GARFIELD COUNTY
2009 AIR QUALITY MONITORING SUMMARY

Prepared for:

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EXECUTIVE SUMMARY

This report summarizes air quality monitoring data collected during 2009 in Garfield County, Colorado. The monitoring stations include the Parachute, Rifle, Brock, and Rulison sites, which are all in close proximity to oil and gas development in the county. Parameters monitored at these sites include the criteria pollutants ozone (O_3), particulate matter < 10 micrometers in diameter (PM_{10}), and particulate matter < 2.5 micrometers in diameter ($PM_{2.5}$), volatile organic compounds (VOCs), and meteorology. VOCs monitored included speciated non-methane hydrocarbons (SNMOC) and carbonyl compounds.

Criteria pollutants are pollutants subject to the National Ambient Air Quality Standards (NAAQS). Criteria pollutants monitored in 2009 included PM_{10} at the Parachute and Rifle sites, and $PM_{2.5}$ and O_3 at the Rifle site. At present, air quality measurements in Garfield County do not violate air quality standards for O_3, PM_{10}, or $PM_{2.5}$.

Highest concentrations of PM and SNMOCs were observed during the colder winter months. High PM measurements in the winter are affected by temperature inversions in the Colorado River Basin. During an inversion, air pollutants can build up due to limited atmospheric mixing. High SNMOCs measurements can also be affected by inversions, but are also generally higher in the winter because these compounds become more reactive and deplete faster during warm winter months.

Light alkanes, which are SNMOC compounds with fewer than five carbon atoms, made up between 83 and 89% of the total SNMOC compounds measured. Natural gas production activities appear to be the largest contributing source of light alkanes, which include ethane, propane, iso/n-butane and iso/n-pentane. These compounds are some of the least reactive in terms of ground level ozone formation, but the large quantities of these compounds increase the potential for ozone formation. Light alkanes are not considered hazardous air pollutants (HAPs), so they are of lesser concern with respect to health effects.

Some of the less abundant SNMOCs, including the heavy alkane methylcyclohexane, the aromatics toluene and m/p-xylene, and the alkenes isobutene, ethylene and propylene, indicated high ozone formation potential. These compounds were measured in much lower quantities than the light alkanes, but can more readily contribute to ozone formation due to higher reactivity. Sources for these compounds include gasoline, diesel, fire sources, and oil and gas production. In addition to VOC availability and reactivity, ozone formation can be affected by nitrogen dioxide (NO_2) availability and meteorological factors. Currently, ozone levels in Garfield County do not exceed national standards, but if levels become more of a concern in Garfield County, it would be useful to monitor NO_2.

HAPs are a subset of VOC compounds, and include compounds that are known or believed to cause human health effects at low doses. HAPs measurements for 2009 were compared to regional measurements from sites that are part of the Environmental Protection Agency (EPA) for sites in the national Urban Air Toxics Monitoring Program (UATMP) and National Air Toxics Trends Stations (NATTS) network, including the Grand Junction monitoring site, which is an urban site located about 30 miles upwind of the Garfield County sites, along Interstate 70 and the Colorado River Valley. Regional comparison showed that several

compounds, including acetaldehyde, formaldehyde, acetone, propioaldehyde, and styrene were lower in Garfield County than the Grand Junction site. The BTEX parameters benzene, toluene, and the xylenes were higher than Grand Junction at the Parachute, Rulison, and Rifle sites. The BTEX parameter ethylbenzene averaged higher than Grand Junction measurements at only the Rifle site. High BTEX measurements in Garfield County may indicate more localized sources for these BTEX parameters, which have primarily gasoline and diesel combustion sources that include motor vehicles, oil and gas development activities (such as drill rigs and compressor engines) as well as oil and gas production equipment such as condensate tanks.

The Garfield County Air Toxics Inhalation Screening Level Human Risk Assessment (CDPHE 2010) assessed data collected in 2008. Findings of this report indicated that, individually, the HAPs components were below risk assessment criteria, but cumulative effects approached chronic (70 year exposure period) non-hazard levels. The largest contributors to the cumulative levels were benzene and formaldehyde. A risk assessment based on 2009 HAPs levels will be prepared in a separate annual risk assessment report prepared separately by the Colorado Department of Public Health and Environment (CDPHE) Disease Control and Environmental Epidemiology Division.

1.0 INTRODUCTION

Oil and gas exploration and production within the Piceance Basin in Colorado, and elsewhere in the Rocky Mountain region, has undergone rapid growth over the last decade. In response to this growth, concerns have grown regarding the impacts of oil and gas development in Garfield County.

The Garfield County Public Health Department (GCPHD) is committed to protecting the health and welfare of its citizens. In 2005, in response to citizen concerns, the GCPHD enhanced air quality monitoring efforts to evaluate levels of particulate matter < 10 micrometers in diameter (PM_{10}) and volatile organic compounds (VOCs) in the area. In 2008, the monitoring network was modified to encompass speciated non-methane hydrocarbons (SNMOC) and carbonyl compounds and the regulatory monitoring network expanded from PM_{10} to include particulate matter < 2.5 micrometers in diameter ($PM_{2.5}$) and ozone (O_3). These changes were designed to serve a wide range of purposes, including monitoring of criteria pollutant levels, ozone formation potential, toxics assessments, and source attribution.

In 2009, Garfield County monitored air quality at four locations, with one station relocated in January 2009. Characteristics of the monitoring sites are described below.

- Parachute (PACO): Parachute is a small urban center of approximately 1,300 people within very close proximity to oil and development and production activities. The town is located along Interstate 70 and is the transportation hub for heavily traveled roads which service the surrounding canyons.
- Rifle (RICO): Rifle is a rapidly growing urban center on the Interstate 70 corridor with estimated population of about 9,200 people. Rifle is in close proximity to oil and gas development activities, and is also central to industrial support for the oil and gas industry.
- Bell-Melton (BRCO): The Bell-Melton site is a rural homestead approximately four miles south of the town of Silt, in close proximity to moderate oil and gas development and heavy natural gas production.
- Brock (MOCO): The Brock site is a rural location about four miles south of Rifle, amid substantial natural gas development and production activities. This site was relocated to Rulison location in January 2009.
- Rulison (RUCO): Rulison is a rural community located about nine miles southeast of Parachute and five miles west of Rifle along Interstate 70. This site began operation in late January 2009.

Figure 1-1 is a map of the monitoring sites in Garfield County, and Table 1-1 lists the parameters monitored. The GCPHD monitors pollutants and meteorology at these stations with technical support from several agencies. Filter based PM_{10} monitors in Rifle and Parachute are operated by the GCPHD, with filter analysis supported by the CDPHE. SNMOC and carbonyl compounds are sampled at all sites and analyzed by the Eastern Research Group, Inc. (ERG). The GCPHD monitors meteorology at the Parachute, Rulison, and Bell-Melton sites and PM_{10}, $PM_{2.5}$, O_3, and meteorology along with digital camera images at the Rifle site. Air Resource Specialists, Inc. (ARS) supports monitoring, data collection, and data validation at the Rifle site.

Camera images and air quality data collected at the Rifle site are displayed in real-time on the Garfield County Air Quality Monitoring Web site (http://www.garfieldcountyaq.net).

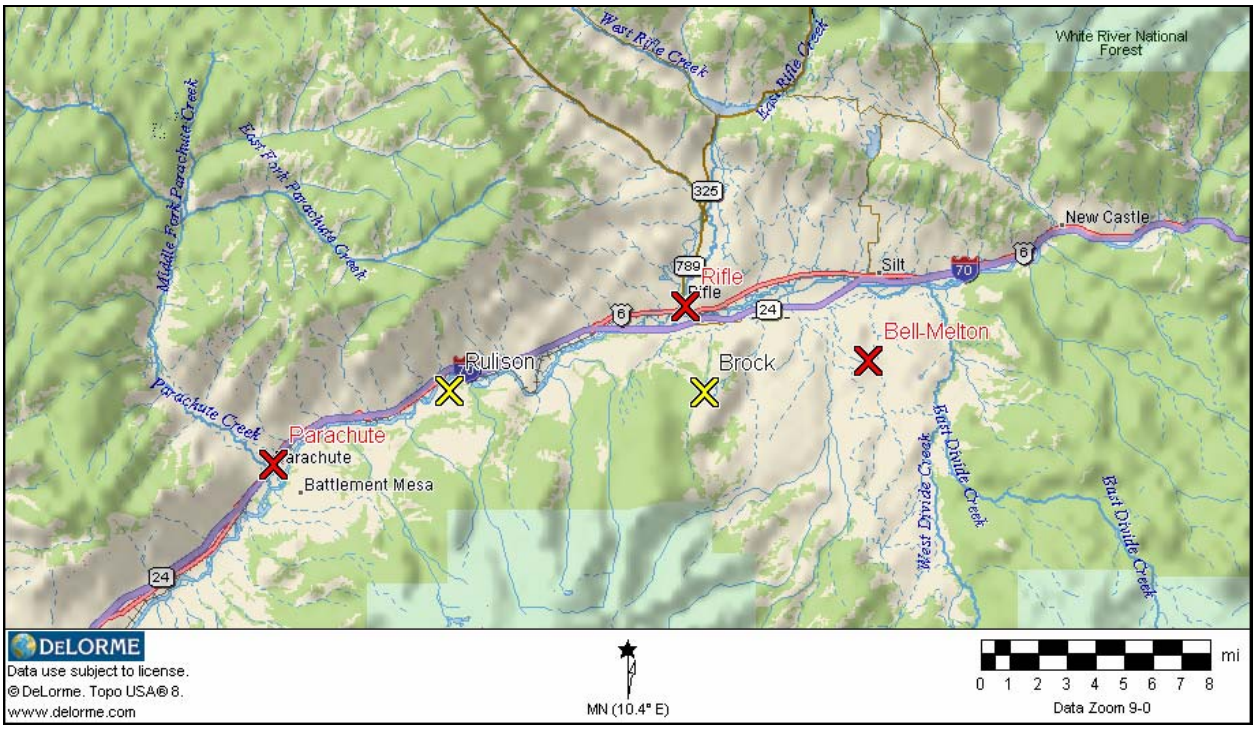


Figure 1-1. Map of Garfield County Monitoring Sites. Yellow sites indicate locations of the mobile station which was relocated from the Brock site to the Rulison site in January 2009.

Table 1-1

Garfield County
Parameters Monitored by Site

Component	Method	Sampling Frequency	Supporting Agency
Rifle, Colorado			
SNMOC	TO-12	24-hour (1/6 day)	ERG
Carbonyls	TO-11A	24-hour (1/12 day)	ERG
PM_{10}	FRM	24-hour (1/3 day)	CDPHE
PM_{10}	TEOM	Hourly	ARS
$PM_{2.5}$	TEOM	Hourly	ARS
Ozone	42C	Hourly	ARS
Meteorology	Various	Hourly	ARS
Visibility Web Camera	Digital	15-min	ARS
Parachute, Colorado			
SNMOC	TO-12	24-hour (1/6 day)	ERG
Carbonyls	TO-11A	24-hour (1/12 day)	ERG
PM_{10}	FRM	24-hour (1/3 day)	CDPHE
Meteorology	Various	Hourly	GCPHD
Bell-Melton, Colorado			
SNMOC	TO-12	24-hour (1/6 day)	ERG
Carbonyls	TO-11A	24-hour (1/12 day)	ERG
Meteorology	Various	Hourly	GCPHD
Brock, Colorado (1/14/2008-2/18/2009)			
SNMOC	TO-12	24-hour (1/6 day)	ERG
Carbonyls	TO-11A	24-hour (1/12 day)	ERG
Meteorology	Various	Hourly	GCPHD
Rulison, Colorado (1/22/2009-current)			
SNMOC	TO-12	24-hour (1/6 day)	ERG
Carbonyls	TO-11A	24-hour (1/12 day)	ERG
Meteorology	Various	Hourly	GCPHD

2.0 METEOROLOGICAL SUMMARIES

Meteorological data collected along with air quality parameters are used to better understand the local conditions and transport of air pollutants. Meteorological data collected at all sites include wind speed, wind direction, temperature, relative humidity, and precipitation.

Quarterly time series plots for all parameters collected during 2009 are presented in Appendix A. Equipment failure affected collection of meteorological data at the Parachute, Bell-Melton, and Rulison sites. Equipment at the Parachute site was upgraded in March 2010, and Garfield County is in the process of updating the meteorology network at the other stations to improve data collection.

Figures 2-1 through 2-4 present wind roses showing the frequency of hourly wind speed and direction for the Garfield County monitoring sites for 2009. The direction of the bar signifies the direction the wind is coming from, the length of the bars indicate the cumulative frequency for each direction, and the colors indicate wind speed.

Winds at the Garfield County site are influenced by flow along the Colorado River Basin, where Interstate 70 crosses through the county. Also, local flow is influenced by various drainage flow through valleys along various Colorado River tributaries. Winds at the Parachute site were generally between the west-southwest and east-northeast, corresponding to flows up and down the Colorado River Valley, and also drainage flow along Parachute Creek. Winds at the Rifle site were scattered, with highest frequency out of the north, along Rifle Creek, and from the west-southwest up the Colorado River Valley. Winds at the Rulison site were also up and down the Colorado River Valley, with winds predominantly from the southwest and northeast. The Bell-Melton site is located south of Interstate 25, and predominant winds at the site measured from the southeast along CR331/Dry Hollow Creek.

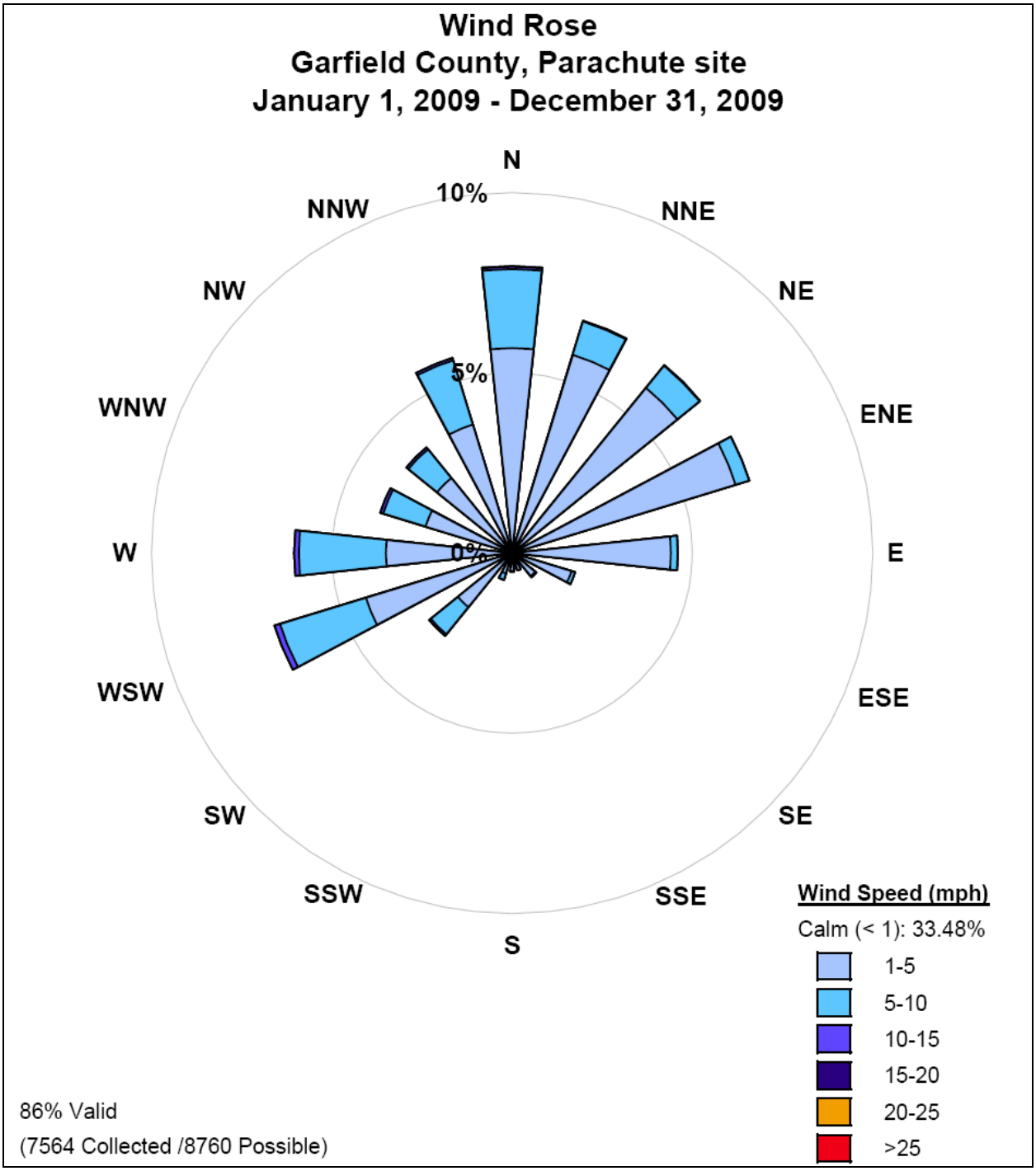


Figure 2-1. 2009 Wind Rose for the Parachute Monitoring Site.

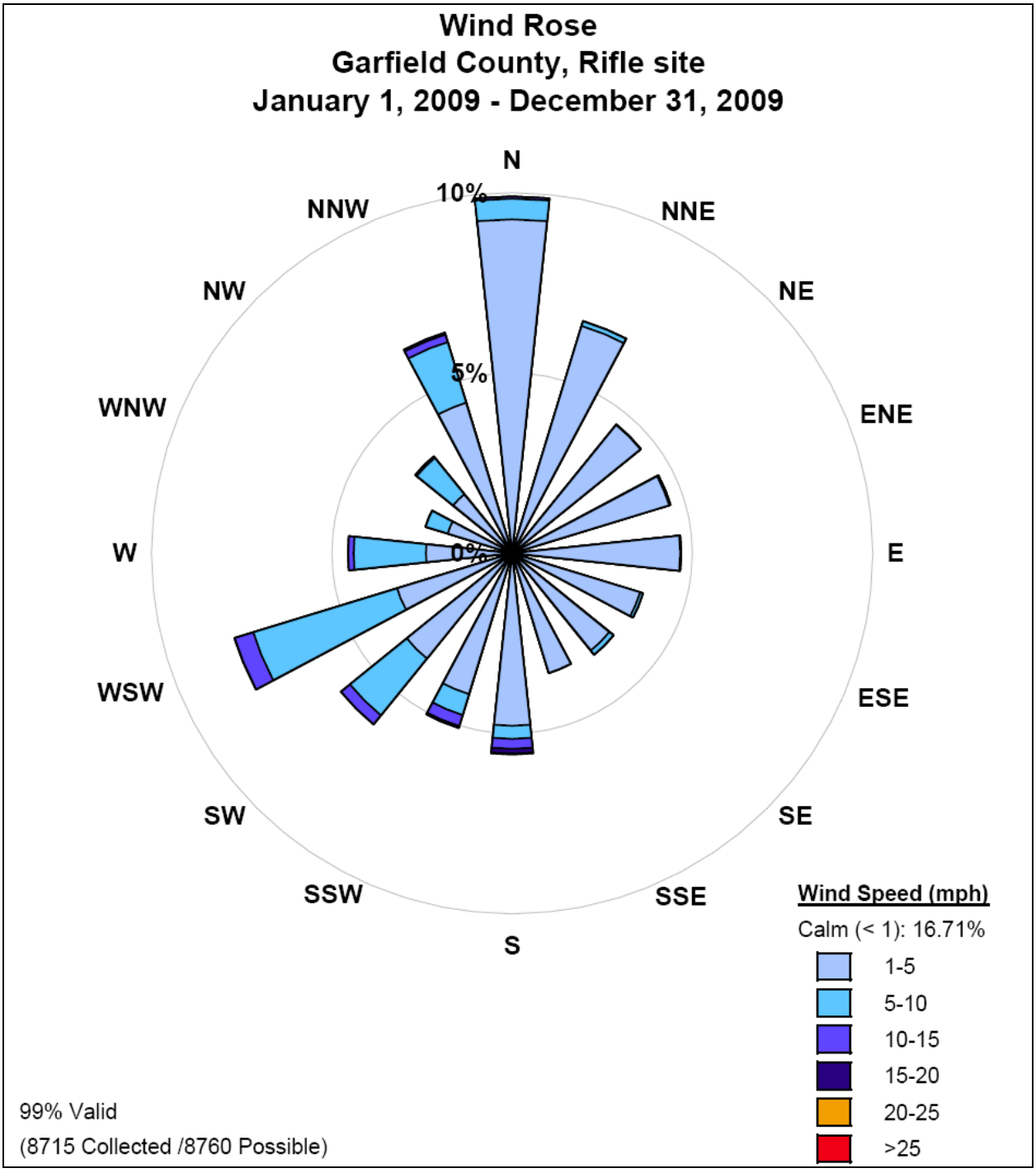


Figure 2-2. 2009 Wind Rose for the Rifle Monitoring Site.

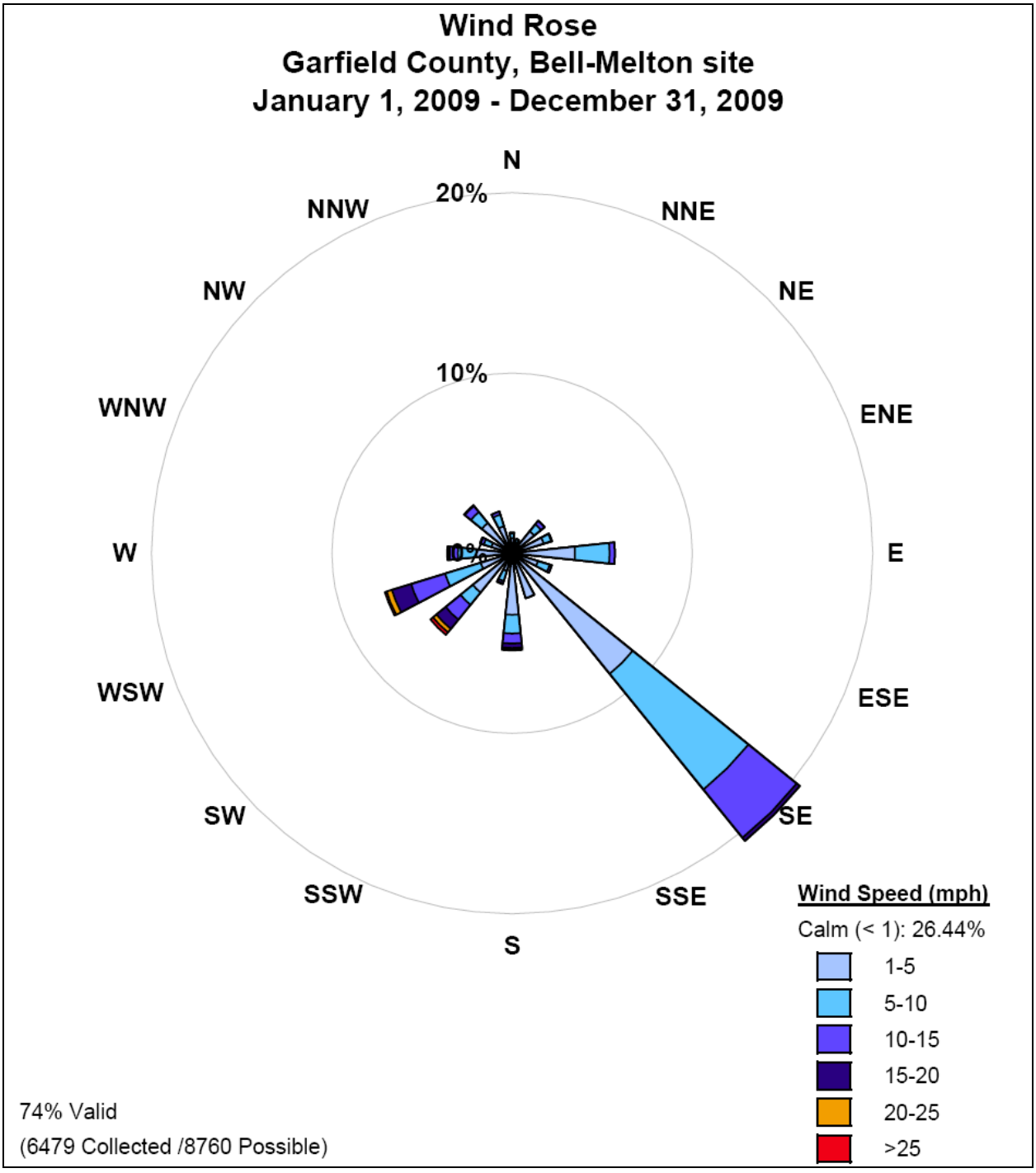


Figure 2-3. 2009 Wind Rose for the Bell-Melton Monitoring Site.

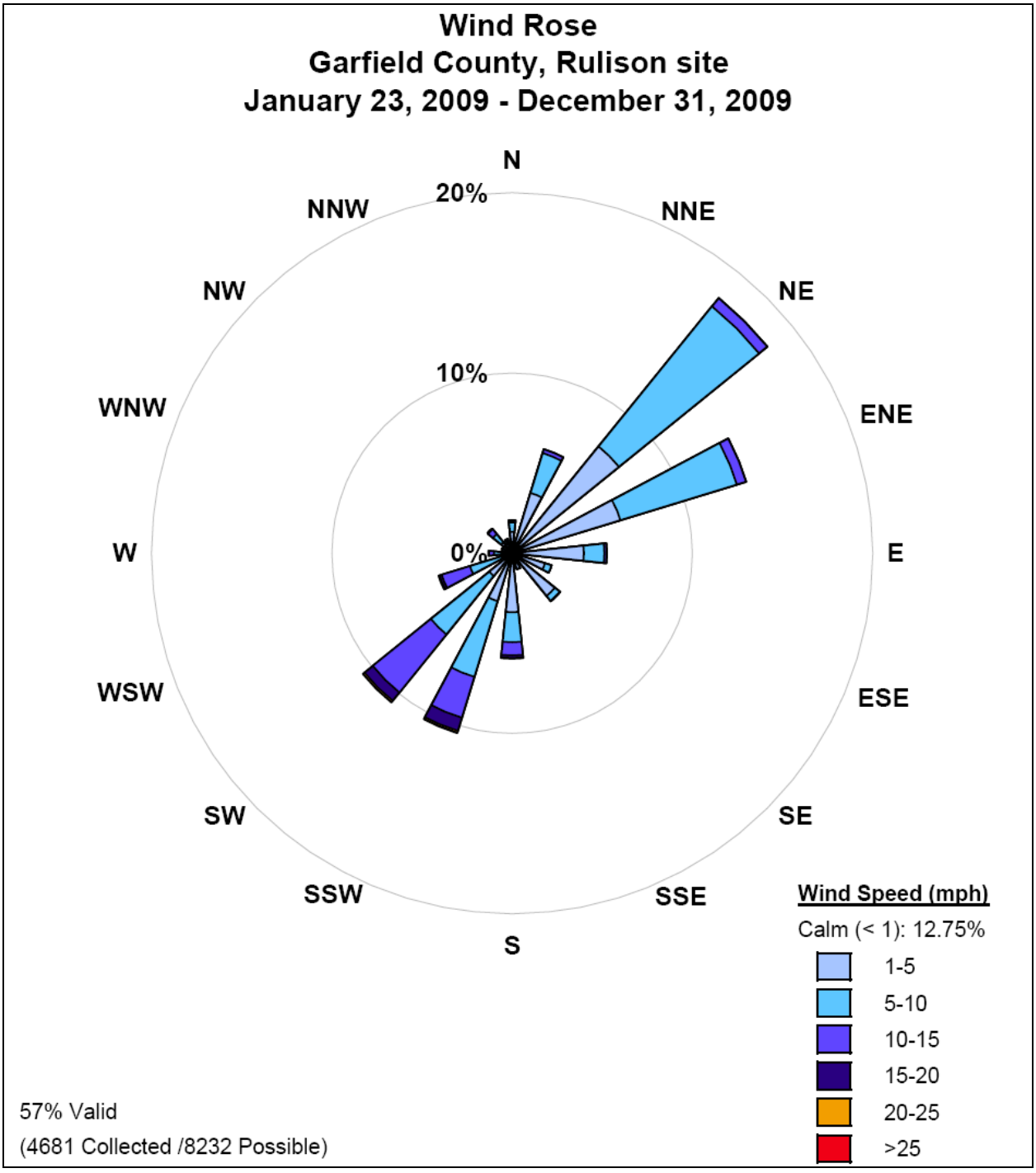


Figure 2-4. 2009 Wind Rose for the Rulison Monitoring Site.

2.1 RESIDENCE TIME MAPS

Some pollutants affecting air quality are emitted locally, while others may be transported from other regions. Fires on the west coast can affect air quality in Garfield County, and regional dust can be transported from semi-arid regions in the southwest. Some air toxics can also persist in the atmosphere long enough to be transported from other regions. Atmospheric lifetimes are characterized for some VOC compounds, and are highly variable depending on the reactivity of the compound and other removal pathways. Benzene, for example, can have a lifetime of up to 84 hours in the atmosphere before oxidizing; formaldehyde for up to 26 hours; and 1,3-butadiene for about 2.8 hours (http://www.scorecard/chemical-profiles/).

Meteorological back trajectories ending at the Rifle site were generated to identify the geographic areas that may influence long range transport of pollutants. Back trajectory analyses use interpolated measured or modeled meteorological fields to estimate the most likely central path over geographical areas that provided air to a receptor at a given time. The method essentially follows a parcel of air backward in hourly steps for a specified length of time. Back trajectories account for the impact of wind direction and wind speed on delivery of emissions to the receptor but do not account for chemical transformation, dispersion, and deposition of emissions.

Trajectories were generated using the Hybrid-Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model developed by the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL). Detailed information regarding the trajectory model and these data sets can be found on NOAA's Web site (http://www.arl.noaa.gov/ready/hysplit4.html). Four back trajectories were generated per day, with end times of 0000, 0600, 1200, and 1800 MST, with end heights of 500 meters. Each hourly point along 72-hour back trajectory paths were binned and summed into 1/4 degree horizontal grid cells of latitude and longitude, and plotted as a residence time where different colors indicate the percent of total back trajectories that traversed each longitude latitude grid cell.

Figure 2-5 presents a map of the 2009 residence time for the Rifle site in Garfield County. One general path of influence comes from the northwest, through Utah and Idaho. Another more pronounced path is from the south-southwest through Utah and Arizona. Figure 2-6 presents quarterly residence time maps, which follow the same general pattern as the annual map, with the Utah-Idaho path more prominent during summer months, and the Arizona-Utah path more prominent during the winter months. Very few back trajectories originate east of Rifle, with the largest eastern influence occurring during the third quarter.

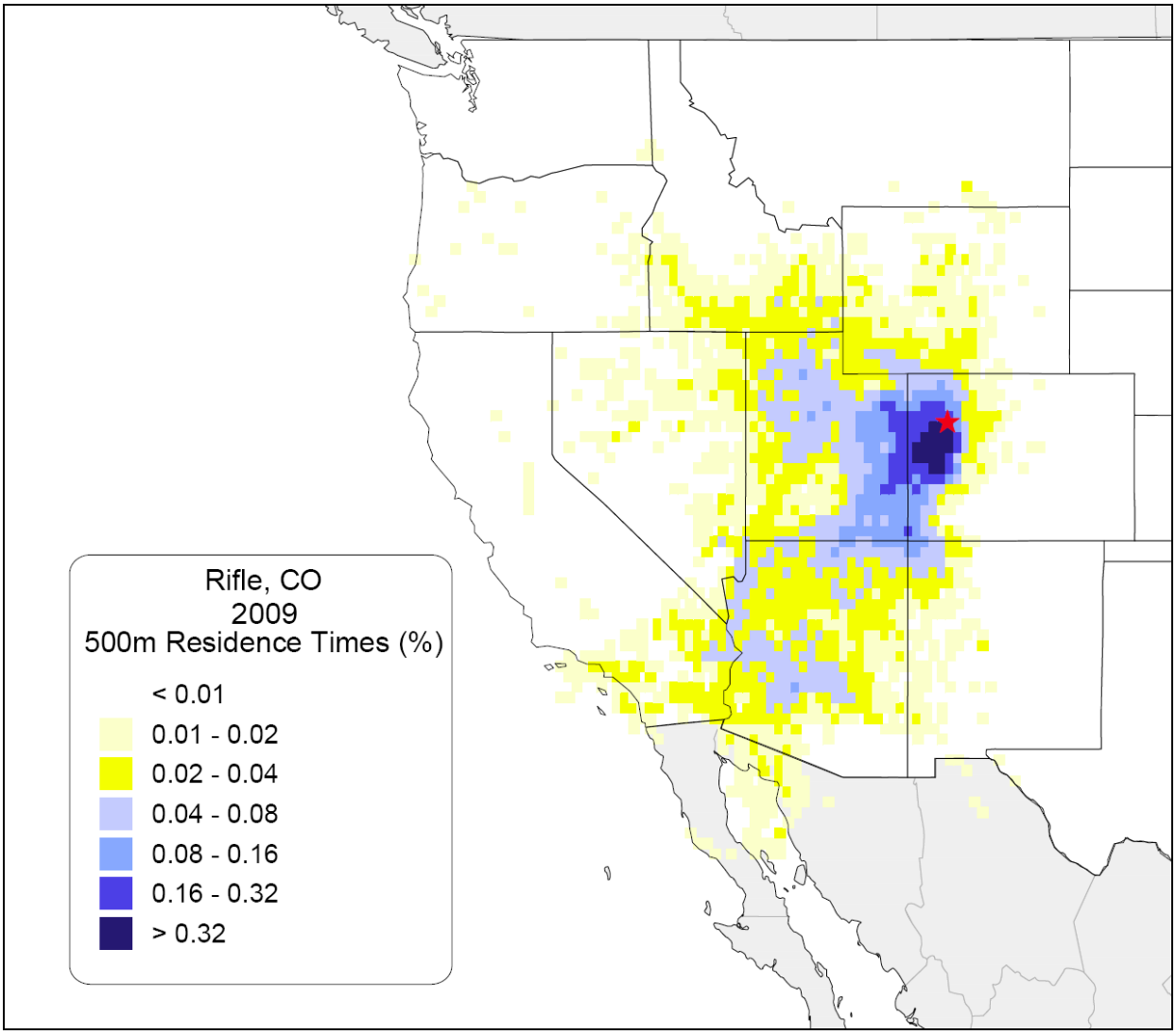


Figure 2-5. 2009 Residence Time Map for Rifle Monitoring Site in Garfield County.

