GARFIELD COUNTY
2012 AIR QUALITY MONITORING SUMMARY

Prepared for:

Garfield County Public Health Department
195 West 14th Street
Rifle, CO 81650

Prepared by:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
www.air-resource.com

July 31, 2013

TABLE OF CONTENTS

Section			Page
LIST OF ACRONYMS AND ABBREVIATIONS			**iv**
EXECUTIVE SUMMARY			**v**
1.0	**INTRODUCTION**		**1-1**
2.0	**METEOROLOGICAL SUMMARIES**		**2-1**
3.0	**CRITERIA POLLUTANT SUMMARIES**		**3-1**
	3.1	Ozone	3-5
	3.2	Nitrogen Dioxide	3-8
	3.3	Particulate Matter	3-9
		3.3.1 Filter Based PM_{10} Measurements	3-9
		3.3.2 Continuous PM Measurements	3-12
4.0	**VOLATILE ORGANIC COMPOUNDS**		**4-1**
	4.1	Speciated Non-Methane Hydrocarbons	4-1
		4.1.1 Annual Average SNMOCs	4-5
	4.2	Carbonyls	4-5
		4.2.1 Annual Average Carbonyl Concentrations	4-8
	4.3	Hazardous Air Pollutants Summaries	4-9
		4.3.1 Annual Average HAP Concentrations	4-9
5.0	**REFERENCES**		**5-1**
APPENDIX A	Garfield County 2012 Monthly Time Series Plots		**A-1**
APPENDIX B	Garfield County 2012 SNMOC Concentrations		**B-1**
APPENDIX C	Garfield County 2012 Carbonyl Concentrations		**C-1**

LIST OF FIGURES

Figure		Page
1-1	Map of Garfield County Monitoring Sites	1-2
2-1	Map with Wind Roses Depicting 2012 Wind Speed and Direction Measured at the Garfield County Monitoring Sites	2-1
3-1	2012 Diurnal Average Concentrations of Ozone and Nitrogen Dioxide Measured at the Battlement Mesa Site	3-6
3-2	Daily Maximum 8-Hour Averages of Ozone Monitored at the Rifle Site	3-7
3-3	Daily Maximum 8-Hour Averages of Ozone Monitored at the Battlement Mesa Site	3-7
3-4	Daily Maximum 8-Hour Averages of Ozone Monitored at the Carbondale Site	3-8

LIST OF FIGURES

Figure		Page
3-5	Daily Maximum 1-Hour Averages of Nitrogen Dioxide Monitored at the Battlement Mesa Site	3-9
3-6	Annual Average PM_{10} Measured at the Parachute Site	3-11
3-7	Annual Average PM_{10} Measured at the Rifle Site	3-11
3-8	Highest and Second Highest 24-Hour Average PM_{10} Measured at the Parachute Site	3-12
3-9	Highest and Second Highest 24-Hour Average PM_{10} Measured at the Rifle Site	3-12
3-10	Annual Average $PM_{2.5}$ Measured at the Rifle Site	3-13
3-11	Highest and 98th Percentile 24-Hour Average $PM_{2.5}$ Measured at the Rifle Site	3-13
4-1	2012 24-Hour SNMOC Measurements by Category in Units of ppbV	4-3
4-2	2012 24-Hour SNMOC Measurements by Category in Units of ppbC	4-4
4-3	Average SNMOC Concentrations Measured by the Garfield County Air Monitoring Program between 2008 and 2012	4-5
4-4	2012 24-Hour Major Carbonyl Compound Concentrations in Units of ppbV	4-7
4-5	Average Carbonyl Concentrations Measured by the Garfield County Air Monitoring Program between 2008 and 2012	4-8
4-6	Annual Average HAP Concentrations Measured at the Parachute Site between 2008 and 2012, along with 2009 US Average, Minimum, and Maximum Annual Average Values as Reported by the EPA	4-15
4-7	Annual Average HAP Concentrations Measured at the Rifle Site between 2008 and 2012, along with 2009 US Average, Minimum, and Maximum Annual Average Values as Reported by the EPA	4-16
4-8	Annual Average HAP Concentrations Measured at the Bell-Melton Site between 2008 and 2012, along with 2009 US Average, Minimum, and Maximum Annual Average Values as Reported by the EPA	4-17
4-9	Annual Average HAP Concentrations Measured at the Battlement Mesa Site between 2008 and 2012, along with 2009 US Average, Minimum, and Maximum Annual Average Values as Reported by the EPA	4-18

LIST OF TABLES

Table		Page
1-1	Garfield County Parameters Monitored by Site	1-3
3-1	2012 Standards Summary for the Rifle Site	3-2
3-2	2012 Standards Summary for the Parachute Site	3-2
3-3	Battlement Mesa Site Standards Summary 10/24/2012-12/31/2012	3-3
3-4	Carbondale Site Standards Summary 3/29/2012-12/31/2012	3-4
4-1	Parachute Site Annual Average Mass Trends (HAPs Parameters) 2008-2012	4-11
4-2	Rifle Site Annual Average Mass Trends (HAPs Parameters) 2008-2012	4-12
4-3	Bell-Melton Site Annual Average Mass Trends (HAPs Parameters) 2008-2012	4-13
4-4	Battlement Mesa Site Annual Average Mass Trends (HAPs Parameters) 2011-2012	4-14

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
EPA	U.S. Environmental Protection Agency
ERG	Eastern Research Group, Inc.
FRM	Federal Reference Method
GCPHD	Garfield County Public Health Department
HAPs	Hazardous Air Pollutants
NAAQS	National Ambient Air Quality Standards
NATTS	National Air Toxics Trends Stations
NIOSH	National Institute for Occupational Safety and Health
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
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 during 2012 in Garfield County, Colorado. Air quality is currently monitored at five locations in the county, 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).
- Volatile organic compounds (VOCs), including subsets of speciated non-methane organic carbon (SNMOCs), carbonyls and hazardous air pollutants (HAPs).

Results through 2012 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 83-89% of the total SNMOC compounds measured. 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 2012 indicate that:

- Most parameters, including benzene, showed statistically significant decreasing annual average trends at all sites.
- Formaldehyde showed slightly decreasing trends at the more rural sites and no significant trend at the more urban Rifle site. Comparisons to regional measurements

indicated that formaldehyde was measured at much lower levels than larger nearby urban sites (e.g., Grand Junction).

- 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.

Detailed air quality monitoring information through 2012 is provided 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 assessments are available from the Garfield County Air Quality Management website (http://www.garfield-county.com/air-quality/. Any questions regarding air quality in Garfield County should be addressed to:

Garfield County Public Health Department
195 West 14th Street
Rifle, CO 81650

Phone: 970-625-5200
Fax: 970-625-4804

1.0 INTRODUCTION

Air quality monitoring in Garfield County has expanded in recent years in response to increases in citizens' concerns regarding air quality in the area, especially related to increased population and the expansion of oil and gas development in the county. 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, including monitoring of criteria pollutant levels, ozone formation potential, toxics assessments, and source attribution for specific pollutants. This annual air quality data report presents data collected in Garfield County through 2012. The 2012 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 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.
- Battlement Mesa (BMCO): Battlement Mesa is a rural community located about 1.5 miles southeast of Parachute. This site began operation in September 2010 in response to a proposed large natural gas development within to 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 Spring 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 and also to gather data downwind of the Colorado valley sites.

Figure 1-1 is a map of the 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 near real-time. Real-time data, including camera images, are displayed on the Garfield County Air Quality Monitoring website (http://www.garfieldcountyaq.net).

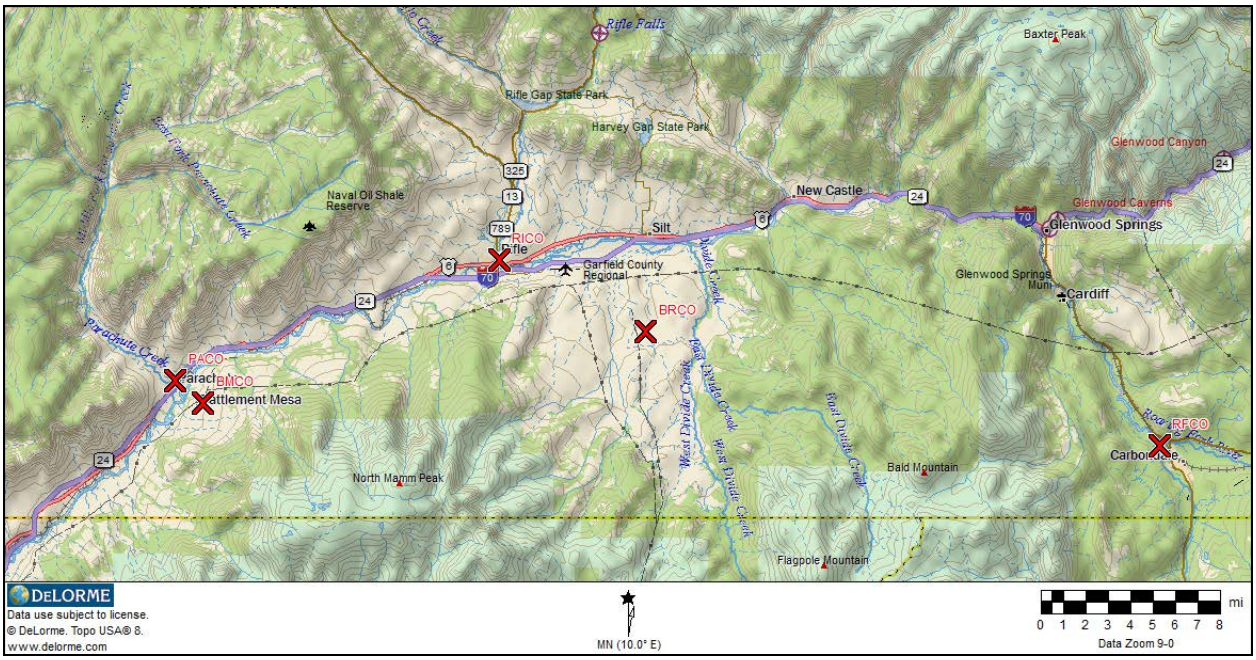


Figure 1-1. Map of Garfield County Monitoring Sites.

Table 1-1

Garfield County
Parameters Monitored by Site

Component	Method	Sampling Frequency	Reporting 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	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 depicting wind direction and wind speed measured in 2012. 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. Note that, due to power supply issues, there was not sufficient wind data collected at the Bell-Melton site to construct an annual wind rose. Also, annual winds for Carbondale are not indicated on the chart, as monitoring at this site began in late 2012.

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. Also, airflow is influenced by various drainage flows through valleys along various Colorado River tributaries.

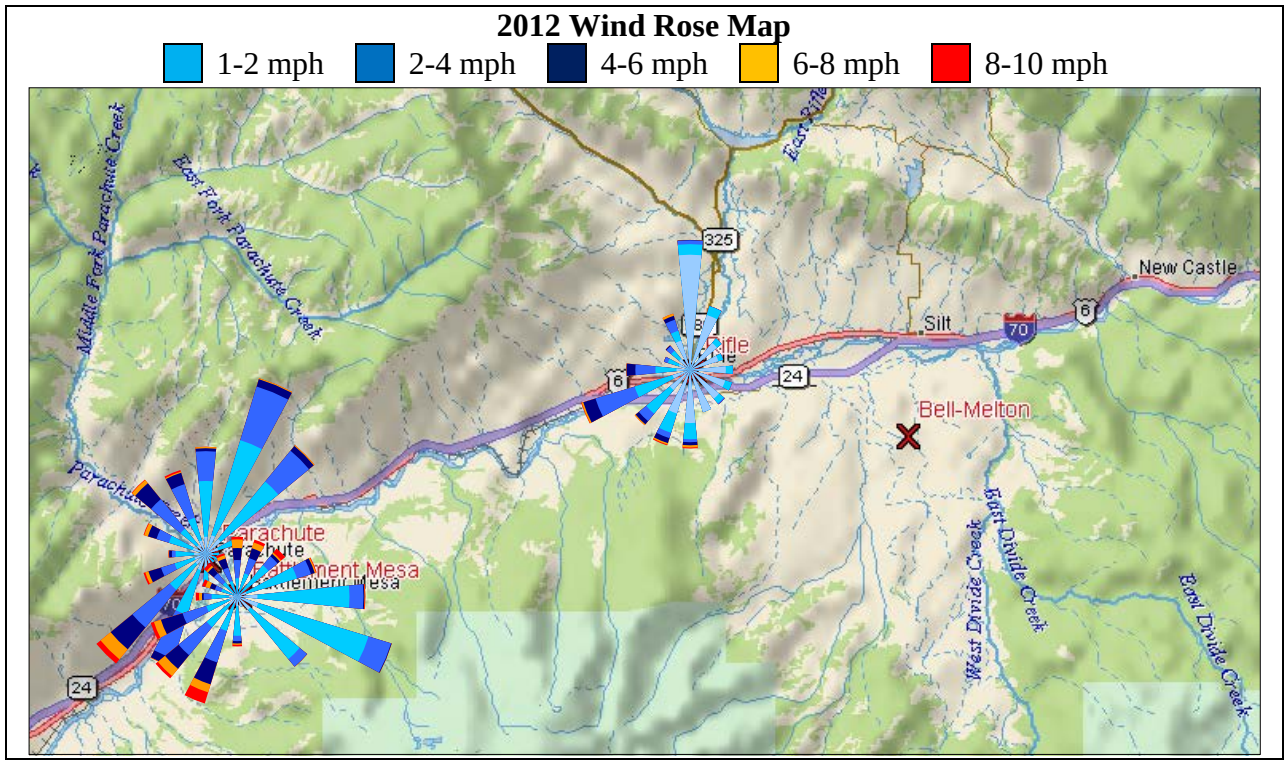


Figure 2-1. Map with Wind Roses Depicting 2012 Wind Speed and Direction Measured at the Garfield County Monitoring Sites.

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 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 effects, including visibility impairment and effects on the environment (e.g., vegetation, soils, water, and wildlife).

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 $PM_{2.5}$ 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 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.

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 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 comparable 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

2012 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.: 78 ppb	4/28
			4th Highest Daily Max.: 68 ppb	4/14, 5/26
Particulate Matter ≤2.5µm* ($PM_{2.5}$)	Annual	15 µg/m^3	Arithmetic Mean: 10.4 µg/m^3	1/1-12/31
	24-hour	35 µg/m^3	Highest Daily Max.: 47.4 µg/m^3	8/16
			2nd Highest Daily Max.: 41.7 µg/m^3	8/17
Particulate Matter ≤10µm (PM_{10})**	24-hour	150 µg/m^3	Highest Daily Max.: 50 µg/m^3	4/6
			2nd Highest Daily Max.: 46 µg/m^3	8/16

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

Table 3-2

2012 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.: 65 µg/m^3	3/7
			2nd Highest Daily Max.: 44 µg/m^3	8/16

*Calculated using 1/3 day filter-based measurements

Table 3-3

Battlement Mesa Site
Standards Summary
October 24, 2012 – December 31, 2012

Parameter	NAAQS		Measured	
	Averaging Time	Standard	Measured Value	Date(s)
Ozone (O_3)	Rolling 8-hour	0.075 ppm/ 75 ppb	Highest Daily Max.: 45 ppb	11/3
			4th Highest Daily Max.: 43 ppb	11/4, 11/8
	Annual	0.053 ppm/ 53 ppb	Arithmetic Mean: 16.6 ppb	10/24- 12/31
Nitrogen Dioxide (NO_2)	1-hour	0.100 ppm/ 100 ppb	Highest Daily Max.: 31.8 ppb	12/30
			2nd Highest Daily Max.: 30.2 ppb	12/23
Particulate Matter ≤2.5µm* ($PM_{2.5}$)	Annual	15 µg/m^3	Arithmetic Mean: 2.6 µg/m^3	10/24-12/31
	24-hour	35 µg/m^3	Highest Daily Max.: 5.9 µg/m^3	12/24
			2nd Highest Daily Max.: 5.6 µg/m^3	11/9
Particulate Matter ≤10µm* (PM_{10})	Annual	50 µg/m^3	Arithmetic Mean: 4.8 µg/m^3	10/24-12/31
	24-hour	150 µg/m^3	Highest Daily Max.: 17.7 µg/m^3	11/9
			2nd Highest Daily Max.: 10.1 µg/m^3	12/30

*Calculated using continuous BAM measurements

Table 3-4

Carbondale Site
Standards Summary
March 29, 2012 – December 31, 2012

Parameter	NAAQS		Measured	
	Averaging Time	Standard	Measured Value	Date(s)
Ozone (O_3)	Rolling 8-hour	0.075 ppm/ 75 ppb	Highest Daily Max.: 69 ppb	5/26
			4th Highest Daily Max.: 66 ppb	4/14
Particulate Matter ≤2.5µm* ($PM_{2.5}$)	Annual	15 µg/m^3	Arithmetic Mean: 5.9 µg/m^3	3/29-12/31
	24-hour	35 µg/m^3	Highest Daily Max.: 24.2 µg/m^3	8/16
			2nd Highest Daily Max.: 21.3 µg/m^3	5/26
Particulate Matter ≤10µm (PM_{10})**	24-hour	150 µg/m^3	Highest Daily Max.: 40 µg/m^3	11/2
			2nd Highest Daily Max.: 38 µg/m^3	8/16

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

3.1 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 + 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.

Ozone measurements began in June 2008 at the Rifle site, in March 2013 at the Carbondale site, and in October 2012 at the Battlement Mesa site. NO_2 is monitored along with the O_3 at the Battlement Mesa site, and Figure 3-1 illustrates the average diurnal cycle of measured hourly O_3 and NO_2 for the partial year available in 2012. The cycle shows 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.

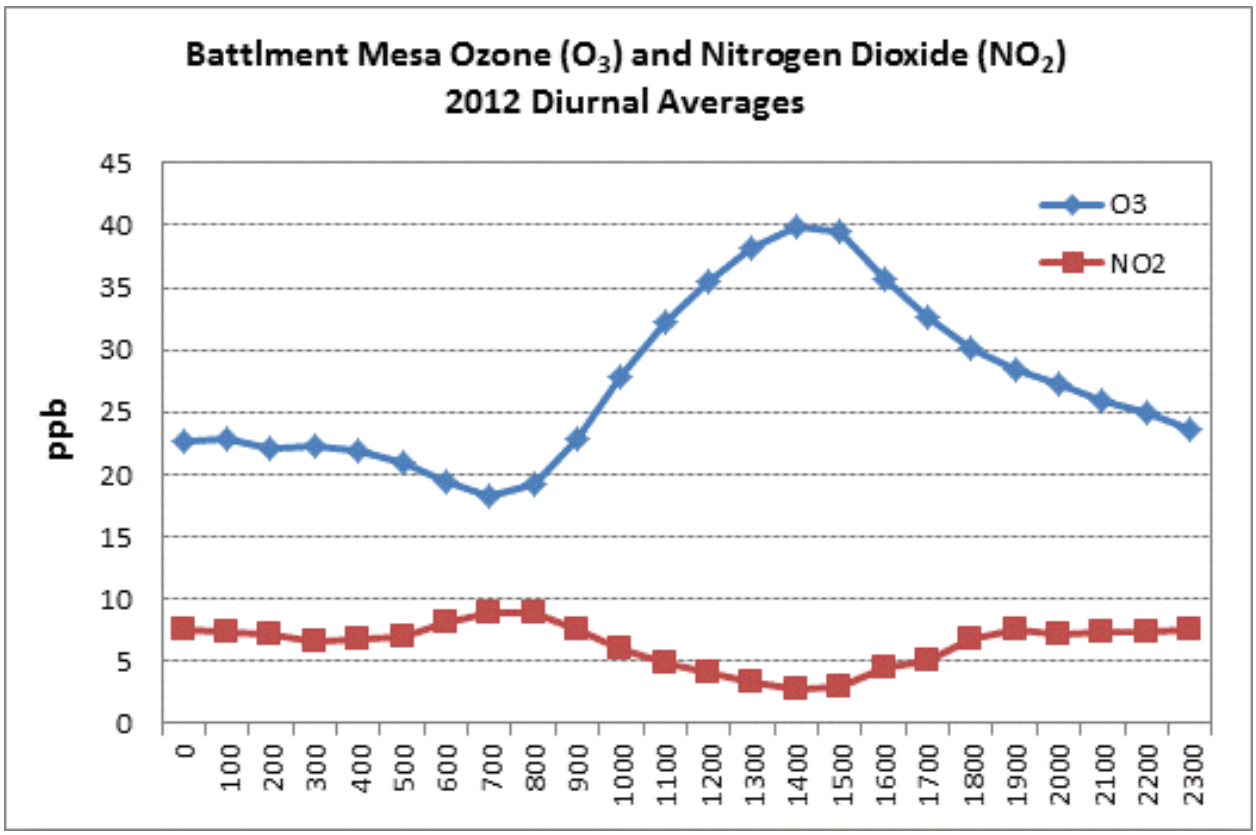


Figure 3-1. 2012 Diurnal Average Concentrations of Ozone and Nitrogen Dioxide Measured at the Battlement Mesa Site.

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 2012 respectively, along with the NAAQS. In Garfield County, O_3 measurements at the Rifle site are highest in the summer, which is consistent with the expected photo activity associated with hot summer months. It was previously thought that, due to the nature of ozone formation, elevated levels of O_3 were only possible during the summer. Recently, high O_3 readings have been recorded during the wintertime in the Green River Basin in Wyoming, and the Uintah Basin in Utah. Wintertime O_3 formation requires, along with VOC and NO_2 emissions, distinct meteorological conditions. The meteorological conditions associated with wintertime O_3 include strong temperature inversions, low winds, snow cover, and bright sunlight. O_3 measurements in Garfield County do not currently appear to be affected by the same conditions that have contributed to wintertime O_3 highs in Wyoming and Utah.

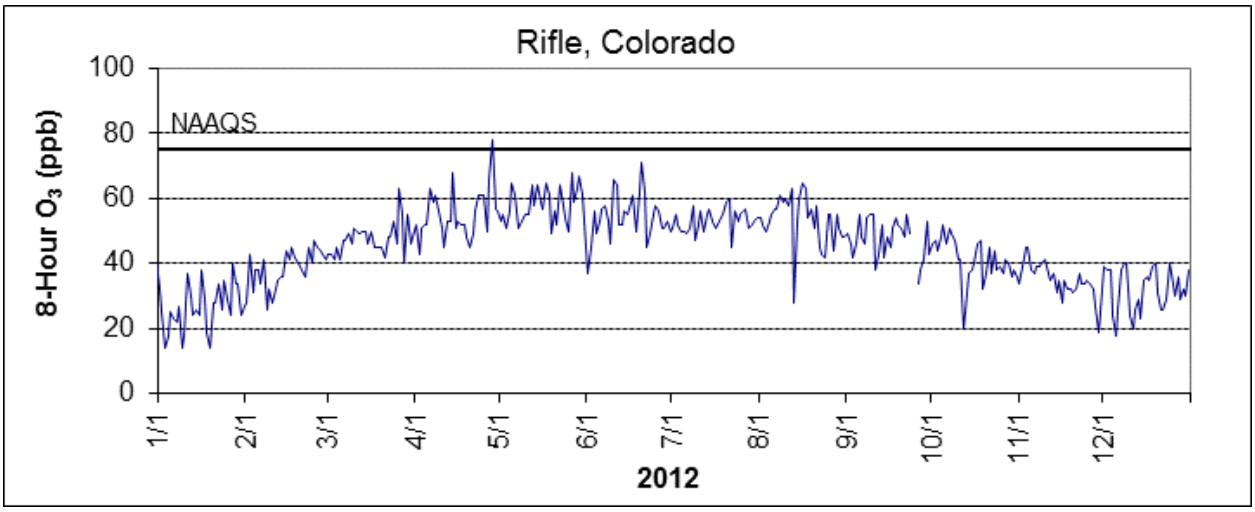


Figure 3-2. Daily Maximum 8-Hour Averages of Ozone Monitored at the Rifle Site.

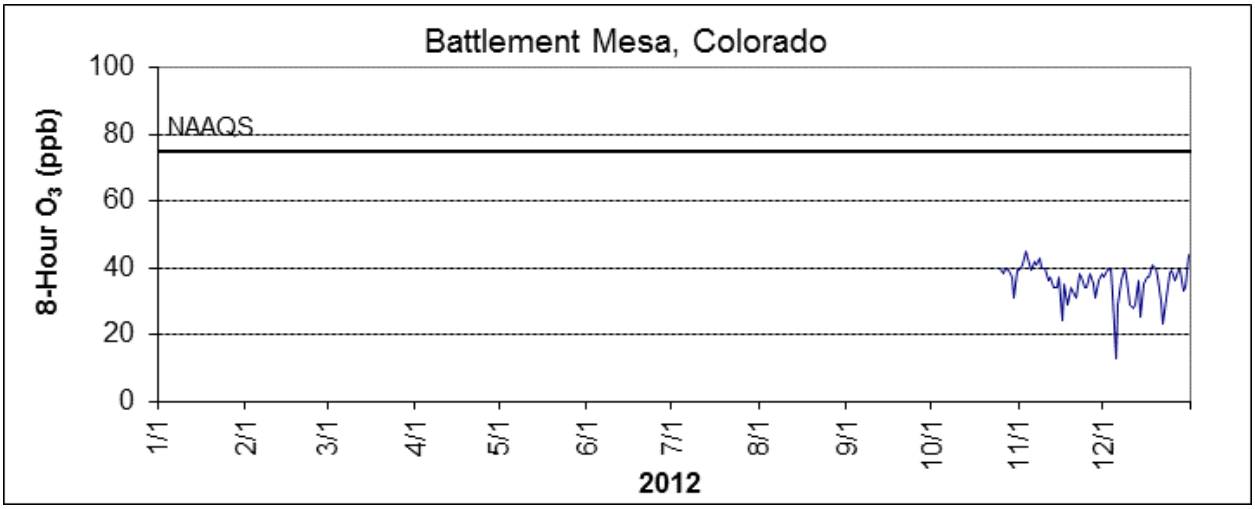


Figure 3-3. Daily Maximum 8-Hour Averages of Ozone Monitored at the Battlement Mesa Site.

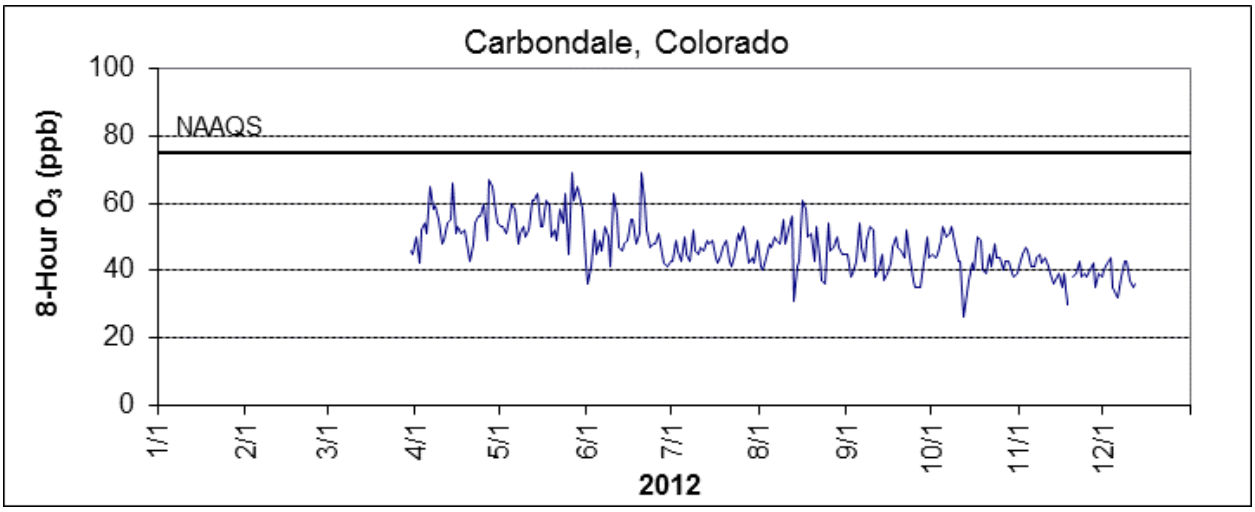


Figure 3-4. Daily Maximum 8-Hour Averages of Ozone Monitored at the Carbondale Site.

3.2 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 reported as 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 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.

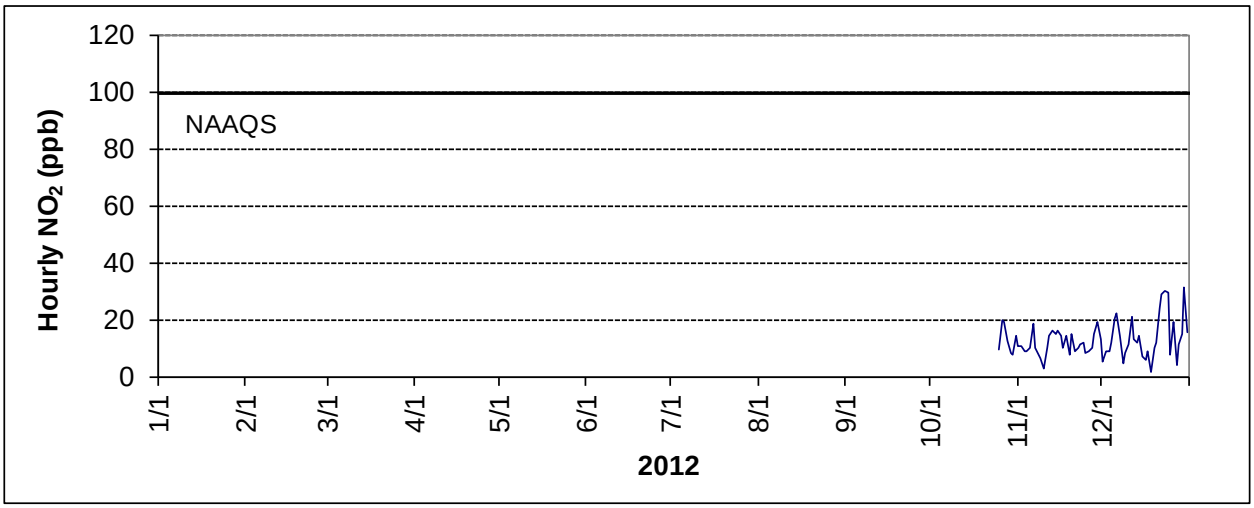


Figure 3-5. Daily Maximum 1-Hour Averages of Nitrogen Dioxide Monitored at the Battlement Mesa Site.

3.3 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 like 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 like 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.

3.3.1 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. Note that annual averages for the Carbondale site are not presented, as only a partial year was available in 2012.

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.

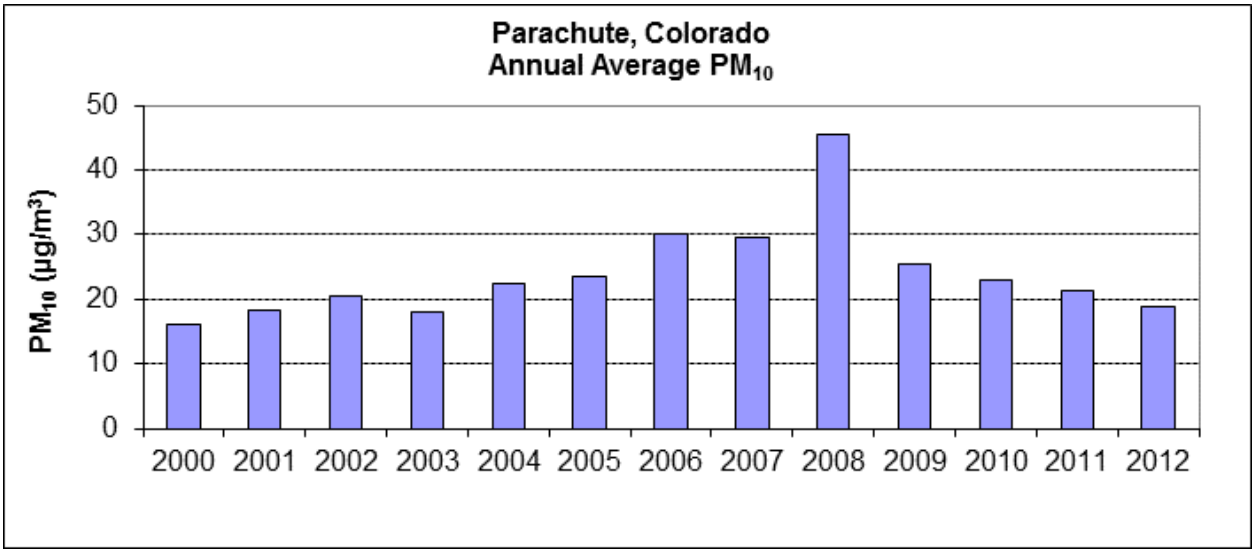


Figure 3-6. Annual Average PM_{10} Measured at the Parachute Site.

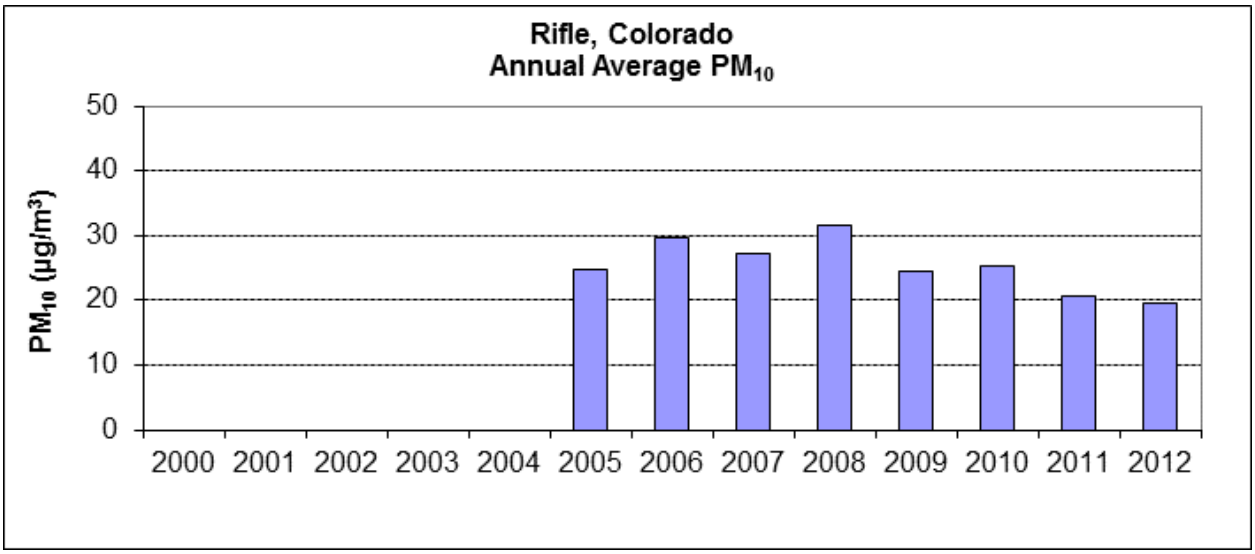


Figure 3-7. Annual Average PM_{10} Measured at the Rifle Site.

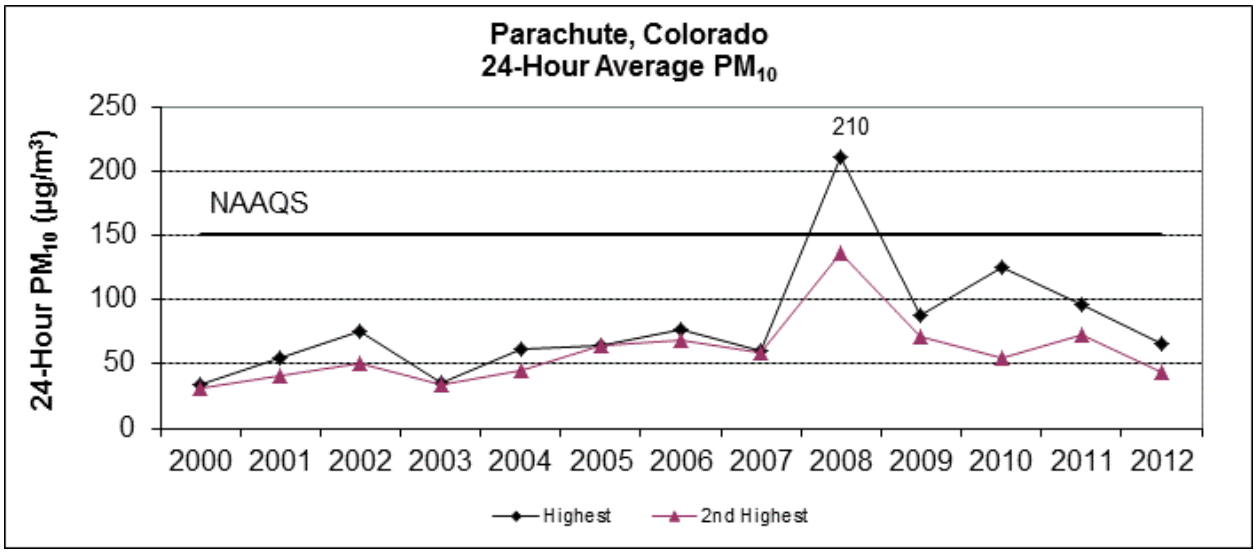


Figure 3-8. Highest and Second Highest 24-Hour Average PM_{10} Measured at the Parachute Site.

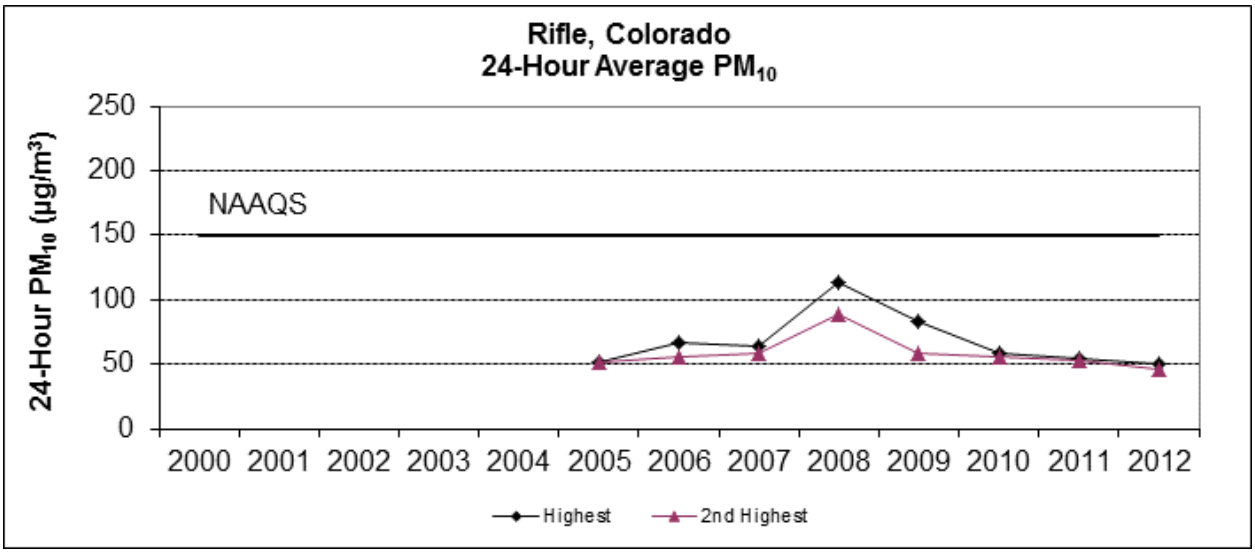


Figure 3-9. Highest and Second Highest 24-Hour Average PM_{10} Measured at the Rifle Site.

3.3.2 Continuous PM 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 15 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 $PM_{2.5}$ value in 2009 measured above the standard, but this is not considered an exceedance because the 98th percentile value was below the standard.

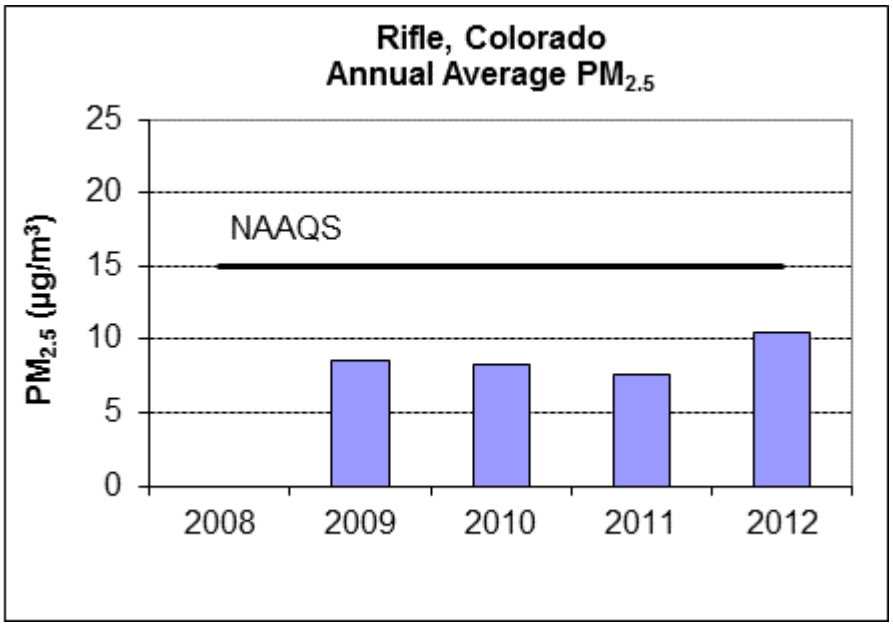


Figure 3-10. Annual Average $PM_{2.5}$ Measured at the Rifle Site.

