

**Annual Data Summary**  
**SHENANDOAH NATIONAL PARK**  
**1999**  
**National Park Service**  
**Gaseous Air Pollutant Monitoring Network**



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At Shenandoah National Park, ARD specifically recognizes Shane Spitzer for performing the technical and administrative skills required to help produce the data presented within this report.

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## **1.0 INTRODUCTION**

### **1.1 THE NATIONAL PARK SERVICE GASEOUS POLLUTANT MONITORING NETWORK**

Gaseous air pollutants, including ozone and sulfur dioxide, are of concern to the National Park Service (NPS). Pollutants like these can affect park unit biological resources as well as the health of park unit residents and visitors. The NPS established a gaseous pollutant monitoring program for several pollutants linked to effects on NPS resources. This program was designed to meet certain resource management objectives.

The primary objective of this monitoring program is to establish the status and trends of park unit air quality conditions and to determine if a park unit is exceeding the National Ambient Air Quality Standards established by the U.S. Environmental Protection Agency (EPA) to protect public health and welfare. In addition, such monitoring is designed to detect changes or trends in pollution levels over time. A monitoring station may also be established if there is documented biological injury due to air pollution in a park unit. Information on ambient air pollution levels is an important part of research on effects of air pollutants on NPS resources, and can help confirm suspected causes of observed effects.

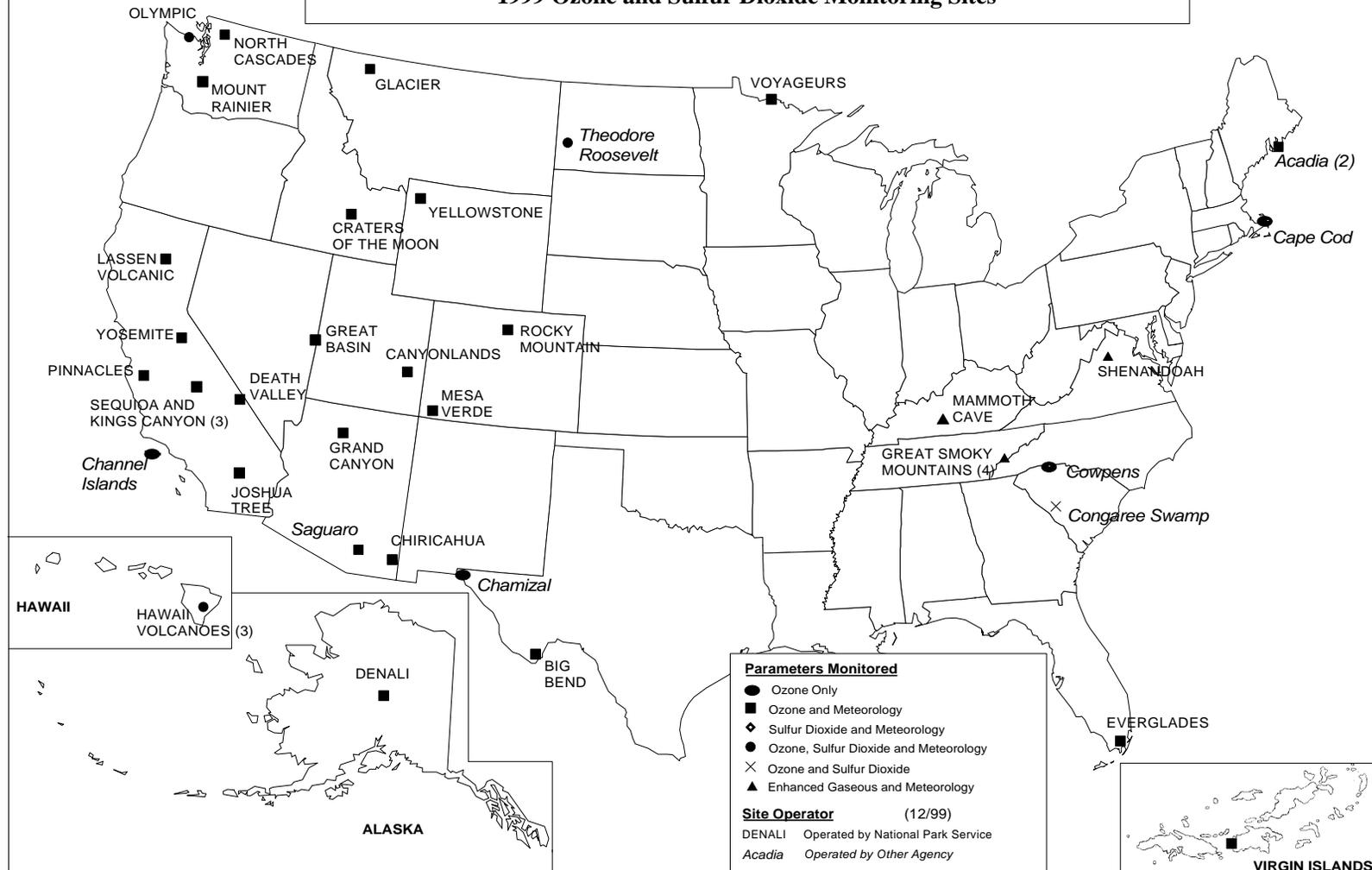
Other monitoring objectives call for the collection of data to support the National Park Service's required involvement in both the development of state air quality control plans, and the evaluation of permit applications for new or expanding air pollution sources wishing to locate near park units. The Clean Air Act gives federal land managers and superintendents an affirmative responsibility to protect air quality related values in Class I areas and to assess whether new sources will have an adverse impact on park unit resources and values. Information on air quality levels in NPS units can also be used to evaluate the performance of atmospheric models that simulate how pollutants are transported into park units and predict impacts on the park unit caused by air pollution sources.

The National Park Service Gaseous Pollutant Monitoring Network site locations and measured parameters collected in this reporting year are shown on the map on the following page. During this reporting period, 43 monitoring sites in 35 units of the National Park System had some combination of ozone, sulfur dioxide, meteorological, and CASTNet dry deposition monitoring. Monitoring methods and quality assurance procedures used in the national park network meet the applicable 40 CFR Part 58 EPA requirements. This allows for the direct comparison of NPS collected data with that collected by the EPA, and state and local air pollution control agencies. Data collected by this network are incorporated in the EPA Aerometric Information Retrieval System (AIRS) database which is a national database of all air quality data collected throughout the country. These data are also stored in the NPS Air Resources Division's Information Management Center (IMC) that allows for easy access and analysis of data.

This report includes a variety of data summaries for data collected at an individual monitoring site at a national park unit during this reporting period. These summaries highlight the average range and frequency of the data collected during the year. A PC-compatible diskette containing a digital copy of all data collected during the year and data summary products included in this report is available. Individual reports are generated for each site where monitoring was conducted in the national park network.

# NATIONAL PARK SERVICE GASEOUS POLLUTANT MONITORING NETWORK

## 1999 Ozone and Sulfur Dioxide Monitoring Sites



## **1.2 SHENANDOAH NATIONAL PARK**

Shenandoah National Park, a Class I area, lies along the crest of the Blue Ridge Mountains in northern Virginia, extending from Front Royal to Waynesboro, for a distance of 80 miles. There is one monitoring site located in the park (Big Meadows). Shenandoah National Park's location and site specifications are presented on the following page.

The park was authorized by Congress in 1926 and fully established in 1935. The legislative history of Shenandoah National Park clearly indicates that the Congress intended the park to be a natural place, and to exist as a sample and vignette of the Southern Appalachian portion of primitive America. It also intended for the park's natural, scenic, and historic resources to be used and enjoyed, without degradation, by great numbers of visitors each year. Nearly 80,000 acres of the park were designated by Congress as a wilderness area in 1976 and 1978.

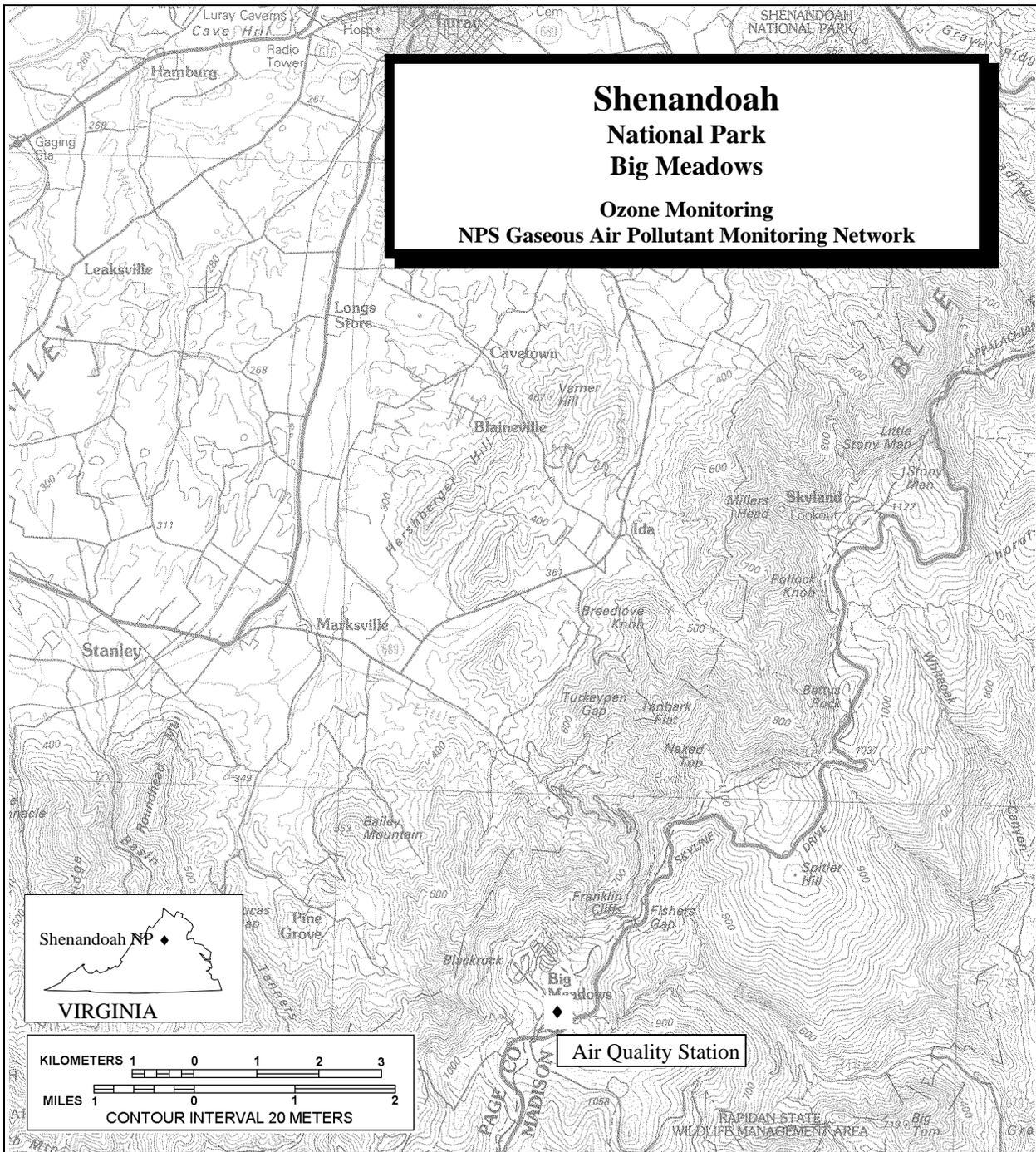
The Shenandoah part of the Blue Ridge Mountains is a single crest of rounded peaks and lower ridges situated in a general northeast-southwest direction. Elevations along the ridge range from 4,049 feet atop Hawksbill Mountain to a low of 478 feet at Front Royal. Within the park are more than two dozen peaks over 3,000 feet high. From the main crest, lateral ridges separated by stream valleys or hollows branch off to the Piedmont on the east and to the Shenandoah Valley on the west.

Shenandoah National Park is included within the most floristically diverse region of the United States and represents one of the nation's most valuable botanical areas. The documented flora of the park numbers about 1,400 species of plants. Many species have limited distribution and are restricted to the central and southern parts of the Appalachian Highlands.

The park also includes a diverse population of birds, fish, reptiles, amphibians, and insects. At least 200 species of birds have been observed, including about 100 that breed in the park. Over 50 species of amphibians and reptiles, and over 20 species of fish are found within the park.

Outstanding scenery is a key to the identity of Shenandoah, as the views from the ridge were a primary consideration in the creation of the park and its famous 100 mile long Skyline Drive. The inspiring views of the Piedmont, Shenandoah Valley, enclosed hollows, and multiple ridges are comprised of a complex tapestry of landforms, vegetation, and natural features seen at varying distances under different times and weather conditions.

The naturally occurring blue haze for which the Blue Ridge Mountains were named shades the distant horizons and limits visibility. However, anthropogenic haze has become much more prevalent and is associated with increased air pollution emissions and transport throughout the entire eastern United States. The National Park Service believes that this anthropogenic air pollution not only produces significantly impaired visibility, but may also cause acidification of sensitive park streams and threaten sensitive park vegetation.



