GARFIELD COUNTY
2013 AIR QUALITY MONITORING REPORT

Prepared for:

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LIST OF ACRONYMNS AND ABBREVIATIONS

ARS	Air Resource Specialists, Inc.
ATSDR	Agency for Toxic Substances and Disease Registry
BMCO	Battlement Mesa, Colorado Air Quality Monitoring Site
BRCO	Bell-Melton, Colorado Air Quality Monitoring Site
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CARB	California Air Resources Board
CDPHE	Colorado Department of Public Health and Environment
CH_4	Methane
EPA	U.S. Environmental Protection Agency
ERG	Eastern Research Group, Inc.
FRM	Federal Reference Method
GCPHD	Garfield County Public Health Department
GHG	Greenhouse Gas
HAPs	Hazardous Air Pollutants
NAAQS	National Ambient Air Quality Standards
NATTS	National Air Toxics Trends Stations
NIOSH	National Institute for Occupational Safety and Health
NMHC	Non-Methane Hydrocarbons
NO	Nitric Oxide
NO2	Nitrogen Dioxide
NO_X	Oxides of nitrogen
O_3	Ozone
PACO	Parachute Creek, Colorado Air Quality Monitoring Site
$PM_{2.5}$	Particulate matter $\leq$ 2.5 microns in diameter
PM_{10}	Particulate matter $\leq$ 10 microns in diameter
RICO	Rifle, Colorado Air Quality Monitoring Site
RFCO	Carbondale, Colorado Roaring Fork Air Quality Monitoring Site
SNMOC	Speciated non-methane organic compounds
TEI	Thermo Environmental Instruments
TEOM	Tapered Element Oscillating Microbalance
TNMOC	Total non-methane organic compounds
UATMP	Urban Air Toxics Monitoring Program
VOC	Volatile organic compounds

EXECUTIVE SUMMARY

This report summarizes air quality monitoring data collected through 2013 in Garfield County, Colorado. Air quality is currently monitored at five locations, which are all in close proximity to urban areas in the county, and to oil and gas development areas. Parameters monitoring include:

- Meteorology (e.g., wind speed, wind direction, temperature, relative humidity and precipitation).
  - Meteorological data are collected along with air quality parameters to better understand the local conditions and transport of air pollutants.
- Criteria pollutants (e.g. particulate matter $\leq$ 10 micrometers in diameter (PM_{10}), particulate matter $\leq$ 2.5 micrometers in diameter ($PM_{2.5}$), ozone (O_3) and (NO_2).
  - Criteria pollutants are pollutants subject to National Ambient Air Quality Standards (NAAQS) and have set regulatory limits.
- Volatile organic compounds (VOCs), including methane (CH_4) and subsets of speciated non-methane organic compounds (SNMOCs), carbonyls and hazardous air pollutants (HAPs).

Results through 2013 indicate that:

- Air quality measurements in Garfield County did not violate NAAQS for PM_{10}, $PM_{2.5}$, O_3, or NO_2.
- Total SNMOC measurements have decreased on an annual average basis since measurements began in 2008.
- Light alkanes (e.g., ethane, propane, iso/n-butane, and iso/n-pentane), which are commonly associated with natural gas, made up 85-87% of the total SNMOC compounds measured at the Colorado River sites. These light alkanes may contribute to ozone formation and odor issues but are not considered HAPs.

Of the 78 SNMOC and 12 carbonyl compounds measured in Garfield County, 21 compounds are considered as HAPs. The health effects of HAPs measured in Garfield County were reported for data collected in 2008 in the *Garfield County Air Toxics Inhalation Screening Level Human Risk Assessment* (CDPHE 2010), which is available from the Garfield County Air Quality Management website (http://www.garfield-county.com/air-quality/). Findings of this risk assessment report indicated that, individually, the HAP 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. For HAPs measurements, results through 2013 indicate that:

- A number of HAPs compounds have measured statistically significant decreasing annual average trends at all sites.

- Of the 21 HAPS measured in Garfield County, the only parameter that showed an increasing annual average trend was styrene, which is primarily associated with the production of polystyrene plastics and resins. There are manufacturing facilities in Grand Junction that report emissions of styrene, but it is not clear that emissions from these facilities are contributing to increases in Garfield County.

Air quality monitoring data collected through 2013 are summarized in this report. Additional information, including real-time air quality data, previous air quality data reports, educational materials, air quality management plans, emissions assessments, and health risk assessments are available from the Garfield County Air Quality Management website (http://www.garfield-county.com/air-quality/. Any questions regarding this report or air quality in Garfield County should be addressed to:

Garfield County Public Health Department
195 West 14th Street
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1.0 INTRODUCTION

The Garfield County Public Health Department (GCPHD) has implemented and maintains a network of air quality monitors designed to serve a wide range of purposes related to public health and environmental concerns. This annual air quality data report presents data collected in Garfield County through 2013. The 2013 monitoring network in Garfield County consisted of five monitoring locations, which 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 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.
- Battlement Mesa (BMCO): Battlement Mesa is a rural community located about 1.5 miles southeast of Parachute. The site began operation in September 2010 in response to a proposed large natural gas development within the community, and to begin developing baseline data in advance of the project.
- Carbondale (RFCO): Carbondale is a rural community located about 12.5 miles southeast of Glenwood Springs at the confluence of the Roaring Fork and Crystal River valleys. The Carbondale, or Roaring Fork, monitor began monitoring in March 2012 to characterize air quality in the area.

Figure 1-1 is a map of the current monitoring sites and Table 1-1 lists the parameters monitored. The GCPHD monitors pollutants and meteorology at these stations with technical support from several agencies, as noted in Table 1-1. Real-time data, including camera images, are displayed on the Garfield County Air Quality Monitoring website (http://www.garfield-county.com/air-quality/).

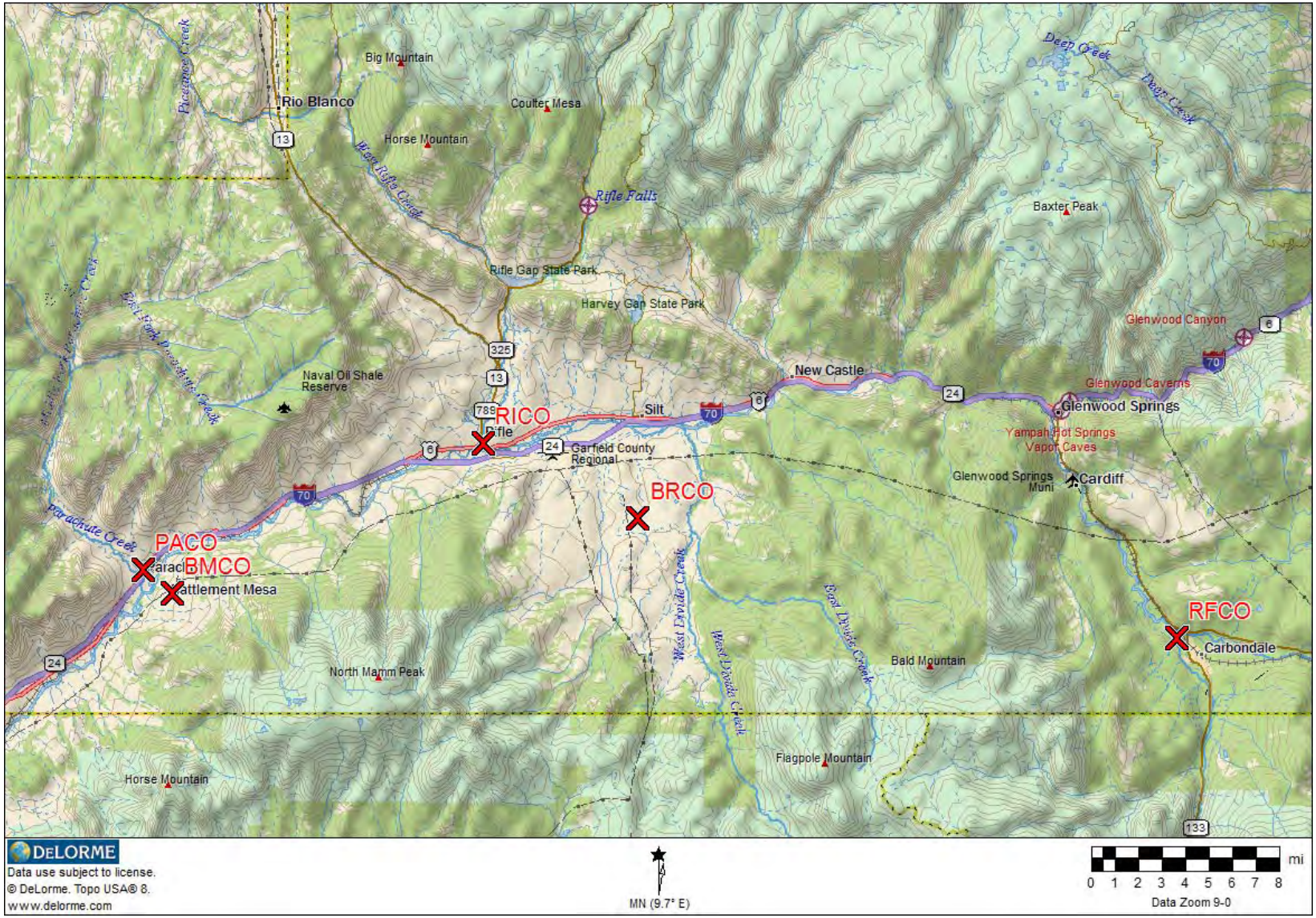

Figure 1-1. Map of Garfield County monitoring sites.

Table 1-1

Garfield County
Parameters Monitored by Site

Component	Method	Sampling Frequency	Agency Responsible
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	ARS
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
Battlement Mesa, Colorado			
SNMOC	TO-12	24-hour (1/6 day)	ERG
Carbonyls	TO-11A	24-hour (1/12 day)	ERG
PM_{10}	BAM	Hourly	ARS
$PM_{2.5}$	BAM	Hourly	ARS
Ozone	API	Hourly	ARS
$NO/NO_2/NO_X$	API	Hourly	ARS
CH_4/NMHC/THC	Baseline MOCON	Hourly	ARS
Meteorology	Various	Hourly	ARS
Carbondale, 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
$PM_{2.5}$	E-BAM	Hourly	ARS
Ozone	2B	Hourly	ARS
Meteorology	Various	Hourly	ARS

2.0 METEOROLOGICAL SUMMARIES

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

Figure 2-1 presents a map overlaid with wind roses from each of the Garfield County monitoring sites. Wind roses depict wind direction and wind speed, where the direction of the bar signifies the direction the wind is coming from, the length of the bars indicate the cumulative frequency from each direction, and the colors indicate wind speed. Note that, due to instrument issues, there was not sufficient wind data collected at the Bell-Melton site to construct an annual wind rose.

The map shows that winds at the Garfield County sites are influenced by flow along the Colorado River Basin, where Interstate 70 crosses through the county. Airflow is also influenced by various drainage flows through valleys along various Colorado River tributaries.

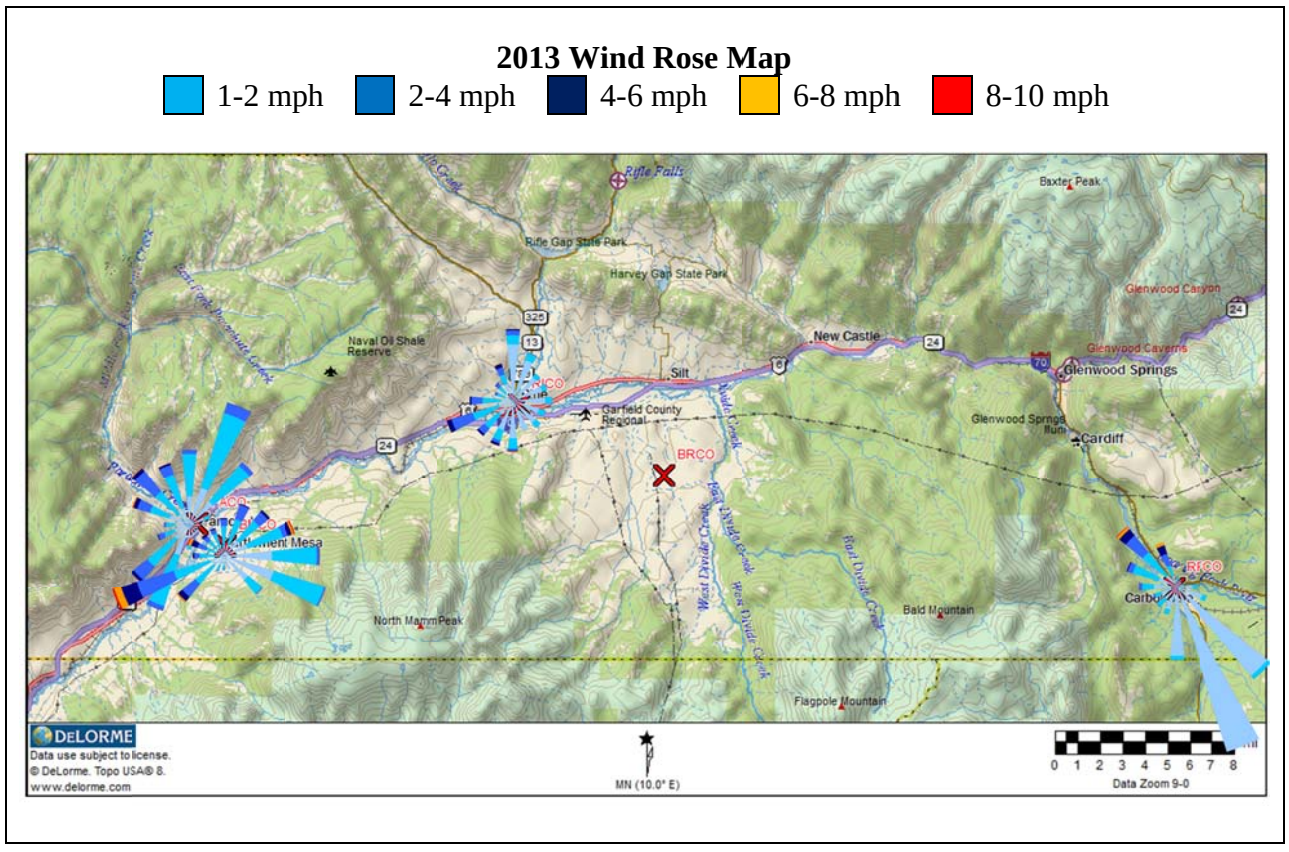

Figure 2-1. Map with wind roses depicting 2013 wind speed and direction measured at the Garfield County monitoring sites.

3.0 CRITERIA POLLUTANT SUMMARIES

The Clean Air Act requires the Environmental Protection Agency (EPA) to set two types of National Ambient Air Quality Standards (NAAQS) for pollutants including ground-level ozone (O_3), particle pollution ($PM_{2.5}$ and PM_{10}), lead, nitrogen dioxide (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 pollution effects, including visibility impairment and effects on the environment (e.g., vegetation, soils, water, and wildlife).

In many cases, secondary standards are equal to primary standards. Criteria pollutants monitoring in Garfield County include PM_{10}, $PM_{2.5}$, O_3 and NO_2. This section includes comparisons of measured values as compared to the relevant NAAQS, followed by more comprehensive summaries of each pollutant.

3.1 NAAQS COMPARISONS

Criteria pollutants (e.g. particulate matter $\leq$ 10 micrometers in diameter (PM_{10}), particulate matter $\leq$ 2.5 micrometers in diameter ($PM_{2.5}$), ozone (O_3) and (NO_2). Each standard is defined by an averaging time, a concentration level and a period of evaluation. Note that a measured value which exceeds the concentration level may be termed an “exceedance”, but the concentration measured are not consideration a “violation” of the standard unless all criteria and considered, including the period of evaluation is also considered. The relevant criteria for each pollutant monitoring, along with the monitored values, are described below. In general, not exceedances or violations of the NAAQS were recorded in 2013.

PM_{10} is monitored using filter-based Federal Reference Method (FRM) samplers at the Parachute, Rifle and Carbondale sites. Continuous $PM_{2.5}$ and PM_{10} are also monitored at the Rifle and Battlement Mesa sites, and continuous $PM_{2.5}$ is monitored at the Carbondale site. 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 average number of days with a 24-hour average concentration above 150 $\mu g/m^3$ over a 3-year period is greater than one. The standards for $PM_{2.5}$ are an annual arithmetic mean of12 $\mu g/m^3$ (changed from 15 $\mu g/m^3$ in December, 2012), 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.

Continuous O_3 is monitored at the Rifle, Battlement Mesa, and Carbondale sites. The NAAQS for O_3 is currently 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 three-year average of the fourth highest daily maximum 8-hour average ozone concentration equals or exceeds 76 ppb.

Continuous NO_2 is monitored along with NO and NO_X at the Battlement Mesa site. The NAAQS for NO_2 include an annual arithmetic mean of 0.053 ppm (53 ppb) and a 1-hour daily maximum of 0.100 ppm (100 ppb). A violation of the 1-hour standard occurs when the 3-year average of the 98th percentile of the daily maximum 1-hour averages is greater than the standard.

Values measured as compared to standards are presented with the corresponding NAAQS in Tables 3-1 through 3-4. At present, air quality measurements in Garfield County do not violate air quality standards for these criteria pollutants.

Table 3-1

Rifle Site
NAAQS Summary
January 1, 2013 – December 31, 2013

Parameter	NAAQS		Measured	
	Averaging Time	**Standard**	**Measured Value**	**Date(s)**
Ozone (O_3)	Rolling 8-hour	0.075 ppm/ 75 ppb	Highest Daily Max.: 65 ppb	5/31
			4th Highest Daily Max.: 62 ppb	6/5, 6/21, 7/11
Particulate Matter ≤2.5µm* ($PM_{2.5}$)	Annual	15 µg/m^3	Arithmetic Mean: 6.9 µg/m^3	1/1-12/31
	24-hour	35 µg/m^3	Highest Daily Max.: 17.5 µg/m^3	6/24
			2nd Highest Daily Max.: 14.8 µg/m^3	5/24, 11/19
Particulate Matter ≤10µm (PM_{10})**	24-hour	150 µg/m^3	Highest Daily Max.: 46 µg/m^3	3/29
			2nd Highest Daily Max.: 34 µg/m^3	6/21, 10/25

*Calculated using continuous TEOM measurements
**Calculated using 1/3 day filter-based measurements

Table 3-2

Parachute Site
NAAQS Summary
January 1, 2013 – December 31, 2013

Parameter	NAAQS		Measured	
	Averaging Time	**Standard**	**Measured Value**	**Date(s)**
Particulate Matter ≤10µm* (PM_{10})	24-hour	150 µg/m^3	Highest Daily Max.: 29 µg/m^3	9/25
			2nd Highest Daily Max.: 28 µg/m^3	6/24

*Calculated using 1/3 day filter-based measurements

Table 3-3

Battlement Mesa Site
NAAQS Summary
January 1, 2013 – December 31, 2013

Parameter	NAAQS		Measured	
	Averaging Time	Standard	Measured Value	Date(s)
Ozone (O_3)	Rolling 8-hour	0.075 ppm/ 75 ppb	Highest Daily Max.: 70 ppb	5/31
			4th Highest Daily Max.: 69 ppb	5/23, 6/18, 7/10, 7/18
Nitrogen Dioxide (NO_2)	Annual	0.053 ppm/ 53 ppb	Arithmetic Mean: 6 ppb	1/1-12/31
	1-hour	0.100 ppm/ 100 ppb	Highest Daily Max.: 48.6 ppb	1/24
			2nd Highest Daily Max.: 46.0 ppb	12/12
Particulate Matter ≤2.5µm* ($PM_{2.5}$)	Annual	15 µg/m^3	Arithmetic Mean: 3.9 µg/m^3	1/1-12/31
	24-hour	35 µg/m^3	Highest Daily Max.: 16.5 µg/m^3	6/19
			2nd Highest Daily Max.: 14.7 µg/m^3	5/23
Particulate Matter ≤10µm* (PM_{10})	24-hour	150 µg/m^3	Highest Daily Max.: 23 µg/m^3	6/13
			2nd Highest Daily Max.: 22 µg/m^3	5/24, 6/20

*Calculated using continuous BAM measurements

Table 3-4

Carbondale Site
NAAQS Summary
January 1, 2013 – December 31, 2013

Parameter	NAAQS		Measured	
	Averaging Time	Standard	Measured Value	Date(s)
Ozone (O_3)	Rolling 8-hour	0.075 ppm/ 75 ppb	Highest Daily Max.: 67 ppb	5/31
			4th Highest Daily Max.: 58 ppb	4/26, 5/30
Particulate Matter ≤2.5µm* ($PM_{2.5}$)	24-hour	35 µg/m^3	Highest Daily Max.: 18.4 µg/m^3	1/25
			2nd Highest Daily Max.: 17.5 µg/m^3	1/26
Particulate Matter ≤10µm (PM_{10})**	24-hour	150 µg/m^3	Highest Daily Max.: 45 µg/m^3	2/3
			2nd Highest Daily Max.: 33 µg/m^3	7/24

*Calculated using continuous E-BAM measurements
**Calculated using 1/3 day filter-based measurements

3.2 OZONE

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

$NO_2 + \text{sunlight} \rightarrow NO + O$

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

$NO + O_3 \rightarrow NO_2 + O_2$

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:

$NO + RO \rightarrow NO_2 + RO_2$ (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. A diurnal cycle will generally show lowest O_3 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.

Ozone measurements began in June 2008 at the Rifle site, in March 2012 at the Carbondale site, and in October 2012 at the Battlement Mesa site. Figure 3-1 shows annual averages of ozone measured at the Rifle site since 2008. At the long term Rifle site, the highest recorded 8-hour averages exceeded the standard in 2008 and 2012, but the 4th highest values did not, so this was not considered a violation of the standard.

Figures 3-2 through 3-4 present daily maximum 8-hour averages of O_3 monitored at the Rifle, Battlement Mesa, and Carbondale sites in 2013 respectively, along with the NAAQS. The highest O_3 measurements were recorded in the summer, which is consistent with the expected photo activity associated with hot summer months. Note that there were some data gaps in the O_3 at Battlement Mesa (9/28-10/22) due to instruments issues, and at the Carbondale site (1/1-1/19 and 10/21-11/7) when the instrument was removed for routine maintenance and calibration.