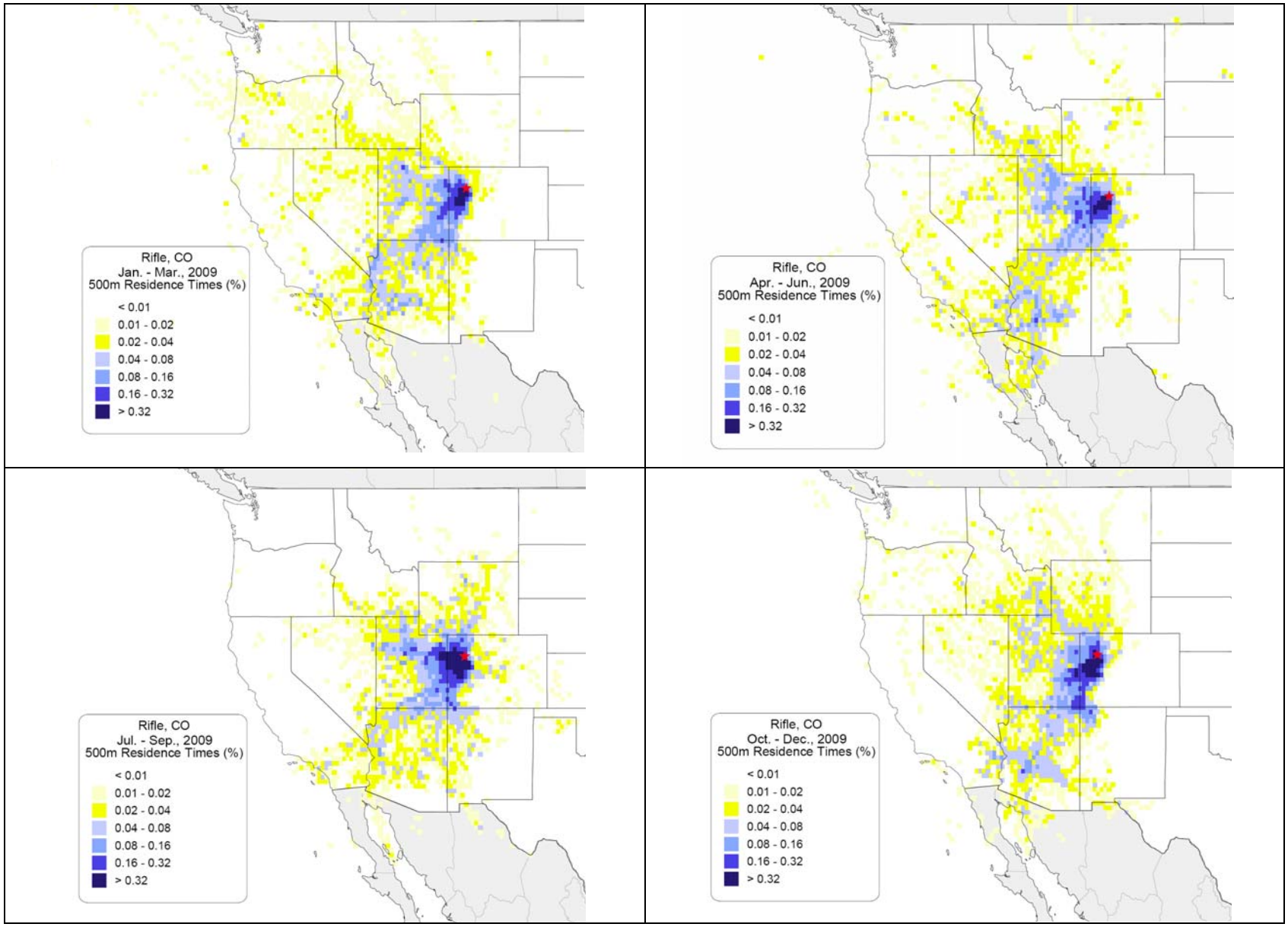


Figure 2-6. 2009 Quarterly Residence Time Maps for Rifle Monitoring Site in Garfield County.

3.0 CRITERIA POLLUTANT SUMMARIES

The Clean Air Act requires EPA to set two types of NAAQS for ground-level O_3, particle pollution ($PM_{2.5}$ and PM_{10}), lead, NO_2, carbon monoxide (CO), and sulfur dioxide (SO_2). The types of standards are as follows:

- Primary Standards: These standards are designed to protect public health with an adequate margin of safety, including the health of sensitive populations such as asthmatics, children, and the elderly.

- Secondary Standards: These standards are designed to protect public welfare from adverse effects, including visibility impairment and effects on the environment (e.g., vegetation, soils, water, and wildlife).

Filter-based PM_{10} measurements have been made every third day at the Parachute and Rifle sites for several years. Garfield County began monitoring continuous $PM_{2.5}$ and PM_{10} at the Rifle site in September 2008. The level of the national primary and secondary ambient air quality standards for PM_{10} is a 24-hour average concentration of 150 micrograms per cubic meter ($\mu g/m^3$). A violation of the standard occurs when the number of days with a 24-hour average concentration above 150 $\mu g/m^3$ over a 3-year period is equal to or less than one. The standards for $PM_{2.5}$ are an annual arithmetic mean of 15 $\mu g/m^3$ and a 24-hour average of 35 $\mu g/m^3$. A violation of the $PM_{2.5}$ standard occurs when the 3-year average of the weighted annual mean exceeds that annual standard, or the 3-year average of the 98th percentile 24-hour average value exceeds the 24-hour standard.

O_3 monitoring began at the Rifle site in June 2008. The current NAAQS for O_3 is 0.075 ppm (75 ppb) over an 8-hour period. An exceedance of the standard occurs when an 8-hour average O_3 concentration is greater than or equal to 76 ppb. A violation of the standard occurs when the 3-year average of the fourth highest daily maximum 8-hour average ozone concentration equals or exceeds 76 ppb.

Values measured for O_3, $PM_{2.5}$, and PM_{10} in 2009 at the Rifle site are presented with corresponding NAAQS in Table 3-1. PM_{10} measured at the Parachute site is presented in Table 3-2. At present, air quality measurements in Garfield County do not violate air quality standards for these criteria pollutants.

Table 3-1

2009 Standards Summary for the Rifle Site

Parameter	NAAQS		Measured	
	Averaging Time	Standard	Measured Value	Date(s)
Ozone (O_3)	Rolling 8-hour	0.075 ppm/ 75 ppb*	Highest Daily Max.: 64 ppb	4/30
			4th Highest Daily Max.: 62 ppb	3/29
Particulate Matter ≤2.5µm ($PM_{2.5}$)	Annual	15 µg/m^3	Arithmetic Mean: 9.0 µg/m^3	1/1-12/31
	24-hour	35 µg/m^3	Highest Max: 41 µg/m^3	1/2
			98th percentile: 27 µg/m^3	8/31
Particulate Matter ≤10µm (PM_{10})	24-hour	150 µg/m^3**	Highest Daily Max.: 83 µg/m^3	3/29
			2nd Highest Daily Max.: 59 µg/m^3	2/3

*To attain the O_3 standard, the 3-year average of the fourth-highest daily maximum 8-hour average O_3 concentrations must not exceed the standard.

**To attain the PM_{10} standard, the average cannot exceed the standard more than once per year on average over 3 years.

Table 3-2

2009 Standards Summary for the Parachute Site

Parameter	NAAQS		Measured	
	Averaging Time	Standard	Measured Value	Date(s)
Particulate Matter ≤10µm (PM_{10})	24-hour	150 µg/m^3	Highest Daily Max.: 88 µg/m^3	3/29
			2nd Highest Daily Max.: 71 µg/m^3	2/6

3.1 OZONE (O_3)

Ozone is a secondary pollutant, meaning it is not emitted directly from sources, but is formed from photochemical interactions of VOCs and oxides of nitrogen (NO_X) in the presence of sunlight. The basic formation and depletion equations for O_3 are presented below:

NO_2 + sunlight → NO + O

O + O_2 + M → O_3 + M (where M is a non-reactive molecule required for this process)

NO + O_3 → NO_2 + O_2

Without the presence of VOCs, the diurnal cycle is a balanced reaction, with equal production and depletion of O_3. When VOCs are present, they can react with nitric oxide (NO) to produce NO_2, as follows:

NO + RO → NO_2 + RO_2 (where R represents a reactive VOC)

This effectively creates competition for NO, allowing O_3 to build up instead of being depleted by NO. Also, when NO reacts with hydrocarbons, additional NO_2 is produced without consuming O_3. The produced NO_2 can further react to produce more O_3.

It was previously thought that, due to the nature of ozone formation, elevated levels of ozone were only possible during hot summer months. Recently, high-ozone readings have been recording during the wintertime in the Green River Basin in Wyoming, and the Uintah Basin in Utah. Wintertime ozone formation requires, along with VOC and NO_2 emissions, distinct meteorological conditions. The meteorological conditions associated with wintertime ozone include strong temperature inversions, low winds, snow cover, and bright sunlight.

Ozone measurements began in June 2008 at the Rifle site. Figures 3-1 and 3-2 present daily maximum 8-hour averages of O_3 monitored at the site in 2008 and 2009, respectively, along with the NAAQS. Ozone measurements at the Rifle site are highest in the summer, and Rifle has not seen the wintertime ozone highs that have been observed in Wyoming and Utah.

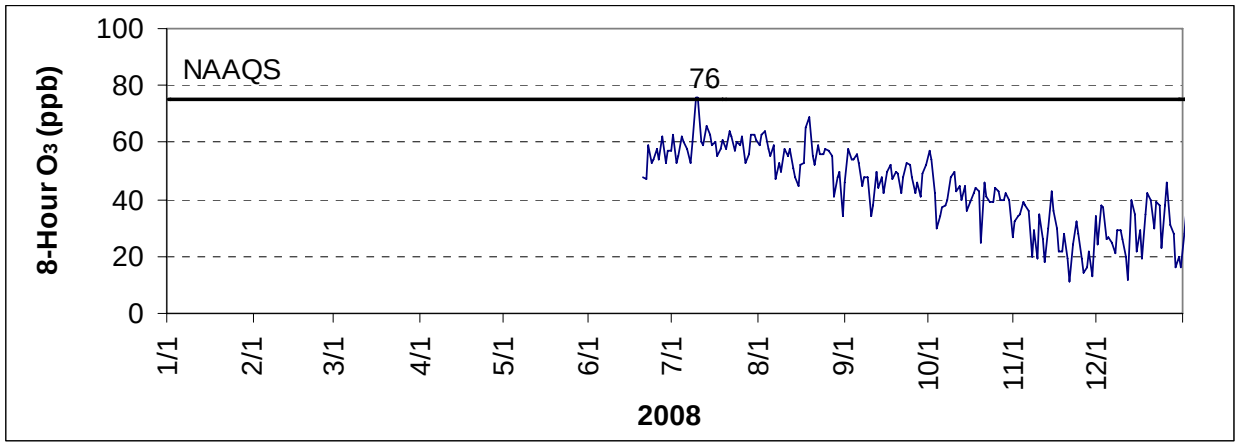


Figure 3-1. Daily Maximum 8-Hour Averages of Ozone Monitored at the Rifle Site in 2008.

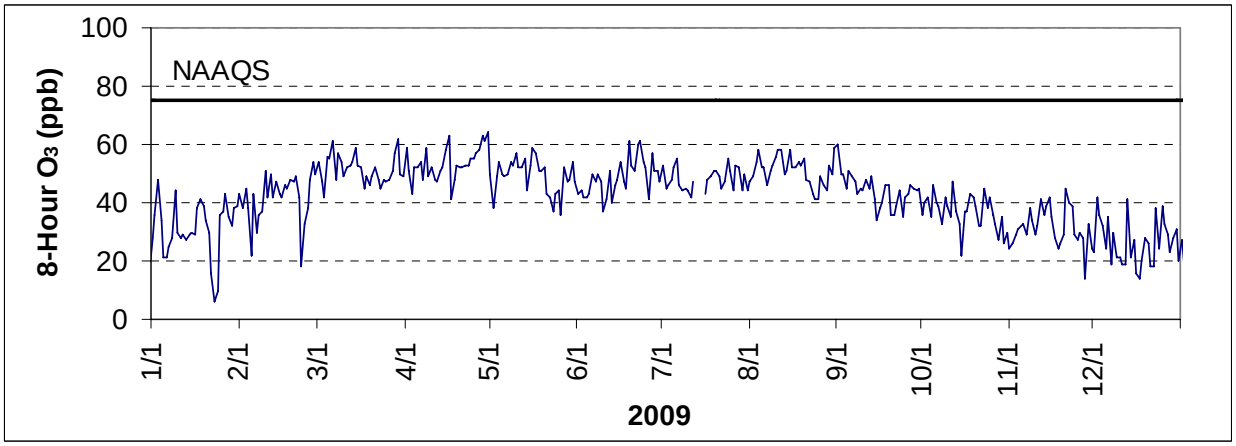


Figure 3-2. Daily Maximum 8-Hour Averages of Ozone Monitored at the Rifle Site in 2009.

Table 3-3 presents the highest daily maximum O_3 measurements in 2009. In 2008, the daily maximum 8-hour average O_3 exceeded the standard at 76 ppb on July 9, 2008 and July 10, 2008, but this is not considered an exceedance because the 4th highest daily 8-hour average was lower than the standard at 66 ppb. No exceedances were recorded in 2009. A violation of the standard does not occur unless the 3-year average of the 4th highest daily maximum values is greater than 75 ppb.

Table 3-3

Rifle Site
Ten Highest Daily Maximum 8-Hour Ozone Averages in 2009

Level	Date	Daily Maximum 8-Hour Ozone (ppb)
1	4/30	64
2	4/16	63
3	4/28	63
4*	**3/29**	**62**
5	3/6	61
6	4/29	61
7	6/19	61
8	6/23	61
9	6/22	60
10	9/1	60

* The 3-year average of the 4th highest daily maximum is used to determine attainment status.

Figure 3-3 presents a wind rose for the Rifle site showing wind speed and direction for hours where O_3 measured greater than or equal to 40 ppb. A pollutant rose shows the frequency of wind direction and uses different shading to represent O_3 values. The wind rose indicates that highest concentrations of O_3 were measured when winds were out of the west-southwest through south.

Figure 3-4 presents the diurnal cycle of measured hourly O_3 at the Rifle station. The cycle shows lowest concentrations in the early morning hours and maximum concentrations in the late afternoon. This pattern results from daytime photochemical production from NO_X ($NO + NO_2$) and VOC precursors, and ozone loss by dry deposition and reaction with NO at night.

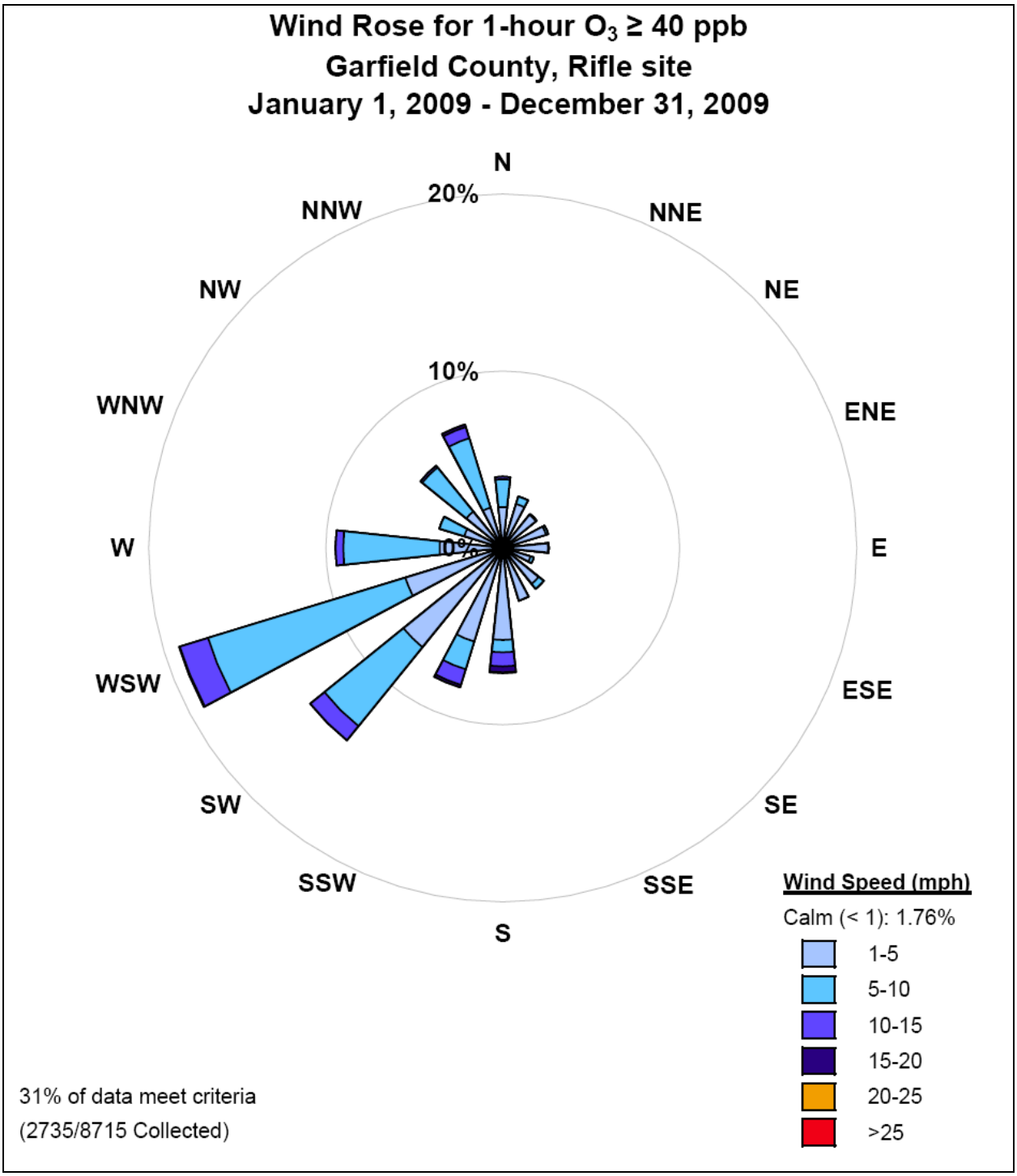


Figure 3-3. 2009 Wind Rose Corresponding to Ozone Measurements Greater than or Equal to 40 ppb at the Rifle Monitoring Site.

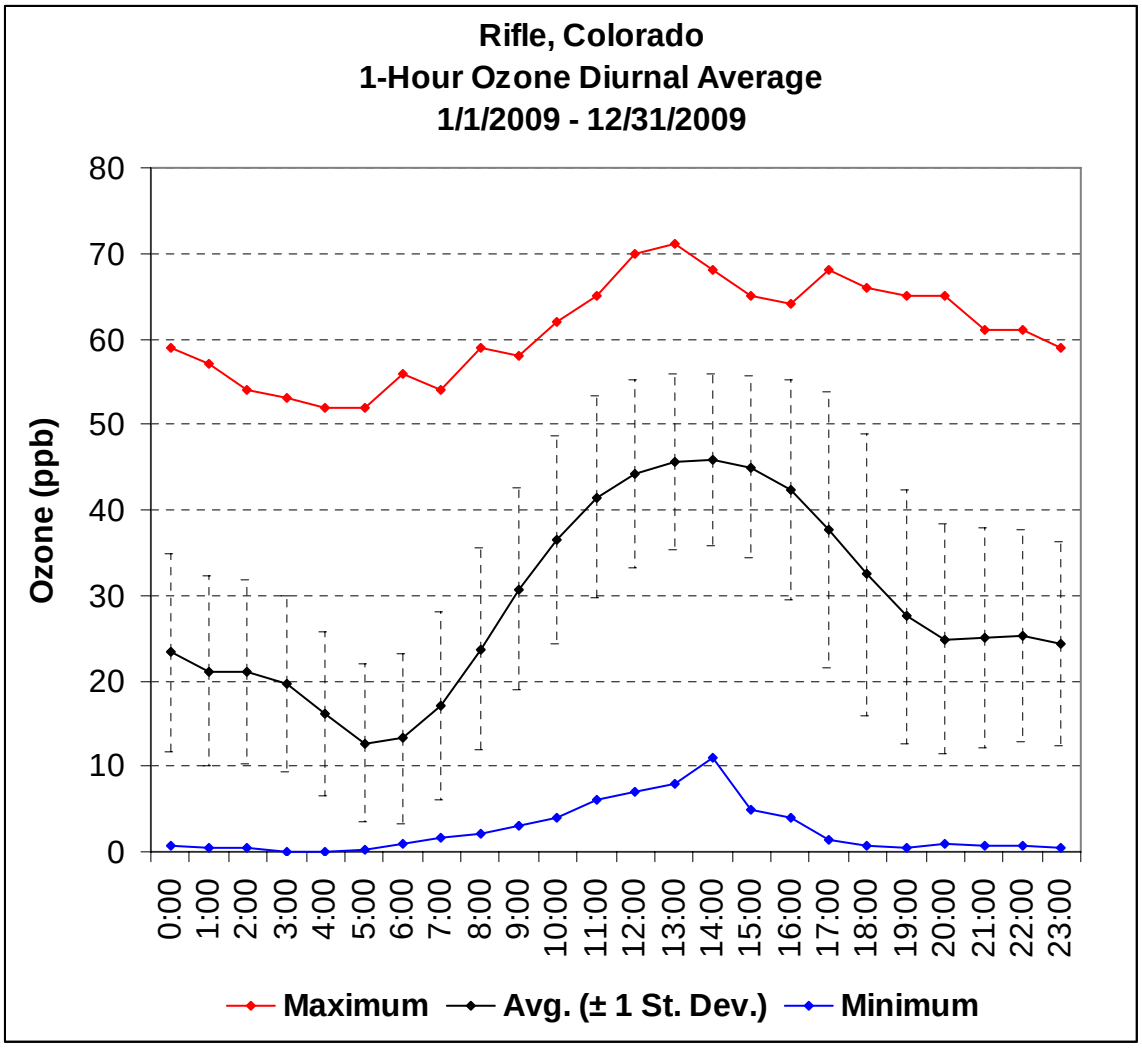


Figure 3-4. 2009 Diurnal Plot Showing Average Concentrations of Ozone at the Rifle Site.

3.2 PARTICULATE MATTER (PM_{10} AND $PM_{2.5}$)

The Parachute and Rifle sites monitor 24-hour PM_{10}. Continuous PM_{10} and $PM_{2.5}$ monitoring began at the Rifle site in September 2008.

3.2.1 Filter Based PM_{10} Measurements

Figure 3-5 presents the annual average PM_{10} measured at the Parachute site since 2000, and Figure 3-6 presents annual average PM_{10} measured at the Rifle site since 2005. PM_{10} at the Parachute site began increasing in 2004, reaching a high in 2008, but dropped significantly in 2009. At the Rifle site, the highest average recorded PM_{10} was again in 2008, but measurements at this site also dropped in 2009.

Figures 3-7 and 3-8 present the highest and second highest 24-hour average values measured at the Parachute and Rifle sites, respectively. The NAAQS for PM_{10} is a 24-hour average of 150 ppb (shown on chart), which was exceeded at the Parachute site in 2008. No exceedances have been recorded at the Rifle site. An exceedance of the standard does not constitute a violation unless the average number of annual exceedances over a 3-year period is greater than or equal to 1.

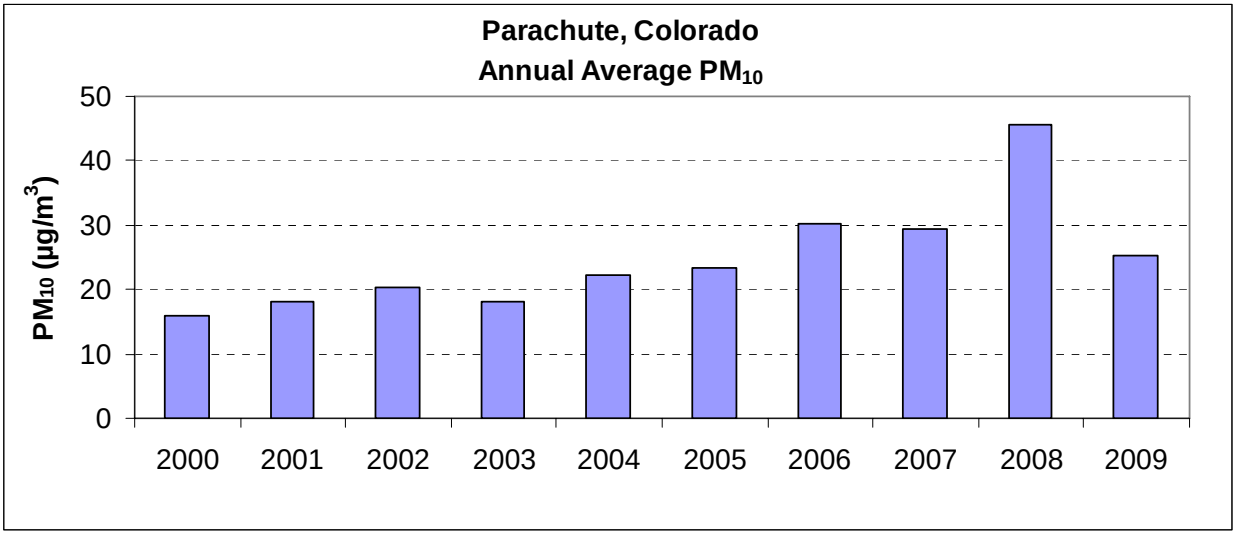


Figure 3-5. Annual Average PM_{10} Measured at the Parachute Site.

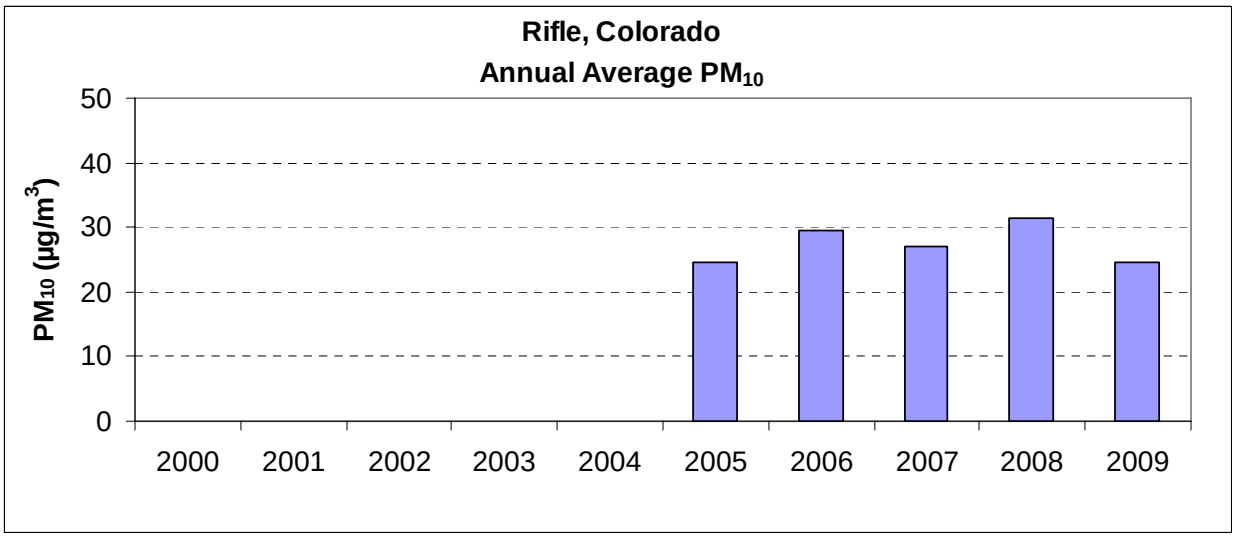


Figure 3-6. Annual Average PM_{10} Measured at the Rifle Site.

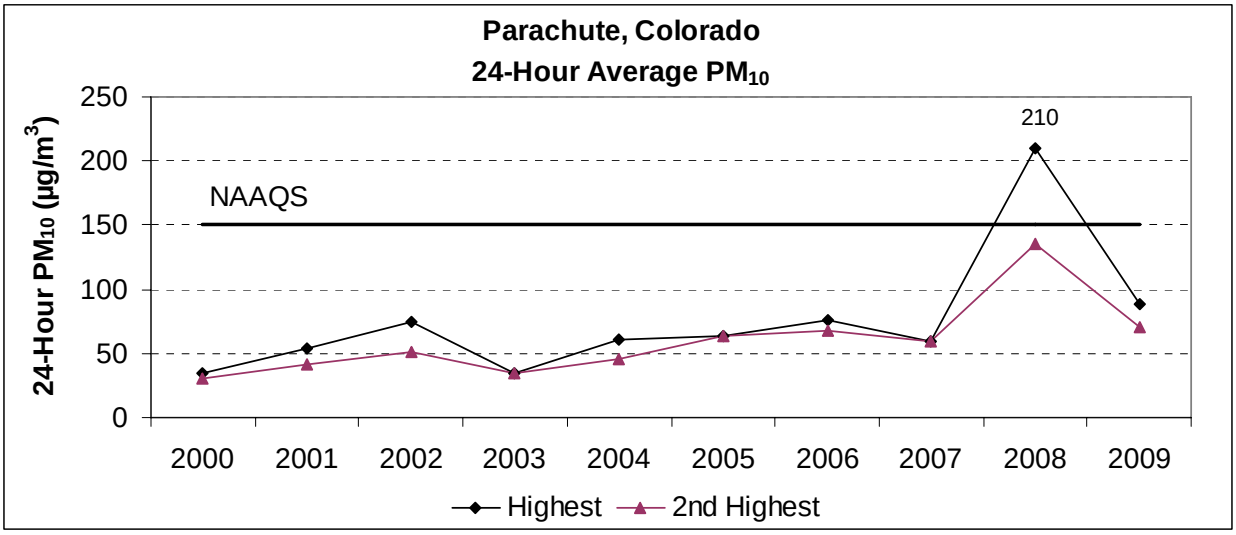


Figure 3-7. Highest and Second Highest 24-Hour Average PM_{10} Measured at the Parachute Site.

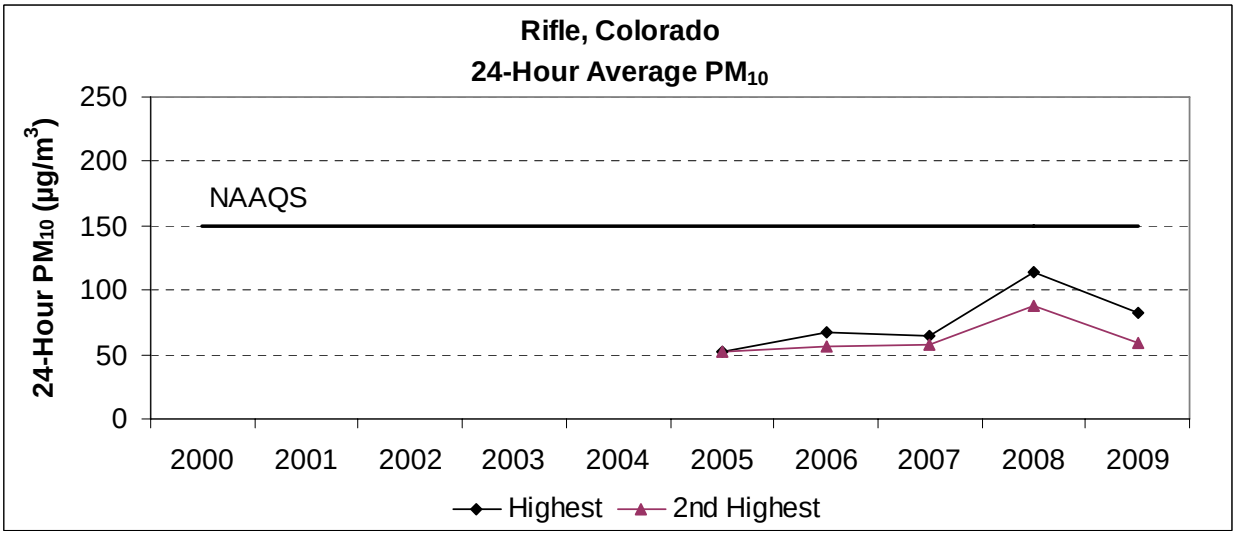


Figure 3-8. Highest and Second Highest 24-Hour Average PM_{10} Measured at the Rifle Site.

3.2.2 Continuous PM Measurements

Continuous PM_{10} is collocated with the filter based PM_{10} measurements at the Rifle site. Figure 3-9 presents a correlation plot comparing 24-hour averages from both methods showing good correlation (R^2 = 0.92) between the collocated methods. The FRM data is useful for comparison to NAAQS, but is only available every third day in 24-hour averages. Continuous data are useful to assess particulate pollution because they are available on an hourly basis, and are available in real-time.

Figure 3-10 is a wind rose showing wind direction for hourly PM_{10} values measured at or above 30 µg/m^3. The wind rose indicates that highest PM_{10} measurements occurred when winds were out of the north and the west-southwest to south range. Figure 3-11 is a wind rose showing wind direction for hourly $PM_{2.5}$ values measured at or above 10 µg/m^3. Fine mass was generally associated with winds out of the north.