SITE IDENTIFICATION		MAP INFORMATION
Site Abbreviation: SHEN-BM		Mean Elevation: 1073 m
AIRS ID NO.: 51-113-0003		Longitude: 78° 26' 10"W
		Latitude: 38° 31' 19"N
		UTM Zone: 17
		Easting: 723520 m
		Northing: 4266637 m
		Map Reference: Front Royal
		1986
		1:100,000
		38078-E1-TM-
		100
INSTRUMENTATION		
O <sub>3</sub> Analyzer	Temperature	
Calibrator	Delta Temperature	
Wind Speed	Solar Radiation	
Wind Direction	Precipitation	
Relative Humidity	Barometric Pressure	
SO <sub>2</sub> Analyzer		

## **2.0 DATA SUMMARY**

### **2.1 OVERVIEW**

Based on the site specifications during this annual reporting period, data summaries and statistics are provided in this section.

Data Collection Statistics  
Shenandoah National Park  
Big Meadows

Final Data

01/01/99 - 12/31/99

Parameter	Par Code	Data Recovery			Valid Data	
		No. Possible	No. Collected	% Collected	No. Valid	% Valid
Ozone Analyzer	O3	8760	8257	94.3	7926	90.5
Sulfur Dioxide Analyzer	SO2	5592	5345	95.6	5299	94.8
Scalar Wind Speed	SWS	8760	8656	98.8	8641	98.6
Vector Wind Speed	VWS	8760	8656	98.8	8640	98.6
Vector Wind Direction	VWD	8760	8656	98.8	8640	98.6
Standard Deviation for Wind Direction	SDWD	8760	8656	98.8	8655	98.8
Ambient Temperature (aspirated)	TMP	8760	8656	98.8	8656	98.8
Delta Temperature	DTP	8760	8656	98.8	8656	98.8
Relative Humidity	RH	8760	8564	97.8	7099	81.0
Precipitation	RNF	8760	8654	98.8	8654	98.8
Wetness Sensor	WET	8759	8654	98.8	8654	98.8
Solar Radiation	SOL	8759	8655	98.8	8650	98.8
Barometric Pressure	BAR	8760	8690	99.2	8437	96.3
Filter Pack Flow Rate	FLOW	8760	8630	98.5	8630	98.5

Notes: All statistics are for hourly averages.

The number collected does not include normal maintenance or events beyond the control of the network.

The percent valid is calculated against the number possible.

Automatic zeros and spans are performed daily on most ambient gas analyzers, therefore, no ambient data can be collected during this time. As a result, the maximum percent valid for ambient gas data typically can not be greater than 95.8.

NPS Performance Goals:

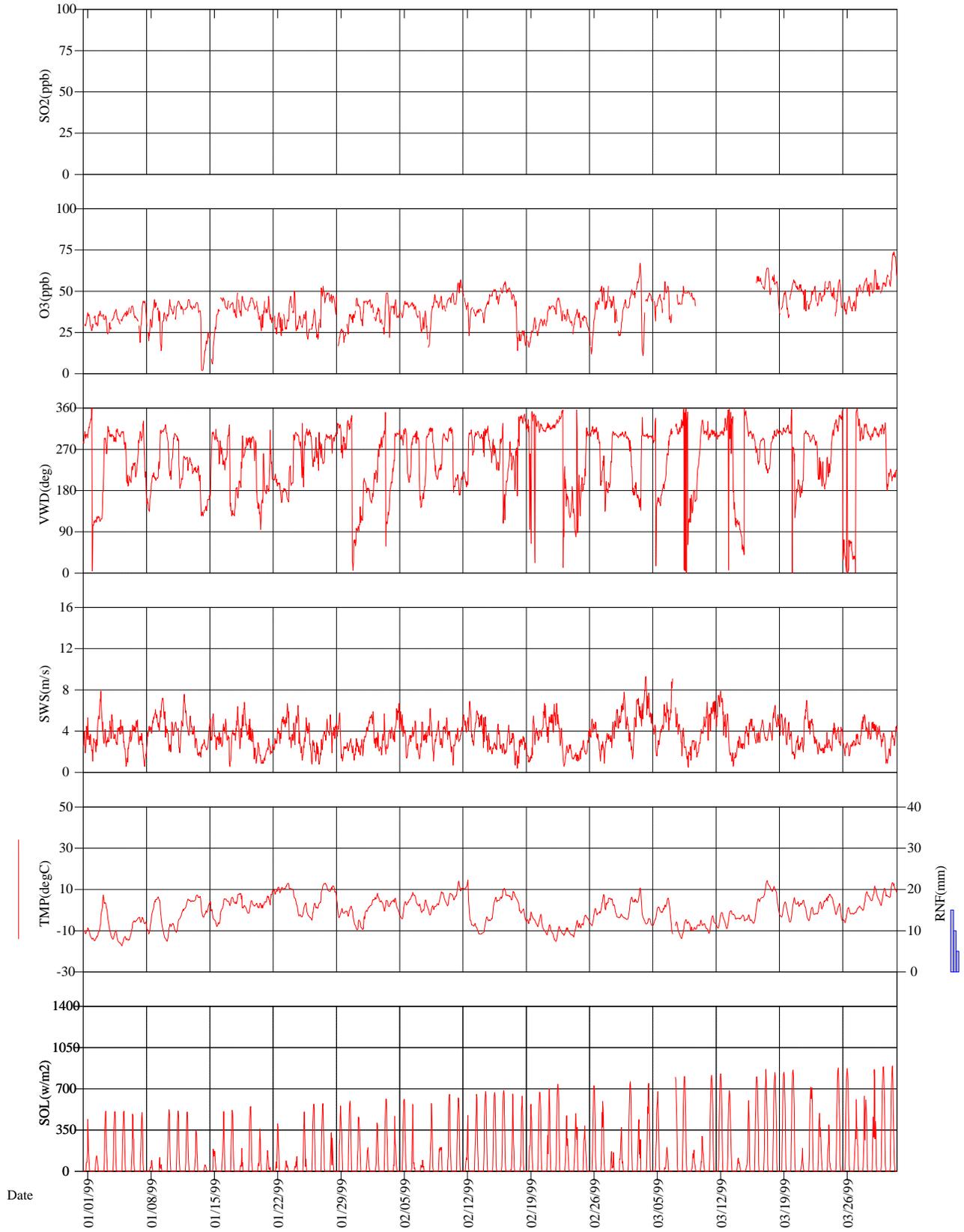
Quarterly Criteria:

100% of sites, >= 85% valid data capture  
90% of sites, >= 90% valid data capture  
80% of sites, >= 95% valid data capture

Monthly Criteria:

100% of sites, >= 60% valid data capture  
90% of sites, >= 75% valid data capture  
80% of sites, >= 85% valid data capture