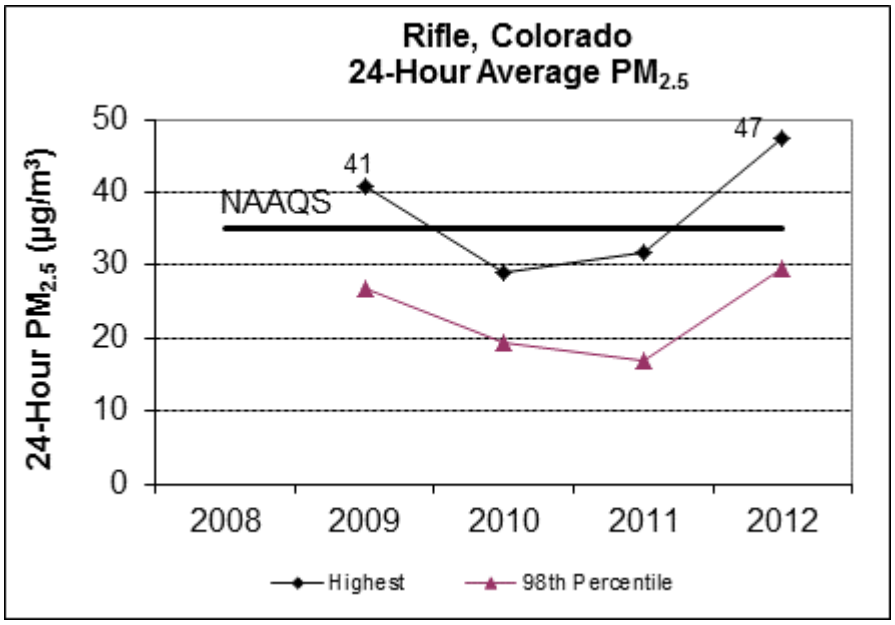


Figure 3-11. Highest and 98th Percentile 24-Hour Average $PM_{2.5}$ Measured at the Rifle Site.

4.0 VOLATILE ORGANIC COMPOUNDS

In 2012, speciated non-methane hydrocarbons (SNMOCs) and carbonyl compounds were monitored at all Garfield County sites. 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 SNMOCs, carbonyls, and HAP levels measured in 2012 are presented in this section. Plots of the sum of all SNMOCs measured, or total non-methane organic carbon (TNMOC), are presented alongside other particulate, gaseous and meteorological measurements at each site in Appendix A.

4.1 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. 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 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, 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 2012 at each site. In general, measured compounds consisted mostly of light alkanes, which represented between 83% and 89% of total SNMOCs measured. 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 4-2 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). 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.

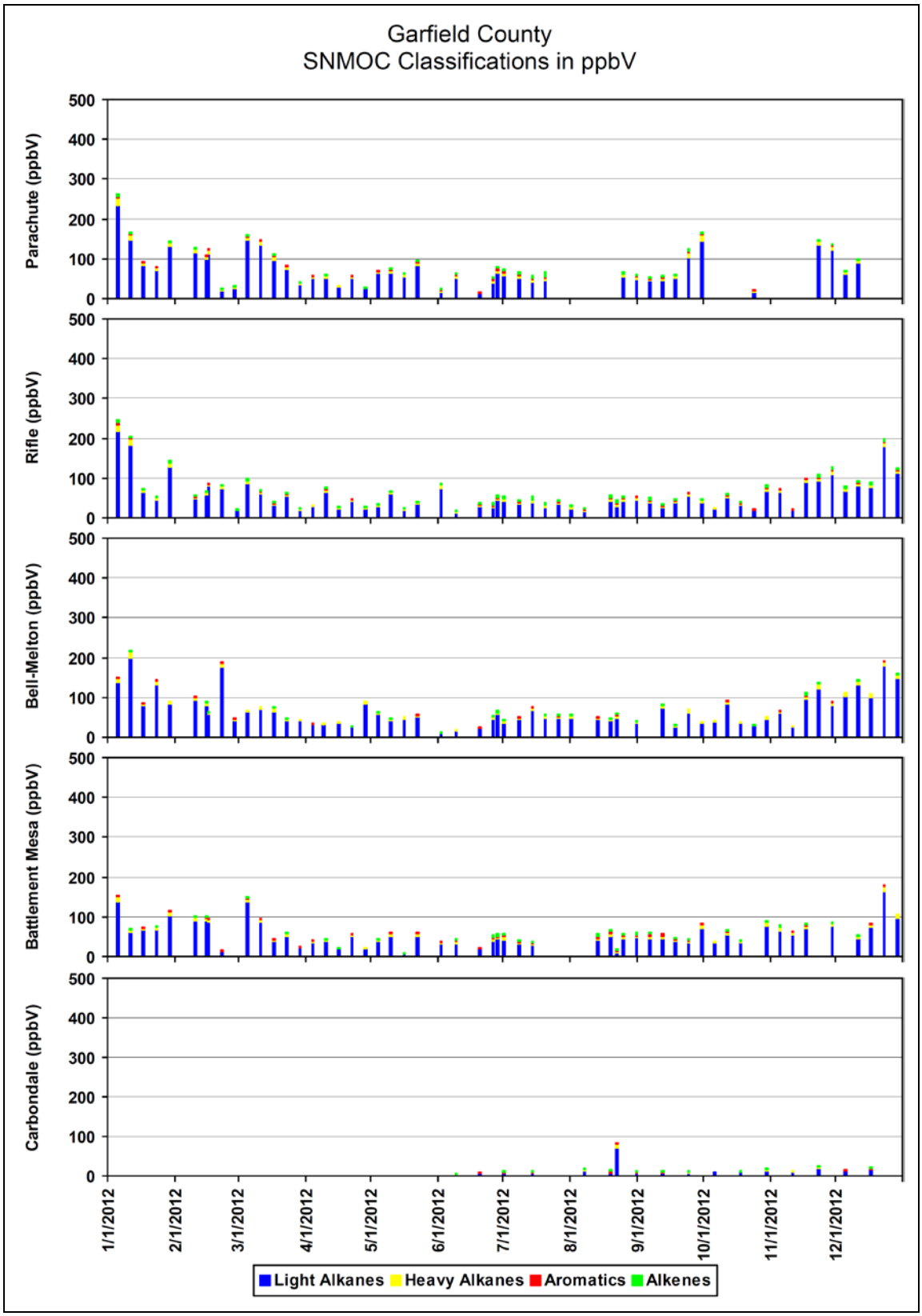


Figure 4-1. 2012 24-Hour SNMOC Measurements by Category in Units of ppbV.

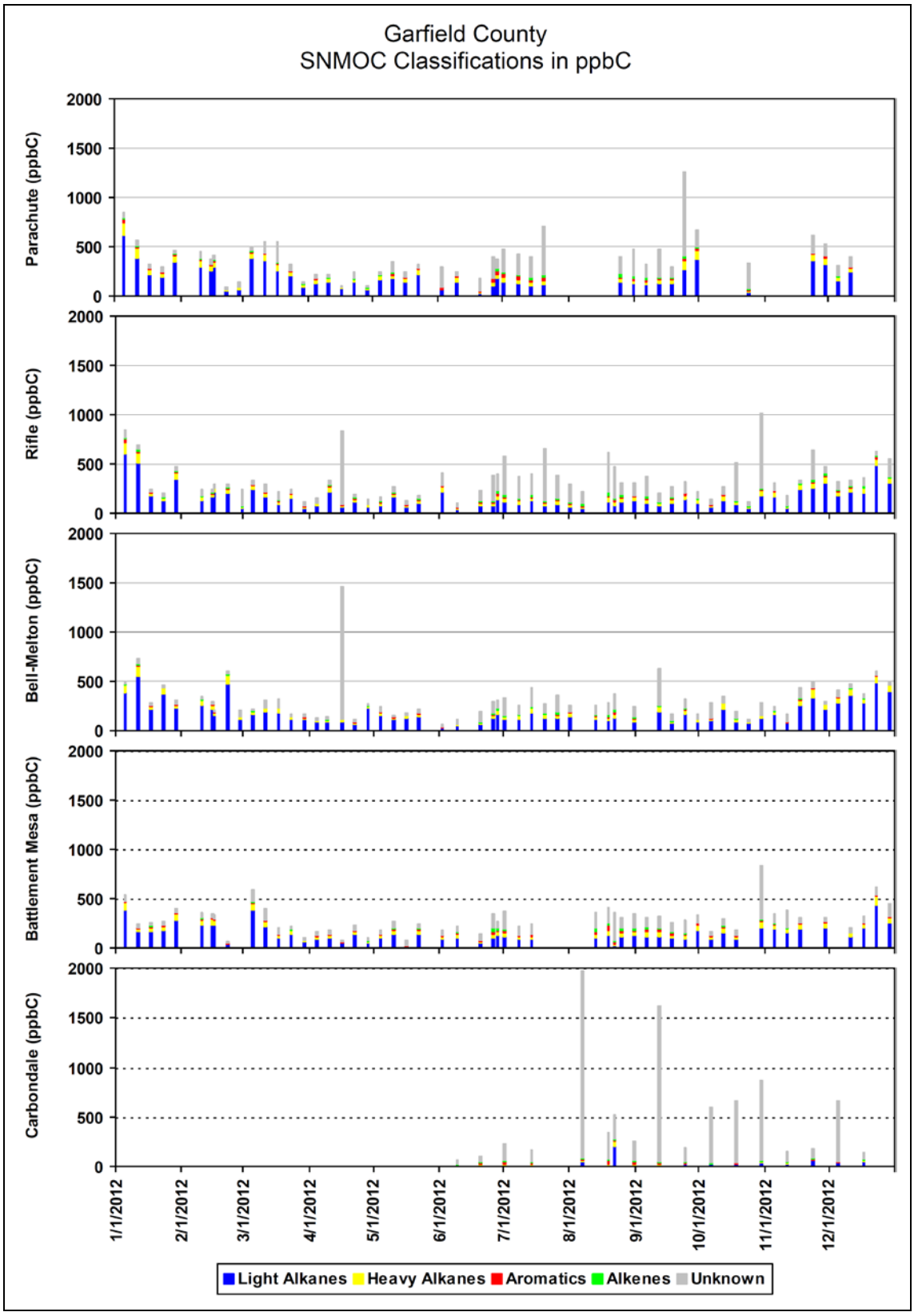


Figure 4-2. 2012 24-Hour SNMOC Measurements by Category in Units of ppbC.

4.1.1 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 4-3 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 2008, with the largest relative decreases between 2011 and 2012. 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. Note that insufficient data were available for the RFCO site to calculate a representative annual average.

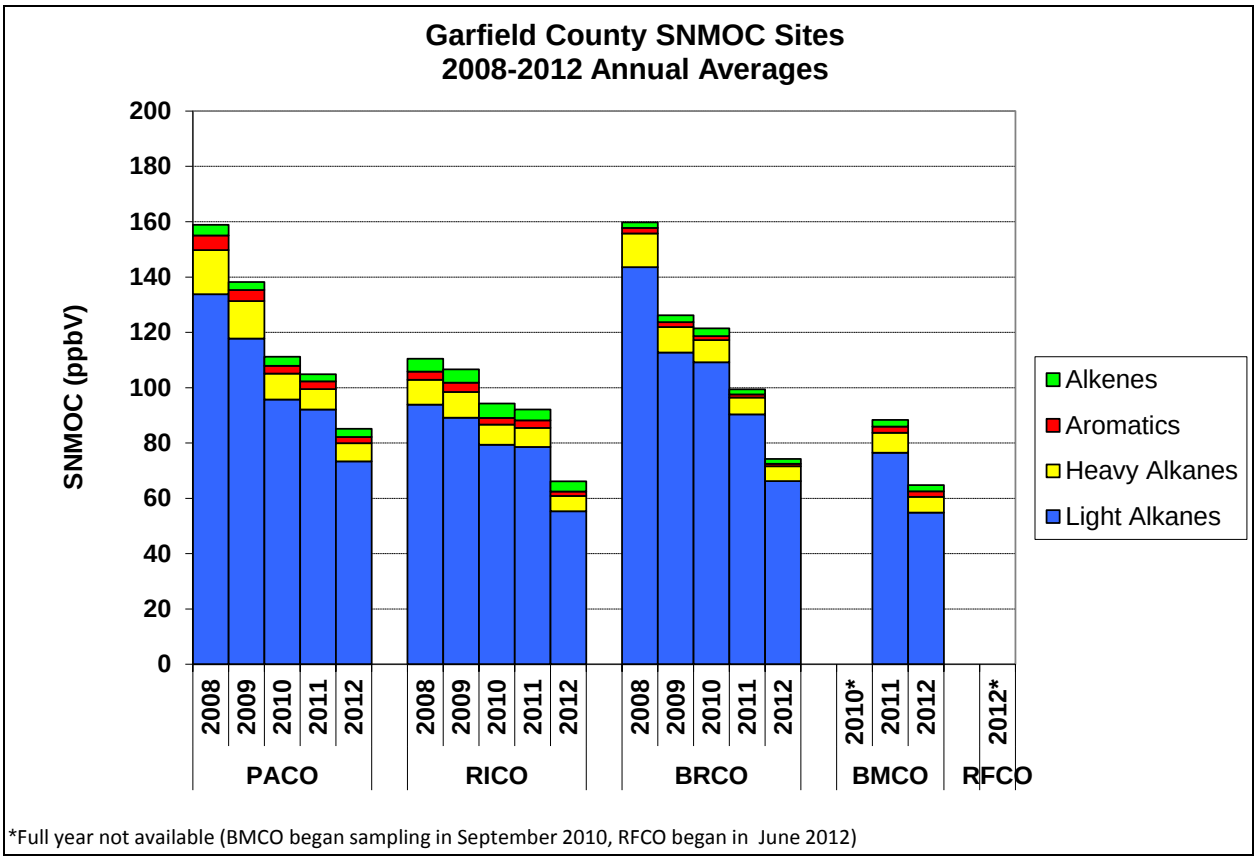


Figure 4-3 Average SNMOC Concentrations Measured by the Garfield County Air Monitoring Program between 2008 and 2012.

4.2 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 4-4 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.

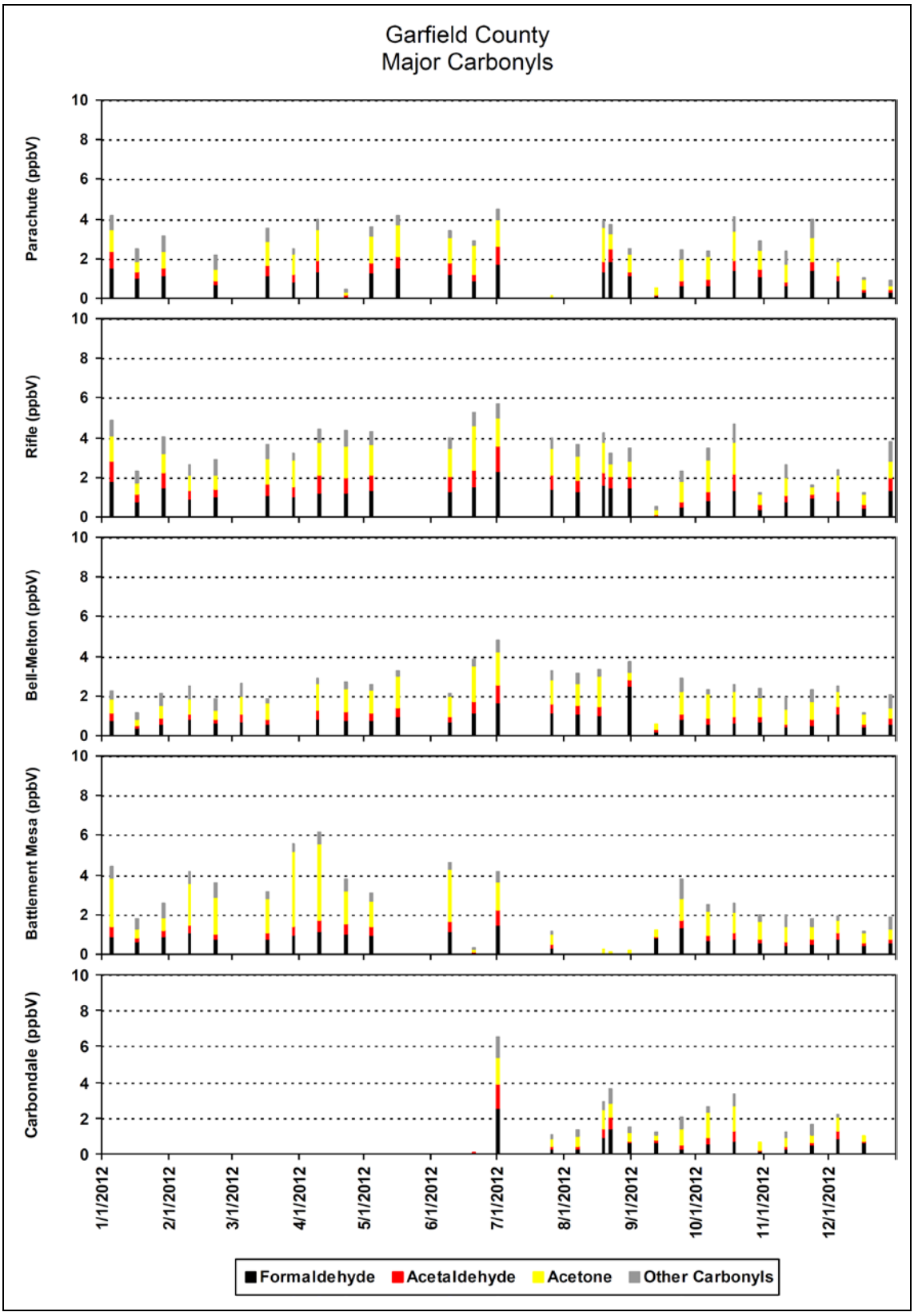


Figure 4-4. 2012 24-Hour Major Carbonyl Compound Concentrations in Units of ppbV.

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 4-5 presents comparisons of annual average carbonyl data collected between 2008 and 2012. In 2012, average measured total carbonyl levels were the lowest since measurements began 2008.

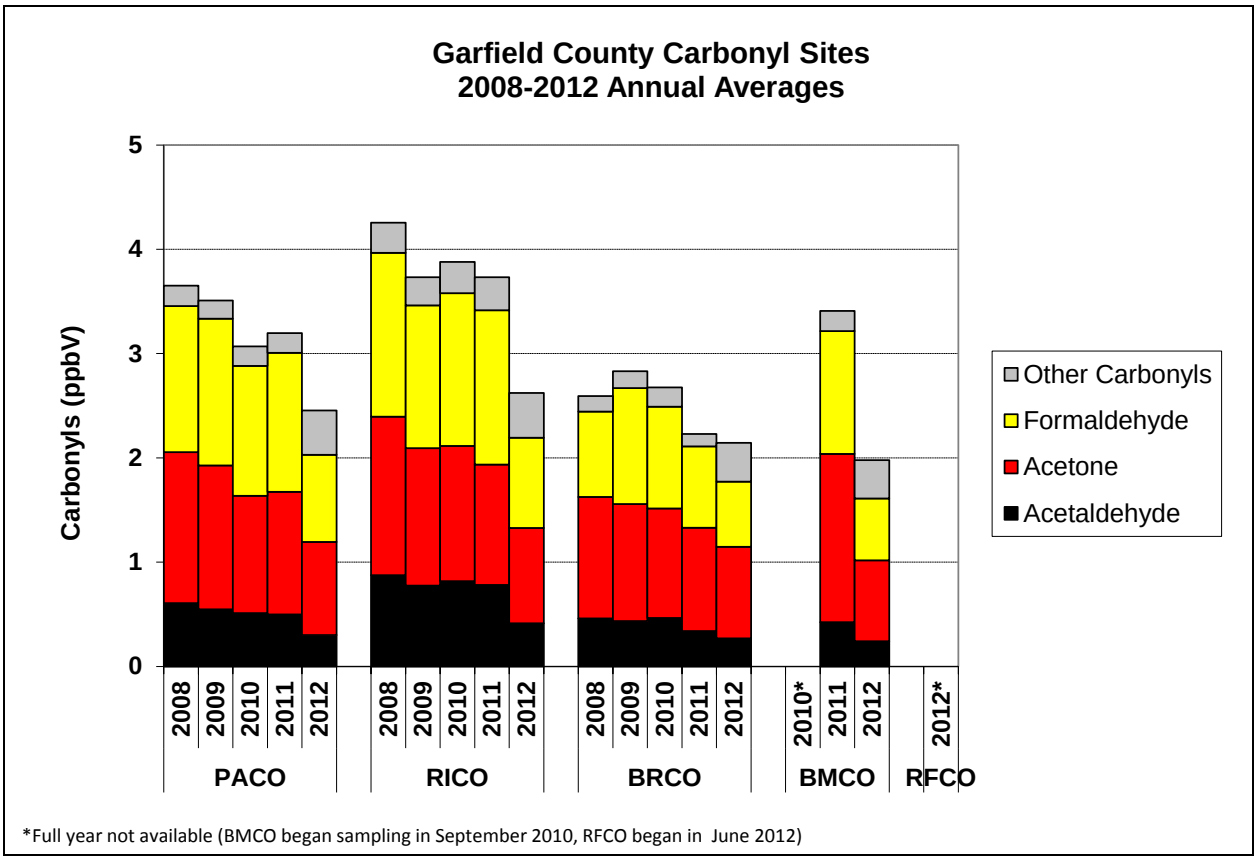


Figure 4-5. Average Carbonyl Concentrations Measured by the Garfield County Air Monitoring Program between 2008 and 2012.

4.3 HAZARDOUS AIR POLLUTANTS SUMMARIES

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.

4.3.1 Annual Average HAP Concentrations

Tables 4-1 through 4-4 present annual averages and trends for of 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 0.05 (95% 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 2011 and 2012 measurements at the Battlement Mesa site, but trends are not calculated as the EPA recommends using at least five years of data to determine reliable trend statistics.

Annual averages for these components are also depicted graphically in in Figures 4-6 through 4-9. For perspective on concentrations measured in Garfield County, the average, maximum, and minimum of annual average data reported for 45 urban sites across the United States in 2009, excluding the Garfield County sites, is also presented in the figures. The 2009 average was obtained from an annual report published by the EPA for sites across the country as part of the Urban Air Toxics Monitoring Program (UATMP) and National Air Toxics Trends Stations (NATTS) (EPA 2011). Specific observations are listed below.

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

- A number of additional compounds, including formaldehyde, showed statistically significant decreasing trends at the Parachute and Bell-Melton sites, but insignificant trends at the more urban Rifle site.

- 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 $\mu g/m^3$ 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)
2008-2012

HAP	Average Mass (µg/m^3)					Slope (µg/m^3 per year)	p-Value
	2008	2009	2010	2011	2012		
1,2,4-Trimethylbenzene	0.91	0.62	0.42	0.43	0.39	**-0.11**	**0.04**
1,3,5-Trimethylbenzene	0.61	0.51	0.40	0.22	0.18	**-0.11**	**0.01**
1,3-Butadiene	0.08	0.12	0.10	0.10	0.09	0.00	0.59
Acetaldehyde	1.11	0.99	0.92	0.90	0.75	**-0.08**	**0.01**
Acetone	3.42	3.28	2.67	2.79	2.34	**-0.26**	**0.04**
Benzene	2.31	2.69	1.74	1.44	1.31	**-0.28**	**0.04**
Crotonaldehyde	0.10	0.10	0.12	0.09	0.08	-0.01	0.24
Cyclohexane	3.92	3.77	2.90	2.22	1.99	**-0.54**	**0.01**
Ethylbenzene	0.59	0.44	1.04	0.32	0.17	-0.10	0.12
Formaldehyde	1.74	1.73	1.53	1.64	1.27	**-0.11**	**0.04**
Isopropylbenzene	0.09	0.08	0.07	0.08	0.06	**-0.01**	**0.04**
Methylcyclohexane	9.24	9.43	6.41	4.65	4.19	**-1.47**	**0.04**
m-Xylene/p-Xylene	3.91	3.63	2.20	1.11	1.15	**-0.84**	**0.04**
n-Hexane	5.78	5.64	3.93	3.34	3.01	**-0.75**	**0.01**
n-Nonane	2.20	2.01	1.13	0.97	0.61	**-0.40**	**0.01**
n-Propylbenzene	0.18	0.15	0.13	0.10	0.10	**-0.02**	**0.01**
o-Xylene	0.77	0.65	0.43	0.40	0.27	**-0.13**	**0.01**
Propionaldehyde	0.12	0.09	0.09	0.09	0.07	**-0.01**	**0.04**
Propylene	0.57	0.57	0.62	0.55	0.69	0.03	0.41
Styrene	0.12	0.08	0.12	0.13	1.56	**0.04**	**0.04**
Toluene	9.86	5.83	3.96	5.79	4.27	-1.38	0.12

Table 4-2

Rifle Site
Annual Average Mass Trends (HAPs Parameters)
2008-2012

HAP	Average Mass (µg/m^3)					Slope (µg/m^3 per year)	p-Value
	2008	2009	2010	2011	2012		
1,2,4-Trimethylbenzene	0.62	0.71	0.52	0.42	0.54	-0.05	0.24
1,3,5-Trimethylbenzene	0.33	0.33	0.30	0.18	0.17	**-0.04**	**0.04**
1,3-Butadiene	0.13	0.12	0.17	0.19	0.16	0.02	0.24
Acetaldehyde	1.55	1.39	1.47	1.41	1.16	-0.07	0.12
Acetone	3.58	3.11	3.08	2.74	2.80	**-0.19**	**0.04**
Benzene	1.68	2.22	1.44	1.27	0.97	**-0.21**	**0.04**
Crotonaldehyde	0.15	0.17	0.18	0.14	0.13	-0.01	0.24
Cyclohexane	2.46	2.48	1.95	1.86	1.55	**-0.24**	**0.04**
Ethylbenzene	0.48	0.56	0.84	0.35	0.27	-0.07	0.24
Formaldehyde	1.89	1.67	1.80	1.82	1.52	-0.05	0.24
Isopropylbenzene	0.08	0.08	0.08	0.08	0.06	0.00	0.41
Methylcyclohexane	4.78	5.08	3.74	3.36	2.58	**-0.57**	**0.04**
m-Xylene/p-Xylene	2.35	2.58	1.70	0.90	1.08	-0.40	0.12
n-Hexane	4.50	4.61	3.48	4.40	2.88	-0.35	0.12
n-Nonane	0.81	0.86	0.59	0.44	0.32	**-0.13**	**0.04**
n-Propylbenzene	0.15	0.16	0.16	0.12	0.13	-0.01	0.24
o-Xylene	0.64	0.75	0.51	0.43	0.38	**-0.07**	**0.04**
Propionaldehyde	0.16	0.15	0.16	0.13	0.11	**-0.01**	**0.04**
Propylene	0.86	1.05	1.04	0.93	0.96	0.00	0.59
Styrene	0.08	0.08	0.08	0.10	0.75	**0.01**	**0.04**
Toluene	4.34	4.62	3.07	5.90	2.14	-0.51	0.41

Table 4-3

Bell-Melton Site
Annual Average Mass Trends (HAPs Parameters)
2008-2012

HAP	Average Mass (µg/m^3)					Slope (µg/m^3 per year)	p-Value
	2008	2009	2010	2011	2012		
1,2,4-Trimethylbenzene	0.91	0.62	0.42	0.43	0.39	**-0.11**	**0.04**
1,3,5-Trimethylbenzene	0.61	0.51	0.40	0.22	0.18	**-0.11**	**0.01**
1,3-Butadiene	0.08	0.12	0.10	0.10	0.09	0.00	0.59
Acetaldehyde	1.11	0.99	0.92	0.90	0.75	**-0.08**	**0.01**
Acetone	3.42	3.28	2.67	2.79	2.34	**-0.26**	**0.04**
Benzene	2.31	2.69	1.74	1.44	1.31	**-0.28**	**0.04**
Crotonaldehyde	0.10	0.10	0.12	0.09	0.08	-0.01	0.24
Cyclohexane	3.92	3.77	2.90	2.22	1.99	**-0.54**	**0.01**
Ethylbenzene	0.59	0.44	1.04	0.32	0.17	-0.10	0.12
Formaldehyde	1.74	1.73	1.53	1.64	1.27	**-0.11**	**0.04**
Isopropylbenzene	0.09	0.08	0.07	0.08	0.06	**-0.01**	**0.04**
Methylcyclohexane	9.24	9.43	6.41	4.65	4.19	**-1.47**	**0.04**
m-Xylene/p-Xylene	3.91	3.63	2.20	1.11	1.15	**-0.84**	**0.04**
n-Hexane	5.78	5.64	3.93	3.34	3.01	**-0.75**	**0.01**
n-Nonane	2.20	2.01	1.13	0.97	0.61	**-0.40**	**0.01**
n-Propylbenzene	0.18	0.15	0.13	0.10	0.10	**-0.02**	**0.01**
o-Xylene	0.77	0.65	0.43	0.40	0.27	**-0.13**	**0.01**
Propionaldehyde	0.12	0.09	0.09	0.09	0.07	**-0.01**	**0.04**
Propylene	0.57	0.57	0.62	0.55	0.69	0.03	0.41
Styrene	0.12	0.08	0.12	0.13	1.56	**0.04**	**0.04**
Toluene	9.86	5.83	3.96	5.79	4.27	-1.38	0.12

Table 4-4

Battlement Mesa Site
Annual Average Mass Trends (HAPs Parameters)
2011-2012

HAP	Average Mass (µg/m^3)					Slope* (µg/m^3 per year)	p-Value*
	2008	2009	2010	2011	2012		
1,2,4-Trimethylbenzene	--	--	--	0.44	0.37	N/A	N/A
1,3,5-Trimethylbenzene	--	--	--	0.22	0.15	N/A	N/A
1,3-Butadiene	--	--	--	0.06	0.09	N/A	N/A
Acetaldehyde	--	--	--	0.76	0.57	N/A	N/A
Acetone	--	--	--	3.83	3.28	N/A	N/A
Benzene	--	--	--	1.56	1.10	N/A	N/A
Crotonaldehyde	--	--	--	0.07	0.07	N/A	N/A
Cyclohexane	--	--	--	2.09	1.64	N/A	N/A
Ethylbenzene	--	--	--	0.37	0.19	N/A	N/A
Formaldehyde	--	--	--	1.45	0.93	N/A	N/A
Isopropylbenzene	--	--	--	0.08	0.05	N/A	N/A
Methylcyclohexane	--	--	--	4.23	3.35	N/A	N/A
m-Xylene/p-Xylene	--	--	--	1.12	1.03	N/A	N/A
n-Hexane	--	--	--	3.34	2.68	N/A	N/A
n-Nonane	--	--	--	0.68	0.42	N/A	N/A
n-Propylbenzene	--	--	--	0.14	0.10	N/A	N/A
o-Xylene	--	--	--	0.46	0.27	N/A	N/A
Propionaldehyde	--	--	--	0.08	0.06	N/A	N/A
Propylene	--	--	--	0.42	0.42	N/A	N/A
Styrene	--	--	--	0.08	1.94	N/A	N/A
Toluene	--	--	--	2.99	4.40	N/A	N/A

*Note that annual averages are indicated, but trend statistics could not be calculated with only 2 years of complete data.
(--) No data available.

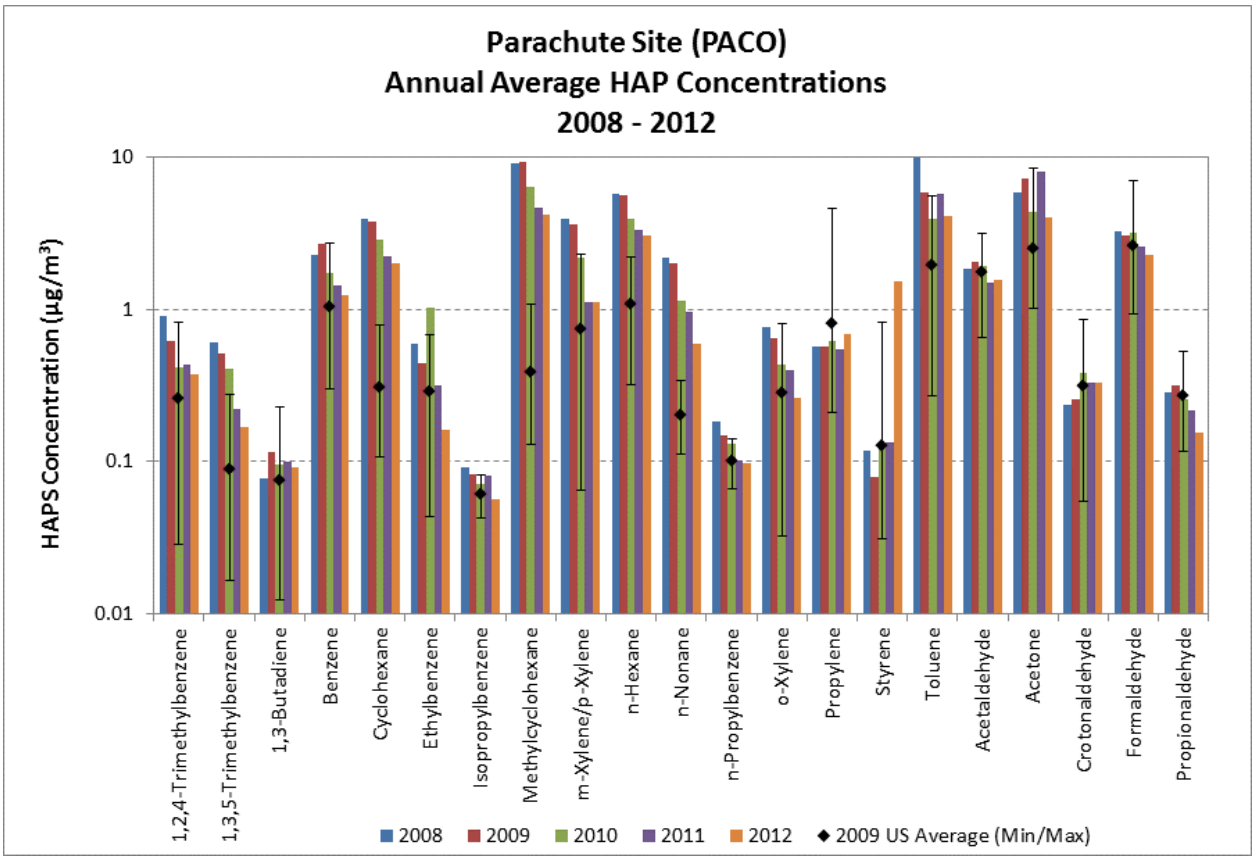


Figure 4-6. Annual Average HAP Concentrations Measured at the Parachute Site between 2008 and 2012, along with 2009 US Average, Minimum, and Maximum Annual Average Values as Reported by the EPA.

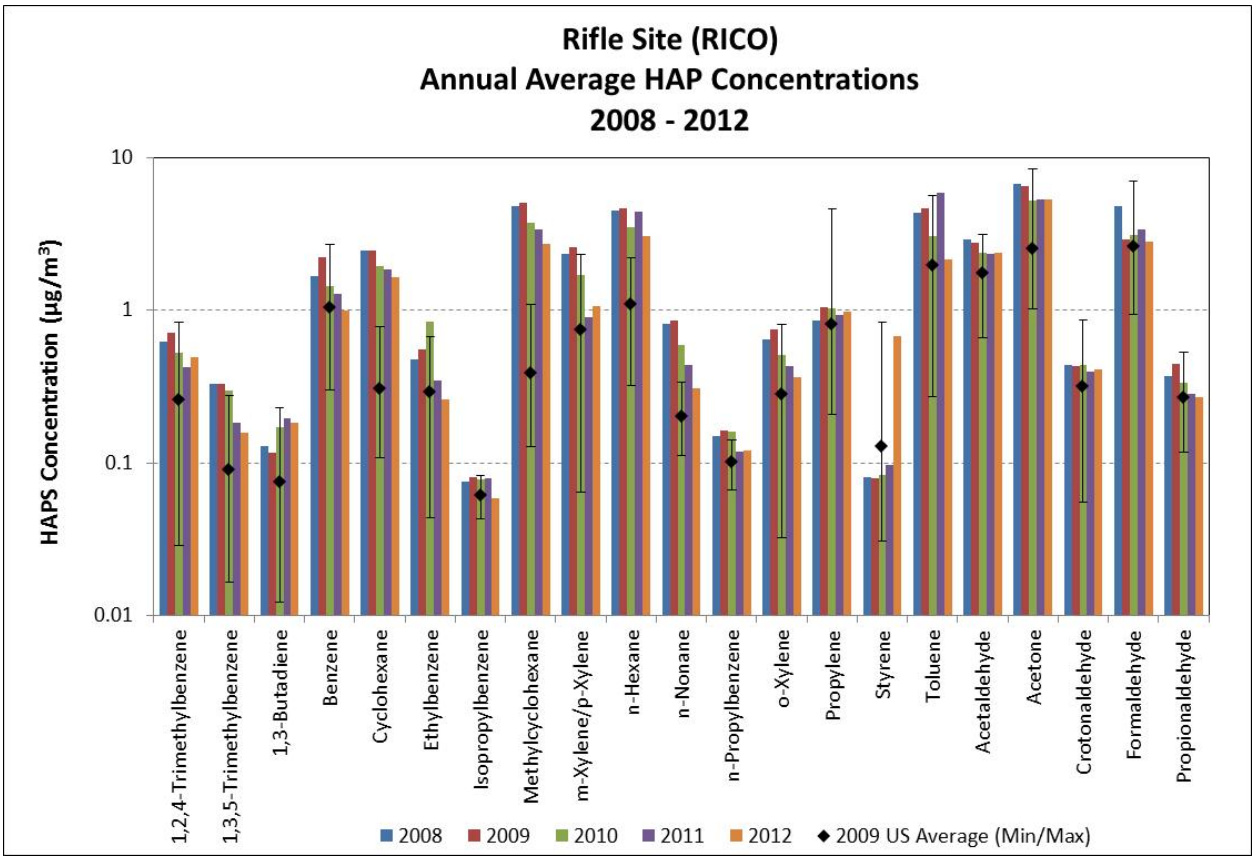


Figure 4-7. Annual Average HAP Concentrations Measured at the Rifle Site between 2008 and 2012, along with 2009 US Average, Minimum, and Maximum Annual Average Values as Reported by the EPA.

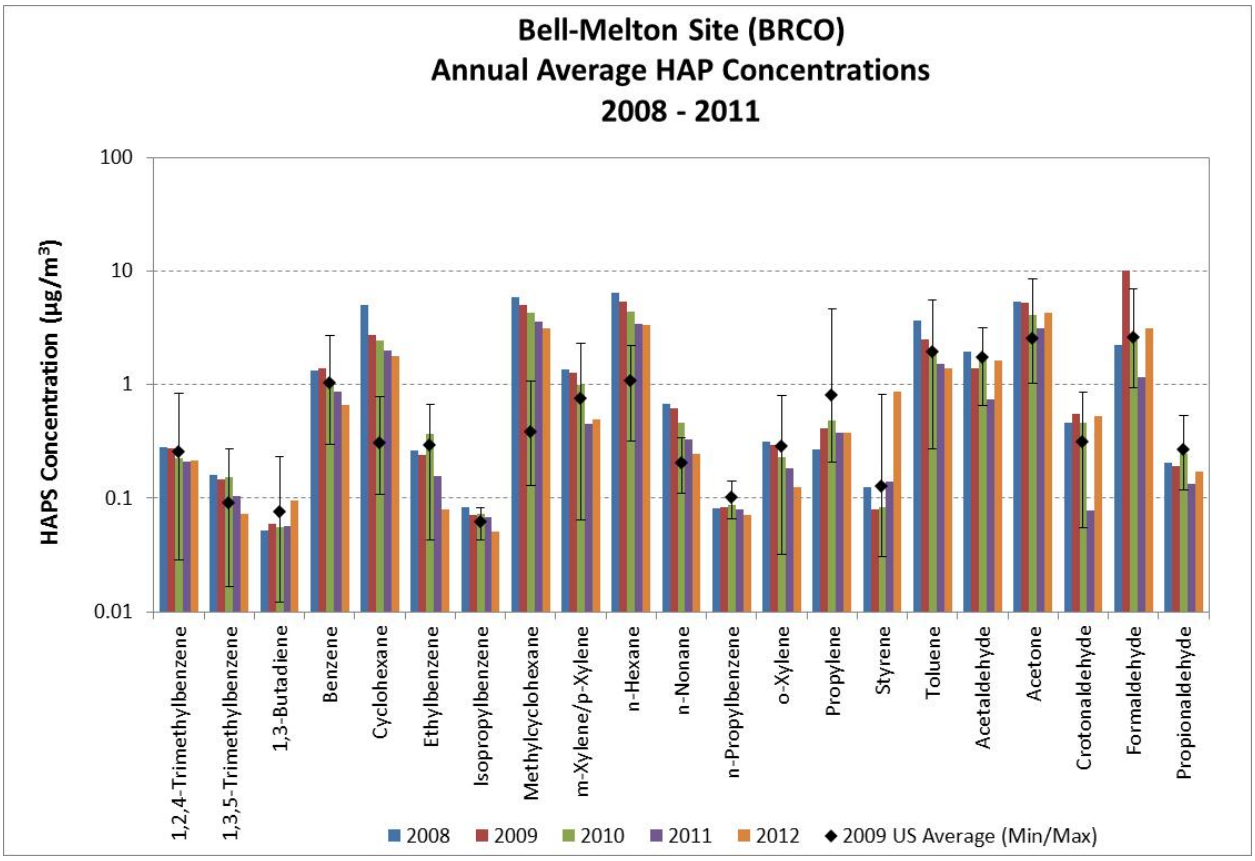


Figure 4-8. Annual Average HAP Concentrations Measured at the Bell-Melton Site between 2008 and 2012, along with 2009 US Average, Minimum, and Maximum Annual Average Values as Reported by the EPA.

