UPPER GREEN RIVER OZONE INVESTIGATION
(O3i)

01/31/2009– 07/31/2009

EXECUTIVE SUMMARY

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WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
122 West 25th Street
Cheyenne, Wyoming 82002

Prepared by

Robert Field and Jeffrey Soltis
University of Wyoming
Atmospheric Science Department
1000 East University Avenue
Laramie, WY 82071

Any comments or questions regarding this report should be addressed to:

Robert Field, Principal Investigator
RField1@uwyo.edu
(307) 766 2158
or

Derek Montague, Principal Investigator
DCM@uwyo.edu
(307) 766 4949
or

Lori Bocchino, Project Manager
LBocch@wy.gov
(307) 777 8578
Wyoming Department of Environmental Quality
Air Quality Division
Herschler Building
Cheyenne, WY 82002

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The Wyoming Department of Environmental Quality, Air Quality Division (DEQ-AQD) contracted with the University of Wyoming, Atmospheric Science Department (ATSC) to perform the project entitled Upper Green River Ozone Investigation (O3i). The project consisted of three objectives: an ozone spatial distribution survey**,** mobile monitoring of ozone precursors, and a traffic survey.

Ozone spatial distribution survey

While recent studies overseen by the DEQ-AQD have resulted in an increasing understanding of the causes of ozone production in the winter months, there remains some lack of knowledge of the geographical extent of elevated ozone episodes and variability of concentrations within the area affected. The existing DEQ-AQD monitoring stations provide temporal information at three sites – Daniel, Pinedale and Boulder – but a desire for more data from the Pinedale Anticline Development Area (PAPA) and the town of Pinedale was identified. The spatial distribution study was designed to complement existing monitoring by DEQ-AQD by performing eight-hour assessments of ozone concentrations at 50 ambient sites along with 20 human exposure volunteers. Two surveys were performed – one in winter (February 2009) and the other in summer (June 2009).

The methodological design for passive sampling of ozone to derive an understanding of spatial distribution over a large geographic area was successful. Comparison with continuous analyzers operated according to Federal Equivalent Methodology showed close comparability, with differences of less than five percent.

For the two days sampled, winter-time ozone concentrations had greater variation and higher absolute levels than summer-time concentrations. Lowest ozone concentrations were located in the western and northern portions of the study area. Highest ozone concentrations were in the southeastern section of the study area, located downwind of PAPA, in the region of the Jonah development. Based on the winter-time map, elevated ozone concentrations do not appear to be due to transport into the study area, but rather indicate the likelihood of local production.

Human exposure to ozone is strongly influenced by the amount of time an individual spends outdoors. Ozone levels indoors are generally much lower than outdoors. An unusual outdoor source of ozone identified at Pinedale High School was the vent from the ozonator used to sanitize swimming pool water.

Mobile monitoring of ozone precursors

A mobile laboratory allows for short term monitoring at different locations without having to site and operate permanent stations. As such a mobile monitoring approach allows for flexibility of site selection and sampling duration. Five sites were identified to consider differences between sites upwind and downwind of both PAPA and Jonah developments. Because measurement of ozone precursors is essential for

understanding ozone formation, oxides of nitrogen (NO_x) and non-methane hydrocarbons (NMHC) were selected as the most important bulk precursor measurements. Oil and gas development is the major source of these compound groups in Sublette County. At each monitoring site one-minute average measurements of ozone, methane (CH_4), NMHC, nitric oxide (NO), nitrogen dioxide (NO_2) and NO_x were collected. Simultaneous measurements of wind speed, wind direction, temperature, barometric pressure and relative humidity were also performed.

A mobile laboratory was commissioned and operated for the first six months of 2009 at five strategic ambient air sites. These sites were placed considering the location of existing DEQ-AQD monitors. The first site, at Big Piney, was upwind of the PAPA and Jonah developments, and was considered a boundary site. The second site, at Luman Road, was downwind of the Jonah development. The third site, at Boulder South Road, was downwind of the PAPA. The fourth site, at Pinedale, was upwind of the PAPA and Jonah developments; and as such was considered a boundary site. The fifth site at Olson Ranch was between the PAPA and Jonah developments.