# Shenandoah National Park

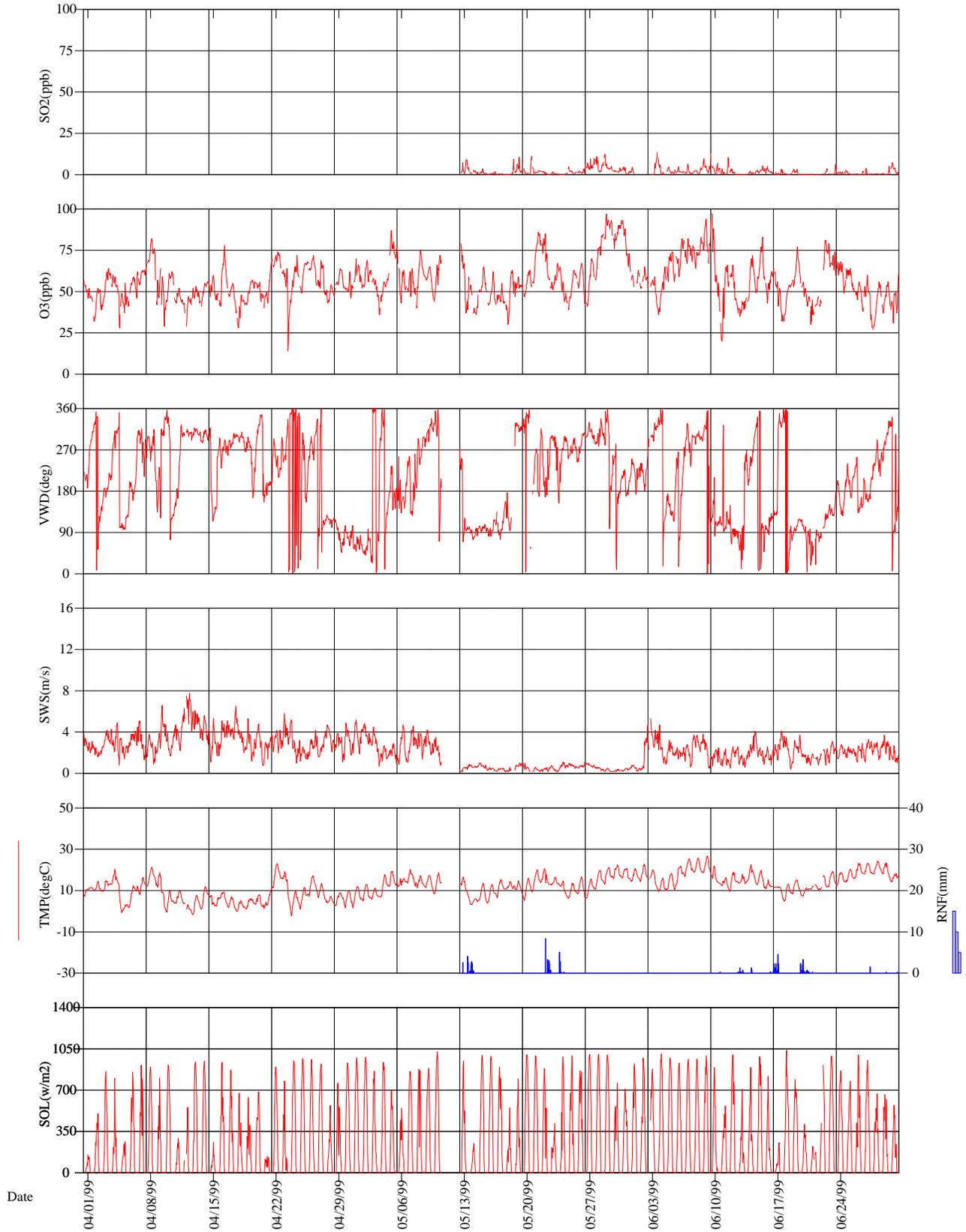


Final Validation

First Quarter 1999

shen-bm.stk - shen99.dat 06-19-2000

# Shenandoah National Park

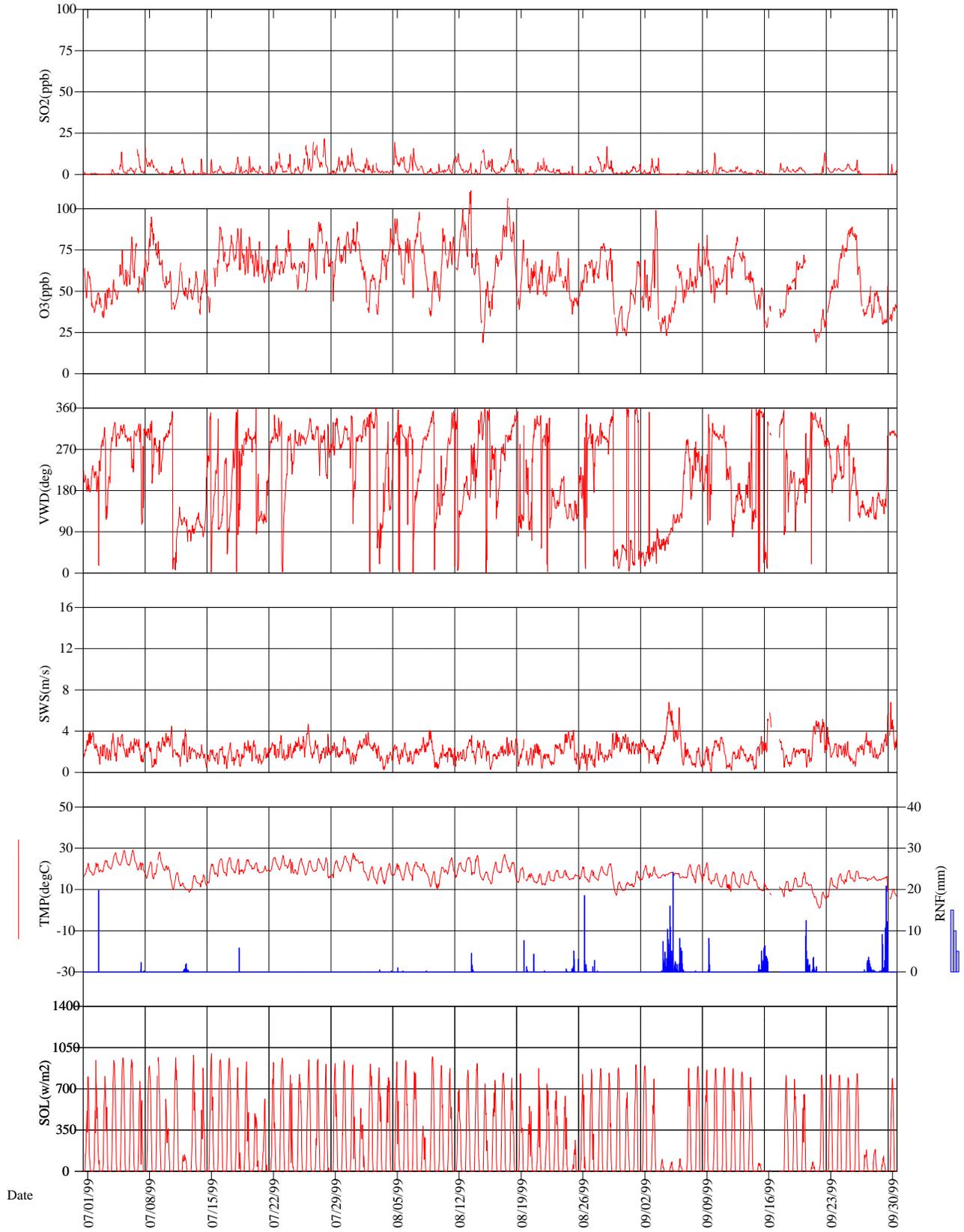


Final Validation

Second Quarter 1999

shen-bm.stk - shen99.dat 06-19-2000

# Shenandoah National Park

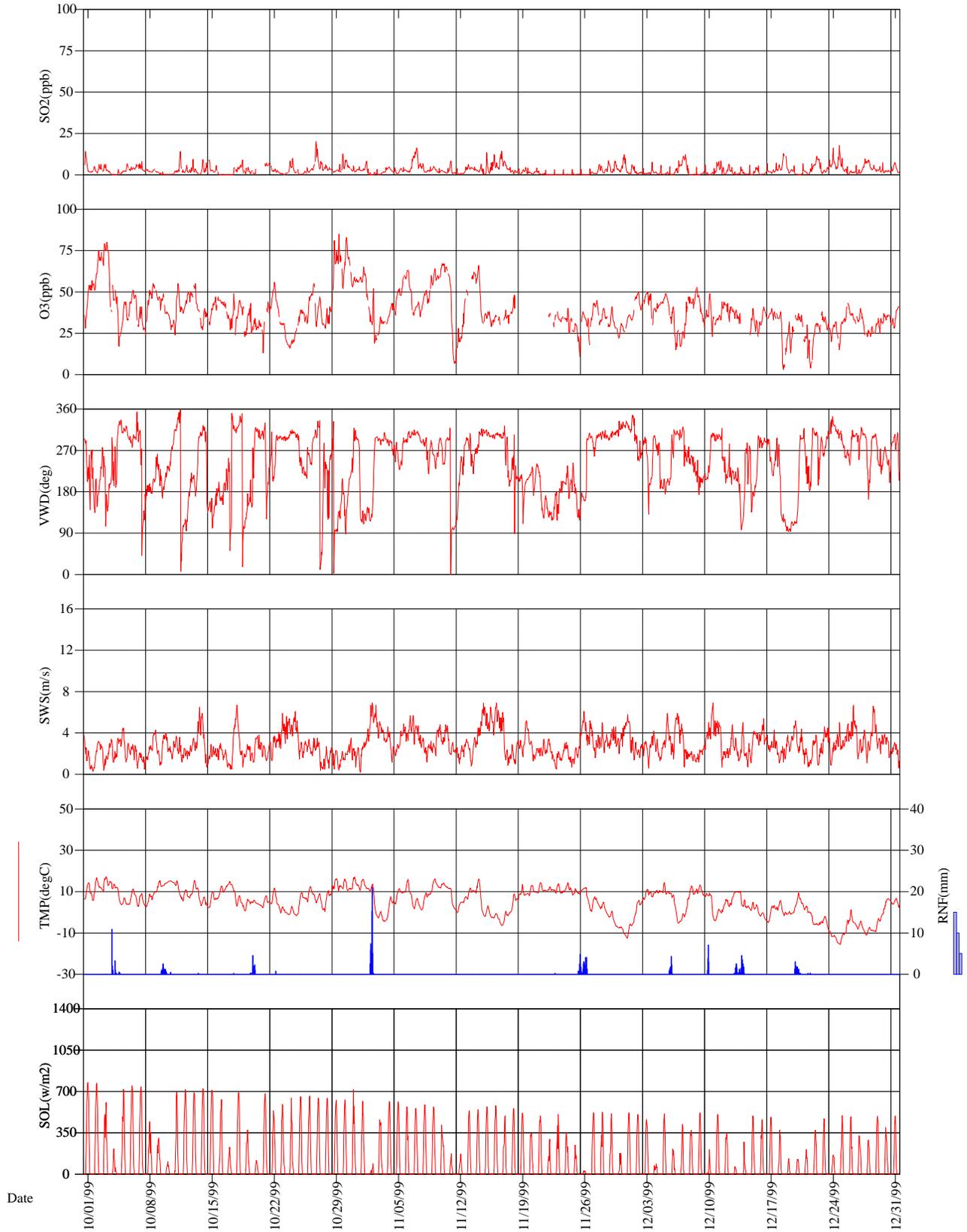


Final Validation

Third Quarter 1999

shen-bm.stk - shen99.dat 07-14-2000

# Shenandoah National Park



Final Validation

Fourth Quarter 1999

shen-bm.stk - shen99.dat 06-19-2000

## **2.2 OZONE DATA SUMMARY**

Ozone Quick Look Annual Summary Statistics  
 Shenandoah National Park  
**Big Meadows**  
 01/01/99 - 12/31/99

STATISTIC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAY-SEP	ANNUAL
DAILY 1-HR MAXIMUM	53	57	74	82	97	97	95	111	99	85	67	53	111	111
NO. OF DAYS	(31)	(28)	(25)	(30)	(29)	(30)	(31)	(31)	(30)	(31)	(27)	(31)	(151)	(354)
AVERAGE DAILY MAXIMUM	43	44	55	62	71	68	76	78	62	52	47	40	71	59
NO. OF DAYS	(31)	(28)	(25)	(30)	(29)	(30)	(31)	(31)	(30)	(31)	(27)	(31)	(151)	(354)
MAXIMUM DAILY MEAN	45	51	65	73	90	80	79	87	82	73	64	46	90	90
NO. OF DAYS	(31)	(28)	(22)	(30)	(29)	(29)	(30)	(31)	(26)	(30)	(23)	(30)	(145)	(339)
AVERAGE DAILY MEAN	35	38	48	53	60	56	64	62	53	43	39	33	59	49
NO. OF DAYS	(31)	(28)	(22)	(30)	(29)	(29)	(30)	(31)	(26)	(30)	(23)	(30)	(145)	(339)
MAX PEAK:MIN RATIO	16.500	3.667	6.091	4.714	2.135	3.300	1.886	2.947	2.475	3.000	9.000	12.667	3.300	16.500
NO. OF DAYS	(31)	(28)	(22)	(30)	(29)	(29)	(30)	(31)	(26)	(30)	(23)	(30)	(145)	(339)
AVERAGE PEAK:MIN RATIO	2.293	1.633	1.677	1.585	1.519	1.622	1.456	1.730	1.583	1.726	2.028	2.439	1.583	1.777
NO. OF DAYS	(31)	(28)	(22)	(30)	(29)	(29)	(30)	(31)	(26)	(30)	(23)	(30)	(145)	(339)
MAX 9AM-4PM AVERAGE	50	53	69	77	92	85	85	86	84	78	66	48	92	92
NO. OF DAYS	(31)	(28)	(24)	(29)	(29)	(27)	(30)	(31)	(27)	(30)	(26)	(31)	(144)	(343)
MONTHLY 9AM-4PM AVERAGE	36	40	51	55	62	59	65	64	55	45	41	35	61	51
NO. OF DAYS	(31)	(28)	(24)	(29)	(29)	(27)	(30)	(31)	(27)	(30)	(26)	(31)	(144)	(343)
MAX 7AM-7PM AVERAGE	48	53	68	75	92	83	82	88	83	77	65	47	92	92
NO. OF DAYS	(31)	(28)	(24)	(30)	(29)	(28)	(30)	(31)	(28)	(30)	(25)	(31)	(146)	(345)
MONTHLY 7AM-7PM AVERAGE	35	39	50	54	61	57	64	63	54	44	40	34	60	50
NO. OF DAYS	(31)	(28)	(24)	(30)	(29)	(28)	(30)	(31)	(28)	(30)	(25)	(31)	(146)	(345)
MONTHLY MEAN	35	38	48	53	60	57	63	62	53	43	40	34	59	49
NO. OF HOURS	(708)	(643)	(543)	(680)	(664)	(669)	(700)	(709)	(644)	(704)	(574)	(688)	(3386)	(7926)
SUM0 EXPOSURE INDEX	24681	24487	26118	36247	39930	37837	44446	44213	33911	29937	22780	23056	200337	387643
NO. OF HOURS	(708)	(643)	(543)	(680)	(664)	(669)	(700)	(709)	(644)	(704)	(574)	(688)	(3386)	(7926)
SUM60 EXPOSURE INDEX	-	-	2162	11343	21408	18219	31044	29972	15317	5554	3693	-	115960	138712
NO. OF HOURS	(0)	(0)	(33)	(172)	(297)	(260)	(433)	(407)	(217)	(78)	(59)	(0)	(1614)	(1956)
SUM80 EXPOSURE INDEX	-	-	-	324	6739	2485	6419	9601	2991	574	-	-	28235	29133
NO. OF HOURS	(0)	(0)	(0)	(4)	(78)	(29)	(76)	(109)	(35)	(7)	(0)	(0)	(327)	(338)
W126 EXPOSURE INDEX	772	1206	3691	8734	16537	13538	21971	22270	11354	5098	2709	674	85670	108552
NO. OF HOURS	(708)	(643)	(543)	(680)	(664)	(669)	(700)	(709)	(644)	(704)	(574)	(688)	(3386)	(7926)

2-8

Concentrations in parts per billion (ppb)

\* Statistics defined in the Quick Look subsection of the Glossary

Exposures in parts per billion-hours (ppb-hr)

Frequency Distribution Ozone Analyzer  Shenandoah National Park Big Meadows Monitoring Season: 04/01/99 - 10/31/99 <sup>1</sup>																			
Averaging Period	% Obs. <sup>3</sup>	# Obs. <sup>2</sup>	Min. Obs. <sup>4</sup>	10	30	50	Percentile <sup>5</sup>				70	90	95	99	Max. Obs.	2nd Max.	Arith. Mean	Geo. Mean	Geo. Stdv.
1-Hour	95	4770	0.026	0.047	0.058	0.066	0.077	0.088	0.095	0.105	0.111	0.106	0.0676	0.0657	1.28				
Concentrations in parts per million (ppm)																			

<sup>1</sup> Records for this report are selected in accordance with the AIRS Geo-Common file criteria. These criteria are based on the state-specific Monitoring Season defined in AIRS.

<sup>2</sup> The number of observations (# Obs.) includes all valid observations recorded within the Monitoring Season.

<sup>3</sup> The percent of valid observations (% Obs.) is the percentage of valid days to the number of possible monitoring days during the Monitoring Season. A valid day is defined as a day with 9 or more valid observations between 9:00 a.m. and 9:00 p.m..

<sup>4</sup> The minimum observation value (Min. Obs.) is the minimum daily maximum recorded during the Monitoring Season.

<sup>5</sup> The percentiles and other statistics are derived from the daily maximums.

**Ozone Standards Report and  
Daily Maximum 1-Hour Concentrations (ppm)**

**Shenandoah National Park**

**Big Meadows**

01/01/99 - 12/31/99

Day	Jan-99	Feb-99	Mar-99	Apr-99	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99
1	.037 F	.045 M	.045 M	.059 T	.070 S	T	.064 T	.091 S	.068 W	.057 F	.065 M	.036 W
2	.038 S	.041 T	.051 T	.052 F	.069 S	.065 W	.049 F	.060 M	.069 T	.075 S	.052 T	.050 T
3	.036 S	.049 W	.067 W	.064 S	.063 M	.059 T	.052 S	.075 T	.099 F	.080 S	.035 W	.050 F
4	.039 M	.045 T	.049 T	.061 S	.058 T	.065 F	.057 S	.088 W	.042 S	.054 M	.043 T	.043 S
5	.038 T	.044 F	.048 F	.055 M	.087 W	.074 S	.075 M	.094 T	.044 S	.044 T	.054 F	.049 S
6	.041 W	.043 S	.056 S	.059 T	.077 T	.082 S	.083 T	.082 F	.066 M	.051 W	.063 S	.041 M
7	.044 T	.038 S	S	.063 W	.064 F	.082 M	W	.095 S	.064 T	.041 T	.044 S	.044 T
8	.045 F	.048 M	.053 M	.082 T	.075 S	.083 T	.095 T	.098 S	.079 W	.055 F	.051 M	.048 W
9	.043 S	.047 T	.049 T	.072 F	.065 S	.094 W	.083 F	.062 M	.084 T	.053 S	.064 T	.053 T
10	.045 S	.049 W	W	.062 S	.072 M	.097 T	.062 S	.088 T	.065 F	.049 S	.067 W	.049 F
11	.044 M	.057 T	T	.059 S	T	.066 F	.064 S	.083 W	.071 S	.055 M	.063 T	.044 S
12	.045 T	.049 F	F	.047 M	W	.066 S	.067 M	.100 T	.083 S	.050 T	.043 F	.044 S
13	.043 W	.040 S	S	.053 T	.079 T	.046 S	.062 T	.111 F	.081 M	.055 W	S	.041 M
14	.033 T	.048 S	S	.056 W	.059 F	.072 M	.063 W	.076 S	.062 T	.040 T	.066 S	T
15	.039 F	.051 M	M	.060 T	.065 S	.083 T	T	.056 S	.052 W	.047 F	.038 M	.040 W
16	.046 S	.056 T	.059 T	.078 F	.062 S	.062 W	.089 F	.072 M	T	.047 S	T	.041 T
17	.044 S	.052 W	.064 W	.056 S	.055 M	.064 T	.084 S	.102 T	F	.049 S	.039 W	.040 F
18	.049 M	.026 T	.060 T	.048 S	.063 T	.054 F	.088 S	.106 W	.054 S	.045 M	T	.038 S
19	.046 T	.034 F	.050 F	.057 M	.059 W	.077 S	.083 M	.081 T	.068 S	.043 T	F	.032 S
20	.044 W	.033 S	.057 S	.056 T	.063 T	.058 S	.080 T	.105 F	M	.034 W	S	.037 M
21	.047 T	.041 S	.054 S	.067 W	.086 F	.047 M	.075 W	.069 S	T	T	S	.033 T
22	.037 F	.046 M	.053 M	.074 T	.085 S	T	.078 T	.065 S	.039 W	.056 F	M	.031 W
23	.047 S	.039 T	.051 T	.066 F	.067 S	.079 W	.076 F	.074 M	.057 T	.038 S	.038 T	.038 T
24	.050 S	.039 W	.056 W	.072 S	.065 M	.068 T	.087 S	.070 T	.078 F	.026 S	.040 W	.032 F
25	.038 M	.035 T	.057 T	.067 S	.063 T	.064 F	.068 S	.047 W	.089 S	.039 M	.034 T	.036 S
26	.039 T	.044 F	.047 F	.072 M	.067 W	.056 S	.082 M	.066 T	.085 S	.055 T	.038 F	.043 S
27	.053 W	.053 S	.054 S	.069 T	.070 T	.060 S	.092 T	.069 F	.047 M	.055 W	.045 S	.040 M
28	.049 T	.053 S	.058 S	.054 W	.084 F	.056 M	.084 W	.079 S	.053 T	.041 T	.040 S	.029 T
29	.047 F		.063 M	.064 T	.097 S	.056 T	.083 T	.076 S	.053 W	.085 F	.041 M	.034 W
30	.036 S		.060 T	.062 F	.090 S	.059 W	.086 F	.041 M	.042 T	.083 S	.031 T	.037 T
31	.046 S		.074 W		.093 M		.092 S	.051 T		.068 S		.041 F
Valid Days	31	28	24	30	29	28	29	31	26	30	23	30
Maximum	.053	.057	.074	.082	.097	.097	.095	.111	.099	.085	.067	.053
Violations	0	0	0	0	0	0	0	0	0	0	0	0