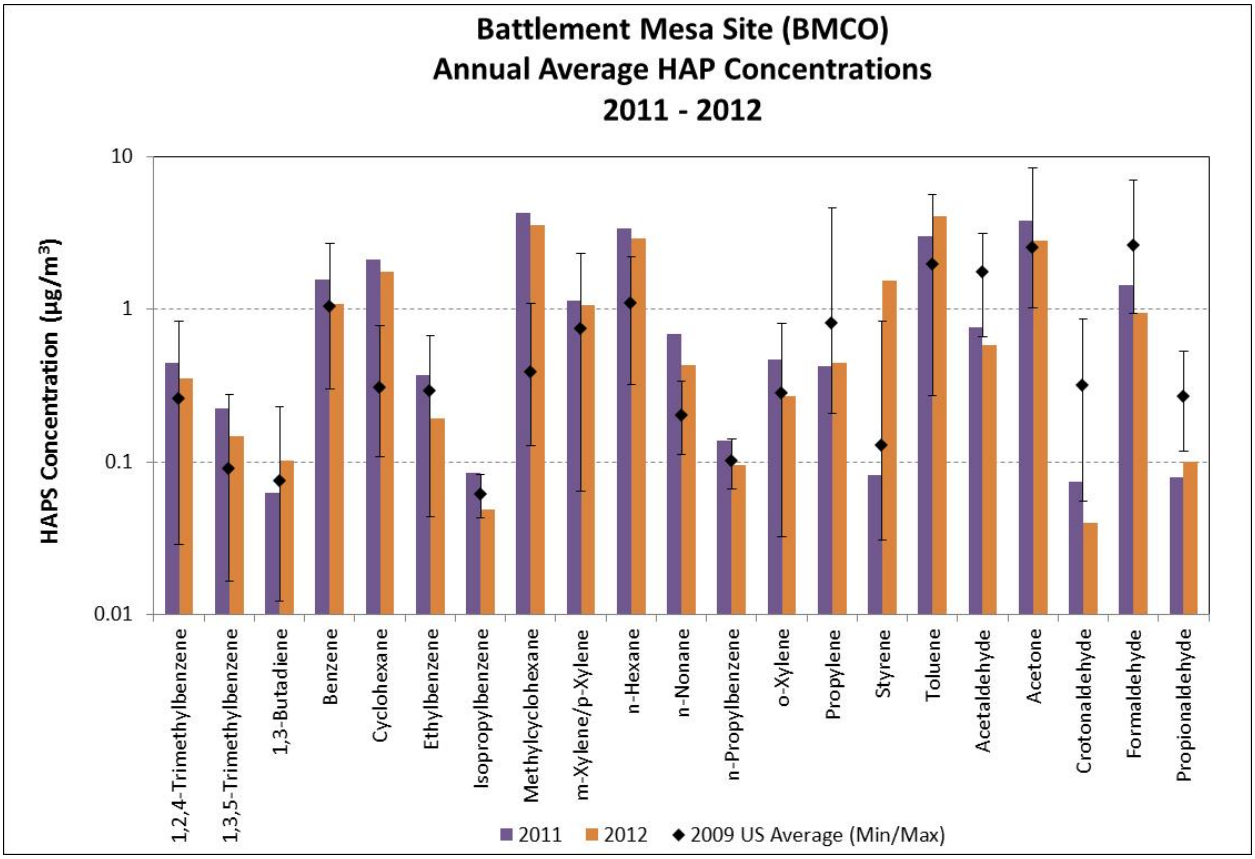


Figure 4-9. Annual Average HAP Concentrations Measured at the Battlement Mesa Site in 2011 and 2012, along with 2009 US Average, Minimum and Maximum Annual Average Values as Reported by the EPA.

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/.

Environmental Protection Agency (EPA). 2011. *2008-2009 National Monitoring Programs Annual Report (UATMP, NATTS, and CSATAM).* Available online at http://www.epa.gov/ttnamti1/uatm.html.

APPENDIX A

Garfield County

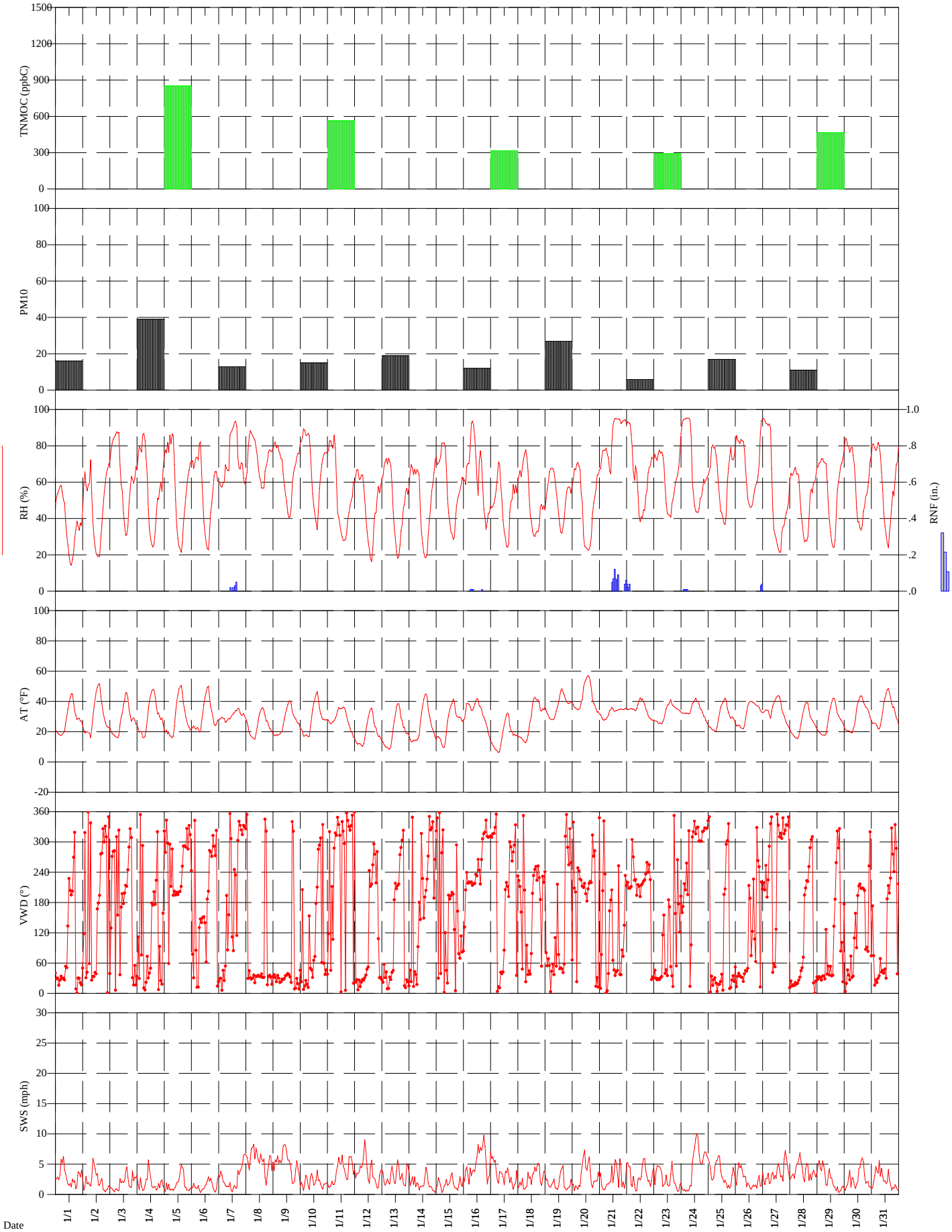
2012 Monthly Time Series Plots

Acronyms Used on Plots:

TNMOC = Total Non-Methane Organic Carbon
PM_{10} = Particulate Matter ≤ 10 μm
$PM_{2.5}$ = Particulate Matter ≤ 2.5 μm
O_3 = Ozone
RH = Relative Humidity
AT = Atmospheric Temperature
VWD = Vector Wind Direction
SWS = Scalar Wind Speed