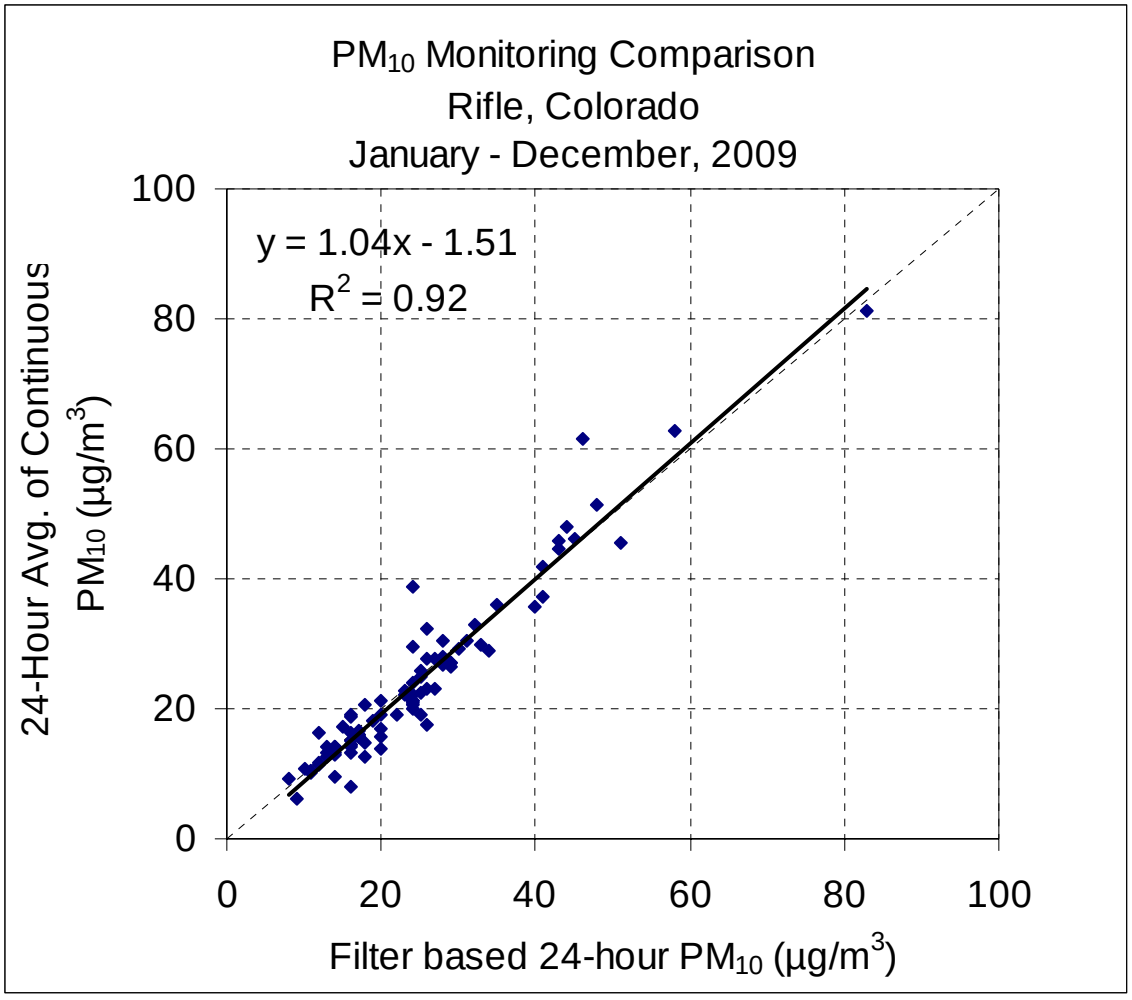


Figure 3-9. Correlation between Continuous and Filter Based Measurements at the Rifle Monitoring Site in 2009.

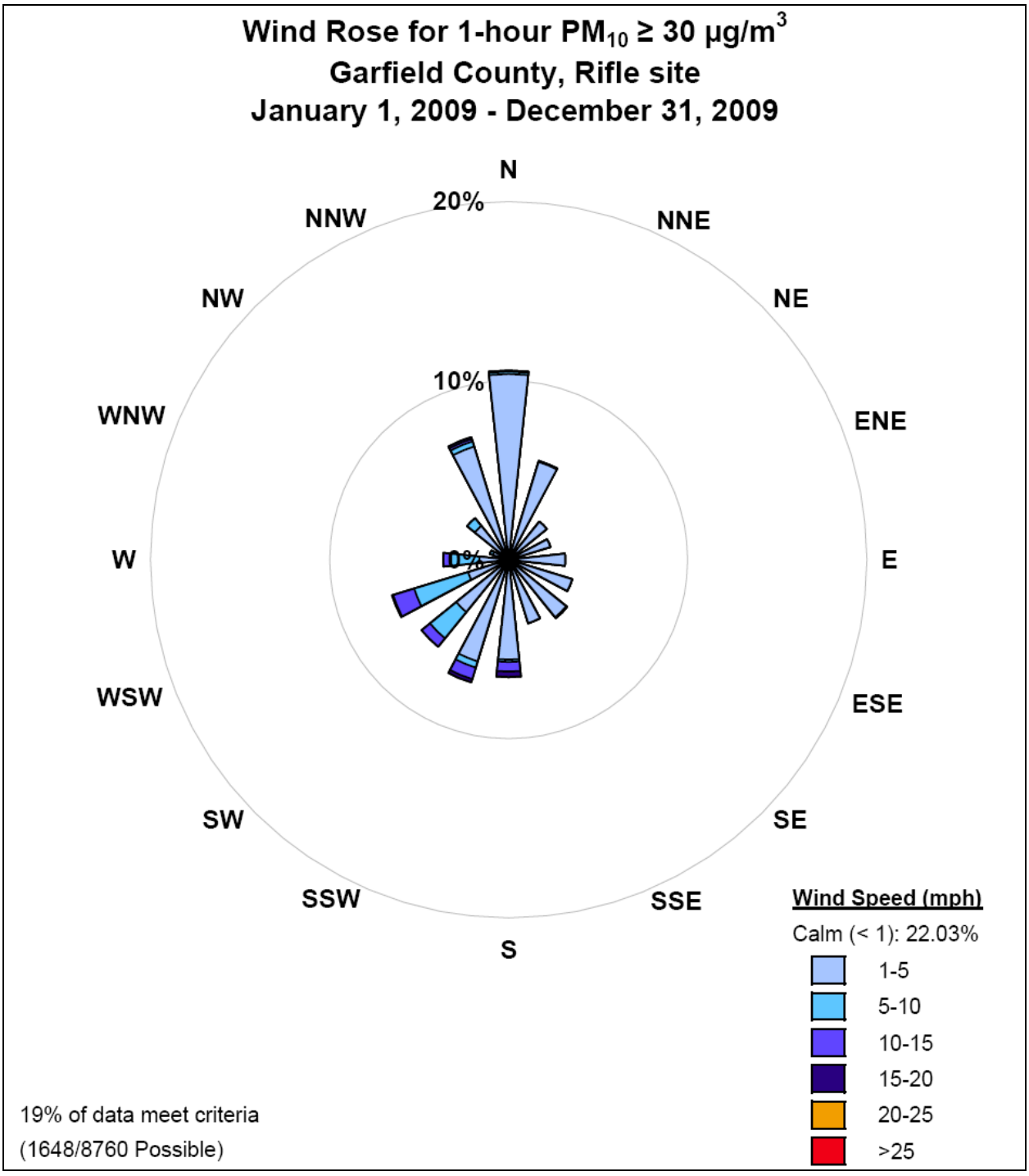


Figure 3-10. 2009 Wind Rose Corresponding to PM_{10} Measurements Greater than or Equal to 30 µg/m^3 at the Rifle Monitoring Site.

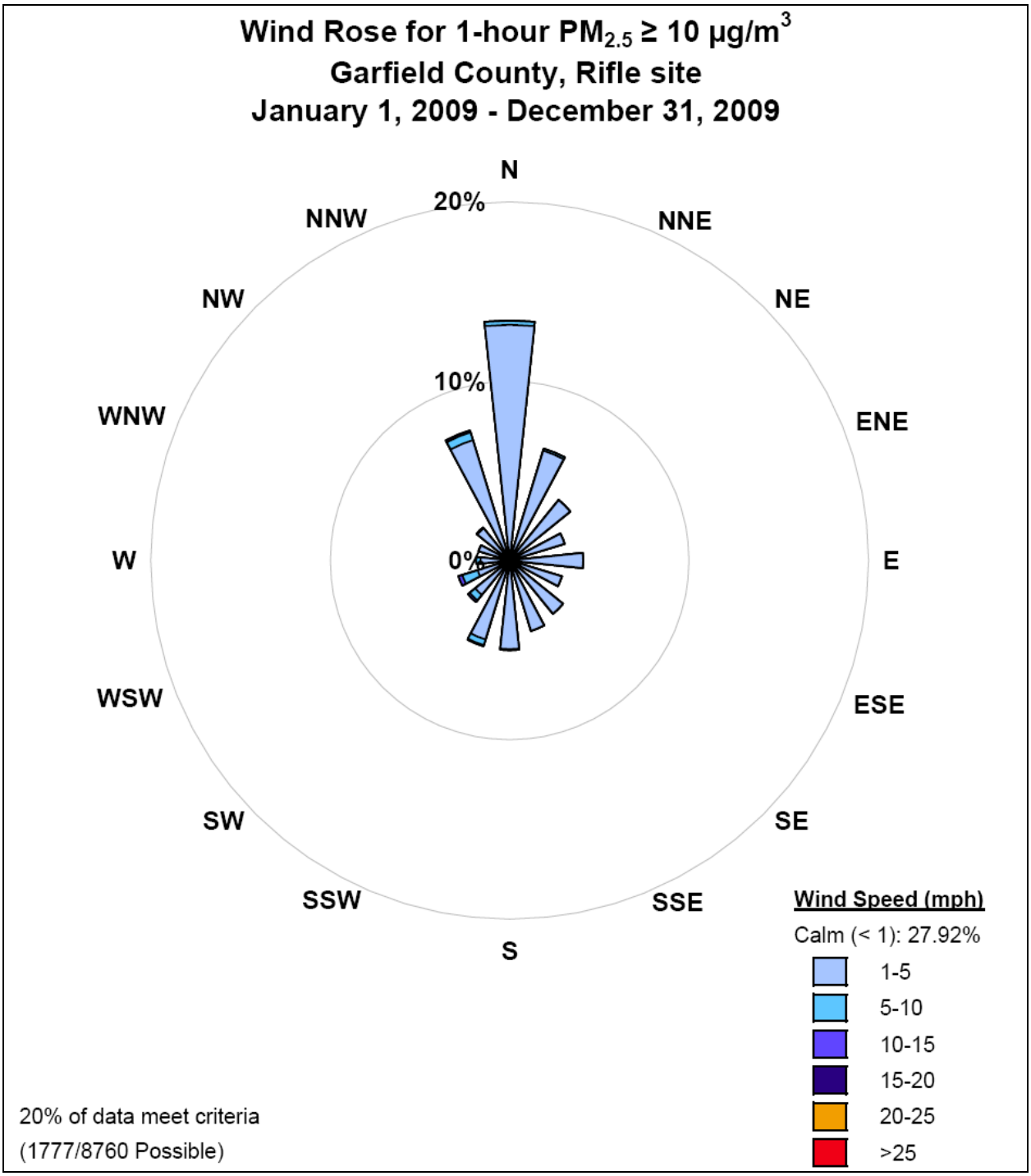


Figure 3-11. 2009 Wind Rose Corresponding to $PM_{2.5}$ Measurements Greater than or Equal to 10 µg/m^3 at the Rifle Monitoring Site.

Figure 3-12 presents a monthly average plot. Monthly averages of PM were higher during the winter months. High PM measurements in the winter are affected by temperature inversions in the Colorado River Basin. These occur when snow cover and low winds promote the development of an inversion, where cold air is trapped under a layer of warmer air. Air pollutants can build up during inversions because of the limited atmospheric mixing. The passage of a storm front, and the associated strong winds can break up the inversion and disperse pollutants. Figure 3-13 presents an example of a temperature inversion in Garfield County which led to high particulate concentrations. The figure shows the 1-hour PM_{10} and $PM_{2.5}$ and 24-hour $PM_{2.5}$ measurements and several meteorological parameters measured between December 28, 2008 and January 9, 2009. The 24-hour NAAQS is also plotted. During this event, 24-hour $PM_{2.5}$ measurements were above the NAAQS levels between December 31, 2008 and January 2, 2009. Winds were low during this period. On January 3, 2009, the winds increased and broke up the inversion causing PM levels to drop.

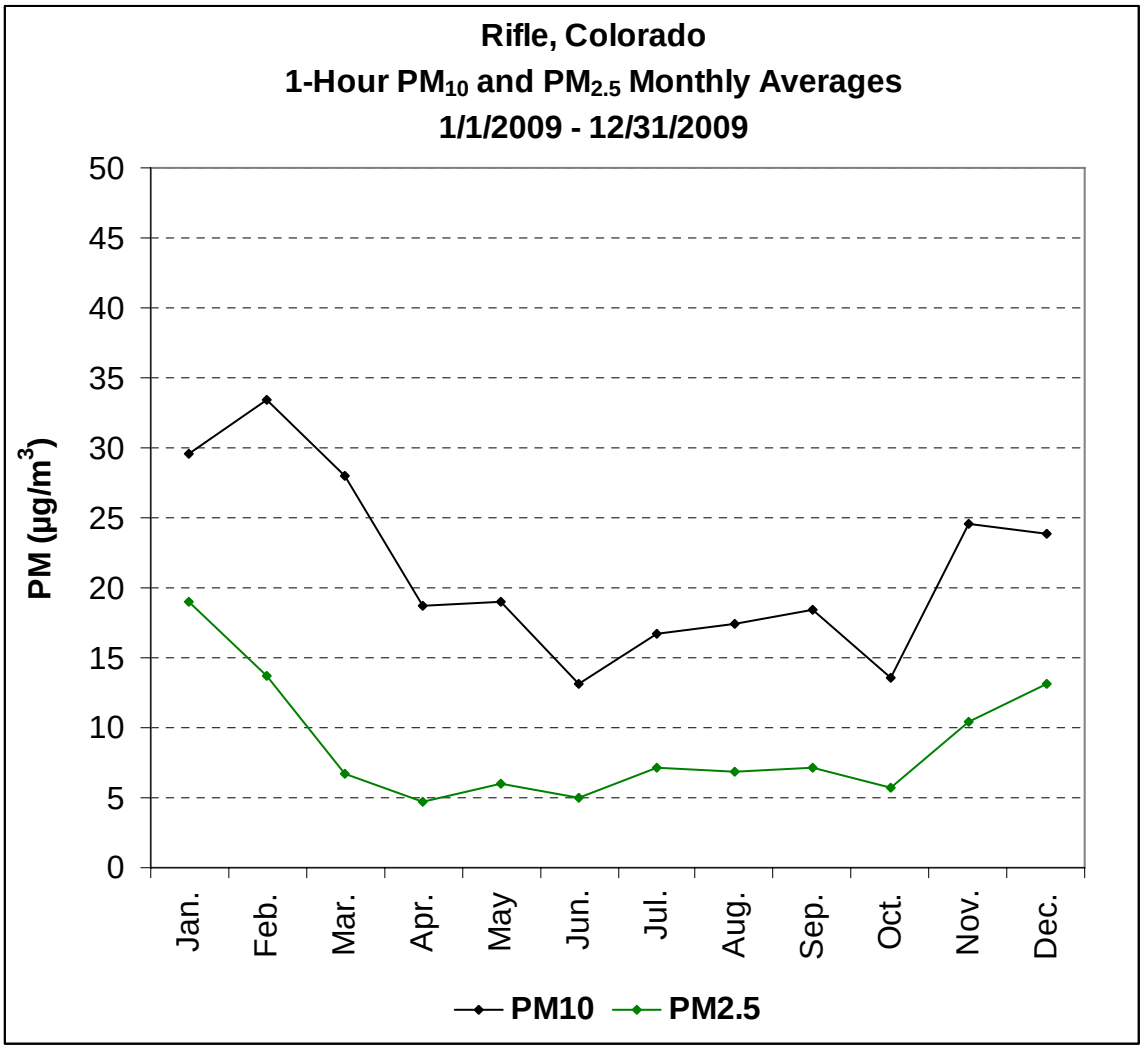


Figure 3-12. Monthly Average of Continuous Particulate Matter Measurements at the Rifle Monitoring Site in 2009.

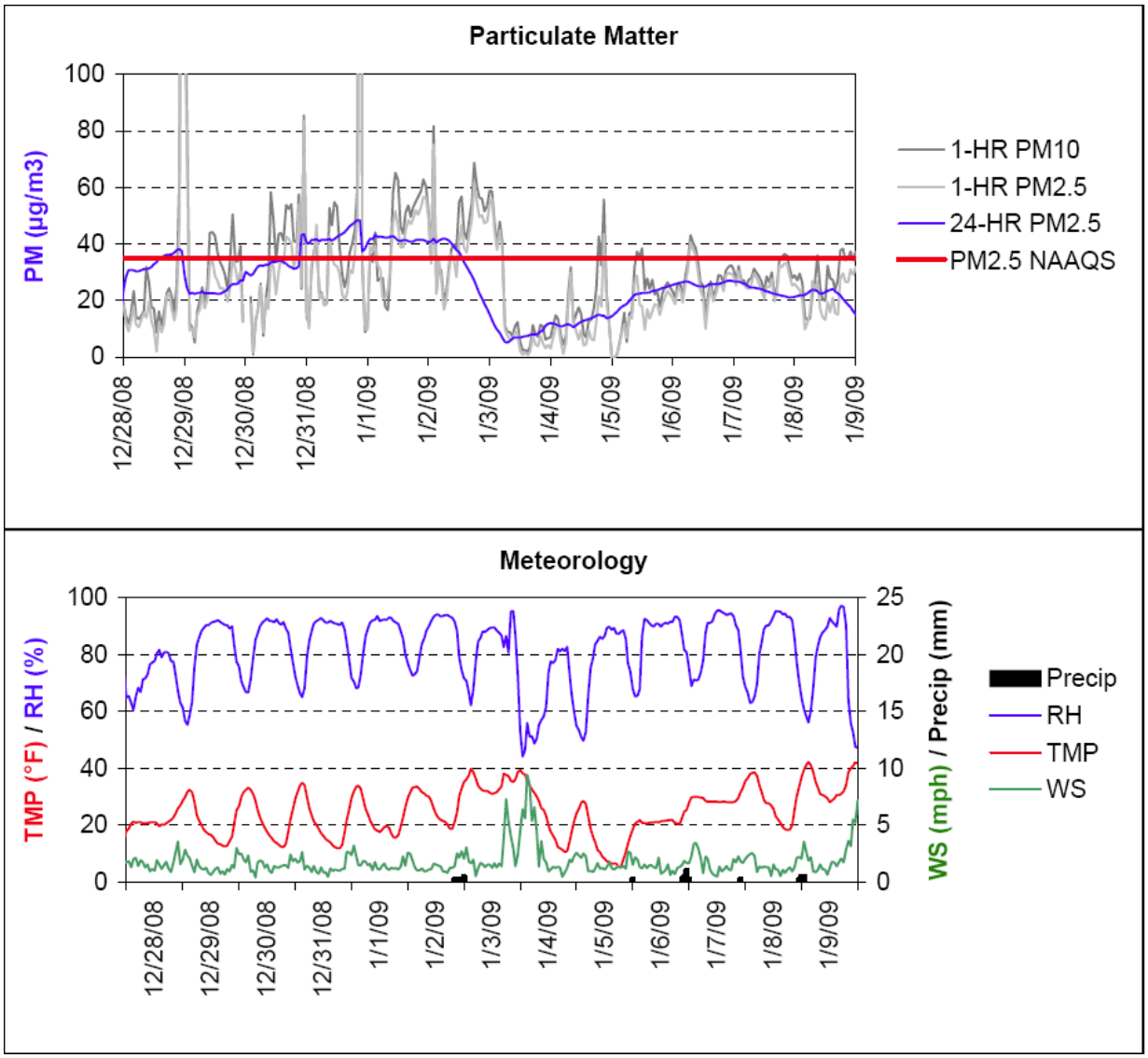


Figure 3-13. Hourly Particulate and Meteorological Measurements at the Rifle Monitoring Site between December 28, 2008 and January 9, 2009.

4.0 SPECIATED NON-METHANE HYDROCARBONS (SNMOC) AND CARBONYL SUMMARIES

In 2009, SNMOCs and carbonyl compounds were monitored at all sites in Garfield County, with some overlap at the Brock and Rulison sites when monitoring began at the Rulison site in January 2009, and monitoring at the Brock site was discontinued in February 2009. SNMOCs and carbonyl compounds are subsets of VOCs. VOCs are generally carbon- and hydrogen-based chemicals that exist in the gas phase or can evaporate from liquids. VOCs can react in the atmosphere to form O_3 and $PM_{2.5}$. HAPs are a subset of VOC compounds, and include compounds that are known or believed to cause human health effects at low doses. Summaries of SNMOCs, carbonyls, and HAPs levels measured in 2009 are presented in this section.

4.1 SPECIATED NON-METHANE HYDROCARBONS (SNMOC)

SNMOC compounds were collected and analyzed according to EPA Compendium Method TO-12, with 24-hour samples collected at all sites on a 1-in-6 day schedule. This method includes analyses for 81 different compounds. Appendix B lists minimum, maximum, and average concentrations of all detected SNMOC compounds by site.

SNMOC compounds can be grouped into classifications with similar characteristics. For these summaries, measured SNMOC compounds were grouped into the following categories:

- Light Alkanes: Alkanes are the simplest hydrocarbons, consisting of only carbon and hydrogen with single bonds. Light alkanes, which here include alkanes with up to five carbon atoms (ethane, propane, iso/n-butane and iso/n-pentane) are the primary components of natural gas.

- Heavy Alkanes: The hydrocarbons in crude oil are mostly heavy alkanes, which here include alkanes with more than five carbon atoms (C5). Crude oil products include gasoline, a refined mix of predominantly C6 to C10 hydrocarbons, and diesel, which is a refined mix ranging from approximately C10 to C15.

- Alkenes: Alkenes are more complex than alkanes, with at least one carbon to carbon double bond. These compounds are not generally found in crude oil. Alkenes are much more reactive than alkanes, and will deplete quickly in the atmosphere. Alkenes are produced in refineries when larger alkane molecules are dissociated (or cracked) into smaller compounds. Some alkene compounds, including terpenes such as isoprene and a- and b-pinene, are naturally emitted from vegetation.

- Aromatics: Aromatic compounds are the most abundant compounds emitted from gas-fired engines. These compounds include the BTEX parameters (benzene, toluene, ethylbenzene and m/p-xylenes), which are commonly associated with motor vehicles, but can also have sources associated with oil and gas production.

Figure 4-1 presents categories of measured SNMOCs in units of ppbV (parts per billion by volume) measured in 2009 at each site. In general, measured compounds consisted mostly of light alkanes, which represented between 83 and 89% of total SNMOCs measured. Seasonal variation shows higher concentrations in winter and lower concentrations in summer. These trends can be influenced by the variations in temperature, as VOCs deplete faster during the summer due to higher reactivity at higher temperatures. Also, some emissions, including cold-start engine emissions and residential wood burning, are higher in the winter.

Figure 4-2 presents measurements by category in units of ppbC, where ppbC represents the number of carbon molecules measured (ppbV multiplied by the number of carbons in each compound). Carbon content in a molecule is related to the compound reactivity, which contributes to ozone formation potential. Heavier alkanes and aromatics are more significant sources of carbon than the lighter alkanes. The unknown category indicates the part of the total carbon measurements where individual species were not identified.

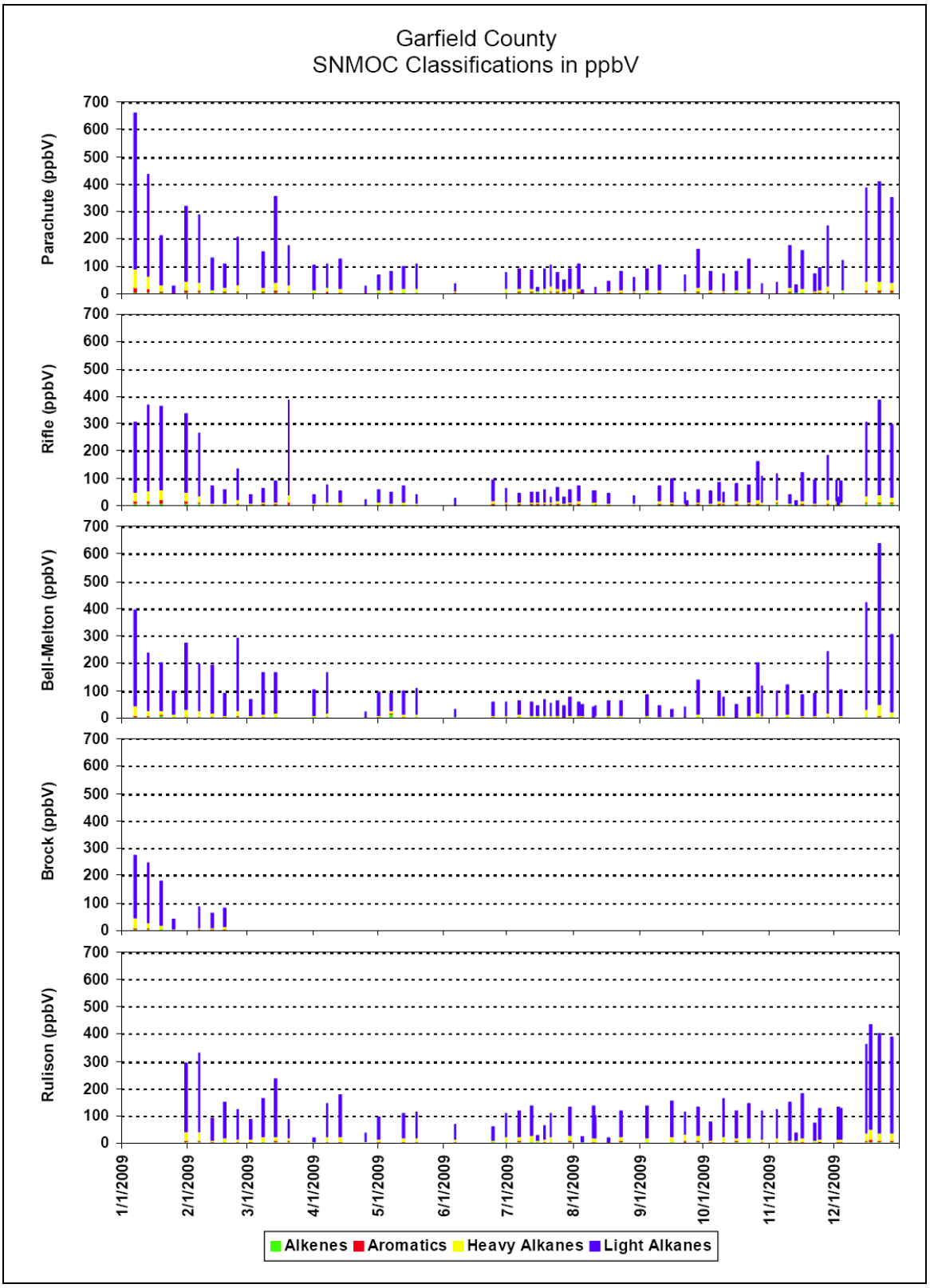


Figure 4-1. 2009 24-Hour SNMOC Measurements by Category in Units of ppbV.

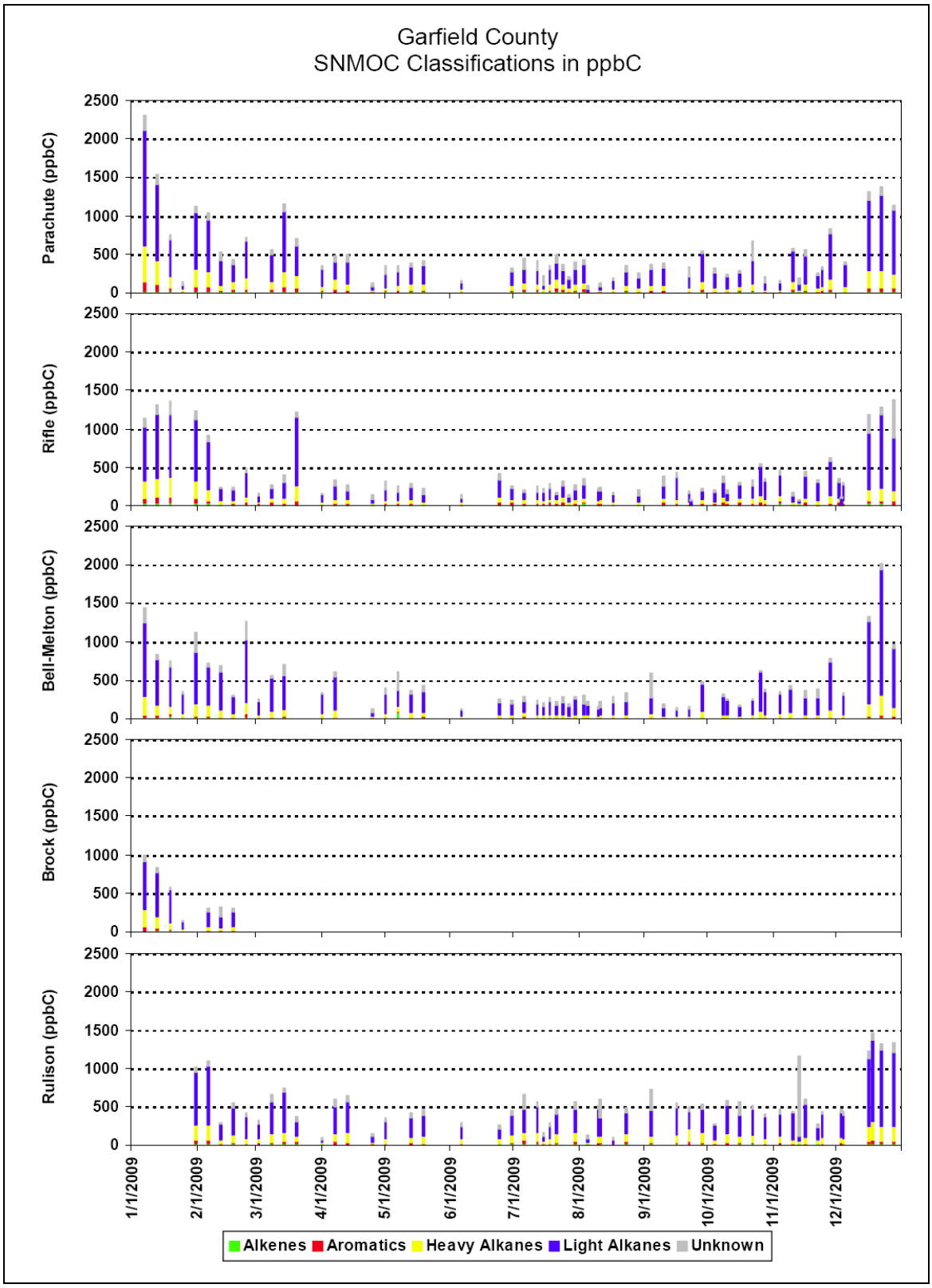


Figure 4-2. 2009 24-Hour SNMOC Measurements by Category in Units of ppbC.

4.1.1 SNMOC Ozone Formation Potential

Ozone is formed from photochemical interactions of VOCs and NO_X in the presence of sunlight as described in Section 3.1. The potential of individual VOCs to contribute to O_3 formation depends on the reactivity of each compound. Ozone formation potential can be quantified using a maximum incremental reactivity (MIR) scale developed using scenarios where ambient ozone is most sensitive to changes in VOC emissions (Carter 1994). The California Air Resources Board (CARB) regularly updates and publishes these values. This report uses MIR values published by CARB as updated on March 17, 2009. While MIRs are actually calculated in terms of O_3 impact per unit VOC emitted, the MIR potential of measured atmospheric VOCs gives an idea of the relative potential for the VOCs to contribute to ozone formation.

Theoretically, based on MIR numbers, a large mass of a low-reacting VOC might replace a smaller mass of high-reacting VOC. For example, it would take 25g of ethane to match the ozone formation potential of 1g of m/p-xylenes. Table 4-1 presents the top 10 potential contributors to ozone formation based on MIR reactivity and measured concentration. The top 10 compounds were the same for all sites with the exception of Rifle, which is the only site where the alkene compounds propylene and isobutene were included in the top 10.

The light alkanes that dominate measurements by volume are the least reactive compounds but still contribute significantly to O_3 formation potential. Highly reactive compounds like toluene and x/p-xylenes are less abundant, but high reactivity allows for greater potential to contribute to the O_3 formation. These compounds have sources such as gasoline, diesel, fire sources and oil and gas production. Currently, Garfield County does not violate O_3 standards. Also, ozone reactions can be limited by NO_2 availability and meteorological factors. If O_3 levels become more of a concern in Garfield County, it would be useful to monitor NO_2, and to target further controls for emissions of the identified VOCs that have the greatest potential to contribute to O_3 formation.

Table 4-1

Top 10 Ranked Maximum Incremental Reactivity Levels by Component

Group	ANALYTE	MIR (mol O_3/mol C)	Reactivity Rank (MIR * ppbC)			
			PACO	RICO	BRCO	RUCO
Light Alkanes	Ethane	0.08	**3** (139 ppbC)	**8** (94 ppbC)	**5** (110 ppbC)	**6** (129 ppbC)
	Propane	0.14	**5** (74 ppbC)	**7** (58 ppbC)	**2** (87 ppbC)	**4** (82 ppbC)
	n-Butane	0.33	**7** (29 ppbC)	**5** (26 ppbC)	**1** (42 ppbC)	**3** (36 ppbC)
	Isobutane	0.36	**6** (27 ppbC)	**6** (24 ppbC)	**4** (32 ppbC)	**2** (34 ppbC)
	n-Pentane	0.37	**10** (16 ppbC)	N/A	**6** (20 ppbC)	**8** (21 ppbC)
	Isopentane	0.41	**4** (27 ppbC)	**1** (28 ppbC)	**3** (28 ppbC)	**1** (31 ppbC)
Heavy Alkane	Methylcyclohexane	0.46	**8** (17 ppbC)	N/A	**10** (9 ppbC)	**9** (16 ppbC)
Aromatics	Toluene	1.06	**2** (11 ppbC)	**4** (9 ppbC)	**9** (5 ppbC)	**7** (9 ppbC)
	m/p-Xylene	2.10	**1** (7 ppbC)	**3** (5 ppbC)	**8** (2 ppbC)	**5** (5 ppbC)
Alkenes	Isobutene	2.27	N/A	**10** (3 ppbC)	N/A	N/A
	Ethylene	2.56	**9** (3 ppbC)	**2** (4 ppbC)	**7** (2 ppbC)	**10** (3 ppbC)
	Propylene	3.32	N/A	**9** (2 ppbC)	N/A	N/A

4.1.2 Annual Average SNMOCs

Garfield County began collecting SNMOC data in 2008, with the Brock (MOCO) station relocated to the Rulison (RUCO) site in 2009. Figure 4-3 presents comparisons of annual average SNMOC data collected in 2008 and 2009. In 2009, total measured SNMOC levels were lower at all sites that collected both 2008 and 2009 data, due mostly to decreased light alkane concentrations, which are primary components of natural gas.