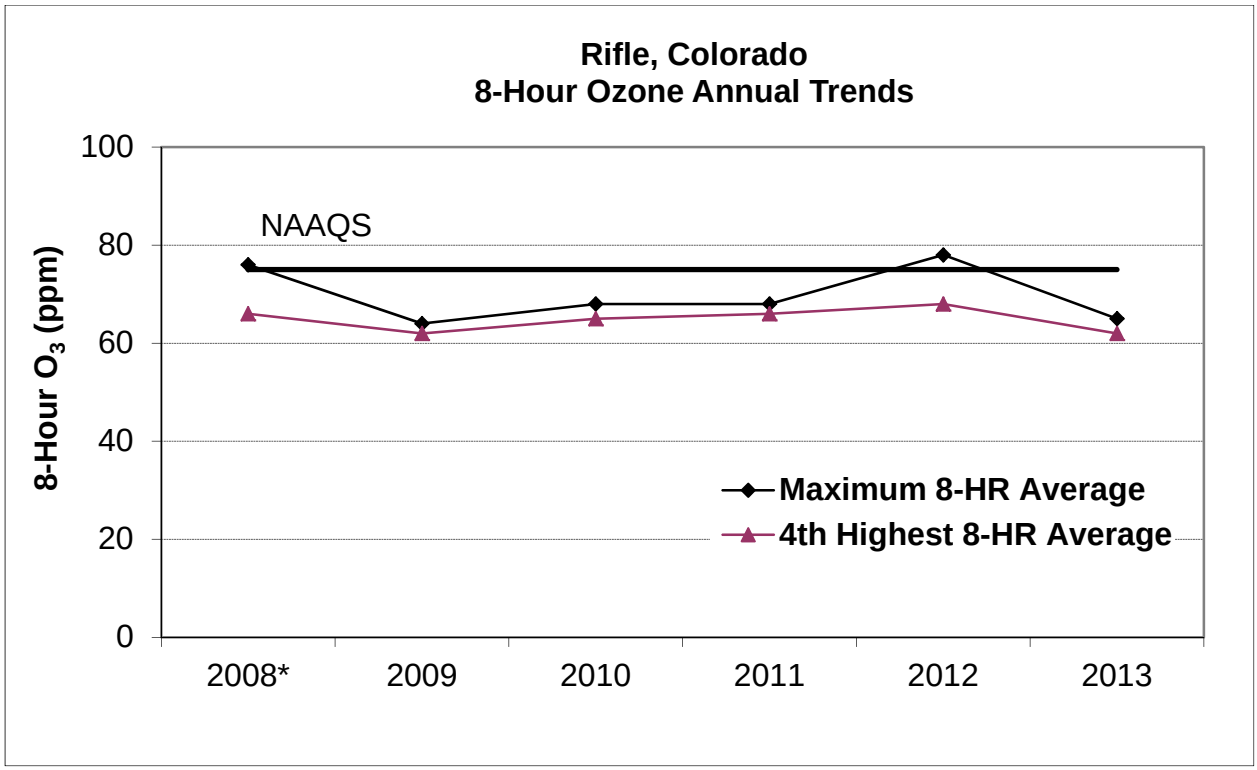

Figure 3-1. Annual trends in ozone measured at the Rifle site.

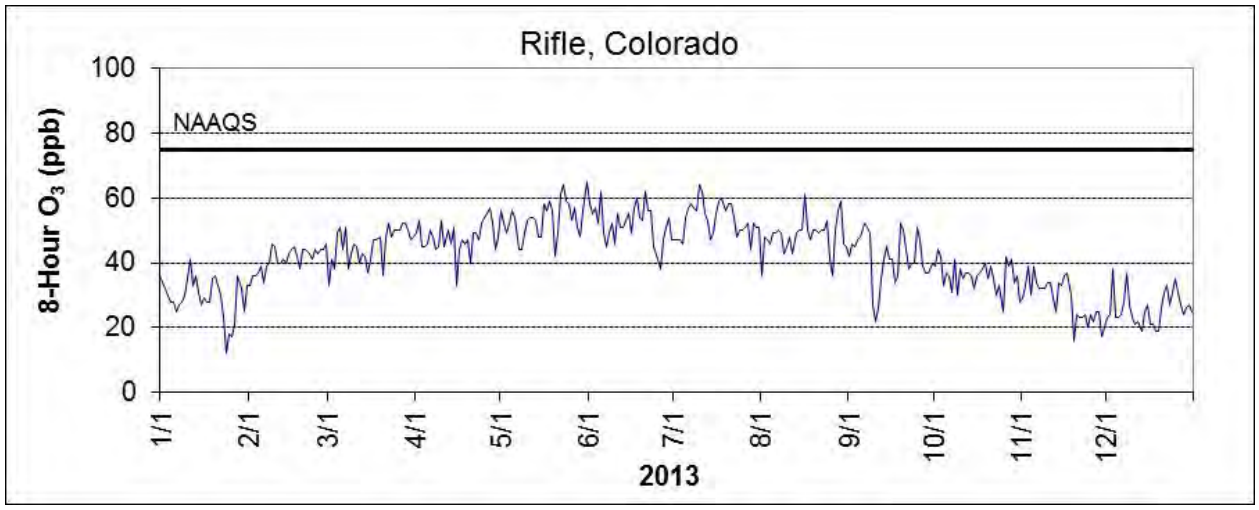

Figure 3-2. Daily maximum 8-hour averages of ozone monitored at the Rifle site.

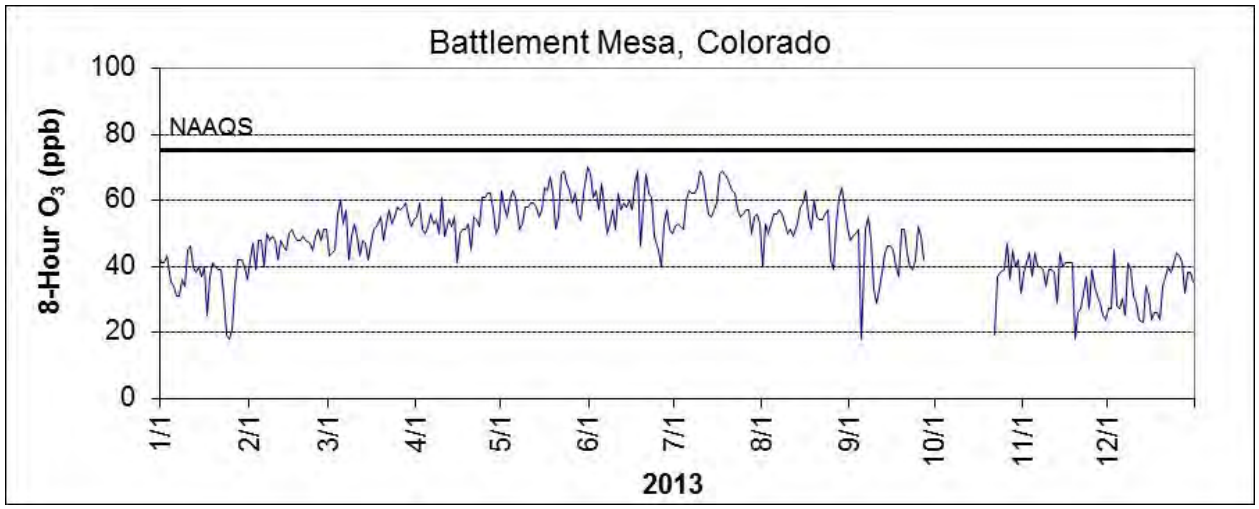

Figure 3-3. Daily maximum 8-hour averages of ozone monitored at the Battlement Mesa site.

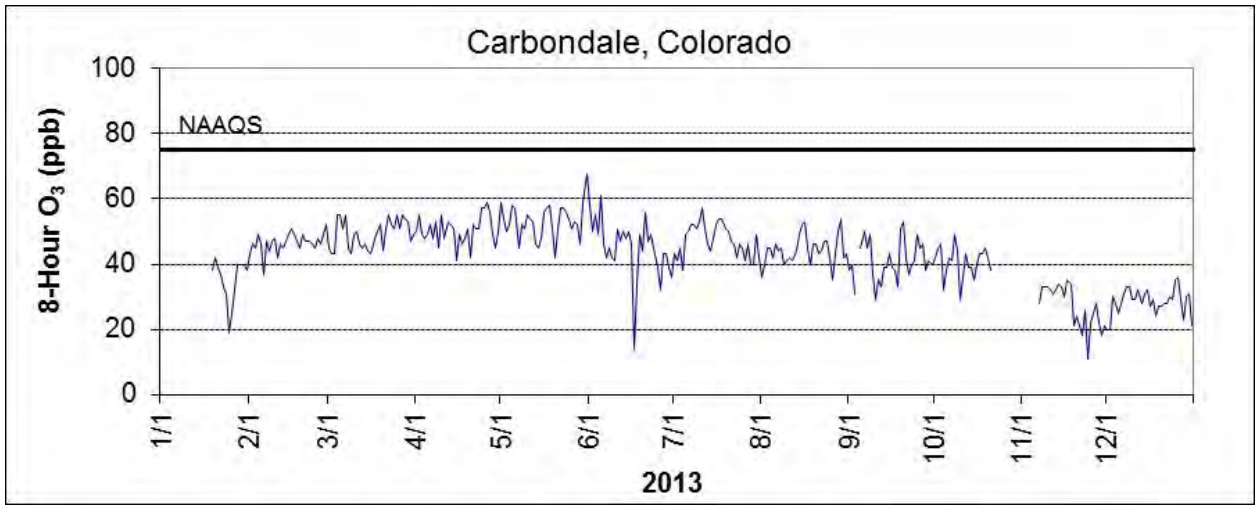

Figure 3-4. Daily maximum 8-hour averages of ozone monitored at the Carbondale site.

3.3 NITROGEN DIOXIDE

Oxides of nitrogen (NO_X) released from emission sources primarily consist of nitric oxide (NO), with lesser amounts of nitrogen dioxide (NO_2). NO is a colorless and odorless gas which, in the presence of O_3, will react to form NO_2. NO_2 is a reddish-brown gas which is partially responsible for the "brown haze" observed near large cities. Only NO_2 is considered a regulated pollutant, but it is generally measured alongside NO, where NO and NO_2 are collectively termed NOx ($NOx = NO + NO_2$). The components of NOx have been identified as precursors for both O_3 and particulate matter.

NO_2 measurements began at the Battlement Mesa site in late 2012. Figure 3-5 presents daily maximum 1-hour averages of NO_2 in 2013 along with the NAAQS, indicating that measured values were well below the standard. Hourly average values for the Battlement Mesa site are presented in time series plots along with other parameters in Appendix A.

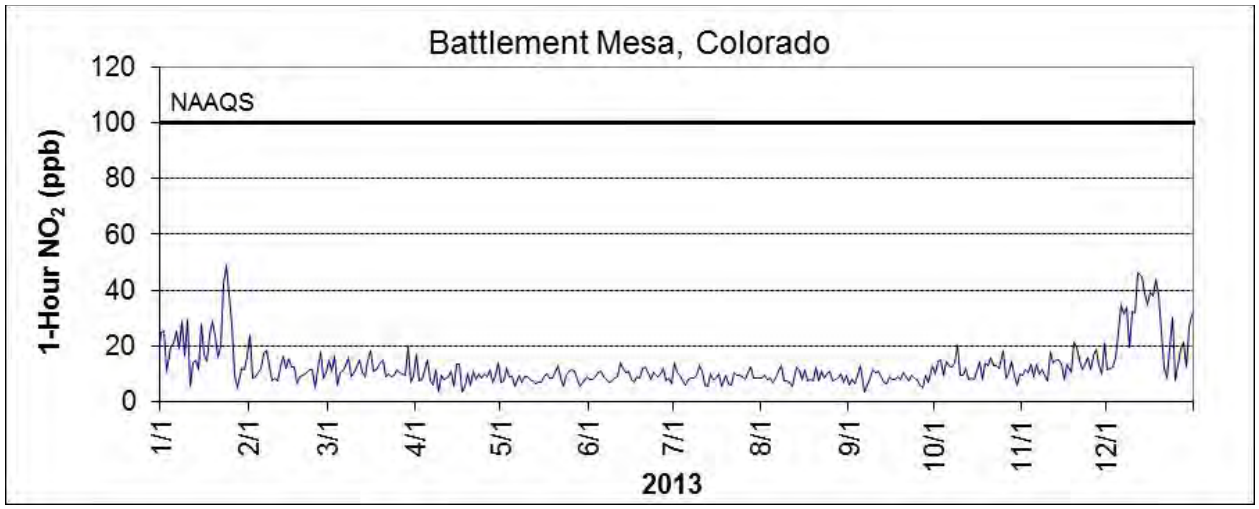

Figure 3-5. Daily maximum 1-hour averages of nitrogen dioxide monitored at the Battlement Mesa site.

3.4 PARTICULATE MATTER

Particulate matter (PM) consists of solid particles and liquid droplets that are small enough to be inhaled. The size of particles is directly linked to their potential for causing health problems. Particulate matter with diameter larger than 2.5 microns ($PM_{2.5}$) and smaller than 10 microns (PM_{10}) pose the greatest concern, because they can get deep into the lungs and cause serious health problems. Particulate matter can be emitted directly into the air or can be formed in the atmosphere through complex chemical reactions from emissions of sulfur dioxides, nitrogen oxides, and other compounds. Coarse particulate matter can come from sources such as road dust, construction, and wood-burning. Particulate sources associated with natural gas development may include grading and leveling of well pads, construction of facilities, construction of access roads to well pads, and subsequent vehicle traffic. Natural emissions such as forest fires can also contribute to particulate matter.

Filter based 24-hour PM_{10} is measured every third day at the Parachute, Rifle, and Carbondale sites. Continuous PM_{10} and $PM_{2.5}$ monitoring began at the Rifle site in September 2008 and at the Battlement Mesa site in November 2012, and continuous $PM_{2.5}$ monitoring began at the Carbondale site in March 2012. Annual summaries are provided here, and hourly and 24-hour average values for these sites are presented in time series plots along with other parameters in Appendix A.

3.4.1 Filter-Based PM_{10} Measurements

Figure 3-6 presents the annual average PM_{10} measured at the Parachute site since 2000, and Figure 3-7 presents annual average PM_{10} measured at the Rifle site since 2005. At both the Rifle and Parachute sites, the highest average recorded PM_{10} was recorded in 2008, but measurements at this site have dropped since 2009.

Figures 3-8 and 3-9 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, which was exceeded at the Parachute site in 2008. No exceedances have been recorded at the Rifle site. Note that an exceedance of the standard is not a violation unless the average number of annual exceedances over a 3-year period is greater than or equal to 1, so the exceedance at the Parachute site was not considered a violation.

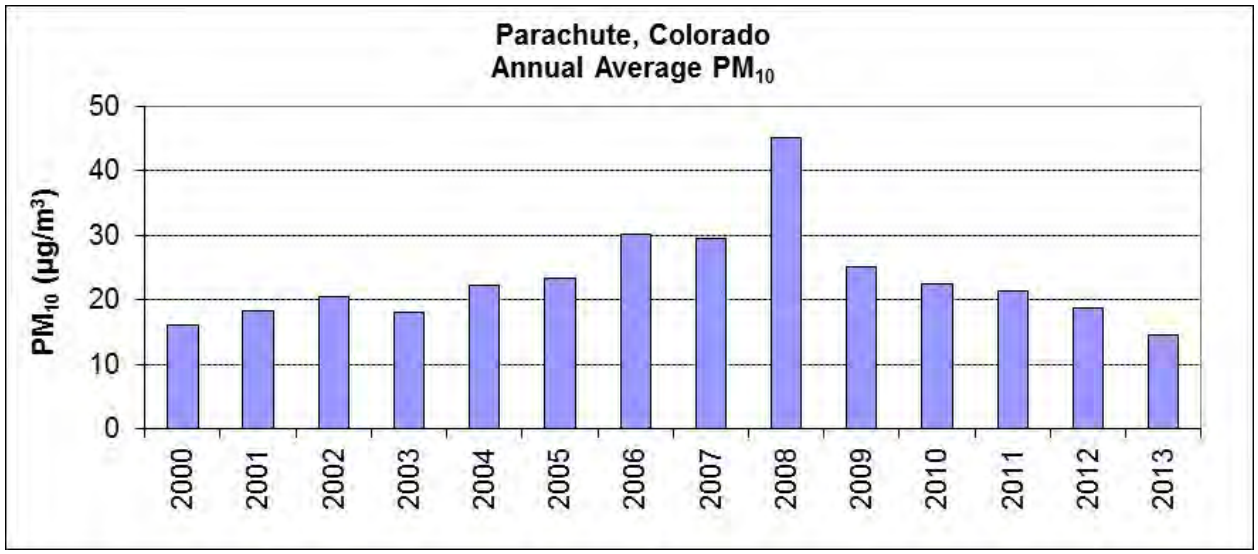

Figure 3-6. Annual average PM_{10} measured at the Parachute site.

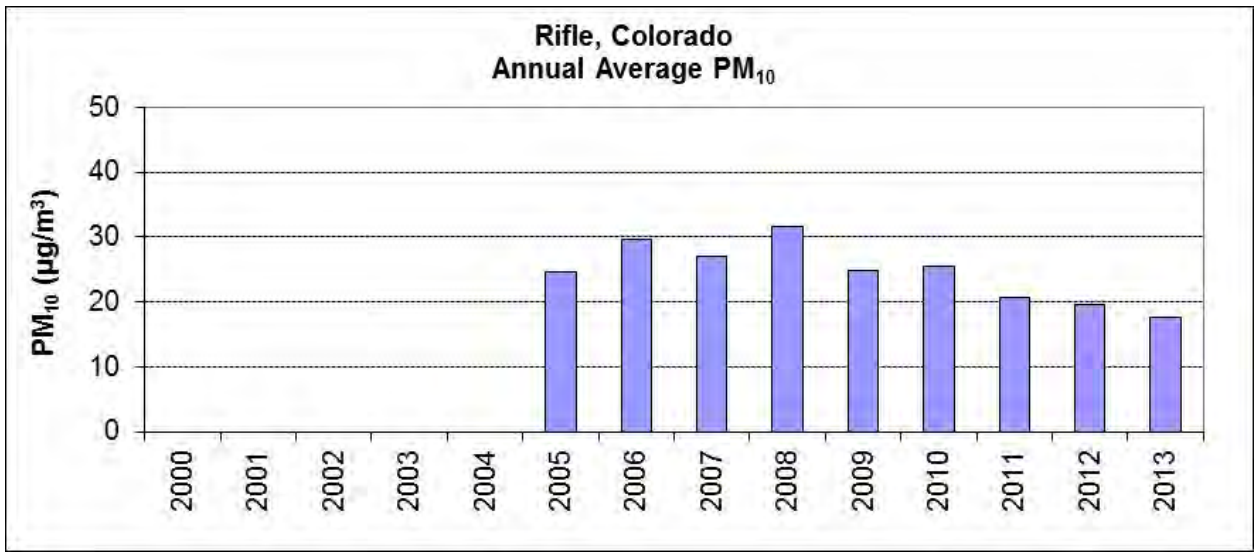

Figure 3-7. Annual average PM_{10} measured at the Rifle site.

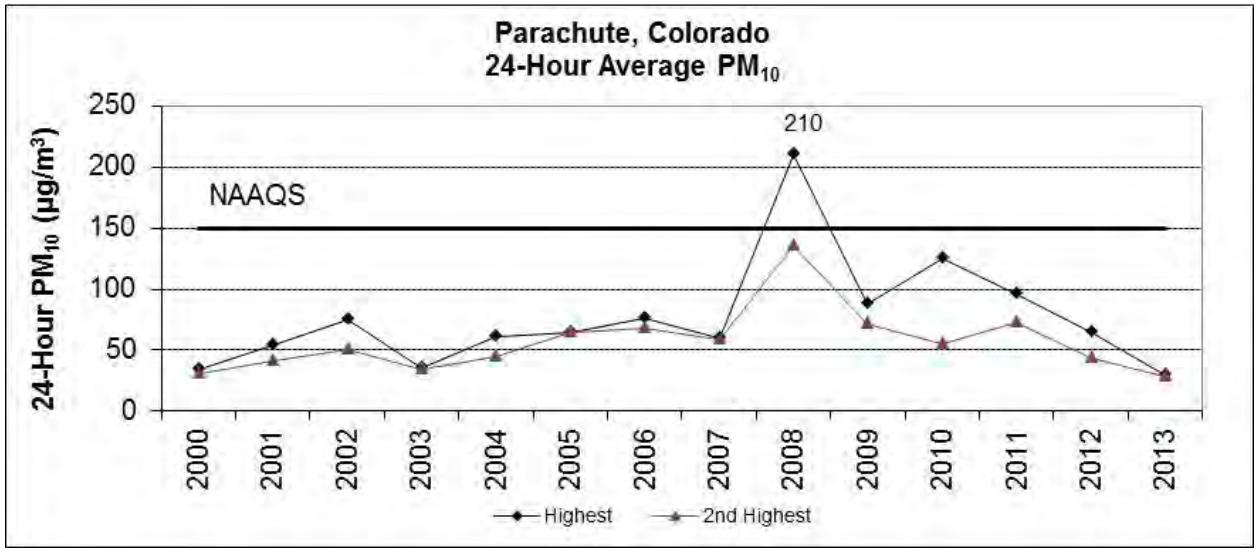

Figure 3-8. Highest and second highest 24-hour average PM_{10} measured at the Parachute site.

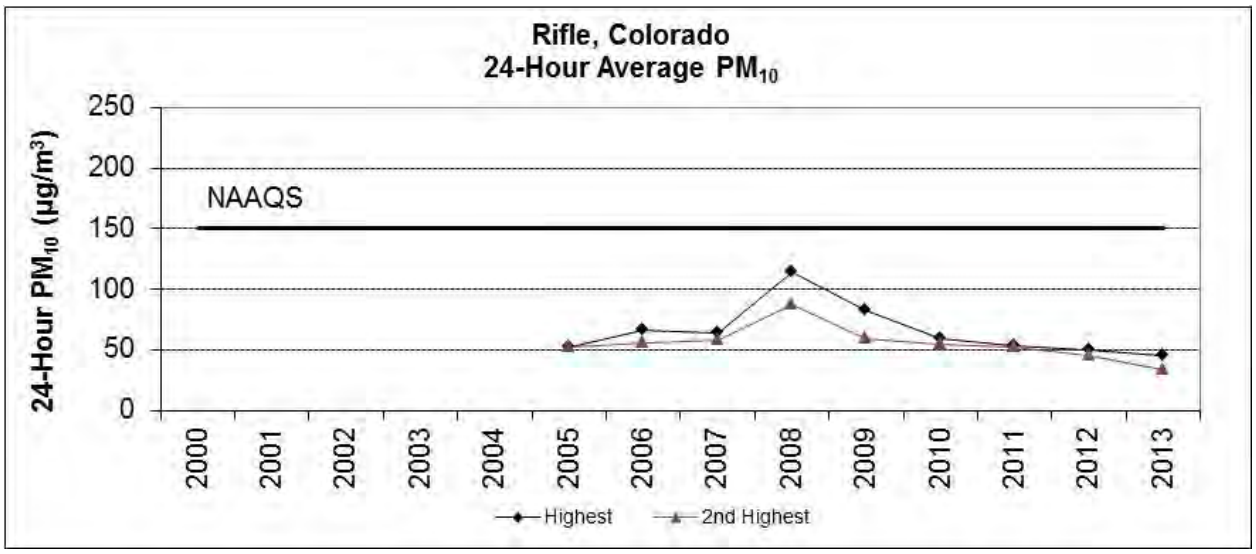

Figure 3-9. Highest and second highest 24-hour average PM_{10} measured at the Rifle site.

3.4.2 Continuous $PM_{2.5}$ Measurements

Continuous PM_{10} and $PM_{2.5}$ have been monitored at the Rifle site since mid-2008, at the Battlement Mesa site since November 2012 and continuous $PM_{2.5}$ has been monitoring at the Carbondale site since March 2012. Continuous PM_{10} data are useful to monitor alongside filter-based PM in part to make continuous data available in real-time on the Garfield County Air Quality Management website (http://www.garfield-county.com/air-quality/).