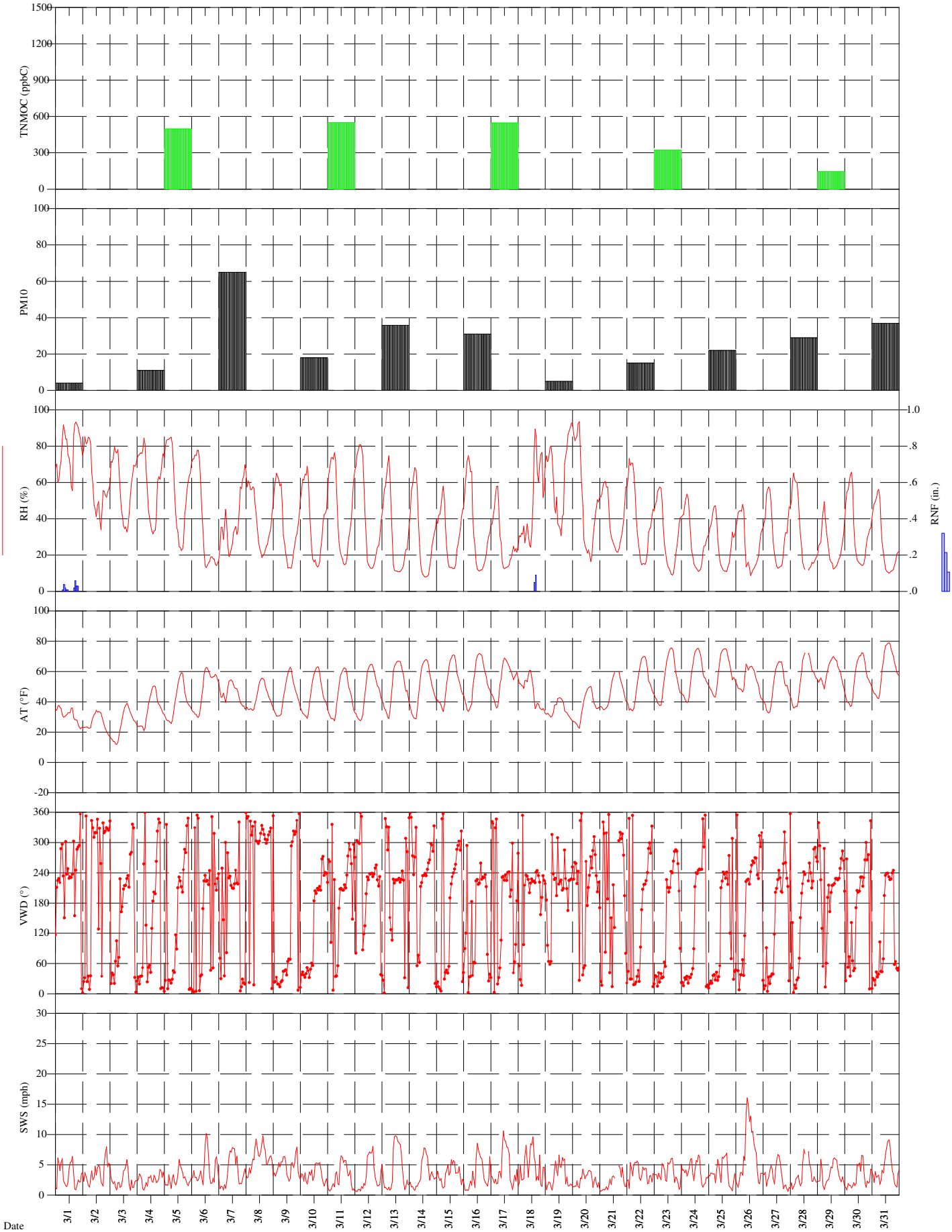
Garfield County, CO

Parachute Site



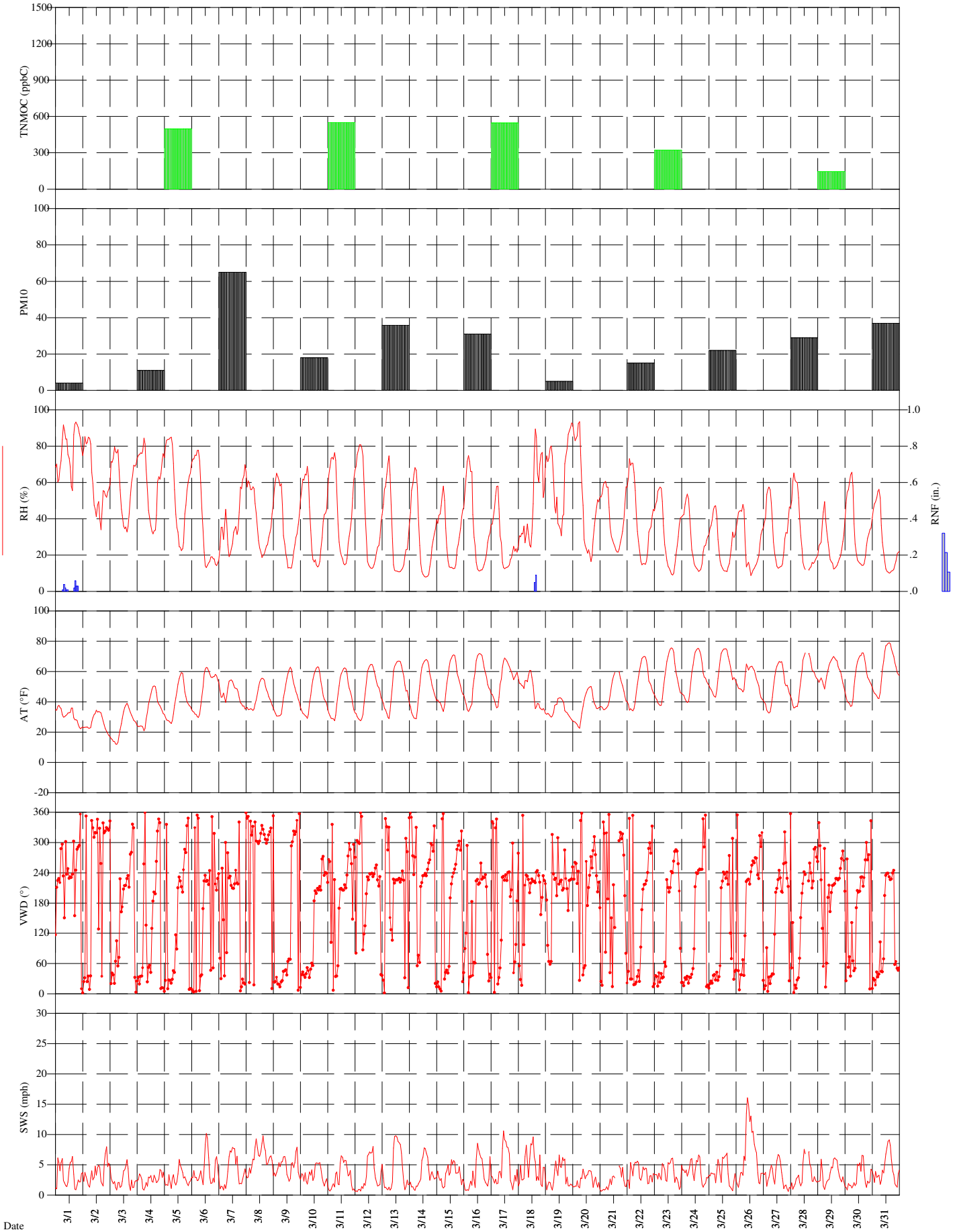
Garfield County, CO

Parachute Site



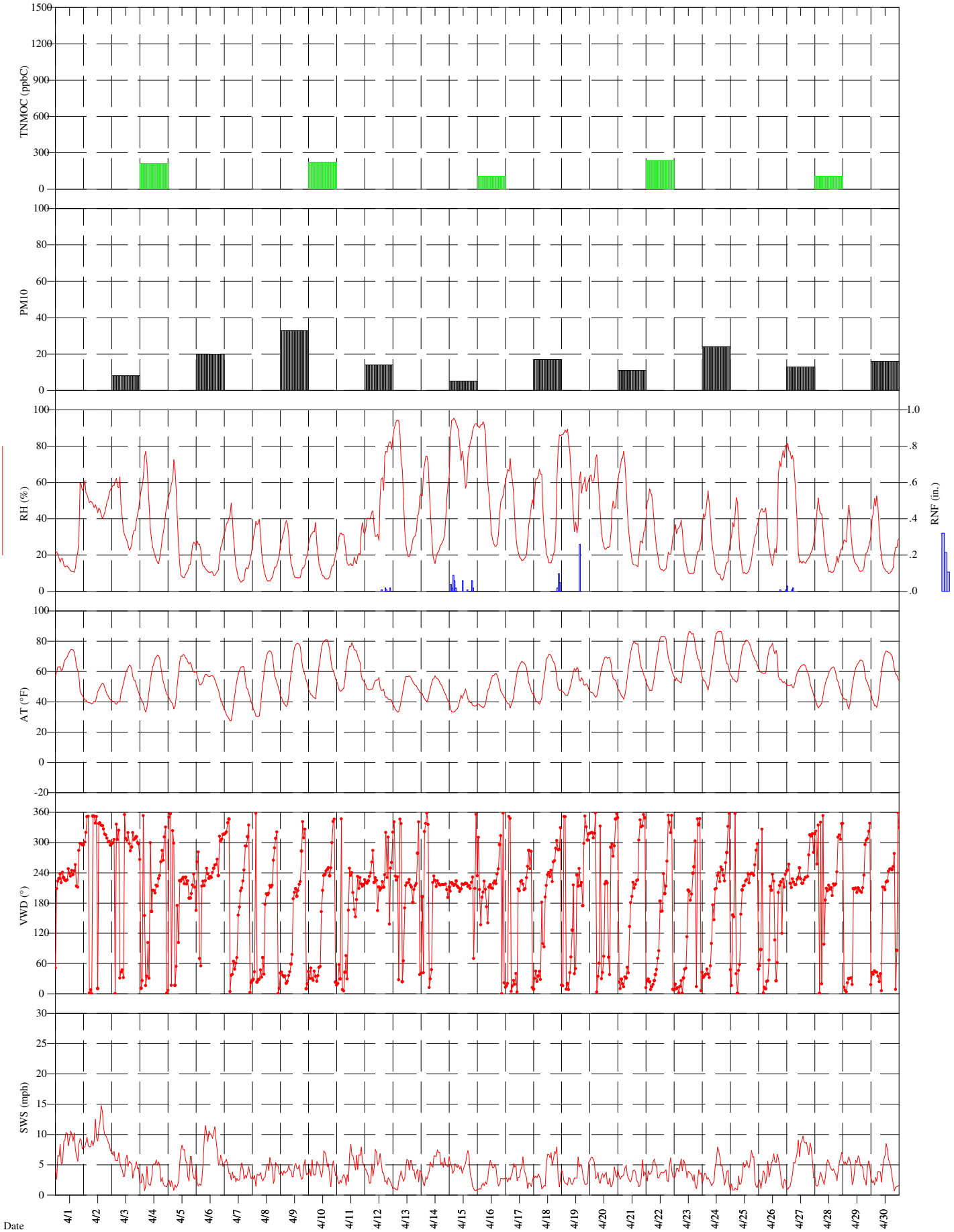
Garfield County, CO

Parachute Site



Garfield County, CO

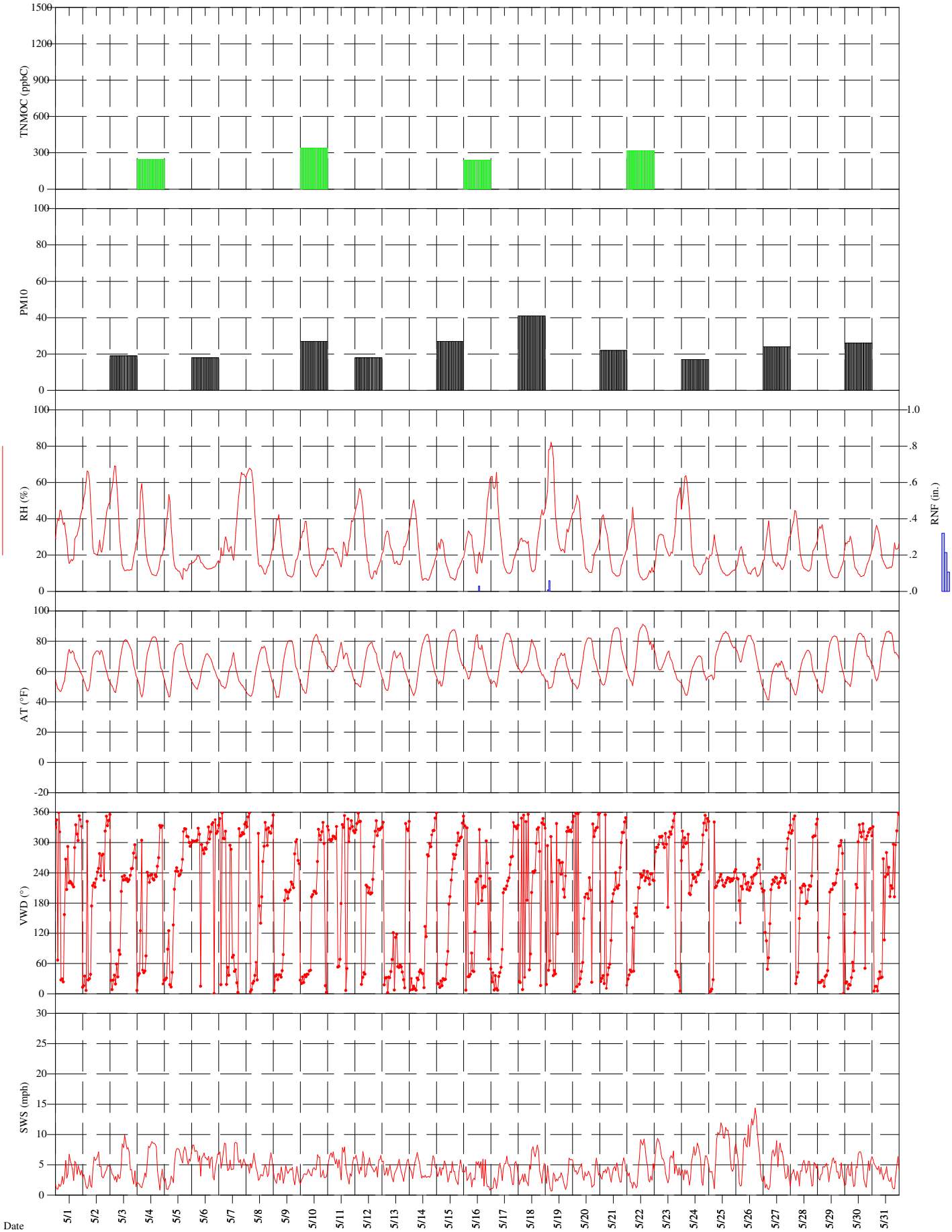
Parachute Site



Date

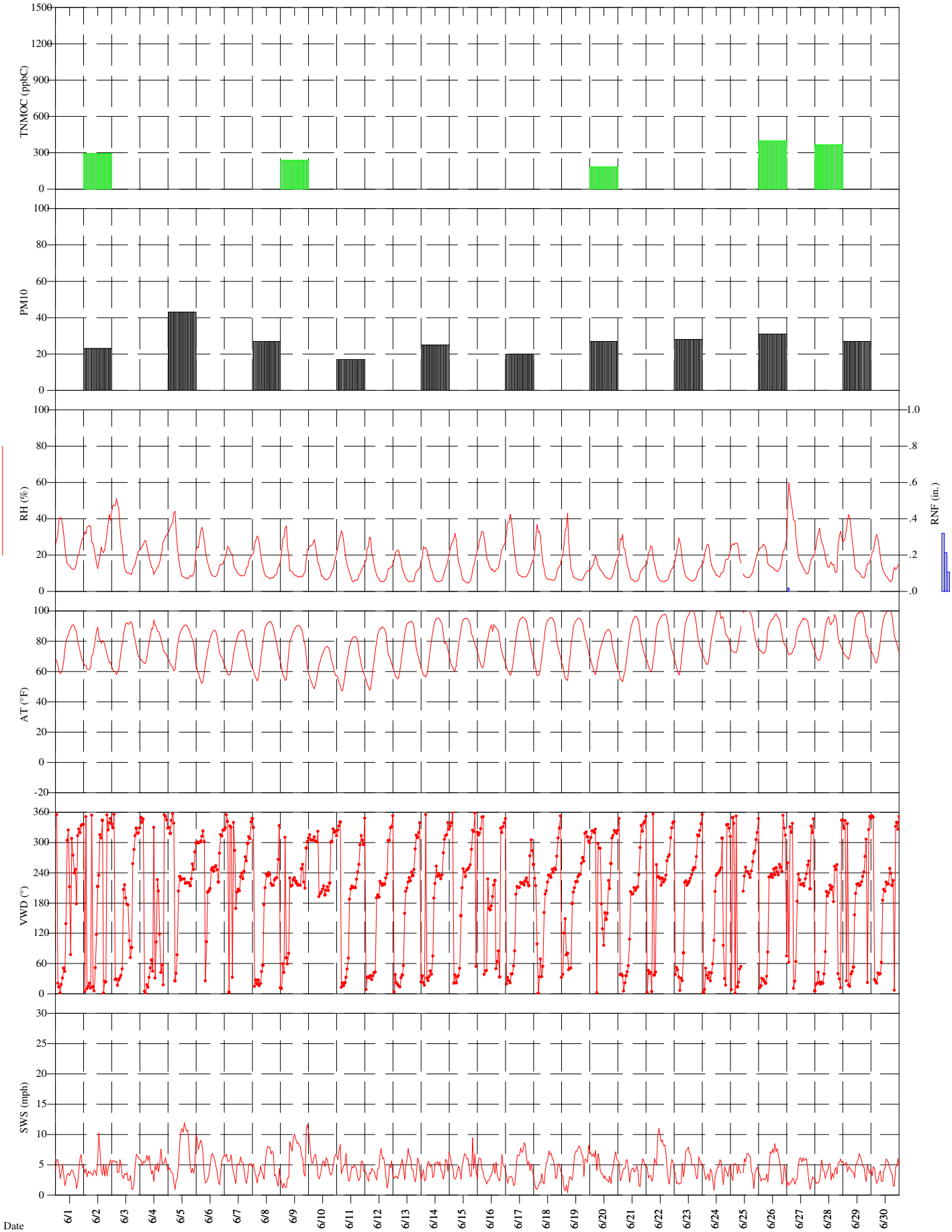
Garfield County, CO

Parachute Site



Garfield County, CO

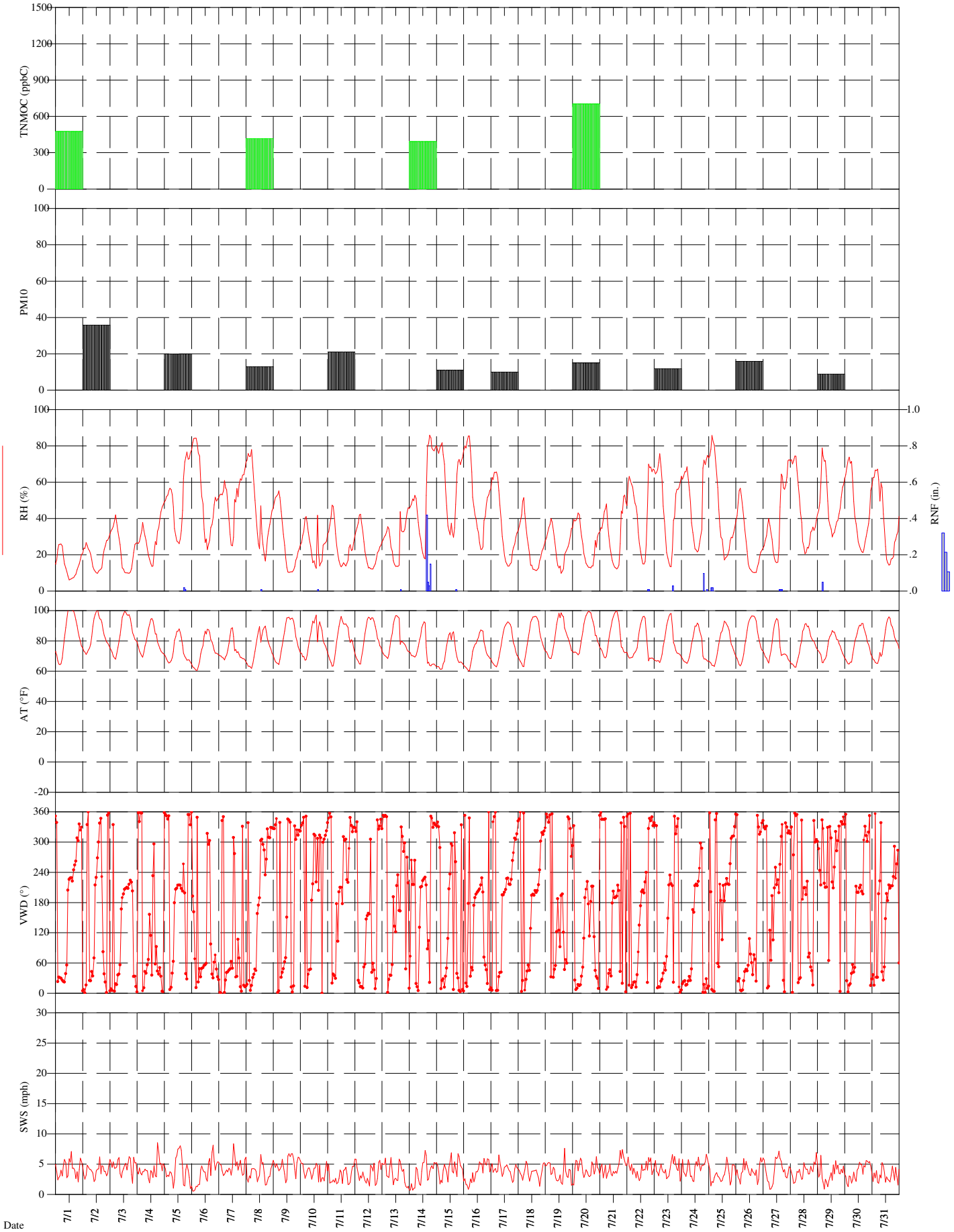
Parachute Site



Date

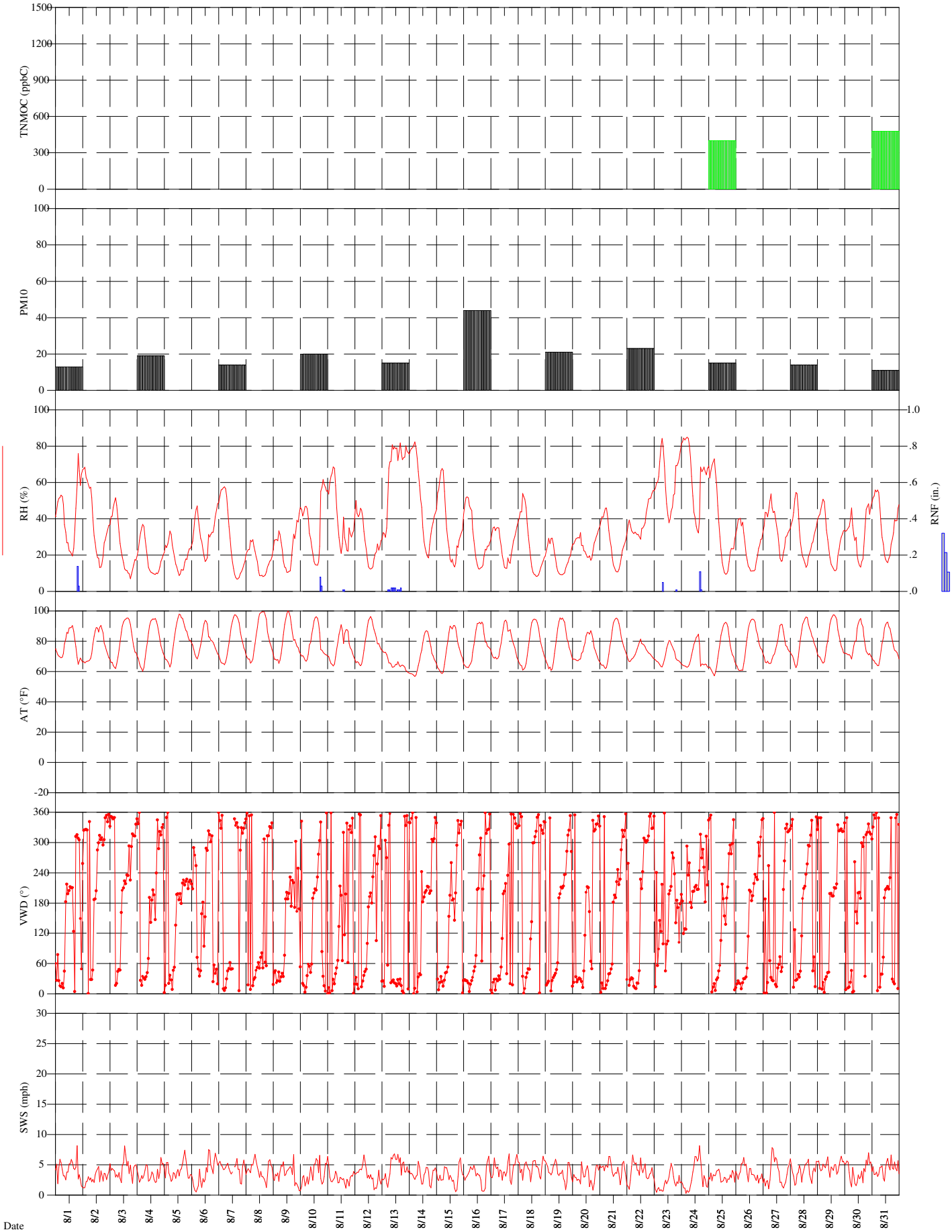
Garfield County, CO

Parachute Site



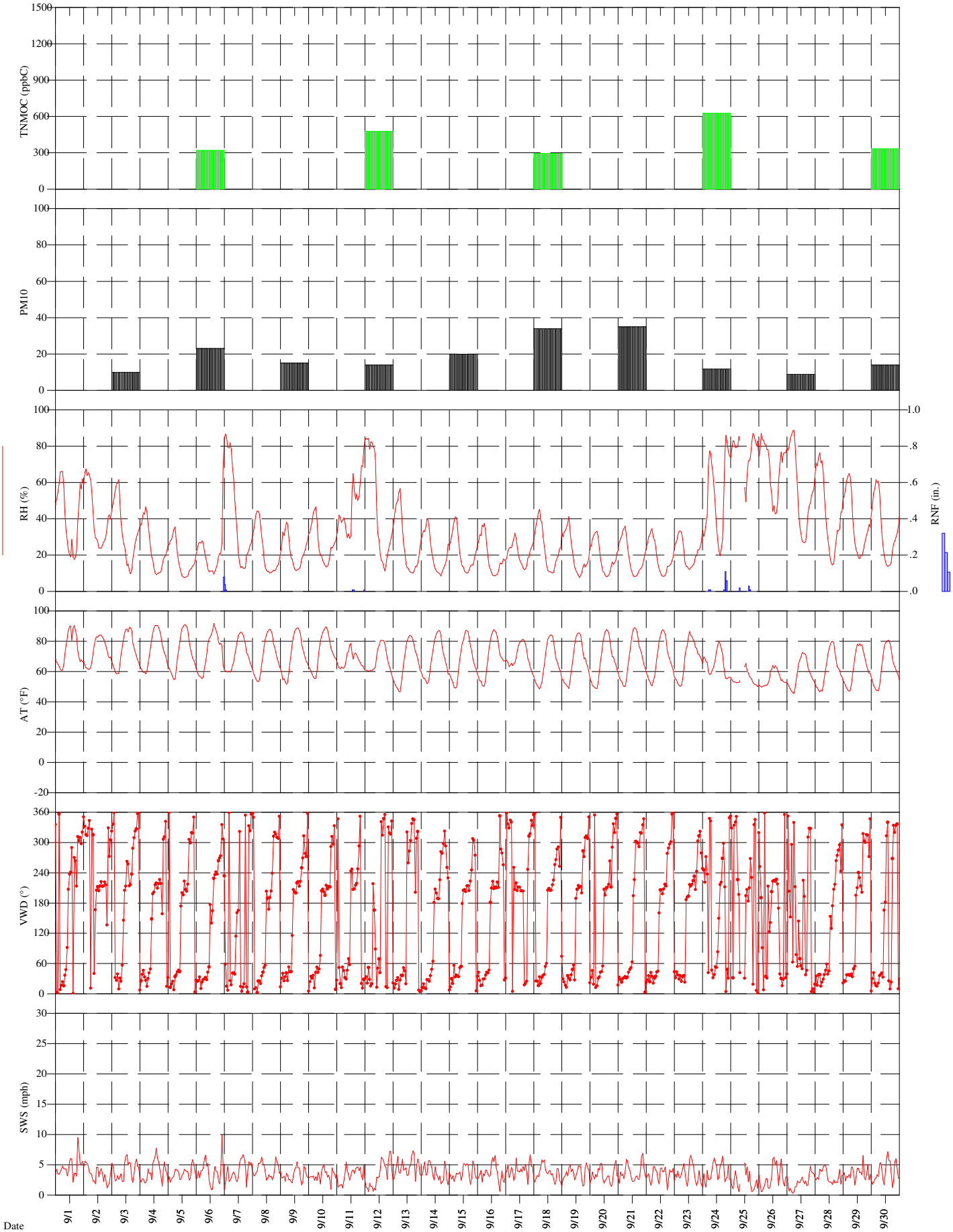
Garfield County, CO

Parachute Site



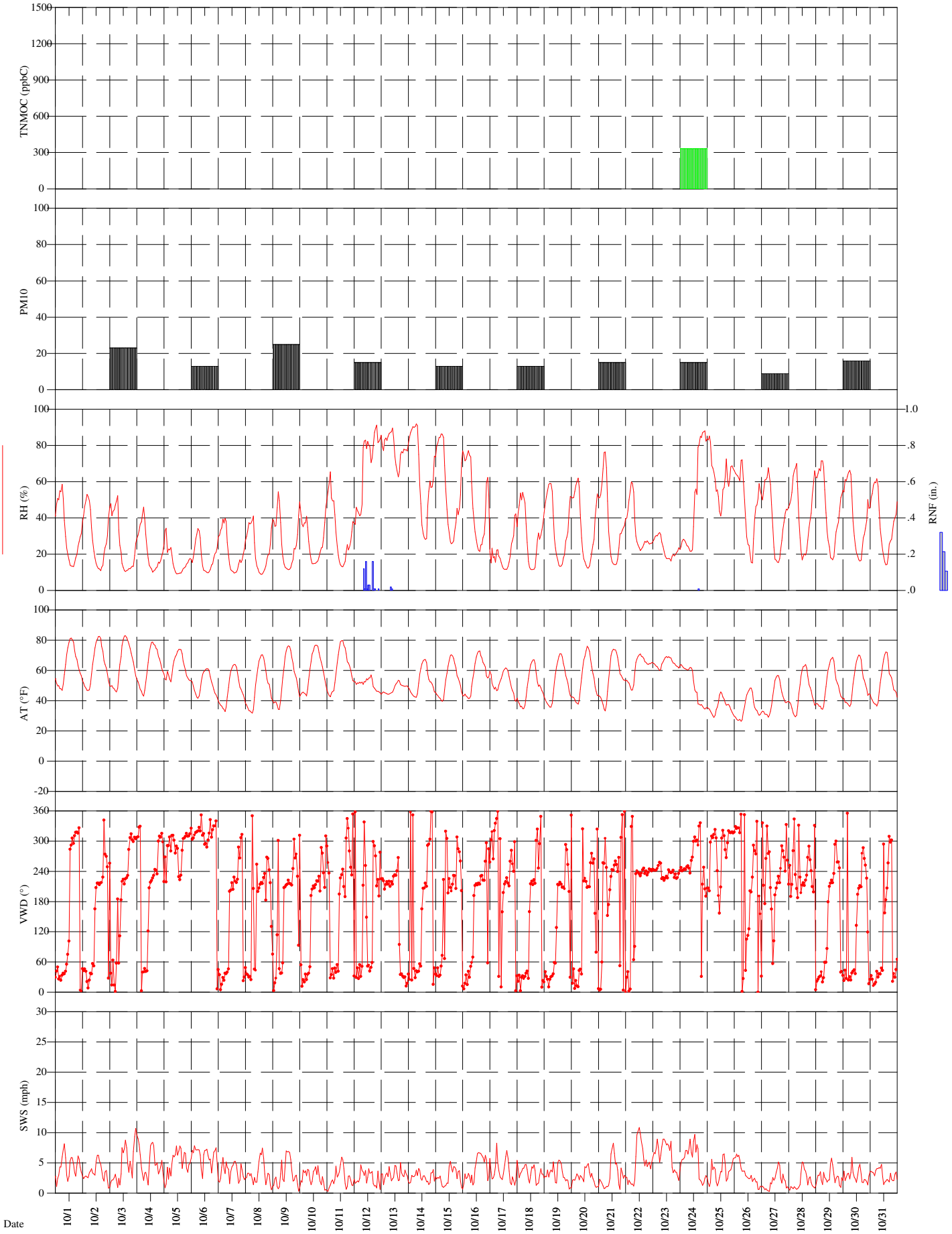
Garfield County, CO

Parachute Site



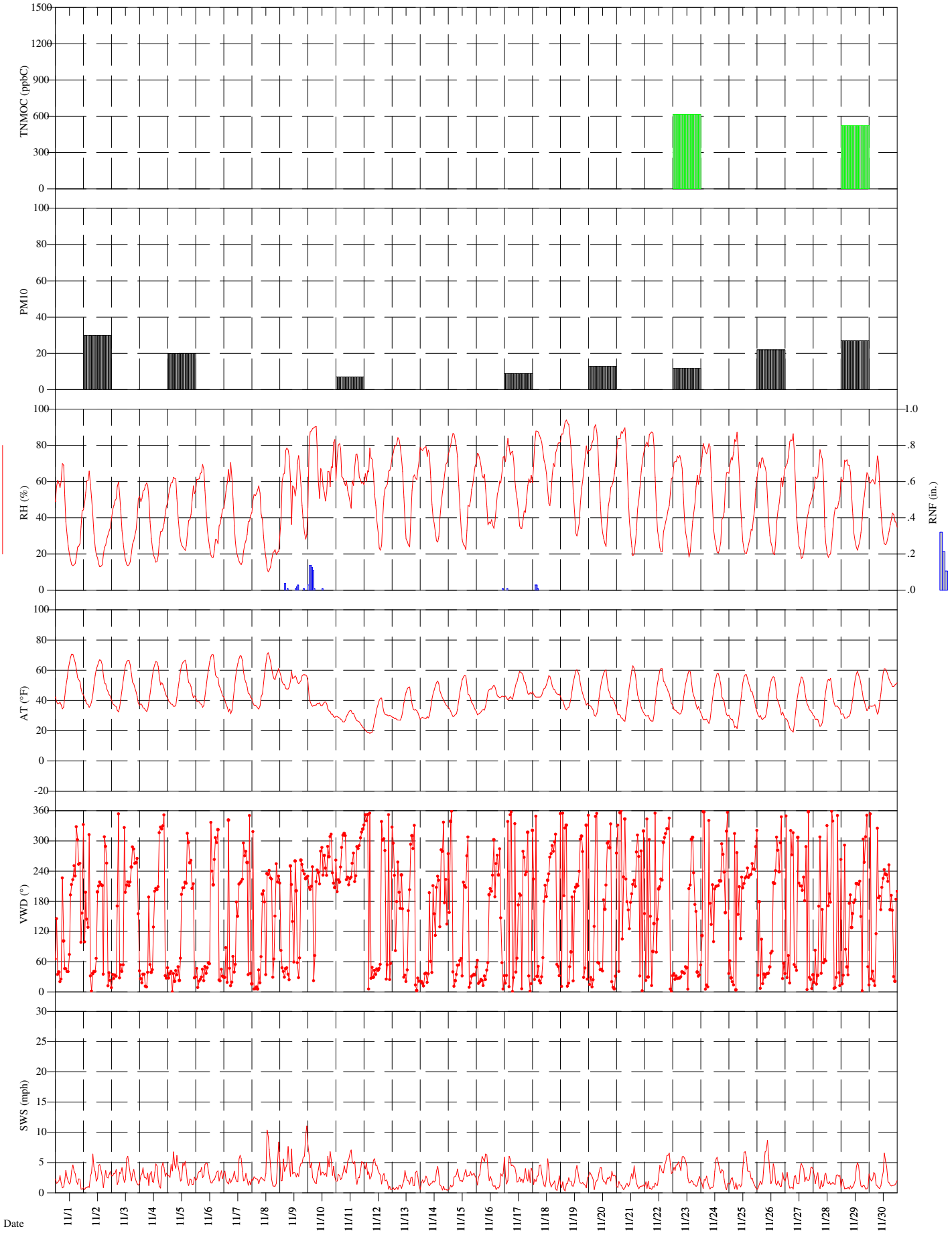
Garfield County, CO

Parachute Site



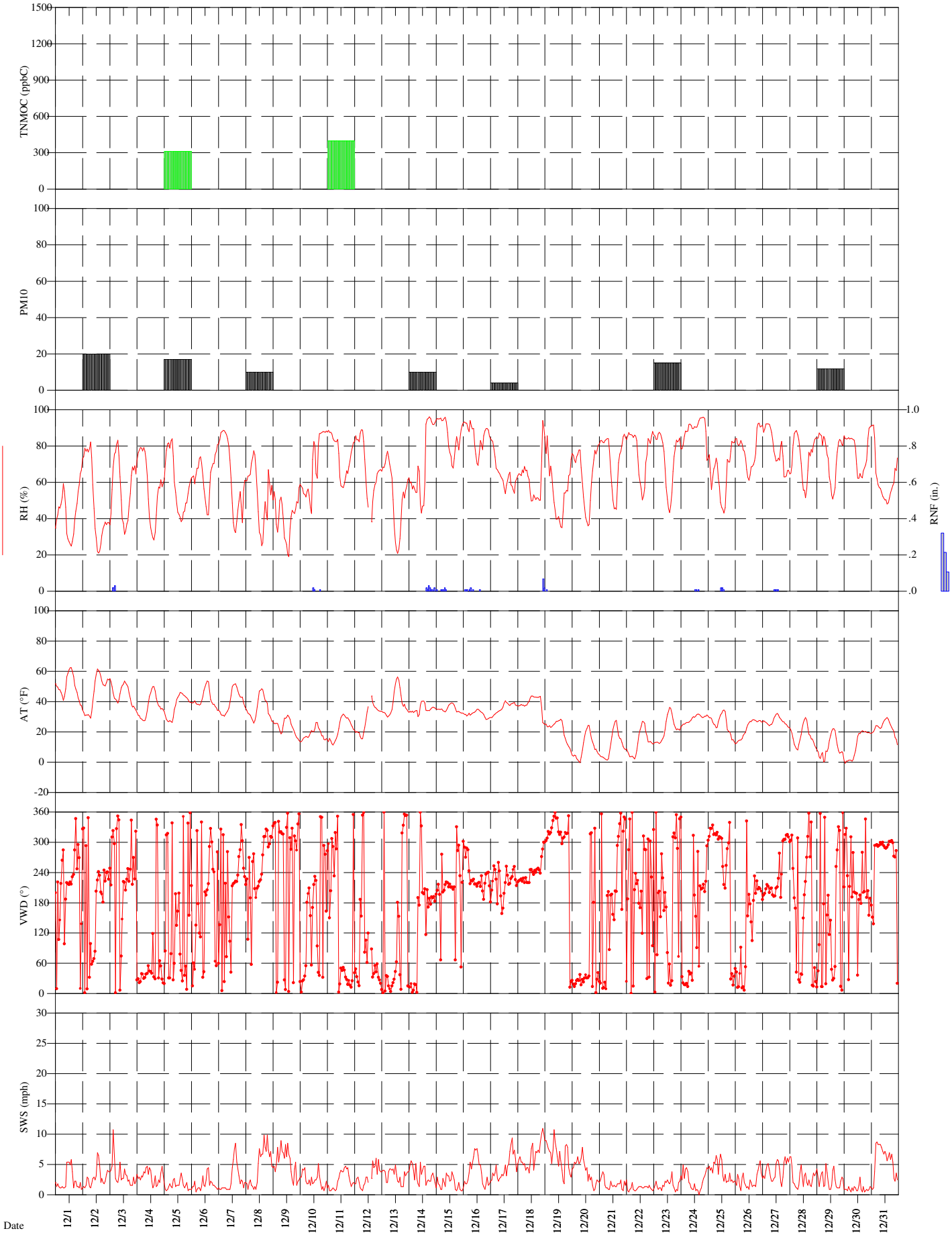
Garfield County, CO

Parachute Site



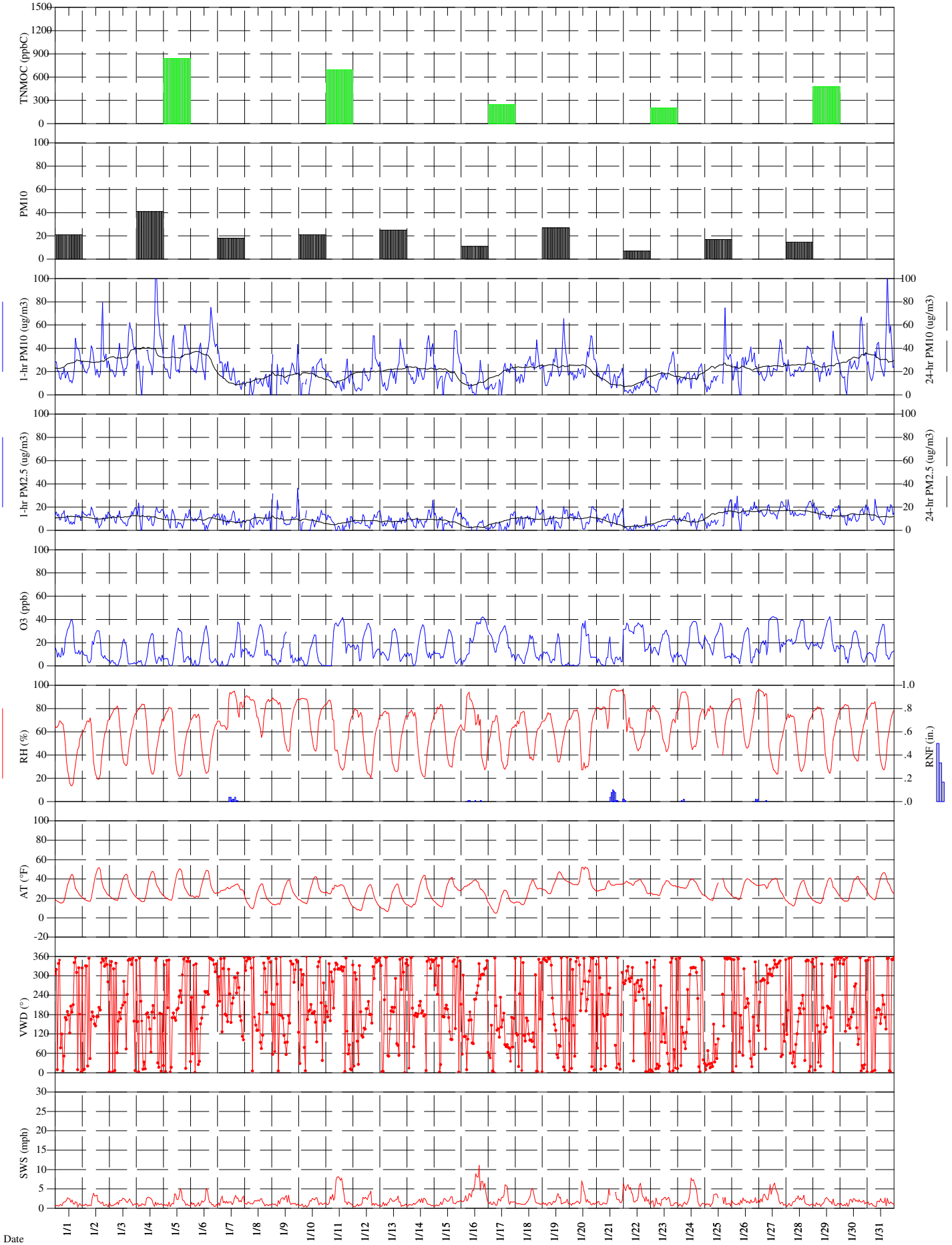
Garfield County, CO

Parachute Site



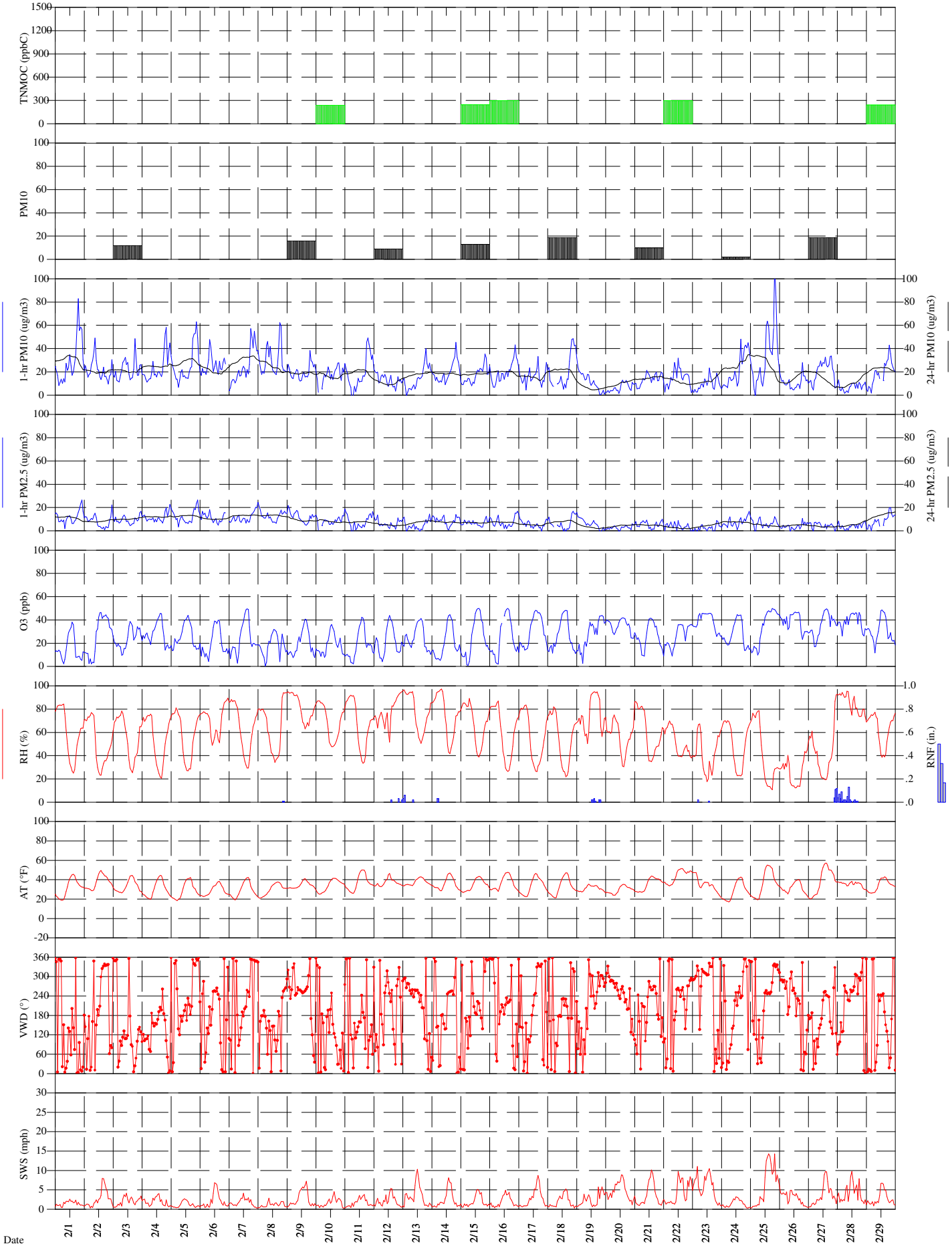
Garfield County, CO

Rifle Site



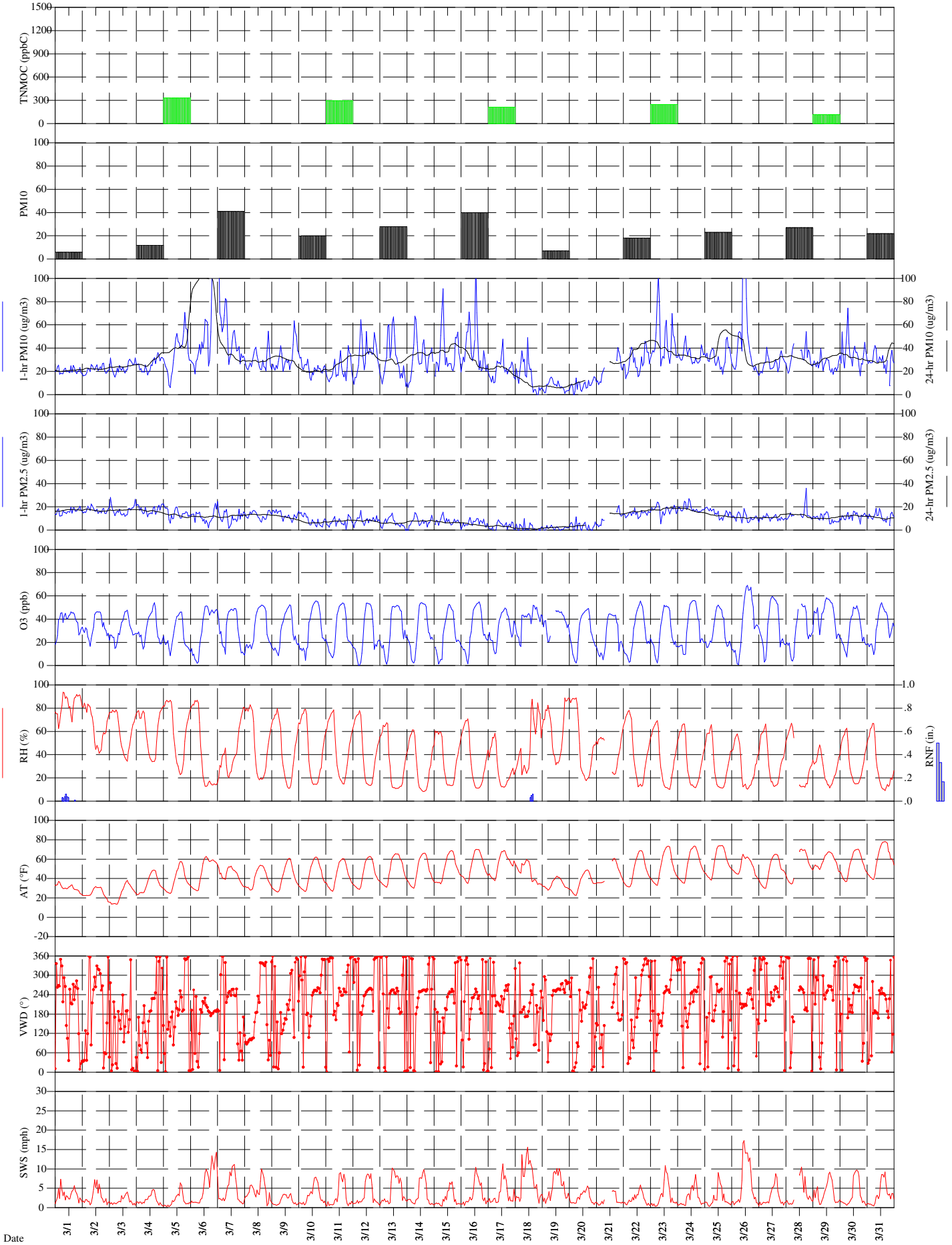
Garfield County, CO

Rifle Site



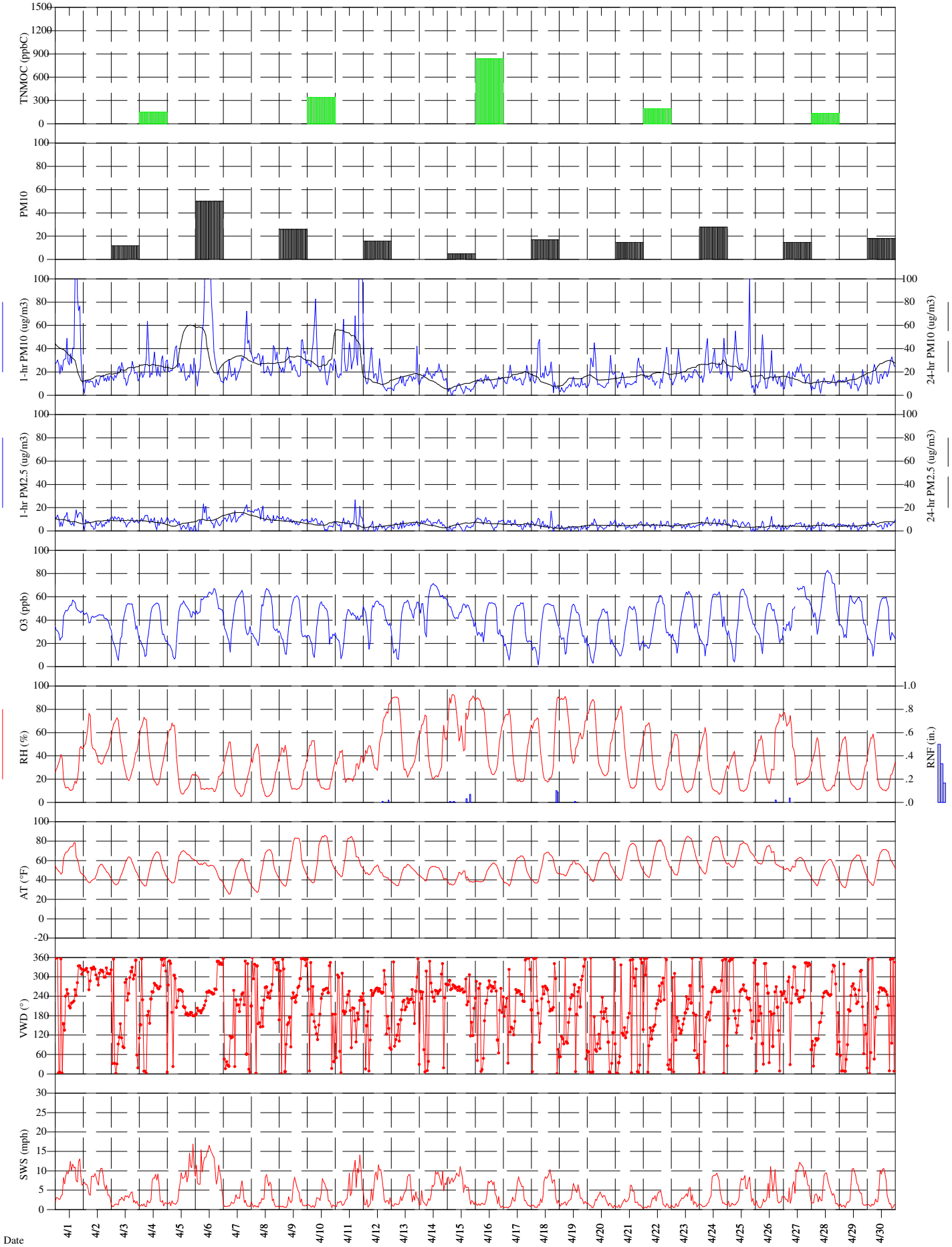
Garfield County, CO

Rifle Site



Garfield County, CO

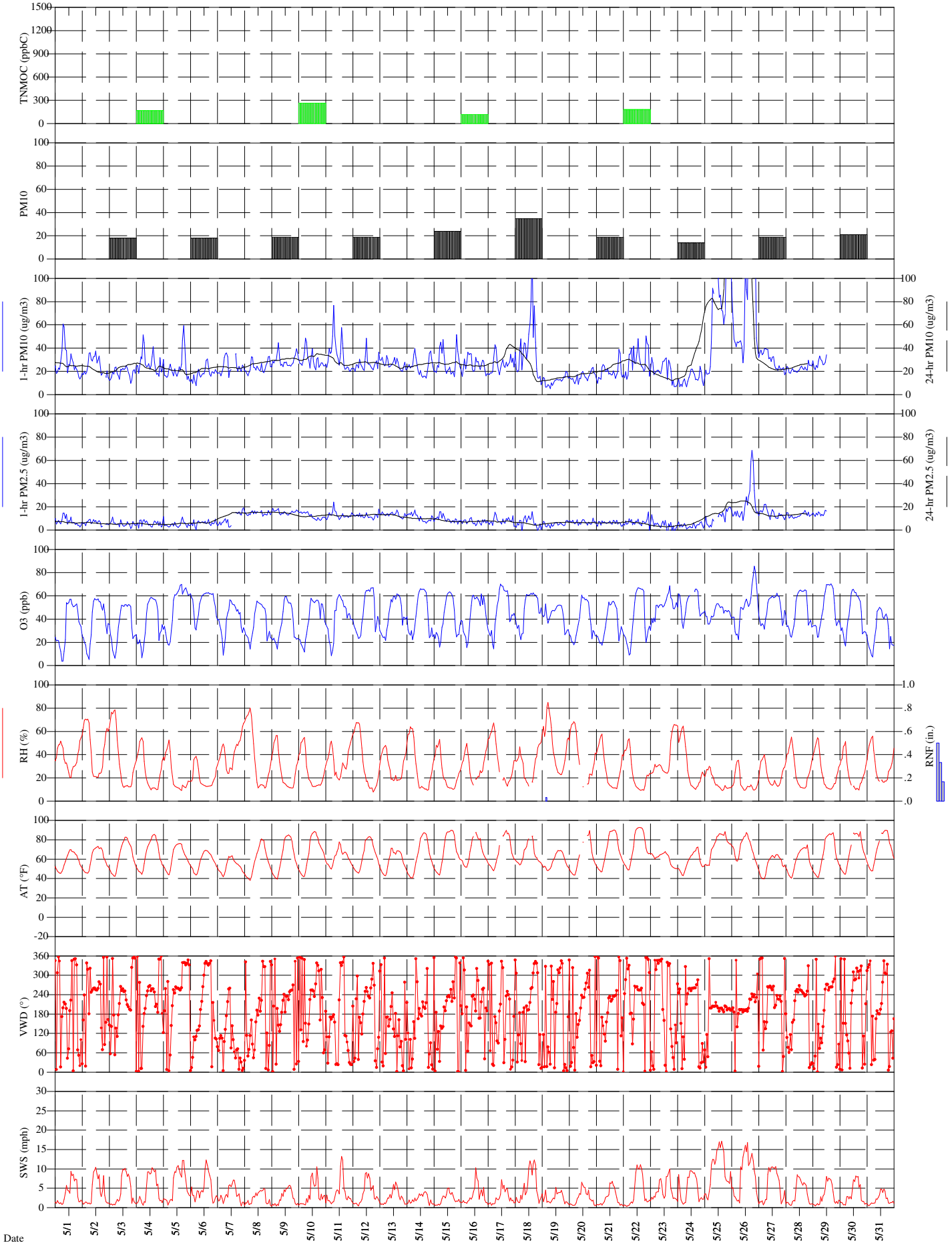
Rifle Site



Date

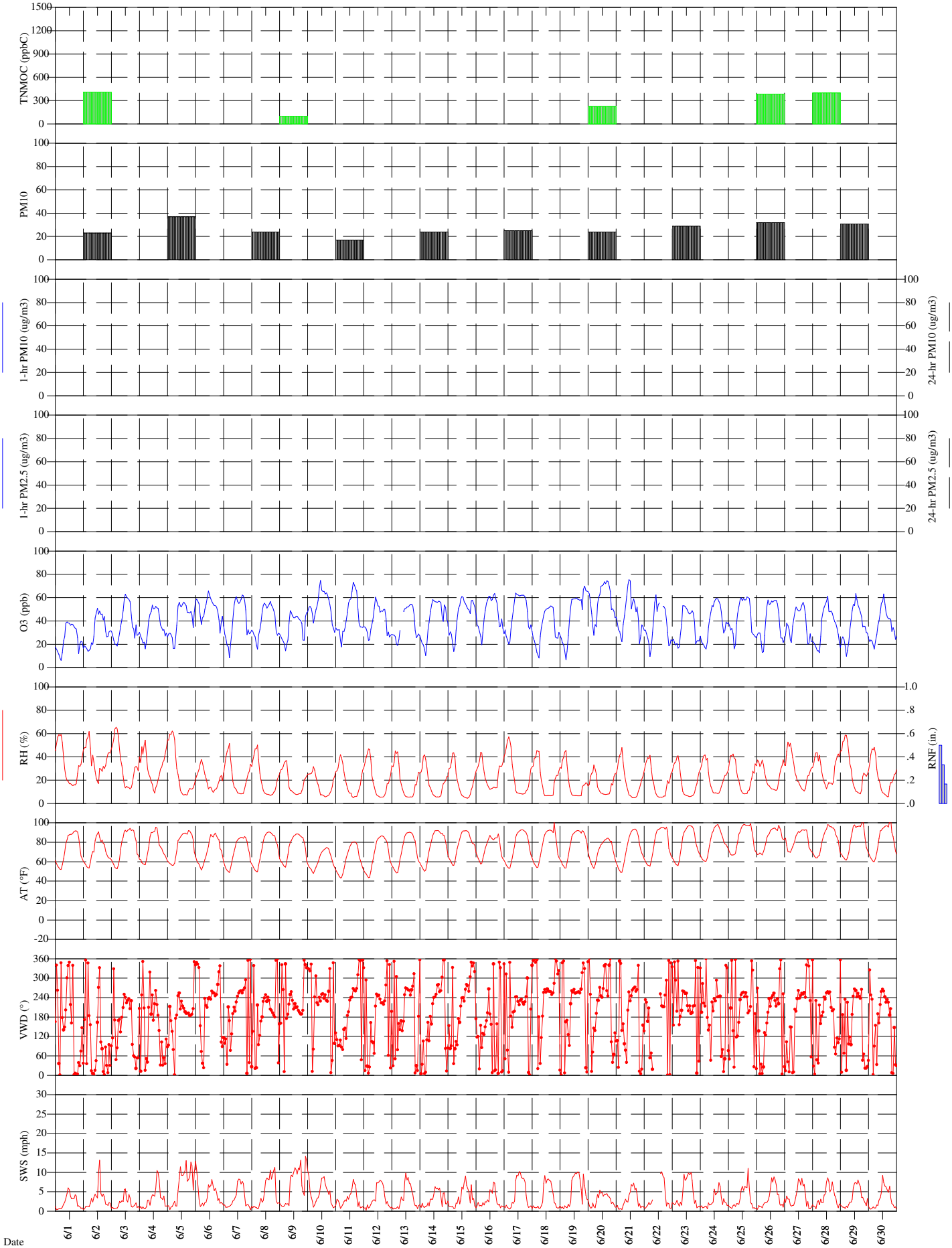
Garfield County, CO

Rifle Site



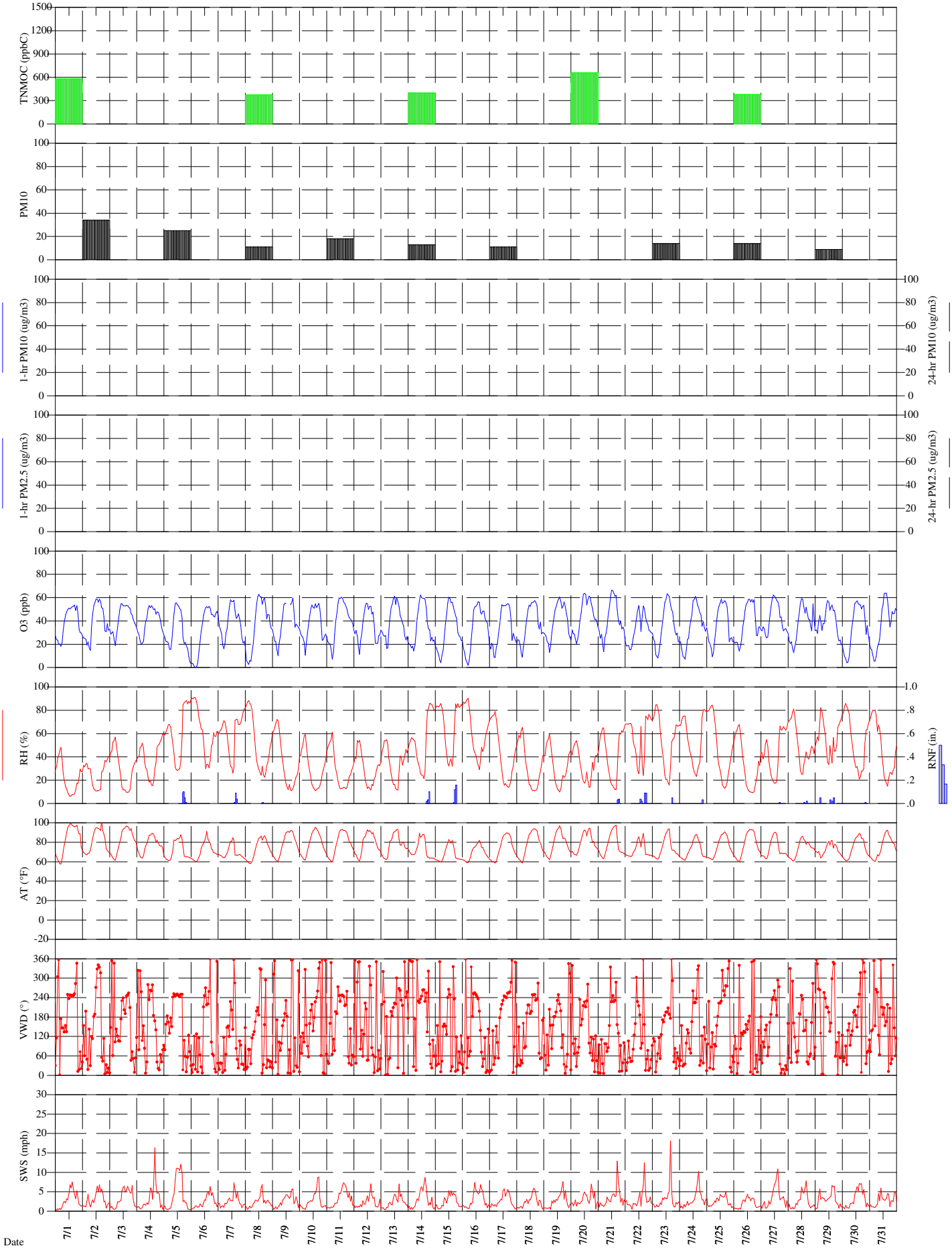
Garfield County, CO

Rifle Site



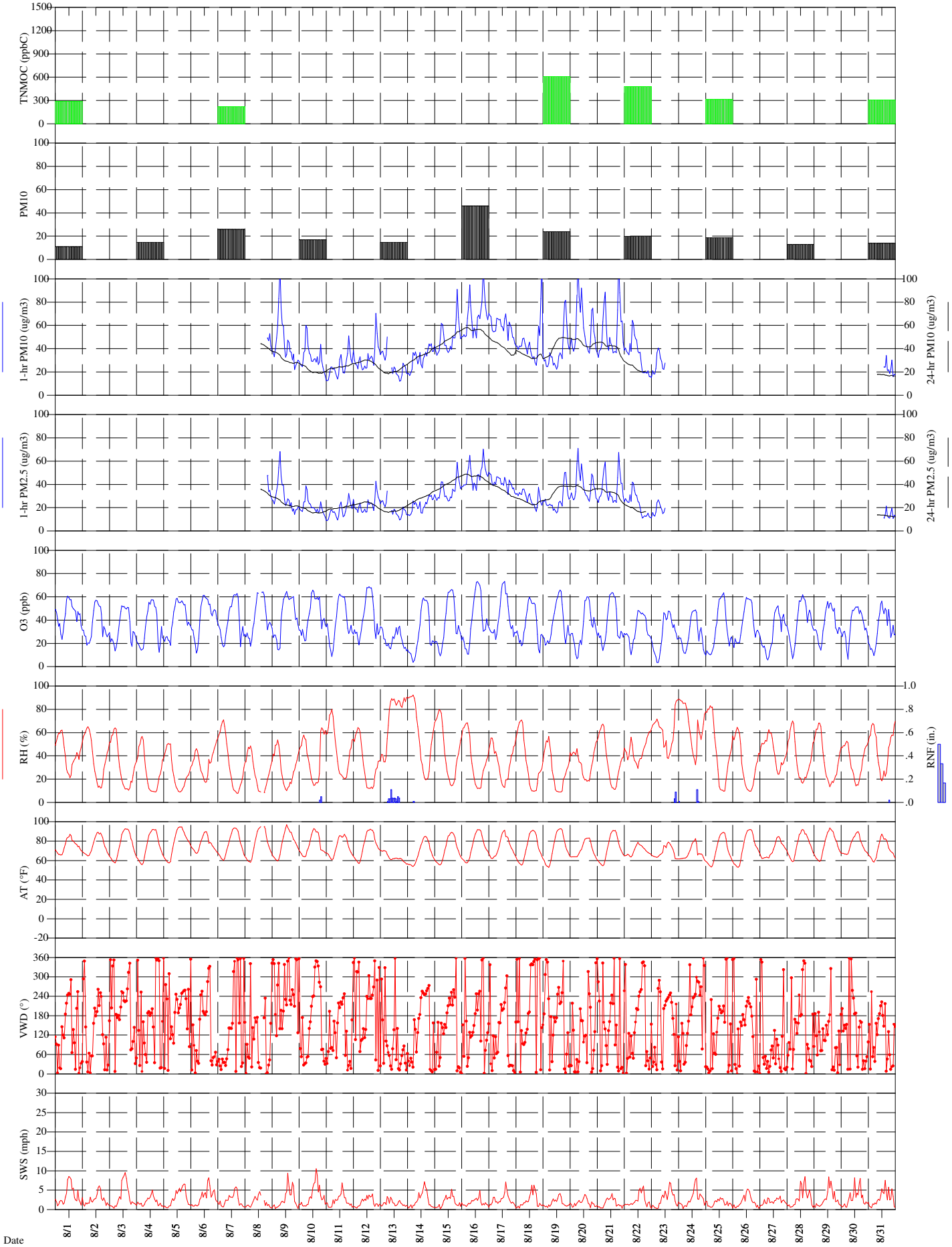
Garfield County, CO

Rifle Site



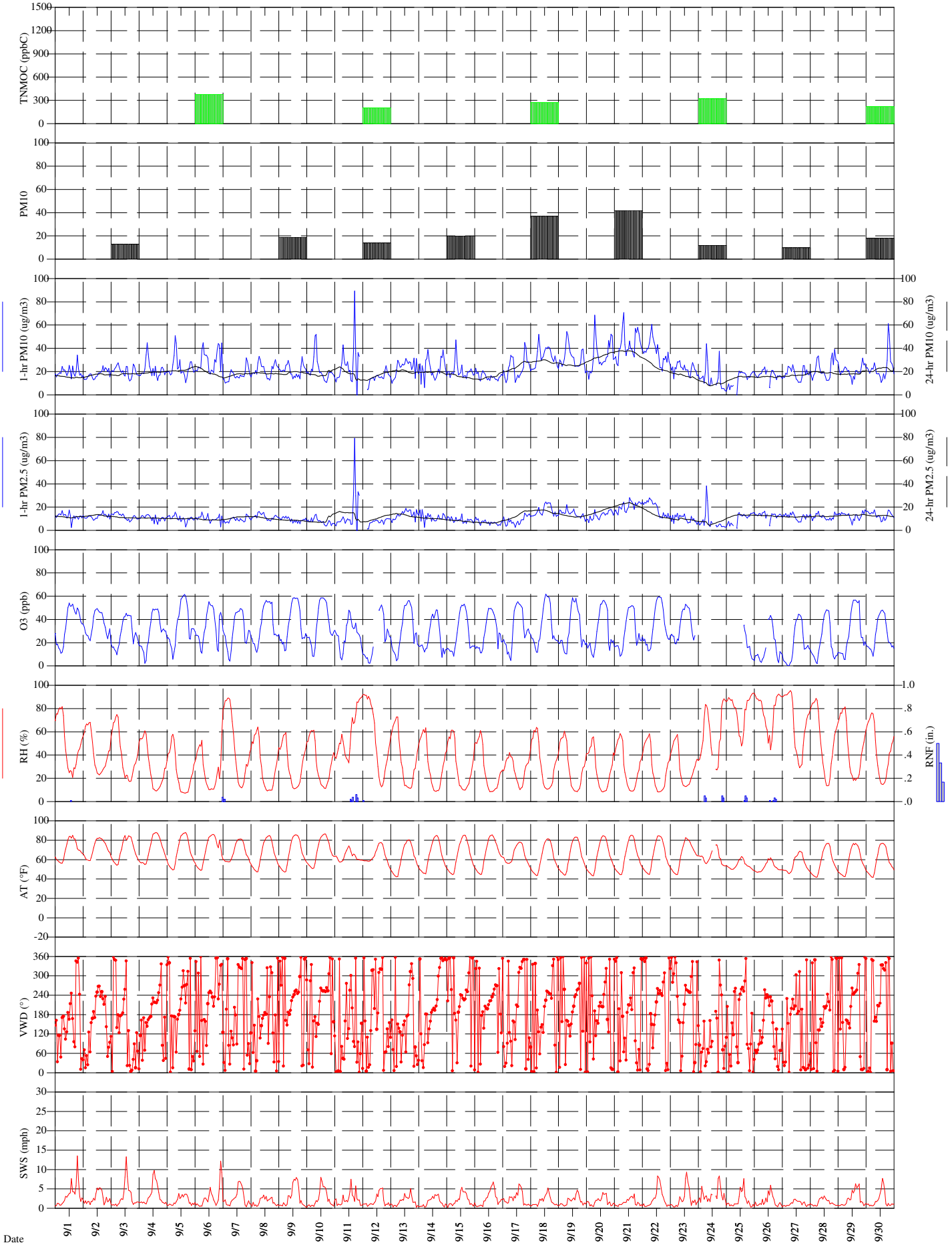
Garfield County, CO

Rifle Site



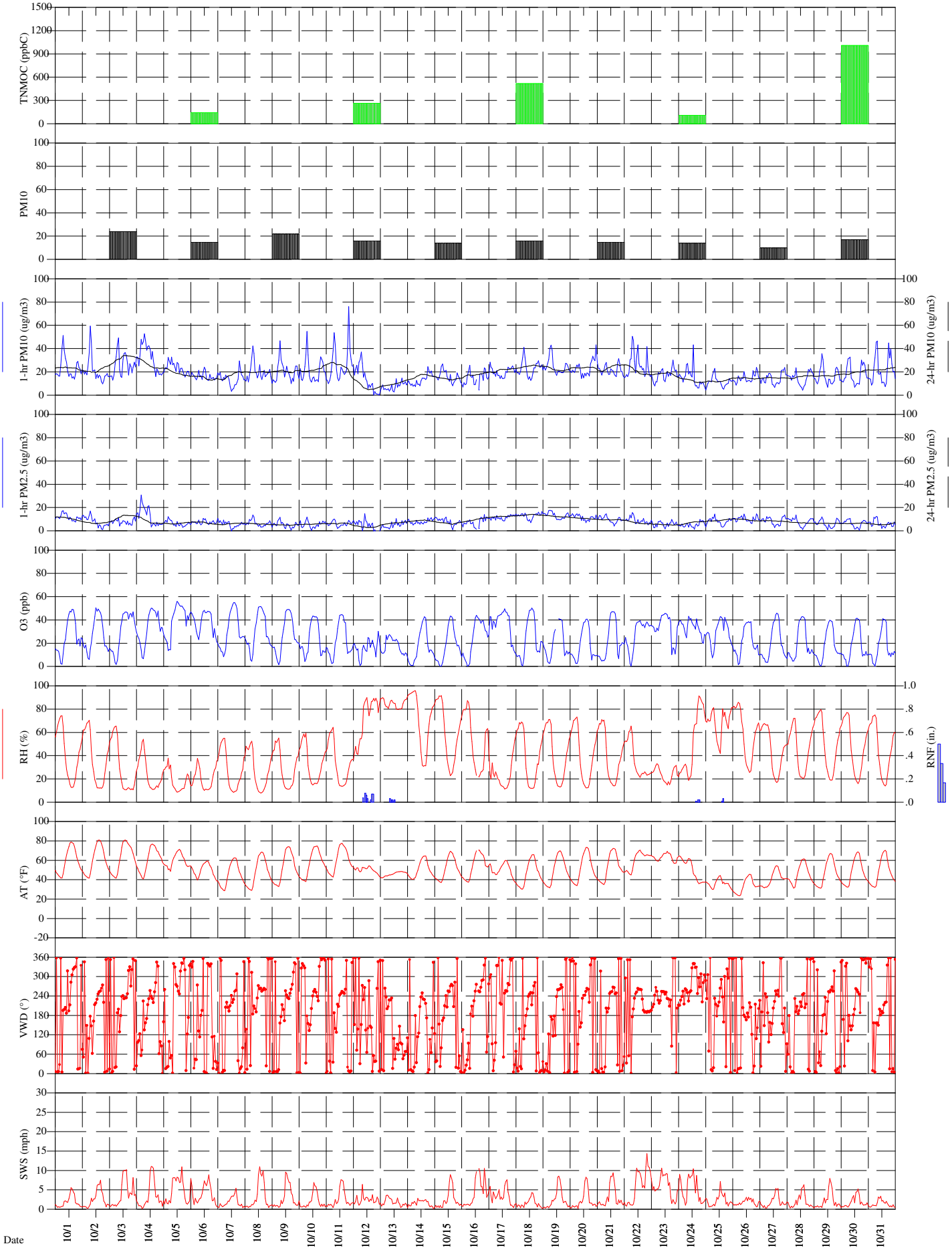
Garfield County, CO

Rifle Site



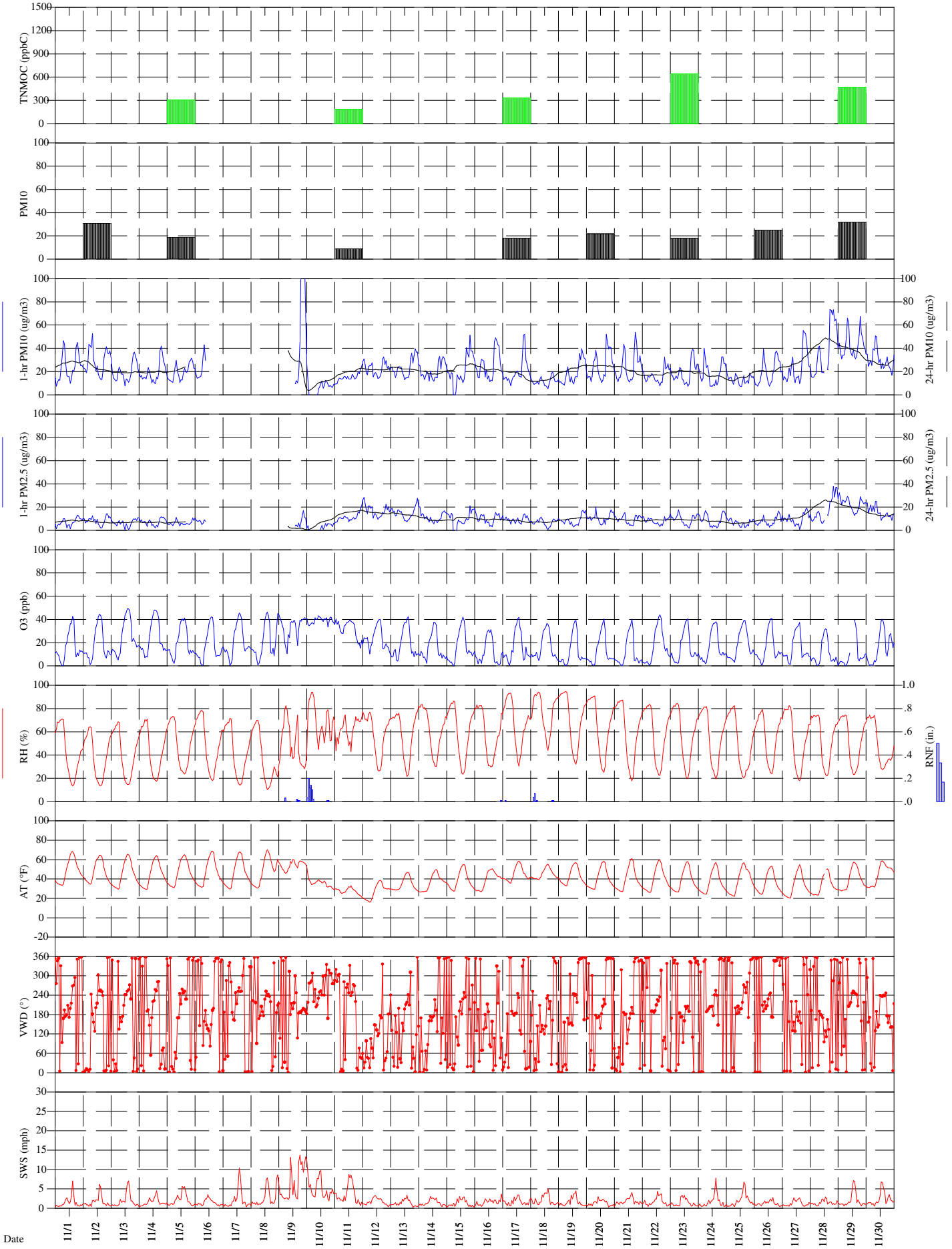
Garfield County, CO

Rifle Site



Garfield County, CO

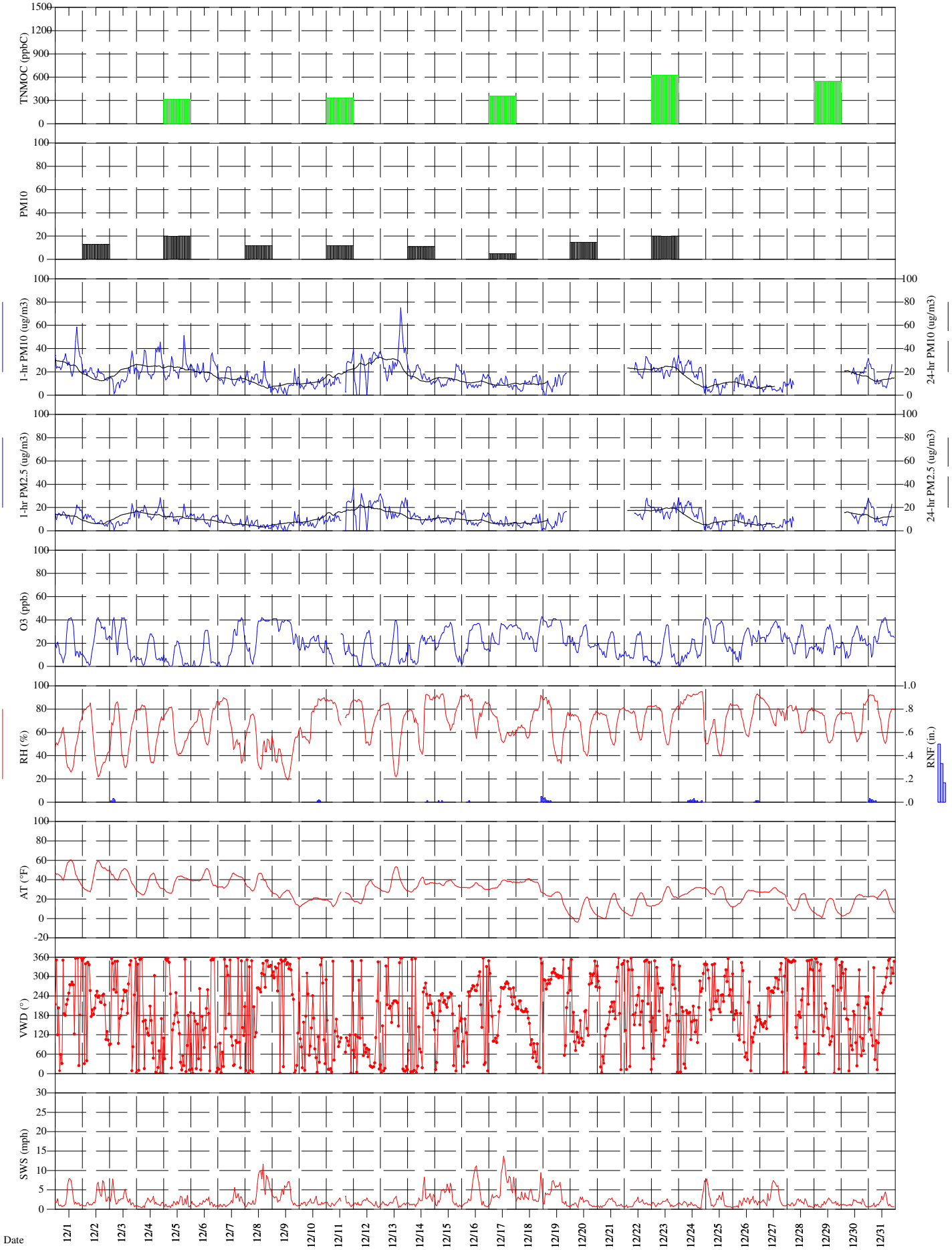
Rifle Site



Date

Garfield County, CO

Rifle Site

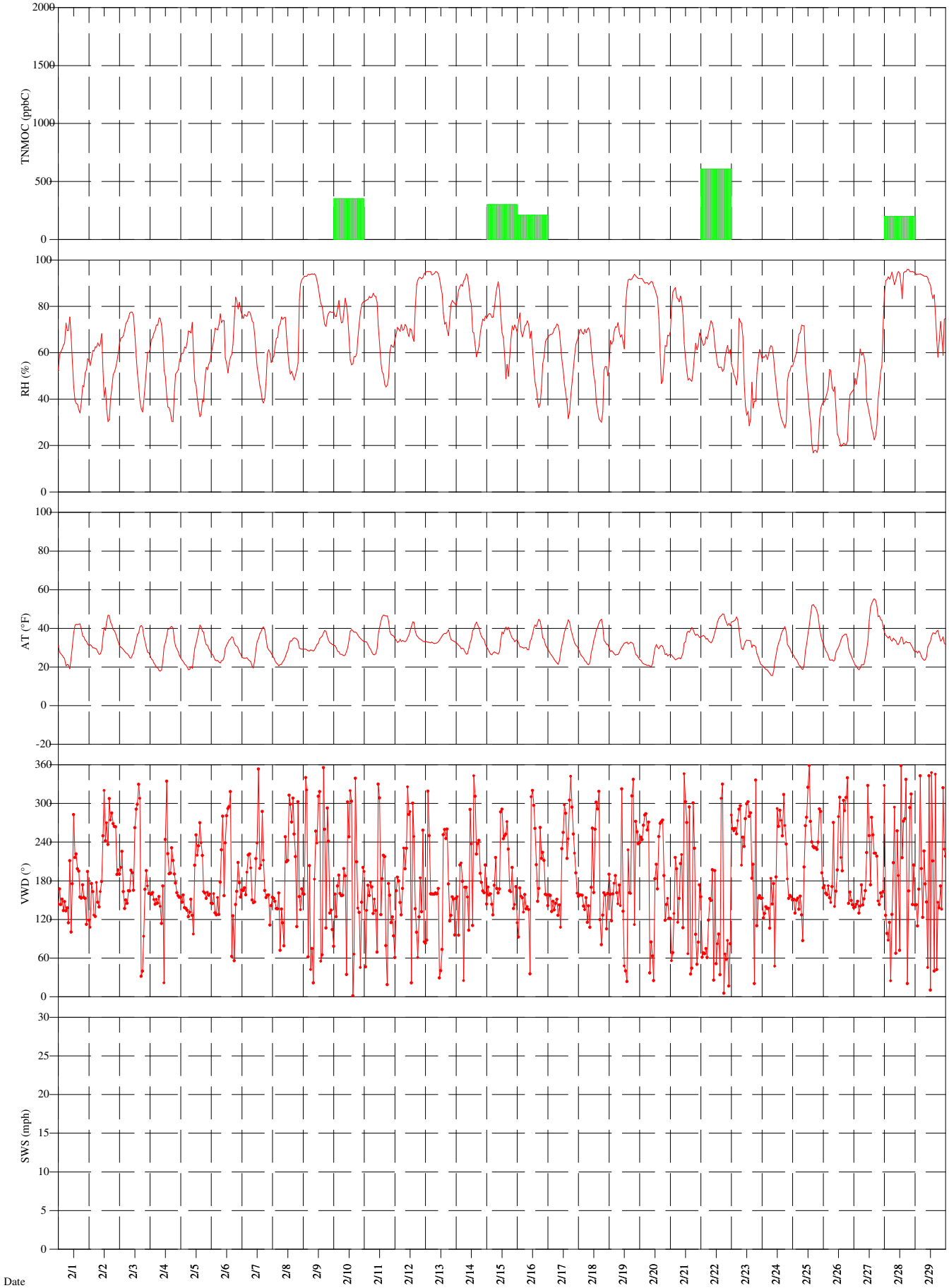


Garfield County, CO

Bell Melton Site

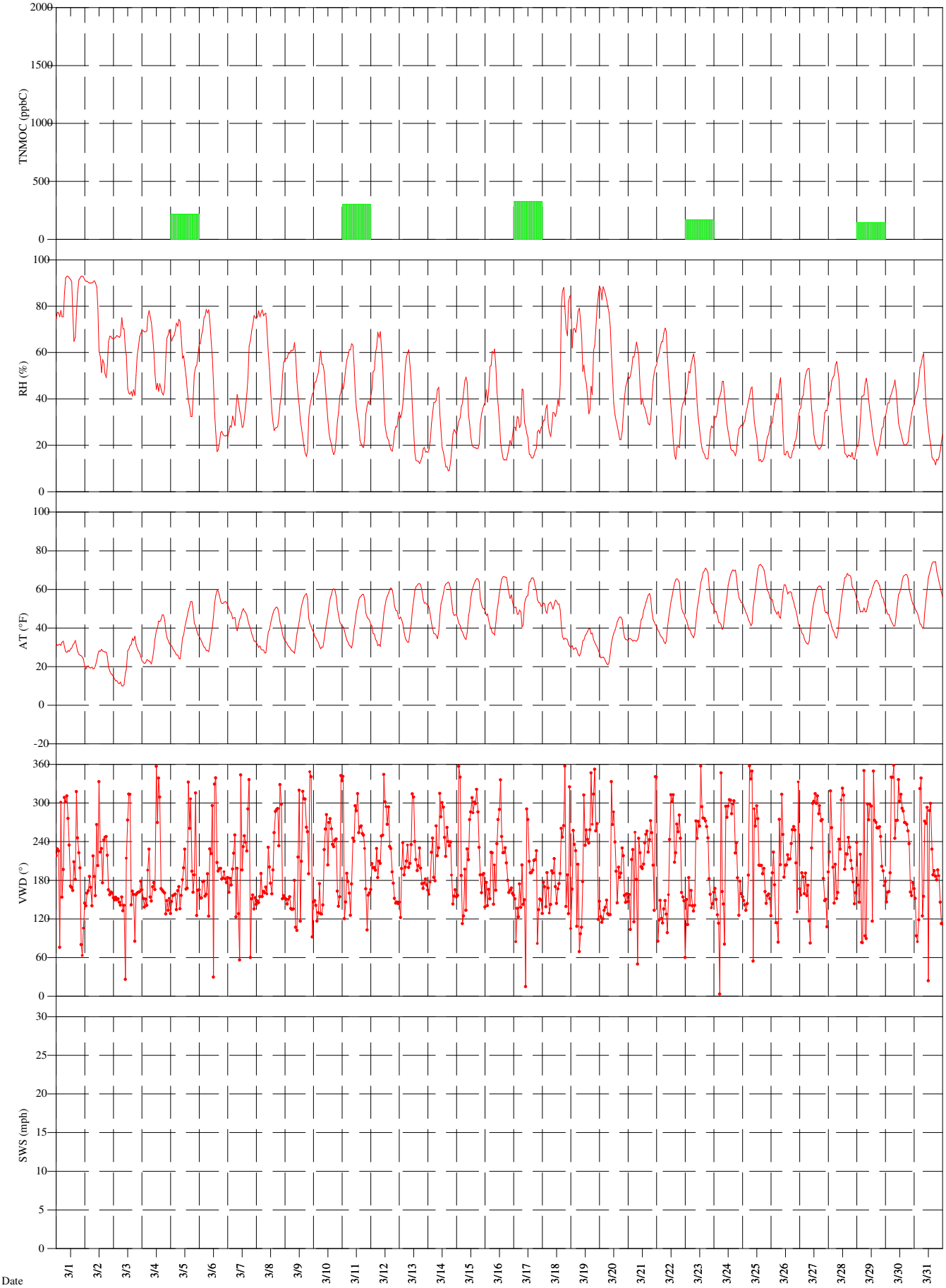
Garfield County, CO

Bell Melton Site



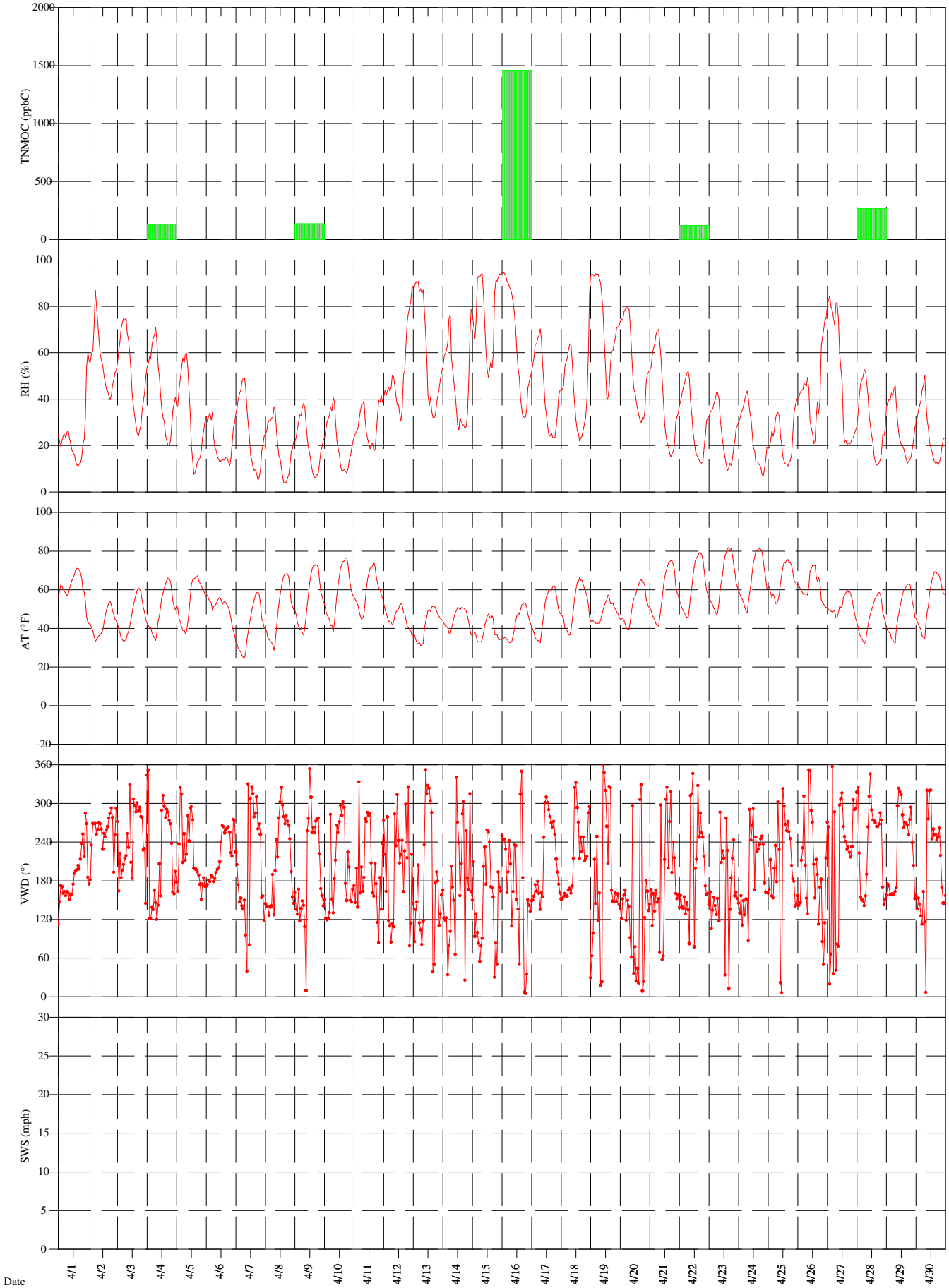
Garfield County, CO

Bell Melton Site



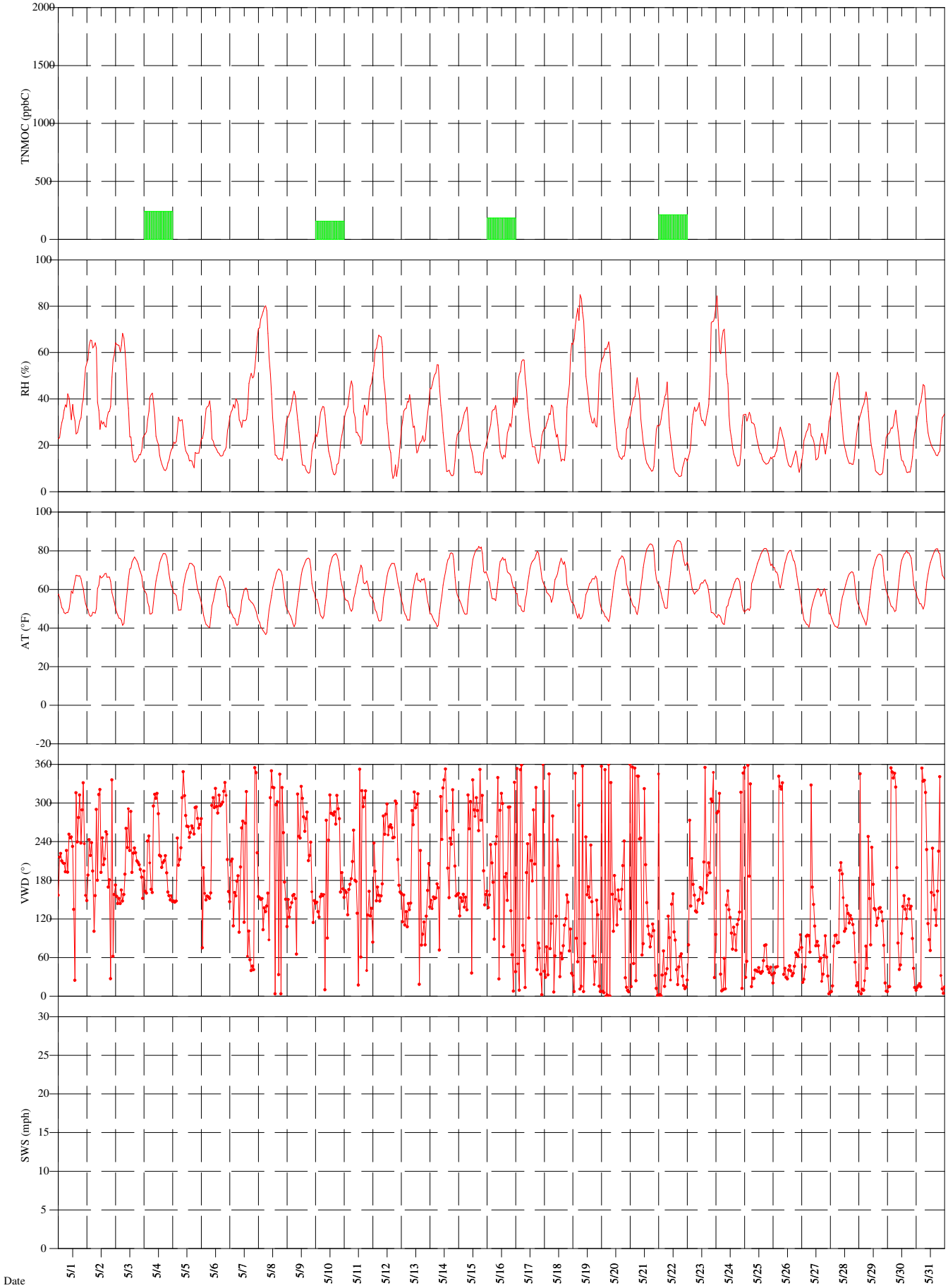
Garfield County, CO

Bell Melton Site



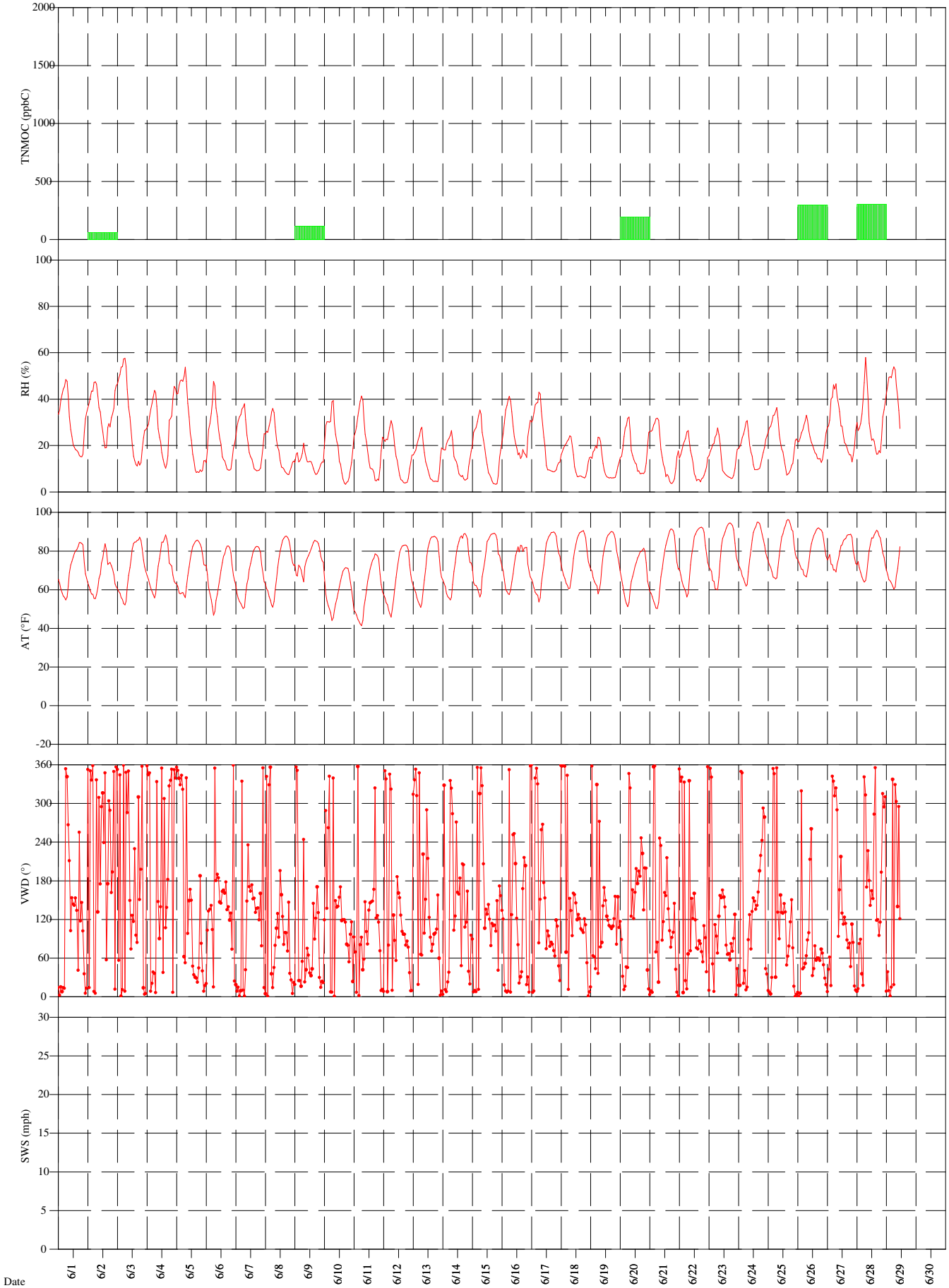
Garfield County, CO

Bell Melton Site



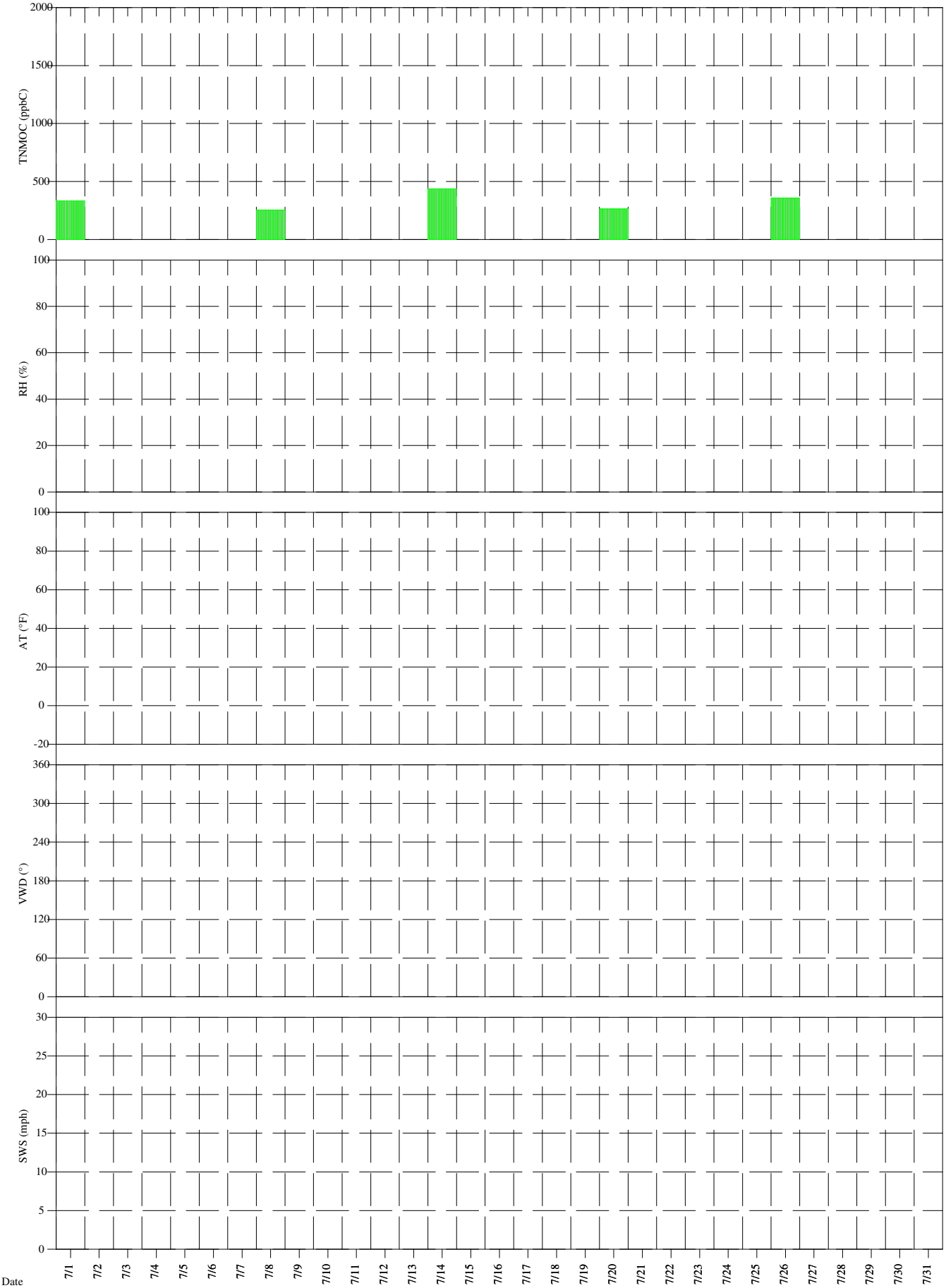
Garfield County, CO

Bell Melton Site



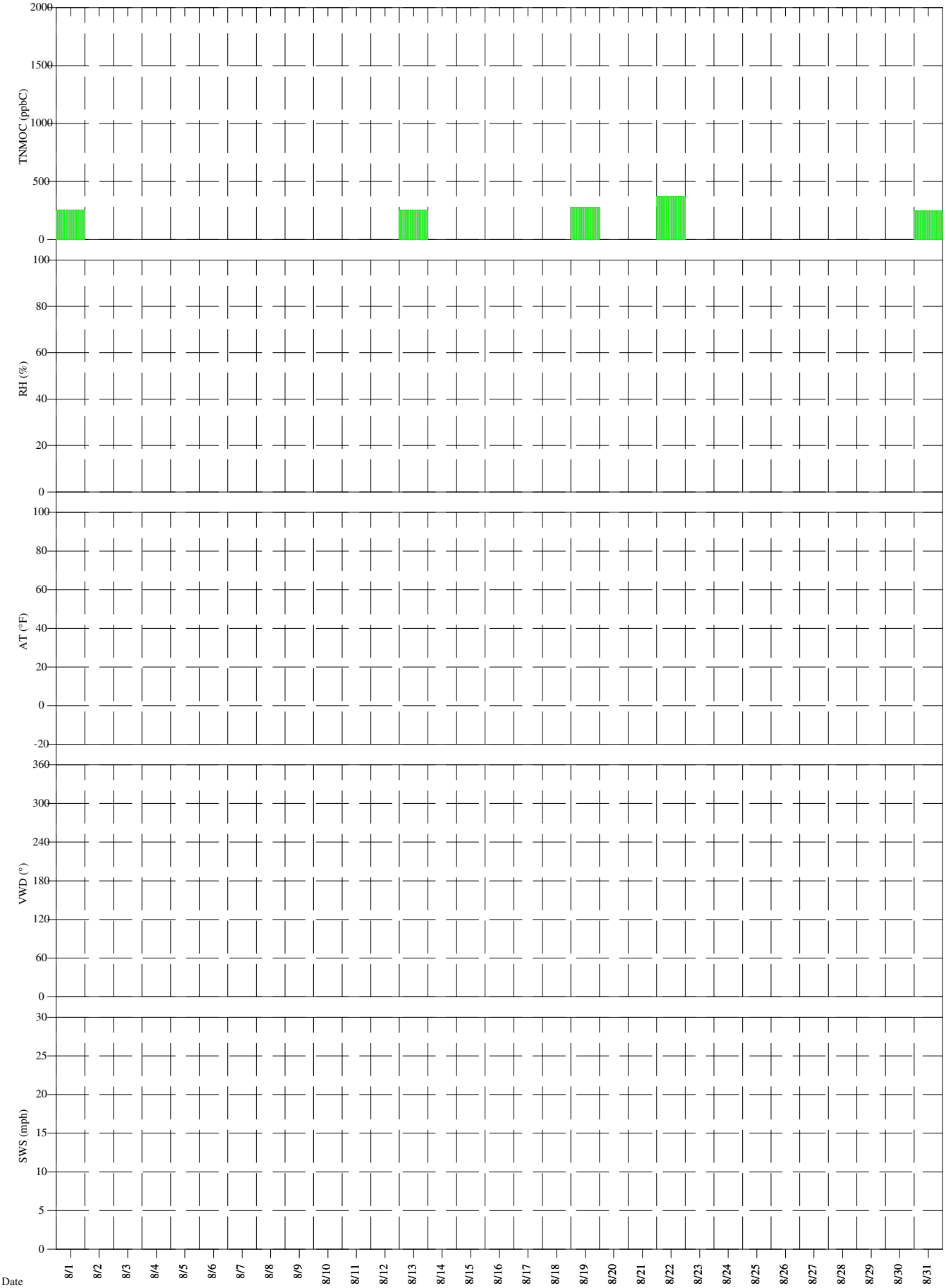
Garfield County, CO

Bell Melton Site



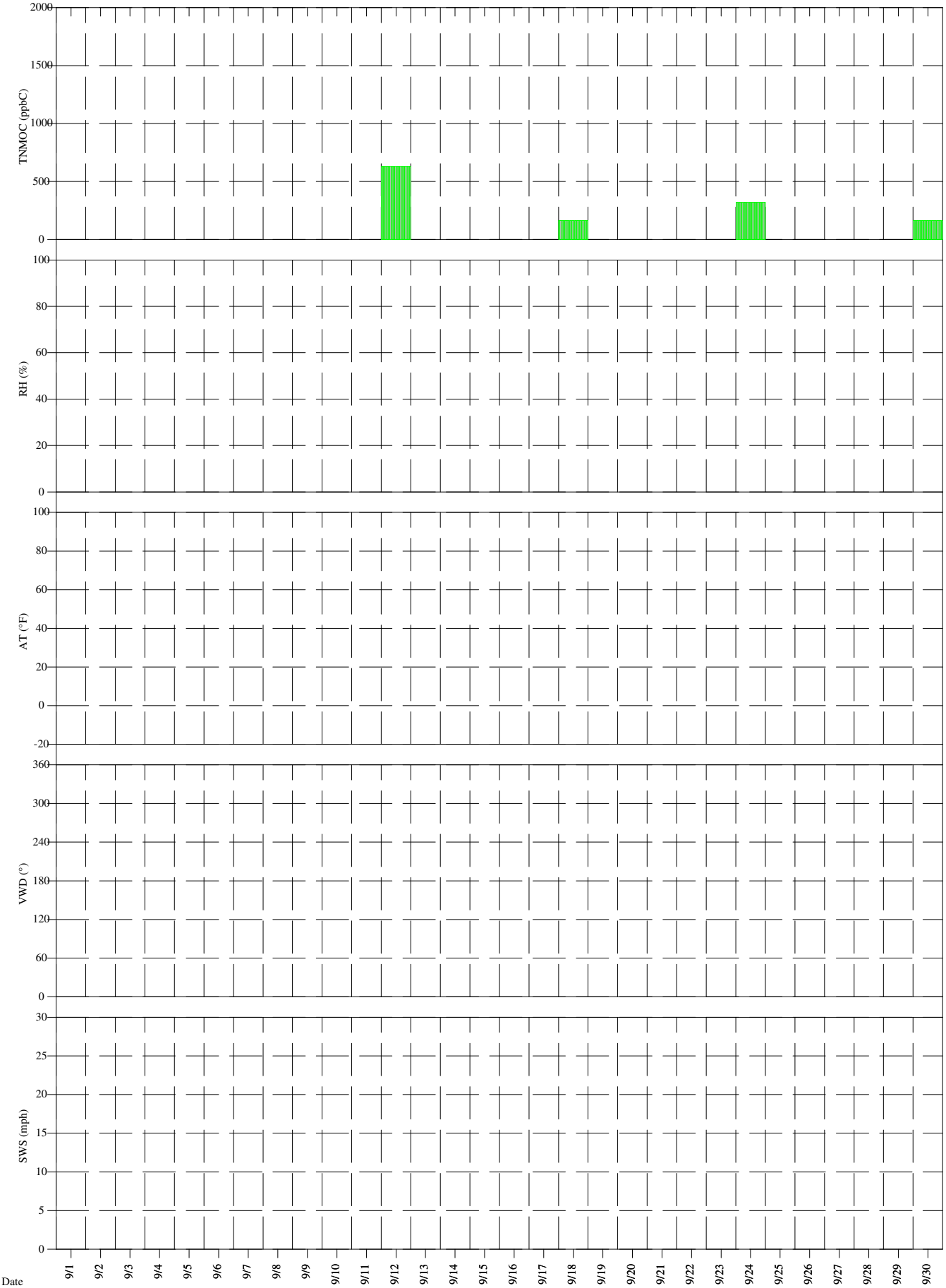
Garfield County, CO

Bell Melton Site



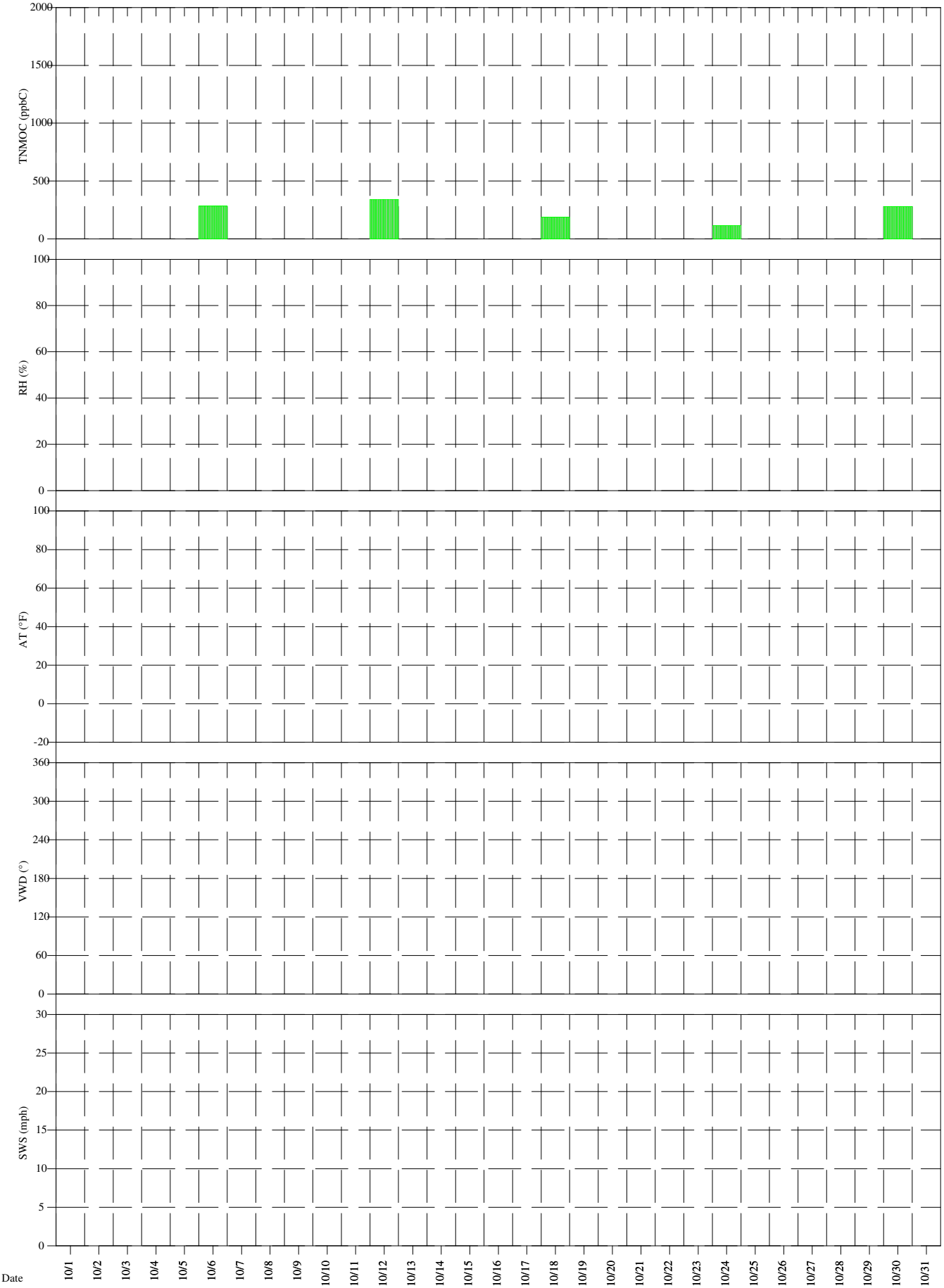
Garfield County, CO

Bell Melton Site



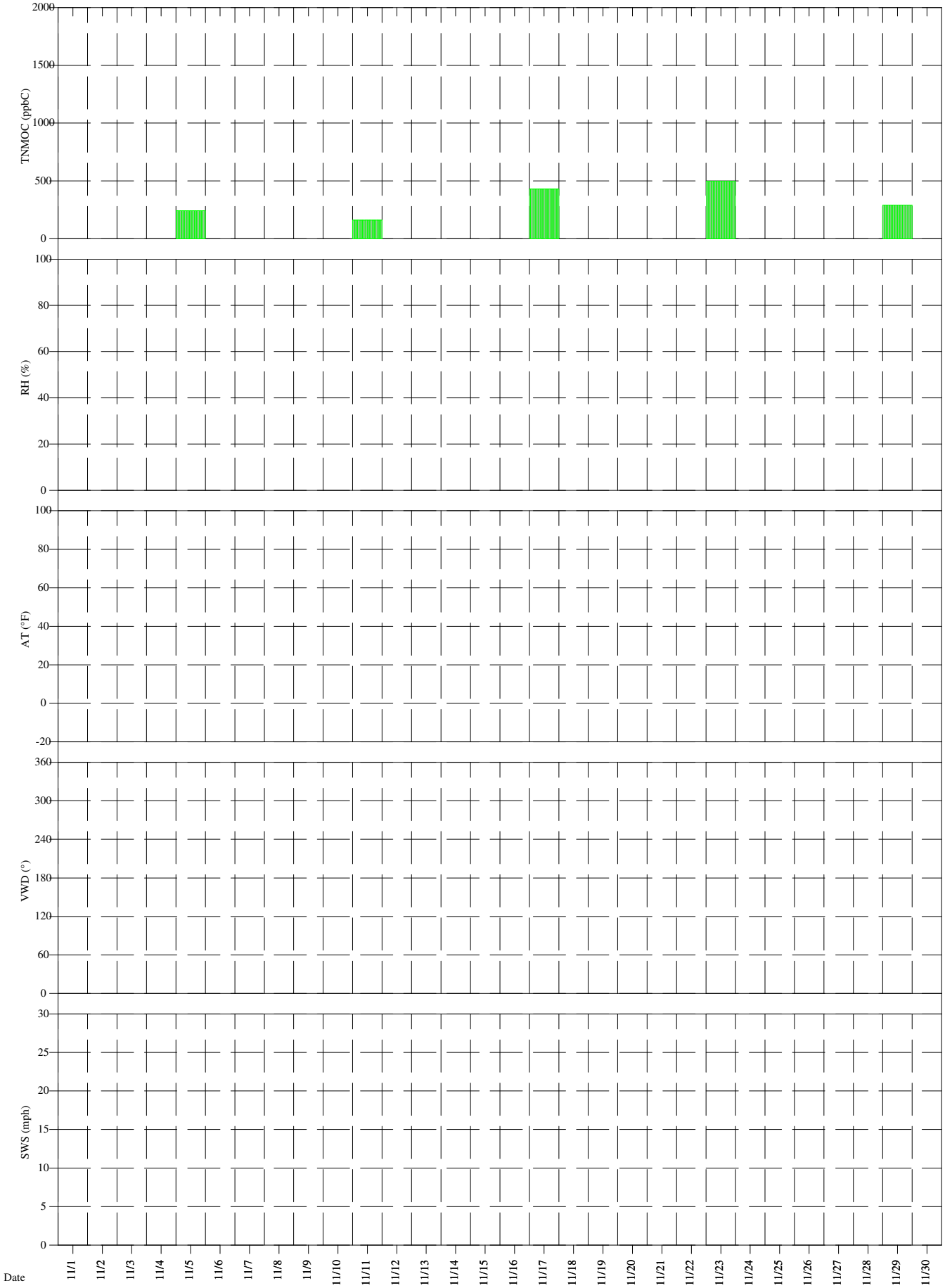
Garfield County, CO

Bell Melton Site



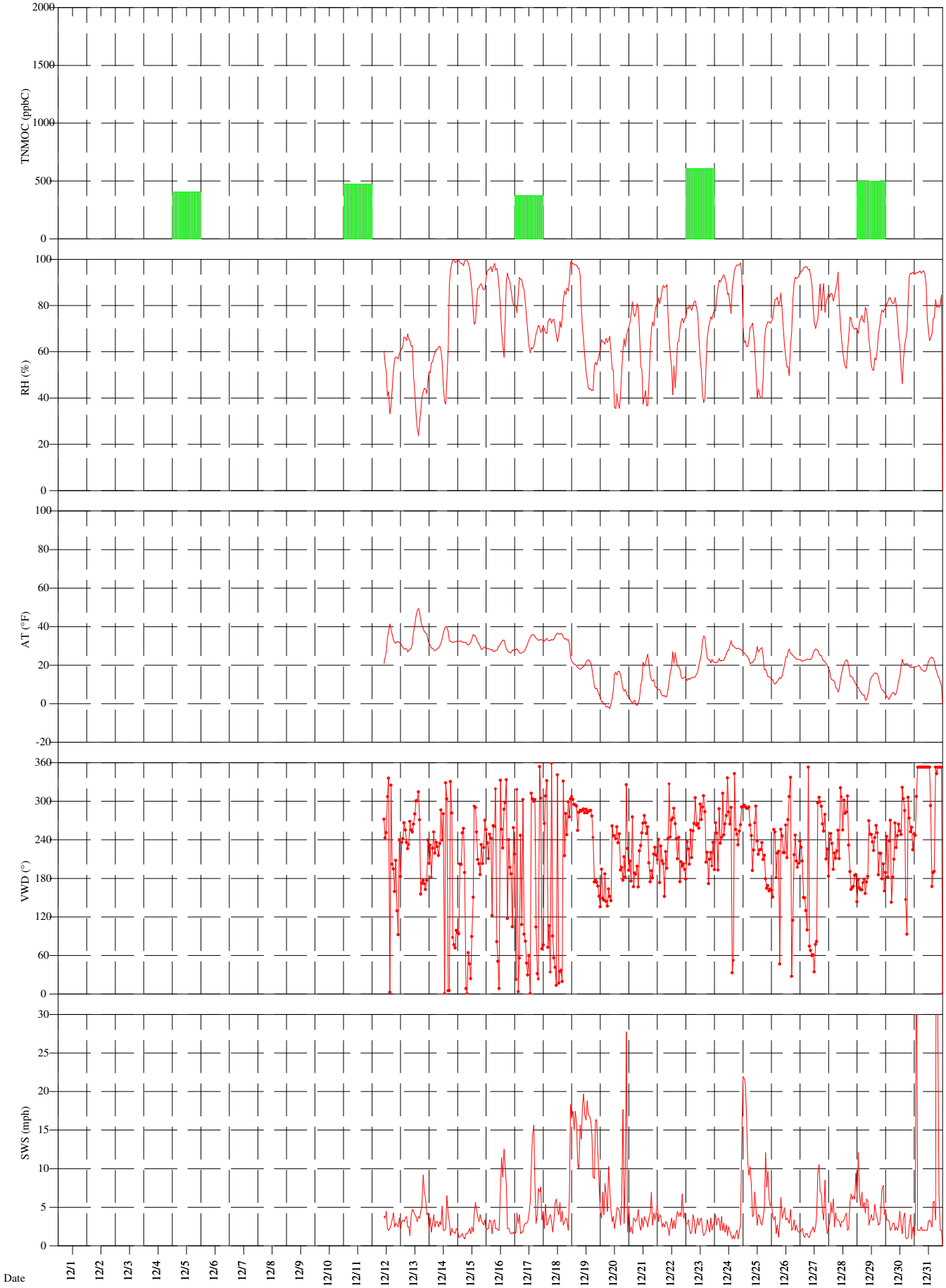
Garfield County, CO

Bell Melton Site



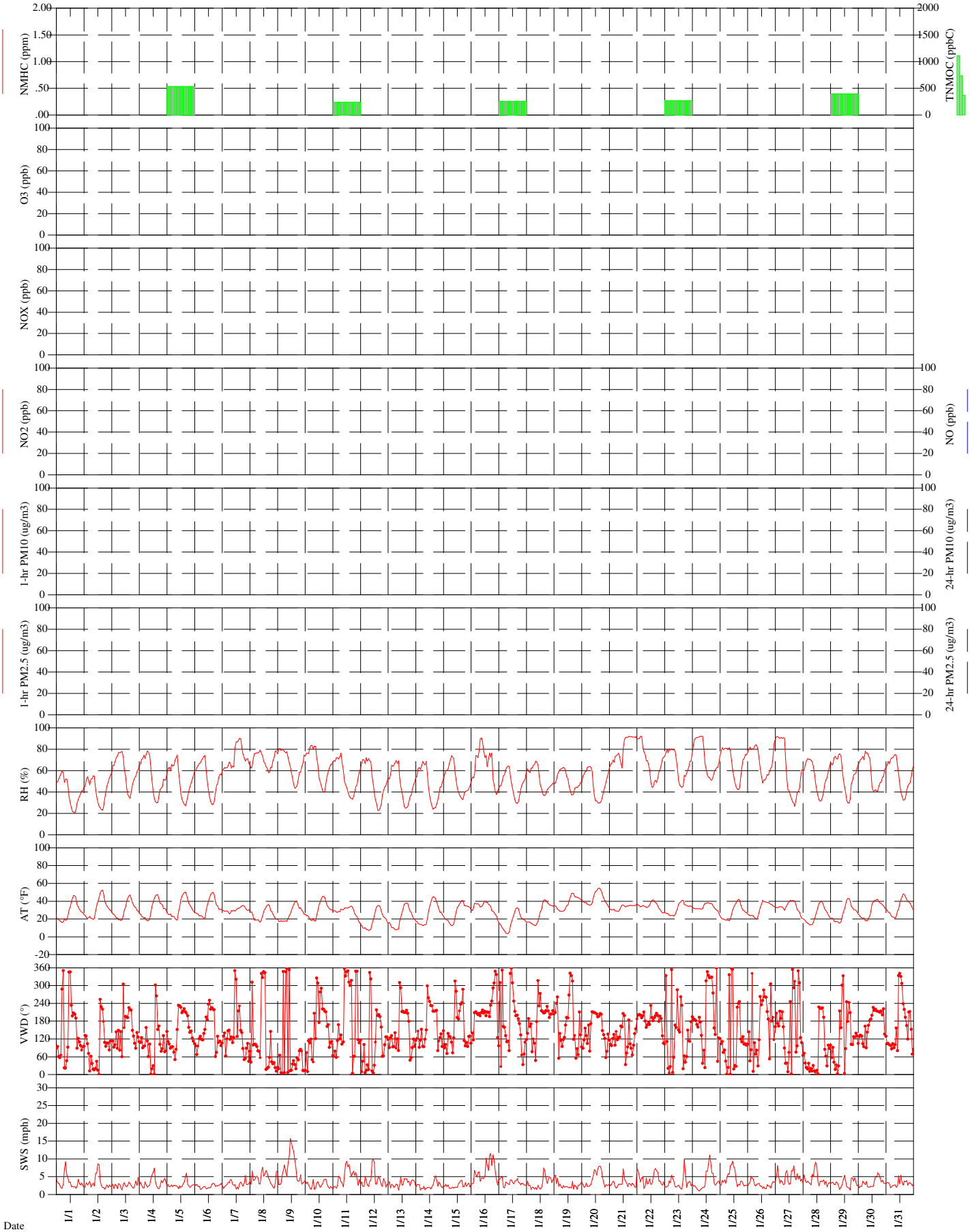
Garfield County, CO

Bell Melton Site



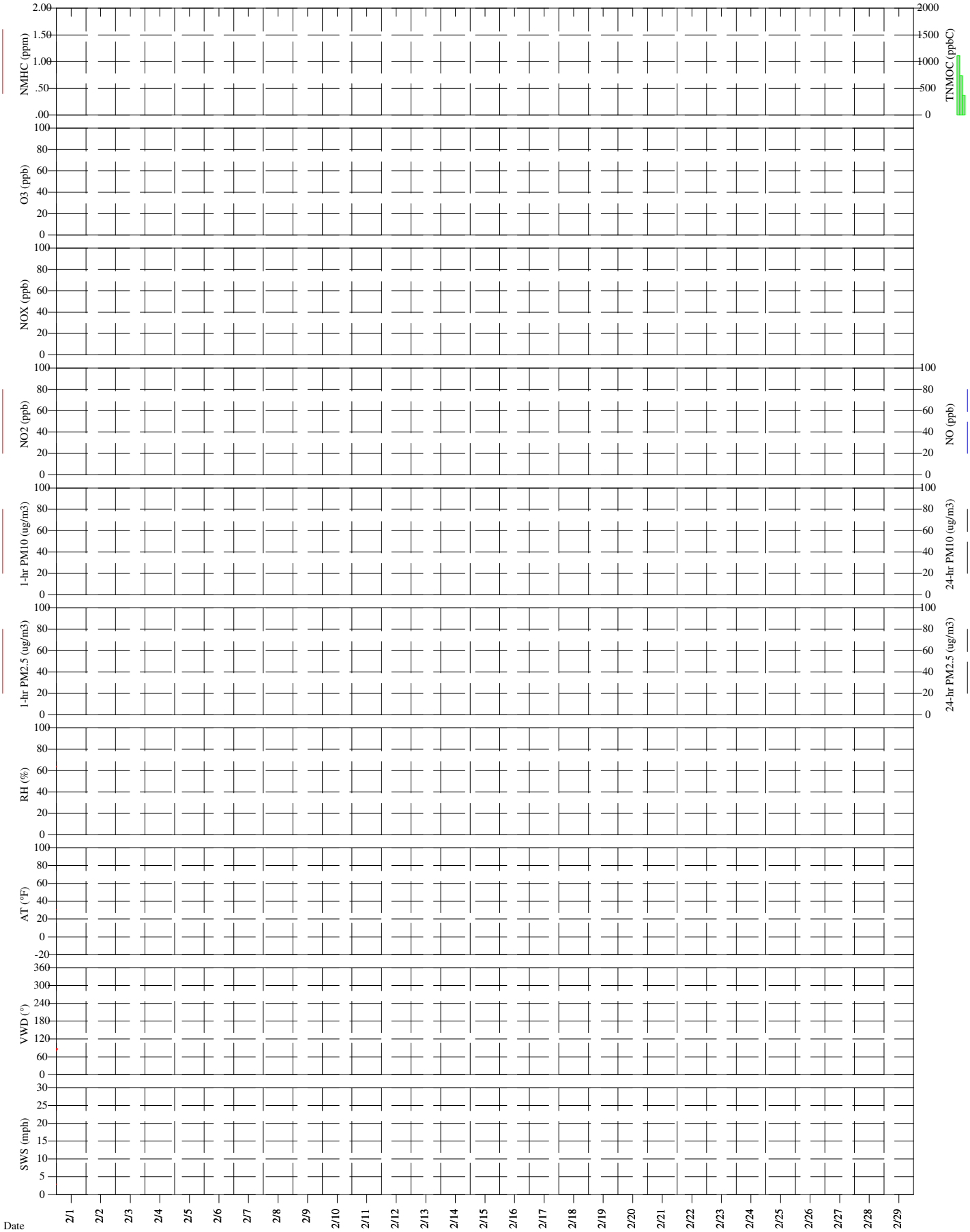
Garfield County, CO

Battlement Mesa Site



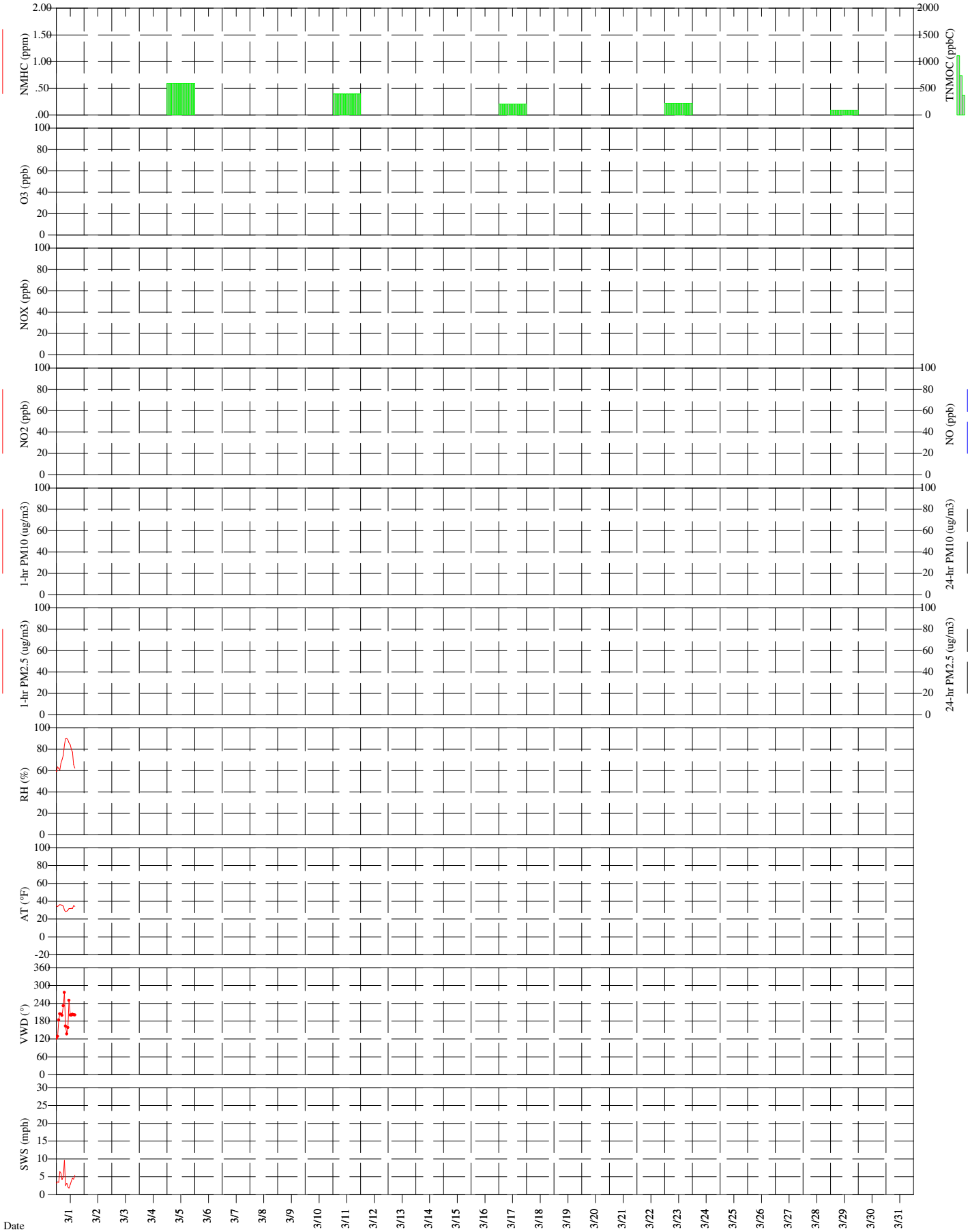
Garfield County, CO

Battlement Mesa Site



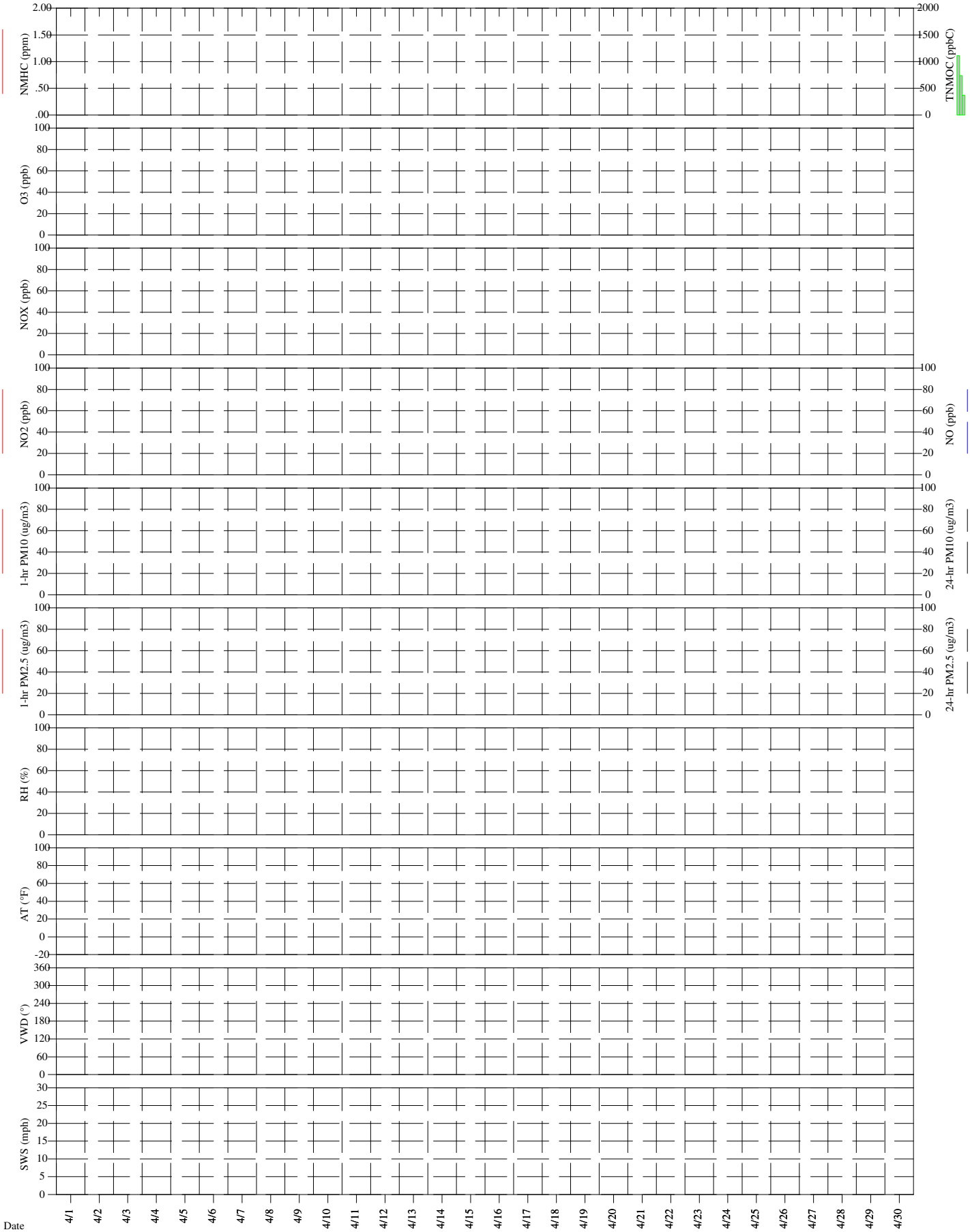
Garfield County, CO

Battlement Mesa Site



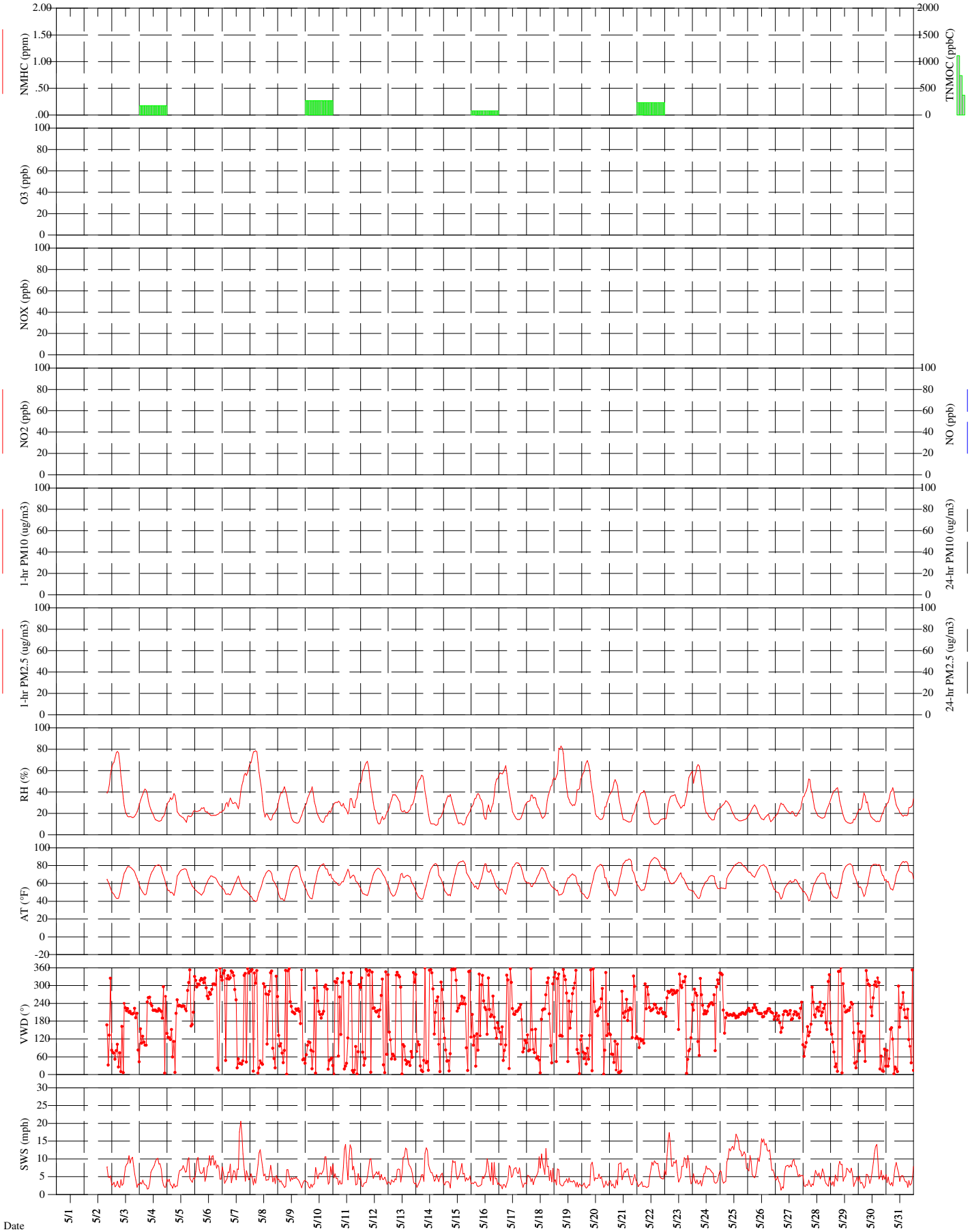
Garfield County, CO

Battlement Mesa Site

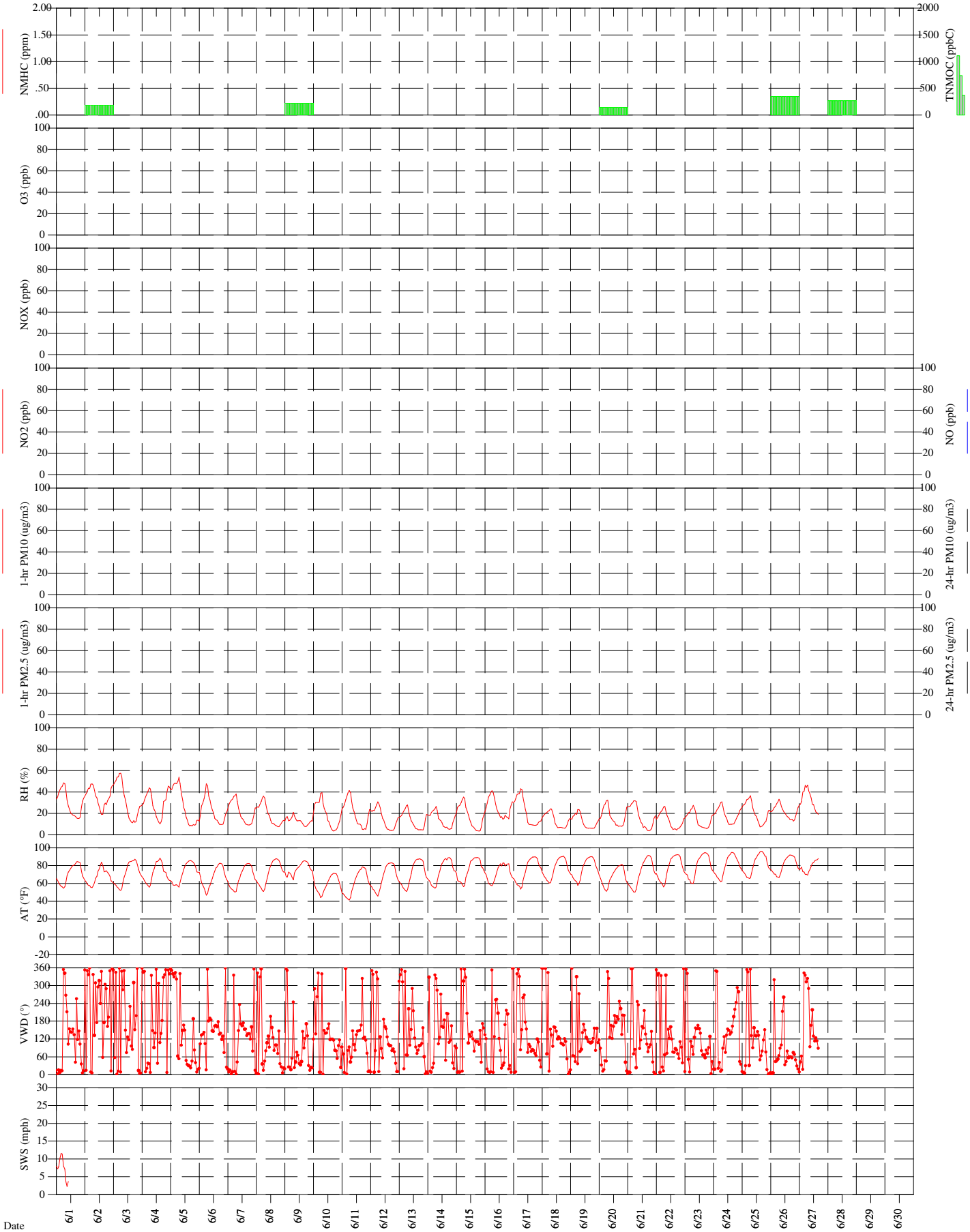


Garfield County, CO

Battlement Mesa Site

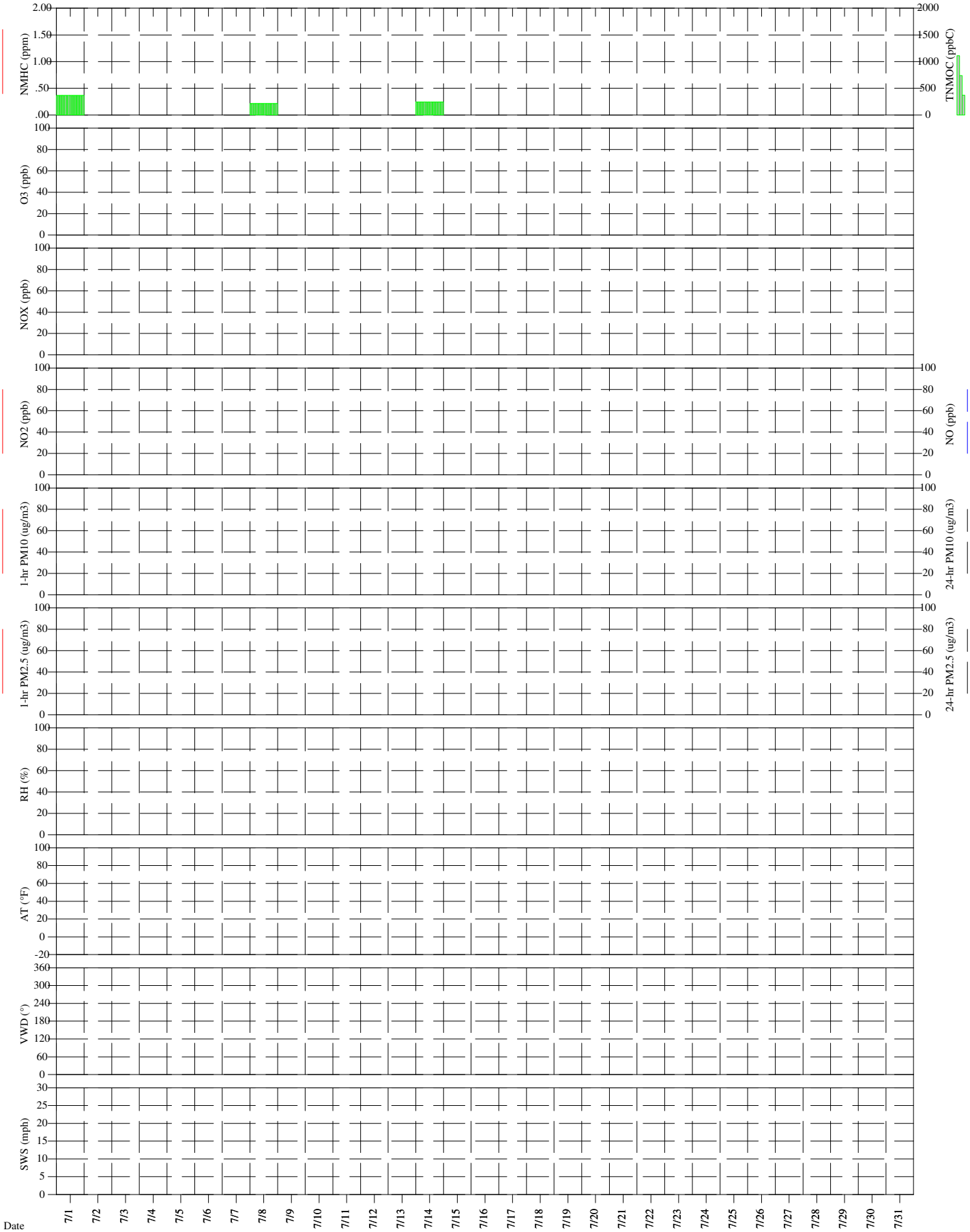


Garfield County, CO
Battlement Mesa Site



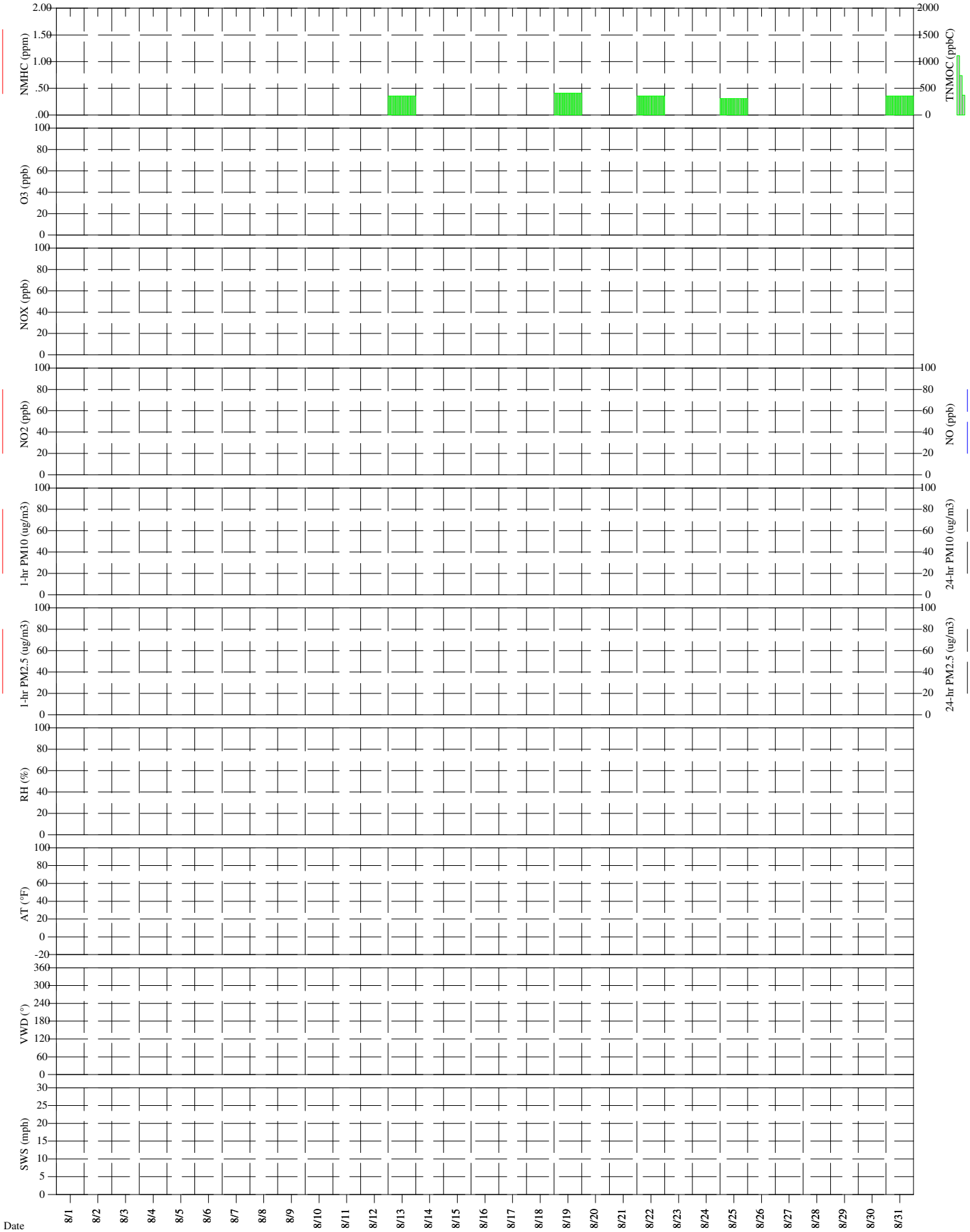
Garfield County, CO

Battlement Mesa Site



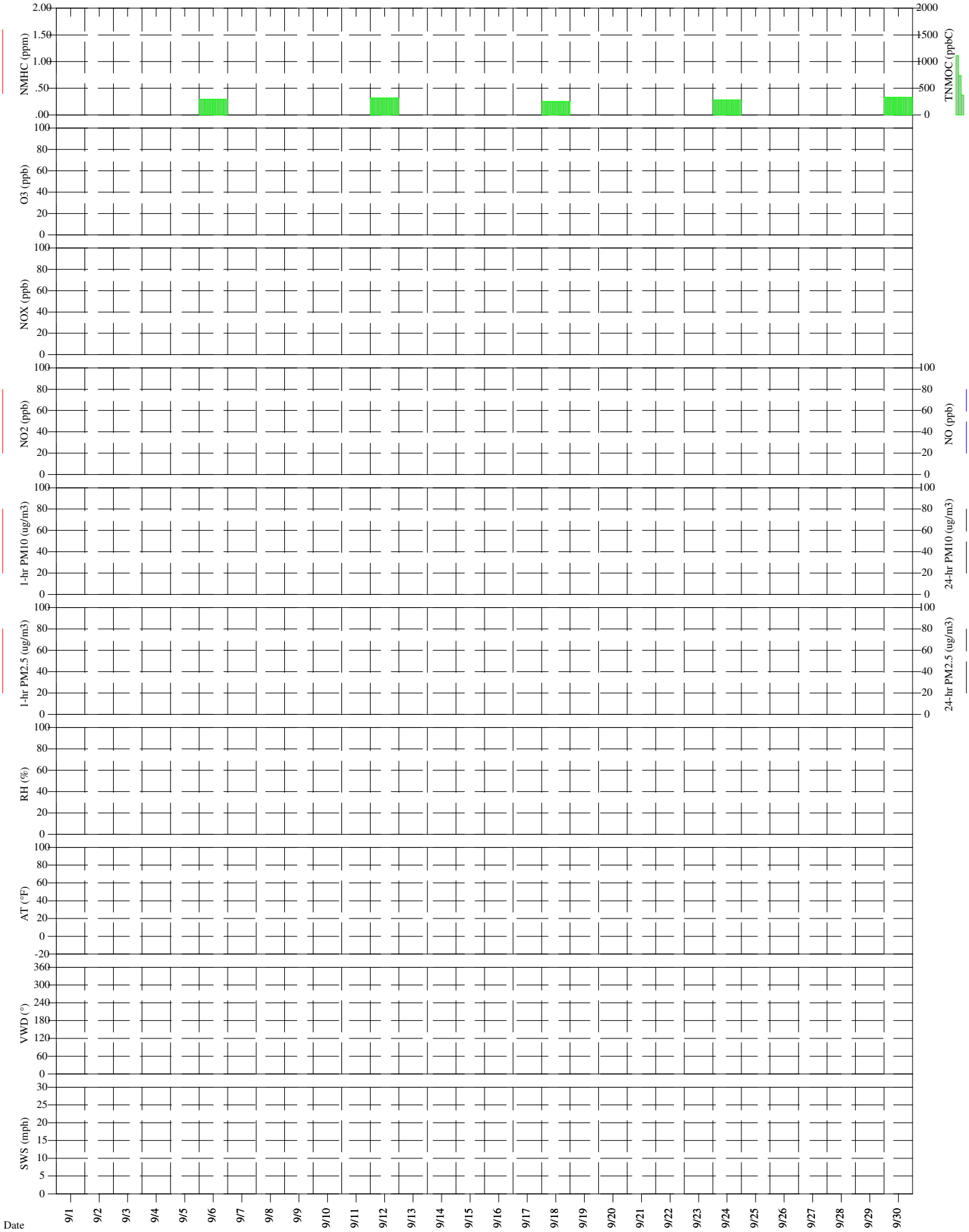
Garfield County, CO

Battlement Mesa Site



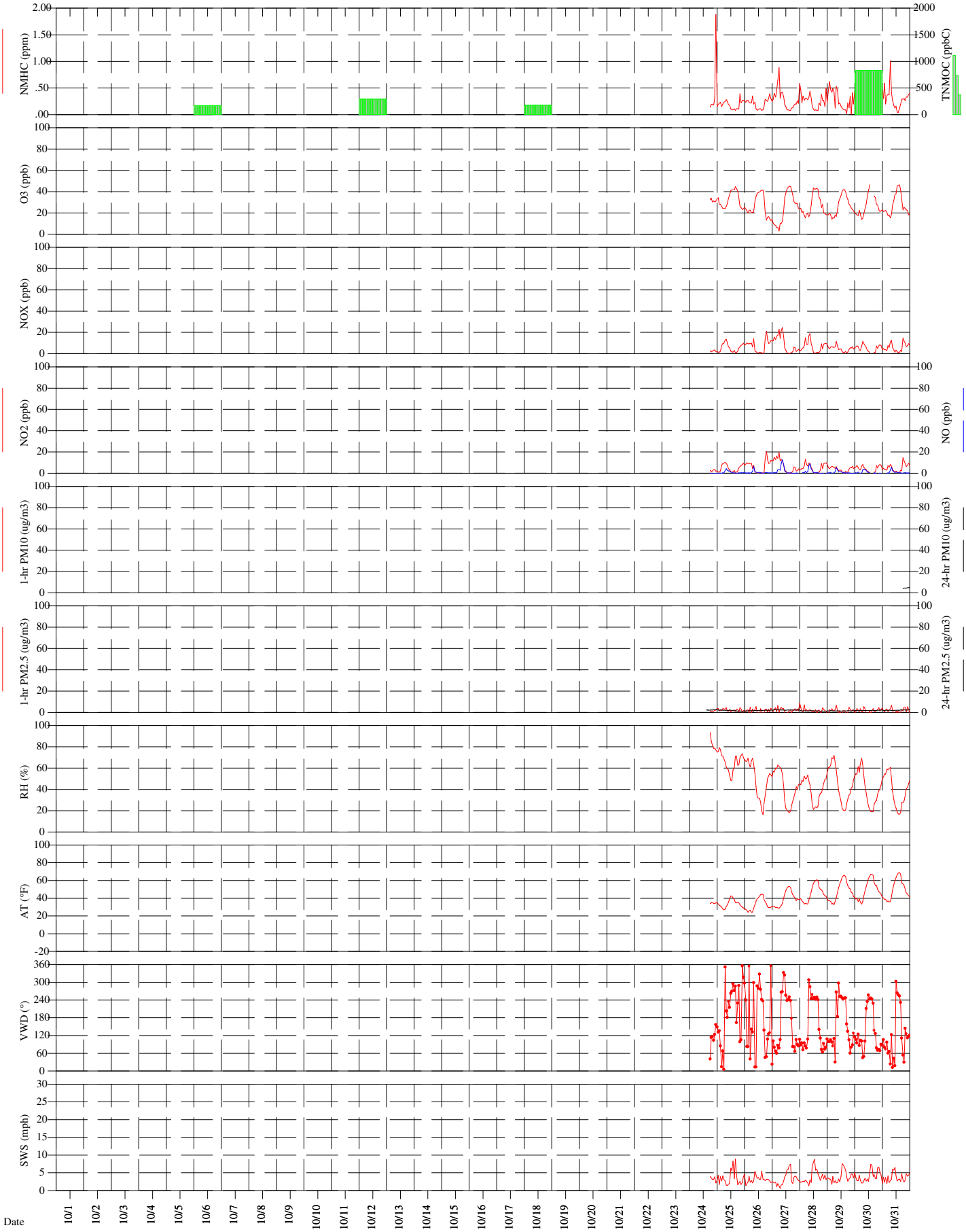
Garfield County, CO

Battlement Mesa Site



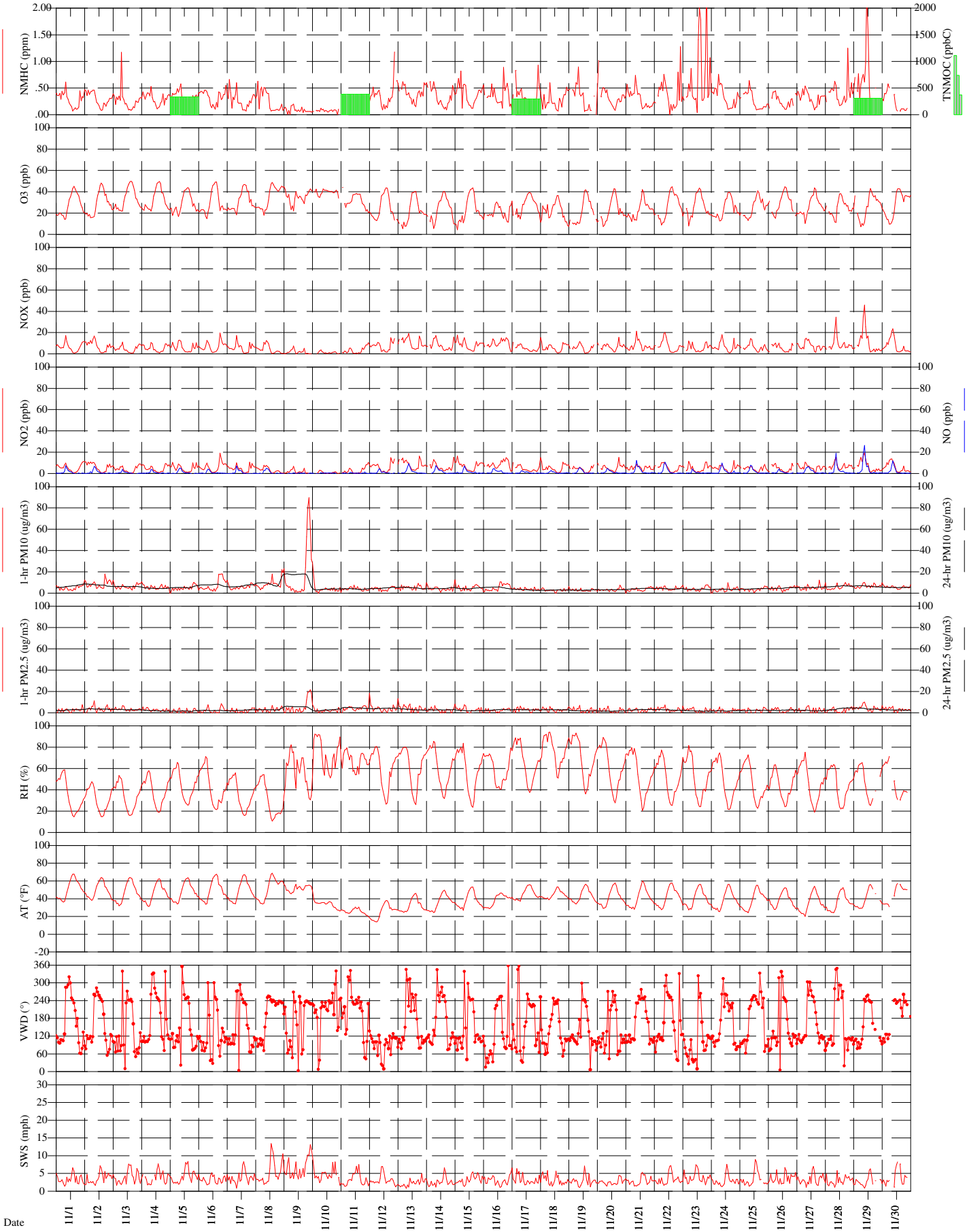
Garfield County, CO

Battlement Mesa Site



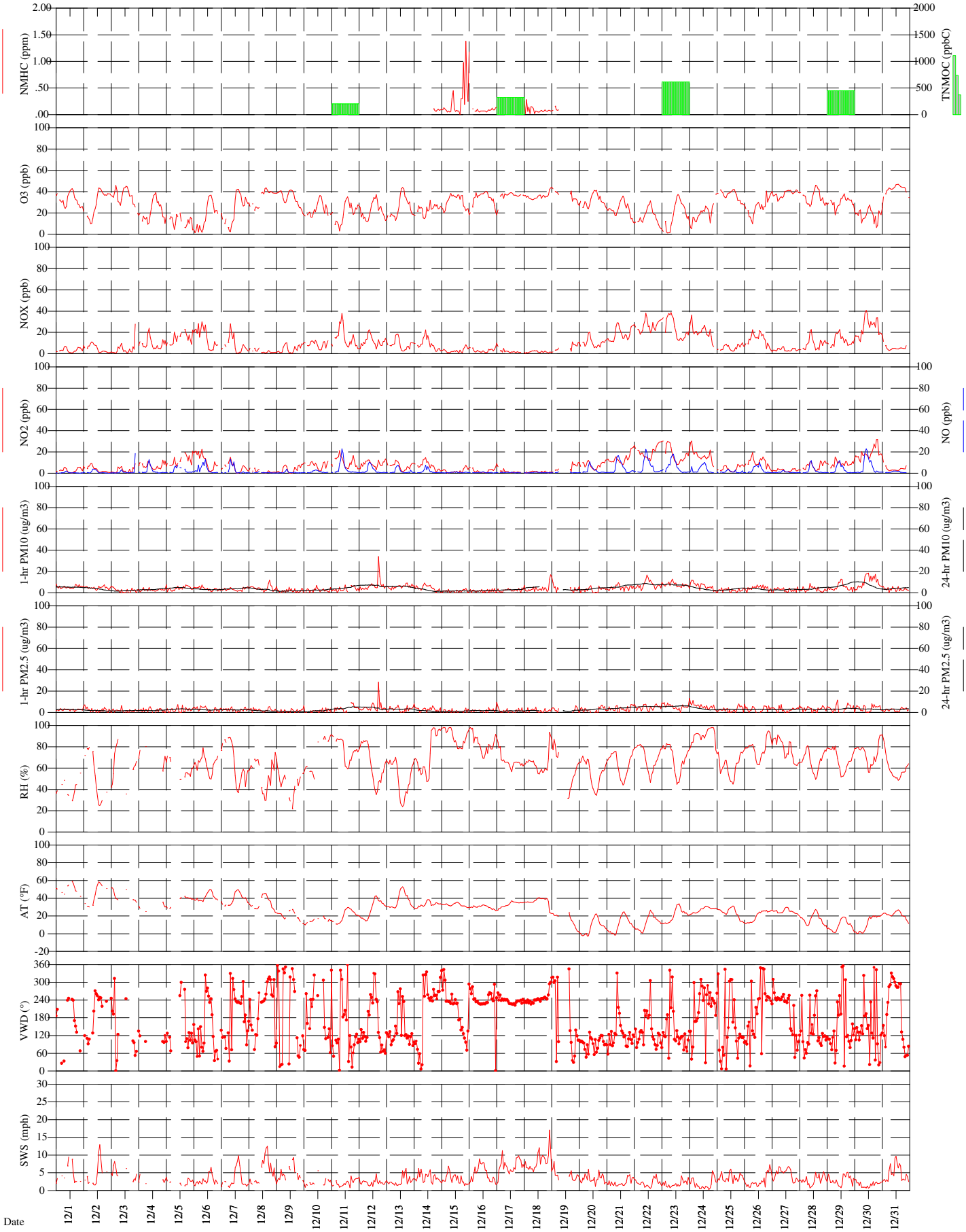
Garfield County, CO

Battlement Mesa Site



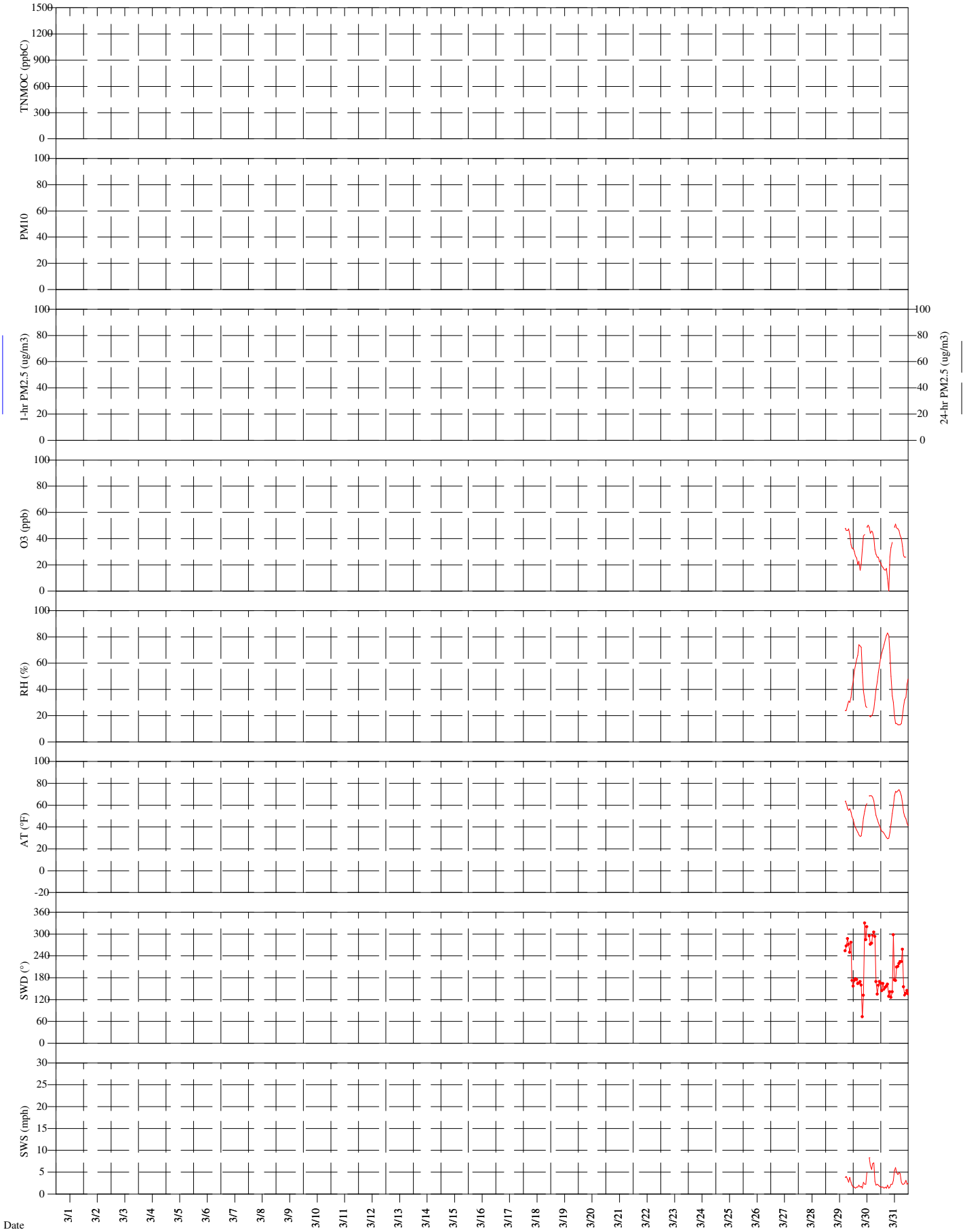
Garfield County, CO

Battlement Mesa Site



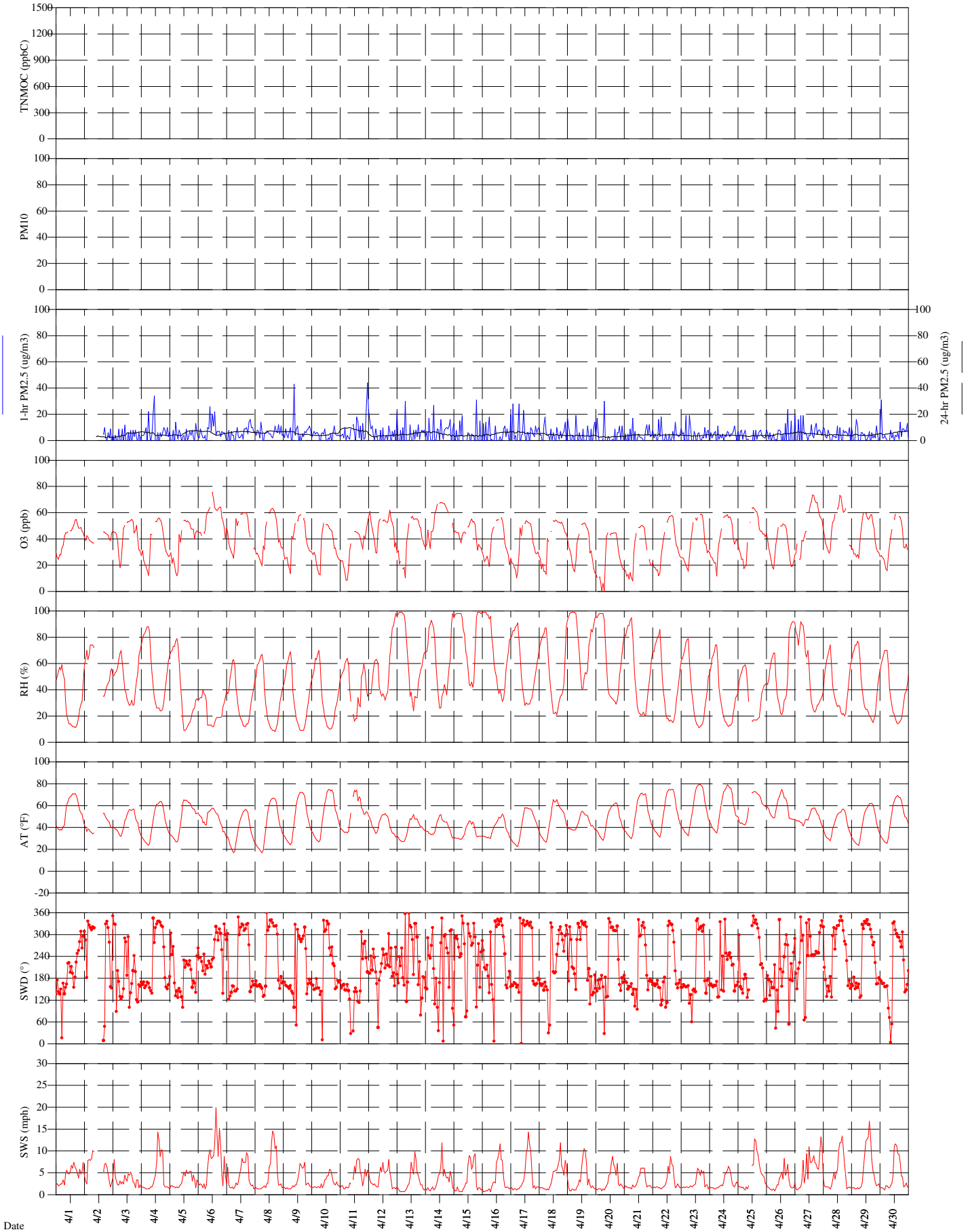
Garfield County, CO

Carbondale Site



Garfield County, CO

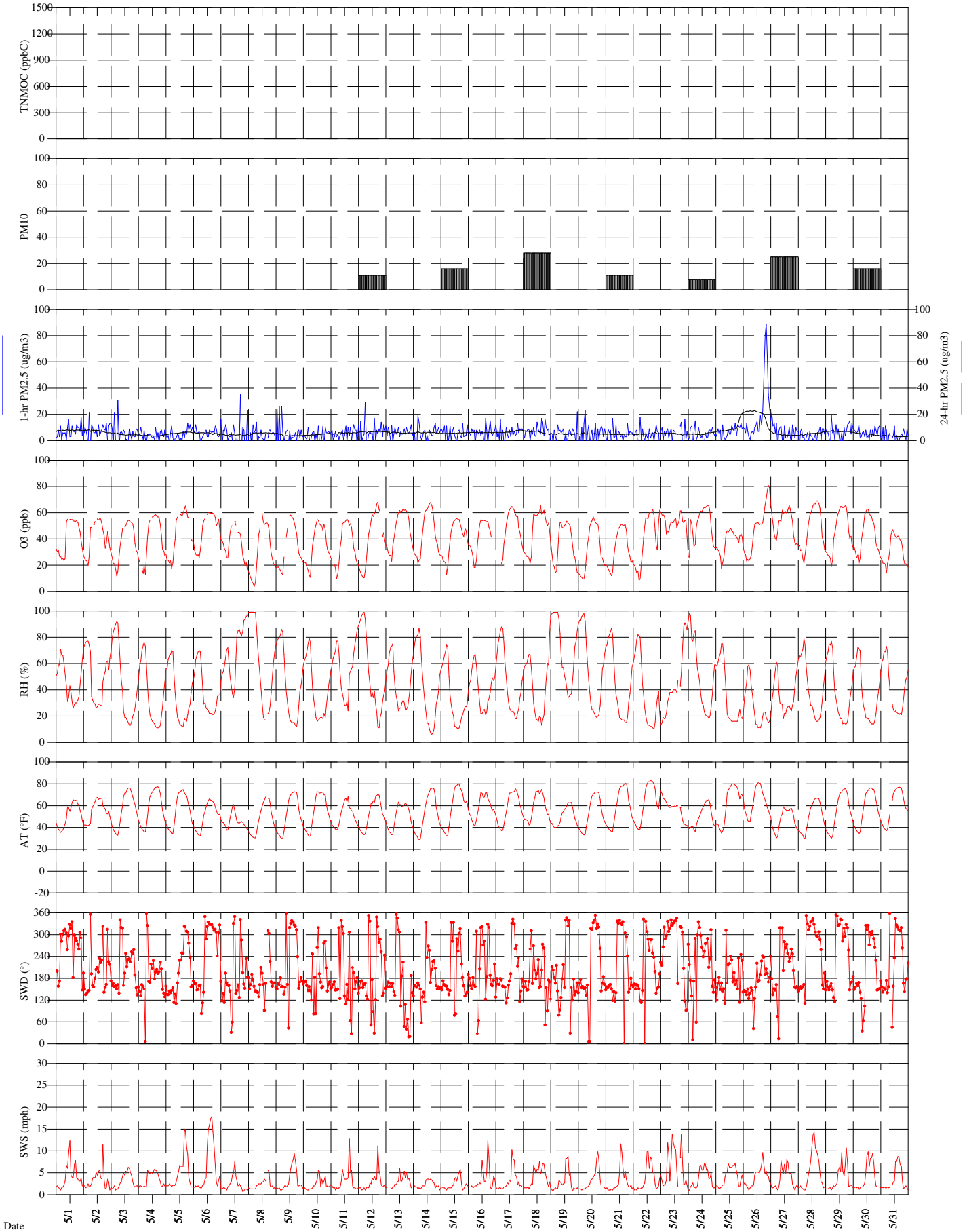
Carbondale Site



Date

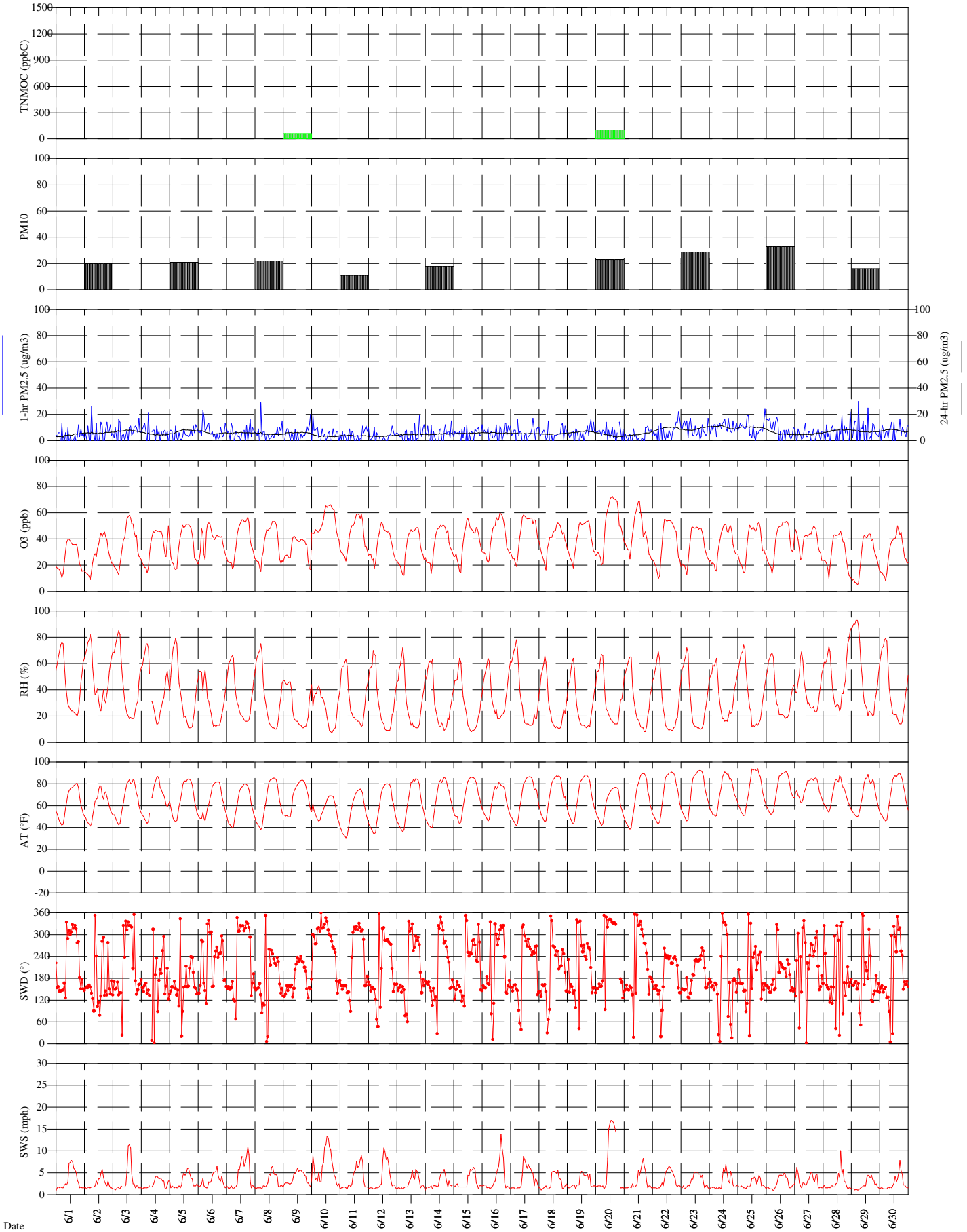
Garfield County, CO

Carbondale Site



Garfield County, CO

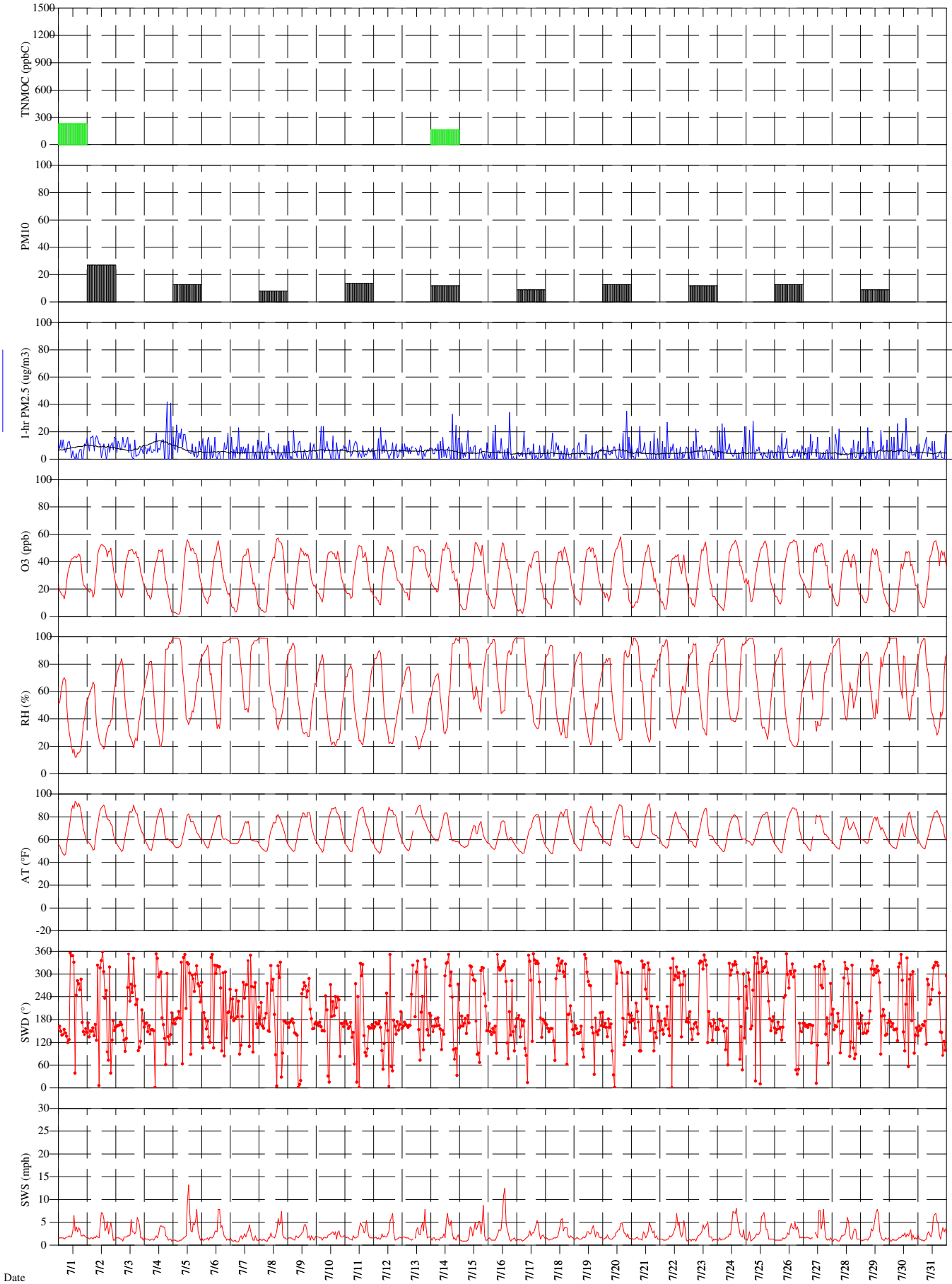
Carbondale Site



Date

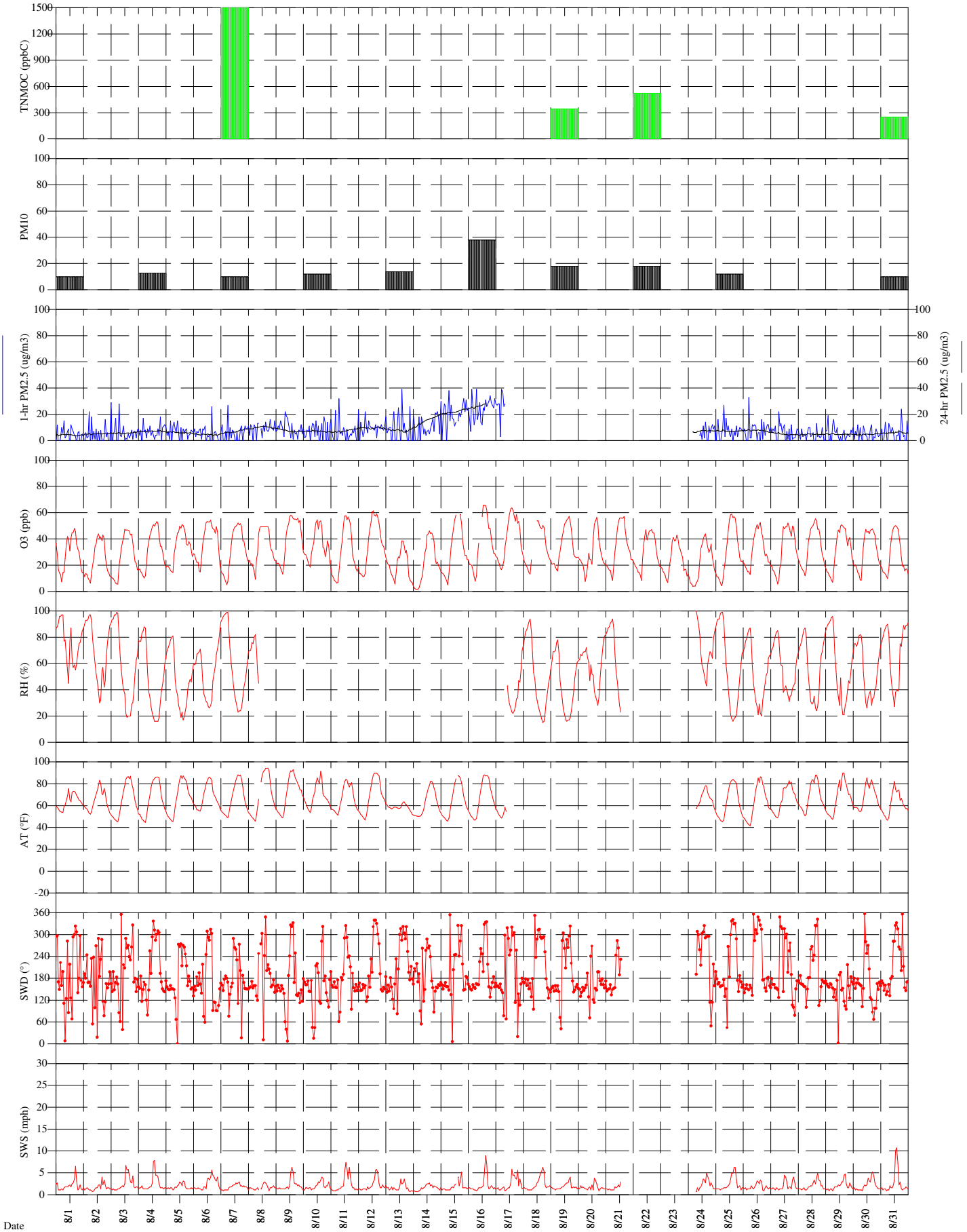
Garfield County, CO

Carbondale Site



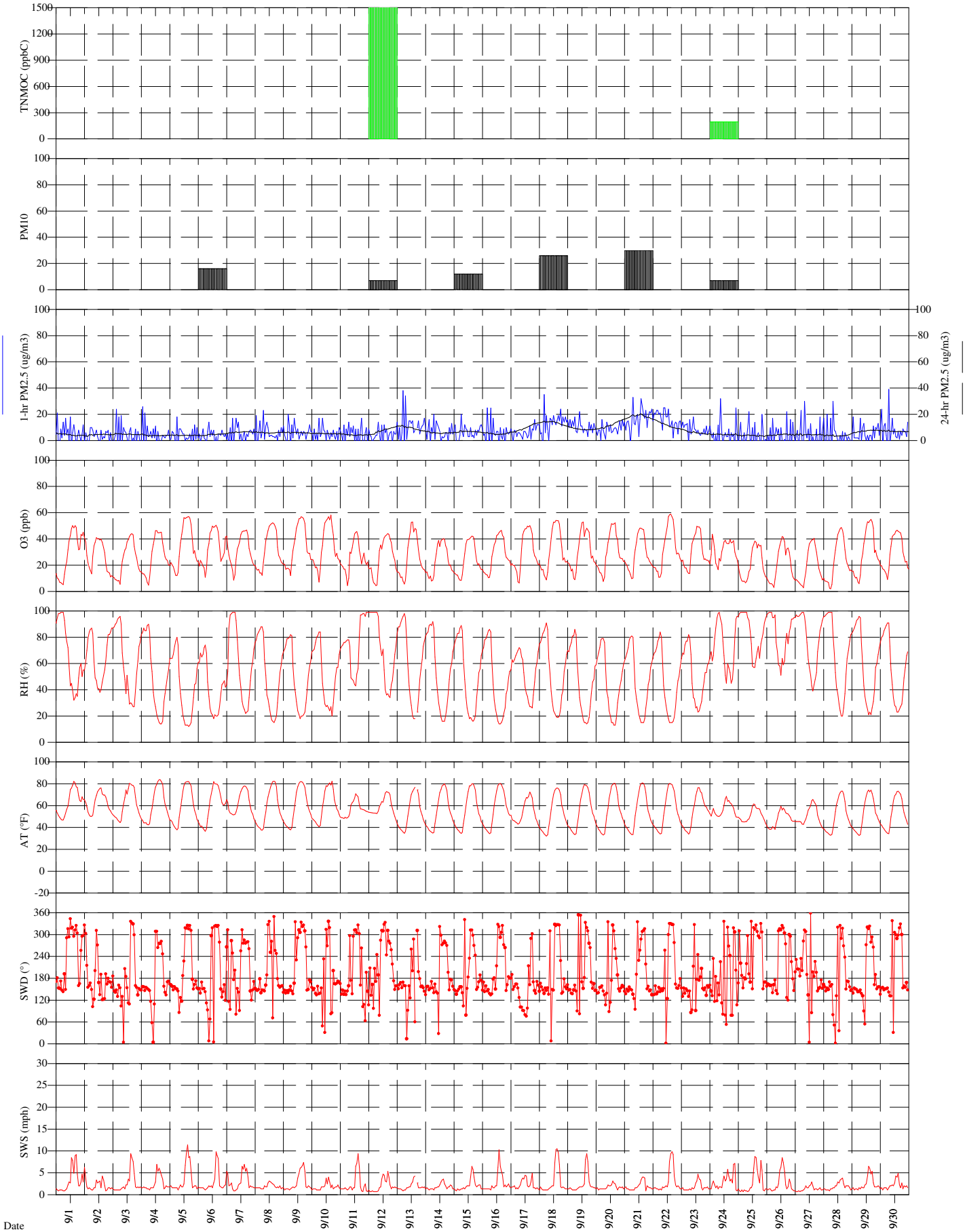
Garfield County, CO

Carbondale Site



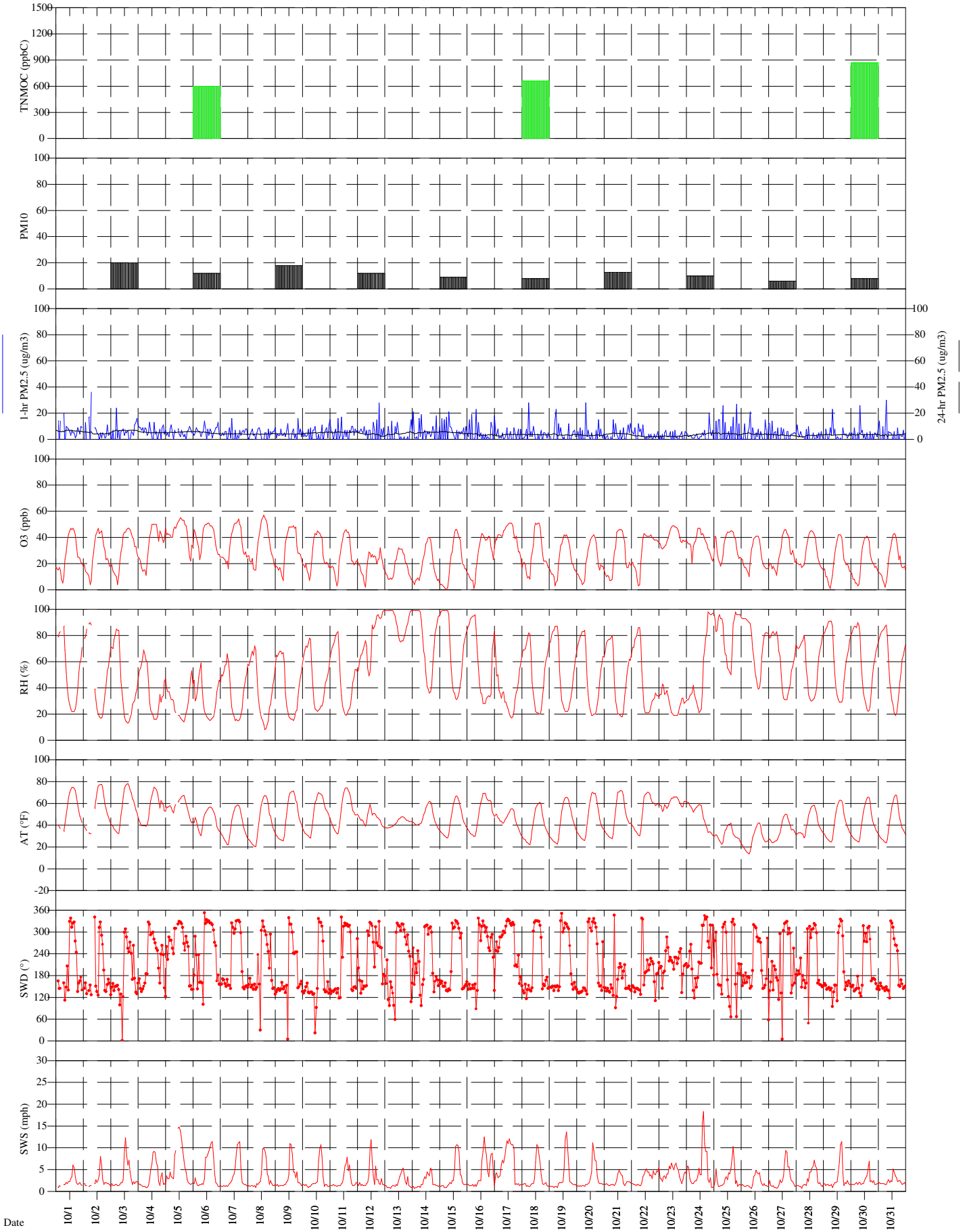
Garfield County, CO

Carbondale Site



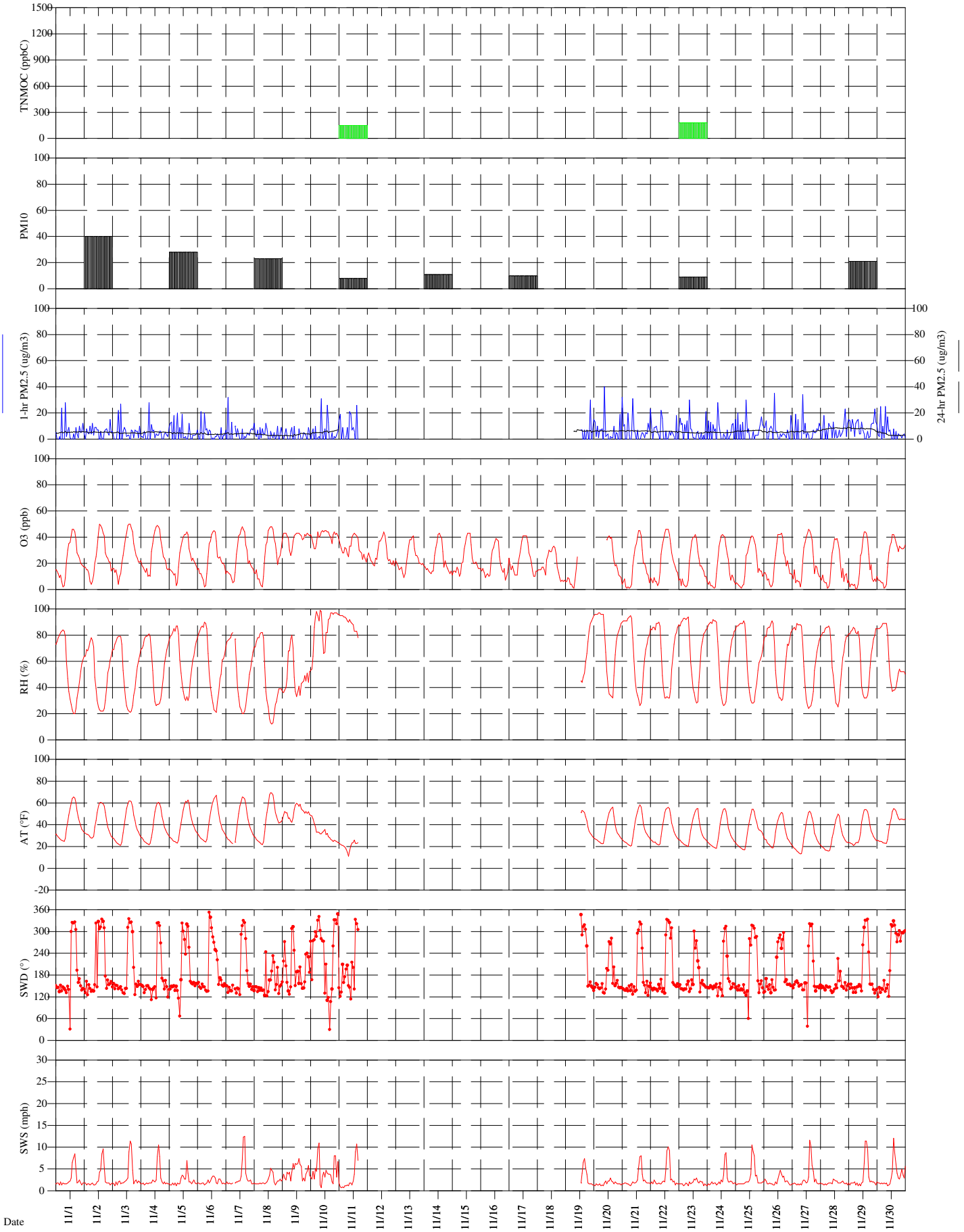
Garfield County, CO

Carbondale Site



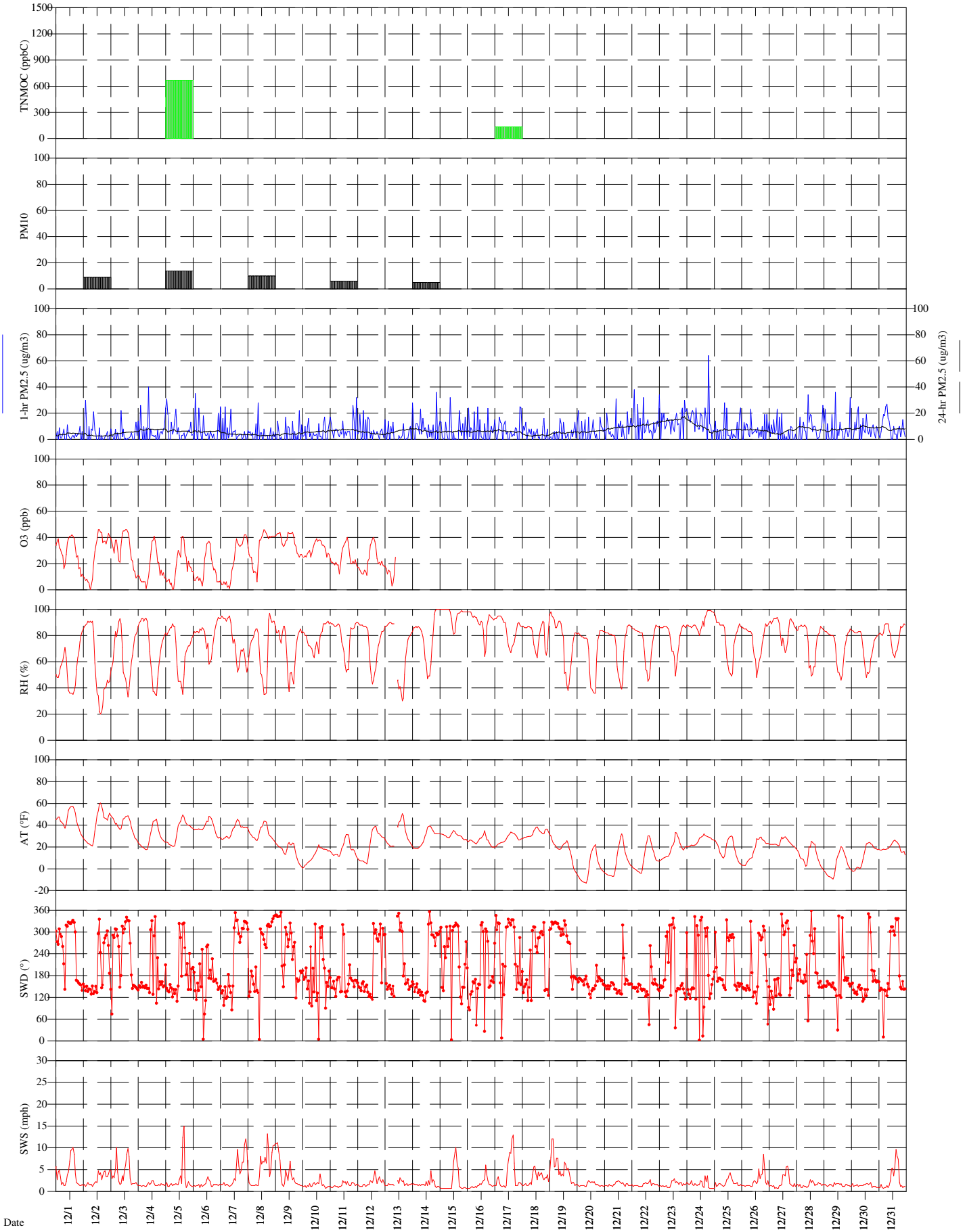
Garfield County, CO

Carbondale Site



Garfield County, CO

Carbondale Site



APPENDIX B

Garfield County

2012 SNMOC Concentrations

Table B-1
Garfield County SNMOC Monitoring
Parachute (PACO)
1/5/2012-12/11/2012 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	47	25	0.01	0.06	0.01
1,2,4-Trimethylbenzene (95-63-6)	47	47	0.02	0.28	0.08
1,3,5-Trimethylbenzene (108-67-8)	47	37	0.01	0.10	0.03
1,3-Butadiene (106-99-0)	47	33	0.02	0.13	0.04
1-Dodecene (112-41-4)	47	7	0.01	0.10	0.02
1-Heptene (592-76-7)	47	30	0.04	0.34	0.09
1-Hexene (592-41-6)	47	13	0.01	0.07	0.03
1-Nonene (124-11-8)	47	20	0.01	0.05	0.02