The mobile monitoring study was based on the concept of multiple short-term measurement campaigns; therefore we draw short-term preliminary conclusions, as it is not possible to determine long-term trends. The use of the mobile laboratory to monitor pollutants in different locations within the study area helped determine variability of pollutant behavior and the influence of meteorology and emission sources.

Wind rose diagrams demonstrate variable wind behavior in and around the study area. This is important when considering variability of pollutant behavior throughout the study area. The wind rose diagram for the Boulder South Road site showed that this site had the most evenly spread wind field of the O3i monitoring sites during the study period. The presence of katabatic (down-slope) air-flows near the Boulder South Road site may, along with temperature inversions, facilitate trapping and mixing of ozone precursors here.

Ozone NAAQS were not exceeded at any sites during the O3i monitoring period. Data for CH_4 and NMHC show episodic concentrations above background levels at all O3i sites except Pinedale. There is a wide variation of the relative amount of time that sites other than Pinedale have background versus elevated levels of methane. Methane and NMHC concentrations appear to be elevated based on 1) proximity to production emissions; 2) meteorology; and 3) seasonality. Pollution rose diagrams for Big Piney indicate wind flows from the SW have elevated levels of CH_4. Pollution rose diagrams for Luman Road show elevated pollution levels from westerly winds from the PAPA and Jonah developments. Pollutant roses from Boulder South Road show the wind field of this site with pollutant inflow from all directions. This effect is most pronounced for ambient ozone concentrations. Monitoring data at Pinedale indicate that the mobile laboratory was not directly influenced by oil and gas emissions while placed there. Intermittent elevation of nitrogen species are due to locally produced traffic emissions related to Town Park activity. Pollution roses created from Olson Ranch monitoring data indicate elevated levels of CH_4 and NMHC are present during stable atmospheric conditions and are most likely produced locally. The ratios of CH_4 to NMHC at sites with elevated concentrations showed similarity between Luman Road, Boulder South and

Olson Ranch. At the Big Piney site, high CH_4 had relatively low associated NHMC concentrations.

The importance of atmospheric mixing and air pollutant concentration was shown by the diurnal curves for methane, as afternoon mixing tended to show the closest approximation to tropospheric background levels. Diurnal curves for CH_4 and NMHC showed that local sources are most likely to influence measured concentration during times associated with the highest atmospheric stability.

Behavior of measured nitrogen species indicates additional influence from local sources. Nitric Oxide concentrations from traffic sources are important at Big Piney and Luman Road, as well as at Pinedale. Elevated levels of nitrogen species at Big Piney and Luman Road highlight the role that local traffic can play in creating ozone precursors, as both areas had frequent periods nearby vehicle idling. Luman Road, a primary arterial access point to Jonah Field, is subject to heavy truck traffic and is located in an area of acceleration and deceleration. Time series data for nitrogen species shows the high level of variability associated with these compared to hydrocarbon species. Nitrogen species had frequent periods of low concentrations followed by pollution spikes. This spiking behavior was particularly evident at sites influenced by emissions from traffic. For NO_2 concentrations the influence of daytime photochemical production is evident in late afternoon hours.

Diurnal curves for ozone showed a similar shape at all the monitoring sites, albeit with some variation related to afternoon peaks and duration of highest levels. This curve represents the daily pattern of production and destruction of ozone. Ozone time series show more stability with diurnal variations clearly visible. Geography appears to be important at Boulder South Road site. This location had more O_3 values over 70 ppb than all of the other sites combined.

Traffic survey

Air quality assessments that aggregate emission information from relatively large areas and use standard factors have a greater uncertainty than those that use locally relevant information. Any associated predictive modeling is diminished if inappropriate input data is used. It is important to consider all natural, fugitive and anthropogenic emission sources. Traffic emissions related to vehicles entering and leaving development areas, both with respect to vehicle numbers and fleet composition, are one such source. As such two traffic surveys were undertaken at two of the most important access points to both the Jonah development and PAPA – namely Luman Road close to US 191 and Paradise Road close to US 351.

Vehicle distribution at both monitoring sites was similar. Larger engine vehicles dominate the vehicle fleet. Single two axle trucks are the predominant vehicle type, accounting for 70% of the vehicle fleet. This class is associated with servicing activities. Single five axle and single six or more axle trucks accounted for 20% of the vehicle fleet. These trucks are often associated with the transport of condensate, water and other fluids.