2-10

7926 Total Samples	0 Daily-maxima exceeding the standard of .12 ppm (starred[*])
90.5 % Possible	7 Missing days assumed to be less than the standard
339 Valid daily maxima	0 Daily maximas exceed the alert level of .200 ppm

Concentrations in parts per million (ppm)

## Shenandoah National Park - Big Meadows

### 1999 Attainment Status With U.S. Environmental Protection Agency (EPA) PRIMARY Ozone National Ambient Air Quality Standard

#### Ozone Season: April through October

The primary National Ambient Air Quality Standard for ozone is designed to protect human health. The level of the primary ozone standard promulgated by the EPA on July 18, 1997 is 0.08 parts per million (ppm) [80 parts per billion, (ppb)], daily maximum 8-hour average. The primary ozone standard is met at an ambient monitoring site when the 3-year average of the annual fourth-highest daily maximum 8-hour average ozone concentration is less than or equal to 0.08 ppm. This standard is not met when the 3-year average is greater than 0.08 ppm. Using the EPA's rounding convention, a computed 3-year average ozone concentration of 0.085 ppm (85 ppb) is the smallest value that is greater than the level of the 0.08 ppm standard.

The primary standard requires 90 percent data completeness, on average, during the 3-year period, with no single year within the period having less than 75 percent data completeness. This data completeness requirement would have to be satisfied in order to determine that the standard has been met at a monitoring site. However, calendar years with less than 75 percent data completeness are included in the computation if the annual fourth-highest daily maximum 8-hour concentration is greater than the level of the standard. A site could be found not to have met the standard with less than complete data. The percent data completeness is the percent of valid ozone monitoring days. A day is valid if valid 8-hour averages are available for at least 75 percent of possible hours in the day (i.e., at least 18 of the 24 averages). An 8-hour average is considered valid if at least 75 percent (or 6) of the hourly averages for the 8-hour period are available.

The table below lists the 3-year average fourth-highest daily maximum 8-hour ozone concentration based on data collected during the reported year and the two previous years. This is the number to compare to the level of the new primary standard. The 3-year average data completeness percent and the reported year highest five daily maximum 8-hour averages are also tabulated. A 'No' in the Data Comp % Met? column indicates EPA data completeness requirement was not met for the three-year period.

Year	3-Year Avg 4th High Daily Max 8-hr Ozone (ppb)	3-Year Avg Data Complete %	Data Complete % Met?	Annual 1st High Daily Max 8-hr Ozone (ppb)	Annual 2nd High Daily Max 8-hr Ozone (ppb)	Annual 3rd High Daily Max 8-hr Ozone (ppb)	Annual 4th High Daily Max 8-hr Ozone (ppb)	Annual 5th High Daily Max 8-hr Ozone (ppb)
1999	96	93%	Yes	101	100	97	93	92

Ozone  
 Ten Highest Daily 1-Hour Average Maximum Concentrations  
 Shenandoah National Park  
 Big Meadows  
 Final Data  
 01/01/99 - 12/31/99

Rank	Date	Hour	Concentration (ppb)
1	08/13/99	20	111*
2	08/18/99	0	106*
3	08/20/99	1	105
4	08/17/99	23	102
5	08/12/99	22	100*
6	09/03/99	18	99
7	08/08/99	0	98
8	05/29/99	9	97*
9	06/10/99	3	97*
10	07/08/99	17	95**

\* Other high value(s) were also recorded during one or more hours in the day.

\*\* This value was also recorded on one or more days later in the reporting period.

Episodes with 1-Hour Ozone Concentrations  
 > 100 ppb and > 124 ppb  
 Shenandoah National Park  
 Big Meadows

Final Data  
 01/01/99 - 12/31/99

Date	Beginning Hour	No. Hours		Max (ppb)
		> 100 ppb	>124 ppb	
08/12/99	22	1	0	100
08/13/99	15	1	0	100
08/13/99	17	4	0	111
08/17/99	23	1	0	102
08/18/99	0	2	0	106
08/18/99	3	1	0	101
08/20/99	1	1	0	105
<b>Total</b>		11	0	111

Note: The primary and secondary national ambient air standard for ozone that applied in 1996 is 0.12 ppm over a one hour period not to be exceeded more than once per year. (A value greater than .12 ppm, 124 ppb, or 235 ug/m<sup>3</sup> exceeds the standard.) (40 CFR 50.9 with reference to Appendix D and H.)

Episodes with 8-Hour Average Ozone Concentrations > 84 ppb  
Shenandoah National Park  
Big Meadows

Final Data  
01/01/99 - 12/31/99

Date	Start and End Time of Daily Maximum 8-Hour Average > 84 ppb (hr)	Daily Maximum 8-Hour Average (ppb)	Number of 8-Hour Averages > 84 ppb During the Day
05/29/99	08 - 15	93	22
05/30/99	23 - 06	91	13
05/31/99	00 - 07	91	7
06/09/99	22 - 05	89	8
06/10/99	01 - 08	89	4
07/08/99	14 - 21	88	7
07/27/99	14 - 21	90	10
08/05/99	05 - 12	91	9
08/07/99	20 - 03	92	9
08/12/99	20 - 03	91	10
08/13/99	14 - 21	101	10
08/17/99	22 - 05	100	15
08/18/99	00 - 07	97	6
09/25/99	16 - 23	87	11
14	Days with 8-hour average concentrations > 84 ppb		

Note: This table presents episodes of high ozone based on running 8-hour averages. In 1997, the EPA published new primary and secondary national ambient air quality standards for ozone based on 8-hour average ozone concentrations. Attainment of the new primary standard is reached if the annual fourth highest daily maximum 8-hour ozone concentration, averaged over three years, does not exceed 0.08 ppm (84 ppb or 157 ug/m<sup>3</sup>). (40 CFR 50.10.)

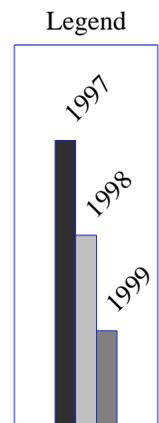
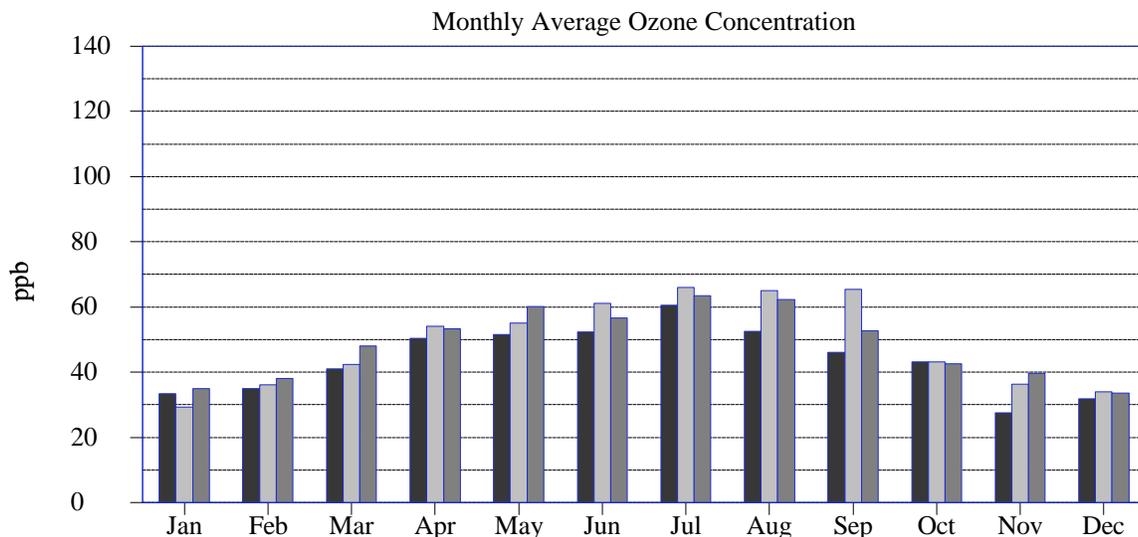
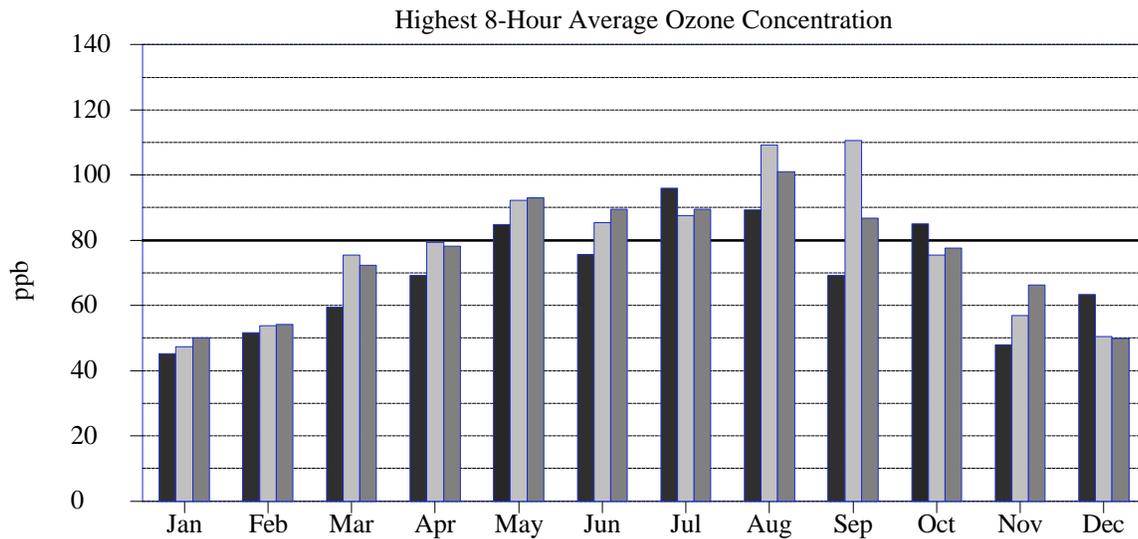
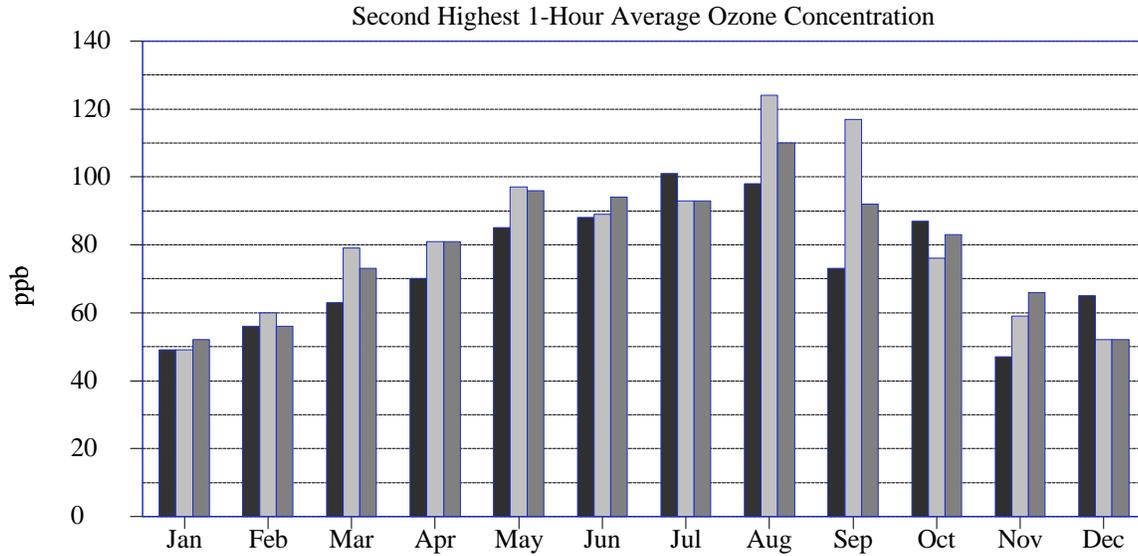
Ozone Rank Listings of Second Highest 1-Hour Average Concentrations, 4th Highest 8-Hour Average Concentrations, and Annual SUM60 Exposure Index for All NPS Monitoring Sites