1-Octene (111-66-0)	47	26	0.02	0.08	0.03
1-Pentene (109-67-1)	47	40	0.02	0.15	0.04
1-Tridecene (2437-56-1)	47	1	0.01	0.01	0.01
1-Undecene (821-95-4)	47	2	0.01	0.02	0.01
2,2,3-Trimethylpentane (564-02-3)	47	12	0.02	0.04	0.02
2,2,4-Trimethylpentane (540-84-1)	47	7	0.01	0.12	0.01
2,2-Dimethylbutane (75-83-2)	47	45	0.02	0.33	0.11
2,3,4-Trimethylpentane (565-75-3)	47	27	0.01	0.04	0.02
2,3-Dimethylbutane (79-29-8)	47	35	0.04	0.36	0.13
2,3-Dimethylpentane (565-59-3)	47	46	0.02	0.22	0.08
2,4-Dimethylpentane (108-08-7)	47	45	0.01	0.17	0.06
2-Ethyl-1-butene (760-21-4)	47	1	0.77	0.77	0.04
2-Methyl-1-butene (563-46-2)	47	22	0.02	0.14	0.04
2-Methyl-2-butene (513-35-9)	47	24	0.02	0.18	0.04
2-Methylheptane (592-27-8)	47	47	0.01	0.33	0.10
2-Methylhexane (591-76-4)	47	47	0.08	0.67	0.27
2-Methylpentane (107-83-5)	47	47	0.18	2.58	0.85
3-Methyl-1-butene (563-45-1)	47	3	0.03	0.09	0.03
3-Methylheptane (589-81-1)	47	47	0.02	0.25	0.08
3-Methylhexane (589-34-4)	47	45	0.05	0.66	0.24
3-Methylpentane (96-14-0)	47	47	0.09	1.46	0.46
Acetylene (74-86-2)	47	47	0.09	1.48	0.49
a-Pinene (80-56-8)	47	2	0.02	0.03	0.01
Benzene (71-43-2)	47	45	0.14	0.93	0.39
b-Pinene (127-91-3)	47	20	0.02	0.26	0.04
cis-2-Butene (590-18-1)	47	32	0.02	0.54	0.06
cis-2-Hexene (7688-21-3)	47	1	0.01	0.01	0.03
cis-2-Pentene (627-20-3)	47	14	0.02	0.06	0.02
Cyclohexane (110-82-7)	47	47	0.13	1.92	0.58
Cyclopentane (287-92-3)	47	47	0.04	0.38	0.13
Cyclopentene (142-29-0)	47	5	0.02	0.25	0.03
Ethane (74-84-0)	47	47	6.10	138.00	41.95
Ethylbenzene (100-41-4)	47	45	0.01	0.10	0.04
Ethylene (74-85-1)	47	47	0.51	6.70	1.52

*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)
1/5/2012-12/11/2012 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Isobutane (75-28-5)	47	47	0.55	14.15	4.05
Isobutene/1-Butene (115-11-7 / 106-98-9)	47	2	1.12	1.30	0.07
Isopentane (78-78-4)	47	28	0.53	7.98	2.10
Isoprene (78-79-5)	47	31	0.02	0.41	0.11
Isopropylbenzene (98-82-8)	47	12	0.01	0.03	0.01
m-Diethylbenzene (141-93-5)	47	16	0.01	0.58	0.03
Methylcyclohexane (108-87-2)	47	47	0.23	3.30	1.04
Methylcyclopentane (96-37-7)	47	47	0.10	1.61	0.50
m-Ethyltoluene (620-14-4)	47	44	0.01	0.25	0.06
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	47	47	0.07	0.82	0.26
n-Butane (106-97-8)	47	47	0.86	14.52	4.23
n-Decane (124-18-5)	47	47	0.02	0.24	0.07
n-Dodecane (112-40-3)	47	43	0.01	0.06	0.03
n-Heptane (142-82-5)	47	47	0.09	1.22	0.41
n-Hexane (110-54-3)	47	47	0.18	2.85	0.87
n-Nonane (111-84-2)	47	47	0.03	0.38	0.11
n-Octane (111-65-9)	47	46	0.07	0.84	0.26
n-Pentane (109-66-0)	47	47	0.37	5.90	1.84
n-Propylbenzene (103-65-1)	47	26	0.01	0.08	0.02
n-Tridecane (629-50-5)	47	20	0.00	0.02	0.01
n-Undecane (1120-21-4)	47	46	0.01	0.13	0.04
o-Ethyltoluene (611-14-3)	47	27	0.01	0.06	0.02
o-Xylene (95-47-6)	47	47	0.02	0.14	0.06
p-Diethylbenzene (105-05-5)	47	6	0.01	0.04	0.01
p-Ethyltoluene (622-96-8)	47	39	0.01	0.15	0.04
Propane (74-98-6)	47	47	2.71	51.33	15.43
Propylene (115-07-1)	47	47	0.14	2.19	0.40
Styrene (100-42-5)	47	15	0.16	2.76	0.36
Toluene (108-88-3)	47	47	0.20	4.24	1.09
trans-2-Butene (624-64-6)	47	33	0.02	0.60	0.07
trans-2-Pentene (646-04-8)	47	29	0.01	0.12	0.03

*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)
1/5/2012-12/29/2012 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	60	36	0.01	0.11	0.02
1,2,4-Trimethylbenzene (95-63-6)	60	60	0.03	0.43	0.10
1,3,5-Trimethylbenzene (108-67-8)	60	53	0.01	0.10	0.03
1,3-Butadiene (106-99-0)	60	56	0.02	0.26	0.08
1-Dodecene (112-41-4)	60	11	0.01	0.25	0.02
1-Heptene (592-76-7)	60	36	0.03	0.34	0.06
1-Hexene (592-41-6)	60	21	0.02	0.07	0.03
1-Nonene (124-11-8)	60	18	0.01	0.42	0.02
1-Octene (111-66-0)	60	34	0.01	0.07	0.02
1-Pentene (109-67-1)	60	59	0.02	0.18	0.07
1-Tridecene (2437-56-1)	60	1	0.01	0.01	0.01
1-Undecene (821-95-4)	60	3	0.01	0.03	0.01
2,2,3-Trimethylpentane (564-02-3)	60	27	0.01	0.05	0.02
2,2,4-Trimethylpentane (540-84-1)	60	42	0.01	0.69	0.04
2,2-Dimethylbutane (75-83-2)	60	60	0.03	0.30	0.10
2,3,4-Trimethylpentane (565-75-3)	60	52	0.01	0.09	0.03
2,3-Dimethylbutane (79-29-8)	60	48	0.05	0.40	0.14
2,3-Dimethylpentane (565-59-3)	60	60	0.03	0.26	0.09
2,4-Dimethylpentane (108-08-7)	60	60	0.02	0.18	0.06
2-Methyl-1-butene (563-46-2)	60	51	0.03	0.28	0.07
2-Methyl-1-pentene (763-29-1)	60	1	0.01	0.01	0.03
2-Methyl-2-butene (513-35-9)	60	54	0.03	0.35	0.08
2-Methylheptane (592-27-8)	60	60	0.02	0.26	0.07
2-Methylhexane (591-76-4)	60	59	0.08	0.70	0.25
2-Methylpentane (107-83-5)	60	60	0.26	2.92	0.89
3-Methyl-1-butene (563-45-1)	60	5	0.03	0.16	0.03
3-Methylheptane (589-81-1)	60	60	0.02	0.19	0.06
3-Methylhexane (589-34-4)	60	59	0.06	0.71	0.22
3-Methylpentane (96-14-0)	60	60	0.14	1.58	0.47
4-Methyl-1-pentene (691-37-2)	60	5	0.02	0.02	0.03
Acetylene (74-86-2)	60	60	0.31	3.30	1.02
a-Pinene (80-56-8)	60	14	0.01	0.05	0.01
Benzene (71-43-2)	60	60	0.12	0.96	0.31
b-Pinene (127-91-3)	60	23	0.02	0.44	0.03
cis-2-Butene (590-18-1)	60	57	0.03	0.63	0.10
cis-2-Hexene (7688-21-3)	60	1	0.01	0.01	0.03
cis-2-Pentene (627-20-3)	60	48	0.02	0.15	0.03
Cyclohexane (110-82-7)	60	60	0.13	1.72	0.48
Cyclopentane (287-92-3)	60	60	0.05	0.43	0.14
Cyclopentene (142-29-0)	60	5	0.02	0.09	0.03
Ethane (74-84-0)	60	60	5.75	113.00	28.47