Continuous data are also comparable to regulatory standards, as presented for $PM_{2.5}$ here. Figure 3-10 presents the annual average of continuous $PM_{2.5}$ measured at the Rifle site since 2009, and Figure 3-11 presents the highest and 98th percentile 24-hour average values measured at the Rifle site. The NAAQS for $PM_{2.5}$ is an arithmetic mean of 12 µg/m^3 and a 24-hour average of 35 µg/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. The highest 24-hour $PM_{2.5}$ values measured in 2009 and 2012 were above the standard, but are not considered exceedances because the 98th percentile values were below the standard.

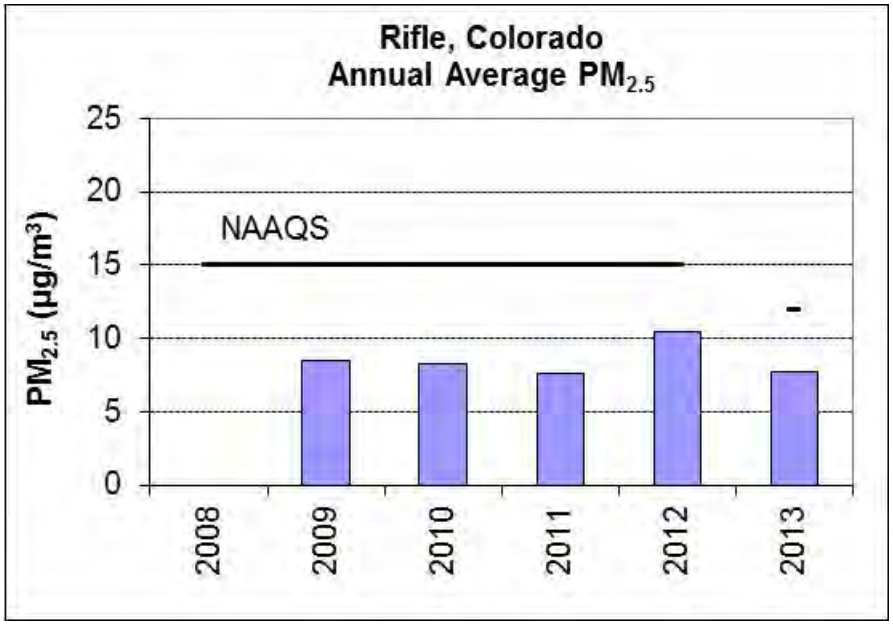

Figure 3-10. Annual average $PM_{2.5}$ measured at the Rifle site. Note that the NAAQS level changed from 15 to 12 µg/m^3 in 2013.

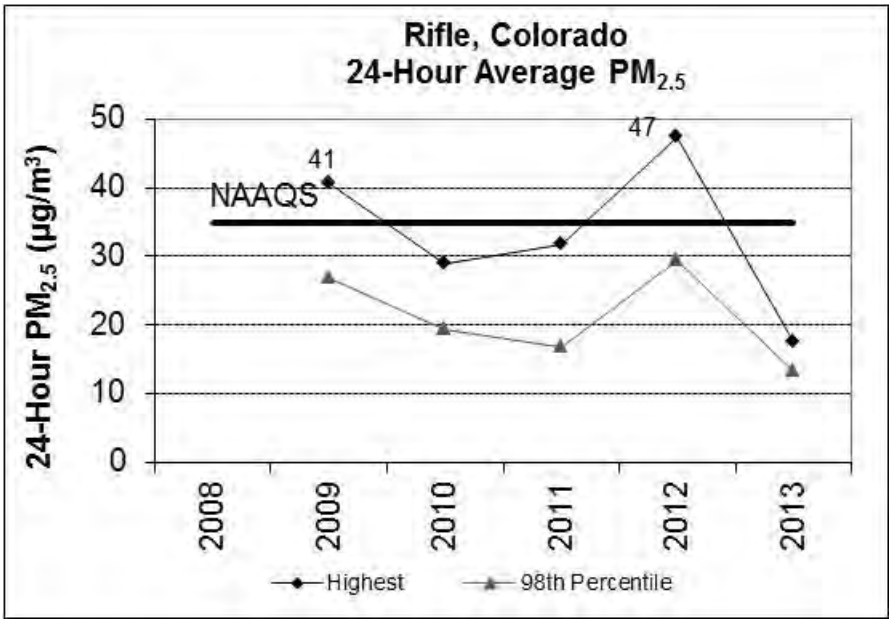

Figure 3-11. Highest and 98th percentile 24-hour average $PM_{2.5}$ measured at the Rifle site.

4.0 VOLATILE ORGANIC COMPOUNDS

Garfield County has measured speciated non-methane organic carbon (SNMOCs) and carbonyl compounds using on a 1-in-6 or 1-in-12 day schedule since 2008. Additionally, the County added continuous measurements of Methane (CH_4) and total hydrocarbons to the Battlement Mesa site in late 2012.

Methane, SNMOCs and carbonyl compounds are subsets of volatile organic compounds (VOCs), which are carbon- and hydrogen-based chemicals that exist in the gas phase or can evaporate from liquids. VOCs can react in the atmosphere to form ozone (O_3) and particulate matter. Hazardous air pollutants (HAPs) are a subset of VOC compounds, and include compounds that are known or believed to cause human health effects. Summaries of methane, SNMOCs, carbonyls, and HAP levels measured in 2013 are presented in this section.

4.1 Continuous Methane and Non-Methane Hydrocarbons

Continuous Methane (CH_4) and Non-Methane Hydrocarbon (NMHC) measurements are collocated with the canister based SNMOC measurements at the Battlement Mesa site. Figure 4-1 presents daily maximum 1-hour concentrations of methane measured at the site in units of ppb. Methane is a pollutant that persists in the atmosphere for long periods of time (~12 years), so there is generally a background concentration of methane present globally even very remote locations. Methane is also the primary component in natural gas, and can be elevated in gas development areas. The plot shows a baseline just above 2 ppb, with elevated levels in October and December. Note that data gaps occurred early in the year (1/1-1/9 and 1/17-2/11) due to analyzer configuration issues.

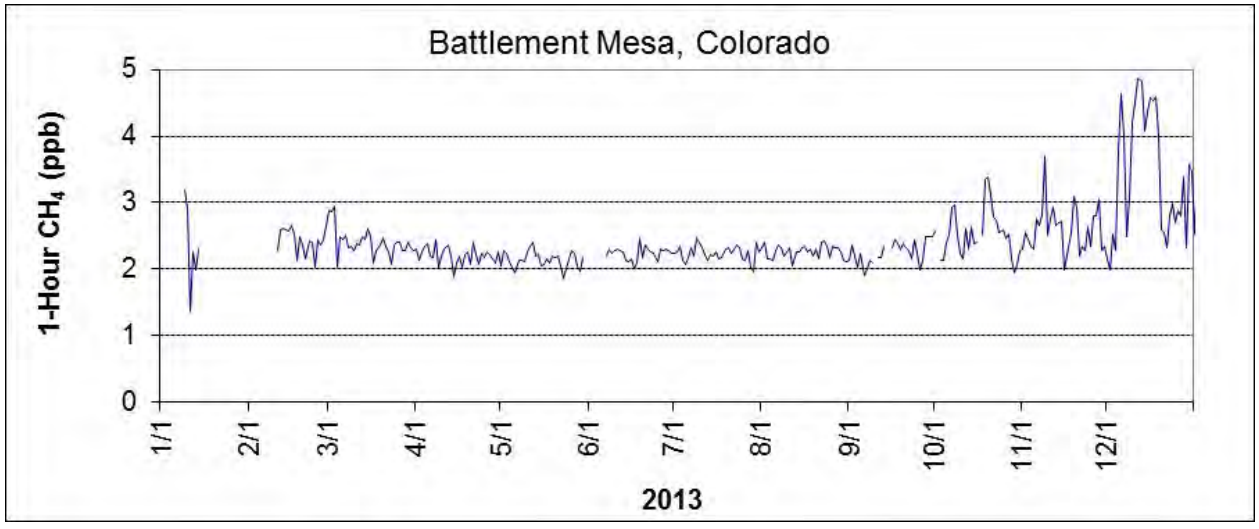

Figure 4-1. Daily maximum 1-hour averages of methane measured at the Battlement Mesa site in 2013.

Concentrations of specific compounds besides methane are only available from the canister sample analysis, but continuous measurements of NMHCs are also collected at the

Battlement Mesa site. Continuous NMHC measurements are useful along with canister measurements because these measurements are available on an hourly basis in real-time, while canister samples are only available every sixth day as 24-hour averages. Figure 4-2 presents a correlation plot comparing 24-hour averages from both methods showing the correlation between the collocated methods. The correlation showed a slight lower bias in the canister measurements, with good agreement for the higher values.

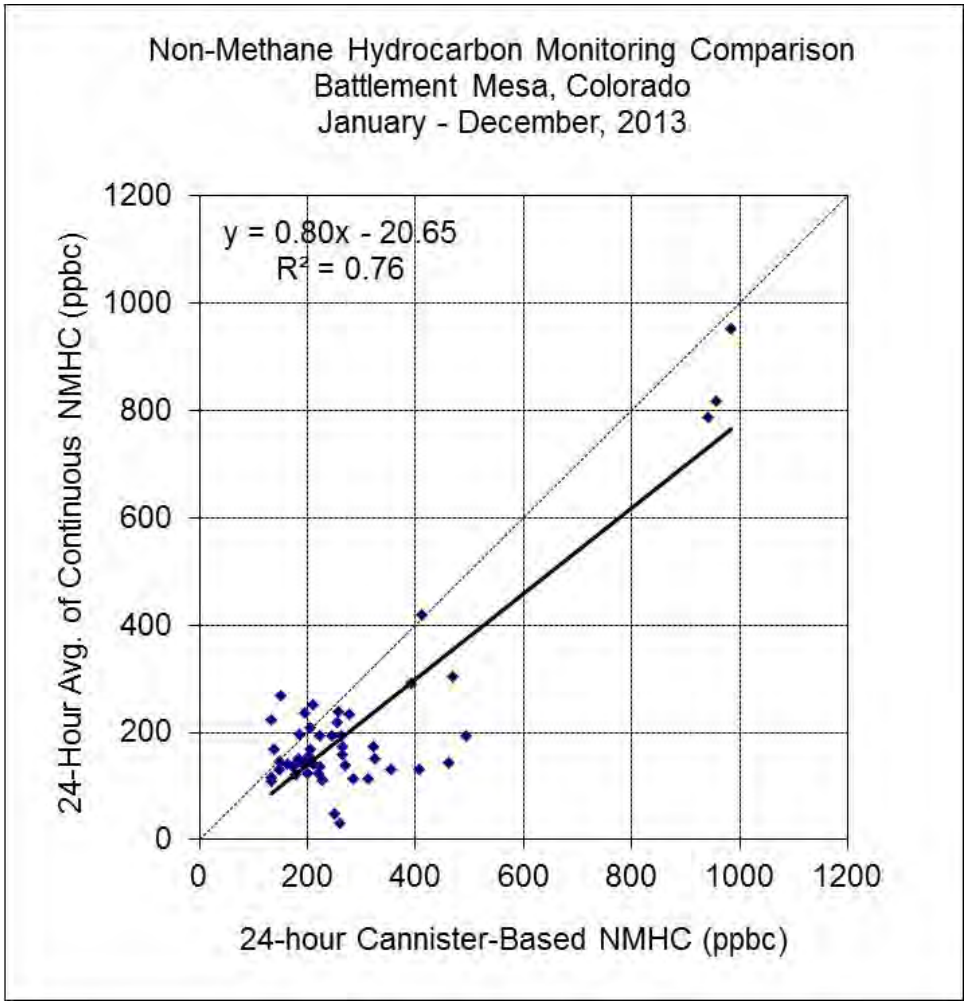

Figure 4-2. Correlation between continuous and canister-based NMHC measurements at the Battlement Mesa monitoring site in 2013.

4.2 Speciated Non-Methane Hydrocarbons

SNMOC compounds were collected and analyzed according to EPA Compendium Method TO-12, with 24-hour samples collected on a 1-in-6 day schedule at all five sites. This method includes analyses for 78 different compounds. Annual averages are presented here, and 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 annual average 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), along with methane, are primary components of natural gas and gasoline vapors.

- 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, and engine sources associated with oil and gas production.

Figure 4-3 presents categories of measured SNMOCs in units of ppbV (parts per billion by volume) measured in 2013 at each site. In general, measured compounds consisted mostly of light alkanes, which represented between 85% and 87% of total SNMOCs measured at all but the Carbondale site, where the specific SNMOC compounds measured were lower than other sites. Seasonal variation showed 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 4-4 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). 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. Note that for the Carbondale site, the majority of carbon compounds detected were not among the species identified. The specific compounds targeted for analysis in Garfield County are intended to focus on natural gas influences and hazardous compounds, which appear to comprise relatively small proportions of the compounds measured in Carbondale.

Carbon content in a molecule is important because it is related to compound reactivity, which contributes to O_3 formation potential. O_3 is formed from photochemical interactions of VOCs and NO_X in the presence of sunlight, as described in Section 3.1. The light alkanes that dominate measurements by volume are the least reactive compounds but could theoretically contribute significantly to O_3 formation potential. Highly reactive compounds including aromatics such as toluene and m/p-xylenes, which are less abundant, but have greater potential to contribute to the O_3 formation due to their higher reactivity. Currently, Garfield County does not violate O_3 standards, but if O_3 levels become more of a concern in Garfield County, it would be useful to target further controls for emissions of VOCs that have the greatest potential to contribute to O_3 formation.

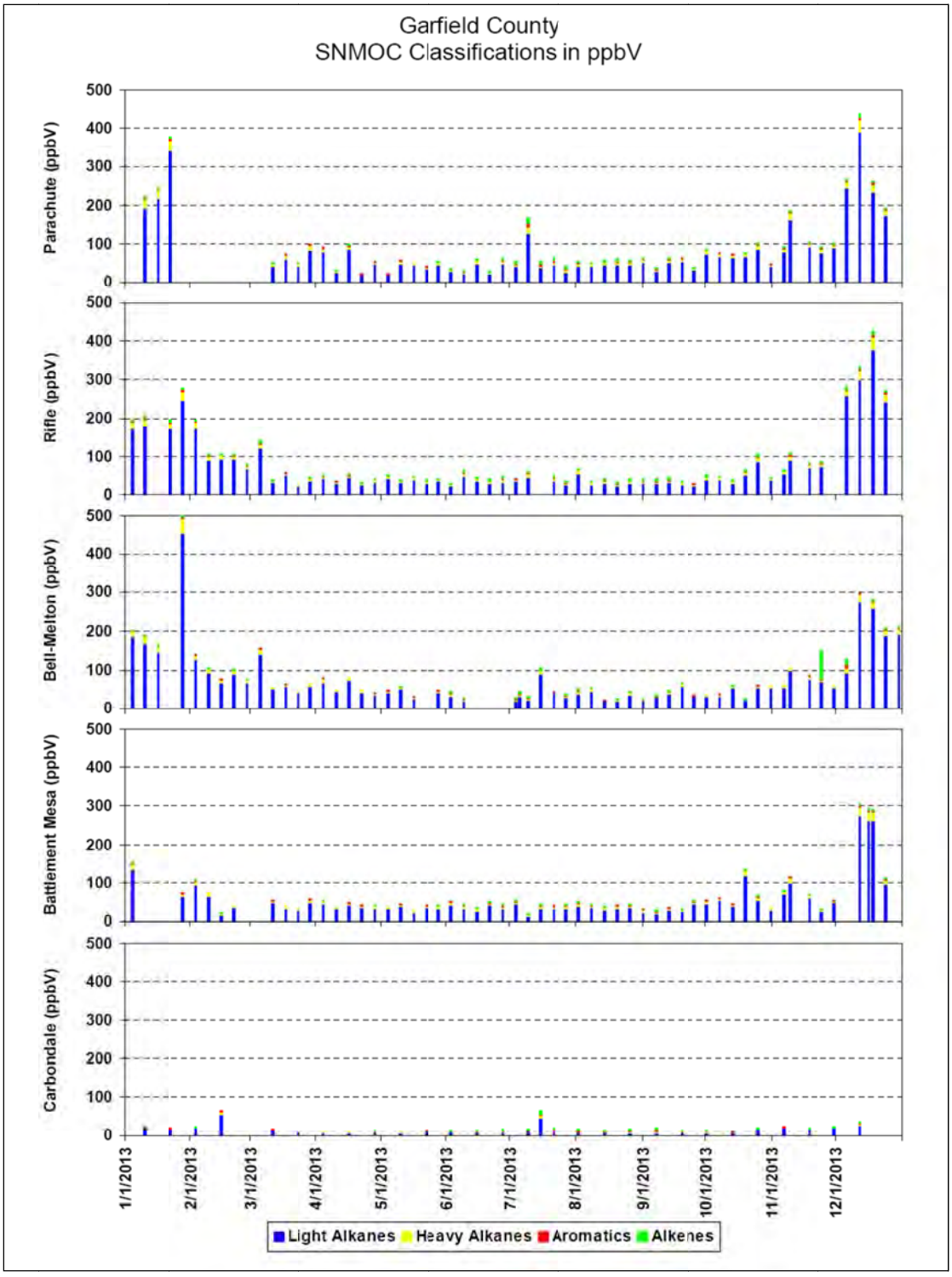

Figure 4-3. 2013 24-hour SNMOC measurements by category in units of ppbV.

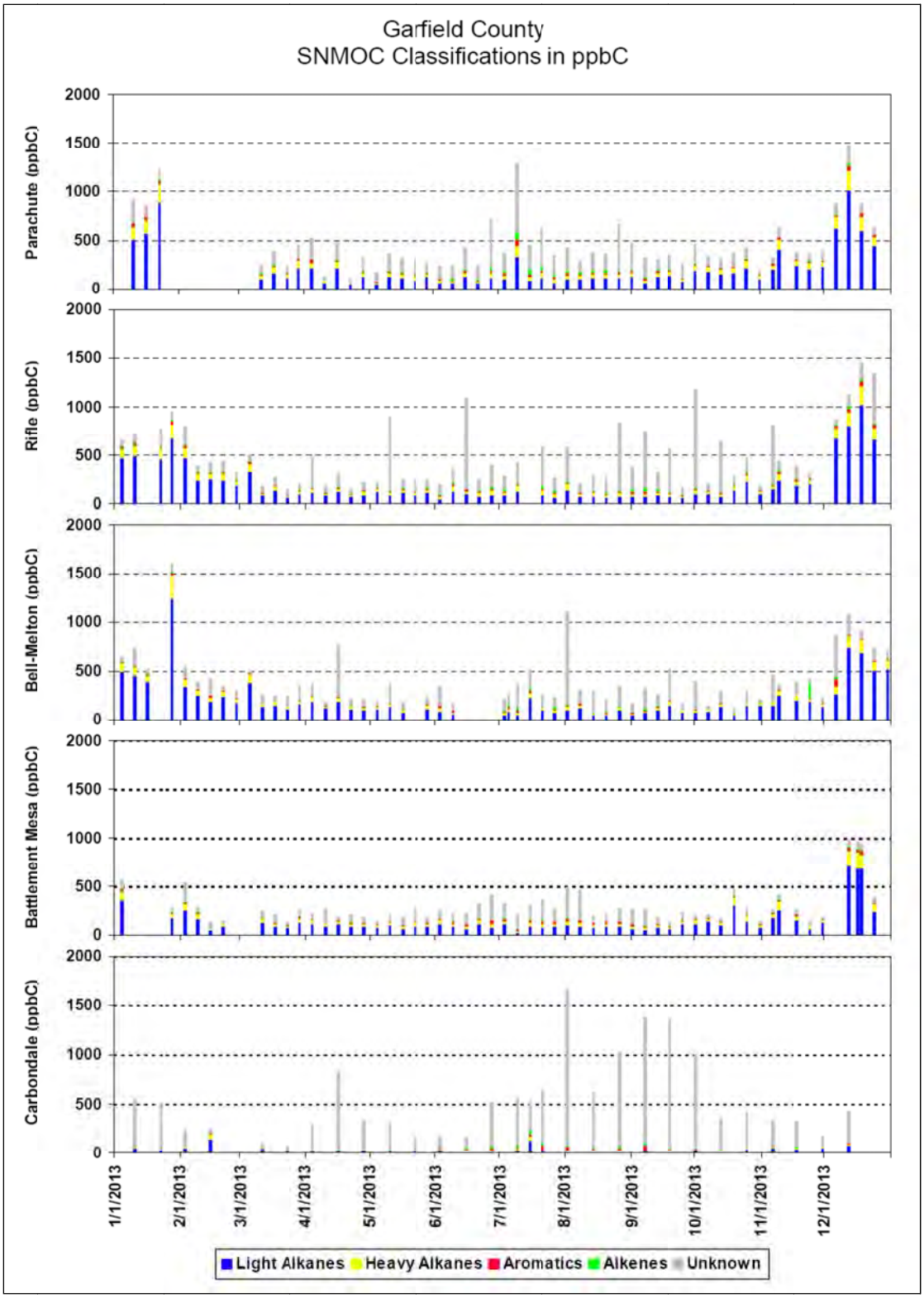

Figure 4-4. 2013 24-hour SNMOC measurements by category in units of ppbC.

4.2.1 Annual Average SNMOCs

Garfield County began collecting SNMOC data at the Parachute (PACO), Rifle (RICO), and Bell-Melton (BMCO) sites in 2008, at the Battlement Mesa (BMCO) in September 2010, and at the Carbondale (RFCO) in 2012. Figure 4-5 presents comparisons of annual average SNMOC data collected between 2008 and 2012. For sites that monitored all five years (PACO, RICO and BRCO), SNMOC concentrations have been decreasing since through 2012, with slight increases in 2013. Decreases in total SNMOC concentrations are mainly attributable to decreases in light alkane concentrations (depicted in blue), which are the primary components of natural gas.