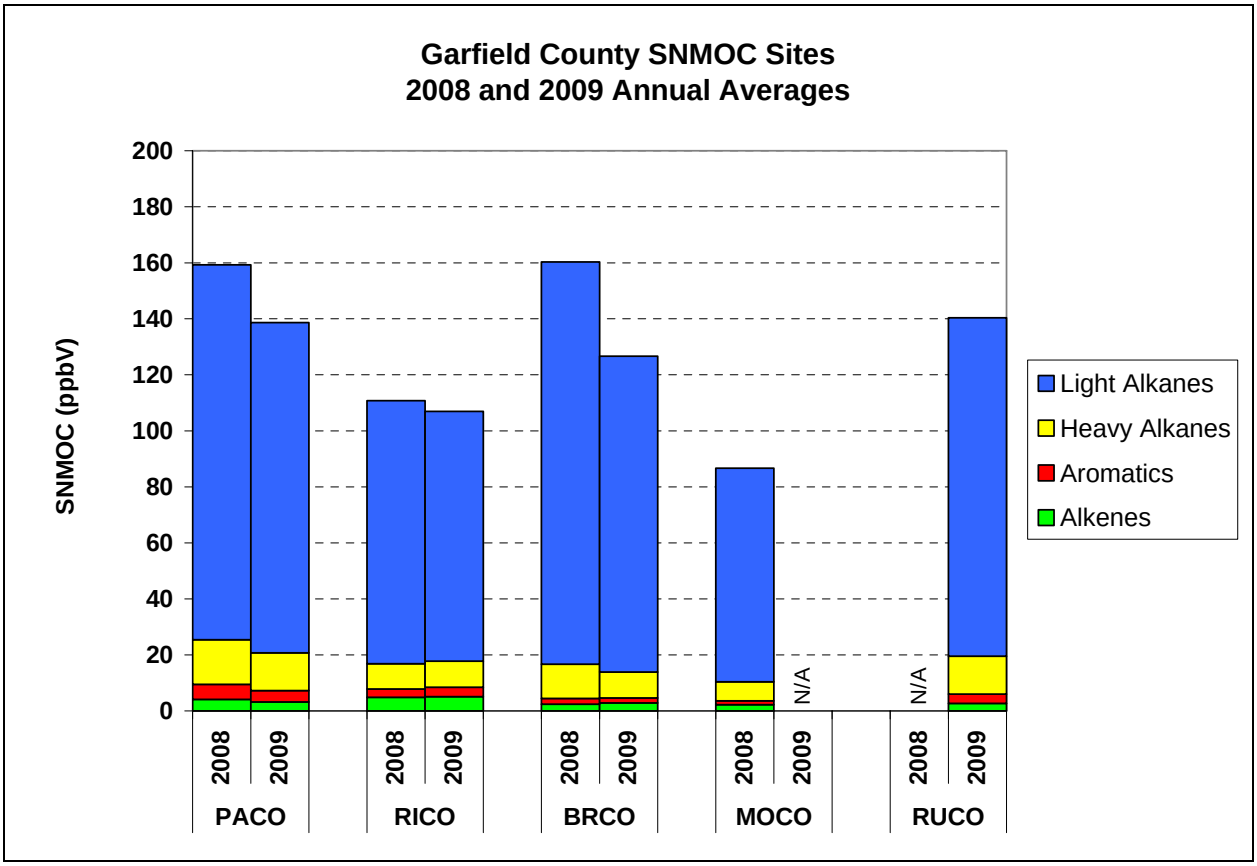


Figure 4-3 Average SNMOC Concentrations Measured by the Garfield County Air Monitoring Program in 2008 and 2009.

4.1.3 Regional SNMOC Comparisons

The EPA publishes an annual report encompassing data collected from sites across the country as part of the Urban Air Toxics Monitoring Program (UATMP) and National Air Toxics Trends Stations (NATTS) National Monitoring Programs. Participating agencies have samples analyzed by the Eastern Research Group, Inc. (ERG) laboratory in Morrisville, North Carolina. In 2009, eight sites, including the four Garfield County sites, sampled for SNMOC concentrations. Annual average concentrations for data collected in 2009 were provided by the ERG laboratory.

Figure 4-4 shows, in descending order, the annual average concentrations measured at the SNMOC sites in 2009. There are additional sites monitoring pollutants in the EPA UATMP/NATTS networks, but only these sites were analyzed by ERG using method TO-12 for the same suite of SNMOC compounds, making total concentration comparable. Notably, concentrations of SNMOCs are highest at the Garfield County sites, although the sites shown here do not represent broad regional coverage. The additional sites are a mix of rural and urban sites with a variety of source influences. The highest average ppbV concentrations outside of Garfield County were observed at the Bountiful, Utah site. In the 2007 EPA UATMP/NATTS monitoring report, it is noted that several emission sources involving petroleum and natural gas production and refining are located two to five miles from the Bountiful site (EPA 2008).

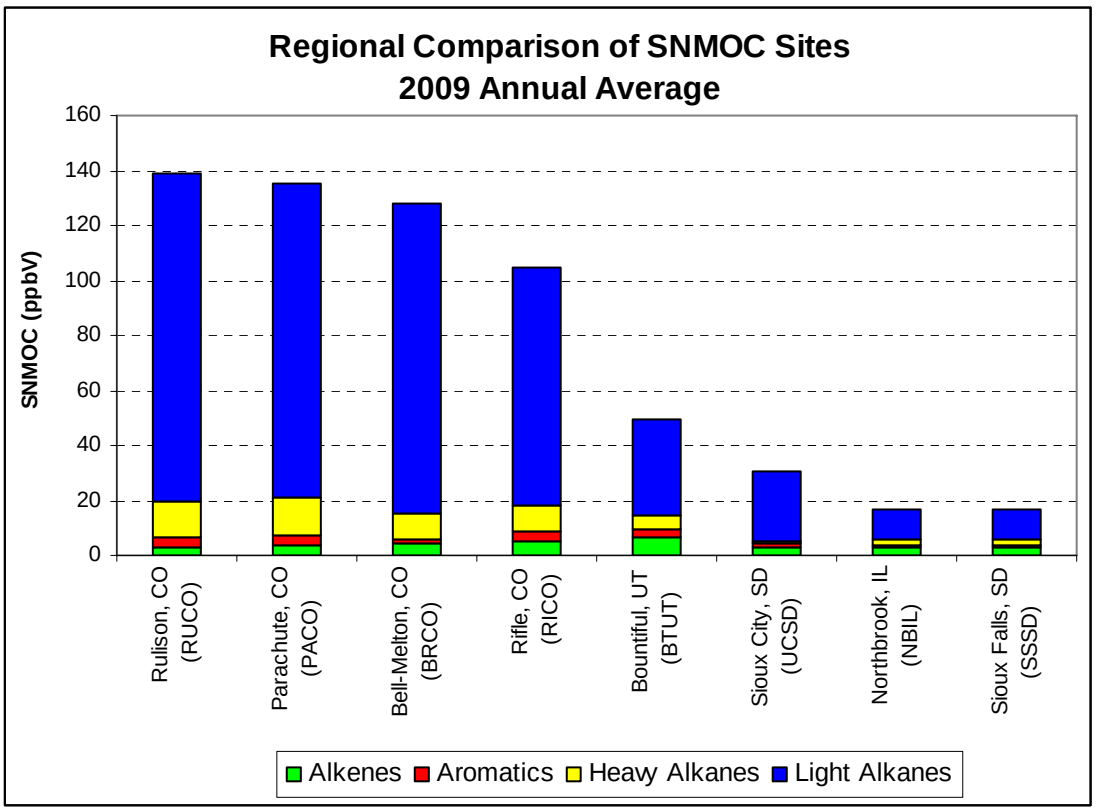


Figure 4-4 Average SNMOC Concentrations Measured by the EPA UATMP/NATTS National Monitoring Programs in 2009.

4.2 CARBONYLS

Carbonyl compounds were collected and analyzed according to EPA Compendium Method TO-11A, with 24-hour samples collected at all four sites on a 1-in-12 day schedule. This method includes analysis for 12 different carbonyl compounds.

Carbonyls are highly reactive and play a critical role in the formation of O_3. Some carbonyls, including formaldehyde and acetaldehyde, also have adverse chronic and acute health

effects. The major sources of directly emitted carbonyls are fuel combustion, mobile sources, and process emissions from oil refineries (CARB 2009).

Appendix C lists minimum, maximum, and average concentrations of all detected carbonyl compounds. Major compounds included formaldehyde, acetaldehyde, and acetone. Figure 4-5 presents a time series of the major compounds measured in 2009. Formaldehyde and acetaldehyde show highs in both the coldest and warmed months. The formation of these compounds during warm months is influenced by photochemical production. Cold season peaks may be related to elevated sources or lower mixing heights.

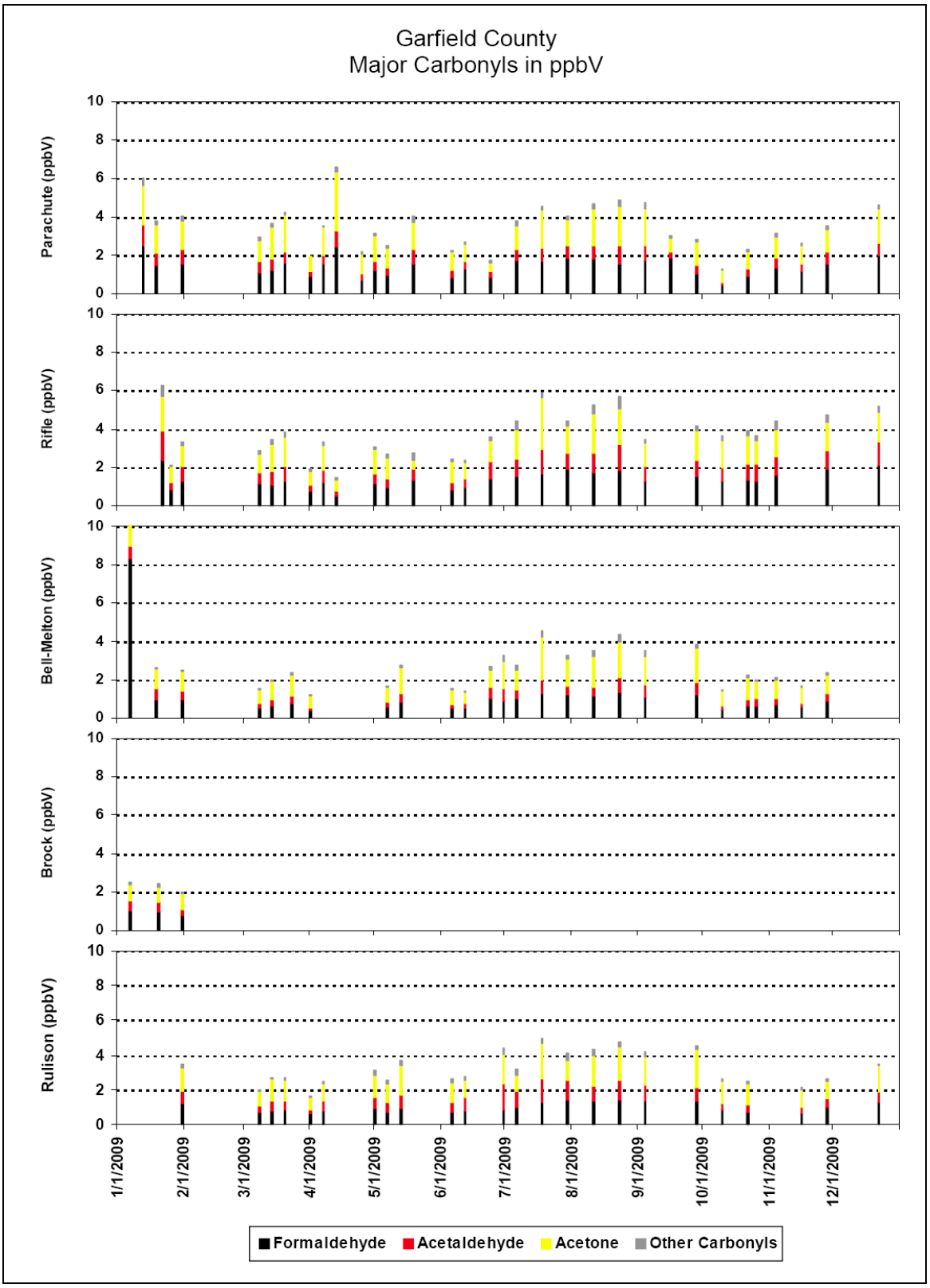


Figure 4-5. 2009 24-Hour Major Carbonyl Compound Concentrations in Units of ppbV.

4.2.1 Annual Average Carbonyl Concentrations

Garfield County began collecting carbonyl data in 2008, with the Brock (MOCO) station relocated to the Rulison (RUCO) site in 2009. Figure 4-6 presents comparisons of annual average carbonyl data collected in 2008 and 2009. In 2009, total measured carbonyl levels were slightly lower at the Parachute (PACO) and Rifle (RICO) sites, and slightly higher at the Bell-Melton (BRCO) site. The higher total carbonyl concentration at the BRCO site was due to higher formaldehyde concentrations.

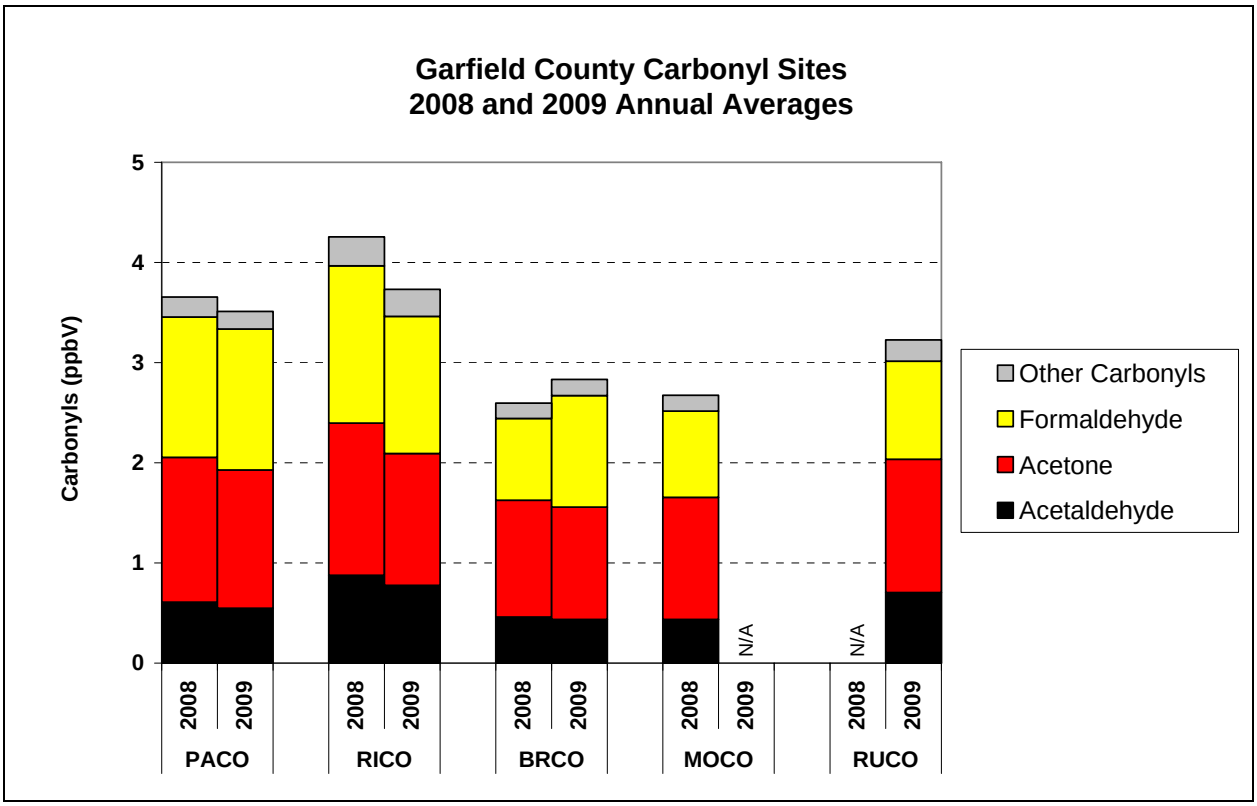


Figure 4-6. Average Carbonyl Concentrations Measured by the Garfield County Air Monitoring Program in 2008 and 2009.

4.2.2 Regional Carbonyl Comparisons

In 2009, 37 sites, including the 4 Garfield County sites, sampled for carbonyl concentrations in cooperation with the EPA UATMP/NATTS National Monitoring Programs. Annual average concentrations for data collected in 2009 were provided by ERG.

Figure 4-7 shows major carbonyl concentrations for all sites. Colorado sites, including the Garfield County sites and the nearby Grand Junction site, are listed in descending order on the left, and other U.S. sites in descending order on the right. Measured carbonyls at the Garfield County sites are lower than the more urban Grand Junction site, and among the lower levels observed across the U.S. Formaldehyde is the dominant carbonyl measured at most sites.

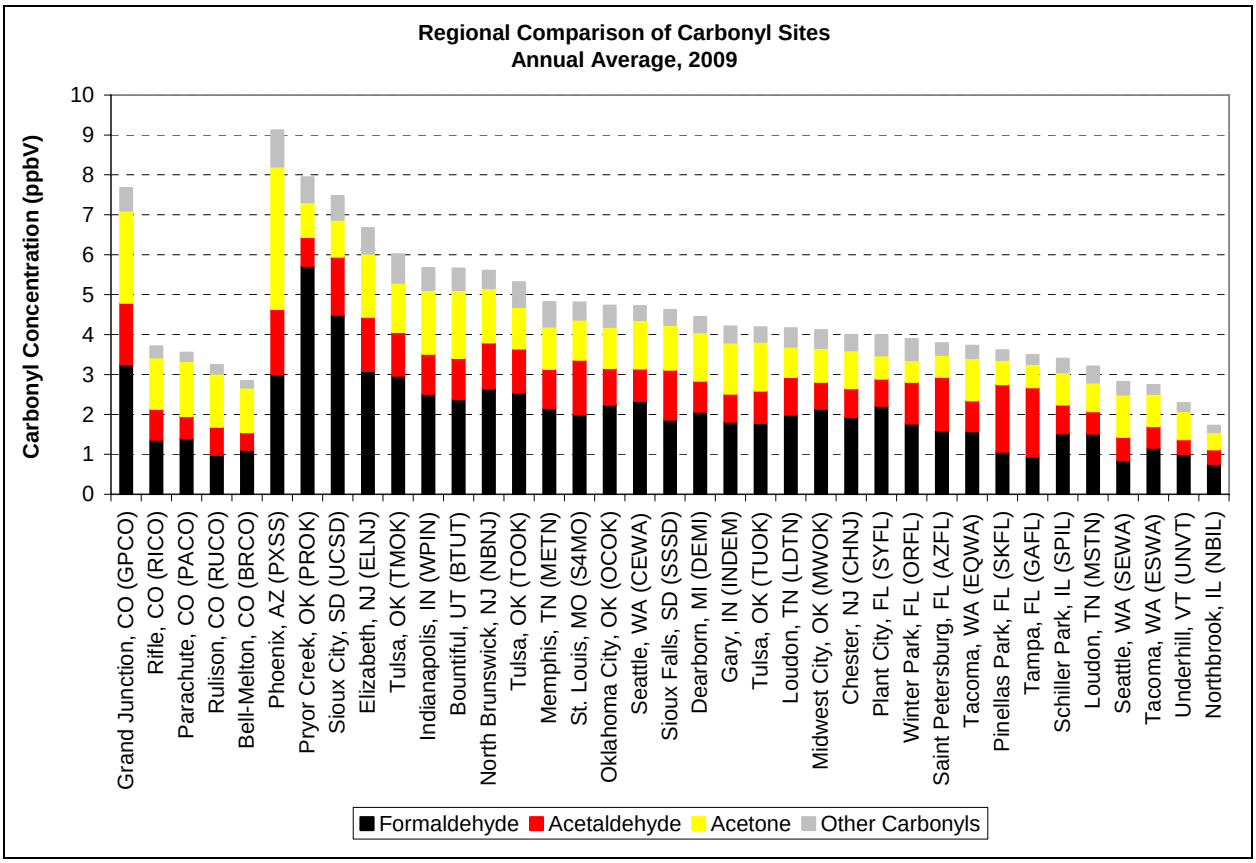


Figure 4-7. Average Carbonyl Concentrations Measured by the EPA UATMP/NATTS National Monitoring Program in 2009.

4.3 HAZARDOUS AIR POLLUTANTS (HAPS) SUMMARIES

Not all measured VOCs have associated risk factors, and those that do are also referred to as HAPs. Of the SNMOC and carbonyl compounds measured in Garfield County, 21 compounds have been identified as HAPs. No NAAQS or any other ambient air standards exist for VOCs. Instead, emissions limits on industrial sources have been set. The EPA has developed a set of risk factors for both acute and chronic exposures for HAPs. In addition, risk factors from the Agency for Toxic Substances and Disease Registry (ATSDR), the California Air Resources Board (CARB), the National Institute for Occupational Safety and Health (NIOSH), and others can be used to determine potential risks from exposure to VOCs.

The Garfield County Air Toxics Inhalation Screening Level Human Risk Assessment (CDPHE 2010) assessed data collected in 2008, and a risk assessment based on 2009 HAPs levels will be prepared in a separate annual risk assessment report prepared by the CDPHE Disease Control and Environmental Epidemiology Division. Findings of the 2008 report indicated that, individually, the HAPs components were below risk assessment criteria, but cumulative effects approached chronic (70 year exposure period) non-hazard levels. The largest contributors to the cumulative levels were benzene and formaldehyde.

4.3.1 Annual Average HAPs Concentrations

Figures 4-8 through 4-12 present annual averages of HAPs concentrations measured in 2008 and 2009. Overall, detected HAPs concentrations were similar in 2009 to those measured in 2008, with some slight increases and slight decreases. Actual magnitudes of these HAPs compounds related to possible health risk will be evaluated in the CDPHE risk assessment report.

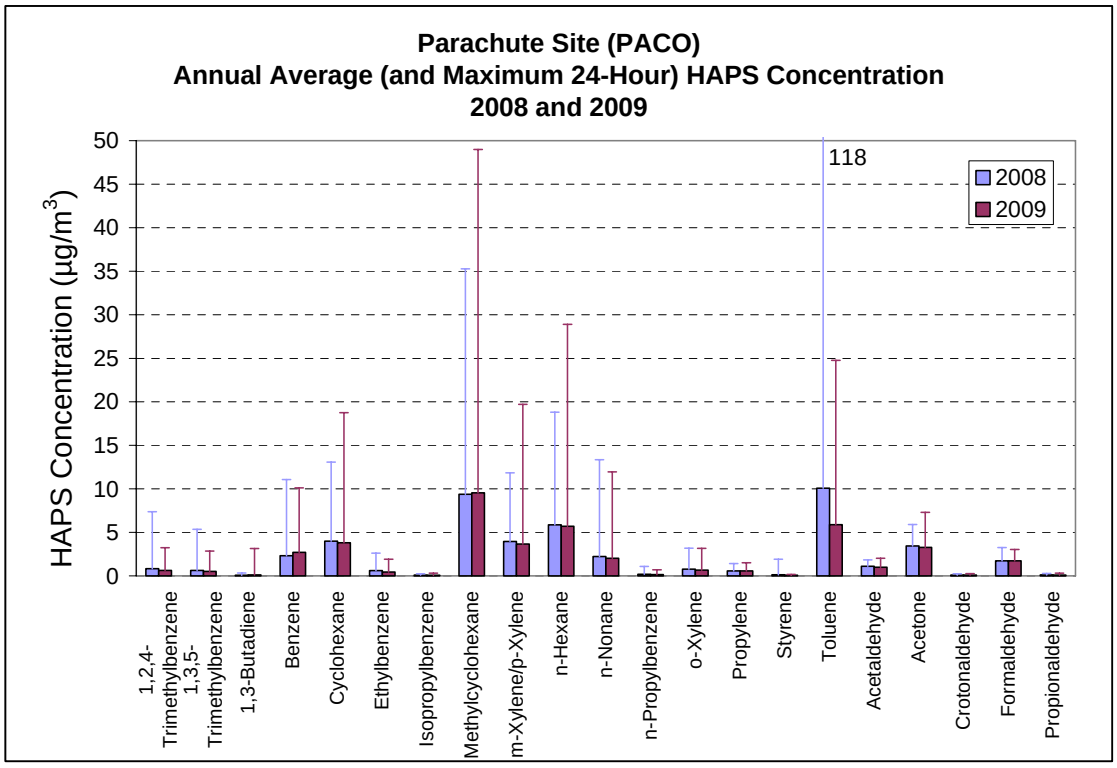


Figure 4-8. Annual Average and 24-hour Maximum HAPs Concentrations Measured at the Parachute Site in 2008 and 2009.

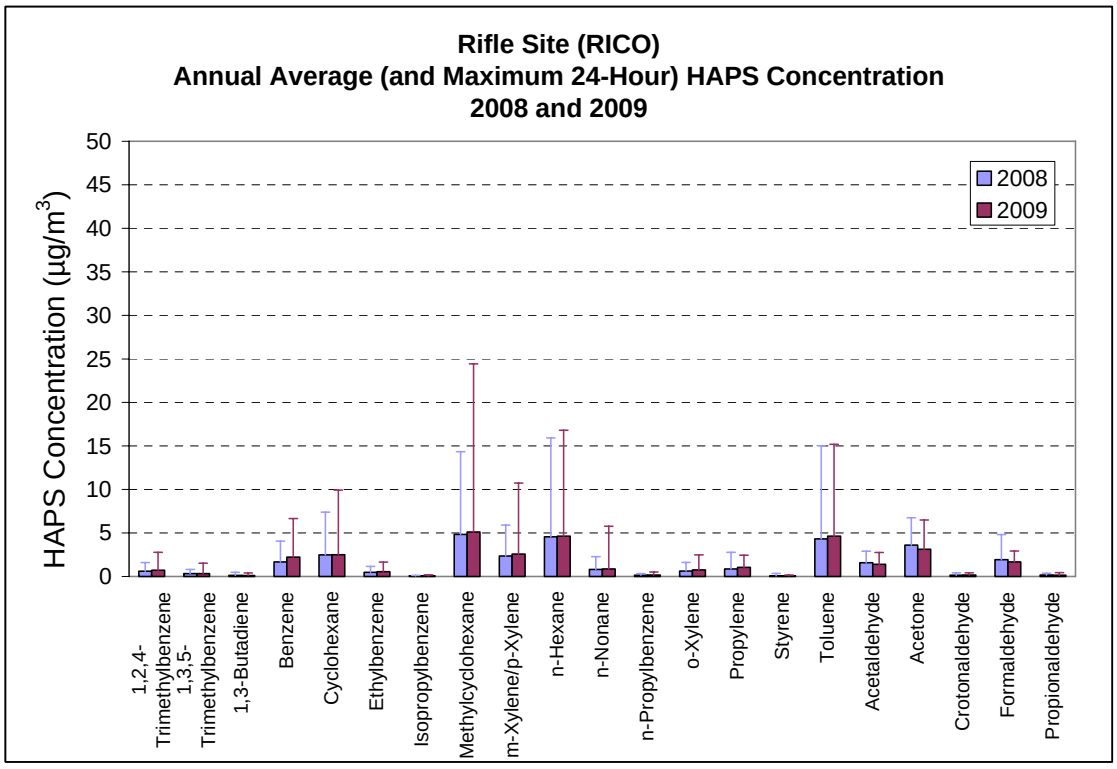


Figure 4-9. Annual Average and 24-Hour Maximum HAPs Concentrations Measured at the Rifle Site in 2008 and 2009.

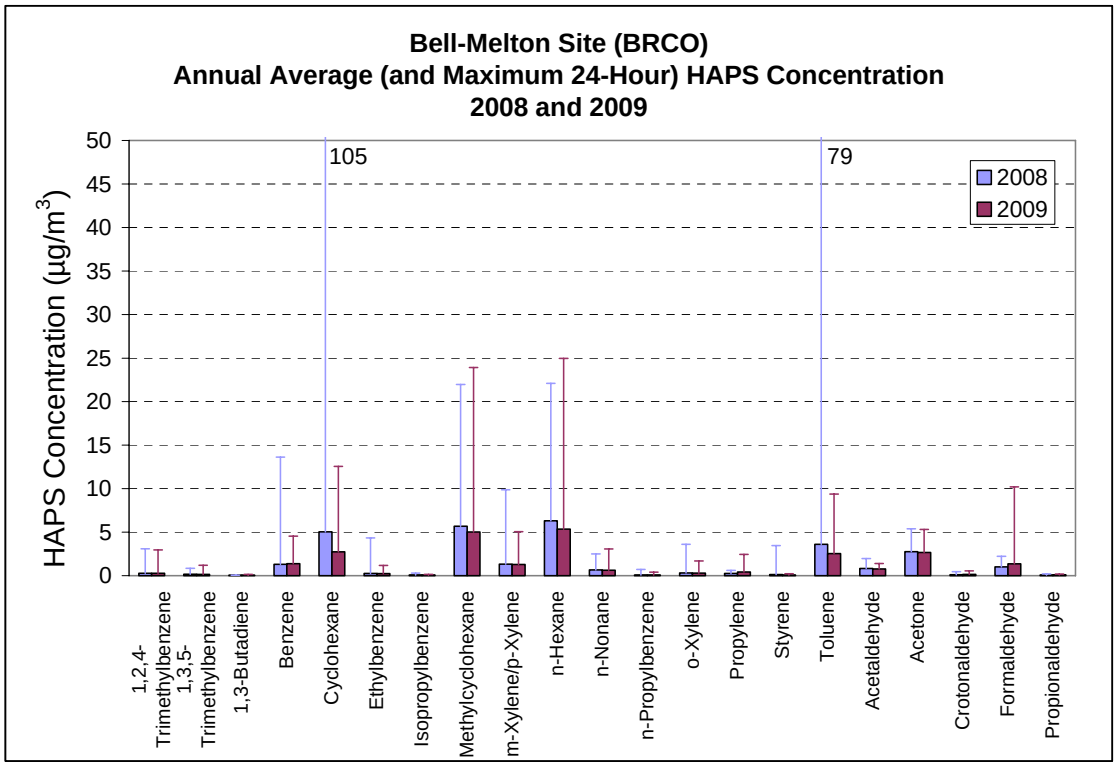


Figure 4-10. Annual Average and 24-Hour Maximum HAPs Concentrations Measured at the Bell-Melton Site in 2008 and 2009.

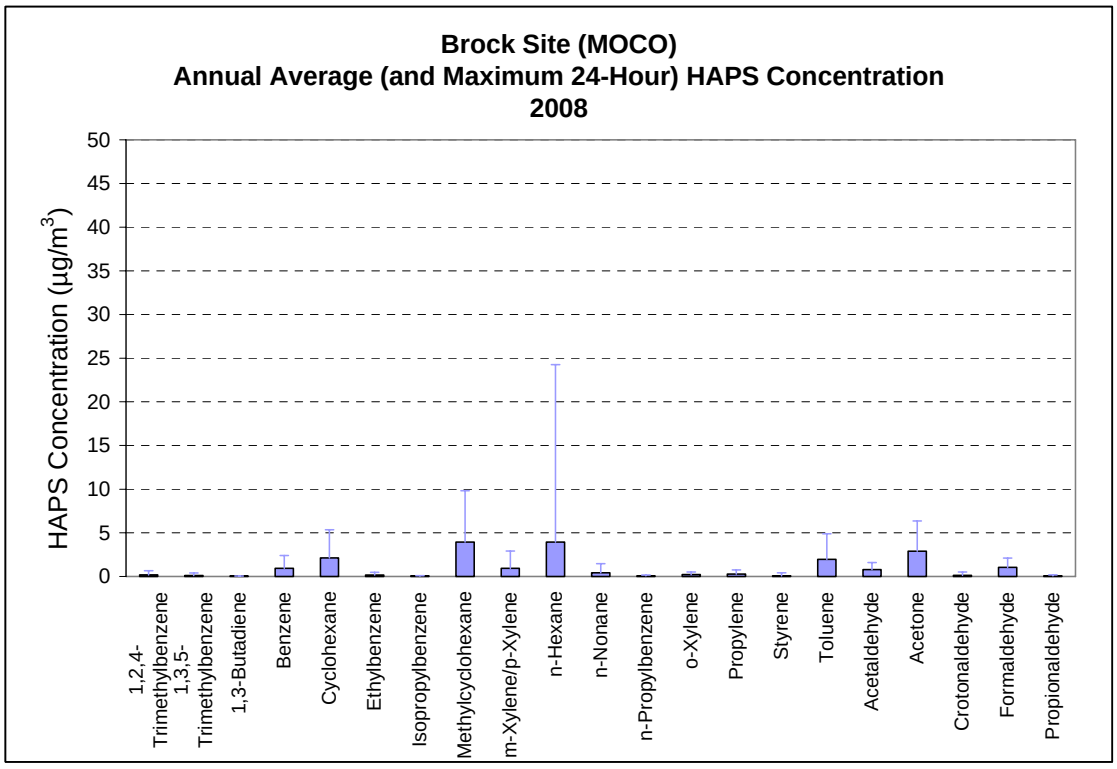


Figure 4-11. Annual Average and 24-Hour Maximum HAPs Concentrations Measured at the Brock Site in 2008.