01/01/99 - 12/31/99

Second Highest 1-Hour Average Concentration		
Site	Rank	Concentration (ppb)
JOTR-YV	1	134
CACO-XX	2	127
GRSM-CM	3	126
SEKI-AS	4	125
ACAD-CM	5	123
GRSM-LR	6	123
MACA-HM	7	123
SEKI-LP	8	122
GRSM-CC	9	114
GRSM-CD	10	114
COWP-XX	11	111
SEKI-LK	12	111
SHEN-BM	13	110
CHAM-XX	14	108
LAVO-ML	15	108
COSW-XX	16	106
PINN-ES	17	105
ROMO-LP	18	98
EVER-BC	19	95
YOSE-TD	20	95
DEVA-PV	21	92
MORA-TW	22	90
SAGU-PC	23	89
GRBA-MY	24	83
GRCA-AS	25	83
CANY-IS	26	82
CHIS-XX	27	82
VOYA-SB	28	82
CHIR-ES	29	81
CRMO-VC	30	80
YELL-WT	31	78
MEVE-MY	32	75
BIBE-KB	33	74
GLAC-WG	34	67
THRO-VC	35	63
NOCA-MM	36	62
DENA-HQ	37	57
VIIS-LP	38	52
OLYM-VC	39	47

4th Highest 8-hour Average Concentration		
Site	Rank	Concentration (ppb)
SEKI-LP	1	108
GRSM-LR	2	107
SEKI-AS	3	106
CACO-XX	4	102
GRSM-CM	5	102
GRSM-CD	6	101
JOTR-YV	7	101
MACA-HM	8	98
SEKI-LK	9	98
COWP-XX	10	94
SHEN-BM	11	93
ACAD-CM	12	91
GRSM-CC	13	89
YOSE-TD	14	85
LAVO-ML	15	84
PINN-ES	16	83
COSW-XX	17	80
DEVA-PV	18	80
GRCA-AS	19	77
CANY-IS	20	74
ROMO-LP	21	74
VOYA-SB	22	74
CHIR-ES	23	72
GRBA-MY	24	72
CHAM-XX	25	71
YELL-WT	26	71
CHIS-XX	27	70
MEVE-MY	28	70
CRMO-VC	29	69
SAGU-PC	30	69
EVER-BC	31	68
BIBE-KB	32	65
MORA-TW	33	65
THRO-VC	34	59
GLAC-WG	35	58
DENA-HQ	36	55
NOCA-MM	37	50
VIIS-LP	38	49
OLYM-VC	39	44

Annual Sum60 Exposure Index			
Site	Rank	Sum60 Count	
GRSM-CM	1	197289	2690
GRSM-LR	2	190523	2584
GRSM-CD	3	185668	2568
JOTR-YV	4	173371	2396
SEKI-LP	5	171734	2226
SHEN-BM	6	138712	1956
SEKI-LK	7	132466	1810
YOSE-TD	8	118407	1733
SEKI-AS	9	115750	1479
MACA-HM	10	110354	1532
DEVA-PV	11	105594	1595
GRCA-AS	12	71624	1098
COWP-XX	13	67263	940
GRSM-CC	14	63011	877
CANY-IS	15	57417	894
PINN-ES	16	52155	766
GRBA-MY	17	49296	770
LAVO-ML	18	47614	700
MEVE-MY	19	42052	661
CHIR-ES	20	37707	588
CACO-XX	21	36823	480
COSW-XX	22	36011	499
SAGU-PC	23	35374	546
YELL-WT	24	35254	552
ROMO-LP	25	34055	522
ACAD-CM	26	33463	464
CHAM-XX	27	17847	257
CRMO-VC	28	15368	241
VOYA-SB	29	12346	184
CHIS-XX	30	10294	157
EVER-BC	31	8408	122
BIBE-KB	32	8364	132
MORA-TW	33	4657	69
THRO-VC	34	1607	26
GLAC-WG	35	1285	20
NOCA-MM	36	314	5
DENA-HQ	37	0	0
OLYM-VC	38	0	0
VIIS-LP	39	0	0

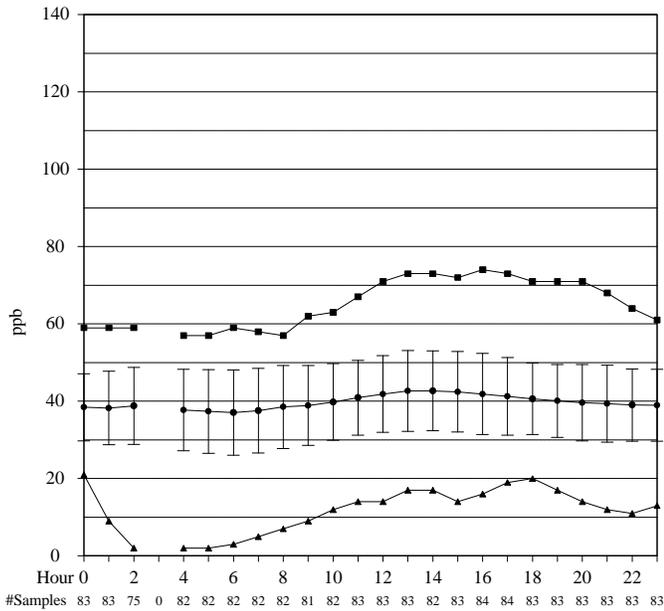


# NATIONAL PARK SERVICE GASEOUS POLLUTANT MONITORING NETWORK

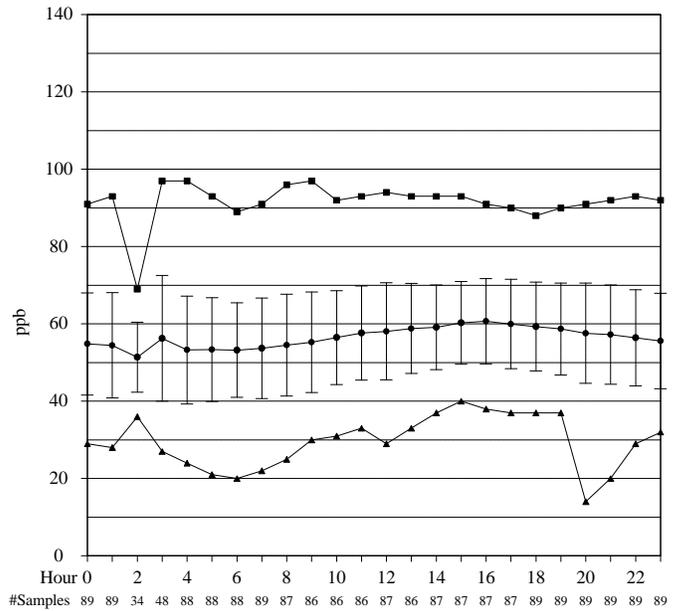
## 1999 Second Highest 1-Hour Ozone Concentrations



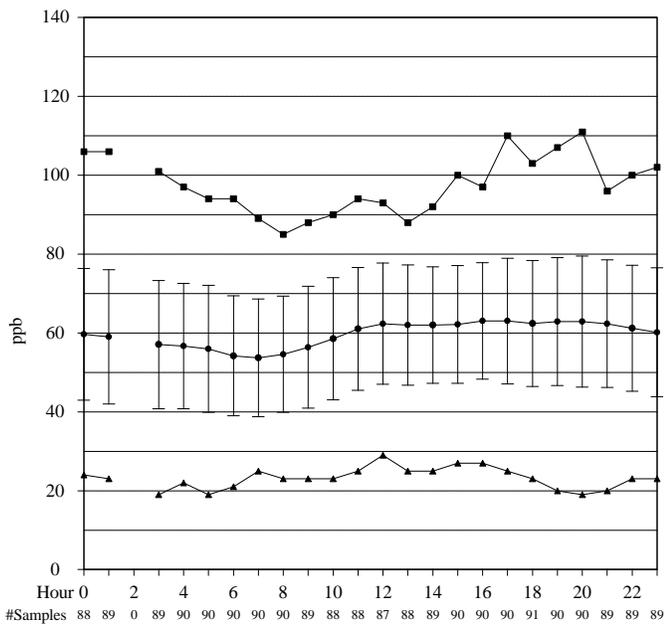
FIRST QUARTER (JAN-MAR)



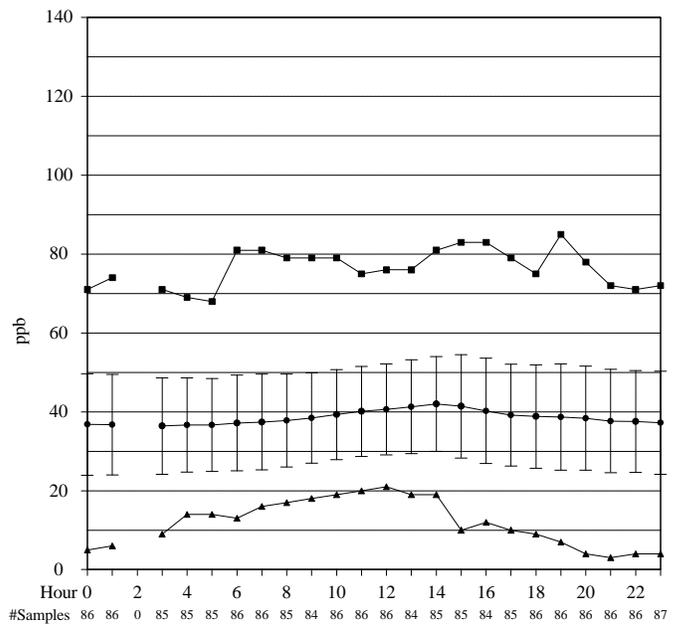
SECOND QUARTER (APR-JUN)



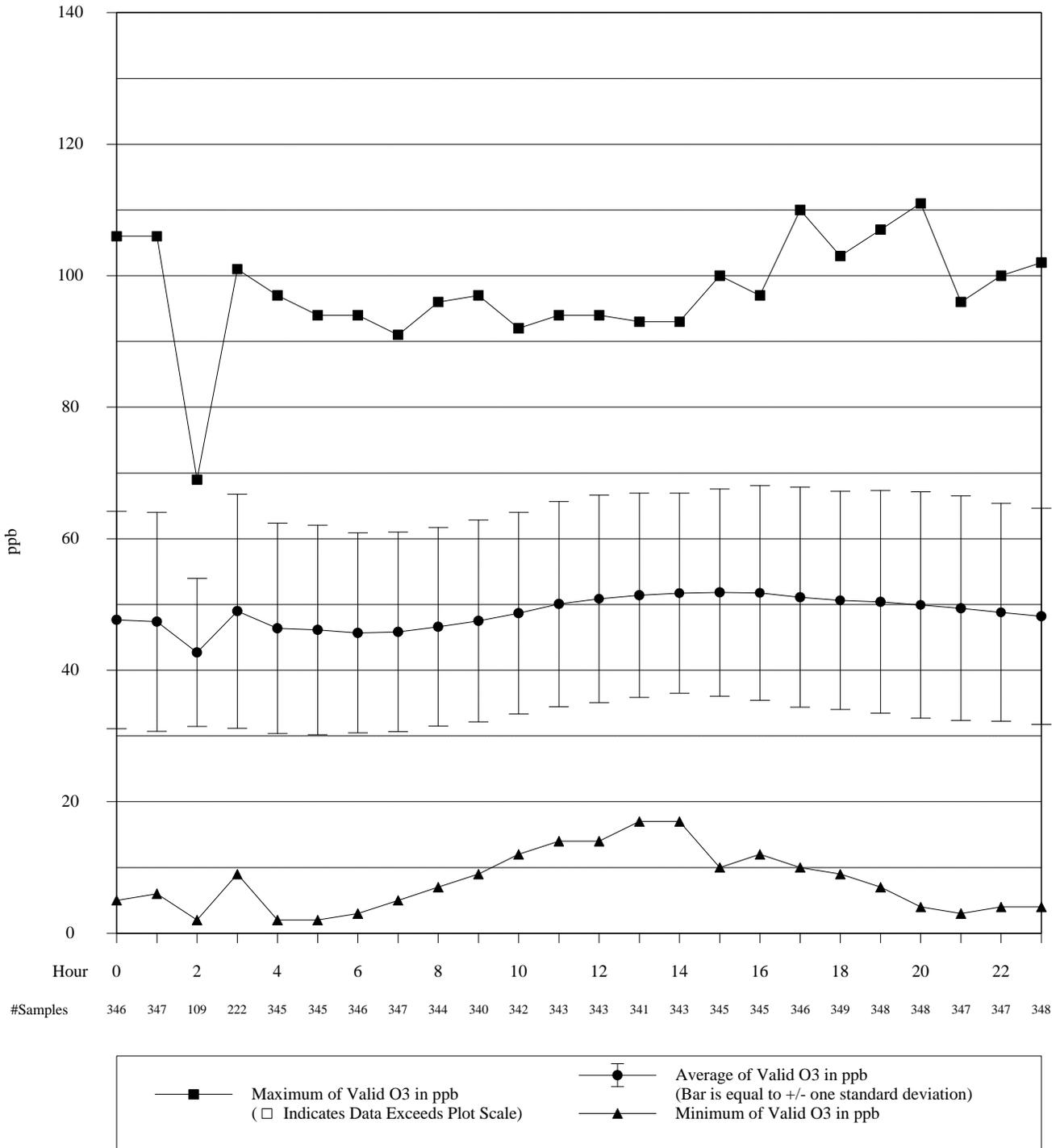
THIRD QUARTER (JUL-SEP)