Ethylbenzene (100-41-4)	60	60	0.02	0.16	0.06

*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)
1/5/2012-12/29/2012 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Ethylene (74-85-1)	60	60	0.73	6.30	2.04
Isobutane (75-28-5)	60	60	0.92	15.30	3.89
Isobutene/1-Butene (115-11-7 / 106-98-9)	60	2	0.82	1.38	0.06
Isopentane (78-78-4)	60	37	0.73	10.74	2.35
Isoprene (78-79-5)	60	53	0.02	0.58	0.11
Isopropylbenzene (98-82-8)	60	22	0.01	0.02	0.01
m-Diethylbenzene (141-93-5)	60	20	0.01	0.69	0.04
Methylcyclohexane (108-87-2)	60	60	0.18	2.57	0.67
Methylcyclopentane (96-37-7)	60	60	0.14	1.53	0.44
m-Ethyltoluene (620-14-4)	60	60	0.01	0.22	0.07
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	60	60	0.08	0.77	0.25
n-Butane (106-97-8)	60	60	1.30	17.40	4.62
n-Decane (124-18-5)	60	60	0.01	0.13	0.05
n-Dodecane (112-40-3)	60	55	0.00	0.08	0.02
n-Heptane (142-82-5)	60	60	0.10	1.17	0.32
n-Hexane (110-54-3)	60	60	0.23	3.17	0.87
n-Nonane (111-84-2)	60	60	0.02	0.19	0.06
n-Octane (111-65-9)	60	60	0.05	0.56	0.16
n-Pentane (109-66-0)	60	60	0.59	6.98	2.05
n-Propylbenzene (103-65-1)	60	45	0.01	0.11	0.02
n-Tridecane (629-50-5)	60	11	0.00	0.03	0.01
n-Undecane (1120-21-4)	60	58	0.01	0.06	0.02
o-Ethyltoluene (611-14-3)	60	41	0.01	0.06	0.02
o-Xylene (95-47-6)	60	60	0.03	0.20	0.08
p-Diethylbenzene (105-05-5)	60	9	0.01	0.02	0.01
p-Ethyltoluene (622-96-8)	60	57	0.01	0.13	0.04
Propane (74-98-6)	60	60	2.56	51.00	12.79
Propylene (115-07-1)	60	60	0.15	1.48	0.57
Styrene (100-42-5)	60	20	0.02	1.66	0.16
Toluene (108-88-3)	60	60	0.18	1.63	0.57
trans-2-Butene (624-64-6)	60	57	0.03	0.67	0.12
trans-2-Hexene (4050-45-7)	60	5	0.01	0.03	0.03
trans-2-Pentene (646-04-8)	60	56	0.02	0.28	0.07

*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)
1/5/2012-12/29/2012 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	58	13	0.01	0.03	0.01
1,2,4-Trimethylbenzene (95-63-6)	58	54	0.01	0.19	0.04
1,3,5-Trimethylbenzene (108-67-8)	58	27	0.01	0.07	0.01
1,3-Butadiene (106-99-0)	58	23	0.01	0.12	0.04
1-Dodecene (112-41-4)	58	5	0.02	0.04	0.02
1-Heptene (592-76-7)	58	35	0.02	0.26	0.06
1-Hexene (592-41-6)	58	13	0.02	0.06	0.03
1-Nonene (124-11-8)	58	18	0.01	0.05	0.02
1-Octene (111-66-0)	58	32	0.01	0.12	0.03
1-Pentene (109-67-1)	58	39	0.02	0.12	0.04
1-Undecene (821-95-4)	58	4	0.01	0.03	0.01
2,2,3-Trimethylpentane (564-02-3)	58	7	0.01	0.03	0.01
2,2,4-Trimethylpentane (540-84-1)	58	6	0.01	0.06	0.01
2,2-Dimethylbutane (75-83-2)	58	57	0.02	0.26	0.09
2,3,4-Trimethylpentane (565-75-3)	58	21	0.01	0.05	0.01
2,3-Dimethylbutane (79-29-8)	58	46	0.02	0.48	0.13
2,3-Dimethylpentane (565-59-3)	58	57	0.02	0.19	0.07
2,4-Dimethylpentane (108-08-7)	58	55	0.02	0.14	0.05
2-Methyl-1-butene (563-46-2)	58	9	0.02	0.08	0.03
2-Methyl-2-butene (513-35-9)	58	13	0.01	0.13	0.03
2-Methylheptane (592-27-8)	58	55	0.01	0.16	0.07
2-Methylhexane (591-76-4)	58	58	0.04	0.54	0.21
2-Methylpentane (107-83-5)	58	58	0.12	2.80	0.84
3-Methyl-1-butene (563-45-1)	58	2	0.02	0.23	0.03
3-Methylheptane (589-81-1)	58	55	0.01	0.11	0.04
3-Methylhexane (589-34-4)	58	54	0.05	0.54	0.18
3-Methylpentane (96-14-0)	58	58	0.05	1.48	0.43
4-Methyl-1-pentene (691-37-2)	58	4	0.02	0.02	0.03
Acetylene (74-86-2)	58	58	0.08	2.58	0.49
a-Pinene (80-56-8)	58	13	0.01	0.06	0.02
Benzene (71-43-2)	58	57	0.05	0.47	0.21
b-Pinene (127-91-3)	58	21	0.01	0.40	0.03
cis-2-Butene (590-18-1)	58	19	0.02	0.30	0.03
cis-2-Pentene (627-20-3)	58	9	0.02	0.07	0.02
Cyclohexane (110-82-7)	58	58	0.06	1.64	0.52
Cyclopentane (287-92-3)	58	57	0.05	0.41	0.13
Cyclopentene (142-29-0)	58	2	0.02	0.05	0.03
Ethane (74-84-0)	58	58	4.42	101.00	35.28
Ethylbenzene (100-41-4)	58	45	0.01	0.09	0.02
Ethylene (74-85-1)	58	58	0.35	3.48	1.01
Isobutane (75-28-5)	58	58	0.50	14.02	4.49
Isobutene/1-Butene (115-11-7 / 106-98-9)	58	1	1.27	1.27	0.04

*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)
1/5/2012-12/29/2012 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Isopentane (78-78-4)	58	39	0.80	8.34	2.17
Isoprene (78-79-5)	58	28	0.03	0.45	0.07
Isopropylbenzene (98-82-8)	58	11	0.01	0.02	0.01
m-Diethylbenzene (141-93-5)	58	19	0.01	0.12	0.02
Methylcyclohexane (108-87-2)	58	58	0.11	2.30	0.79
Methylcyclopentane (96-37-7)	58	58	0.06	1.40	0.43
m-Ethyltoluene (620-14-4)	58	44	0.01	0.15	0.03
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	58	58	0.03	0.36	0.11
n-Butane (106-97-8)	58	57	0.57	15.90	5.05
n-Decane (124-18-5)	58	55	0.01	0.11	0.03
n-Dodecane (112-40-3)	58	38	0.01	0.04	0.02
n-Heptane (142-82-5)	58	58	0.05	1.06	0.34
n-Hexane (110-54-3)	58	58	0.13	3.28	0.94
n-Nonane (111-84-2)	58	58	0.01	0.13	0.05
n-Octane (111-65-9)	58	58	0.03	0.43	0.16
n-Pentane (109-66-0)	58	58	0.26	6.94	2.12
n-Propylbenzene (103-65-1)	58	25	0.01	0.07	0.01
n-Tridecane (629-50-5)	58	5	0.00	0.02	0.01
n-Undecane (1120-21-4)	58	43	0.01	0.04	0.02
o-Ethyltoluene (611-14-3)	58	22	0.01	0.06	0.01
o-Xylene (95-47-6)	58	53	0.01	0.11	0.03
p-Diethylbenzene (105-05-5)	58	10	0.01	0.02	0.01
p-Ethyltoluene (622-96-8)	58	40	0.01	0.10	0.02
Propane (74-98-6)	58	58	1.92	49.67	16.51
Propylene (115-07-1)	58	58	0.10	0.94	0.22
Styrene (100-42-5)	58	22	0.02	2.56	0.21
Toluene (108-88-3)	58	58	0.09	1.04	0.37
trans-2-Butene (624-64-6)	58	13	0.02	0.33	0.03
trans-2-Pentene (646-04-8)	58	24	0.02	0.11	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