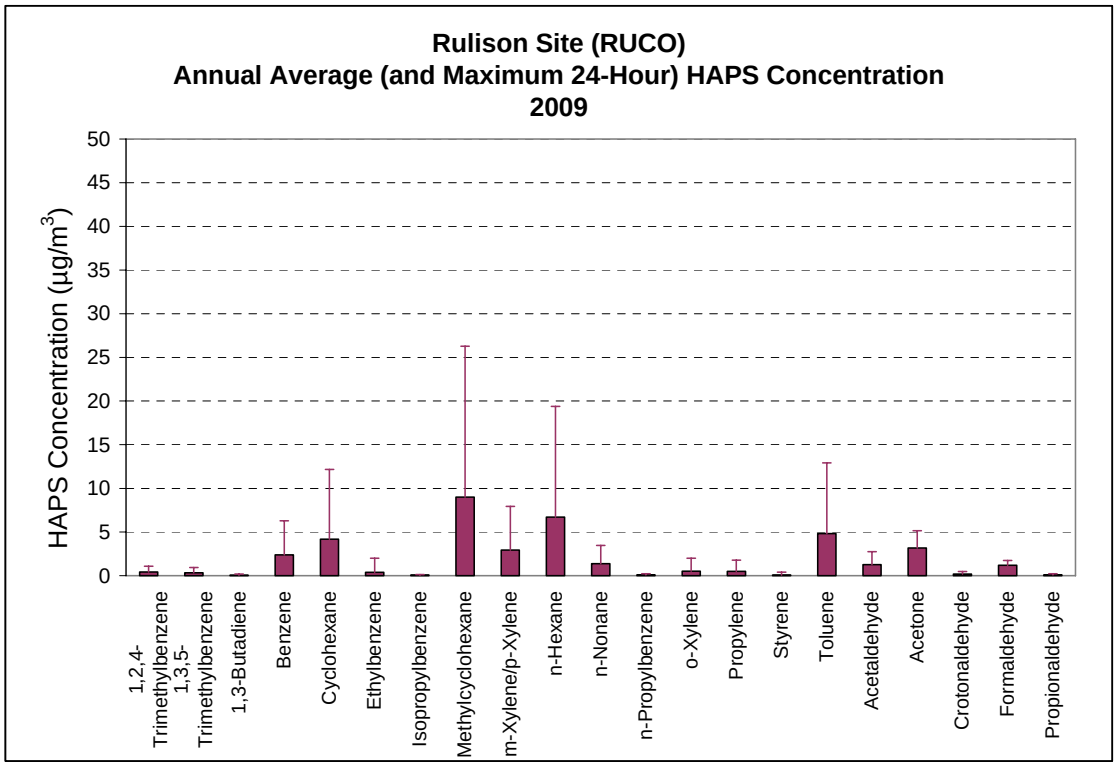


Figure 4-12. Annual Average and 24-Hour Maximum HAPs Concentrations Measured at the Rulison Site in 2009.

4.3.2 Regional HAPs Comparisons

Figures 4-13 through 4-27 present regional comparisons for the HAPs concentrations measured in Garfield County in 2009. Sites are presented in descending order, with the Garfield County sites and the Grand Junction site highlighted. Back-trajectories in Section 2.0 indicated significant airflow from the west-southwest, from the direction of Grand Junction, up the Colorado River Valley. Regional observations include the following:

- Compounds that averaged higher at the upwind, more urban Grand Junction site than in Garfield County sites included acetaldehyde, formaldehyde, acetone, propioaldehyde, and styrene. Concentration of these compounds at the Garfield County sites are among the lowest regional measurements, indicating that these values might be more representative of background concentrations with limited local sources.

- For the BTEX parameter (benzene, toluene, ethylbenzene, and the xylenes) the Parachute site, followed by the Rulison and Rifle sites, measured the highest averages for benzene, toluene, and the m/p xylenes. These compounds were also higher than the Grand Junction site. For ethylbenzene, only the Rifle site measured a higher average than Grand Junction. Because Grand Junction is a nearby, more urban upwind site, concentrations higher than Grand Junction might indicate that local sources are major contributors to these pollutants. BTEX compounds are common from both gasoline and diesel combustion sources, including motor vehicles and oil and gas sources.

- In addition to BTEX parameters, compounds that measured among the highest 10% of regional averages at the Parachute and Rifle sites included 1,2,4-Trimethylbenzene and 1,3,5-Trimethylbenzene. The Rulison site was also among the top 10% of readings for 1,3,5-Trimethylbenzene. These compounds are also common from gasoline and diesel combustion sources.

- The Bell-Melton site generally averaged the lowest HAPS among Garfield County sites, but was among the highest 25% of regional measurements for benzene, 1,3,5-Trimethylbenzene and the m/p xylenes.

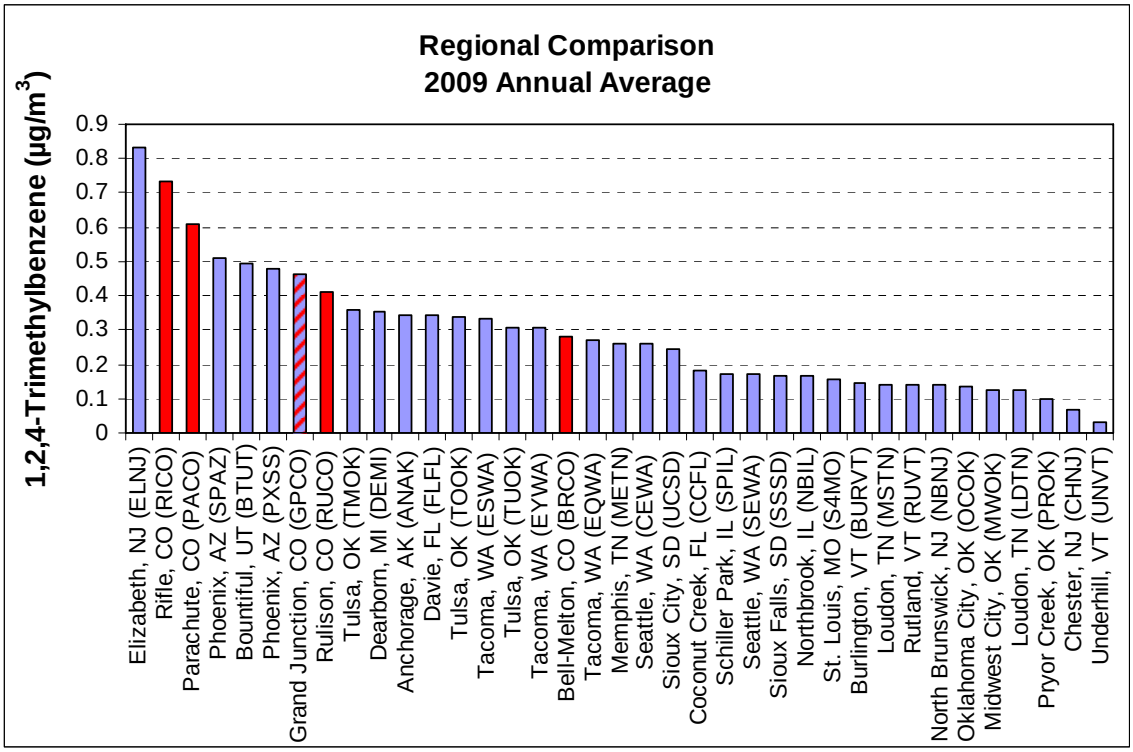


Figure 4-13. 2009 Annual Average 1,2,4-Trimethylbenzene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

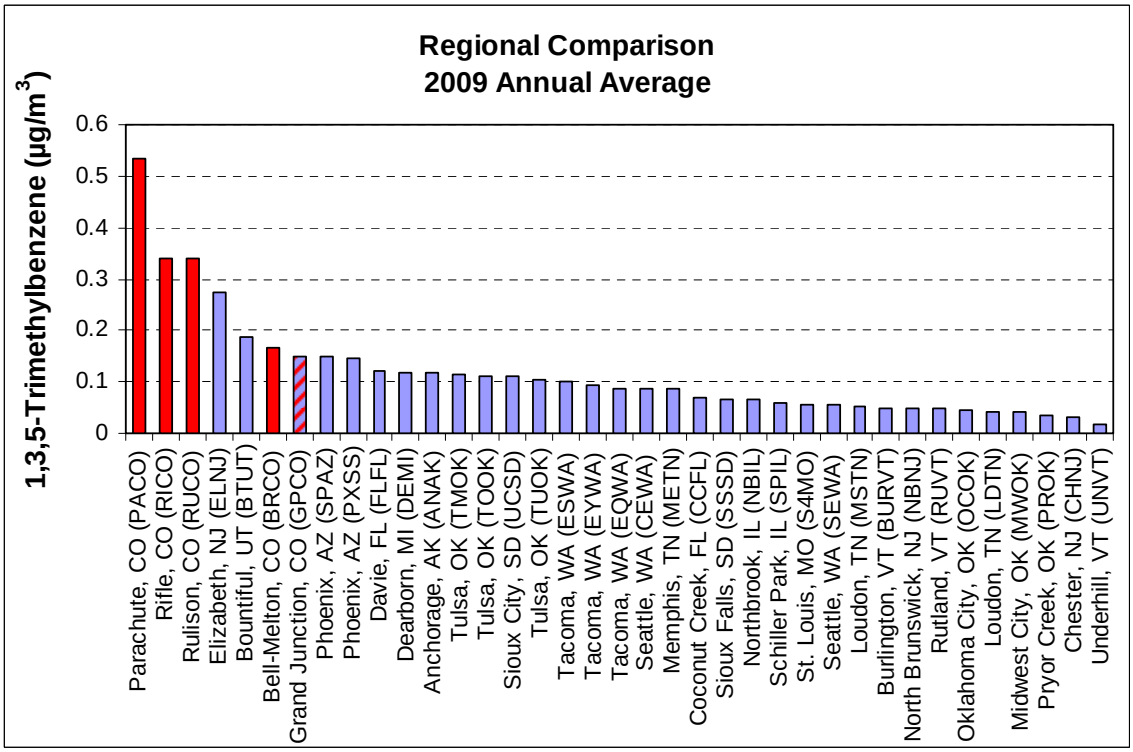


Figure 4-14. 2009 Annual Average 1,3,5-Trimethylbenzene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

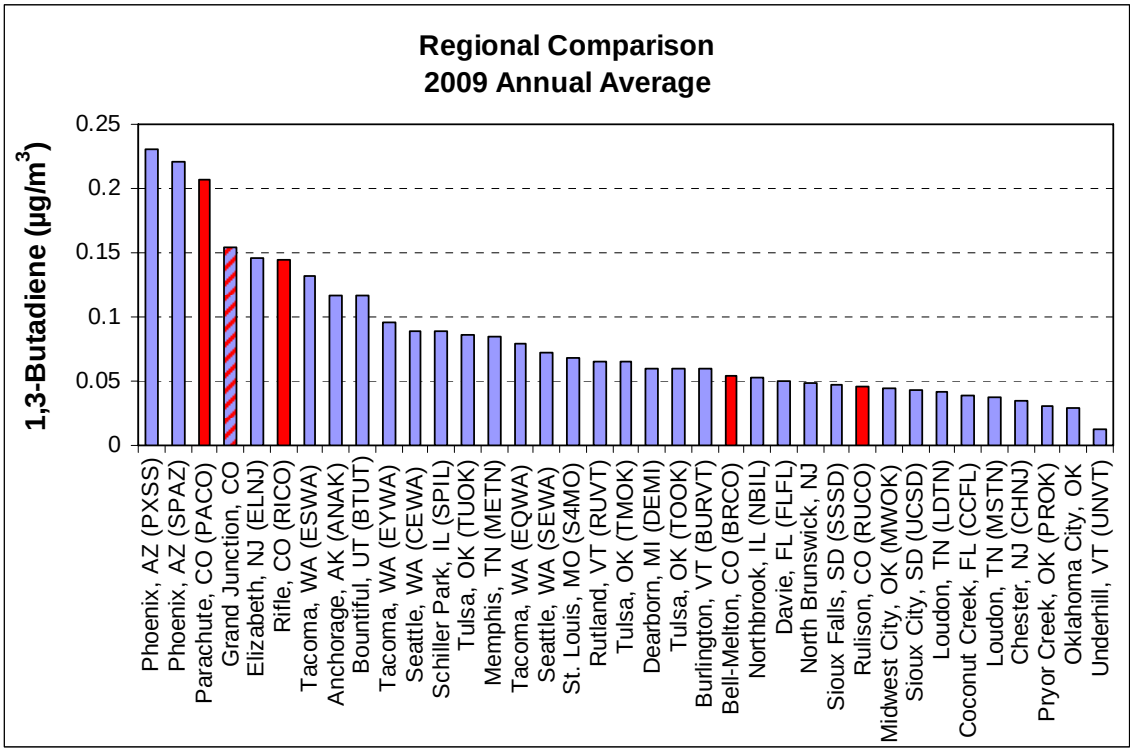


Figure 4-15. 2009 Annual Average 1,3-Butadiene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

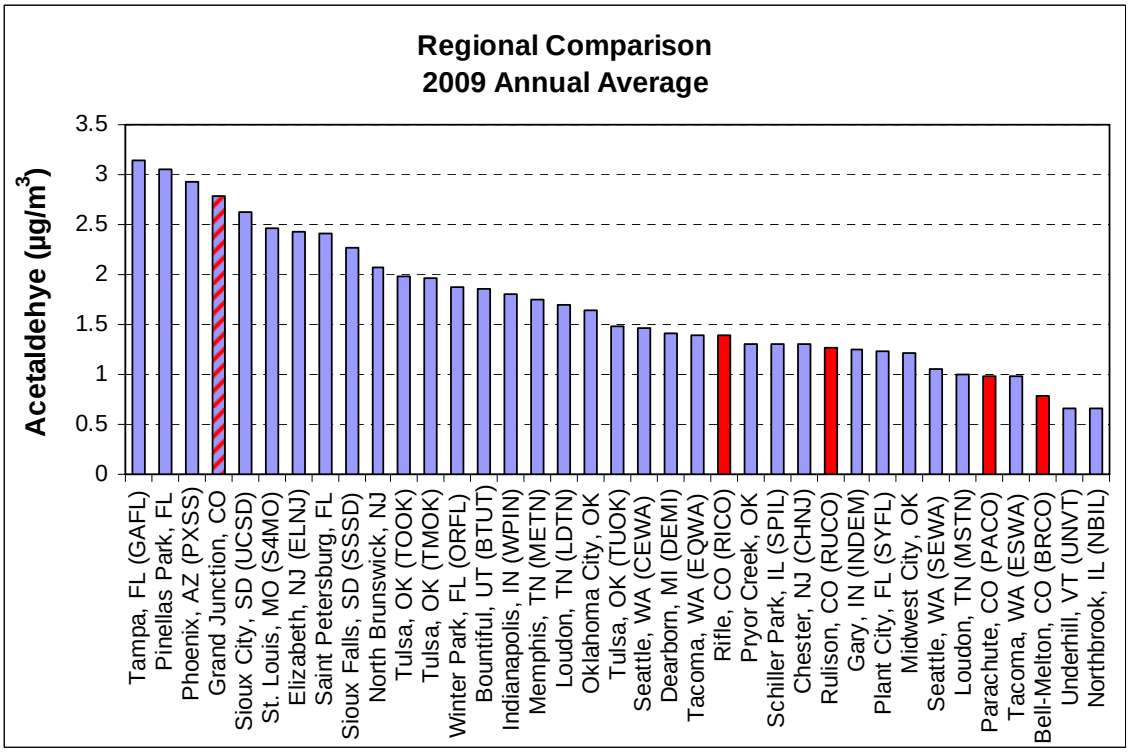


Figure 4-16. 2009 Annual Average Acetaldehyde Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

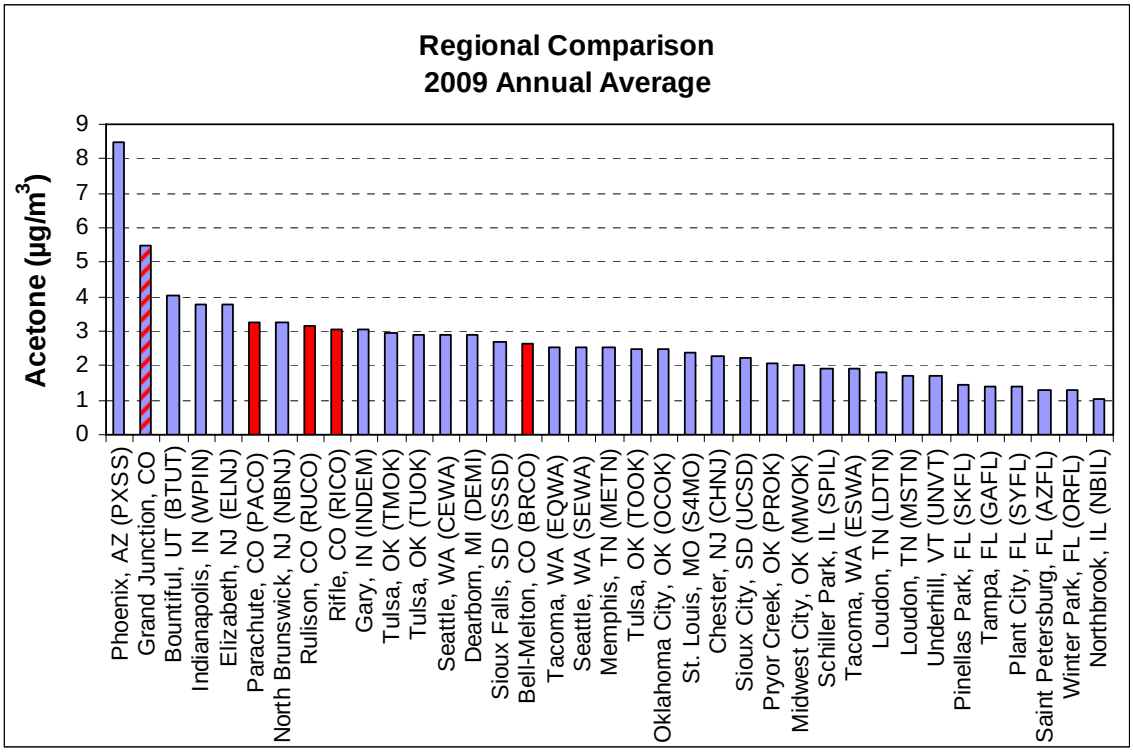


Figure 4-17. 2009 Annual Average Acetone Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

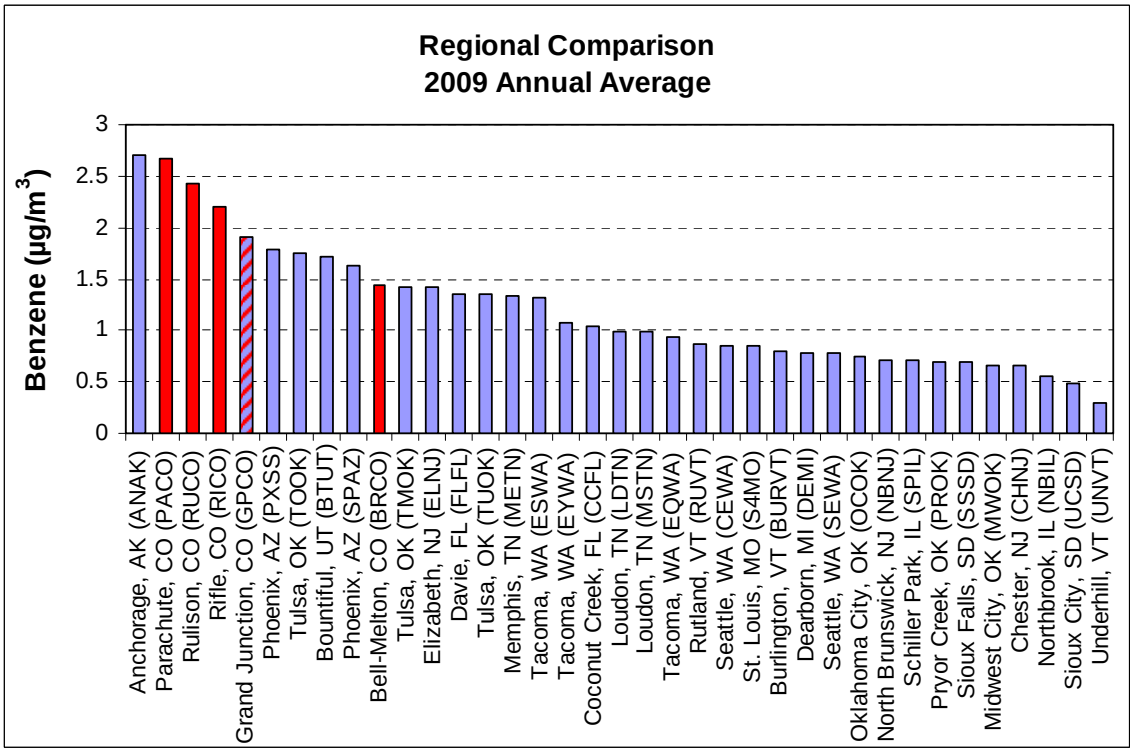


Figure 4-18. 2009 Annual Average Benzene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

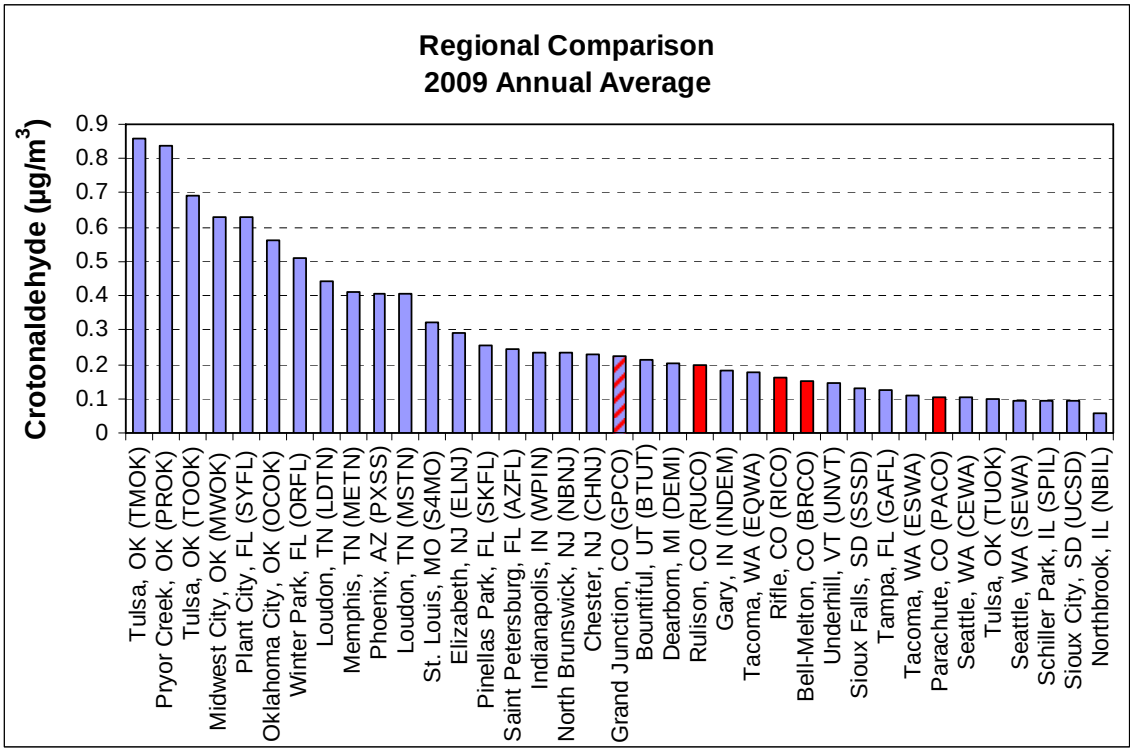


Figure 4-19. 2009 Annual Average Crotonaldehyde Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

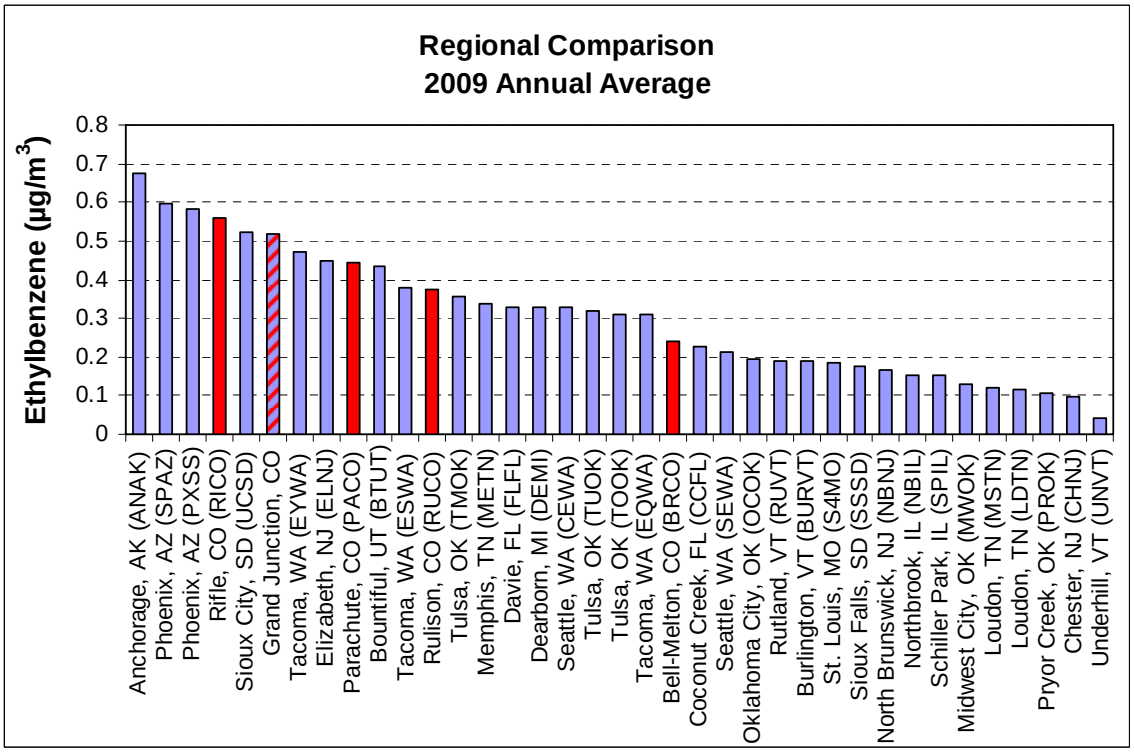


Figure 4-20. 2009 Annual Average Ethylbenzene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

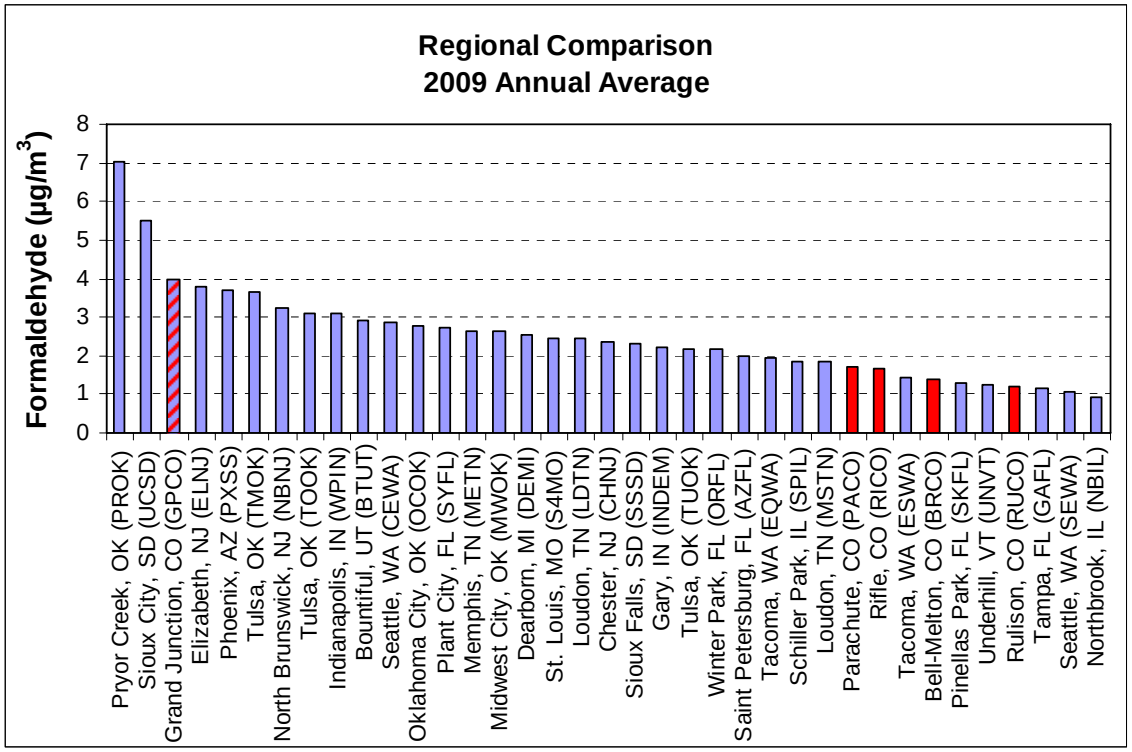


Figure 4-21. 2009 Annual Average Formaldehyde Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

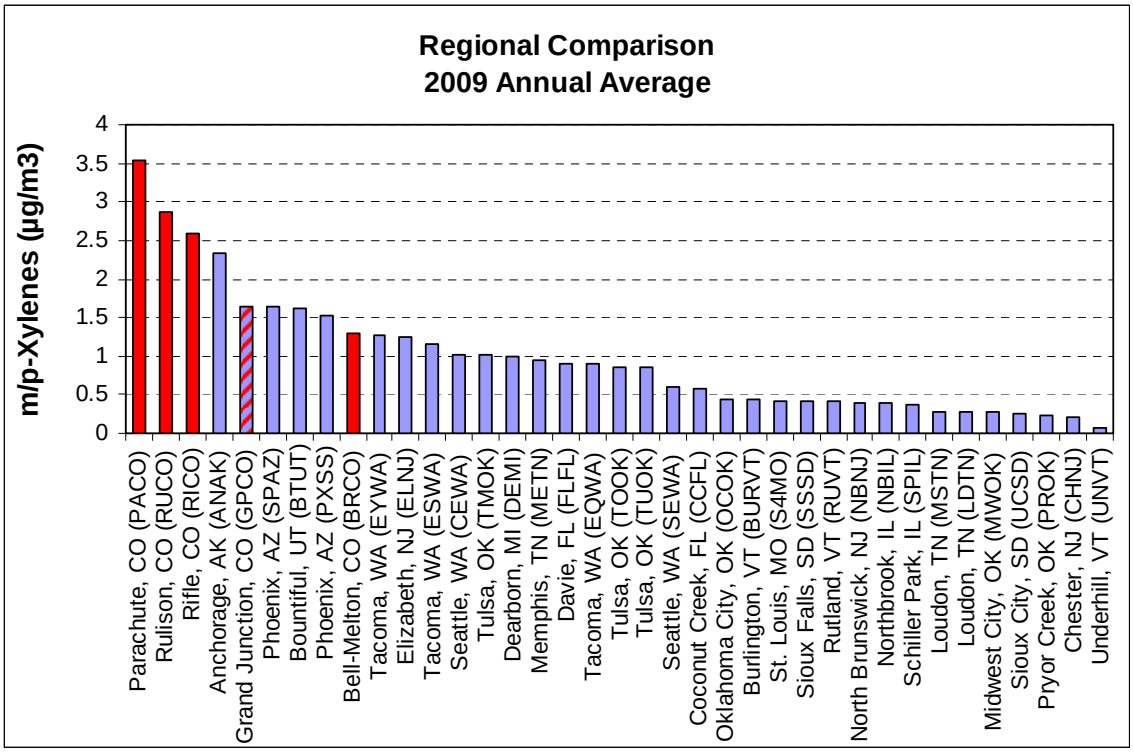


Figure 4-22. 2009 Annual Average m/p-Xylene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

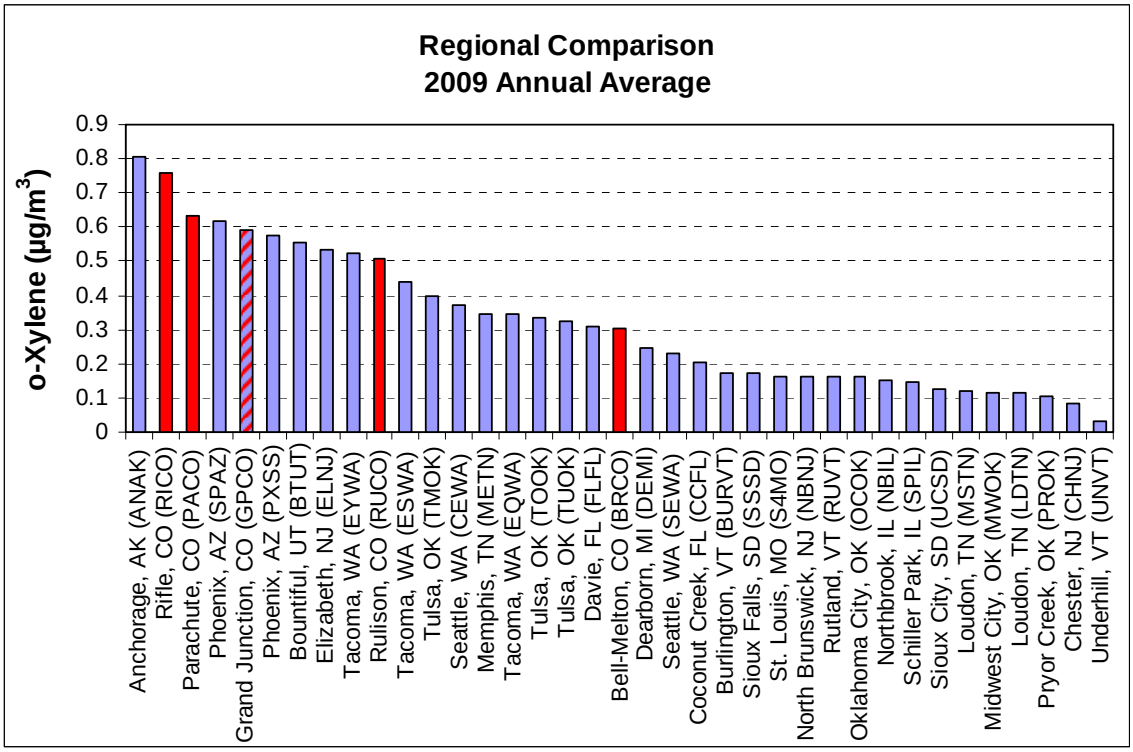


Figure 4-23. 2009 Annual Average o-Xylene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