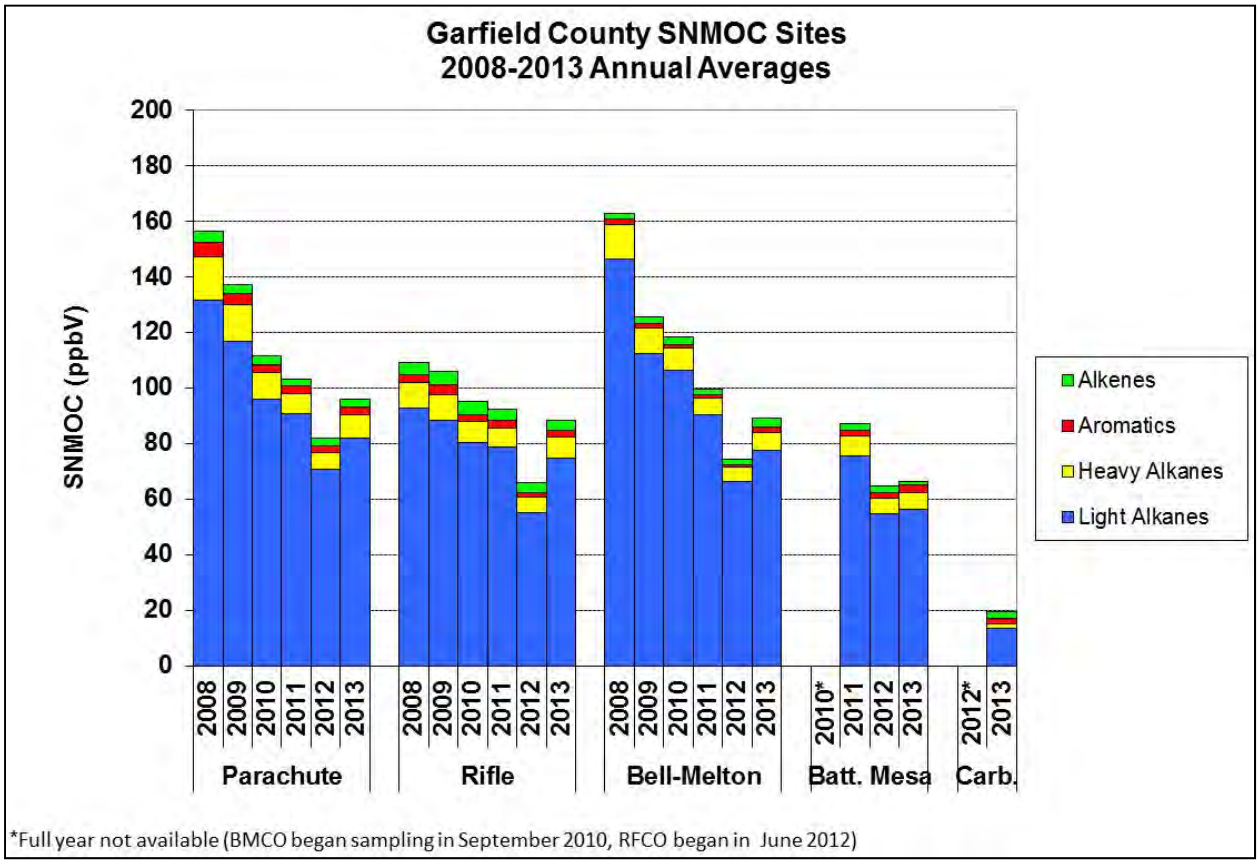

Figure 4-5 Average SNMOC concentrations measured at Garfield County sites between 2008 and 2013.

4.3 CARBONYLS

Carbonyl compounds were collected and analyzed according to EPA Compendium Method TO-11A, with 24-hour samples collected at all five 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.

Figure 4-6 presents time series plots of the major compounds, and Appendix C lists minimum, maximum, and average concentrations of all detected carbonyl compounds. Major compounds measured included formaldehyde, acetaldehyde, and acetone. In general, carbonyl compounds were highest during summer months as warm temperatures affected the photochemical production that contributes to the formation of these compounds.

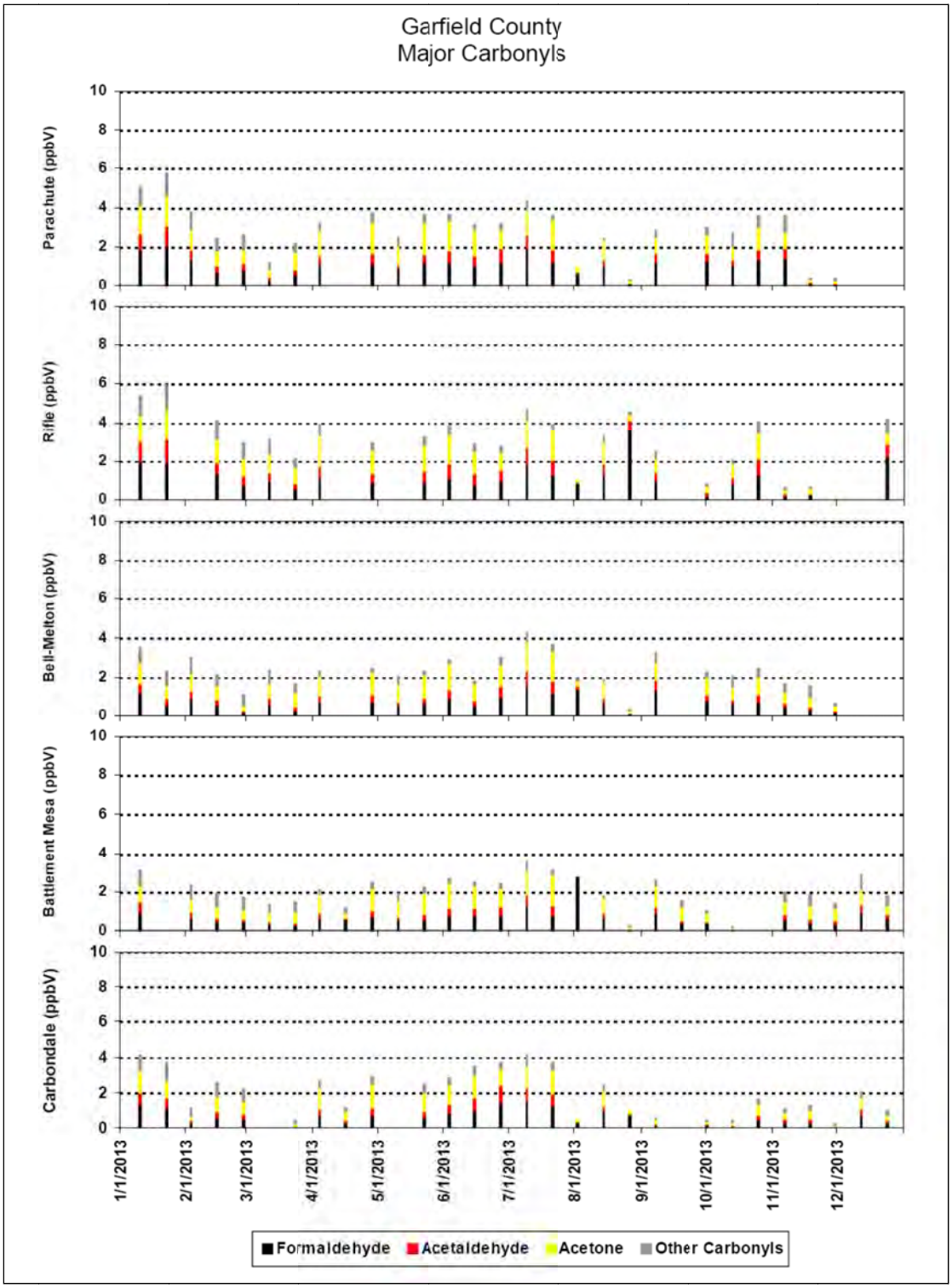

Figure 4-6. 2013 24-hour major carbonyl compound concentrations in units of ppbV.

4.2.1 Annual Average Carbonyl Concentrations

Garfield County began collecting SNMOC data at the Parachute, Rifle, and Bell-Melton sites in 2008, at the Battlement Mesa (BMCO) in September 2010, and at the Carbondale (RFCO) in June 2012. Figure 4-7 presents comparisons of annual average carbonyl data collected between 2008 and 2013, showing generally decreasing concentrations.

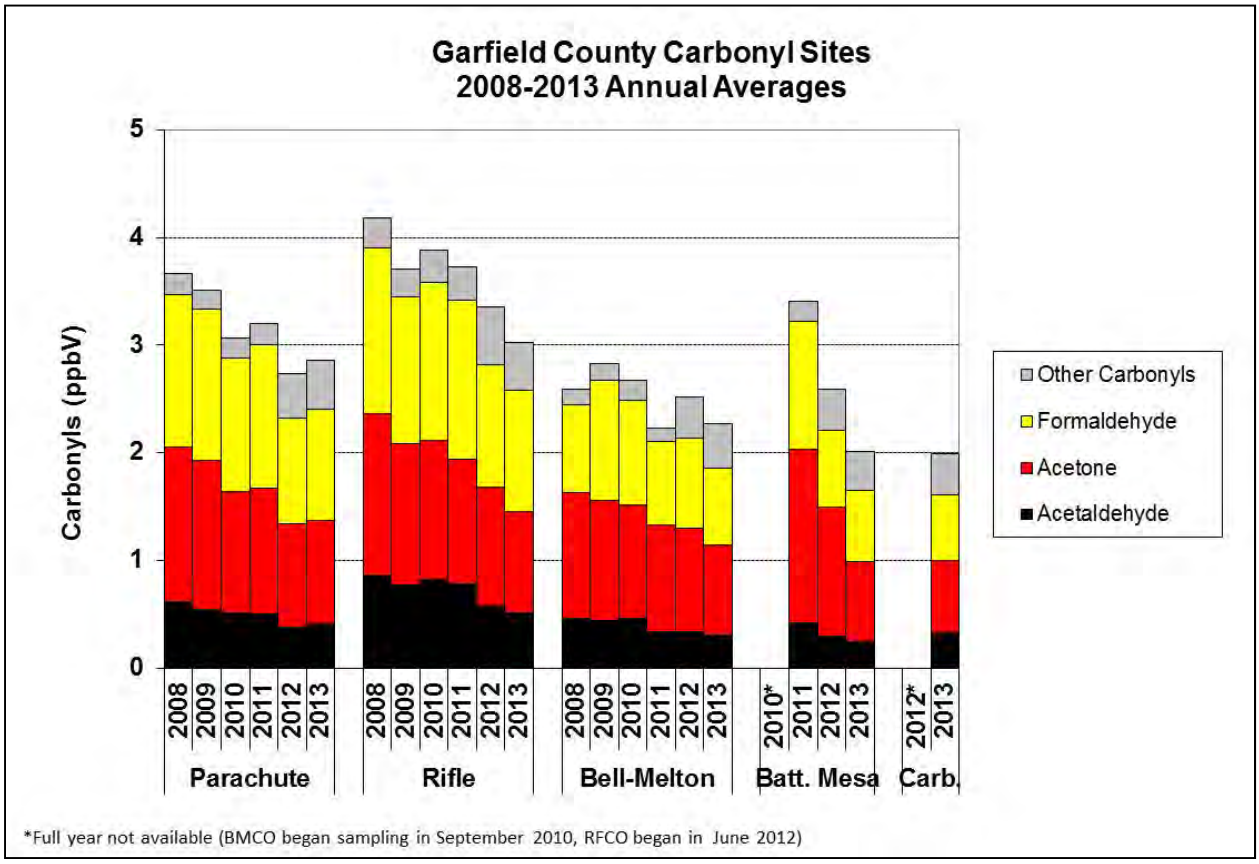

Figure 4-7. Average carbonyl concentrations measured at Garfield County sites between 2008 and 2013.

4.4 HAZARDOUS AIR POLLUTANTS (HAPS)

VOCs include a class of compounds called hazardous air pollutants (HAPs). The EPA has designated approximately 190 VOC compounds as HAPs, including benzene, toluene, ethyl-benzene and xylenes (also known as the BTEX compounds). No NAAQS or any other ambient air standards exist for VOCs. Instead, emissions limits on industrial sources have been set, and 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.

Of the 78 SNMOC and 12 carbonyl compounds measured in Garfield County, 21 compounds have been identified as HAPs. *The Garfield County Air Toxics Inhalation Screening Level Human Risk Assessment* (CDPHE 2010) assessed data collected in 2008, and risk assessments based on 2009 through 2012 HAP levels will be prepared in separate risk assessment reports prepared by the CDPHE Disease Control and Environmental Epidemiology Division. Findings of the 2008 report indicated that, individually, the HAP 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. Summaries below look at annual averages for the HAPs measured in Garfield County and regionally, but do not address health effects of these compounds.

4.4.1 Annual Average HAP Concentrations

Tables 4-1 through 4-5 present annual averages and trends for HAP concentrations measured between 2008 and 2012. Annual trends were calculated for each HAP, with a trend defined as the slope derived using Theil statistics, which is a nonparametric regression technique that is commonly applied to environmental data to determine statistically significant trends. The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes. Regional trends are presented here for aerosol species trends with p-value statistics less than 0.10 (90% confidence level). Statistically significant decreasing trends are indicated in blue, and statistically significant increasing trends are depicted in red. Note that annual averages are presented for the Battlement Mesa and Carbondale sites, but trends are not calculated as the EPA recommends using at least five years of data to determine reliable trend statistics.

- A number of HAPs compounds have measured statistically significant decreasing annual average trends at all sites.

- Of the 21 HAPS measured in Garfield County, the only statistically significant increasing trend was measured for styrene at all sites, where annual average increases were small, between 0.01 to 0.04 µg/m^3 per year. Styrene in the atmosphere is primarily associated with the production of polystyrene plastics and resins. Styrene measurements were much higher in 2012 than previous years, and may require further investigation to determine possible sources for these measurements.

It is important to note that annual average values summarized here do not necessarily indicate a health risk. Actual magnitudes of these HAP compounds related to possible health risk are evaluated separately in the CDPHE risk assessment reports.

Table 4-1

Parachute Site
Annual Average Mass Trends (HAPs Parameters)
2008-2013

HAP	Average Mass (µg/m^3)						Slope (µg/m^3 per year)	p-Value
	2008	2009	2010	2011	2012	2013		
1,2,4-Trimethylbenzene	0.91	0.62	0.42	0.43	0.38	0.79	-0.057	0.235
1,3,5-Trimethylbenzene	0.61	0.51	0.40	0.22	0.17	0.32	**-0.104**	**0.028**
1,3-Butadiene	0.08	0.12	0.10	0.10	0.09	0.06	-0.007	0.235
Acetaldehyde	1.11	0.99	0.92	0.90	0.69	0.73	**-0.075**	**0.008**
Acetone	3.42	3.28	2.67	2.79	2.28	2.29	**-0.245**	**0.028**
Benzene	2.31	2.69	1.74	1.44	1.25	1.85	-0.245	0.136
Crotonaldehyde	0.10	0.10	0.12	0.09	0.06	0.07	-0.008	0.136
Cyclohexane	3.92	3.77	2.90	2.22	2.00	3.15	**-0.448**	**0.068**
Ethylbenzene	0.59	0.44	1.04	0.32	0.16	0.23	**-0.091**	**0.068**
Formaldehyde	1.74	1.73	1.53	1.64	1.20	1.28	**-0.105**	**0.028**
Isopropylbenzene	0.09	0.08	0.07	0.08	0.06	0.06	**-0.007**	**0.028**
Methylcyclohexane	9.24	9.43	6.41	4.65	4.18	6.59	-1.113	0.136
m-Xylene/p-Xylene	3.91	3.63	2.20	1.11	1.13	1.80	**-0.533**	**0.068**
n-Hexane	5.78	5.64	3.93	3.34	3.04	3.12	**-0.595**	**0.008**
n-Nonane	2.20	2.01	1.13	0.97	0.59	0.87	**-0.285**	**0.008**
n-Propylbenzene	0.18	0.15	0.13	0.10	0.10	0.15	-0.018	0.136
o-Xylene	0.77	0.65	0.43	0.40	0.26	0.40	**-0.124**	**0.008**
Propionaldehyde	0.12	0.09	0.09	0.09	0.07	0.07	**-0.008**	**0.028**
Propylene	0.57	0.57	0.62	0.55	0.70	0.49	-0.006	0.360
Styrene	0.12	0.08	0.12	0.13	1.41	3.76	**0.444**	**0.008**
Toluene	9.86	5.83	3.96	5.79	4.18	4.45	-0.673	0.136

Table 4-2

Rifle Site
Annual Average Mass Trends (HAPs Parameters)
2008-2013

HAP	Average Mass (µg/m^3)						Slope (µg/m^3 per year)	p-Value
	2008	2009	2010	2011	2012	2013		
1,2,4-Trimethylbenzene	0.62	0.71	0.52	0.42	0.49	0.76	-0.016	0.500
1,3,5-Trimethylbenzene	0.33	0.33	0.30	0.18	0.16	0.25	**-0.027**	**0.068**
1,3-Butadiene	0.13	0.12	0.17	0.19	0.18	0.12	0.006	0.500
Acetaldehyde	1.55	1.39	1.47	1.41	1.04	0.92	**-0.121**	**0.028**
Acetone	3.58	3.11	3.08	2.74	2.62	2.24	**-0.250**	**0.001**
Benzene	1.68	2.22	1.44	1.27	0.99	1.52	-0.171	0.136
Crotonaldehyde	0.15	0.17	0.18	0.14	0.10	0.09	**-0.013**	**0.068**
Cyclohexane	2.46	2.48	1.95	1.86	1.64	2.88	-0.151	0.360
Ethylbenzene	0.48	0.56	0.84	0.35	0.26	0.35	-0.051	0.235
Formaldehyde	1.89	1.67	1.80	1.82	1.39	1.38	**-0.095**	**0.068**
Isopropylbenzene	0.08	0.08	0.08	0.08	0.06	0.06	-0.004	0.136
Methylcyclohexane	4.78	5.08	3.74	3.36	2.70	4.63	-0.472	0.136
m-Xylene/p-Xylene	2.35	2.58	1.70	0.90	1.07	1.59	-0.314	0.136
n-Hexane	4.50	4.61	3.48	4.40	3.05	3.41	**-0.218**	**0.068**
n-Nonane	0.81	0.86	0.59	0.44	0.31	0.48	**-0.123**	**0.068**
n-Propylbenzene	0.15	0.16	0.16	0.12	0.12	0.14	-0.005	0.235
o-Xylene	0.64	0.75	0.51	0.43	0.36	0.49	**-0.069**	**0.068**
Propionaldehyde	0.16	0.15	0.16	0.13	0.10	0.11	**-0.012**	**0.028**
Propylene	0.86	1.05	1.04	0.93	0.98	0.83	-0.024	0.235
Styrene	0.08	0.08	0.08	0.10	0.68	2.13	**0.200**	**0.008**
Toluene	4.34	4.62	3.07	5.90	2.16	3.25	-0.341	0.360

Table 4-3

Bell-Melton Site
Annual Average Mass Trends (HAPs Parameters)
2008-2013

HAP	Average Mass (µg/m^3)						Slope (µg/m^3 per year)	p-Value
	2008	2009	2010	2011	2012	2013		
1,2,4-Trimethylbenzene	0.28	0.28	0.22	0.21	0.21	0.38	-0.005	0.360
1,3,5-Trimethylbenzene	0.16	0.15	0.15	0.10	0.07	0.12	**-0.014**	**0.068**
1,3-Butadiene	0.05	0.06	0.06	0.06	0.10	0.06	**0.003**	**0.068**
Acetaldehyde	0.83	0.79	0.84	0.61	0.61	0.56	**-0.055**	**0.028**
Acetone	2.77	2.66	2.50	2.35	2.28	1.99	**-0.145**	**0.001**
Benzene	1.34	1.39	1.07	0.86	0.67	1.14	-0.161	0.136
Crotonaldehyde	0.11	0.15	0.15	0.04	0.09	0.11	-0.005	0.360
Cyclohexane	5.08	2.73	2.44	1.99	1.77	2.66	**-0.332**	**0.068**
Ethylbenzene	0.26	0.24	0.37	0.16	0.08	0.12	**-0.035**	**0.068**
Formaldehyde	1.00	1.37	1.20	0.96	1.02	0.87	-0.089	0.136
Isopropylbenzene	0.08	0.07	0.07	0.07	0.05	0.05	**-0.007**	**0.008**
Methylcyclohexane	5.87	4.99	4.29	3.63	3.15	4.59	**-0.614**	**0.068**
m-Xylene/p-Xylene	1.36	1.28	0.99	0.45	0.50	0.78	**-0.186**	**0.068**
n-Hexane	6.39	5.35	4.40	3.46	3.33	3.22	**-0.674**	**0.001**
n-Nonane	0.68	0.62	0.46	0.33	0.25	0.37	**-0.107**	**0.028**
n-Propylbenzene	0.08	0.08	0.09	0.08	0.07	0.09	0.000	0.500
o-Xylene	0.31	0.30	0.23	0.18	0.13	0.20	**-0.043**	**0.028**
Propionaldehyde	0.08	0.09	0.09	0.06	0.07	0.06	-0.005	0.136
Propylene	0.27	0.42	0.48	0.38	0.38	0.39	0.004	0.500
Styrene	0.12	0.08	0.08	0.14	0.88	1.52	**0.265**	**0.028**
Toluene	3.63	2.52	1.91	1.53	1.39	3.56	-0.376	0.136

Table 4-4

Battlement Mesa Site
Annual Average Mass Trends (HAPs Parameters)
2011-2013

HAP	Average Mass (µg/m^3)						Slope* (µg/m^3 per year)	p-Value*
	2008	2009	2010	2011	2012	2013		
1,2,4-Trimethylbenzene	--	--	--	0.44	0.35	0.40	--	--
1,3,5-Trimethylbenzene	--	--	--	0.22	0.15	0.16	--	--
1,3-Butadiene	--	--	--	0.06	0.10	0.05	--	--
Acetaldehyde	--	--	--	0.76	0.53	0.44	--	--
Acetone	--	--	--	3.83	2.86	1.76	--	--
Benzene	--	--	--	1.56	1.09	1.24	--	--
Crotonaldehyde	--	--	--	0.07	0.05	0.06	--	--
Cyclohexane	--	--	--	2.09	1.77	2.40	--	--
Ethylbenzene	--	--	--	0.37	0.19	0.14	--	--
Formaldehyde	--	--	--	1.45	0.87	0.82	--	--
Isopropylbenzene	--	--	--	0.08	0.05	0.05	--	--
Methylcyclohexane	--	--	--	4.23	3.57	5.06	--	--
m-Xylene/p-Xylene	--	--	--	1.12	1.06	1.23	--	--
n-Hexane	--	--	--	3.34	2.89	2.42	--	--
n-Nonane	--	--	--	0.68	0.43	0.62	--	--
n-Propylbenzene	--	--	--	0.14	0.09	0.05	--	--
o-Xylene	--	--	--	0.46	0.27	0.26	--	--
Propionaldehyde	--	--	--	0.08	0.06	0.05	--	--
Propylene	--	--	--	0.42	0.44	0.36	--	--
Styrene	--	--	--	0.08	1.54	0.18	--	--
Toluene	--	--	--	2.99	4.07	5.58	--	--

*Note that annual averages are indicated, but trend statistics could not be calculated with only 3 years of complete data.
(--) No data available.

Table 4-5

Carbondale Site
Annual Average Mass Trends (HAPs Parameters)
2013

HAP	Average Mass (µg/m^3)						Slope* (µg/m^3 per year)	p-Value*
	2008	2009	2010	2011	2012	2013		
1,2,4-Trimethylbenzene	--	--	--	--	--	0.59	--	--
1,3,5-Trimethylbenzene	--	--	--	--	--	0.13	--	--
1,3-Butadiene	--	--	--	--	--	0.06	--	--
Acetaldehyde	--	--	--	--	--	0.58	--	--
Acetone	--	--	--	--	--	1.62	--	--
Benzene	--	--	--	--	--	0.47	--	--
Crotonaldehyde	--	--	--	--	--	0.12	--	--
Cyclohexane	--	--	--	--	--	0.42	--	--
Ethylbenzene	--	--	--	--	--	0.12	--	--
Formaldehyde	--	--	--	--	--	0.75	--	--
Isopropylbenzene	--	--	--	--	--	0.06	--	--
Methylcyclohexane	--	--	--	--	--	0.67	--	--
m-Xylene/p-Xylene	--	--	--	--	--	0.49	--	--
n-Hexane	--	--	--	--	--	0.65	--	--
n-Nonane	--	--	--	--	--	0.13	--	--
n-Propylbenzene	--	--	--	--	--	0.14	--	--
o-Xylene	--	--	--	--	--	0.21	--	--
Propionaldehyde	--	--	--	--	--	0.07	--	--
Propylene	--	--	--	--	--	0.40	--	--
Styrene	--	--	--	--	--	2.80	--	--
Toluene	--	--	--	--	--	4.37	--	--

*Note that annual averages are indicated, but trend statistics could not be calculated with only 1 year of complete data.
(--) No data available.