FOURTH QUARTER (OCT-DEC)



<p>—■— Maximum of Valid O3 in ppb (□ Indicates Data Exceeds Plot Scale)</p>	<p>—○— Average of Valid O3 in ppb (Bar is equal to +/- one standard deviation)</p>
	<p>—▲— Minimum of Valid O3 in ppb</p>

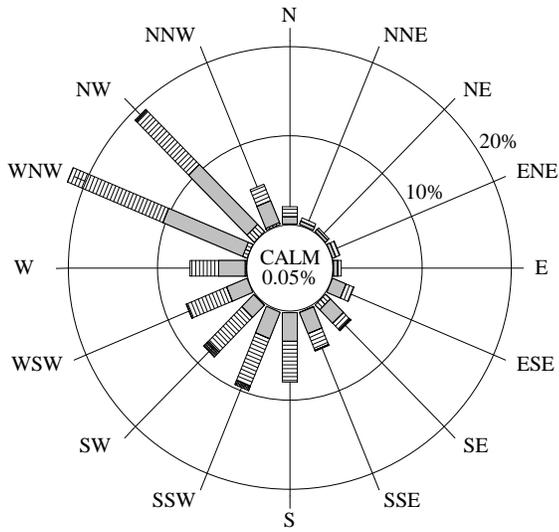


Shenandoah National Park  
Big Meadows

Quarterly Ozone  
Pollutant Rose

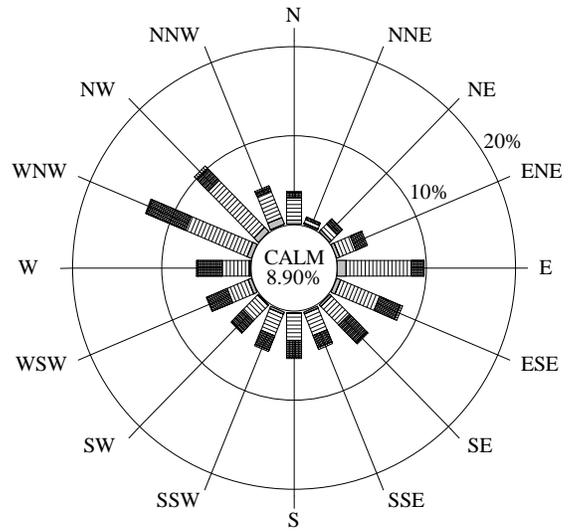
1999

FIRST QUARTER (JAN-MAR)



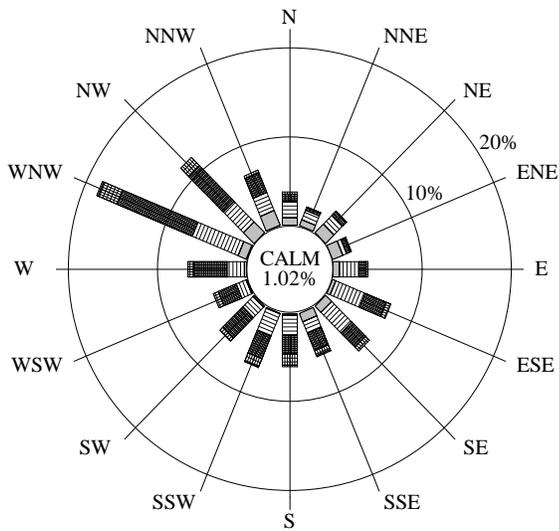
100.0% Collected 87.7% Valid  
2160 Possible /2160 Collected /1894 Valid

SECOND QUARTER (APR-JUN)



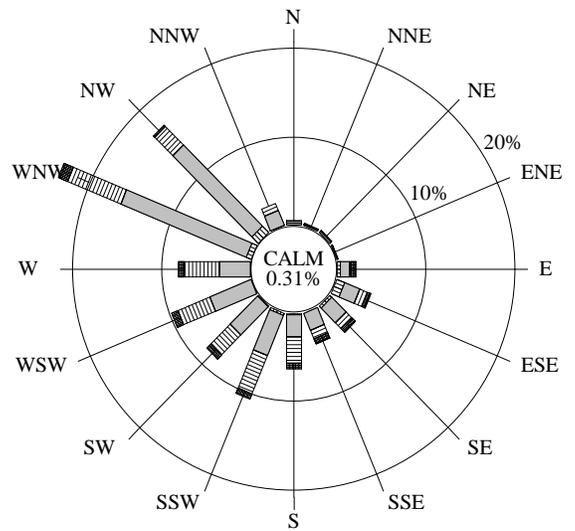
100.0% Collected 91.6% Valid  
2184 Possible /2184 Collected /2000 Valid

THIRD QUARTER (JUL-SEP)



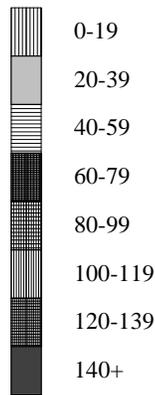
100.0% Collected 92.9% Valid  
2208 Possible /2208 Collected /2052 Valid

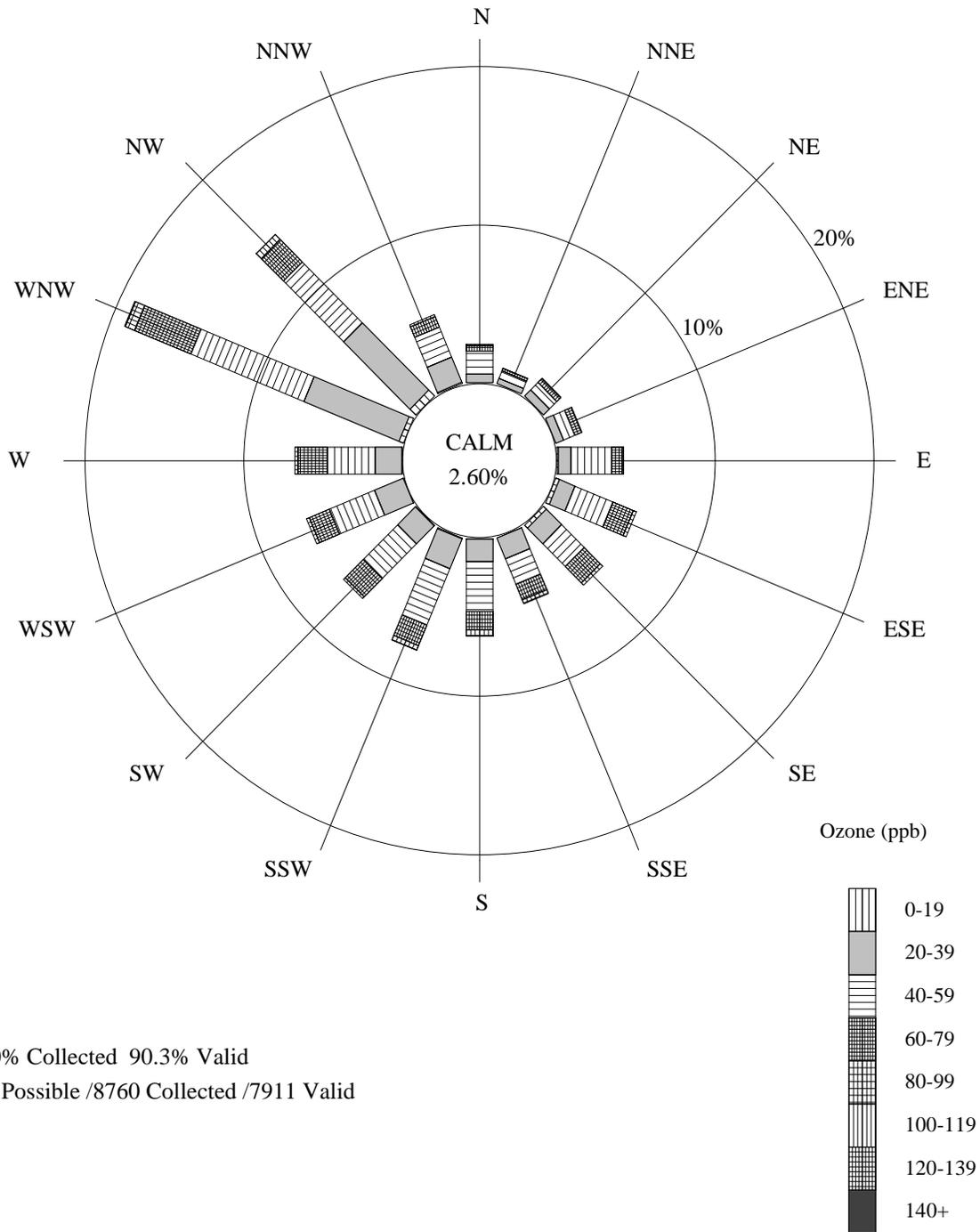
FOURTH QUARTER (OCT-DEC)



100.0% Collected 89.0% Valid  
2208 Possible /2208 Collected /1965 Valid

Ozone (ppb)





Ozone Precision Check Summary  
 Shenandoah National Park  
 Big Meadows

Precision checks are required by the Environmental Protection Agency (EPA) of all monitoring instruments collecting data which are to be submitted to the EPA Aerometric Information Retrieval System (AIRS). A precision check is performed by challenging the pollutant analyzer with a known concentration of gas (between 0.08 and 0.10 ppm for ozone and sulfur dioxide) from the pollutant transfer standard. This precision check must be performed at least every 14 days of monitoring operation. The percent difference between the analyzer and the transfer standard is then calculated.<sup>1</sup> According to NPS Standard Operating Procedures, the pollutant analyzer must respond within 10% of the transfer standard.<sup>2</sup> The table below gives the number of precision checks performed during each quarter, the average of all the individual precision check percent differences for the quarter, and the upper and lower 95% probability limits<sup>3</sup> for precision checks. The probability limits represent the interval having a 95% chance of containing the true average percent difference. The quarterly average percent difference and probability limits should ideally be within +/- 10%.

Final Data 01/01/99 - 12/31/99				
Calendar Quarter	Number of Precision Checks	Average Percent Difference <sup>1 2</sup>	Lower 95% Probability Limit <sup>3</sup>	Upper 95% Probability Limit <sup>3</sup>
1	2	-0.54	-1.61	0.52
2	0			
3	2	10.59	-0.27	21.45
4	38	1.74	0.12	3.37

<sup>1</sup> Percent Difference =  $\frac{\text{analyzer} - \text{transfer std}}{\text{transfer std}} \times 100$ .

<sup>2</sup> Average Percent Difference is the mean of all individual precision check percent differences during the quarter.

<sup>3</sup> Upper/Lower 95% Probability Limits = (Average Percent Difference) +/- (1.96)(Standard Deviation of precision check percent differences in the quarter.)

## **2.3 SULFUR DIOXIDE DATA SUMMARY**

Sulfur Dioxide Five Highest Daily 1-Hour Averages, 3-Hour Block Averages, and 24-Hour Block Averages Shenandoah National Park <b>Big Meadows</b> Final Data 01/01/99 - 12/31/99			
Rank	Date	Hour	Concentration (ppb)
Highest Daily 1-Hour Averages			
1	07/28/99	6	22
2	10/27/99	5	20
3	07/27/99	1	20
4	08/05/99	5	19
5	12/25/99	4	18
Highest 3-Hour Block Averages			
1	07/28/99	6-8	19
2	10/27/99	3-5	16
3	07/27/99	6-8	15
4	11/07/99	12-14	15
5	07/26/99	3-5	15
Highest 24-Hour Block Averages			
1	07/27/99	00-23	11
2	11/07/99	00-23	10
3	10/27/99	00-23	9
4	08/05/99	00-23	9
5	12/07/99	00-23	8

Note: The primary and secondary ambient air standards for SO<sub>2</sub> are:  
 Annual Primary Standard - 0.03 ppm; annual arithmetic mean not to be exceeded.  
 (A value greater than .03 ppm, 34 ppb, or 80 ug/m<sup>3</sup> exceeds the standard.)  
 24-Hour Primary Standard - 0.14 ppm; not to be exceeded more than once per year.  
 (A value greater than .14 ppm, 144 ppb, or 365 ug/m<sup>3</sup> exceeds the standard.)  
 3-Hour Secondary Standard - 0.5 ppm; not to be exceeded more than once per year.  
 (A value greater than .5 ppm, 549 ppb, or 1300 ug/m<sup>3</sup> exceeds the standard.)  
 (40 CFR 50.4 and 50.5 with reference to Appendix A.)