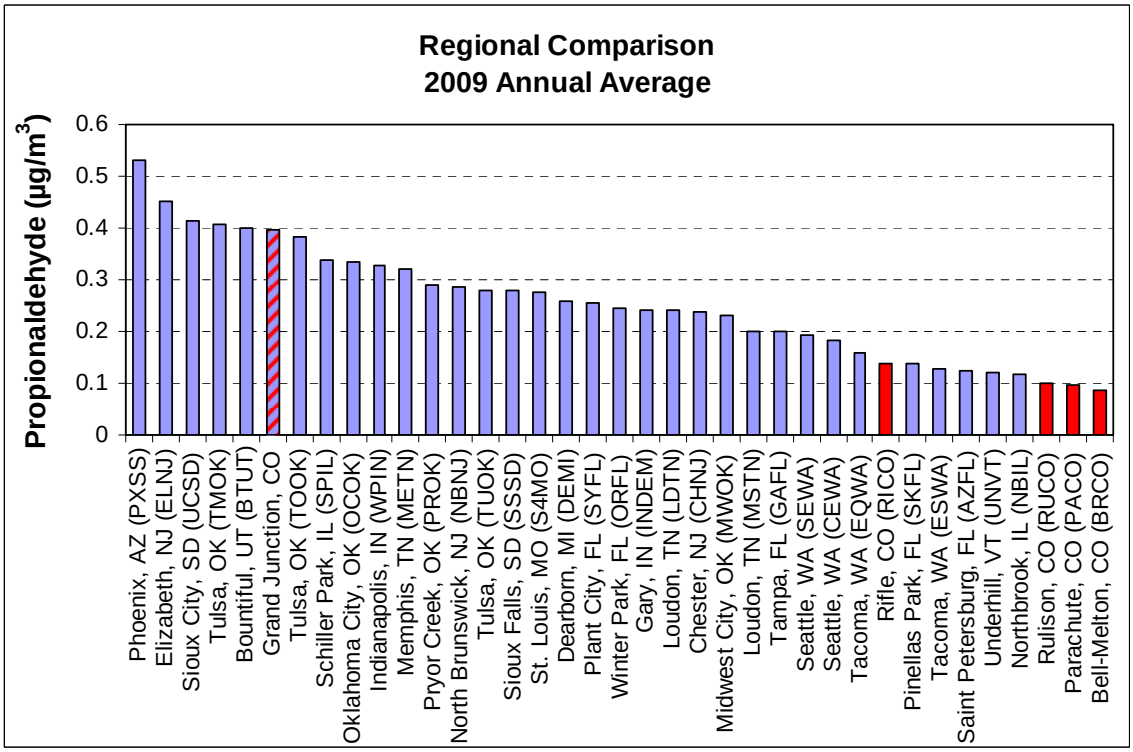


Figure 4-24. 2009 Annual Average Propionaldehyde Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

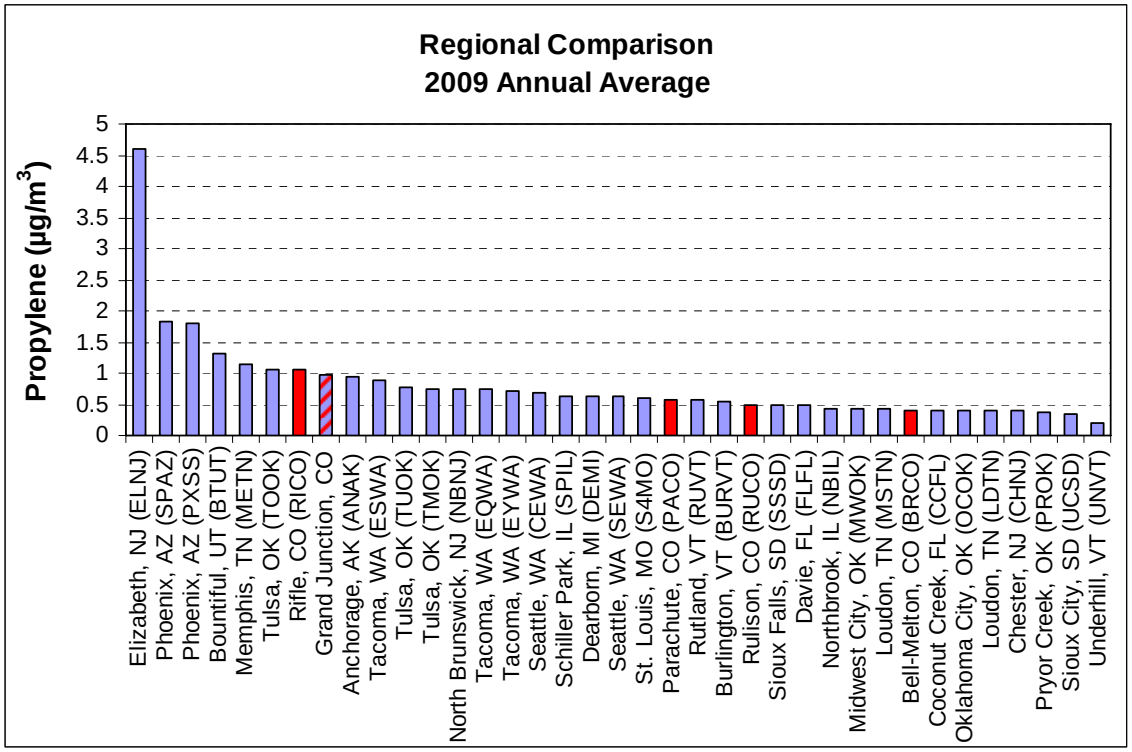


Figure 4-25. 2009 Annual Average Propylene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

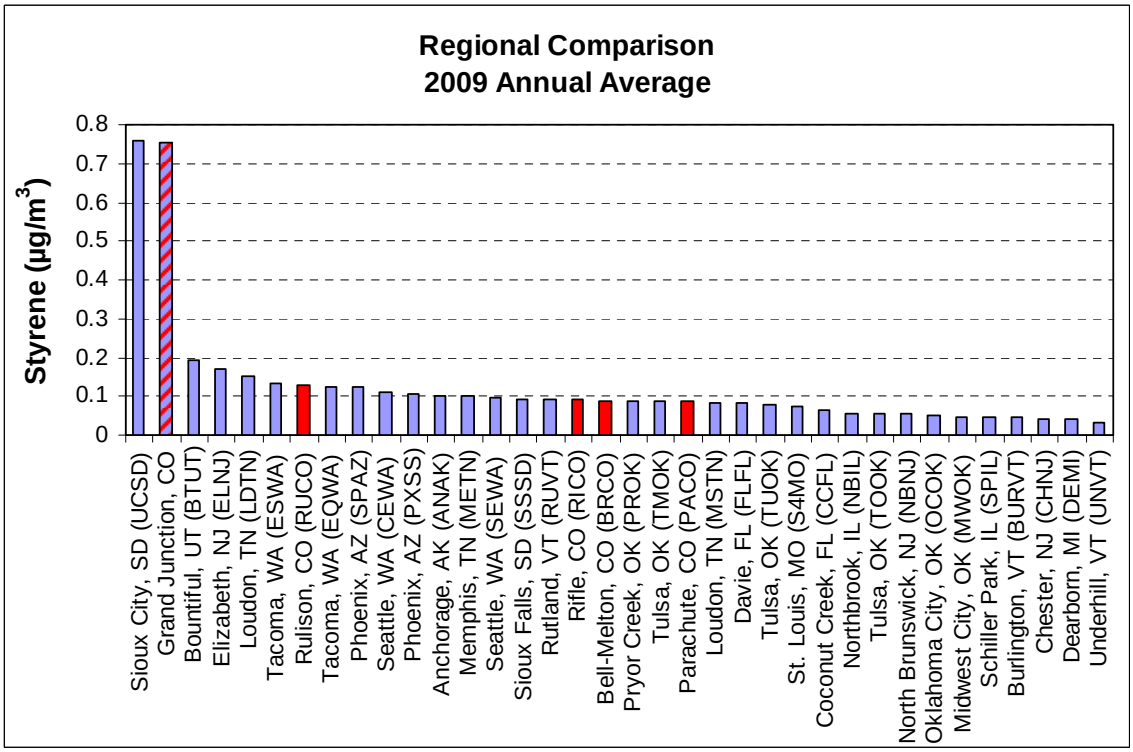


Figure 4-26. 2009 Annual Average Styrene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

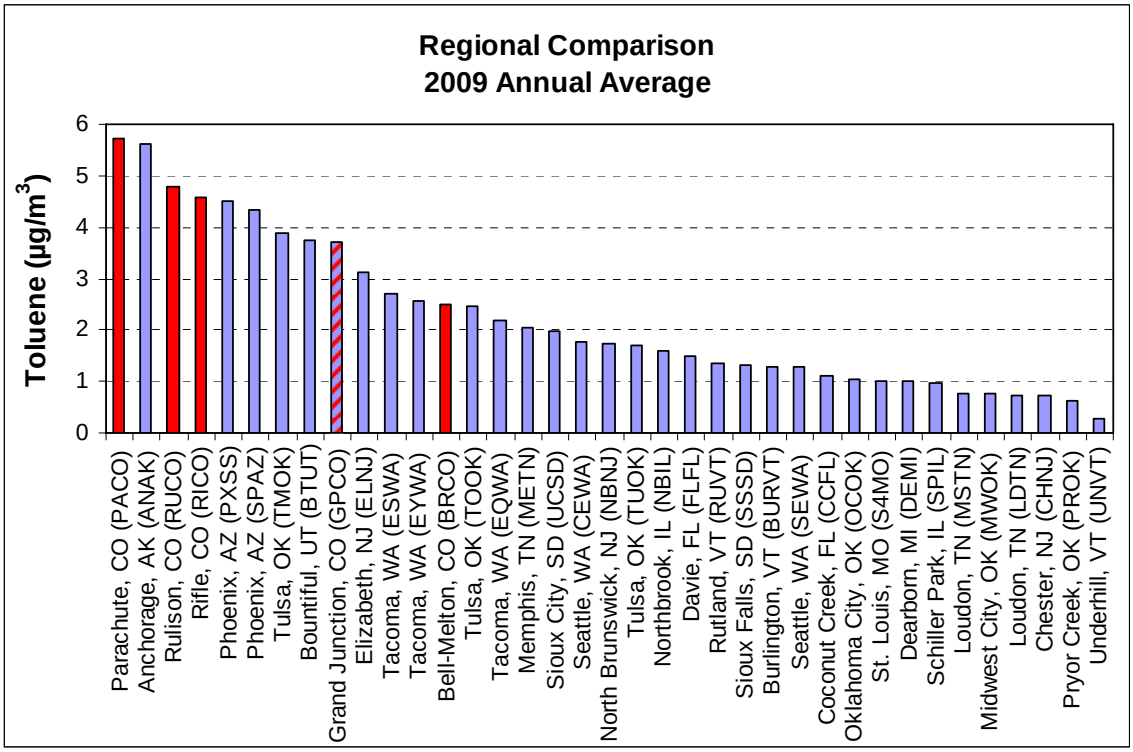


Figure 4-27. 2009 Annual Average Toluene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

5.0 REFERENCES

California Air Resources Board (CARB), 2009, California Toxics Inventory, http://www.arb.ca.gov/toxics/cti/cti.htm. (July 17, 2009).

Carter, W.P.L., 1994, Development of ozone reactivity scales for volatile organic compounds. Journal of the Air & Waste Management Association, 44.

CDPHE, 2010, Garfield County Air Toxics Inhalation: Screening Level Human Health Risk Assessment (June 2010).