5.0 REFERENCES

Colorado Department of Public Health and Environment (CDPHE). 2010. *Garfield County Air Toxics Inhalation: Screening Level Human Health Risk Assessment*. Available online at http://www.garfield-county.com/public-health/documents/.

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APPENDIX A

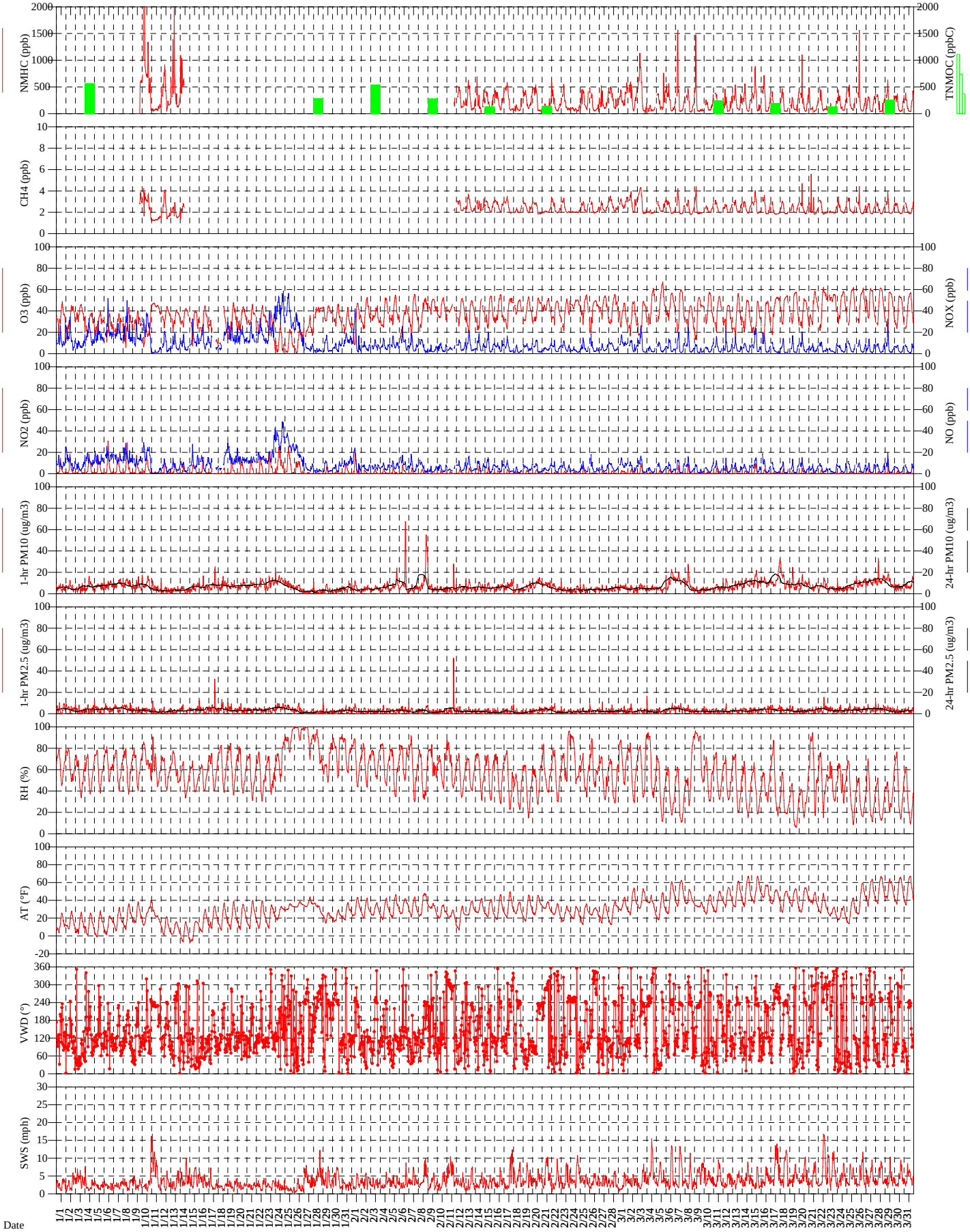
Quarterly Time Series Plots

Acronyms Used on Plots:

TNMOC = Total Non-Methane Organic Carbon
CH4 = Methane
NMHC = Continuous Non-Methane Hydrocarbons
O_3 = Ozone
NO = Nitric Oxide
NO_2 = Nitrogen Dioxide
NOx = Oxides of Nitrogen
PM_{10} = Particulate Matter $\leq$ 10 µm
$PM_{2.5}$ = Particulate Matter $\leq$ 2.5 µm
RH = Relative Humidity
AT = Atmospheric Temperature
VWD = Vector Wind Direction
SWS = Scalar Wind Speed

