the over 2000 wildfires in the latter part of June.

**Table 2**  
**Maximum Hourly PM2.5 Concentration**  
**June 14, and June 25-29, 2008**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PM2.5</td>
<td>34.2</td>
<td>237</td>
<td>306</td>
<td>234.3</td>
<td>200.7</td>
<td>192.2</td>
</tr>
</tbody>
</table>

Finally, satellite images supplied by the District indicate that during this period, smoke filled the northern Sacramento Valley in Shasta County. These images are available in Attachment 1.

The following analyses support the finding that the high ozone concentrations measured at Lassen and Anderson were unusual concentration that would not have occurred but for the wildfire.

**Lassen Volcanic National Park Air Quality Analysis**  
Lassen Volcanic National Park (Lassen) experienced unprecedented ozone levels during the June wildfire period. Graph 1 shows the atypical nature of 8-hour ozone concentrations at Lassen on June 14, 25, and 29, 2008. The graph compares ozone values from May 15 to July 31 in 2008 with the average of the 8-hour concentrations during the same time period from 2005-2007. The average daily concentrations over the past 3 years remained at or below the federal standard. In 2008 however, the values spiked well above what could reasonably be expected to occur.
The 8-hour ozone daily maximum concentration of 0.104 ppm on June 14, 2008 was an extreme concentration that is not typical for Lassen. It is the highest ozone concentration recorded at Lassen in the last twenty years, as shown in Graph 2.
Statistical analyses conducted by ARB staff document the extreme nature of the concentrations on June 14, 25, 28 and 29. The analyses presented in Graph 3 and Graph 4 show that the ozone concentrations are much higher than would be expected from the normal distribution of ozone concentrations measured at Lassen. Graph 3 compares the daily maximum 8-hour ozone concentrations in 2007 to 2008 and Graph 4, compares the normal distribution of concentrations in the previous three years (2005-2007) to 2008. The 8-hour ozone concentrations on each of these days are greater than three standard deviations when compared to the typical distribution of 8-hour ozone concentrations for the last three years.
Graph 3
Scatter Plot of Daily 8-Hour Ozone Concentrations

Scatter Plot of Daily Maximum 8-hour Ozone Concentration (Jan to Dec) at Lassen Volcanic National Park-Manzanita Lake (2008 vs. 2007)
Data Sorted from Highest to Lowest Each Year Separately

Graph 4
Number of Days with the Daily Maximum Federal 8-hour Ozone Concentration Falling within a Concentration Bin for May-October 2005-2007 and May-October 2008
Lassen Volcanic National Park-Manzanita Lake

Mean, 1sigma, 2sigma, 3sigma

June 14
June 29, 25, 28, 24, 15
June 15, 24, 25, and 28, 29
July 25

June 14

2008 Concentration (ppb)
2007 Concentration (ppb)
Table 3 lists the ozone design values at Lassen for years 2002 through 2008, and the range of the four highest concentrations per year. There are a number of compelling observations that can be made from the data in Table 3, all supporting the atypical nature of the ozone concentrations during this period.

**Table 3**  
8-hour Ozone Design Values and Peak Concentrations at Lassen  
(Concentrations in ppm)

<table>
<thead>
<tr>
<th>Year</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Value</td>
<td>.074</td>
<td>.072</td>
<td>.071</td>
<td>.068</td>
<td>.069</td>
<td>.072</td>
<td>.077</td>
</tr>
<tr>
<td>Range of Top 4 8-Hour Ozone Concentrations</td>
<td>.070-.081</td>
<td>.070-.073</td>
<td>.068-.073</td>
<td>.067-.078</td>
<td>.074-.077</td>
<td>.076-.078</td>
<td>.083-.104</td>
</tr>
</tbody>
</table>

Perhaps the most critical observation is that Lassen attained the federal ozone standard for all previous six years. All of the four highest 8-hour ozone concentrations in 2008 occurred during the wildfires (June 14, June 25, June 28, June 29). Over the last six years, the highest ozone concentrations at Lassen were typically distributed throughout the summer and fall months (June through September), and not clustered in a small period. Peak values in 2008 were approximately 0.013 ppm higher than the average for the previous six years. Because Lassen typically has low ozone levels, a contribution as small as 0.013 can make the difference between attainment and violation of the standard.