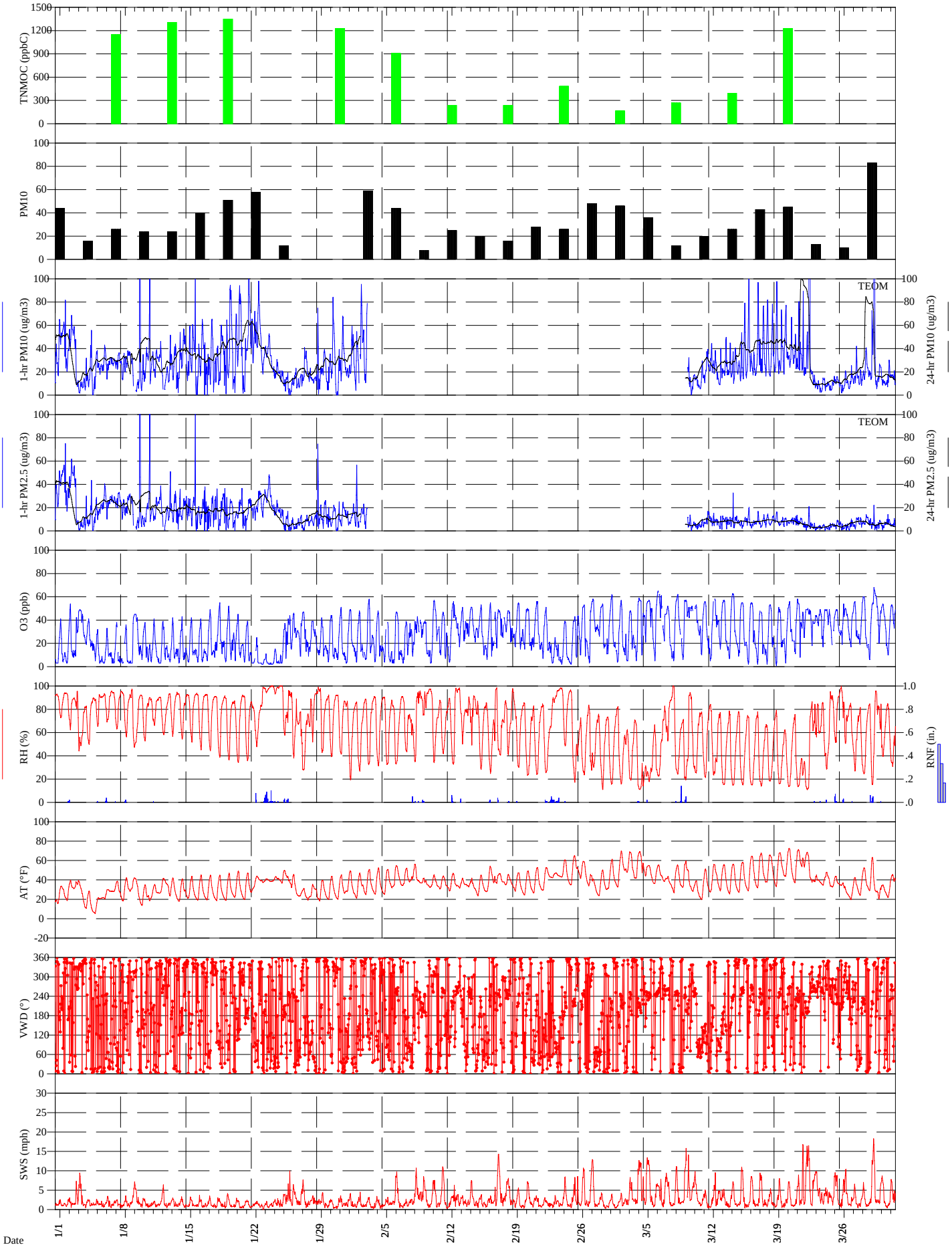
APPENDIX A

Garfield County

2009 Stackplots

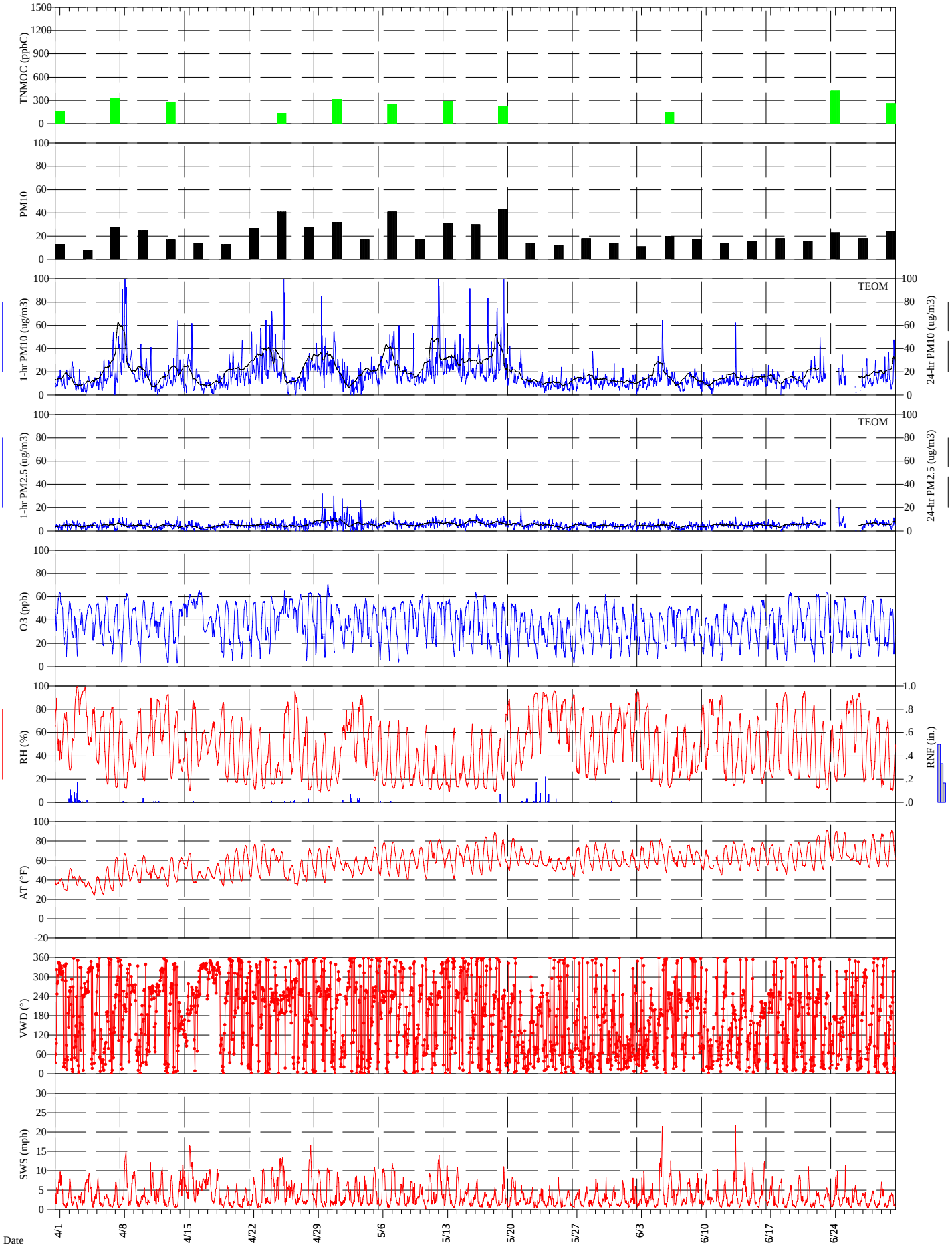
Garfield County, CO

Rifle Site



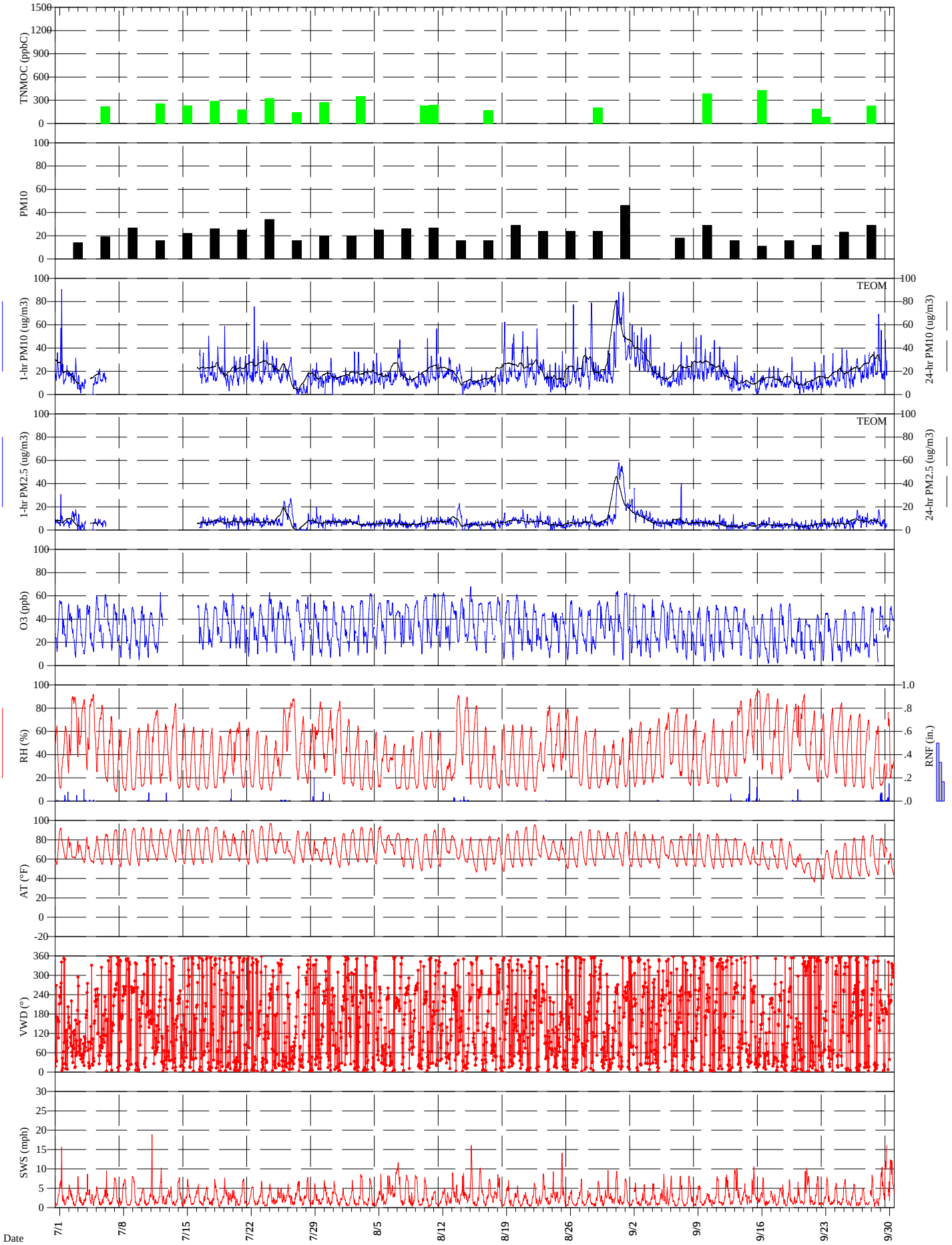
Garfield County, CO

Rifle Site



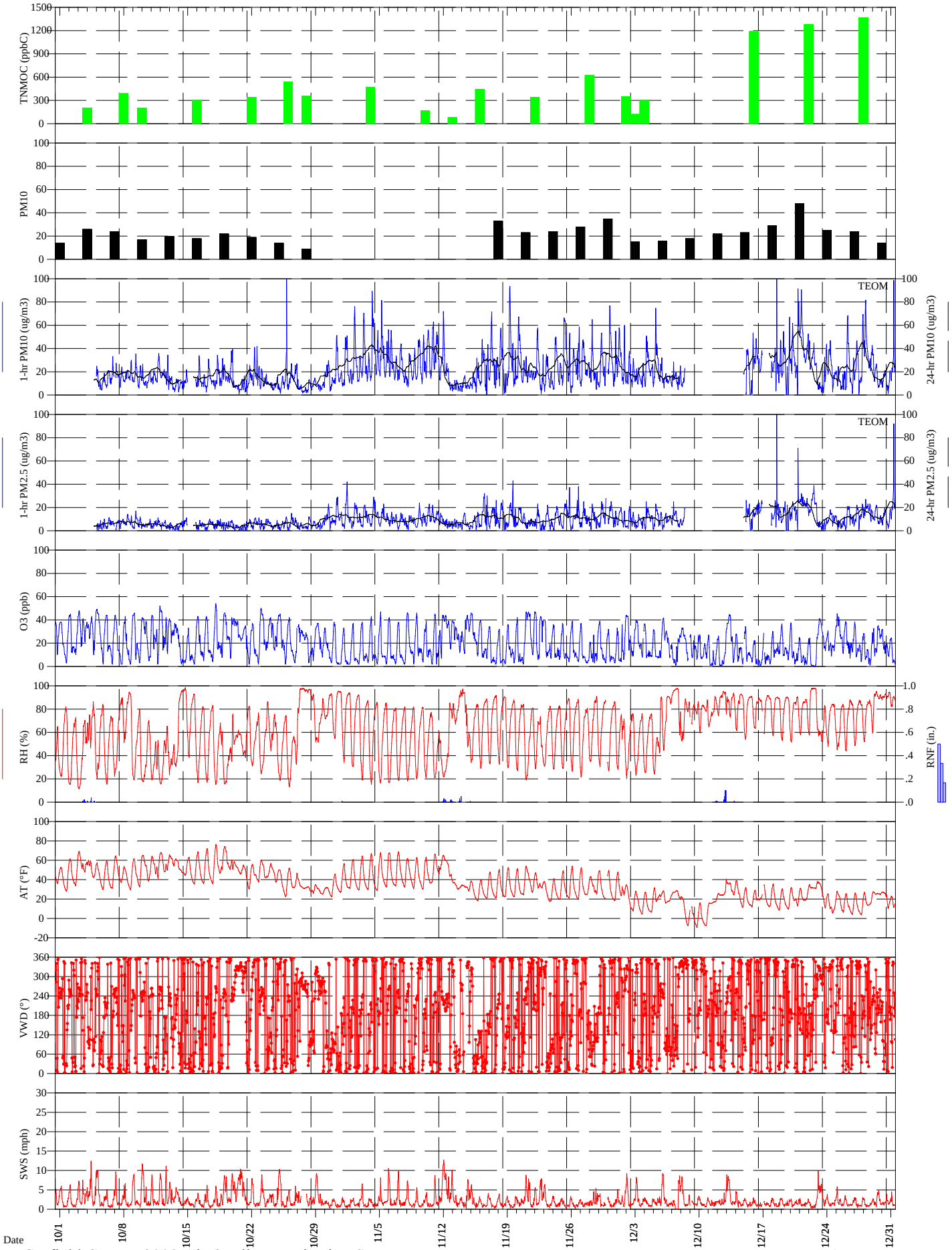
Garfield County, CO

Rifle Site

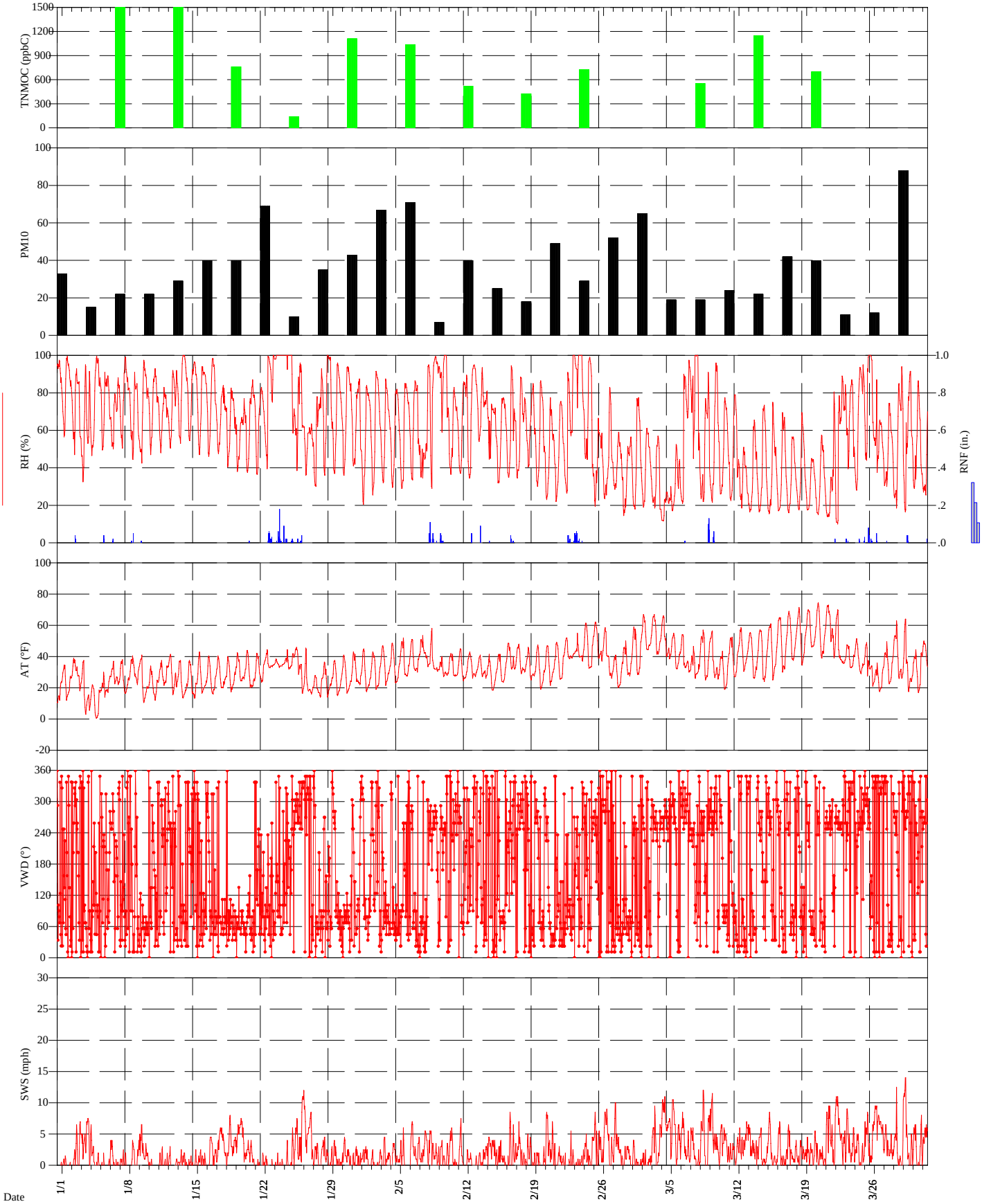


Garfield County, CO

Rifle Site

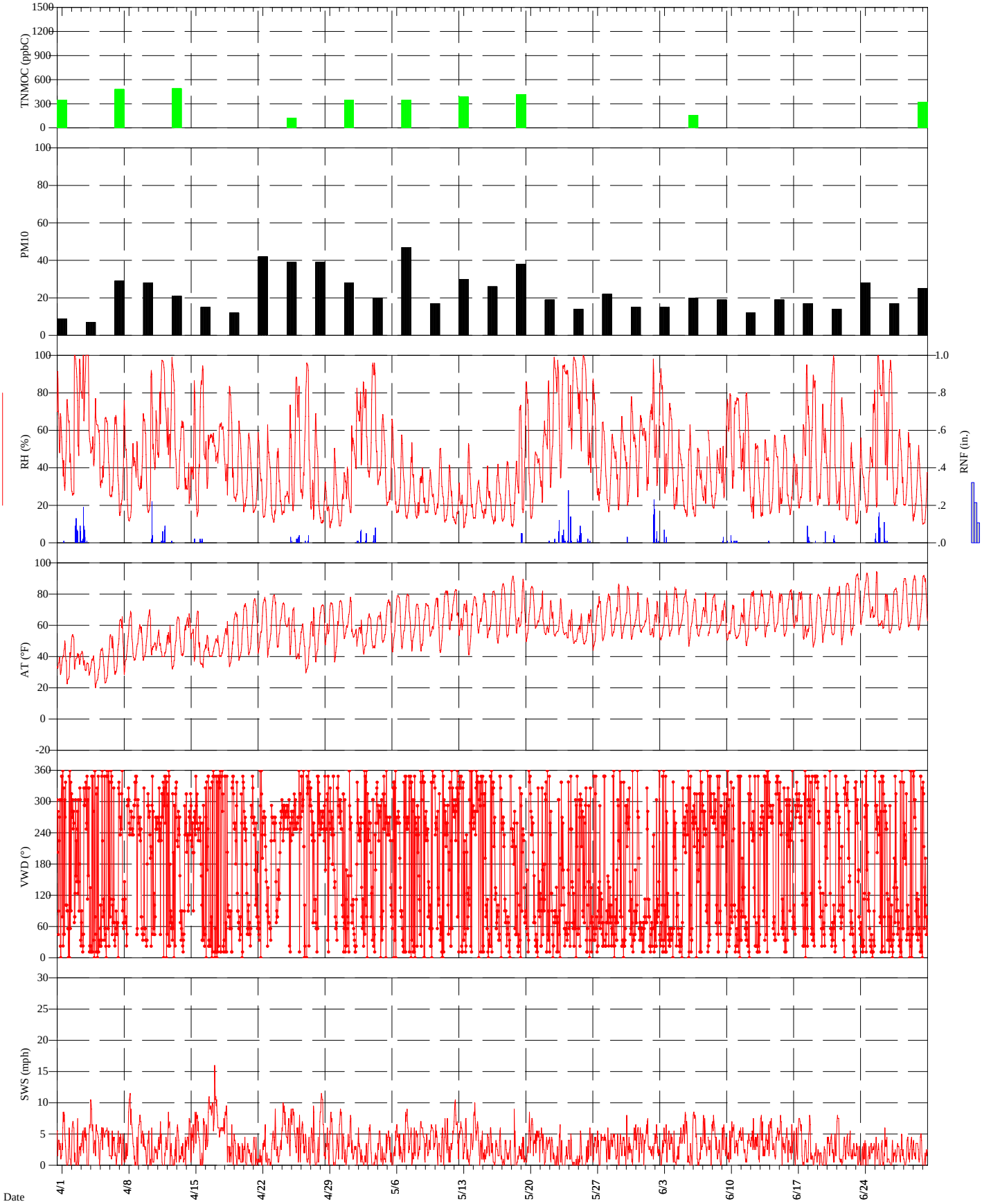


Garfield County, CO
Parachute Site



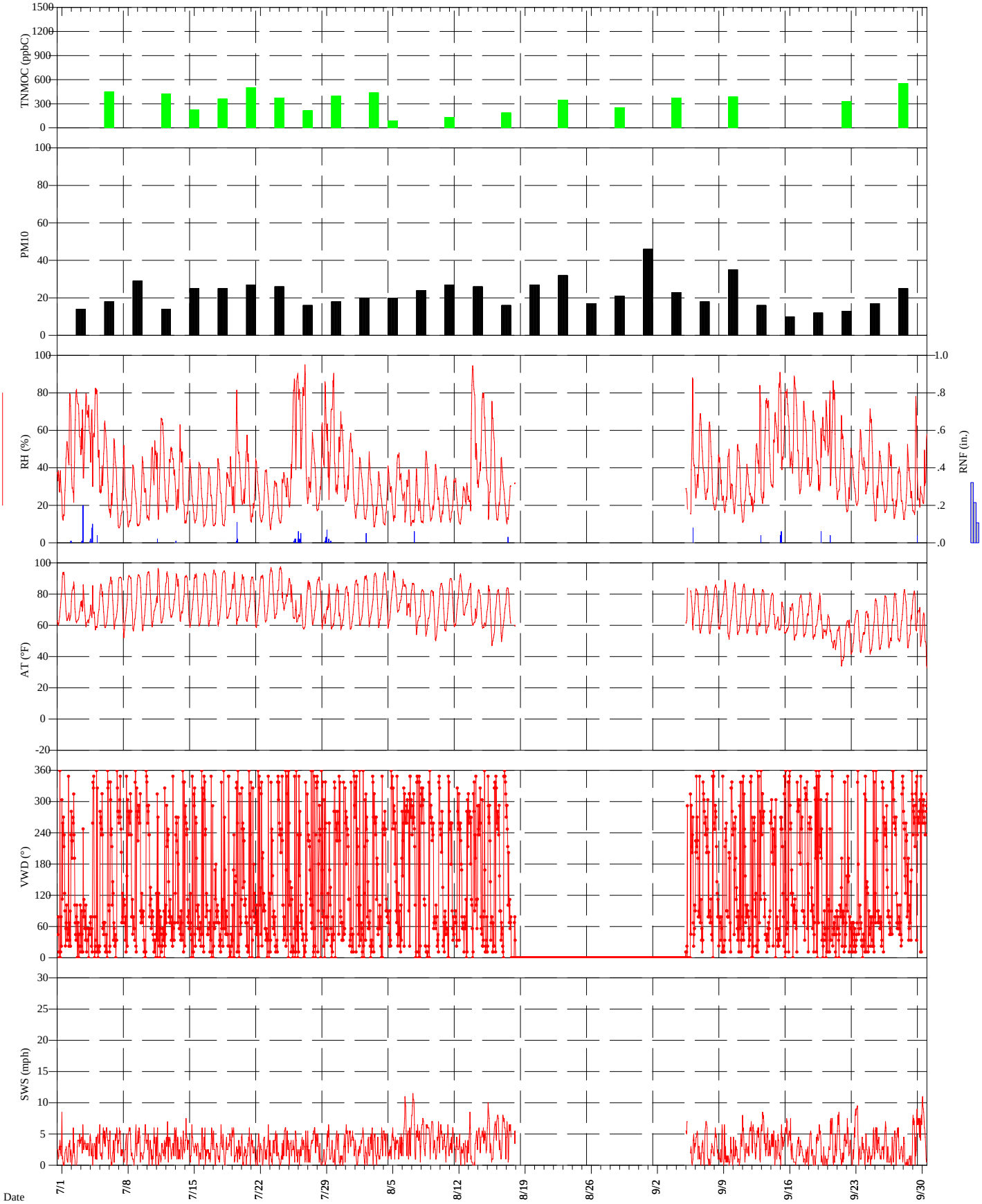
Garfield County, CO

Parachute Site



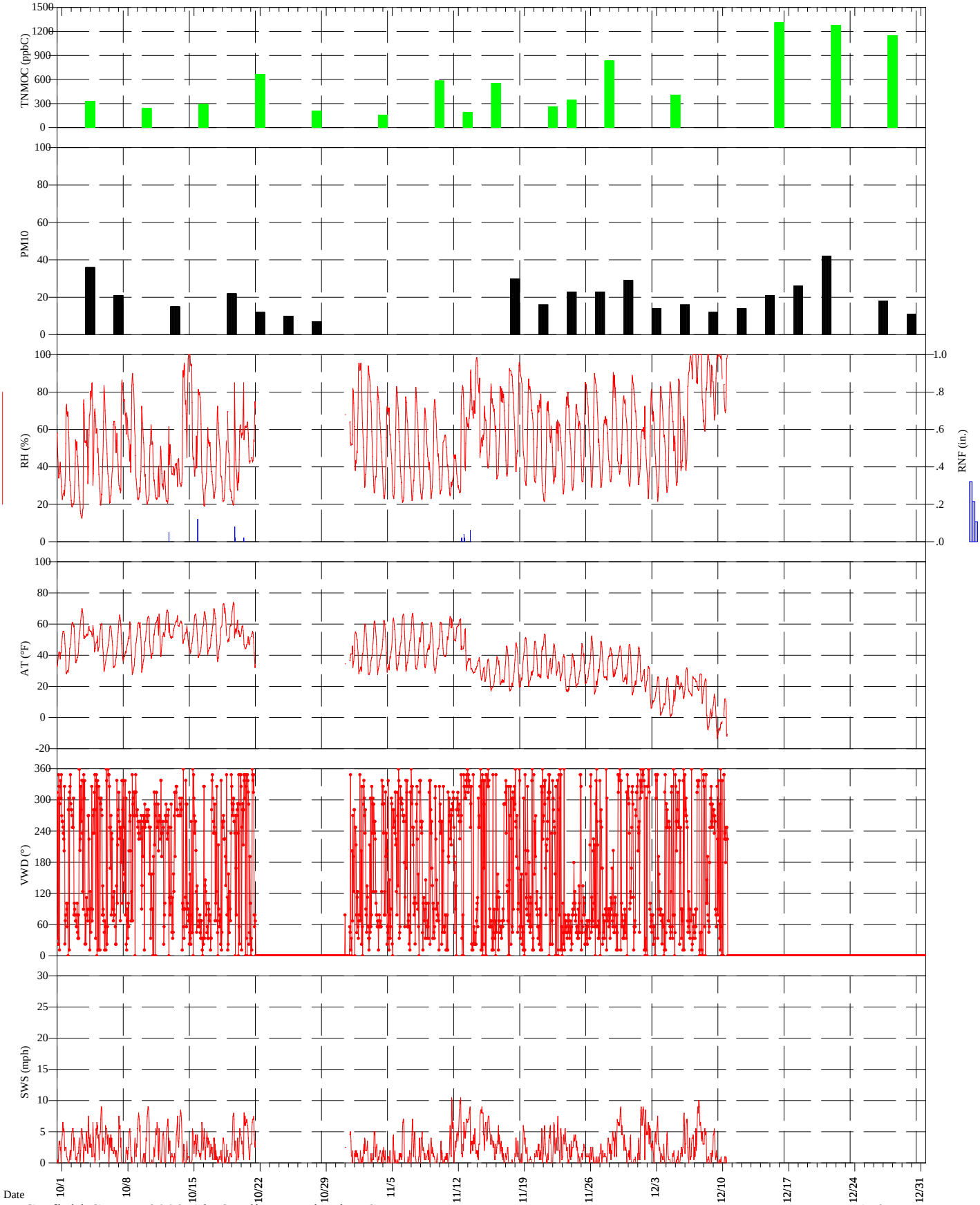
Garfield County, CO

Parachute Site

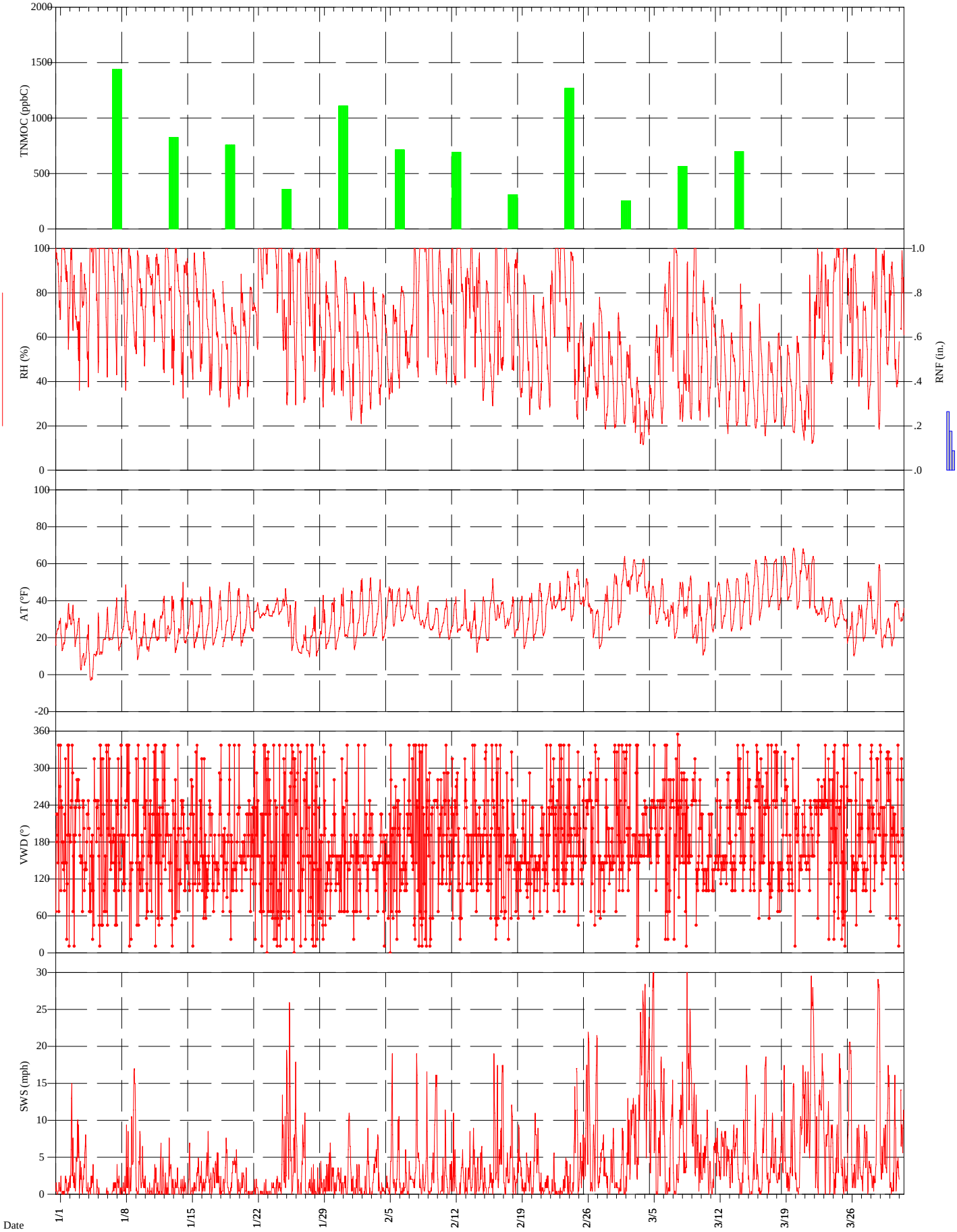


Garfield County, CO

Parachute Site

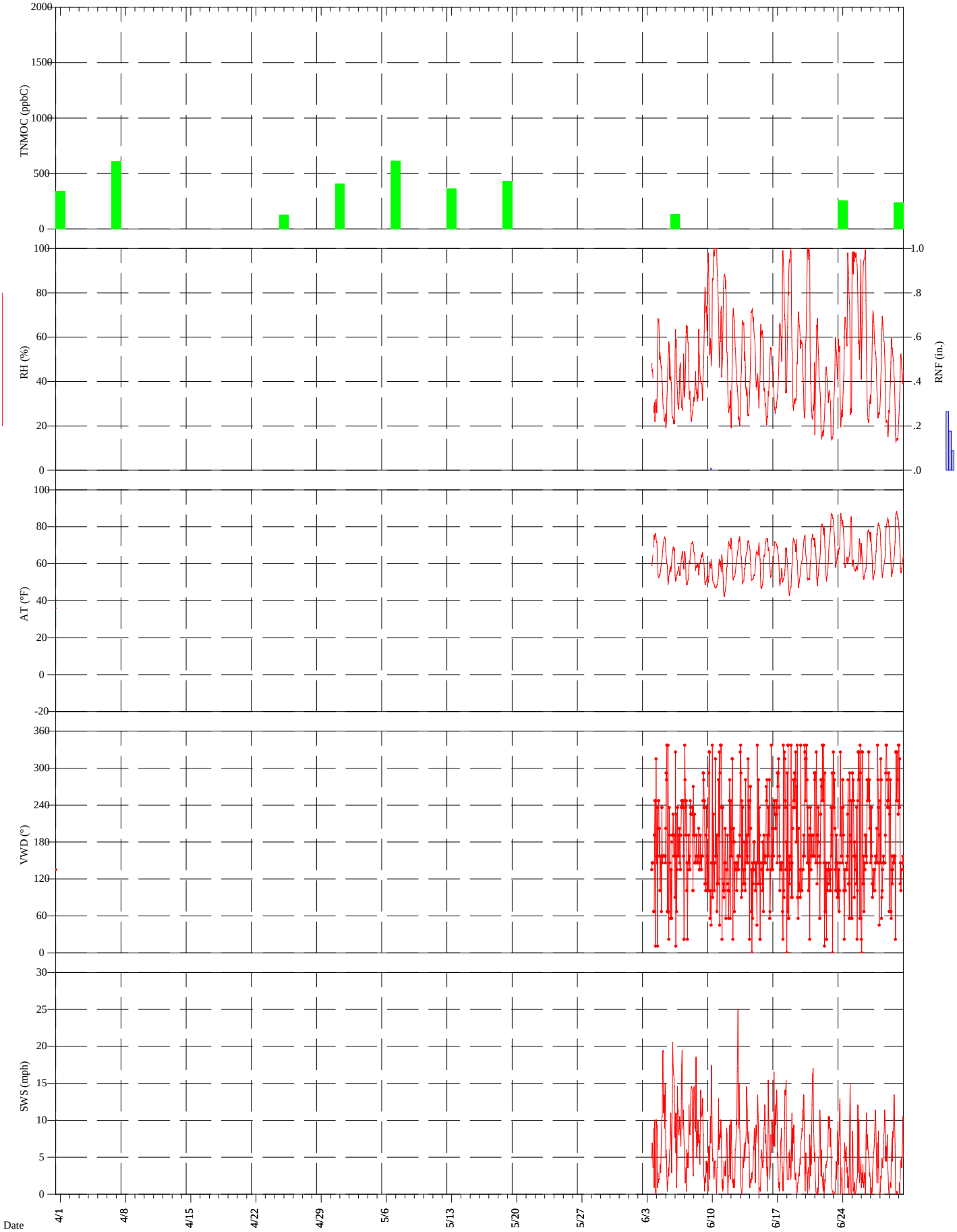


Garfield County, CO
Bell Melton Site



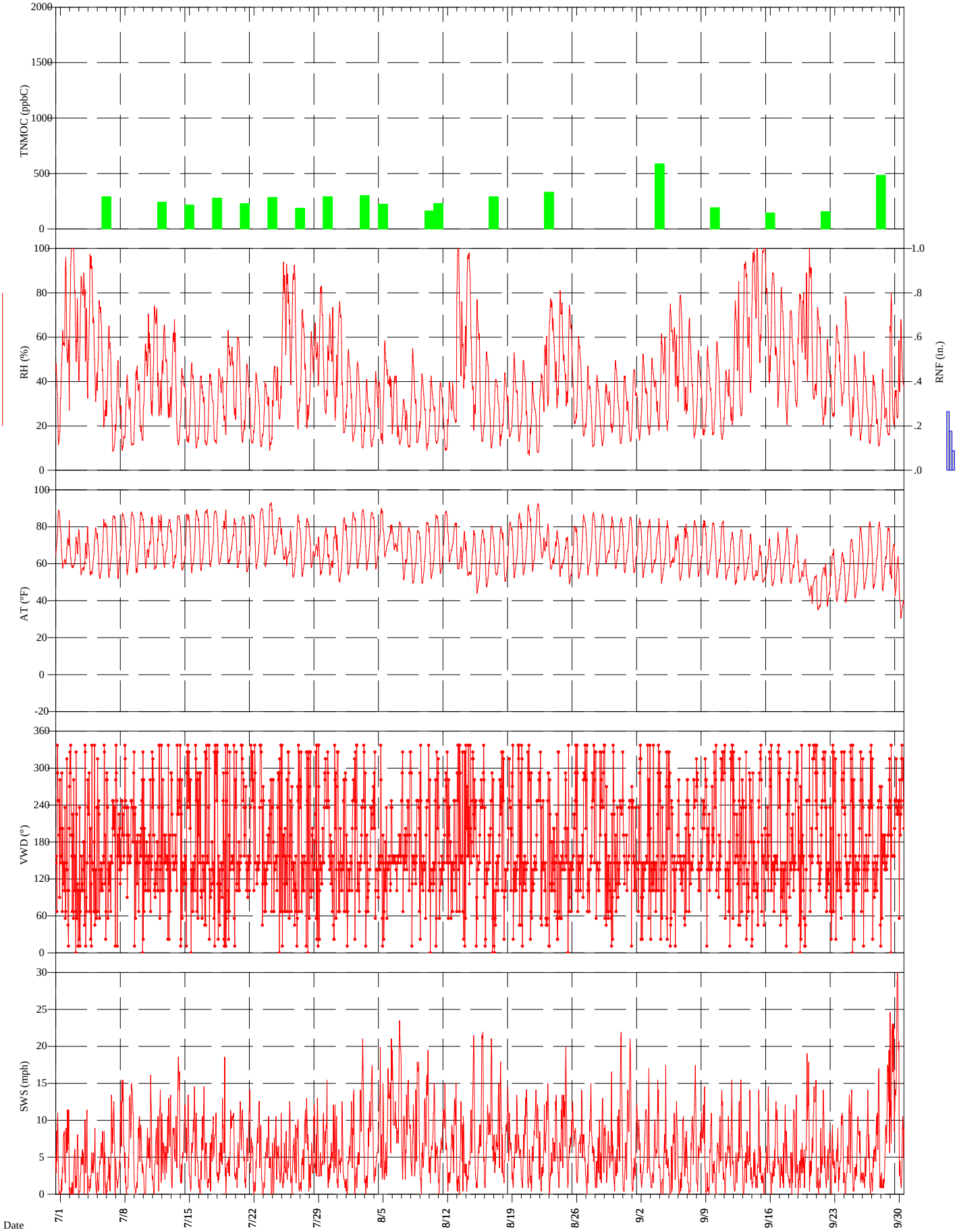
Garfield County, CO

Bell Melton Site

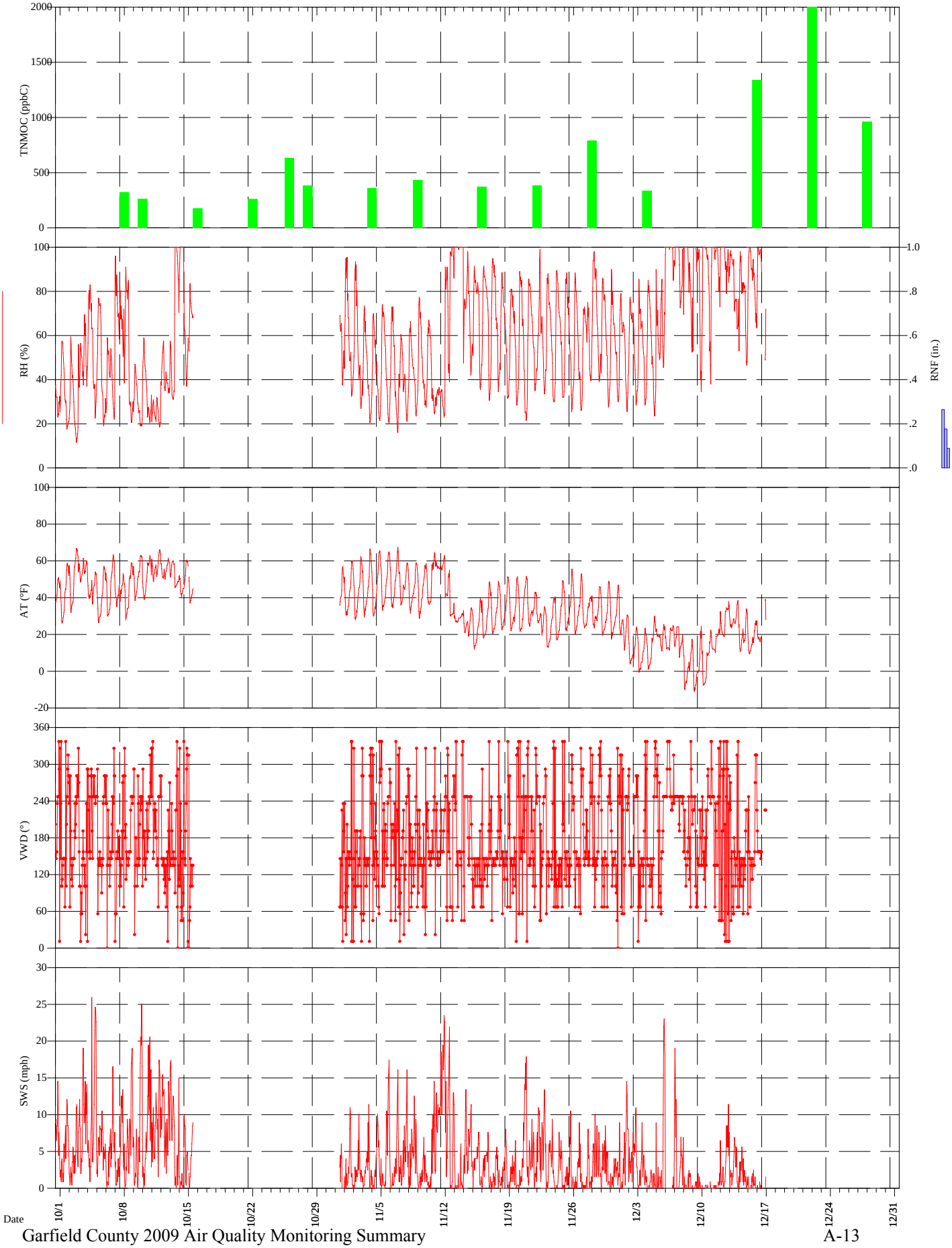


Garfield County, CO

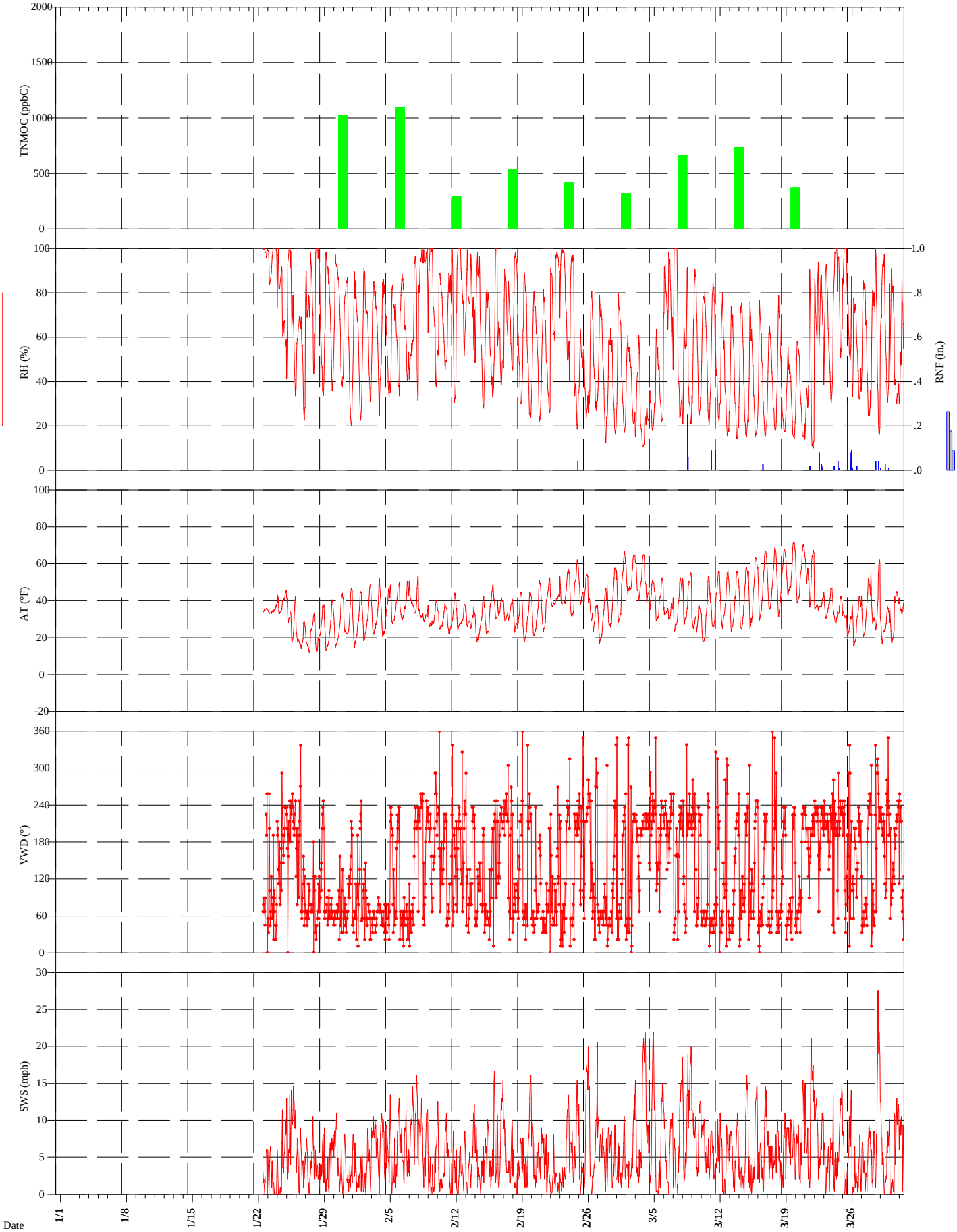
Bell Melton Site



Garfield County, CO
Bell Melton Site



Garfield County, CO
Rulison Site

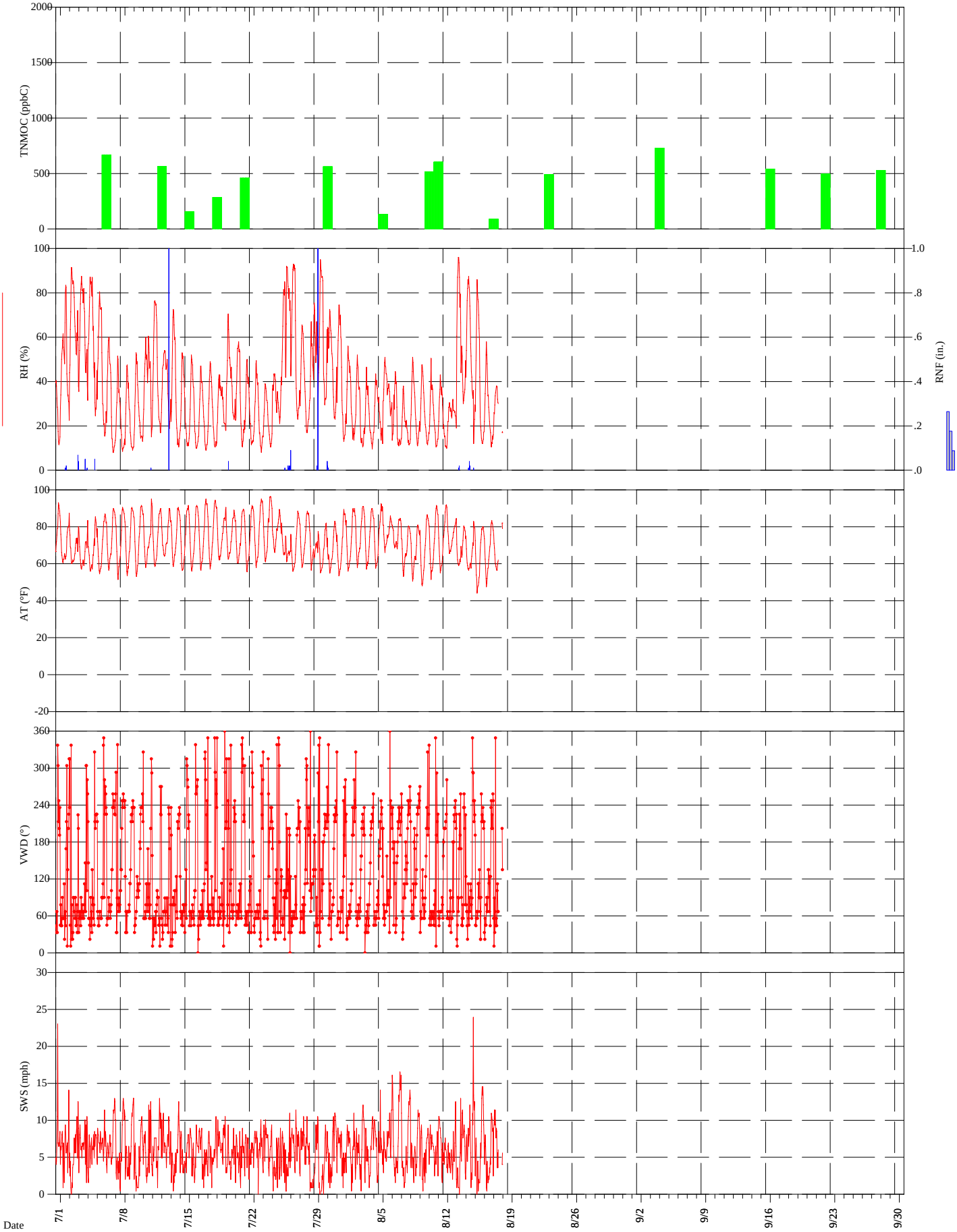


Garfield County, CO

Rulison Site

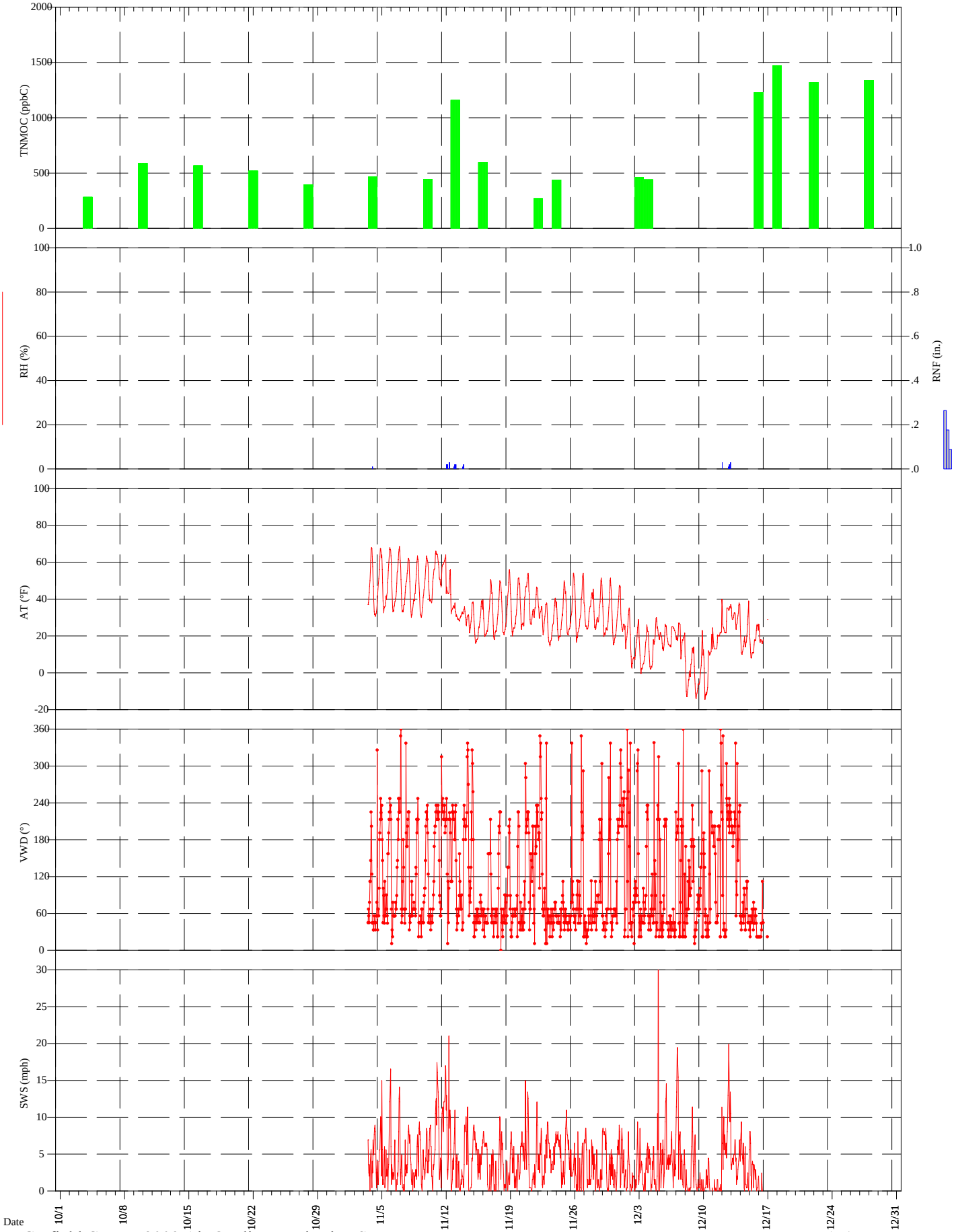
Garfield County, CO

Rulison Site



Garfield County, CO

Rulison Site



APPENDIX B

Garfield County

2009 SNMOC Concentrations

Table B-1
Garfield County SNMOC Monitoring
Parachute (PACO)
1/7/2009-12/28/2009 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	56	35	0.01	0.13	0.03
1,2,4-Trimethylbenzene (95-63-6)	56	55	0.03	0.66	0.13
1,3,5-Trimethylbenzene (108-67-8)	56	52	0.02	0.58	0.10
1,3-Butadiene (106-99-0)	56	18	0.01	1.42	0.05
1-Decene (872-05-9)	56	1	0.02	0.02	0.01
1-Dodecene (112-41-4)	56	15	0.01	0.06	0.02
1-Heptene (592-76-7)	56	52	0.03	0.86	0.23
1-Hexene (592-41-6)	56	29	0.02	0.09	0.03
1-Nonene (124-11-8)	56	31	0.01	0.38	0.05
1-Octene (111-66-0)	56	8	0.01	0.04	0.02
1-Pentene (109-67-1)	56	56	0.02	0.13	0.05
1-Tridecene (2437-56-1)	56	4	0.00	0.02	0.01
1-Undecene (821-95-4)	56	29	0.01	0.15	0.03
2,2,3-Trimethylpentane (564-02-3)	56	45	0.01	0.36	0.07
2,2,4-Trimethylpentane (540-84-1)	56	30	0.01	1.13	0.04
2,2-Dimethylbutane (75-83-2)	56	56	0.03	0.85	0.20
2,3,4-Trimethylpentane (565-75-3)	56	39	0.01	0.05	0.02
2,3-Dimethylbutane (79-29-8)	56	56	0.04	1.64	0.35
2,3-Dimethylpentane (565-59-3)	56	56	0.03	0.74	0.17
2,4-Dimethylpentane (108-08-7)	56	55	0.03	0.56	0.12
2-Methyl-1-butene (563-46-2)	56	22	0.02	0.21	0.04
2-Methyl-1-pentene (763-29-1)	56	2	0.01	0.02	0.02
2-Methyl-2-butene (513-35-9)	56	41	0.02	0.13	0.04
2-Methylheptane (592-27-8)	56	56	0.02	1.59	0.29
2-Methylhexane (591-76-4)	56	56	0.03	2.61	0.54
2-Methylpentane (107-83-5)	56	56	0.18	6.48	1.43
3-Methyl-1-butene (563-45-1)	56	9	0.02	0.04	0.02
3-Methylheptane (589-81-1)	56	56	0.02	1.21	0.23
3-Methylhexane (589-34-4)	56	50	0.06	2.44	0.42
3-Methylpentane (96-14-0)	56	56	0.08	3.80	0.81
Acetylene (74-86-2)	56	56	0.19	19.30	1.03
a-Pinene (80-56-8)	56	26	0.01	0.07	0.02
Benzene (71-43-2)	56	56	0.11	3.17	0.84
b-Pinene (127-91-3)	56	6	0.01	0.12	0.02
cis-2-Butene (590-18-1)	56	45	0.01	0.29	0.06
cis-2-Hexene (7688-21-3)	56	9	0.01	0.02	0.02
cis-2-Pentene (627-20-3)	56	32	0.01	0.06	0.02
Cyclohexane (110-82-7)	56	56	0.07	5.45	1.11
Cyclopentane (287-92-3)	56	56	0.03	0.90	0.22
Cyclopentene (142-29-0)	56	23	0.02	0.30	0.04
Ethane (74-84-0)	56	56	4.78	335.00	69.48
Ethylbenzene (100-41-4)	56	54	0.03	0.44	0.10