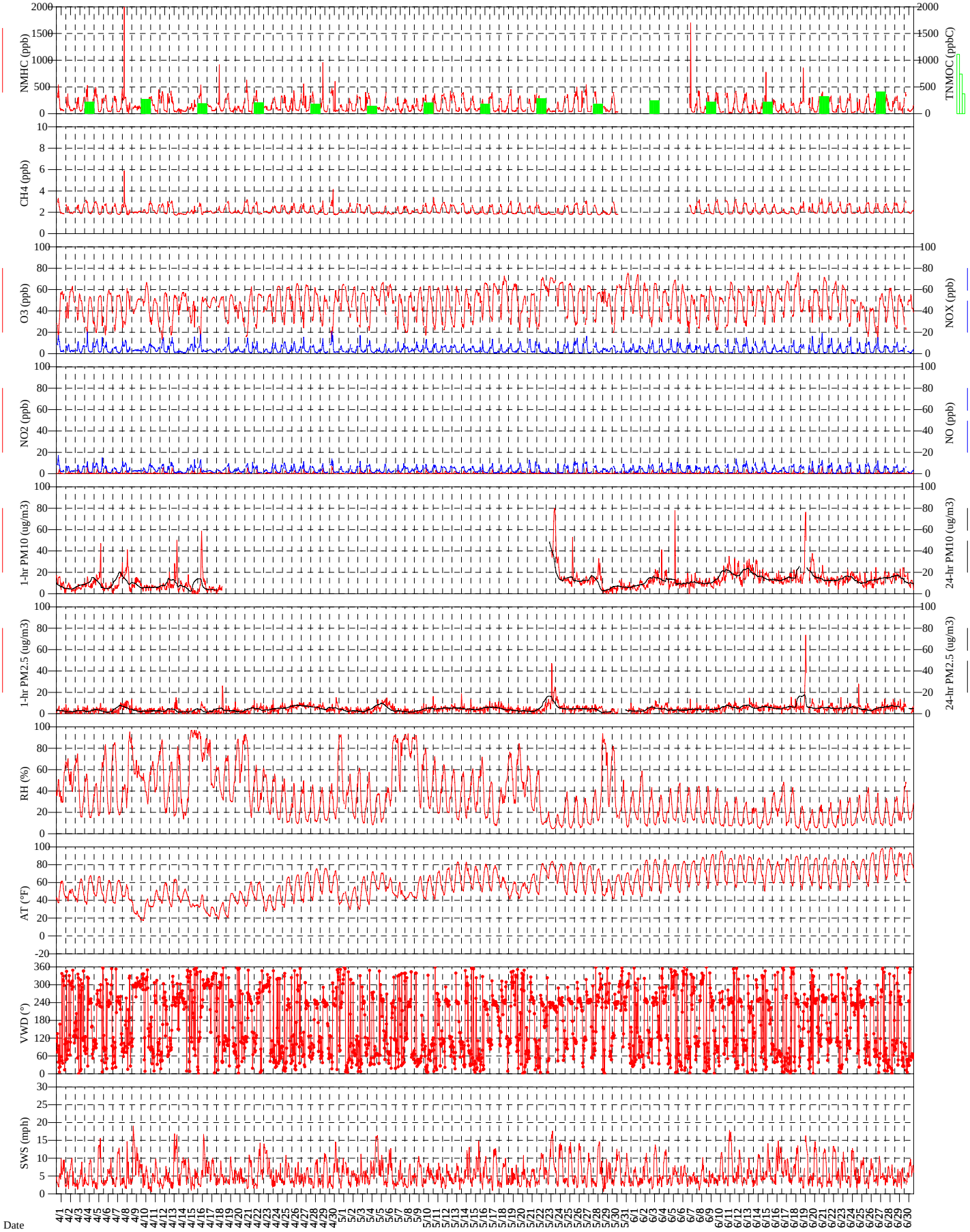
Garfield County, CO

Battlement Mesa Site



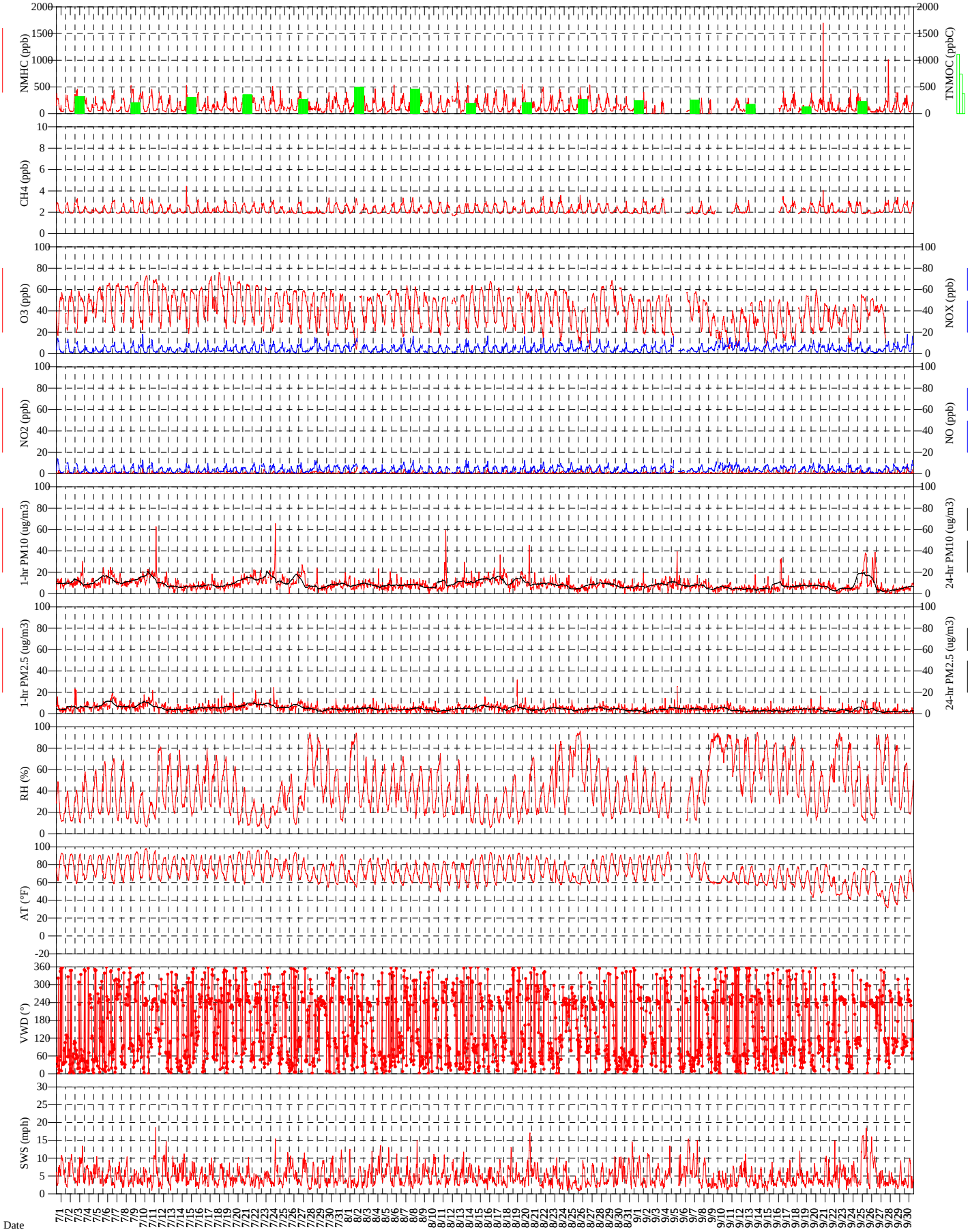
Garfield County, CO

Battlement Mesa Site



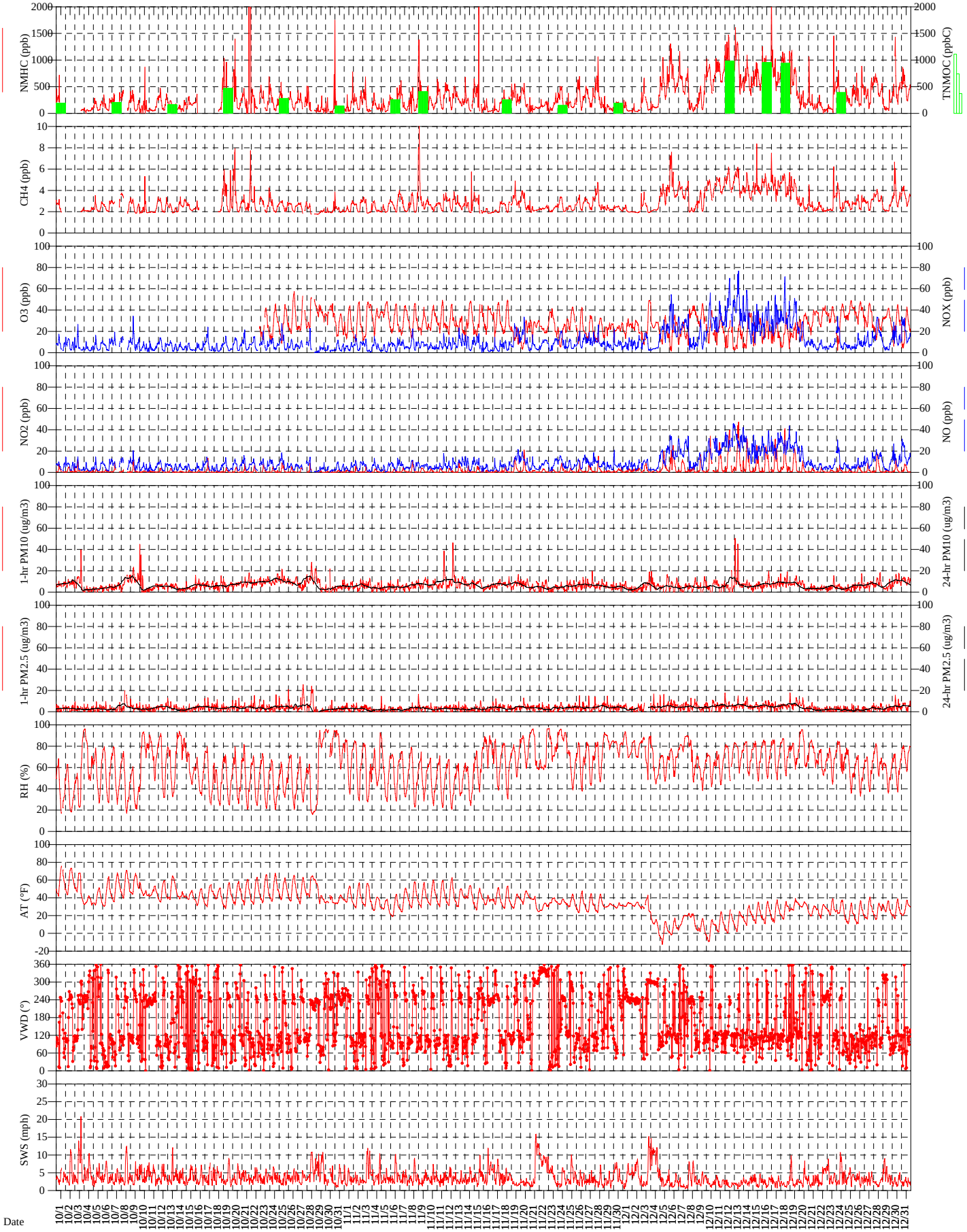
Garfield County, CO

Battlement Mesa Site



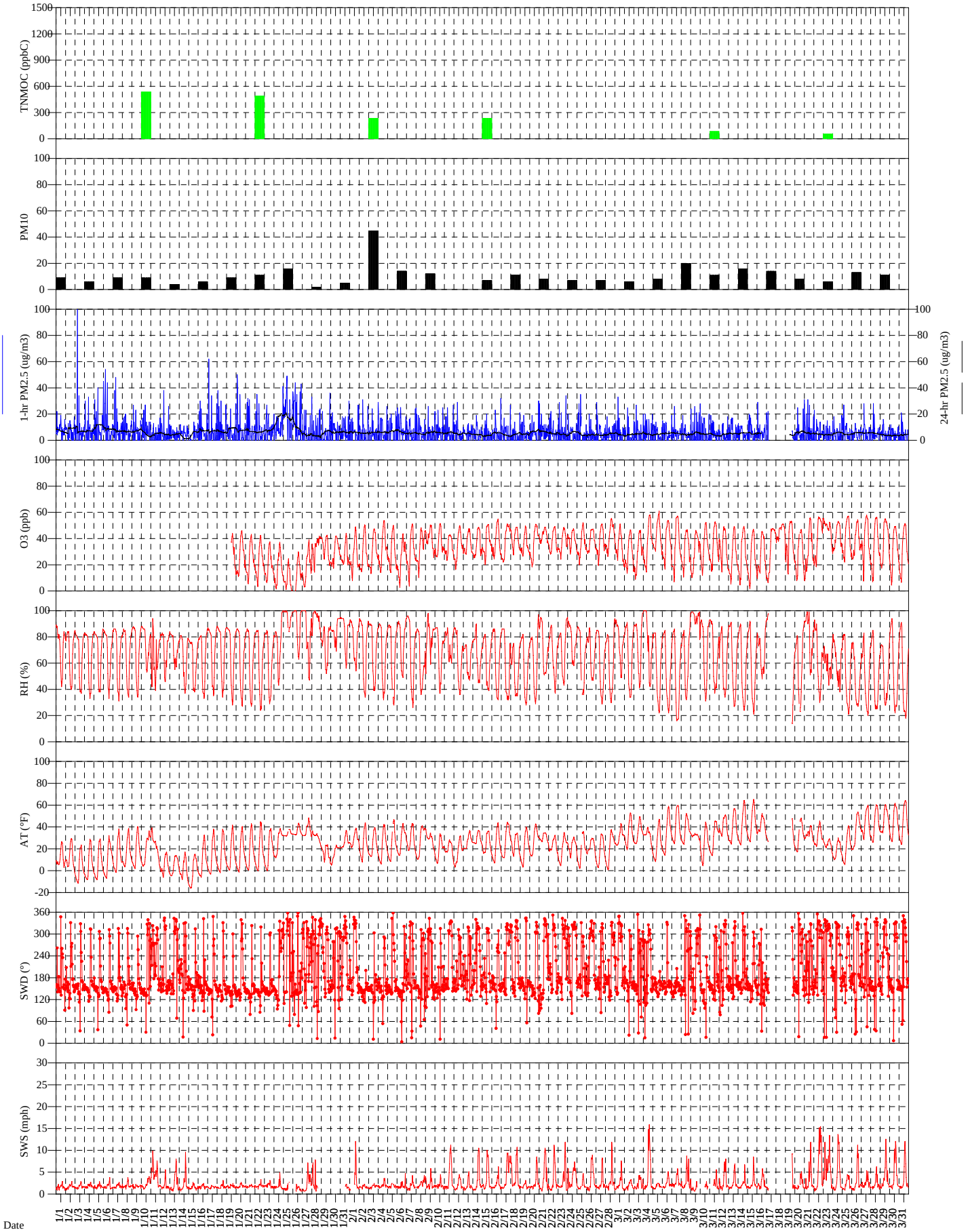
Garfield County, CO

Battlement Mesa Site



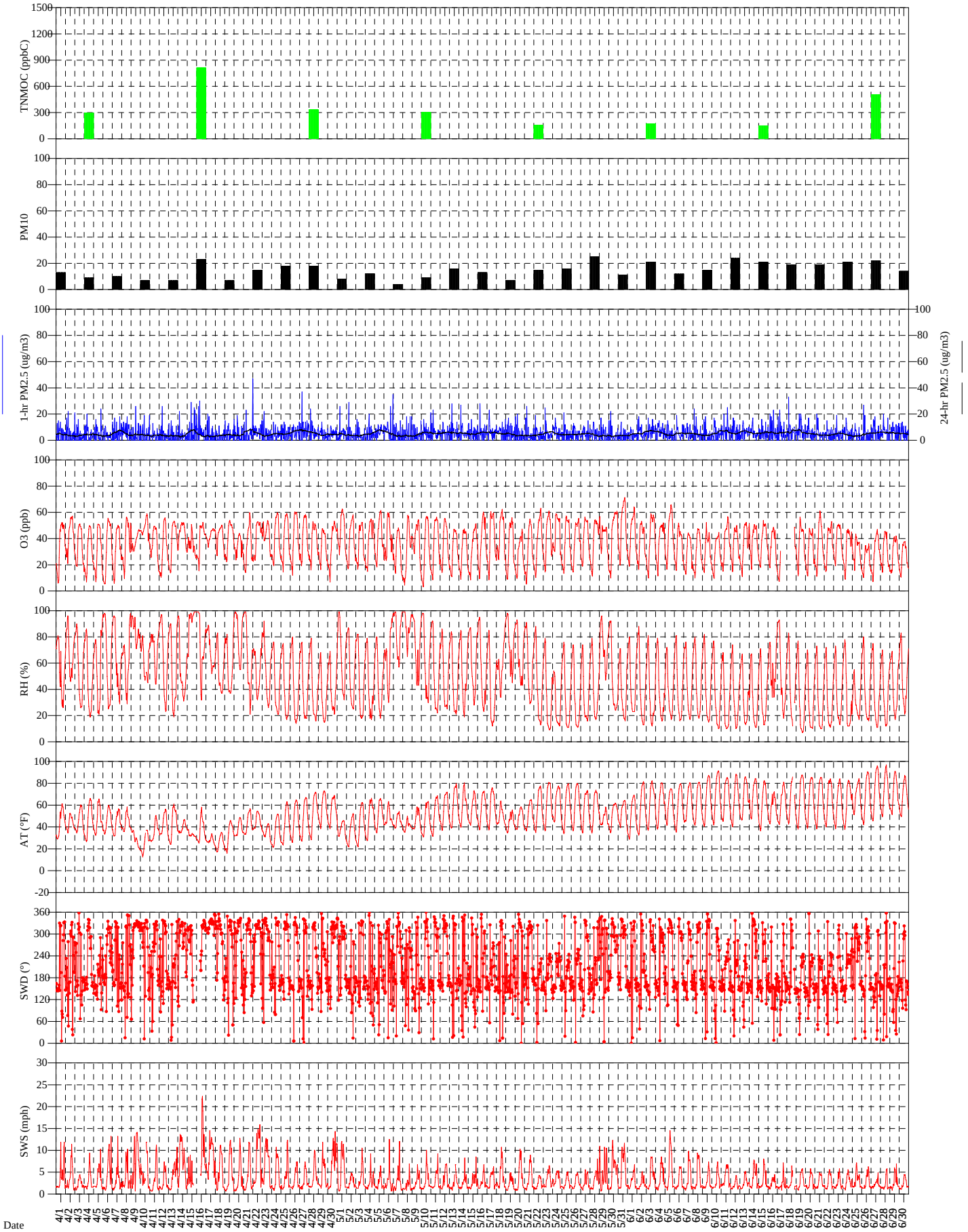
Garfield County, CO

Carbondale Site



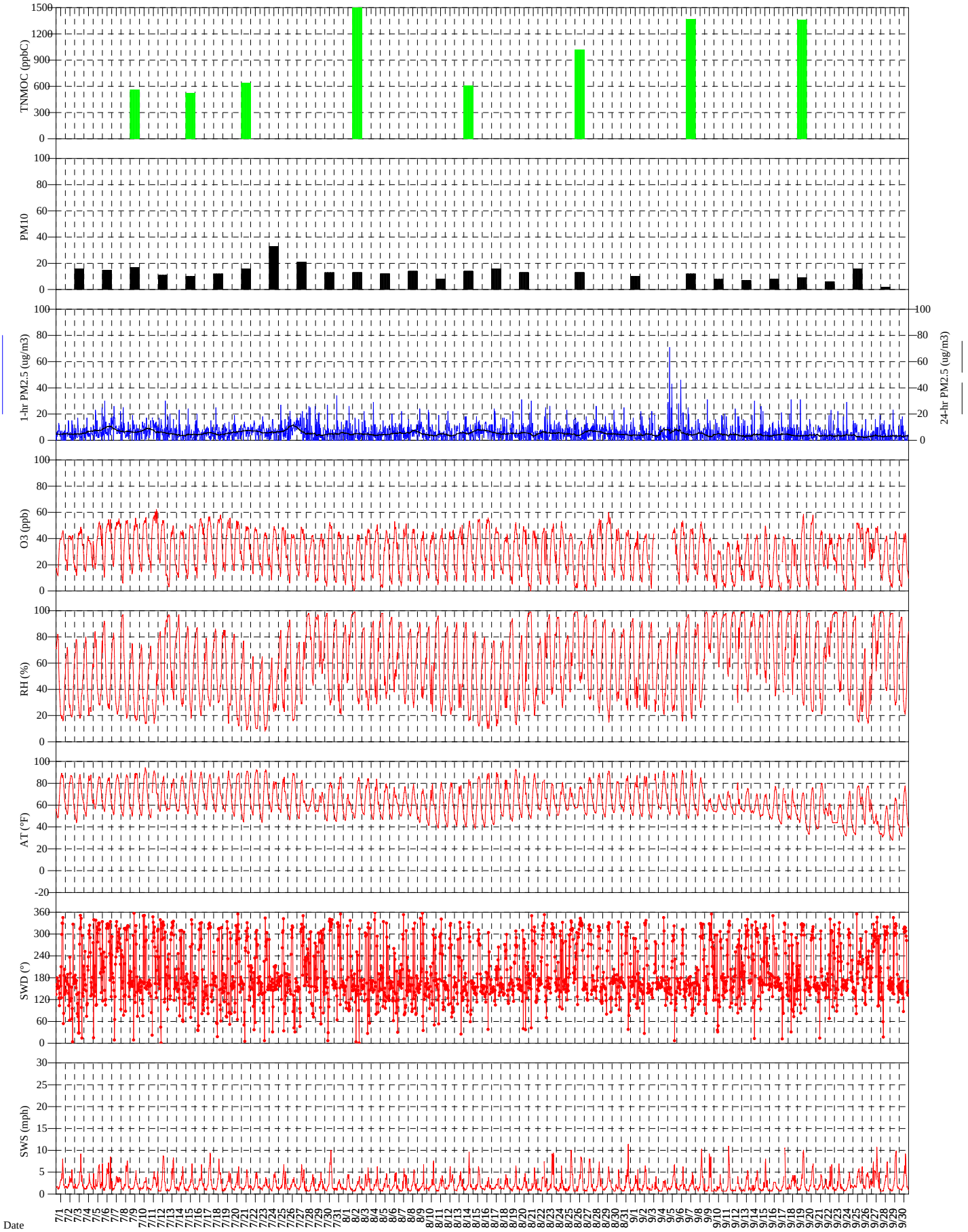
Garfield County, CO

Carbondale Site



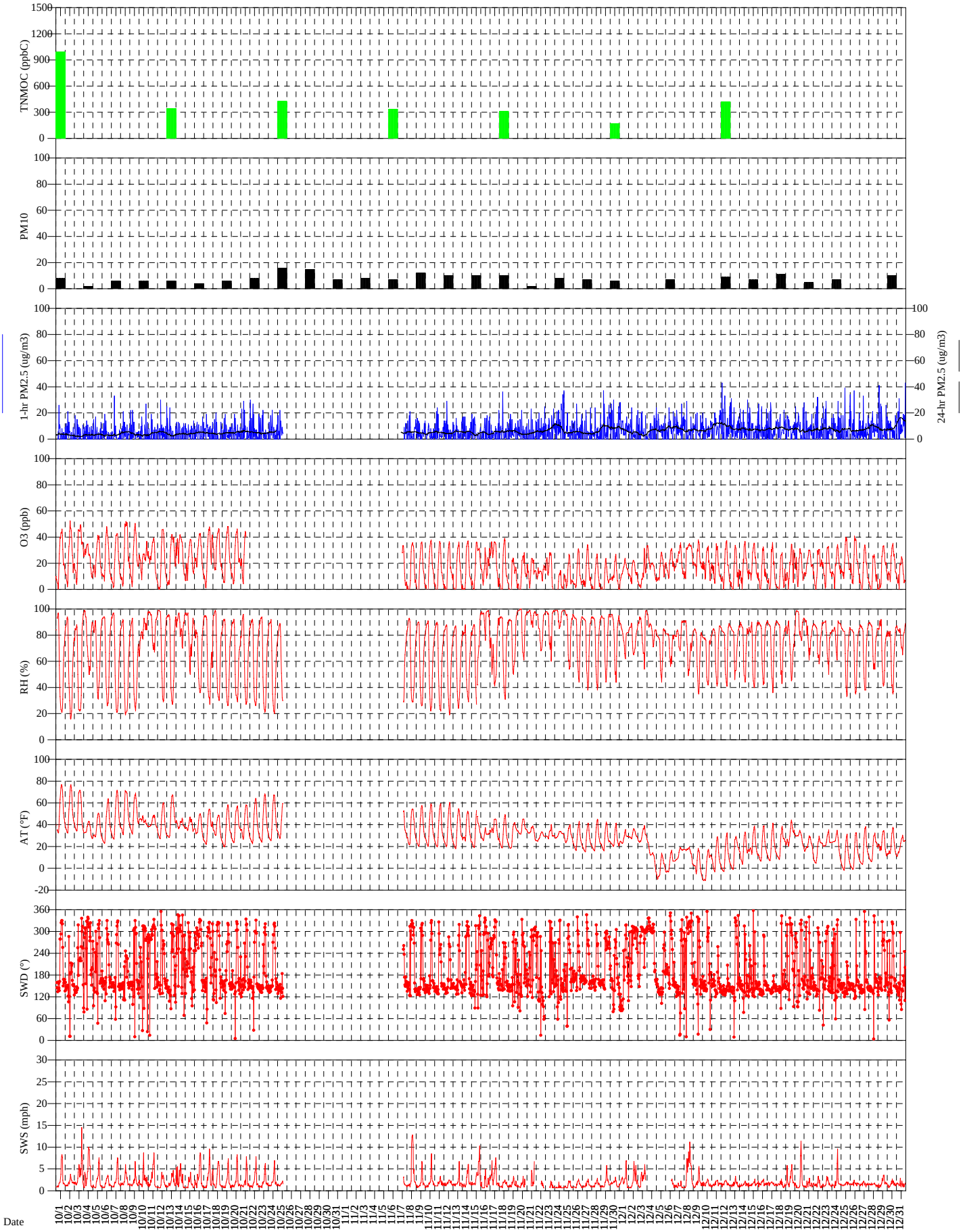
Garfield County, CO

Carbondale Site



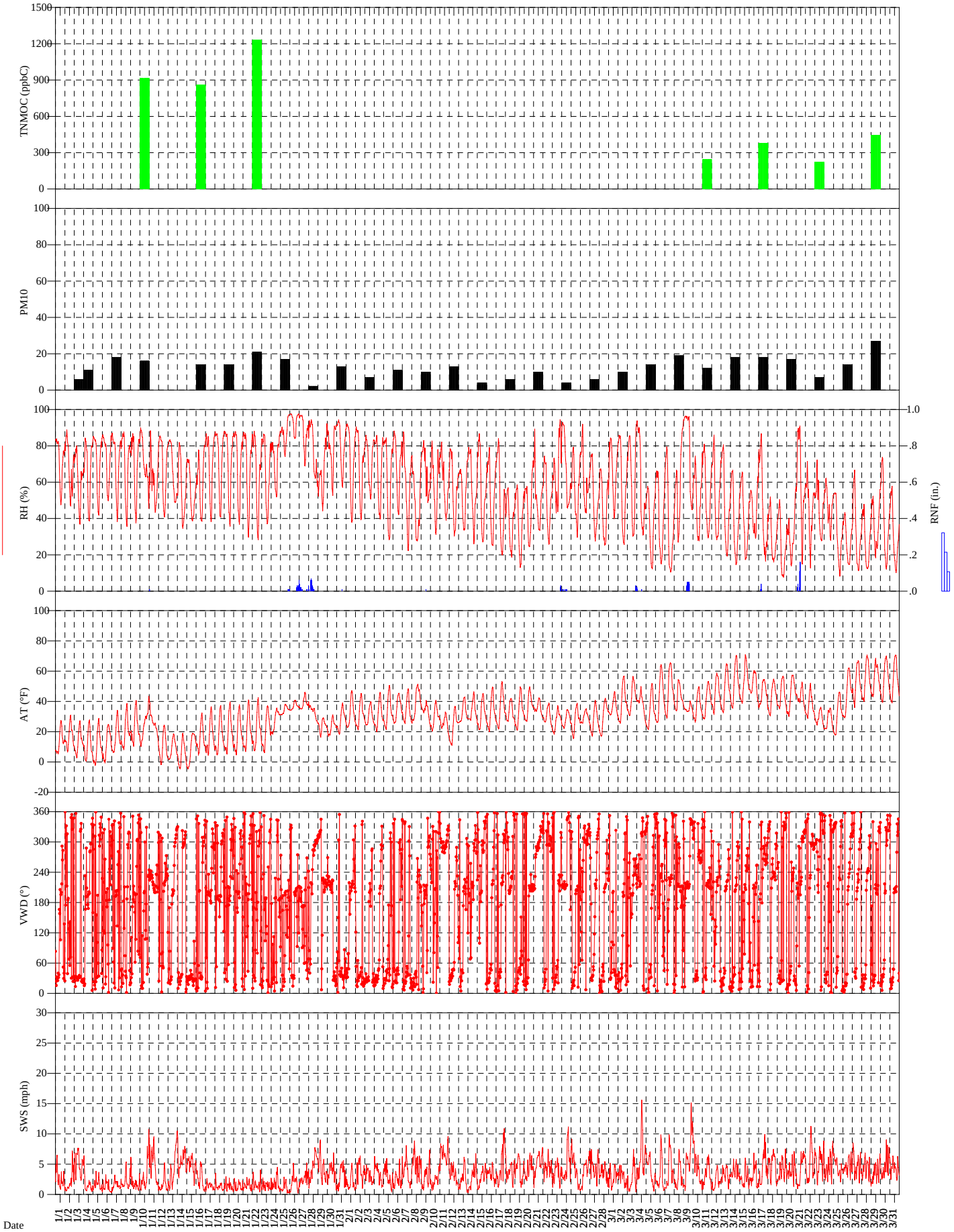
Garfield County, CO

Carbondale Site



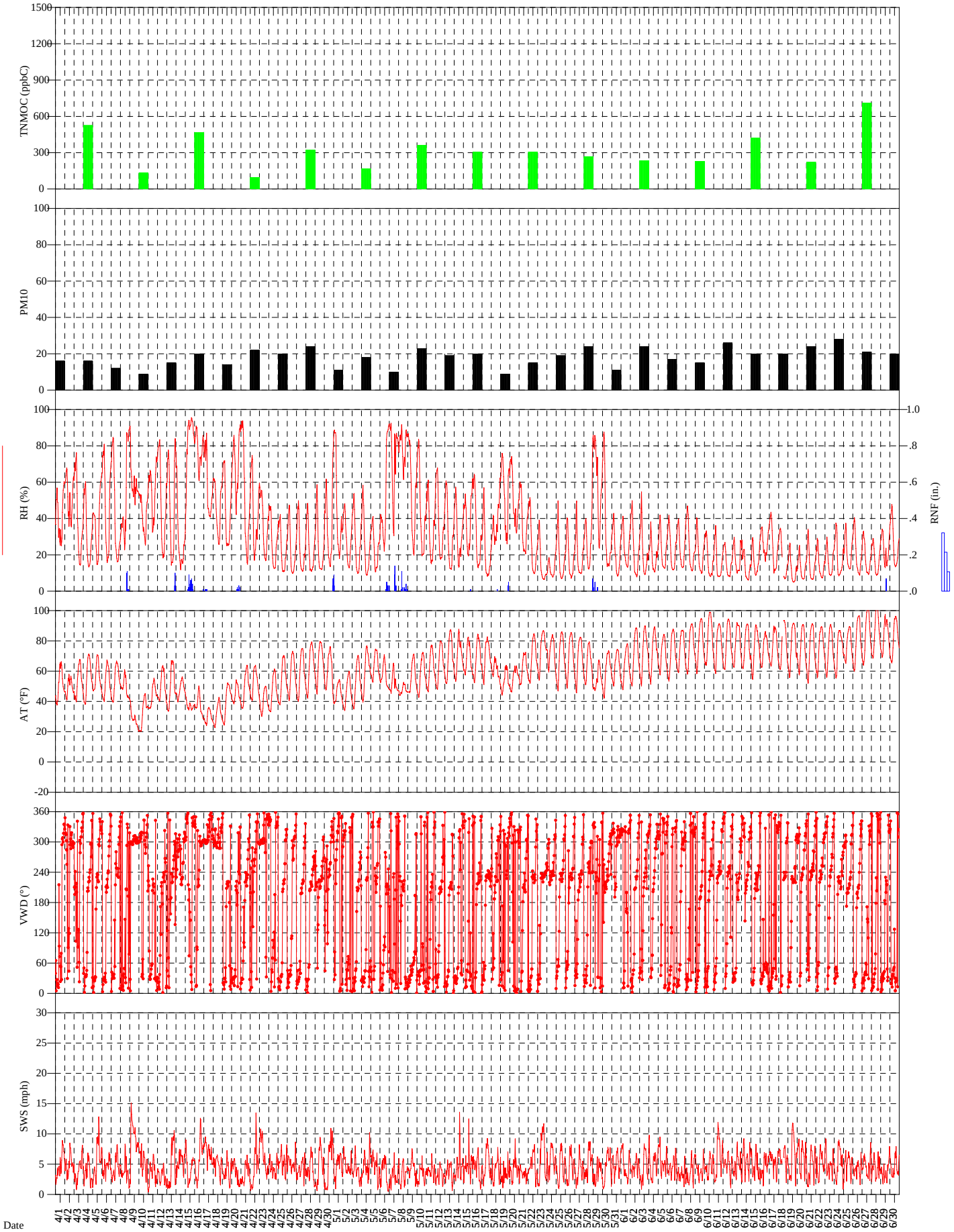
Garfield County, CO

Parachute Site



Garfield County, CO

Parachute Site



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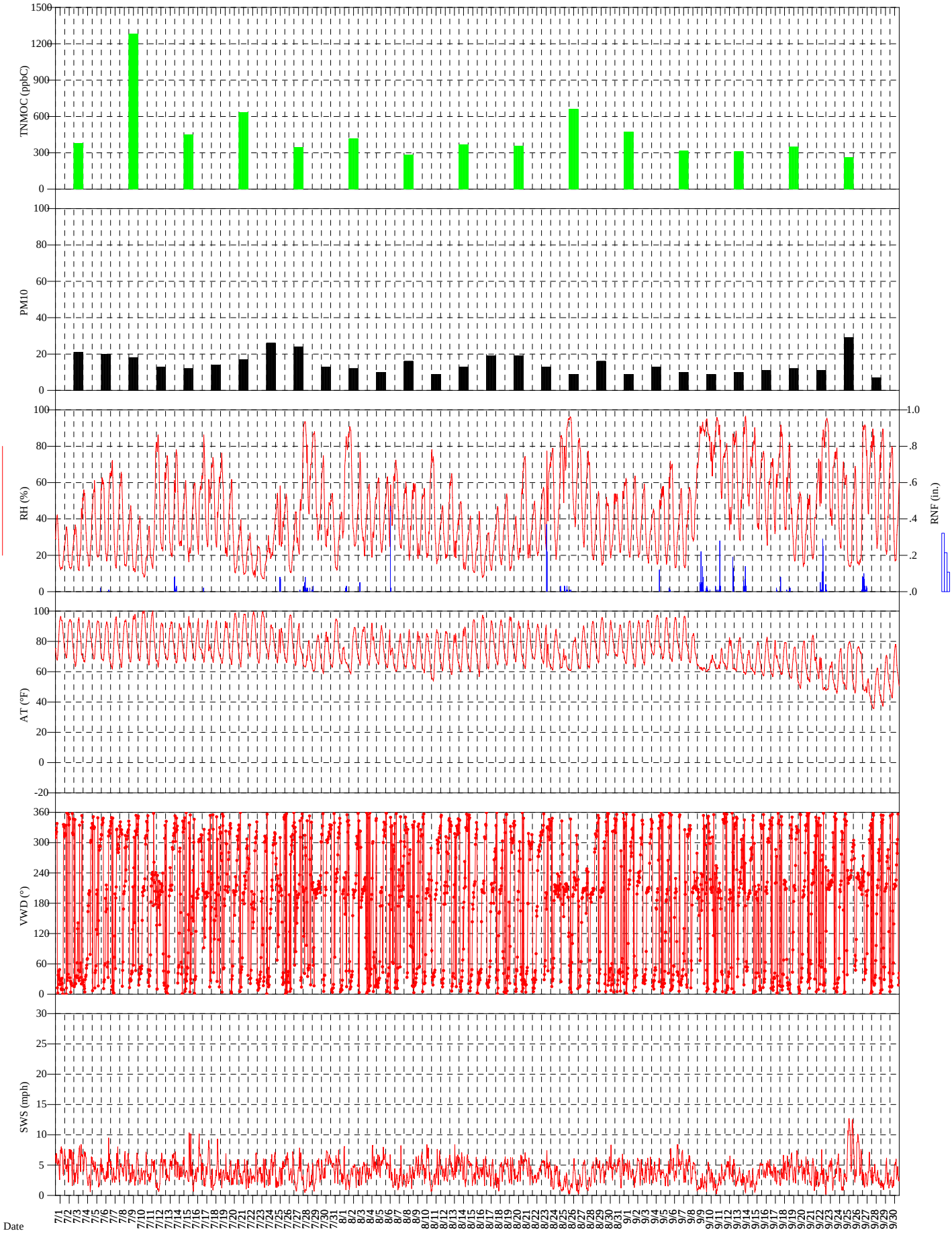
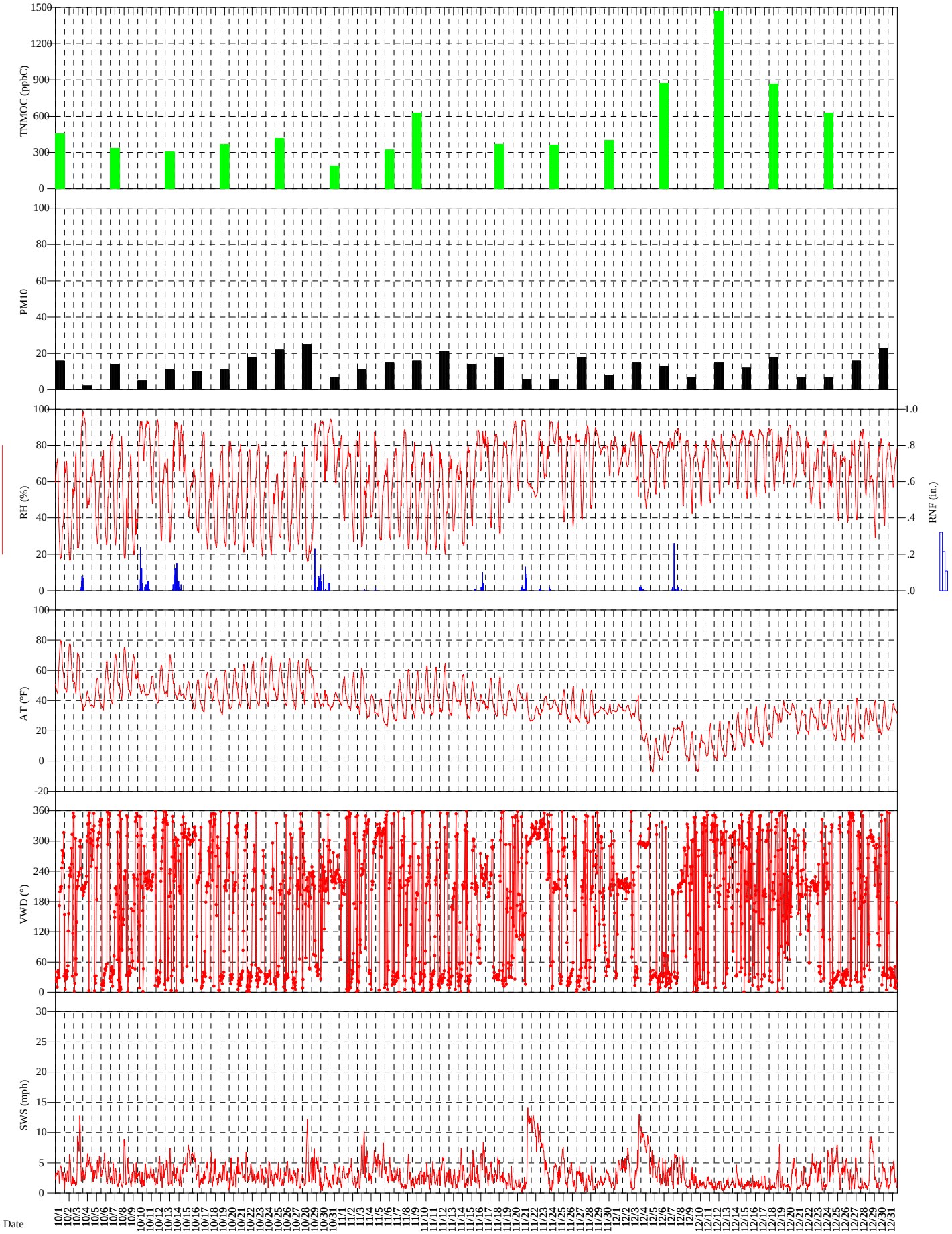
Parachute Site