Sulfur Dioxide Standards Report and  
Daily Maximum 1-Hour Concentrations (ppm)  
Shenandoah National Park  
01/01/99 - 12/31/99

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec								
1	F	M	M	T	S	0.005	T	0.001	T	0.006	S	0.006	W	0.014	F	0.008	M	0.01	W	
2	S	T	T	F	S		W	0.001	F	0.01	M	0.006	T	0.006	S	0.004	T	0.005	T	
3	S	W	W	S	M	0.010	T	0	S	0.007	T	0.01	F	0.006	S	0.003	W	0.004	F	
4	M	T	T	S	T	0.013	F	0.003	S	0.002	W	0.01	S	0.003	M	0.005	T	0.008	S	
5	T	F	F	M	W	0.005	S	0.014	M	0.019	T	0	S	0.007	T	0.004	F	0.006	S	
6	W	S	S	T	T	0.005	S	0.004	T	0.011	F	0.001	M	0.006	W	0.004	S	0.005	M	
7	T	S	S	W	F	0.006	M	0.015	W	0.016	S	0.002	T	0.008	T	0.016	S	0.012	T	
8	F	M	M	T	S	0.004	T	0.016	T	0.005	S	0.003	W	0.004	F	0.007	M	0.006	W	
9	S	T	T	F	S	0.010	W	0.005	F	0.004	M	0.003	T	0.004	S	0.005	T	0.005	T	
10	S	W	W	S	M	0.013	T	0.002	S	0.006	T	0.013	F	0	S	0.004	W	0.006	F	
11	M	T	T	S	T	0.010	F	0.005	S	0.009	W	0.005	S	0.014	M	0.008	T	0.008	S	
12	T	F	F	M	W	0.009	S	0.01	M	0.013	T	0.005	S	0.006	T	0.004	F	0.007	S	
13	W	S	S	T	0.009	T	0.000	S	0.002	T	0.007	F	0.005	M	0.009	W	0.006	S	0.004	M
14	T	S	S	W	0.003	F	0.002	M	0.009	W	0.006	S	0.001	T	0.009	T	0.007	S	0.005	T
15	F	M	M	T	0.003	S	0.005	T	0.009	T	0.015	S	0.003	W	0.009	F	0.014	M	0.006	W
16	S	T	T	F	0.002	S	0.005	W	0.005	F	0.009	M	0	T	0.004	S	0.012	T	0.005	T
17	S	W	W	S	0.001	M	0.003	T	0.002	S	0.006	T	0.007	F	0.004	S	0.014	W	0.007	F
18	M	T	T	S	0.003	T	0.003	F	0.011	S	0.016	W	0.005	S	0.009	M	0.005	T	0.013	S
19	T	F	F	M	0.011	W	0.003	S	0.011	M	0.009	T	0.004	S	0.005	T	0.004	F	0.011	S
20	W	S	S	T	0.009	T	0.000	S	0.005	T	0.001	F	0.004	M	0.003	W	0.004	S	0.005	M
21	T	S	S	W	0.011	F	0.000	M	0.005	W	0.007	S	0	T	0.007	T	0.004	S	0.007	T
22	F	M	M	T	0.002	S	0.003	T	0.008	T	0.01	S	0.013	W	0.007	F	0.003	M	0.011	W
23	S	T	T	F	0.002	S	0.006	W	0.013	F	0.004	M	0.005	T	0.001	S	0.003	T	0.007	T
24	S	W	W	S	0.001	M	0.002	T	0.012	S	0.002	T	0.004	F	0.01	S	0.003	W	0.016	F
25	M	T	T	S	0.005	T	0.003	F	0.008	S	0.005	W	0.006	S	0.003	M	0.003	T	0.018	S
26	T	F	F	M	0.003	W	0.001	S	0.018	M	0.002	T	0.009	S	0.005	T	0.003	F	0.005	S
27	W	S	S	T	0.010	T	0.004	S	0.02	T	0.005	F	0	M	0.02	W	0.004	S	0.006	M
28	T	S	S	W	0.011	F	0.001	M	0.022	W	0.011	S	0	T	0.006	T	0.006	S	0.01	T
29	F		M	T	0.012	S	0.005	T	0.011	T	0.017	S	0	W	0.006	F	0.009	M	0.006	W
30	S		T	F	0.004	S	0.007	W	0.012	F	0.001	M	0.006	T	0.013	S	0.012	T	0.007	T
31	S		W		0.005	M		0.016	S	0.003	T			0.006	S			0.008	F	
Number					435	641	712	709	652	690	720	740								
Maximum					0.012	0.013	0.022	0.019	0.013	0.02	0.016	0.018								
Arith-Mean					0.002	0.002	0.003	0.003	0.002	0.003	0.003	0.003								
5299 Total Samples			.003 Arith-Mean					Does not meet summary criteria												
60.5 % Possible			.003 Arith-StdDev					Primary standard of .030 ppm was met												Concentrations in parts per million (ppm)

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Sulfur Dioxide Standards Report and  
Daily Maximum 3-Hour Concentrations (ppm)  
Shenandoah National Park  
01/01/99 - 12/31/99

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec								
1	F	M	M	T	S	0.004	T	0.001	T	0.005	S	0.005	W	0.011	F	0.007	M	0.009	W	
2	S	T	T	F	S		W	0.001	F	0.005	M	0.003	T	0.005	S	0.002	T	0.004	T	
3	S	W	W	S	M	0.008	T	0.001	S	0.004	T	0.008	F	0.004	S	0.002	W	0.002	F	
4	M	T	T	S	T	0.008	F	0.003	S	0.002	W	0.007	S	0.002	M	0.005	T	0.004	S	
5	T	F	F	M	W	0.004	S	0.009	M	0.014	T	0.001	S	0.006	T	0.004	F	0.003	S	
6	W	S	S	T	T	0.003	S	0.004	T	0.009	F	0.001	M	0.005	W	0.004	S	0.003	M	
7	T	S	S	W	F	0.005	M	0.013	W	0.011	S	0.001	T	0.006	T	0.015	S	0.011	T	
8	F	M	M	T	S	0.004	T	0.008	T	0.005	S	0.002	W	0.003	F	0.006	M	0.004	W	
9	S	T	T	F	S	0.007	W	0.003	F	0.003	M	0.002	T	0.002	S	0.005	T	0.002	T	
10	S	W	W	S	M	0.005	T	0.001	S	0.003	T	0.012	F	0.001	S	0.003	W	0.003	F	
11	M	T	T	S	T	0.007	F	0.002	S	0.008	W	0.004	S	0.012	M	0.007	T	0.007	S	
12	T	F	F	M	W	0.003	S	0.008	M	0.011	T	0.004	S	0.004	T	0.002	F	0.005	S	
13	W	S	S	T	0.008	T	0.001	S	0.001	T	0.006	F	0.002	M	0.005	W	0.006	S	0.003	M
14	T	S	S	W	0.002	F	0.001	M	0.005	W	0.003	S	0.001	T	0.007	T	0.006	S	0.003	T
15	F	M	M	T	0.003	S	0.004	T	0.004	T	0.014	S	0.002	W	0.009	F	0.009	M	0.004	W
16	S	T	T	F	0.001	S	0.004	W	0.004	F	0.005	M	0.001	T	0.001	S	0.011	T	0.004	T
17	S	W	W	S	0.001	M	0.002	T	0.001	S	0.006	T	0.004	F	0.002	S	0.012	W	0.004	F
18	M	T	T	S	0.002	T	0.001	F	0.008	S	0.014	W	0.004	S	0.007	M	0.004	T	0.012	S
19	T	F	F	M	0.006	W	0.003	S	0.009	M	0.004	T	0.004	S	0.004	T	0.003	F	0.004	S
20	W	S	S	T	0.005	T	0.001	S	0.004	T	0.001	F	0.004	M	0.001	W	0.002	S	0.003	M
21	T	S	S	W	0.004	F	0.001	M	0.001	W	0.005	S	0.001	T	0.007	T	0.002	S	0.003	T
22	F	M	M	T	0.001	S	0.002	T	0.005	T	0.005	S	0.011	W	0.005	F	0.002	M	0.011	W
23	S	T	T	F	0.001	S	0.005	W	0.011	F	0.002	M	0.004	T	0.001	S	0.002	T	0.005	T
24	S	W	W	S	0.001	M	0.001	T	0.007	S	0.001	T	0.004	F	0.008	S	0.002	W	0.011	F
25	M	T	T	S	0.004	T	0.002	F	0.005	S	0.002	W	0.006	S	0.002	M	0.002	T	0.014	S
26	T	F	F	M	0.002	W	0.001	S	0.015	M	0.001	T	0.005	S	0.004	T	0.002	F	0.002	S
27	W	S	S	T	0.006	T	0.002	S	0.015	T	0.003	F	0.001	M	0.016	W	0.002	S	0.005	M
28	T	S	S	W	0.009	F	0.001	M	0.019	W	0.01	S	0.001	T	0.005	T	0.005	S	0.008	T
29	F		M	T	0.011	S	0.003	T	0.009	T	0.01	S	0.001	W	0.004	F	0.008	M	0.005	W
30	S		T	F	0.003	S	0.006	W	0.011	F	0.001	M	0.004	T	0.008	S	0.011	T	0.004	T
31	S		W		0.004	M		0.011	S	0.002	T			0.004	S				0.007	F
Number					132		192		216		216		202		209		240		246	
Maximum					0.011		0.008		0.019		0.014		0.012		0.016		0.015		0.014	
1653 Total Samples	0 Plused (+) items exceeded the secondary standard of .550 ppm											Concentrations in parts per million (ppm)								
56.6 % Possible																				

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Sulfur Dioxide Standards Report and  
Daily Maximum 24-Hour Concentrations (ppm)  
Shenandoah National Park  
01/01/99 - 12/31/99

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec								
1	F	M	M	T	S	T	0.001	T	0.003	S	0.003	W	0.004	F	0.004	M	0.003	W		
2	S	T	T	F	S	W	0.001	F	0.003	M	0.001	T	0.003	S	0.001	T	0.001	T		
3	S	W	W	S	M	T	0.001	S	0.002	T	0.003	F	0.003	S	0.001	W	0.001	F		
4	M	T	T	S	T	0.004	F	0.001	S	0.001	W	0.002	S	0.001	M	0.003	T	0.002	S	
5	T	F	F	M	W	0.002	S	0.004	M	0.009	T	0.001	S	0.002	T	0.002	F	0.001	S	
6	W	S	S	T	T	0.002	S	0.002	T	0.005	F	0.001	M	0.004	W	0.002	S	0.002	M	
7	T	S	S	W	F	0.002	M	0.005	W	0.007	S	0.001	T	0.004	T	0.01	S	0.008	T	
8	F	M	M	T	S	0.002	T	0.007	T	0.002	S	0.001	W	0.002	F	0.003	M	0.002	W	
9	S	T	T	F	S	0.004	W	0.002	F	0.001	M	0.001	T	0.001	S	0.003	T	0.001	T	
10	S	W	W	S	M	0.004	T	0.001	S	0.002	T	0.003	F	0.001	S	0.002	W	0.001	F	
11	M	T	T	S	T	0.002	F	0.001	S	0.004	W	0.002	S	0.003	M	0.003	T	0.004	S	
12	T	F	F	M	W	0.002	S	0.003	M	0.007	T	0.002	S	0.002	T	0.001	F	0.003	S	
13	W	S	S	T	0.004	T	0.001	S	0.001	T	0.002	F	0.002	M	0.003	W	0.004	S	0.001	M
14	T	S	S	W	0.001	F	0.001	M	0.002	W	0.001	S	0.001	T	0.004	T	0.003	S	0.001	T
15	F	M	M	T	0.001	S	0.002	T	0.002	T	0.007	S	0.001	W	0.003	F	0.003	M	0.002	W
16	S	T	T	F	0.001	S	0.002	W	0.002	F	0.003	M	T	0.001	S	0.006	T	0.001	T	
17	S	W	W	S	0.001	M	0.001	T	0.001	S	0.003	T	F	0.001	S	0.007	W	0.002	F	
18	M	T	T	S	0.001	T	0.001	F	0.004	S	0.007	W	0.002	S	0.004	M	0.002	T	0.005	S
19	T	F	F	M	0.003	W	0.002	S	0.002	M	0.003	T	0.002	S	0.002	T	0.002	F	0.003	S
20	W	S	S	T	0.002	T	0.001	S	0.002	T	0.001	F	M	W	0.001	S	0.001	M		
21	T	S	S	W	0.002	F	0.001	M	0.001	W	0.003	S	T	T	0.001	S	0.002	T		
22	F	M	M	T	0.001	S	0.001	T	0.003	T	0.003	S	0.004	W	0.003	F	0.001	M	0.007	W
23	S	T	T	F	0.001	S	0.002	W	0.004	F	0.002	M	0.002	T	0.001	S	0.001	T	0.003	T
24	S	W	W	S	0.001	M	0.001	T	0.003	S	0.001	T	0.003	F	0.004	S	0.001	W	0.007	F
25	M	T	T	S	0.002	T	0.001	F	0.002	S	0.001	W	0.004	S	0.001	M	0.001	T	0.006	S
26	T	F	F	M	0.001	W	0.001	S	0.007	M	0.001	T	0.002	S	0.003	T	0.001	F	0.001	S
27	W	S	S	T	0.005	T	0.001	S	0.011	T	0.001	F	0.001	M	0.009	W	0.001	S	0.002	M
28	T	S	S	W	0.005	F	0.001	M	0.007	W	0.005	S	0.001	T	0.004	T	0.003	S	0.006	T
29	F		M	T	0.006	S	0.001	T	0.003	T	0.005	S	0.001	W	0.002	F	0.004	M	0.003	W
30	S		T	F	0.002	S	0.003	W	0.005	F	0.001	M	0.002	T	0.006	S	0.005	T	0.002	T
31	S		W		0.002	M		0.006	S	0.001	T			0.003	S				0.004	F
Number					19	27	31	31	26	29	30	31								
Maximum					0.006	0.004	0.011	0.009	0.004	0.009	0.01	0.008								
224 Total Samples		0 Starred (*) items exceeded the primary standard of .145 ppm										Concentrations in parts per million (ppm)								
61.4 % Possible																				

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Frequency Distribution Sulfur Dioxide Analyzer  Shenandoah National Park Big Meadows Monitoring Season: 01/01/99 - 12/31/99 <sup>1</sup>															
Averaging Period	% Obs. <sup>3</sup>	# Obs. <sup>2</sup>	Min. Obs. <sup>4</sup>	Percentile <sup>5</sup>							Max. Obs.	2nd Max.	Arith. Mean	Geo. Mean	Geo. Stdv.
				10	30	50	70	90	95	99					
1-Hour	95	5299	0.001	0.001	0.001	0.002	0.003	0.006	0.009	0.013	0.022	0.020	0.0026	0.0016	2.94
3-Hour		1960	0.000	0.001	0.001	0.002	0.003	0.006	0.008	0.012	0.019	0.016			
24-Hour		245	0.000	0.001	0.001	0.002	0.003	0.005	0.007	0.009	0.010	0.010			
Concentrations in parts per million (ppm)															

<sup>1</sup> Records for this report are selected in accordance with the AIRS Geo-Common file criteria. These criteria are based on the state-specific Monitoring Season defined in AIRS.