As further evidence of the clear causal relationship between the wildfires and ozone concentrations, Graph 5 compares the 24-hour diurnal ozone profiles for June 14-16, 2008 at Lassen to the composite profile for the five days with the highest 8-hour ozone concentrations. The graph clearly shows the magnitude of the elevated concentration on June 14 and a shift in the timing of the hourly peak on June 15. On June 14, the hourly ozone maximum was 0.029 ppm higher than the average for the five days with the highest 8-hour ozone concentration (0.115ppm compared to 0.086ppm). On June 15, the hourly maximum occurred at 8am, in contrast to the composite high days, which occurred later in the evening (5pm). This represents a significant shift in the timing of the peak on June 15. Analysis conducted by ARB staff confirms that the typical timing of the hourly ozone peak occurs late in the day (2-5pm). Thus, there is compelling evidence that smoke and emissions from the fires reached Lassen and affected the measured ozone concentrations on June 14 and June 15, 2008.
Similarly, Graph 6 compares the measured concentrations for June 24-30, 2008 with the same composite diurnal profile of the five highest 8-hour ozone days. The profiles for June 25 and June 29 show the shift in the timing of the hourly peak during the wildfires, and June 28 reflects elevated ozone concentrations. This graph also supports the conclusion that smoke and emissions from the wildfires reached Lassen and affected measured ozone concentrations on June 25, 28, and June 29, 2008.
Graph 6
Lassen Volcanic National Park-Manzanita Lake 1-hour Ozone Concentrations for June 24-30, 2008 Compared to the Average of the Top 5 Days (2005-2007)

Anderson Air Quality Analysis
Although Anderson has higher concentrations than Lassen, similar statistical analysis indicates the extreme nature of the measured concentration on June 29, 2008. Similar to observations made for Lassen, this concentration is three standard deviations greater than the normal distribution of the data, as shown in Graph 7.
Another important observation is that Anderson has had improving air quality, as measured by the ozone design value. Design values had been decreasing and the trend supports that Anderson would have attained the federal standard in 2008 if not for the exceptional events due to wildfires.

Graph 8 illustrates the atypical nature of ozone concentrations at Anderson on June 14 and June 29 compared with the average daily ozone concentrations over the previous 3 years (2005-2007).
Finally, as further evidence of the clear causal relationship between the wildfires and ozone concentrations, Graph 9 compares the hourly diurnal profile at Anderson to the composite profile for the five days with the highest ozone concentrations in the previous three years. As shown in Graph 7, the timing of the 8-hour peak on June 28 occurred much later in the day compared to the five high days. There is also evidence of carryover to June 29. On June 29, the graph indicates higher peak 1-hour ozone concentrations along with a modest shift in the timing of the ozone peak.
PUBLIC MITIGATION

The District and ARB met all of the requirements for mitigating the impacts of these catastrophic wildfires on the public. The District and ARB issued numerous health advisories during the period spanning the fires so that the public would minimize their exposure to the unhealthy air. This included media interviews to educate the public on the hazardous air quality conditions. Examples are included in the District documentation package (Attachment 1).

Additionally, the District and ARB staff investigated emission-generating activities during the two episodes, and found that ozone precursor emissions were approximately constant before, during, and after the event.

CONCLUSION

The preceding analysis has addressed the criteria as required in the Exceptional Events Rule. In particular, the analysis has shown that:

The event(s) have met the definition of an ‘exceptional event’ and:

- Affected air quality;
- Was not reasonably controllable or preventable; and
- Was a natural event;
A clear causal relationship was demonstrated between the event (catastrophic wildfires) and the concentration measured at the monitoring site:

- The events were above normal historical fluctuations
- The exceedance at the monitoring site would not have occurred but for the event; and
- Reasonable and appropriate actions were taken to protect public health and provide for public comment on the establishment of this event as an ‘exceptional’ event.”

Therefore, based on the weight of evidence provided for in this document, the ozone exceedances would not have occurred, but for the wildfires.
ATTACHMENT 1