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table B-1 (continued)
Garfield County SNMOC Monitoring
Parachute (PACO)
1/7/2009-12/28/2009 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Ethylene (74-85-1)	56	55	0.60	3.07	1.37
Isobutane (75-28-5)	56	56	0.40	32.25	6.73
Isobutene/1-Butene (115-11-7 / 106-98-9)	56	34	0.11	1.92	0.33
Isopentane (78-78-4)	56	55	0.93	20.80	5.31
Isoprene (78-79-5)	56	44	0.02	0.72	0.15
Isopropylbenzene (98-82-8)	56	24	0.01	0.06	0.02
m-Diethylbenzene (141-93-5)	56	29	0.01	0.11	0.02
Methylcyclohexane (108-87-2)	56	56	0.13	12.20	2.38
Methylcyclopentane (96-37-7)	56	56	0.08	4.18	0.90
m-Ethyltoluene (620-14-4)	56	55	0.02	0.41	0.08
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	56	56	0.04	4.54	0.84
n-Butane (106-97-8)	56	56	0.45	32.25	7.15
n-Decane (124-18-5)	56	55	0.04	1.25	0.29
n-Dodecane (112-40-3)	56	49	0.03	1.09	0.12
n-Heptane (142-82-5)	56	56	0.07	5.06	0.99
n-Hexane (110-54-3)	56	56	0.16	8.20	1.61
n-Nonane (111-84-2)	56	56	0.03	2.28	0.39
n-Octane (111-65-9)	56	56	0.05	4.14	0.75
n-Pentane (109-66-0)	56	56	0.39	13.92	3.19
n-Propylbenzene (103-65-1)	56	41	0.01	0.14	0.03
n-Tridecane (629-50-5)	56	24	0.01	0.09	0.02
n-Undecane (1120-21-4)	56	55	0.04	3.17	0.29
o-Ethyltoluene (611-14-3)	56	51	0.02	0.28	0.06
o-Xylene (95-47-6)	56	54	0.03	0.73	0.15
p-Diethylbenzene (105-05-5)	56	21	0.01	0.04	0.01
p-Ethyltoluene (622-96-8)	56	49	0.01	0.31	0.06
Propane (74-98-6)	56	56	1.76	118.67	24.69
Propylene (115-07-1)	56	56	0.13	0.88	0.33
Styrene (100-42-5)	56	1	0.04	0.04	0.02
Toluene (108-88-3)	56	56	0.18	6.57	1.56
trans-2-Butene (624-64-6)	56	55	0.02	0.37	0.08
trans-2-Hexene (4050-45-7)	56	4	0.01	0.01	0.02
trans-2-Pentene (646-04-8)	56	44	0.02	0.11	0.04

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table B-2
Garfield County SNMOC Monitoring
Rifle (RICO)
1/7/2009-12/28/2009 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	60	46	0.01	0.12	0.03
1,2,4-Trimethylbenzene (95-63-6)	60	59	0.02	0.56	0.14
1,3,5-Trimethylbenzene (108-67-8)	60	58	0.02	0.31	0.07
1,3-Butadiene (106-99-0)	60	37	0.01	0.18	0.05
1-Dodecene (112-41-4)	60	18	0.01	0.07	0.02
1-Heptene (592-76-7)	60	58	0.03	0.67	0.17
1-Hexene (592-41-6)	60	39	0.01	0.19	0.04
1-Nonene (124-11-8)	60	22	0.01	0.16	0.03
1-Octene (111-66-0)	60	11	0.01	0.14	0.02
1-Pentene (109-67-1)	60	59	0.03	0.30	0.09
1-Tridecene (2437-56-1)	60	9	0.00	0.02	0.01
1-Undecene (821-95-4)	60	27	0.01	0.30	0.03
2,2,3-Trimethylpentane (564-02-3)	60	42	0.01	0.19	0.05
2,2,4-Trimethylpentane (540-84-1)	60	60	0.02	0.40	0.07
2,2-Dimethylbutane (75-83-2)	60	59	0.04	0.46	0.16
2,3,4-Trimethylpentane (565-75-3)	60	55	0.02	0.22	0.04
2,3-Dimethylbutane (79-29-8)	60	59	0.06	0.96	0.30
2,3-Dimethylpentane (565-59-3)	60	60	0.04	0.49	0.16
2,4-Dimethylpentane (108-08-7)	60	59	0.03	0.34	0.11
2-Methyl-1-butene (563-46-2)	60	47	0.01	0.89	0.11
2-Methyl-1-pentene (763-29-1)	60	15	0.01	0.04	0.02
2-Methyl-2-butene (513-35-9)	60	57	0.04	0.44	0.13
2-Methylheptane (592-27-8)	60	60	0.03	0.84	0.16
2-Methylhexane (591-76-4)	60	60	0.06	1.46	0.39
2-Methylpentane (107-83-5)	60	60	0.23	4.37	1.30
3-Methyl-1-butene (563-45-1)	60	7	0.02	0.07	0.02
3-Methylheptane (589-81-1)	60	60	0.02	0.60	0.12
3-Methylhexane (589-34-4)	60	51	0.08	1.36	0.31
3-Methylpentane (96-14-0)	60	60	0.13	2.33	0.72
4-Methyl-1-pentene (691-37-2)	60	2	0.01	0.02	0.02
Acetylene (74-86-2)	60	60	0.32	4.00	1.58
a-Pinene (80-56-8)	60	33	0.01	0.08	0.02
Benzene (71-43-2)	60	60	0.13	2.08	0.70
b-Pinene (127-91-3)	60	7	0.01	0.04	0.01
cis-2-Butene (590-18-1)	60	58	0.03	0.79	0.15
cis-2-Hexene (7688-21-3)	60	10	0.01	0.05	0.02
cis-2-Pentene (627-20-3)	60	56	0.02	0.19	0.06
Cyclohexane (110-82-7)	60	60	0.09	2.88	0.72
Cyclopentane (287-92-3)	60	60	0.04	0.58	0.20
Cyclopentene (142-29-0)	60	33	0.02	0.68	0.07
Ethane (74-84-0)	60	60	5.45	215.00	46.81
Ethylbenzene (100-41-4)	60	60	0.03	0.38	0.13

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table B-2 (continued)
Garfield County SNMOC Monitoring
Rifle (RICO)
1/7/2009-12/28/2009 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Ethylene (74-85-1)	60	60	0.61	5.40	2.18
Isobutane (75-28-5)	60	60	0.80	26.00	6.01
Isobutene/1-Butene (115-11-7 / 106-98-9)	60	55	0.08	1.75	0.66
Isopentane (78-78-4)	60	59	0.63	27.40	5.65
Isoprene (78-79-5)	60	57	0.03	0.65	0.16
Isopropylbenzene (98-82-8)	60	23	0.01	0.04	0.02
m-Diethylbenzene (141-93-5)	60	32	0.01	0.10	0.02
Methylcyclohexane (108-87-2)	60	60	0.12	6.09	1.27
Methylcyclopentane (96-37-7)	60	60	0.12	2.22	0.65
m-Ethyltoluene (620-14-4)	60	59	0.02	0.34	0.10
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	60	60	0.05	2.48	0.59
n-Butane (106-97-8)	60	59	0.99	27.75	6.54
n-Decane (124-18-5)	60	58	0.03	0.78	0.14
n-Dodecane (112-40-3)	60	40	0.02	0.50	0.07
n-Heptane (142-82-5)	60	60	0.08	2.70	0.62
n-Hexane (110-54-3)	60	60	0.18	4.77	1.32
n-Nonane (111-84-2)	60	59	0.03	1.10	0.16
n-Octane (111-65-9)	60	60	0.05	2.04	0.36
n-Pentane (109-66-0)	60	60	0.41	10.14	2.95
n-Propylbenzene (103-65-1)	60	49	0.01	0.11	0.03
n-Tridecane (629-50-5)	60	27	0.00	0.05	0.02
n-Undecane (1120-21-4)	60	59	0.01	0.59	0.14
o-Ethyltoluene (611-14-3)	60	58	0.01	0.19	0.06
o-Xylene (95-47-6)	60	59	0.04	0.57	0.17
p-Diethylbenzene (105-05-5)	60	24	0.00	0.03	0.01
p-Ethyltoluene (622-96-8)	60	53	0.02	0.21	0.06
Propane (74-98-6)	60	60	2.48	79.67	19.38
Propylene (115-07-1)	60	60	0.20	1.42	0.61
Styrene (100-42-5)	60	7	0.01	0.04	0.02
Toluene (108-88-3)	60	60	0.25	4.03	1.23
trans-2-Butene (624-64-6)	60	59	0.04	1.01	0.18
trans-2-Hexene (4050-45-7)	60	15	0.01	0.08	0.02
trans-2-Pentene (646-04-8)	60	58	0.04	0.42	0.12

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table B-3
Garfield County SNMOC Monitoring
Bell-Melton (BRCO)
1/7/2009-12/28/2009 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	56	21	0.01	0.17	0.02
1,2,4-Trimethylbenzene (95-63-6)	56	51	0.01	0.60	0.06
1,3,5-Trimethylbenzene (108-67-8)	56	40	0.00	0.24	0.03
1,3-Butadiene (106-99-0)	56	7	0.01	0.07	0.03
1-Dodecene (112-41-4)	56	13	0.01	0.08	0.02
1-Heptene (592-76-7)	56	54	0.02	0.74	0.14
1-Hexene (592-41-6)	56	29	0.01	0.08	0.03
1-Nonene (124-11-8)	56	25	0.01	0.08	0.02
1-Octene (111-66-0)	56	10	0.01	0.04	0.02
1-Pentene (109-67-1)	56	56	0.02	0.13	0.04
1-Tridecene (2437-56-1)	56	10	0.00	0.03	0.01
1-Undecene (821-95-4)	56	26	0.01	0.17	0.03
2,2,3-Trimethylpentane (564-02-3)	56	27	0.01	0.13	0.03
2,2,4-Trimethylpentane (540-84-1)	56	36	0.01	0.53	0.03
2,2-Dimethylbutane (75-83-2)	56	56	0.03	0.64	0.15
2,3,4-Trimethylpentane (565-75-3)	56	33	0.01	0.05	0.02
2,3-Dimethylbutane (79-29-8)	56	56	0.06	1.43	0.30
2,3-Dimethylpentane (565-59-3)	56	56	0.03	0.51	0.12
2,4-Dimethylpentane (108-08-7)	56	56	0.02	0.36	0.09
2-Methyl-1-butene (563-46-2)	56	12	0.01	13.72	0.36
2-Methyl-2-butene (513-35-9)	56	24	0.02	0.06	0.03
2-Methylheptane (592-27-8)	56	56	0.02	0.59	0.12
2-Methylhexane (591-76-4)	56	54	0.04	1.39	0.32
2-Methylpentane (107-83-5)	56	56	0.24	6.25	1.36
3-Methyl-1-butene (563-45-1)	56	8	0.02	0.06	0.02
3-Methylheptane (589-81-1)	56	56	0.02	0.37	0.08
3-Methylhexane (589-34-4)	56	49	0.06	1.18	0.23
3-Methylpentane (96-14-0)	56	56	0.14	3.30	0.71
4-Methyl-1-pentene (691-37-2)	56	1	0.13	0.13	0.02
Acetylene (74-86-2)	56	56	0.20	2.74	0.59
a-Pinene (80-56-8)	56	28	0.01	0.16	0.03
Benzene (71-43-2)	56	56	0.11	1.42	0.43
b-Pinene (127-91-3)	56	8	0.01	0.06	0.02
cis-2-Butene (590-18-1)	56	33	0.01	0.16	0.03
cis-2-Hexene (7688-21-3)	56	9	0.01	0.03	0.02
cis-2-Pentene (627-20-3)	56	25	0.01	0.04	0.02
Cyclohexane (110-82-7)	56	56	0.13	3.65	0.80
Cyclopentane (287-92-3)	56	56	0.05	0.96	0.22
Cyclopentene (142-29-0)	56	19	0.02	0.21	0.03
Ethane (74-84-0)	56	56	8.50	311.00	54.86
Ethylbenzene (100-41-4)	56	51	0.02	0.27	0.06
Ethylene (74-85-1)	56	56	0.38	2.56	1.09

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table B-3 (continued)
Garfield County SNMOC Monitoring
Bell-Melton (BRCO)
1/7/2009-12/28/2009 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Isobutane (75-28-5)	56	56	1.41	41.25	7.90
Isobutene/1-Butene (115-11-7 / 106-98-9)	56	28	0.07	1.95	0.30
Isopentane (78-78-4)	56	55	1.74	22.60	5.59
Isoprene (78-79-5)	56	44	0.01	0.77	0.14
Isopropylbenzene (98-82-8)	56	20	0.01	0.03	0.01
m-Diethylbenzene (141-93-5)	56	24	0.01	0.07	0.02
Methylcyclohexane (108-87-2)	56	56	0.19	5.96	1.25
Methylcyclopentane (96-37-7)	56	56	0.13	3.02	0.67
m-Ethyltoluene (620-14-4)	56	52	0.01	0.29	0.04
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	56	56	0.07	1.17	0.30
n-Butane (106-97-8)	56	56	1.26	66.25	10.44
n-Decane (124-18-5)	56	55	0.02	1.06	0.12
n-Dodecane (112-40-3)	56	43	0.01	2.74	0.14
n-Heptane (142-82-5)	56	56	0.10	2.77	0.59
n-Hexane (110-54-3)	56	56	0.26	7.08	1.52
n-Nonane (111-84-2)	56	55	0.02	0.59	0.12
n-Octane (111-65-9)	56	56	0.06	1.44	0.29
n-Pentane (109-66-0)	56	56	0.65	18.20	4.03
n-Propylbenzene (103-65-1)	56	27	0.01	0.08	0.02
n-Tridecane (629-50-5)	56	25	0.00	0.75	0.03
n-Undecane (1120-21-4)	56	54	0.01	1.95	0.19
o-Ethyltoluene (611-14-3)	56	35	0.01	0.29	0.03
o-Xylene (95-47-6)	56	52	0.03	0.39	0.07
p-Diethylbenzene (105-05-5)	56	17	0.00	0.04	0.01
p-Ethyltoluene (622-96-8)	56	32	0.01	0.26	0.03
Propane (74-98-6)	56	56	3.26	148.00	29.08
Propylene (115-07-1)	56	56	0.11	1.43	0.24
Styrene (100-42-5)	56	5	0.01	0.05	0.02
Toluene (108-88-3)	56	56	0.17	2.49	0.67
trans-2-Butene (624-64-6)	56	49	0.02	0.20	0.04
trans-2-Hexene (4050-45-7)	56	1	0.01	0.01	0.02
trans-2-Pentene (646-04-8)	56	27	0.01	0.06	0.02

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table B-4
Garfield County SNMOC Monitoring
Brock (MOCO)
1/7/2009-2/18/2009 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	7	6	0.01	0.03	0.02
1,2,4-Trimethylbenzene (95-63-6)	7	7	0.02	0.16	0.08
1,3,5-Trimethylbenzene (108-67-8)	7	7	0.01	0.13	0.06
1,3-Butadiene (106-99-0)	7	2	0.01	0.01	0.02
1-Dodecene (112-41-4)	7	1	0.09	0.09	0.03
1-Heptene (592-76-7)	7	6	0.03	0.39	0.15
1-Hexene (592-41-6)	7	7	0.01	0.04	0.02
1-Nonene (124-11-8)	7	6	0.01	0.10	0.04
1-Octene (111-66-0)	7	2	0.01	0.01	0.01
1-Pentene (109-67-1)	7	7	0.02	0.05	0.03
1-Tridecene (2437-56-1)	7	2	0.01	0.01	0.01
2,2,3-Trimethylpentane (564-02-3)	7	6	0.02	0.14	0.05
2,2,4-Trimethylpentane (540-84-1)	7	6	0.01	0.58	0.10
2,2-Dimethylbutane (75-83-2)	7	7	0.06	0.39	0.18
2,3,4-Trimethylpentane (565-75-3)	7	6	0.01	0.02	0.01
2,3-Dimethylbutane (79-29-8)	7	7	0.11	0.83	0.34
2,3-Dimethylpentane (565-59-3)	7	7	0.06	0.42	0.17
2,4-Dimethylpentane (108-08-7)	7	7	0.04	0.29	0.12
2-Methyl-1-butene (563-46-2)	7	5	0.04	0.10	0.05
2-Methyl-2-butene (513-35-9)	7	1	0.01	0.01	0.02
2-Methylheptane (592-27-8)	7	7	0.05	0.68	0.25
2-Methylhexane (591-76-4)	7	7	0.14	1.39	0.52
2-Methylpentane (107-83-5)	7	7	0.43	3.60	1.46
3-Methyl-1-butene (563-45-1)	7	1	0.30	0.30	0.06
3-Methylheptane (589-81-1)	7	7	0.04	0.45	0.17
3-Methylhexane (589-34-4)	7	7	0.10	1.28	0.46
3-Methylpentane (96-14-0)	7	7	0.24	2.07	0.81
Acetylene (74-86-2)	7	7	0.37	0.96	0.68
a-Pinene (80-56-8)	7	4	0.01	0.05	0.02
Benzene (71-43-2)	7	7	0.21	1.47	0.61
cis-2-Butene (590-18-1)	7	7	0.01	0.06	0.03
cis-2-Pentene (627-20-3)	7	6	0.01	0.03	0.02
Cyclohexane (110-82-7)	7	7	0.29	2.98	1.11
Cyclopentane (287-92-3)	7	7	0.08	0.49	0.22
Cyclopentene (142-29-0)	7	1	0.02	0.02	0.02
Ethane (74-84-0)	7	7	18.75	128.50	68.76
Ethylbenzene (100-41-4)	7	7	0.02	0.15	0.07
Ethylene (74-85-1)	7	7	0.63	2.18	1.12
Isobutane (75-28-5)	7	7	1.84	14.42	7.12
Isobutene/1-Butene (115-11-7 / 106-98-9)	7	3	0.22	0.25	0.11
Isopentane (78-78-4)	7	7	2.54	11.36	5.37
Isoprene (78-79-5)	7	6	0.01	0.03	0.02

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table B-4 (continued)
Garfield County SNMOC Monitoring
Brock (MOCO)
1/7/2009-2/18/2009 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Isopropylbenzene (98-82-8)	7	6	0.01	0.02	0.01
m-Diethylbenzene (141-93-5)	7	6	0.01	0.02	0.02
Methylcyclohexane (108-87-2)	7	7	0.48	6.00	2.16
Methylcyclopentane (96-37-7)	7	7	0.26	2.38	0.90
m-Ethyltoluene (620-14-4)	7	7	0.02	0.11	0.06
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	7	7	0.09	1.38	0.58
n-Butane (106-97-8)	7	7	2.11	15.65	7.73
n-Decane (124-18-5)	7	7	0.02	0.35	0.17
n-Dodecane (112-40-3)	7	7	0.01	0.11	0.04
n-Heptane (142-82-5)	7	7	0.20	2.96	1.02
n-Hexane (110-54-3)	7	7	0.45	4.87	1.81
n-Nonane (111-84-2)	7	7	0.04	0.71	0.29
n-Octane (111-65-9)	7	7	0.10	1.64	0.64
n-Pentane (109-66-0)	7	7	0.96	7.36	3.28
n-Propylbenzene (103-65-1)	7	6	0.02	0.04	0.02
n-Tridecane (629-50-5)	7	5	0.00	0.02	0.01
n-Undecane (1120-21-4)	7	7	0.02	0.14	0.10
o-Ethyltoluene (611-14-3)	7	6	0.02	0.07	0.04
o-Xylene (95-47-6)	7	7	0.03	0.21	0.10
p-Diethylbenzene (105-05-5)	7	4	0.01	0.02	0.01
p-Ethyltoluene (622-96-8)	7	7	0.01	0.09	0.05
Propane (74-98-6)	7	7	7.07	50.67	26.55
Propylene (115-07-1)	7	7	0.11	0.44	0.20
Styrene (100-42-5)	7	1	0.01	0.01	0.02
Toluene (108-88-3)	7	7	0.22	3.04	1.12
trans-2-Butene (624-64-6)	7	7	0.02	0.04	0.03
trans-2-Pentene (646-04-8)	7	6	0.01	0.03	0.02

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table B-5
Garfield County SNMOC Monitoring
Rulison (RUCO)
1/31/2009-12/28/2009 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	51	29	0.01	0.07	0.02
1,2,4-Trimethylbenzene (95-63-6)	51	50	0.02	0.22	0.09
1,3,5-Trimethylbenzene (108-67-8)	51	49	0.01	0.19	0.07
1,3-Butadiene (106-99-0)	51	12	0.01	0.08	0.03
1-Dodecene (112-41-4)	51	10	0.01	0.06	0.02
1-Heptene (592-76-7)	51	50	0.04	0.74	0.25
1-Hexene (592-41-6)	51	25	0.01	0.10	0.03
1-Nonene (124-11-8)	51	30	0.01	0.12	0.04
1-Octene (111-66-0)	51	12	0.01	0.13	0.03
1-Pentene (109-67-1)	51	50	0.02	0.19	0.05
1-Tridecene (2437-56-1)	51	6	0.01	0.03	0.01
1-Undecene (821-95-4)	51	22	0.01	0.19	0.03
2,2,3-Trimethylpentane (564-02-3)	51	43	0.01	0.15	0.06
2,2,4-Trimethylpentane (540-84-1)	51	32	0.01	0.15	0.03
2,2-Dimethylbutane (75-83-2)	51	51	0.03	0.65	0.23
2,3,4-Trimethylpentane (565-75-3)	51	34	0.01	0.06	0.02
2,3-Dimethylbutane (79-29-8)	51	51	0.04	1.17	0.41
2,3-Dimethylpentane (565-59-3)	51	51	0.04	0.48	0.17
2,4-Dimethylpentane (108-08-7)	51	51	0.02	0.34	0.13
2-Methyl-1-butene (563-46-2)	51	17	0.02	0.18	0.04
2-Methyl-1-pentene (763-29-1)	51	1	0.03	0.03	0.02
2-Methyl-2-butene (513-35-9)	51	21	0.01	0.11	0.03
2-Methylheptane (592-27-8)	51	51	0.01	0.62	0.23
2-Methylhexane (591-76-4)	51	51	0.06	1.44	0.52
2-Methylpentane (107-83-5)	51	51	0.19	4.75	1.69
3-Methyl-1-butene (563-45-1)	51	5	0.02	0.03	0.02
3-Methylheptane (589-81-1)	51	51	0.03	0.44	0.18
3-Methylhexane (589-34-4)	51	42	0.05	1.08	0.36
3-Methylpentane (96-14-0)	51	51	0.09	2.68	0.94
4-Methyl-1-pentene (691-37-2)	51	1	0.03	0.03	0.02
Acetylene (74-86-2)	51	51	0.19	3.03	0.62
a-Pinene (80-56-8)	51	23	0.01	0.53	0.03
Benzene (71-43-2)	51	50	0.15	1.97	0.74
b-Pinene (127-91-3)	51	7	0.01	0.06	0.02
cis-2-Butene (590-18-1)	51	36	0.02	0.08	0.04
cis-2-Hexene (7688-21-3)	51	10	0.01	0.08	0.02
cis-2-Pentene (627-20-3)	51	24	0.01	0.04	0.02
Cyclohexane (110-82-7)	51	51	0.11	3.53	1.21
Cyclopentane (287-92-3)	51	51	0.04	0.72	0.26
Cyclopentene (142-29-0)	51	18	0.02	0.22	0.04
Ethane (74-84-0)	51	51	5.95	210.00	64.63
Ethylbenzene (100-41-4)	51	51	0.02	0.46	0.09

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table B-5 (continued)
Garfield County SNMOC Monitoring
Rulison (RUCO)
1/31/2009-12/28/2009 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Ethylene (74-85-1)	51	51	0.40	2.65	1.10
Isobutane (75-28-5)	51	51	0.49	27.25	8.43
Isobutene/1-Butene (115-11-7 / 106-98-9)	51	27	0.05	1.50	0.24
Isopentane (78-78-4)	51	51	1.12	15.50	6.28
Isoprene (78-79-5)	51	37	0.02	1.12	0.16
Isopropylbenzene (98-82-8)	51	21	0.00	0.03	0.01
m-Diethylbenzene (141-93-5)	51	25	0.01	0.08	0.02
Methylcyclohexane (108-87-2)	51	51	0.19	6.54	2.24
Methylcyclopentane (96-37-7)	51	51	0.09	2.78	0.98
m-Ethyltoluene (620-14-4)	51	50	0.01	0.15	0.06
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	51	51	0.05	1.82	0.67
n-Butane (106-97-8)	51	51	0.60	28.50	8.98
n-Decane (124-18-5)	51	51	0.03	0.68	0.18
n-Dodecane (112-40-3)	51	38	0.02	0.32	0.08
n-Heptane (142-82-5)	51	51	0.07	2.83	0.95
n-Hexane (110-54-3)	51	51	0.12	5.50	1.90
n-Nonane (111-84-2)	51	51	0.04	0.66	0.26
n-Octane (111-65-9)	51	51	0.07	1.62	0.60
n-Pentane (109-66-0)	51	51	0.44	11.74	4.20
n-Propylbenzene (103-65-1)	51	35	0.01	0.04	0.02
n-Tridecane (629-50-5)	51	22	0.00	0.05	0.02
n-Undecane (1120-21-4)	51	51	0.03	0.80	0.17
o-Ethyltoluene (611-14-3)	51	45	0.01	0.09	0.04
o-Xylene (95-47-6)	51	51	0.02	0.46	0.12
p-Diethylbenzene (105-05-5)	51	20	0.01	0.04	0.01
p-Ethyltoluene (622-96-8)	51	43	0.01	0.10	0.04
Propane (74-98-6)	51	51	2.12	91.33	27.36
Propylene (115-07-1)	51	51	0.12	1.03	0.29
Styrene (100-42-5)	51	2	0.03	0.10	0.02
Toluene (108-88-3)	51	51	0.11	3.43	1.28
trans-2-Butene (624-64-6)	51	43	0.02	0.99	0.06
trans-2-Pentene (646-04-8)	51	30	0.01	0.09	0.03

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

APPENDIX C

Garfield County

2009 Carbonyl Concentrations

Table C-1
Garfield County Carbonyl Monitoring
Bell-Melton (BRCO)
1/7/2009-11/28/2009 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	26	0	ND	ND	0.00
Acetaldehyde (75-07-0)	26	26	0.17	0.78	0.44
Acetone (67-64-1)	26	26	0.58	2.24	1.12
Benzaldehyde (100-52-7)	26	24	0.01	0.05	0.02
Butyraldehyde (123-72-8)	26	26	0.01	0.04	0.02
Crotonaldehyde (123-73-9)	26	26	0.01	0.19	0.05
Formaldehyde (50-00-0)	26	26	0.36	8.31	1.11
Hexaldehyde (66-25-1)	26	21	0.01	0.03	0.01
Isovaleraldehyde (590-86-3)	26	0	ND	ND	0.00
Propionaldehyde (123-38-6)	26	26	0.01	0.08	0.04
Tolualdehydes (NA)	26	24	0.01	0.04	0.02
Valeraldehyde (110-62-3)	26	15	0.01	0.02	0.01

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table C-2
Garfield County Carbonyl Monitoring
Brock (MOCO)
1/7/2009-1/31/2009 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	3	0	ND	ND	0.00
Acetaldehyde (75-07-0)	3	3	0.35	0.49	0.44
Acetone (67-64-1)	3	3	0.83	0.84	0.84
Benzaldehyde (100-52-7)	3	3	0.01	0.03	0.02
Butyraldehyde (123-72-8)	3	3	0.01	0.02	0.02
Crotonaldehyde (123-73-9)	3	3	0.02	0.03	0.02
Formaldehyde (50-00-0)	3	3	0.74	1.05	0.92
Hexaldehyde (66-25-1)	3	1	0.02	0.02	0.01
Isovaleraldehyde (590-86-3)	3	0	ND	ND	0.00
Propionaldehyde (123-38-6)	3	3	0.01	0.03	0.02
Tolualdehydes (NA)	3	3	0.02	0.02	0.02
Valeraldehyde (110-62-3)	3	1	0.01	0.01	0.00

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table C-3
Garfield County Carbonyl Monitoring
Parachute (PACO)
1/13/2009-12/22/2009 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	30	1	0.03	0.03	0.00
Acetaldehyde (75-07-0)	30	30	0.18	1.13	0.55
Acetone (67-64-1)	30	30	0.49	3.07	1.38
Benzaldehyde (100-52-7)	30	29	0.01	0.07	0.02
Butyraldehyde (123-72-8)	30	28	0.01	0.11	0.03
Crotonaldehyde (123-73-9)	30	30	0.01	0.09	0.04
Formaldehyde (50-00-0)	30	30	0.42	2.48	1.41
Hexaldehyde (66-25-1)	30	26	0.01	0.04	0.01
Isovaleraldehyde (590-86-3)	30	0	ND	ND	0.00
Propionaldehyde (123-38-6)	30	28	0.01	0.13	0.04
Tolualdehydes (NA)	30	29	0.01	0.05	0.02
Valeraldehyde (110-62-3)	30	21	0.01	0.03	0.01

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table C-4
Garfield County Carbonyl Monitoring
Rifle (RICO)
1/22/2009-12/22/2009 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	28	0	ND	ND	0.00
Acetaldehyde (75-07-0)	28	28	0.27	1.53	0.78
Acetone (67-64-1)	28	28	0.47	2.73	1.32
Benzaldehyde (100-52-7)	28	28	0.01	0.07	0.03
Butyraldehyde (123-72-8)	28	27	0.01	0.16	0.04
Crotonaldehyde (123-73-9)	28	28	0.02	0.15	0.06
Formaldehyde (50-00-0)	28	28	0.52	2.38	1.37
Hexaldehyde (66-25-1)	28	26	0.01	0.05	0.02
Isovaleraldehyde (590-86-3)	28	1	0.01	0.01	0.00
Propionaldehyde (123-38-6)	28	28	0.01	0.19	0.06
Tolualdehydes (NA)	28	28	0.02	0.06	0.04
Valeraldehyde (110-62-3)	28	24	0.01	0.04	0.02

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Table C-5
Garfield County Carbonyl Monitoring
Rulison (RUCO)
1/31/2009-12/22/2009 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	24	0	ND	ND	0.00
Acetaldehyde (75-07-0)	24	24	0.22	1.53	0.70
Acetone (67-64-1)	24	24	0.71	2.17	1.33
Benzaldehyde (100-52-7)	24	24	0.01	0.04	0.02
Butyraldehyde (123-72-8)	24	24	0.01	0.07	0.03
Crotonaldehyde (123-73-9)	24	24	0.02	0.17	0.07
Formaldehyde (50-00-0)	24	24	0.61	1.42	0.98
Hexaldehyde (66-25-1)	24	22	0.01	0.06	0.01
Isovaleraldehyde (590-86-3)	24	1	0.01	0.01	0.00
Propionaldehyde (123-38-6)	24	23	0.01	0.09	0.04
Tolualdehydes (NA)	24	23	0.01	0.08	0.03
Valeraldehyde (110-62-3)	24	20	0.01	0.04	0.01

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.