Battlement Mesa (BMCO)
1/5/2012-12/29/2012 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	53	26	0.01	0.06	0.02
1,2,4-Trimethylbenzene (95-63-6)	53	53	0.01	0.20	0.07
1,3,5-Trimethylbenzene (108-67-8)	53	46	0.02	0.06	0.03
1,3-Butadiene (106-99-0)	53	28	0.02	0.20	0.05
1-Dodecene (112-41-4)	53	10	0.01	0.12	0.02
1-Heptene (592-76-7)	53	36	0.01	0.22	0.07
1-Hexene (592-41-6)	53	11	0.01	0.07	0.03
1-Nonene (124-11-8)	53	10	0.01	0.02	0.01
1-Octene (111-66-0)	53	31	0.01	0.06	0.03
1-Pentene (109-67-1)	53	47	0.02	0.23	0.06
1-Undecene (821-95-4)	53	1	0.01	0.01	0.01
2,2,3-Trimethylpentane (564-02-3)	53	23	0.01	0.05	0.02
2,2,4-Trimethylpentane (540-84-1)	53	15	0.01	0.08	0.02
2,2-Dimethylbutane (75-83-2)	53	51	0.03	0.22	0.10
2,3,4-Trimethylpentane (565-75-3)	53	39	0.01	0.04	0.02
2,3-Dimethylbutane (79-29-8)	53	42	0.02	0.40	0.14
2,3-Dimethylpentane (565-59-3)	53	53	0.02	0.15	0.08
2,4-Dimethylpentane (108-08-7)	53	51	0.02	0.11	0.06
2-Methyl-1-butene (563-46-2)	53	34	0.02	0.21	0.05
2-Methyl-2-butene (513-35-9)	53	39	0.03	0.28	0.06
2-Methylheptane (592-27-8)	53	52	0.01	0.18	0.09
2-Methylhexane (591-76-4)	53	53	0.07	0.57	0.25
2-Methylpentane (107-83-5)	53	53	0.13	1.77	0.79
3-Methyl-1-butene (563-45-1)	53	3	0.03	0.10	0.03
3-Methylheptane (589-81-1)	53	52	0.01	0.15	0.07
3-Methylhexane (589-34-4)	53	52	0.03	0.47	0.22
3-Methylpentane (96-14-0)	53	53	0.06	0.96	0.43
4-Methyl-1-pentene (691-37-2)	53	5	0.02	0.02	0.03
Acetylene (74-86-2)	53	53	0.10	6.50	0.60
a-Pinene (80-56-8)	53	7	0.01	0.03	0.01
Benzene (71-43-2)	53	53	0.08	0.74	0.34
b-Pinene (127-91-3)	53	20	0.01	0.23	0.04
cis-2-Butene (590-18-1)	53	46	0.02	0.61	0.06
cis-2-Pentene (627-20-3)	53	26	0.01	0.12	0.03
Cyclohexane (110-82-7)	53	53	0.04	1.28	0.52
Cyclopentane (287-92-3)	53	51	0.05	0.28	0.13
Cyclopentene (142-29-0)	53	5	0.03	0.08	0.03
Ethane (74-84-0)	53	53	1.98	94.50	31.54
Ethylbenzene (100-41-4)	53	53	0.01	0.09	0.04
Ethylene (74-85-1)	53	53	0.46	2.67	1.04
Isobutane (75-28-5)	53	53	0.13	9.70	3.15
Isobutene/1-Butene (115-11-7 / 106-98-9)	53	2	0.66	1.12	0.05

*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)
1/5/2012-12/29/2012 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Isopentane (78-78-4)	53	35	0.53	8.12	2.07
Isoprene (78-79-5)	53	30	0.02	0.64	0.08
Isopropylbenzene (98-82-8)	53	10	0.01	0.02	0.01
m-Diethylbenzene (141-93-5)	53	22	0.01	0.10	0.02
Methylcyclohexane (108-87-2)	53	51	0.15	2.14	0.89
Methylcyclopentane (96-37-7)	53	53	0.05	1.06	0.46
m-Ethyltoluene (620-14-4)	53	51	0.01	0.17	0.05
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	53	53	0.07	0.43	0.24
n-Butane (106-97-8)	53	53	0.31	10.42	3.78
n-Decane (124-18-5)	53	53	0.01	0.12	0.06
n-Dodecane (112-40-3)	53	49	0.01	0.05	0.02
n-Heptane (142-82-5)	53	53	0.03	0.84	0.36
n-Hexane (110-54-3)	53	53	0.07	1.95	0.82
n-Nonane (111-84-2)	53	53	0.01	0.19	0.08
n-Octane (111-65-9)	53	53	0.02	0.50	0.22
n-Pentane (109-66-0)	53	53	0.18	10.36	1.89
n-Propylbenzene (103-65-1)	53	32	0.01	0.06	0.02
n-Tridecane (629-50-5)	53	13	0.01	0.01	0.01
n-Undecane (1120-21-4)	53	51	0.01	0.07	0.03
o-Ethyltoluene (611-14-3)	53	39	0.01	0.06	0.02
o-Xylene (95-47-6)	53	53	0.02	0.11	0.06
p-Diethylbenzene (105-05-5)	53	7	0.01	0.02	0.01
p-Ethyltoluene (622-96-8)	53	46	0.01	0.11	0.03
Propane (74-98-6)	53	53	1.40	36.33	11.65
Propylene (115-07-1)	53	53	0.12	0.84	0.26
Styrene (100-42-5)	53	18	0.05	3.09	0.36
Toluene (108-88-3)	53	53	0.16	5.20	1.08
trans-2-Butene (624-64-6)	53	46	0.02	0.68	0.07
trans-2-Hexene (4050-45-7)	53	3	0.01	0.02	0.03
trans-2-Pentene (646-04-8)	53	42	0.02	0.23	0.04

*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)
6/9/2012-12/17/2012 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	17	12	0.01	0.05	0.02
1,2,4-Trimethylbenzene (95-63-6)	17	17	0.02	0.16	0.07
1,3,5-Trimethylbenzene (108-67-8)	17	10	0.01	0.04	0.02
1,3-Butadiene (106-99-0)	17	12	0.03	0.14	0.06
1-Dodecene (112-41-4)	17	1	0.13	0.13	0.02
1-Heptene (592-76-7)	17	5	0.01	0.18	0.02
1-Hexene (592-41-6)	17	3	0.03	0.05	0.03
1-Nonene (124-11-8)	17	10	0.01	0.04	0.02
1-Octene (111-66-0)	17	14	0.01	0.06	0.02
1-Pentene (109-67-1)	17	15	0.02	0.14	0.07
2,2,3-Trimethylpentane (564-02-3)	17	2	0.01	0.03	0.01
2,2,4-Trimethylpentane (540-84-1)	17	12	0.01	0.04	0.02
2,2-Dimethylbutane (75-83-2)	17	6	0.02	0.11	0.03
2,3,4-Trimethylpentane (565-75-3)	17	9	0.01	0.03	0.01
2,3-Dimethylbutane (79-29-8)	17	16	0.02	0.26	0.05
2,3-Dimethylpentane (565-59-3)	17	16	0.02	0.11	0.04
2,4-Dimethylpentane (108-08-7)	17	7	0.01	0.08	0.02
2-Methyl-1-butene (563-46-2)	17	8	0.02	0.07	0.04
2-Methyl-2-butene (513-35-9)	17	15	0.04	0.08	0.05
2-Methylheptane (592-27-8)	17	4	0.01	0.14	0.02
2-Methylhexane (591-76-4)	17	17	0.05	0.57	0.11
2-Methylpentane (107-83-5)	17	17	0.10	1.36	0.24
3-Methylheptane (589-81-1)	17	10	0.01	0.07	0.02
3-Methylhexane (589-34-4)	17	7	0.04	0.28	0.05
3-Methylpentane (96-14-0)	17	17	0.04	0.69	0.12
4-Methyl-1-pentene (691-37-2)	17	2	0.01	0.02	0.03
Acetylene (74-86-2)	17	17	0.13	1.01	0.44
a-Pinene (80-56-8)	17	14	0.02	0.19	0.06
Benzene (71-43-2)	17	16	0.06	0.34	0.14
b-Pinene (127-91-3)	17	2	0.06	0.07	0.02
cis-2-Butene (590-18-1)	17	13	0.02	0.19	0.06
cis-2-Pentene (627-20-3)	17	6	0.02	0.04	0.02