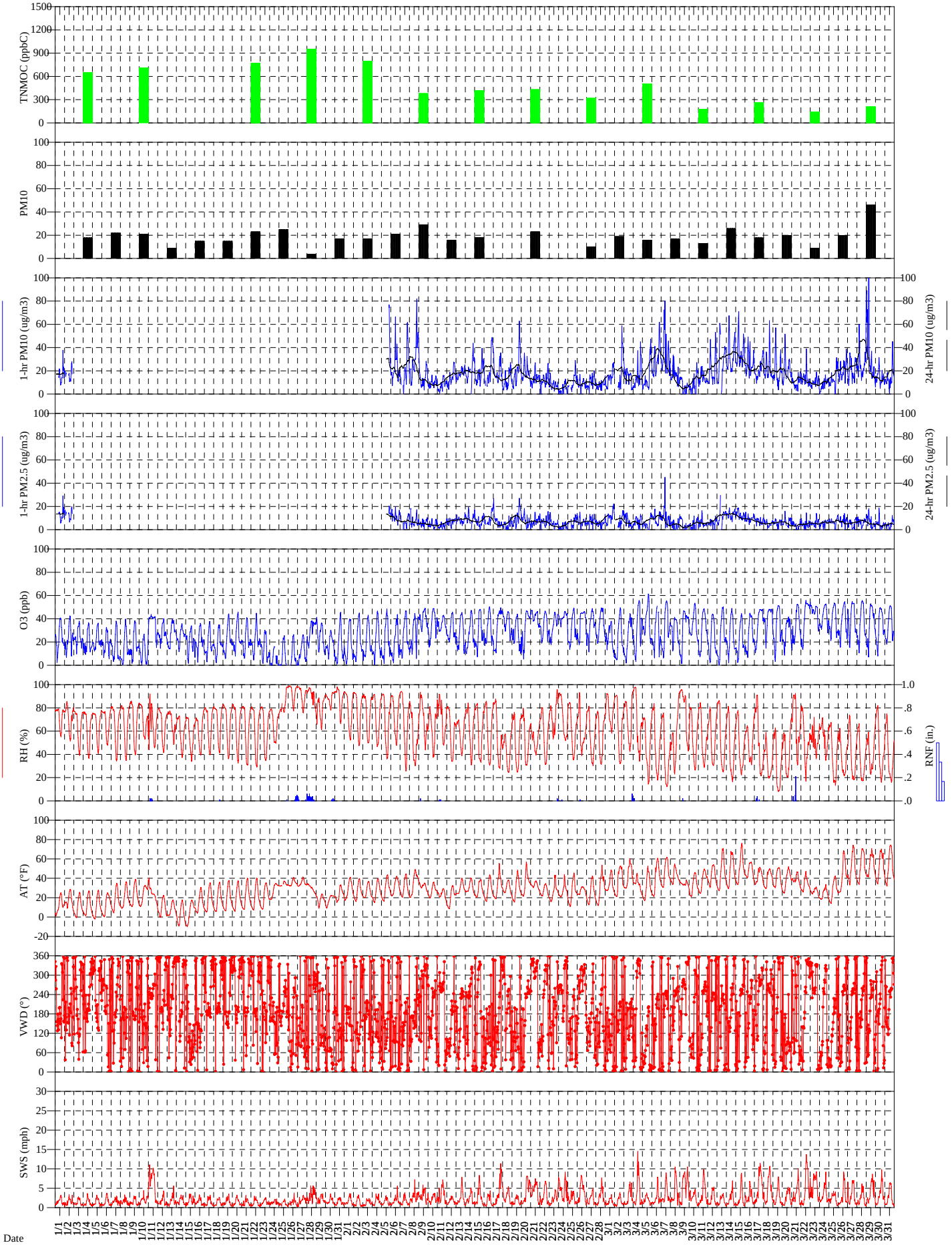
Garfield County, CO

Parachute Site



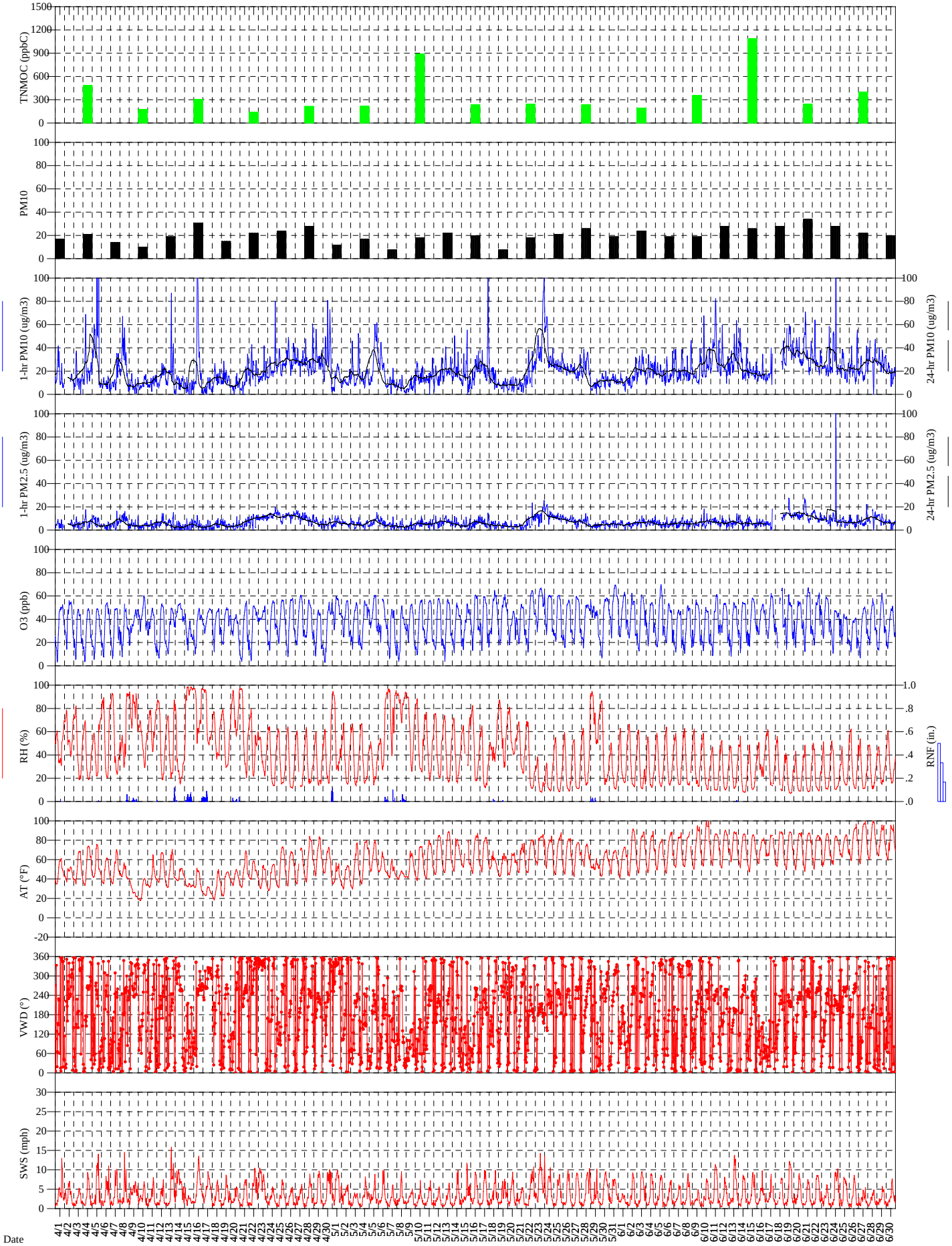
Garfield County, CO

Rifle Site



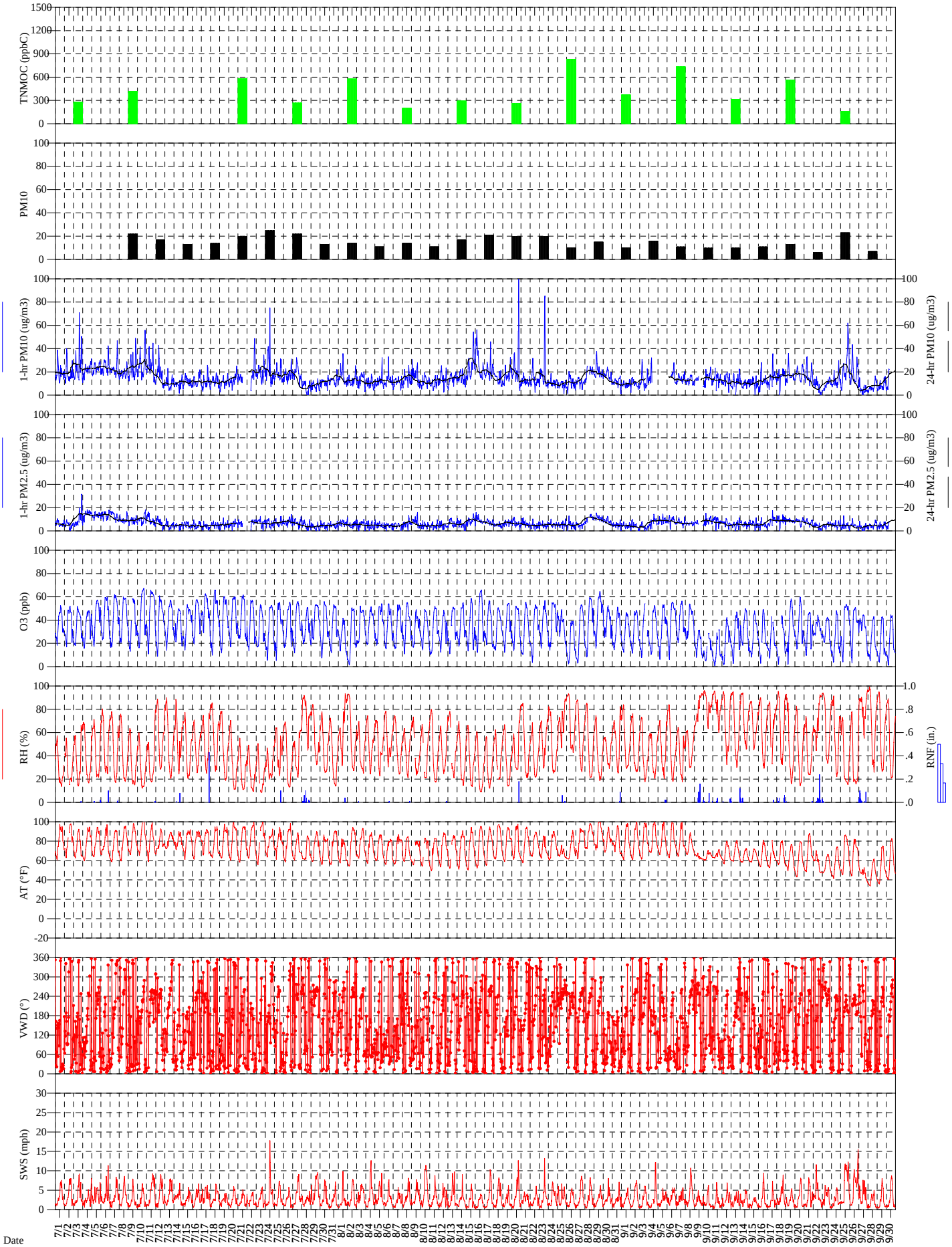
Garfield County, CO

Rifle Site



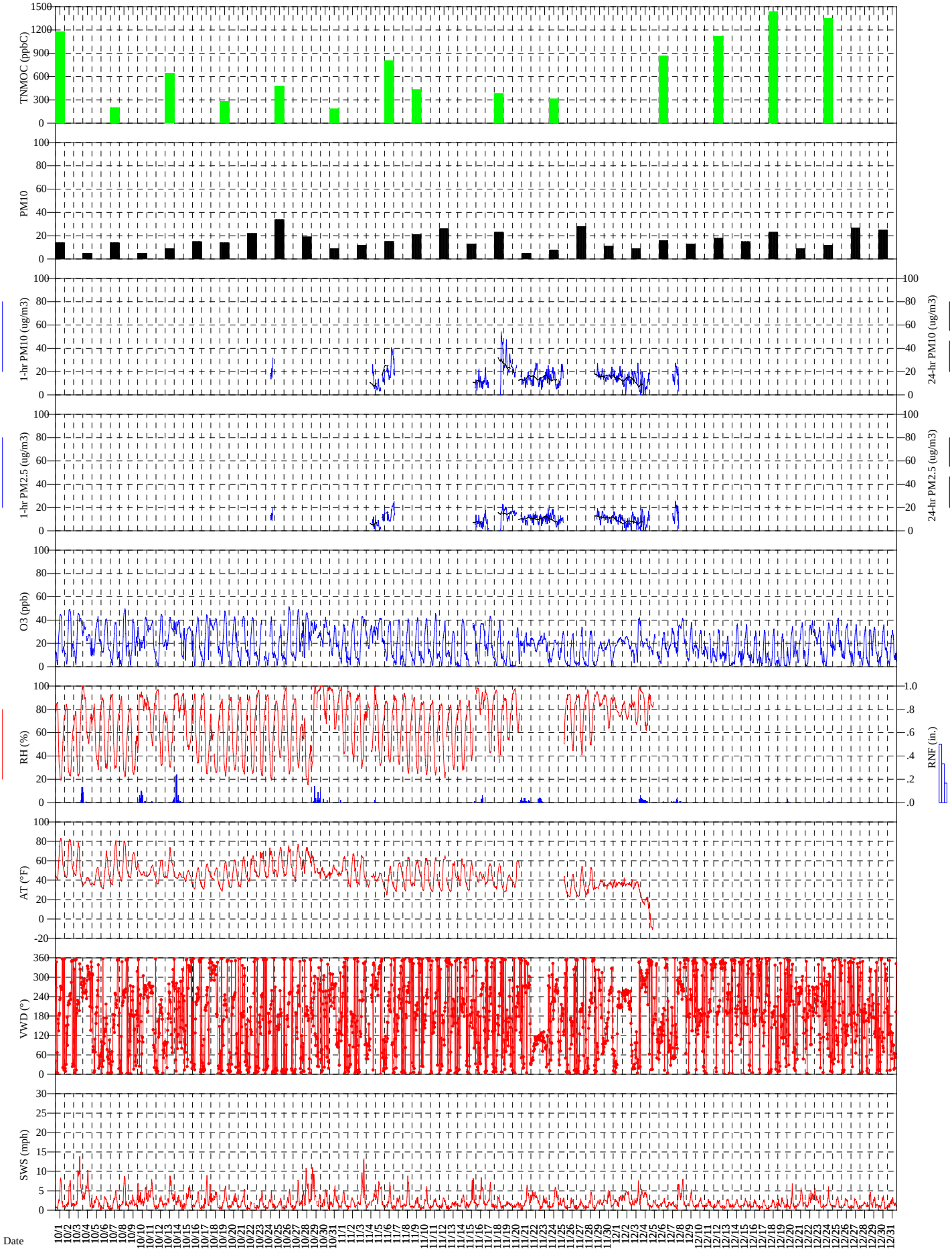
Garfield County, CO

Rifle Site



Garfield County, CO

Rifle Site



APPENDIX B

SNMOC Concentrations

Table B-1
Garfield County SNMOC Monitoring
Parachute (PACO)
1/10/2013-12/24/2013 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	52	30	0.01	0.13	0.03
1,2,4-Trimethylbenzene (95-63-6)	52	52	0.04	0.63	0.16
1,3,5-Trimethylbenzene (108-67-8)	52	47	0.02	0.21	0.06
1,3-Butadiene (106-99-0)	52	9	0.02	0.07	0.03
1-Hexene (592-41-6)	52	7	0.01	0.26	0.04
1-Nonene (124-11-8)	52	35	0.01	0.23	0.03
1-Octene (111-66-0)	52	40	0.03	0.28	0.07
1-Pentene (109-67-1)	52	49	0.01	0.51	0.04
1-Undecene (821-95-4)	52	4	0.01	0.04	0.01
2,2,3-Trimethylpentane (564-02-3)	52	35	0.02	0.15	0.04
2,2-Dimethylbutane (75-83-2)	52	52	0.02	0.46	0.11
2,3,4-Trimethylpentane (565-75-3)	52	36	0.01	0.15	0.03
2,3-Dimethylbutane (79-29-8)	52	52	0.04	0.82	0.20
2,3-Dimethylpentane (565-59-3)	52	52	0.02	0.41	0.12
2,4-Dimethylpentane (108-08-7)	52	51	0.01	0.22	0.06
2-Methyl-1-butene (563-46-2)	52	19	0.02	0.10	0.03
2-Methyl-2-butene (513-35-9)	52	26	0.02	0.15	0.04
2-Methylheptane (592-27-8)	52	52	0.04	0.62	0.16
2-Methylhexane (591-76-4)	52	52	0.12	1.32	0.47
2-Methylpentane (107-83-5)	52	52	0.19	3.22	0.87
3-Methylheptane (589-81-1)	52	52	0.03	0.50	0.13
3-Methylhexane (589-34-4)	52	46	0.12	1.28	0.36
3-Methylpentane (96-14-0)	52	52	0.09	1.85	0.47
Acetylene (74-86-2)	52	52	0.12	1.92	0.45
a-Pinene (80-56-8)	52	15	0.01	0.34	0.02
Benzene (71-43-2)	52	49	0.18	1.68	0.58
cis-2-Butene (590-18-1)	52	29	0.02	0.13	0.03
cis-2-Pentene (627-20-3)	52	3	0.01	0.05	0.02
Cyclohexane (110-82-7)	52	52	0.20	3.53	0.91
Cyclopentane (287-92-3)	52	51	0.04	0.52	0.14
Ethane (74-84-0)	52	52	10.20	245.00	50.88
Ethylbenzene (100-41-4)	52	52	0.02	0.20	0.05
Ethylene (74-85-1)	52	52	0.50	5.20	1.50
Isobutane (75-28-5)	52	52	0.77	20.65	4.34
Isobutylene (115-11-7)	52	1	0.18	0.18	0.03
Isopentane (78-78-4)	52	28	0.64	11.20	2.14
Isoprene (78-79-5)	52	33	0.01	1.92	0.13
Isopropylbenzene (98-82-8)	52	14	0.01	0.04	0.01
m-Diethylbenzene (141-93-5)	52	3	0.04	0.94	0.03
Methylcyclohexane (108-87-2)	52	52	0.37	6.00	1.64
Methylcyclopentane (96-37-7)	52	52	0.10	1.97	0.51
m-Ethyltoluene (620-14-4)	52	51	0.01	0.48	0.12

*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)
1/10/2013-12/24/2013 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	52	52	0.13	1.48	0.41
n-Butane (106-97-8)	52	52	0.80	20.65	4.47
n-Decane (124-18-5)	52	52	0.05	0.48	0.12
n-Dodecane (112-40-3)	52	51	0.01	0.29	0.04
n-Heptane (142-82-5)	52	52	0.16	2.49	0.65
n-Hexane (110-54-3)	52	52	0.16	3.48	0.88
n-Nonane (111-84-2)	52	52	0.06	0.73	0.17
n-Octane (111-65-9)	52	51	0.13	1.68	0.41
n-Pentane (109-66-0)	52	52	0.33	8.14	1.89
n-Propylbenzene (103-65-1)	52	28	0.02	0.15	0.03
n-Tridecane (629-50-5)	52	31	0.01	0.12	0.02
n-Undecane (1120-21-4)	52	52	0.02	0.26	0.06
o-Ethyltoluene (611-14-3)	52	38	0.01	0.20	0.04
o-Xylene (95-47-6)	52	52	0.03	0.33	0.09
p-Diethylbenzene (105-05-5)	52	2	0.05	0.07	0.01
p-Ethyltoluene (622-96-8)	52	44	0.02	0.29	0.06
Propane (74-98-6)	52	52	3.13	83.00	17.57
Propylene (115-07-1)	52	52	0.07	1.48	0.28
Styrene (100-42-5)	52	21	0.03	6.08	0.88
Toluene (108-88-3)	52	52	0.32	3.71	1.18
trans-2-Butene (624-64-6)	52	33	0.02	0.40	0.05
trans-2-Pentene (646-04-8)	52	31	0.01	0.10	0.02

*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)
1/4/2013-12/24/2013 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	57	50	0.01	0.12	0.03
1,2,4-Trimethylbenzene (95-63-6)	57	57	0.06	0.40	0.15
1,3,5-Trimethylbenzene (108-67-8)	57	57	0.02	0.16	0.05
1,3-Butadiene (106-99-0)	57	52	0.02	0.15	0.05
1-Butene (106-98-9)	57	1	0.23	0.23	0.02
1-Hexene (592-41-6)	57	5	0.02	0.19	0.04
1-Nonene (124-11-8)	57	24	0.01	0.10	0.02
1-Octene (111-66-0)	57	34	0.01	0.12	0.02
1-Pentene (109-67-1)	57	56	0.02	0.37	0.05
1-Undecene (821-95-4)	57	1	0.04	0.04	0.01
2,2,3-Trimethylpentane (564-02-3)	57	37	0.02	0.14	0.03
2,2,4-Trimethylpentane (540-84-1)	57	13	0.02	0.07	0.02
2,2-Dimethylbutane (75-83-2)	57	56	0.03	0.40	0.10
2,3,4-Trimethylpentane (565-75-3)	57	53	0.02	0.11	0.03
2,3-Dimethylbutane (79-29-8)	57	57	0.05	0.84	0.21
2,3-Dimethylpentane (565-59-3)	57	57	0.03	0.43	0.12
2,4-Dimethylpentane (108-08-7)	57	57	0.01	0.22	0.06
2-Methyl-1-butene (563-46-2)	57	51	0.02	0.11	0.05
2-Methyl-2-butene (513-35-9)	57	52	0.03	0.14	0.07
2-Methylheptane (592-27-8)	57	57	0.03	0.55	0.12
2-Methylhexane (591-76-4)	57	56	0.09	1.54	0.39
2-Methylpentane (107-83-5)	57	57	0.27	3.60	0.98
3-Methyl-1-butene (563-45-1)	57	1	0.05	0.05	0.02
3-Methylheptane (589-81-1)	57	57	0.02	0.38	0.09
3-Methylhexane (589-34-4)	57	52	0.10	1.33	0.34
3-Methylpentane (96-14-0)	57	57	0.14	1.97	0.53
Acetylene (74-86-2)	57	57	0.32	3.40	1.18
a-Pinene (80-56-8)	57	28	0.01	0.11	0.02
Benzene (71-43-2)	57	57	0.20	1.50	0.48
cis-2-Butene (590-18-1)	57	56	0.03	0.23	0.08
cis-2-Hexene (7688-21-3)	57	1	0.01	0.01	0.02
cis-2-Pentene (627-20-3)	57	45	0.01	0.05	0.02
Cyclohexane (110-82-7)	57	57	0.22	3.30	0.84
Cyclopentane (287-92-3)	57	57	0.06	0.58	0.16
Cyclopentene (142-29-0)	57	2	0.03	0.03	0.02
Ethane (74-84-0)	57	57	11.05	215.00	40.63
Ethylbenzene (100-41-4)	57	57	0.03	0.24	0.08
Ethylene (74-85-1)	57	57	0.81	5.80	2.05
Isobutane (75-28-5)	57	57	1.34	24.42	4.99
Isopentane (78-78-4)	57	30	0.78	14.38	2.68
Isoprene (78-79-5)	57	52	0.01	0.60	0.10
Isopropylbenzene (98-82-8)	57	13	0.01	0.03	0.01