Cyclohexane (110-82-7)	17	17	0.03	0.82	0.10
Cyclopentane (287-92-3)	17	7	0.04	0.18	0.04
Ethane (74-84-0)	17	17	1.37	37.05	6.32
Ethylbenzene (100-41-4)	17	15	0.01	0.04	0.02
Ethylene (74-85-1)	17	17	0.56	2.12	1.07
Isobutane (75-28-5)	17	17	0.15	5.70	0.85
Isobutene/1-Butene (115-11-7 / 106-98-9)	17	1	1.12	1.12	0.08
Isopentane (78-78-4)	17	6	0.34	6.90	0.65
Isoprene (78-79-5)	17	17	0.02	0.98	0.27
Isopropylbenzene (98-82-8)	17	3	0.01	0.02	0.01

*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)
6/9/2012-12/17/2012 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
m-Diethylbenzene (141-93-5)	17	9	0.01	0.07	0.02
Methylcyclohexane (108-87-2)	17	15	0.03	1.26	0.12
Methylcyclopentane (96-37-7)	17	16	0.04	0.71	0.11
m-Ethyltoluene (620-14-4)	17	17	0.02	0.16	0.07
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	17	17	0.03	0.14	0.07
n-Butane (106-97-8)	17	17	0.28	6.85	1.19
n-Decane (124-18-5)	17	17	0.02	0.15	0.05
n-Dodecane (112-40-3)	17	15	0.01	0.09	0.03
n-Heptane (142-82-5)	17	17	0.03	0.58	0.08
n-Hexane (110-54-3)	17	17	0.09	1.62	0.24
n-Nonane (111-84-2)	17	16	0.01	0.06	0.02
n-Octane (111-65-9)	17	17	0.02	0.30	0.06
n-Pentane (109-66-0)	17	17	0.19	2.86	0.56
n-Propylbenzene (103-65-1)	17	13	0.01	0.05	0.02
n-Tridecane (629-50-5)	17	4	0.00	0.08	0.02
n-Undecane (1120-21-4)	17	13	0.01	0.04	0.01
o-Ethyltoluene (611-14-3)	17	12	0.01	0.06	0.02
o-Xylene (95-47-6)	17	17	0.01	0.05	0.03
p-Diethylbenzene (105-05-5)	17	2	0.01	0.02	0.01
p-Ethyltoluene (622-96-8)	17	15	0.01	0.10	0.04
Propane (74-98-6)	17	17	0.93	19.47	3.49
Propylene (115-07-1)	17	17	0.14	0.49	0.28
Styrene (100-42-5)	17	8	0.08	1.20	0.30
Toluene (108-88-3)	17	17	0.13	4.21	1.02
trans-2-Butene (624-64-6)	17	11	0.03	0.24	0.06
trans-2-Pentene (646-04-8)	17	15	0.02	0.07	0.04

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

APPENDIX C

Garfield County

2012 Carbonyl Concentrations

Table C-1
Garfield County Carbonyl Monitoring
Parachute (PACO)
1/5/2012-12/29/2012 (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	24	0.01	0.69	0.29
Acetaldehyde (75-07-0)	27	27	0.02	0.86	0.38
Acetone (67-64-1)	27	27	0.08	1.71	0.96
Benzaldehyde (100-52-7)	27	26	0.00	0.04	0.02
Butyraldehyde (123-72-8)	27	25	0.01	0.06	0.02
Crotonaldehyde (123-73-9)	27	23	0.01	0.12	0.02
Formaldehyde (50-00-0)	27	27	0.03	1.88	0.98
Hexaldehyde (66-25-1)	27	25	0.00	0.03	0.01
Isovaleraldehyde (590-86-3)	27	0	ND	ND	0.00
Propionaldehyde (123-38-6)	27	26	0.00	0.06	0.03
Tolualdehydes (NA)	27	20	0.01	0.05	0.02
Valeraldehyde (110-62-3)	27	21	0.00	0.03	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)
1/5/2012-12/29/2012 (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	25	0.06	0.68	0.33
Acetaldehyde (75-07-0)	28	28	0.06	1.31	0.58
Acetone (67-64-1)	28	28	0.25	2.25	1.10
Benzaldehyde (100-52-7)	28	28	0.01	0.06	0.03
Butyraldehyde (123-72-8)	28	25	0.01	0.11	0.03
Crotonaldehyde (123-73-9)	28	25	0.01	0.14	0.04
Formaldehyde (50-00-0)	28	28	0.08	2.28	1.13
Hexaldehyde (66-25-1)	28	28	0.00	0.04	0.02
Isovaleraldehyde (590-86-3)	28	1	0.01	0.01	0.00
Propionaldehyde (123-38-6)	28	27	0.01	0.11	0.04
Tolualdehydes (NA)	28	24	0.01	0.08	0.03
Valeraldehyde (110-62-3)	28	26	0.00	0.06	0.02

*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)
1/5/2012-12/29/2012 (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	0.57	0.26
Acetaldehyde (75-07-0)	28	28	0.09	0.90	0.34
Acetone (67-64-1)	28	28	0.26	1.80	0.96
Benzaldehyde (100-52-7)	28	27	0.00	0.05	0.02
Butyraldehyde (123-72-8)	28	27	0.01	0.04	0.02
Crotonaldehyde (123-73-9)	28	25	0.00	0.18	0.03
Formaldehyde (50-00-0)	28	28	0.22	2.53	0.83
Hexaldehyde (66-25-1)	28	27	0.00	0.03	0.01
Isovaleraldehyde (590-86-3)	28	0	ND	ND	0.00
Propionaldehyde (123-38-6)	28	27	0.01	0.07	0.03
Tolualdehydes (NA)	28	21	0.01	0.04	0.01
Valeraldehyde (110-62-3)	28	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-4
Garfield County Carbonyl Monitoring
Battlement Mesa (BMCO)
1/5/2012-12/29/2012 (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	24	0.01	0.74	0.25
Acetaldehyde (75-07-0)	27	27	0.02	0.78	0.30
Acetone (67-64-1)	27	27	0.08	3.85	1.20
Benzaldehyde (100-52-7)	27	23	0.00	0.12	0.03
Butyraldehyde (123-72-8)	27	23	0.01	0.04	0.02
Crotonaldehyde (123-73-9)	27	21	0.00	0.13	0.02
Formaldehyde (50-00-0)	27	27	0.02	1.47	0.71
Hexaldehyde (66-25-1)	27	23	0.00	0.06	0.02
Isovaleraldehyde (590-86-3)	27	0	ND	ND	0.00
Propionaldehyde (123-38-6)	27	24	0.00	0.06	0.03
Tolualdehydes (NA)	27	19	0.01	0.05	0.02
Valeraldehyde (110-62-3)	27	21	0.00	0.03	0.01

*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)
6/20/2012-12/17/2012 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	16	0	ND	ND	0.00
2-Butanone (78-93-3)	16	12	0.06	0.58	0.21
Acetaldehyde (75-07-0)	16	16	0.02	1.35	0.31
Acetone (67-64-1)	16	16	0.04	1.49	0.70
Benzaldehyde (100-52-7)	16	13	0.01	0.06	0.02
Butyraldehyde (123-72-8)	16	10	0.00	0.06	0.02
Crotonaldehyde (123-73-9)	16	10	0.01	0.39	0.05
Formaldehyde (50-00-0)	16	16	0.02	2.57	0.67
Hexaldehyde (66-25-1)	16	15	0.00	0.05	0.02
Isovaleraldehyde (590-86-3)	16	0	ND	ND	0.00
Propionaldehyde (123-38-6)	16	15	0.01	0.10	0.03
Tolualdehydes (NA)	16	10	0.01	0.09	0.02
Valeraldehyde (110-62-3)	16	11	0.00	0.03	0.01

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