*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)
1/4/2013-12/24/2013 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
m-Diethylbenzene (141-93-5)	57	2	0.09	0.16	0.02
Methylcyclohexane (108-87-2)	57	57	0.27	5.11	1.15
Methylcyclopentane (96-37-7)	57	57	0.14	1.88	0.50
m-Ethyltoluene (620-14-4)	57	55	0.03	0.36	0.11
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	57	57	0.14	1.38	0.37
n-Butane (106-97-8)	57	57	1.57	25.50	5.54
n-Decane (124-18-5)	57	57	0.03	0.31	0.08
n-Dodecane (112-40-3)	57	55	0.01	0.06	0.02
n-Heptane (142-82-5)	57	57	0.14	2.40	0.55
n-Hexane (110-54-3)	57	57	0.24	3.78	0.97
n-Nonane (111-84-2)	57	57	0.03	0.50	0.09
n-Octane (111-65-9)	57	57	0.08	1.27	0.26
n-Pentane (109-66-0)	57	57	0.64	9.74	2.53
n-Propylbenzene (103-65-1)	57	50	0.01	0.13	0.03
n-Tridecane (629-50-5)	57	14	0.01	0.02	0.01
n-Undecane (1120-21-4)	57	56	0.01	0.12	0.03
o-Ethyltoluene (611-14-3)	57	42	0.02	0.11	0.03
o-Xylene (95-47-6)	57	57	0.05	0.33	0.11
p-Diethylbenzene (105-05-5)	57	1	0.04	0.04	0.01
p-Ethyltoluene (622-96-8)	57	54	0.01	0.21	0.06
Propane (74-98-6)	57	57	4.90	86.67	17.18
Propylene (115-07-1)	57	57	0.18	1.38	0.48
Styrene (100-42-5)	57	25	0.07	3.59	0.50
Toluene (108-88-3)	57	57	0.27	2.69	0.86
trans-2-Butene (624-64-6)	57	57	0.03	0.60	0.11
trans-2-Hexene (4050-45-7)	57	5	0.01	0.02	0.02
trans-2-Pentene (646-04-8)	57	53	0.02	0.11	0.05

*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)
1/4/2013-12/30/2013 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	57	15	0.01	0.05	0.01
1,2,4-Trimethylbenzene (95-63-6)	57	56	0.02	0.22	0.08
1,3,5-Trimethylbenzene (108-67-8)	57	34	0.01	0.07	0.02
1,3-Butadiene (106-99-0)	57	2	0.10	0.25	0.03
1-Butene (106-98-9)	57	1	0.19	0.19	0.02
1-Dodecene (112-41-4)	57	1	0.07	0.07	0.01
1-Heptene (592-76-7)	57	1	0.16	0.16	0.02
1-Hexene (592-41-6)	57	8	0.01	0.16	0.04
1-Nonene (124-11-8)	57	31	0.01	0.08	0.02
1-Octene (111-66-0)	57	45	0.02	0.10	0.04
1-Pentene (109-67-1)	57	45	0.01	0.29	0.03
1-Undecene (821-95-4)	57	1	0.03	0.03	0.01
2,2,3-Trimethylpentane (564-02-3)	57	23	0.01	0.16	0.02
2,2,4-Trimethylpentane (540-84-1)	57	2	0.03	0.48	0.02
2,2-Dimethylbutane (75-83-2)	57	54	0.01	0.52	0.09
2,3,4-Trimethylpentane (565-75-3)	57	20	0.01	0.18	0.02
2,3-Dimethylbutane (79-29-8)	57	57	0.04	1.14	0.18
2,3-Dimethylpentane (565-59-3)	57	57	0.03	0.52	0.09
2,4-Dimethylpentane (108-08-7)	57	55	0.01	0.27	0.05
2-Methyl-1-butene (563-46-2)	57	12	0.02	0.18	0.02
2-Methyl-1-pentene (763-29-1)	57	1	0.03	0.03	0.02
2-Methyl-2-butene (513-35-9)	57	16	0.02	0.29	0.04
2-Methylheptane (592-27-8)	57	56	0.02	0.49	0.09
2-Methylhexane (591-76-4)	57	57	0.11	1.50	0.35
2-Methylpentane (107-83-5)	57	57	0.22	4.98	0.84
3-Methylheptane (589-81-1)	57	56	0.02	0.28	0.06
3-Methylhexane (589-34-4)	57	40	0.10	1.41	0.22
3-Methylpentane (96-14-0)	57	57	0.10	2.67	0.43
Acetylene (74-86-2)	57	57	0.07	5.40	0.50
a-Pinene (80-56-8)	57	29	0.01	0.50	0.03
Benzene (71-43-2)	57	57	0.12	1.25	0.36
cis-2-Butene (590-18-1)	57	3	0.01	0.12	0.01
cis-2-Pentene (627-20-3)	57	1	0.06	0.06	0.02
Cyclohexane (110-82-7)	57	57	0.18	4.75	0.77
Cyclopentane (287-92-3)	57	55	0.03	0.77	0.14
Cyclopentene (142-29-0)	57	1	0.02	0.02	0.02
Ethane (74-84-0)	57	57	9.05	246.50	42.52
Ethylbenzene (100-41-4)	57	47	0.01	0.24	0.03
Ethylene (74-85-1)	57	57	0.36	75.00	2.40
Isobutane (75-28-5)	57	57	1.06	30.50	4.97
Isobutylene (115-11-7)	57	1	0.03	0.03	0.02
Isopentane (78-78-4)	57	35	1.14	17.96	2.54

*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)
1/4/2013-12/30/2013 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Isoprene (78-79-5)	57	25	0.01	0.47	0.10
Isopropylbenzene (98-82-8)	57	2	0.01	0.02	0.01
Methylcyclohexane (108-87-2)	57	57	0.28	6.53	1.14
Methylcyclopentane (96-37-7)	57	57	0.10	2.48	0.42
m-Ethyltoluene (620-14-4)	57	45	0.02	0.19	0.06
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	57	57	0.02	0.72	0.18
n-Butane (106-97-8)	57	57	1.25	33.75	5.52
n-Decane (124-18-5)	57	53	0.02	0.15	0.05
n-Dodecane (112-40-3)	57	44	0.01	0.11	0.02
n-Heptane (142-82-5)	57	57	0.11	2.80	0.52
n-Hexane (110-54-3)	57	57	0.23	5.37	0.91
n-Nonane (111-84-2)	57	56	0.02	0.26	0.07
n-Octane (111-65-9)	57	57	0.02	1.07	0.23
n-Pentane (109-66-0)	57	57	0.47	13.50	2.30
n-Propylbenzene (103-65-1)	57	23	0.01	0.08	0.02
n-Tridecane (629-50-5)	57	12	0.01	0.07	0.01
n-Undecane (1120-21-4)	57	49	0.01	0.07	0.02
o-Ethyltoluene (611-14-3)	57	15	0.01	0.09	0.02
o-Xylene (95-47-6)	57	56	0.01	0.27	0.05
p-Diethylbenzene (105-05-5)	57	2	0.03	0.07	0.01
p-Ethyltoluene (622-96-8)	57	29	0.01	0.13	0.03
Propane (74-98-6)	57	57	4.03	111.00	19.00
Propylene (115-07-1)	57	57	0.07	1.97	0.23
Propyne (74-99-7)	57	1	0.18	0.18	0.03
Styrene (100-42-5)	57	20	0.02	2.80	0.36
Toluene (108-88-3)	57	57	0.16	7.06	0.95
trans-2-Butene (624-64-6)	57	8	0.02	0.23	0.02
trans-2-Hexene (4050-45-7)	57	1	0.04	0.04	0.02
trans-2-Pentene (646-04-8)	57	18	0.01	0.14	0.03

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

Table B-4
Garfield County SNMOC Monitoring
Battlement Mesa (BMCO)
1/4/2013-12/24/2013 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	55	19	0.01	0.13	0.02
1,2,4-Trimethylbenzene (95-63-6)	55	55	0.03	0.47	0.08
1,3,5-Trimethylbenzene (108-67-8)	55	47	0.01	0.16	0.03
1,3-Butadiene (106-99-0)	55	3	0.02	0.04	0.02
1-Dodecene (112-41-4)	55	1	0.05	0.05	0.01
1-Hexene (592-41-6)	55	11	0.01	0.08	0.03
1-Nonene (124-11-8)	55	25	0.01	0.11	0.02
1-Octene (111-66-0)	55	42	0.02	0.13	0.04
1-Pentene (109-67-1)	55	41	0.01	0.13	0.03
1-Undecene (821-95-4)	55	4	0.01	0.14	0.01
2,2,3-Trimethylpentane (564-02-3)	55	36	0.02	0.11	0.03
2,2-Dimethylbutane (75-83-2)	55	53	0.02	0.32	0.08
2,3,4-Trimethylpentane (565-75-3)	55	24	0.01	0.08	0.02
2,3-Dimethylbutane (79-29-8)	55	55	0.03	0.62	0.14
2,3-Dimethylpentane (565-59-3)	55	54	0.02	0.30	0.08
2,4-Dimethylpentane (108-08-7)	55	52	0.02	0.16	0.04
2-Methyl-1-butene (563-46-2)	55	9	0.01	0.05	0.02
2-Methyl-2-butene (513-35-9)	55	8	0.03	0.06	0.02
2-Methylheptane (592-27-8)	55	54	0.02	0.46	0.11
2-Methylhexane (591-76-4)	55	54	0.06	1.04	0.36
2-Methylpentane (107-83-5)	55	55	0.19	2.53	0.64
3-Methyl-1-butene (563-45-1)	55	1	0.16	0.16	0.02
3-Methylheptane (589-81-1)	55	54	0.03	0.36	0.09
3-Methylhexane (589-34-4)	55	45	0.06	1.00	0.24
3-Methylpentane (96-14-0)	55	55	0.07	1.42	0.33
Acetylene (74-86-2)	55	55	0.09	1.19	0.35
a-Pinene (80-56-8)	55	14	0.01	0.14	0.02
Benzene (71-43-2)	55	54	0.18	1.18	0.39
cis-2-Butene (590-18-1)	55	5	0.02	0.07	0.01
cis-2-Hexene (7688-21-3)	55	1	0.02	0.02	0.02
Cyclohexane (110-82-7)	55	55	0.14	2.88	0.70
Cyclopentane (287-92-3)	55	53	0.04	0.41	0.10
Cyclopentene (142-29-0)	55	2	0.06	0.06	0.02
Ethane (74-84-0)	55	55	8.70	168.00	34.21
Ethylbenzene (100-41-4)	55	50	0.01	0.11	0.03
Ethylene (74-85-1)	55	55	0.33	2.52	1.01
Isobutane (75-28-5)	55	55	0.53	15.55	3.08
Isobutylene (115-11-7)	55	1	0.06	0.06	0.02
Isopentane (78-78-4)	55	41	0.67	8.42	1.83
Isoprene (78-79-5)	55	26	0.01	0.25	0.05
Isopropylbenzene (98-82-8)	55	1	0.01	0.01	0.01
m-Diethylbenzene (141-93-5)	55	4	0.03	0.18	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
Battlement Mesa (BMCO)
1/4/2013-12/24/2013 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Methylcyclohexane (108-87-2)	55	55	0.13	4.96	1.26
Methylcyclopentane (96-37-7)	55	55	0.10	1.55	0.38
m-Ethyltoluene (620-14-4)	55	27	0.03	0.09	0.03
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	55	55	0.10	1.08	0.28
n-Butane (106-97-8)	55	55	0.57	15.92	3.28
n-Decane (124-18-5)	55	55	0.03	0.29	0.08
n-Dodecane (112-40-3)	55	52	0.01	0.16	0.02
n-Heptane (142-82-5)	55	55	0.08	2.11	0.50
n-Hexane (110-54-3)	55	55	0.16	2.95	0.69
n-Nonane (111-84-2)	55	55	0.02	0.51	0.12
n-Octane (111-65-9)	55	55	0.05	1.25	0.31
n-Pentane (109-66-0)	55	55	0.28	6.52	1.41
n-Propylbenzene (103-65-1)	55	11	0.01	0.03	0.01
n-Tridecane (629-50-5)	55	18	0.00	0.02	0.01
n-Undecane (1120-21-4)	55	54	0.01	0.10	0.04
o-Ethyltoluene (611-14-3)	55	14	0.01	0.06	0.01
o-Xylene (95-47-6)	55	55	0.02	0.17	0.06
p-Diethylbenzene (105-05-5)	55	16	0.01	0.18	0.03
p-Ethyltoluene (622-96-8)	55	20	0.01	0.08	0.02
Propane (74-98-6)	55	55	2.46	60.00	12.01
Propylene (115-07-1)	55	55	0.06	0.69	0.21
Styrene (100-42-5)	55	2	0.09	0.31	0.04
Toluene (108-88-3)	55	55	0.37	4.21	1.48
trans-2-Butene (624-64-6)	55	16	0.03	0.09	0.02
trans-2-Pentene (646-04-8)	55	8	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
Carbondale (RFCO)
1/10/2013-12/12/2013 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	29	11	0.01	0.10	0.02
1,2,4-Trimethylbenzene (95-63-6)	29	29	0.03	0.47	0.12
1,3,5-Trimethylbenzene (108-67-8)	29	17	0.01	0.09	0.03
1,3-Butadiene (106-99-0)	29	6	0.02	0.05	0.03
1-Heptene (592-76-7)	29	2	0.02	0.03	0.01
1-Hexene (592-41-6)	29	5	0.01	0.03	0.03
1-Nonene (124-11-8)	29	13	0.01	0.55	0.04
1-Octene (111-66-0)	29	28	0.01	0.12	0.04
1-Pentene (109-67-1)	29	26	0.02	0.07	0.03
2,2,3-Trimethylpentane (564-02-3)	29	5	0.02	0.06	0.02
2,2,4-Trimethylpentane (540-84-1)	29	20	0.01	0.07	0.03
2,2-Dimethylbutane (75-83-2)	29	10	0.02	0.08	0.02
2,3,4-Trimethylpentane (565-75-3)	29	20	0.02	0.16	0.04
2,3-Dimethylbutane (79-29-8)	29	25	0.01	0.17	0.03
2,3-Dimethylpentane (565-59-3)	29	24	0.02	0.12	0.04
2,4-Dimethylpentane (108-08-7)	29	10	0.02	0.06	0.02
2-Methyl-1-butene (563-46-2)	29	11	0.03	0.07	0.03
2-Methyl-2-butene (513-35-9)	29	16	0.03	0.08	0.03
2-Methylheptane (592-27-8)	29	10	0.01	0.13	0.02
2-Methylhexane (591-76-4)	29	29	0.03	0.75	0.15
2-Methylpentane (107-83-5)	29	29	0.06	0.95	0.21
3-Methylheptane (589-81-1)	29	17	0.01	0.10	0.02
3-Methylhexane (589-34-4)	29	6	0.07	0.57	0.08
3-Methylpentane (96-14-0)	29	28	0.02	0.46	0.09
Acetylene (74-86-2)	29	29	0.11	1.24	0.44
a-Pinene (80-56-8)	29	26	0.01	0.24	0.08
Benzene (71-43-2)	29	23	0.08	0.40	0.15
b-Pinene (127-91-3)	29	1	0.15	0.15	0.01
cis-2-Butene (590-18-1)	29	15	0.02	0.10	0.02
cis-2-Pentene (627-20-3)	29	3	0.01	0.02	0.02
Cyclohexane (110-82-7)	29	29	0.02	0.76	0.12
Cyclopentane (287-92-3)	29	9	0.04	0.14	0.03
Cyclopentene (142-29-0)	29	2	0.02	0.07	0.02
Ethane (74-84-0)	29	29	3.00	34.55	7.37
Ethylbenzene (100-41-4)	29	26	0.02	0.07	0.03
Ethylene (74-85-1)	29	29	0.23	2.20	1.04
Isobutane (75-28-5)	29	29	0.20	3.35	0.75
Isobutylene (115-11-7)	29	1	0.07	0.07	0.03
Isopentane (78-78-4)	29	13	0.11	2.34	0.50
Isoprene (78-79-5)	29	19	0.01	1.07	0.23
Isopropylbenzene (98-82-8)	29	9	0.01	0.03	0.01
m-Diethylbenzene (141-93-5)	29	2	0.07	0.09	0.02

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

Table B-5 (continued)
Garfield County SNMOC Monitoring
Carbondale (RFCO)
1/10/2013-12/12/2013 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Methylcyclohexane (108-87-2)	29	27	0.02	1.44	0.17
Methylcyclopentane (96-37-7)	29	28	0.02	0.42	0.08
m-Ethyltoluene (620-14-4)	29	26	0.03	0.35	0.11
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	29	29	0.04	0.36	0.11
n-Butane (106-97-8)	29	29	0.28	3.88	0.91
n-Decane (124-18-5)	29	27	0.01	0.17	0.05
n-Dodecane (112-40-3)	29	27	0.01	0.14	0.03
n-Heptane (142-82-5)	29	29	0.02	0.51	0.12
n-Hexane (110-54-3)	29	29	0.04	0.84	0.18
n-Nonane (111-84-2)	29	26	0.01	0.15	0.02
n-Octane (111-65-9)	29	29	0.03	0.34	0.07
n-Pentane (109-66-0)	29	29	0.12	2.00	0.47
n-Propylbenzene (103-65-1)	29	18	0.01	0.11	0.03
n-Tridecane (629-50-5)	29	9	0.01	0.03	0.01
n-Undecane (1120-21-4)	29	19	0.01	0.06	0.02
o-Ethyltoluene (611-14-3)	29	6	0.02	0.09	0.02
o-Xylene (95-47-6)	29	27	0.02	0.15	0.05
p-Diethylbenzene (105-05-5)	29	2	0.02	0.05	0.01
p-Ethyltoluene (622-96-8)	29	22	0.01	0.19	0.05
Propane (74-98-6)	29	29	1.10	11.97	3.10
Propylene (115-07-1)	29	29	0.07	0.60	0.23
Styrene (100-42-5)	29	12	0.15	4.11	0.66
Toluene (108-88-3)	29	29	0.07	5.33	1.16
trans-2-Butene (624-64-6)	29	16	0.02	0.12	0.03
trans-2-Pentene (646-04-8)	29	19	0.02	0.08	0.03

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

APPENDIX C

Carbonyl Concentrations

Table C-1
Garfield County Carbonyl Monitoring
Parachute (PACO)
1/10/2013-11/30/2013 (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
2-Butanone (78-93-3)	26	23	0.04	0.80	0.32
Acetaldehyde (75-07-0)	26	25	0.04	1.02	0.41
Acetone (67-64-1)	26	26	0.13	1.63	0.96
Benzaldehyde (100-52-7)	26	25	0.00	0.11	0.02
Butyraldehyde (123-72-8)	26	24	0.00	0.12	0.03
Crotonaldehyde (123-73-9)	26	24	0.00	0.10	0.02
Formaldehyde (50-00-0)	26	26	0.08	2.04	1.04
Hexaldehyde (66-25-1)	26	26	0.00	0.02	0.01
Isovaleraldehyde (590-86-3)	26	0	ND	ND	0.00
Propionaldehyde (123-38-6)	26	23	0.01	0.14	0.03
Tolualdehydes (NA)	26	21	0.01	0.02	0.01
Valeraldehyde (110-62-3)	26	22	0.00	0.02	0.01

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

Table C-2
Garfield County Carbonyl Monitoring
Rifle (RICO)
1/10/2013-12/24/2013 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	25	0	ND	ND	0.00
2-Butanone (78-93-3)	25	21	0.01	0.82	0.26
Acetaldehyde (75-07-0)	25	25	0.02	1.17	0.51
Acetone (67-64-1)	25	25	0.04	1.59	0.94
Benzaldehyde (100-52-7)	25	24	0.00	0.06	0.03
Butyraldehyde (123-72-8)	25	22	0.00	0.14	0.04
Crotonaldehyde (123-73-9)	25	22	0.01	0.10	0.03
Formaldehyde (50-00-0)	25	25	0.01	3.56	1.13
Hexaldehyde (66-25-1)	25	25	0.00	0.04	0.02
Isovaleraldehyde (590-86-3)	25	0	ND	ND	0.00
Propionaldehyde (123-38-6)	25	24	0.00	0.14	0.05
Tolualdehydes (NA)	25	21	0.00	0.03	0.02
Valeraldehyde (110-62-3)	25	24	0.00	0.02	0.01

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

Table C-3
Garfield County Carbonyl Monitoring
Bell-Melton (BRCO)
1/10/2013-11/30/2013 (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
2-Butanone (78-93-3)	26	23	0.04	0.66	0.28
Acetaldehyde (75-07-0)	26	26	0.03	0.76	0.31
Acetone (67-64-1)	26	26	0.14	1.60	0.84
Benzaldehyde (100-52-7)	26	24	0.00	0.13	0.02
Butyraldehyde (123-72-8)	26	24	0.01	0.06	0.02
Crotonaldehyde (123-73-9)	26	25	0.00	0.19	0.04
Formaldehyde (50-00-0)	26	26	0.11	1.55	0.71
Hexaldehyde (66-25-1)	26	25	0.00	0.03	0.01
Isovaleraldehyde (590-86-3)	26	0	ND	ND	0.00
Propionaldehyde (123-38-6)	26	25	0.01	0.06	0.03
Tolualdehydes (NA)	26	21	0.00	0.02	0.01
Valeraldehyde (110-62-3)	26	21	0.00	0.02	0.01

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

Table C-4
Garfield County Carbonyl Monitoring
Battlement Mesa (BMCO)
1/10/2013-12/24/2013 (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
2-Butanone (78-93-3)	28	26	0.04	0.66	0.28
Acetaldehyde (75-07-0)	28	27	0.02	0.59	0.24
Acetone (67-64-1)	28	28	0.03	1.61	0.74
Benzaldehyde (100-52-7)	28	23	0.00	0.06	0.01
Butyraldehyde (123-72-8)	28	27	0.00	0.06	0.02
Crotonaldehyde (123-73-9)	28	23	0.01	0.11	0.02
Formaldehyde (50-00-0)	28	28	0.04	2.74	0.66
Hexaldehyde (66-25-1)	28	25	0.00	0.02	0.01
Isovaleraldehyde (590-86-3)	28	0	ND	ND	0.00
Propionaldehyde (123-38-6)	28	27	0.00	0.06	0.02
Tolualdehydes (NA)	28	18	0.00	0.02	0.01
Valeraldehyde (110-62-3)	28	20	0.00	0.01	0.00

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

Table C-5
Garfield County Carbonyl Monitoring
Carbondale (RFCO)
1/10/2013-12/24/2013 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	27	0	ND	ND	0.00
2-Butanone (78-93-3)	27	22	0.03	0.78	0.23
Acetaldehyde (75-07-0)	27	27	0.03	0.99	0.32
Acetone (67-64-1)	27	27	0.09	1.34	0.68
Benzaldehyde (100-52-7)	27	24	0.00	0.09	0.02
Butyraldehyde (123-72-8)	27	23	0.00	0.06	0.02
Crotonaldehyde (123-73-9)	27	20	0.01	0.22	0.04
Formaldehyde (50-00-0)	27	27	0.03	1.48	0.61
Hexaldehyde (66-25-1)	27	25	0.00	0.04	0.01
Isovaleraldehyde (590-86-3)	27	0	ND	ND	0.00
Propionaldehyde (123-38-6)	27	22	0.00	0.08	0.03
Tolualdehydes (NA)	27	16	0.00	0.04	0.01
Valeraldehyde (110-62-3)	27	20	0.00	0.02	0.01

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