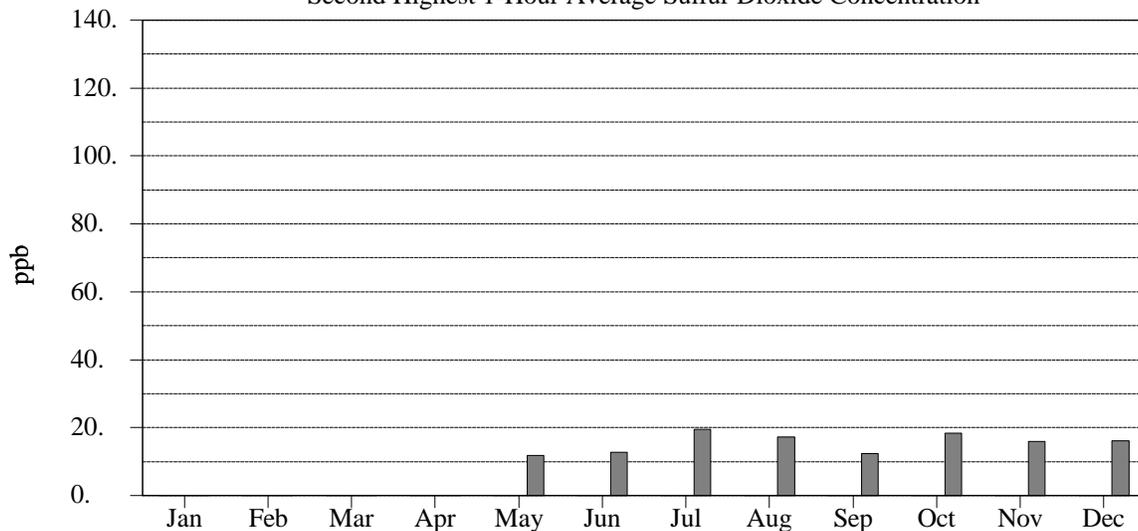
<sup>2</sup> The number of observations (# Obs.) includes all valid observations recorded within the Monitoring Season.

<sup>3</sup> The percent of valid observations (% Obs.) is the percentage of valid days to the number of possible monitoring days during the Monitoring Season. A valid day is defined as a day with 9 or more valid observations between 9:00 a.m. and 9:00 p.m..

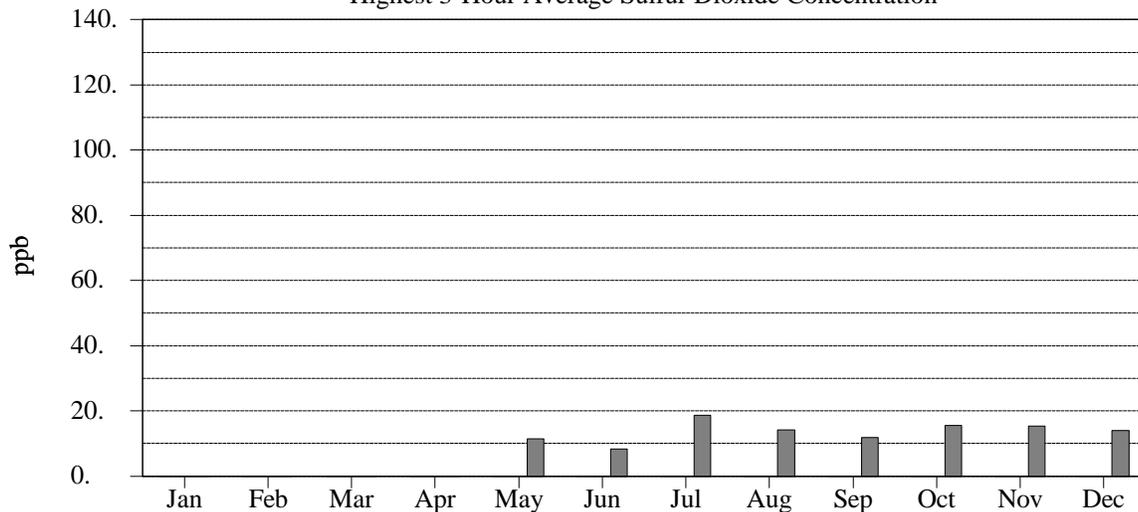
<sup>4</sup> The minimum observation value (Min. Obs.) is the minimum daily maximum recorded during the Monitoring Season.

<sup>5</sup> The percentiles and other statistics are derived from the daily maximums.

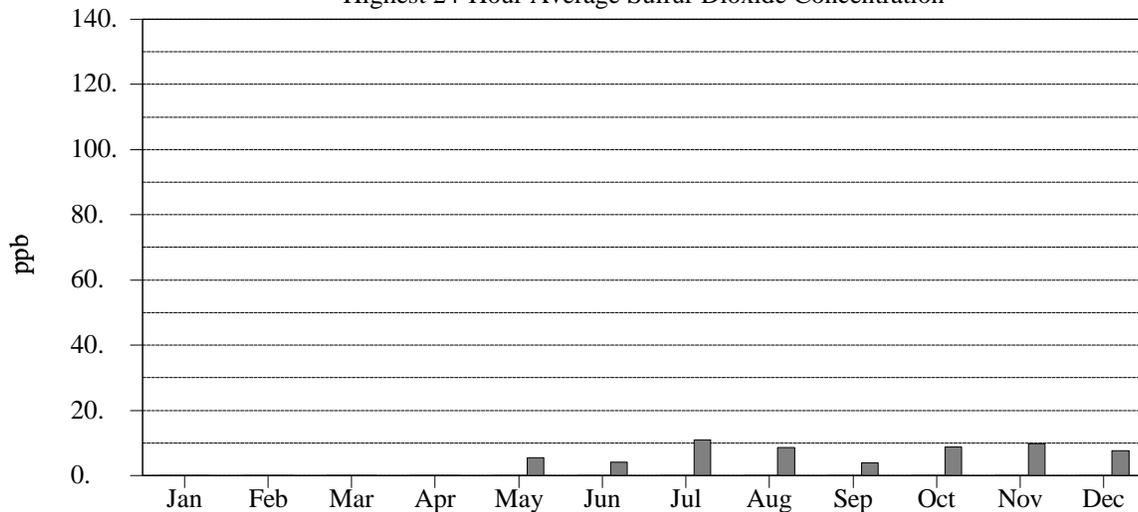
Second Highest 1-Hour Average Sulfur Dioxide Concentration



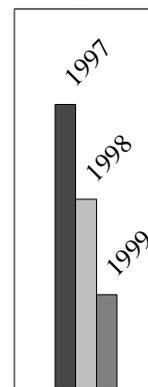
Highest 3-Hour Average Sulfur Dioxide Concentration



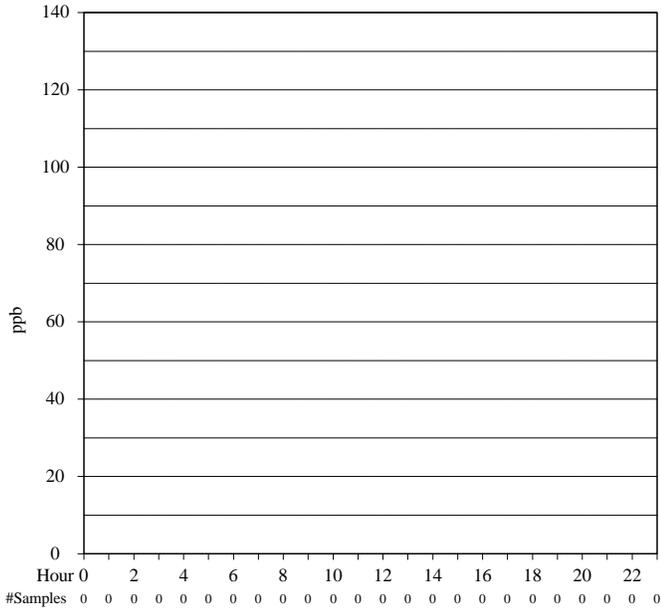
Highest 24-Hour Average Sulfur Dioxide Concentration



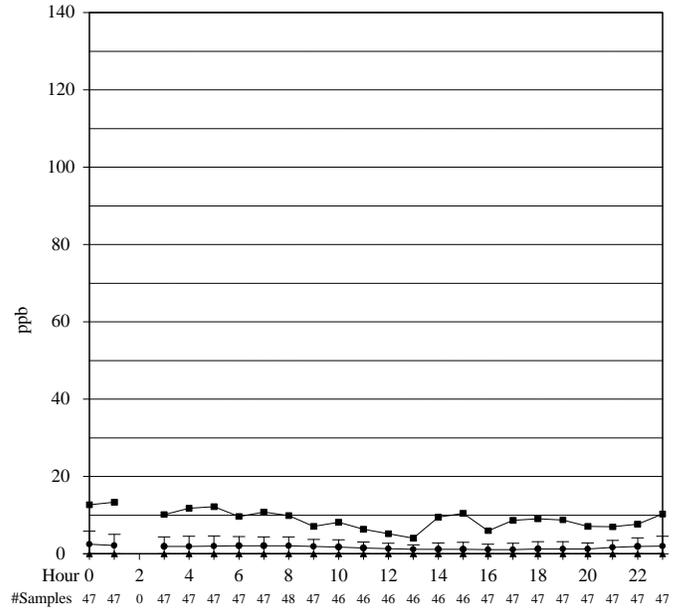
Legend



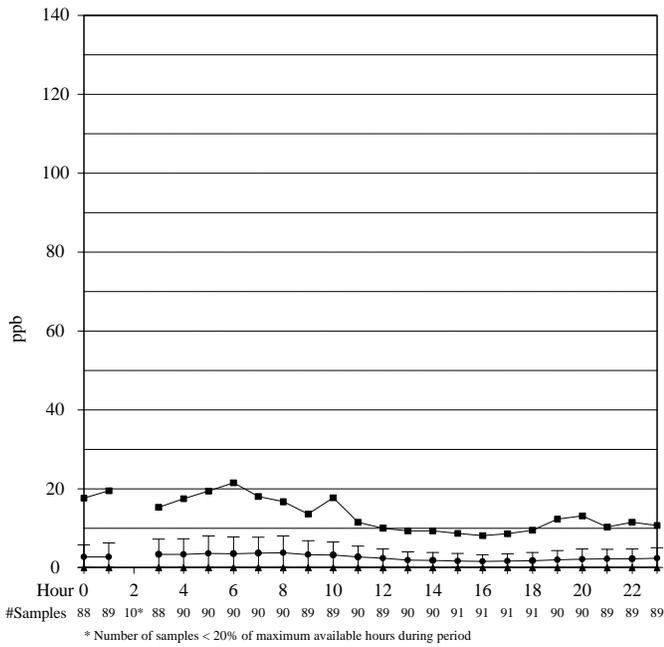
FIRST QUARTER (JAN-MAR)



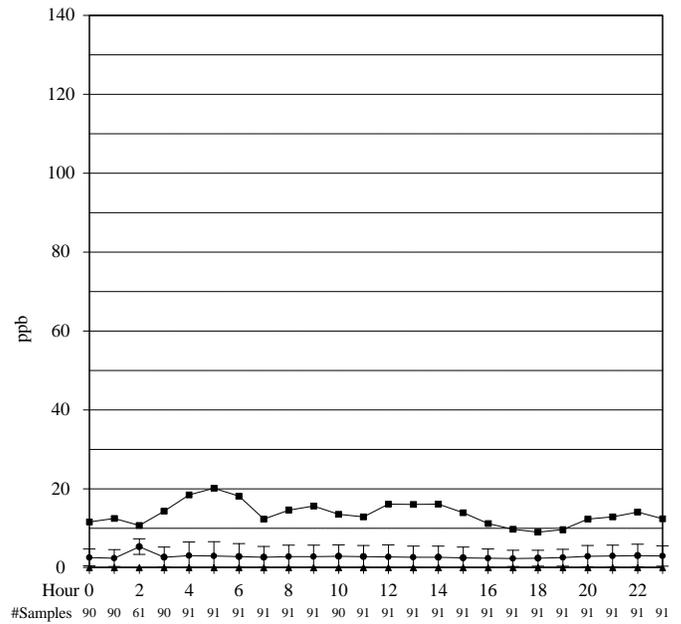
SECOND QUARTER (APR-JUN)



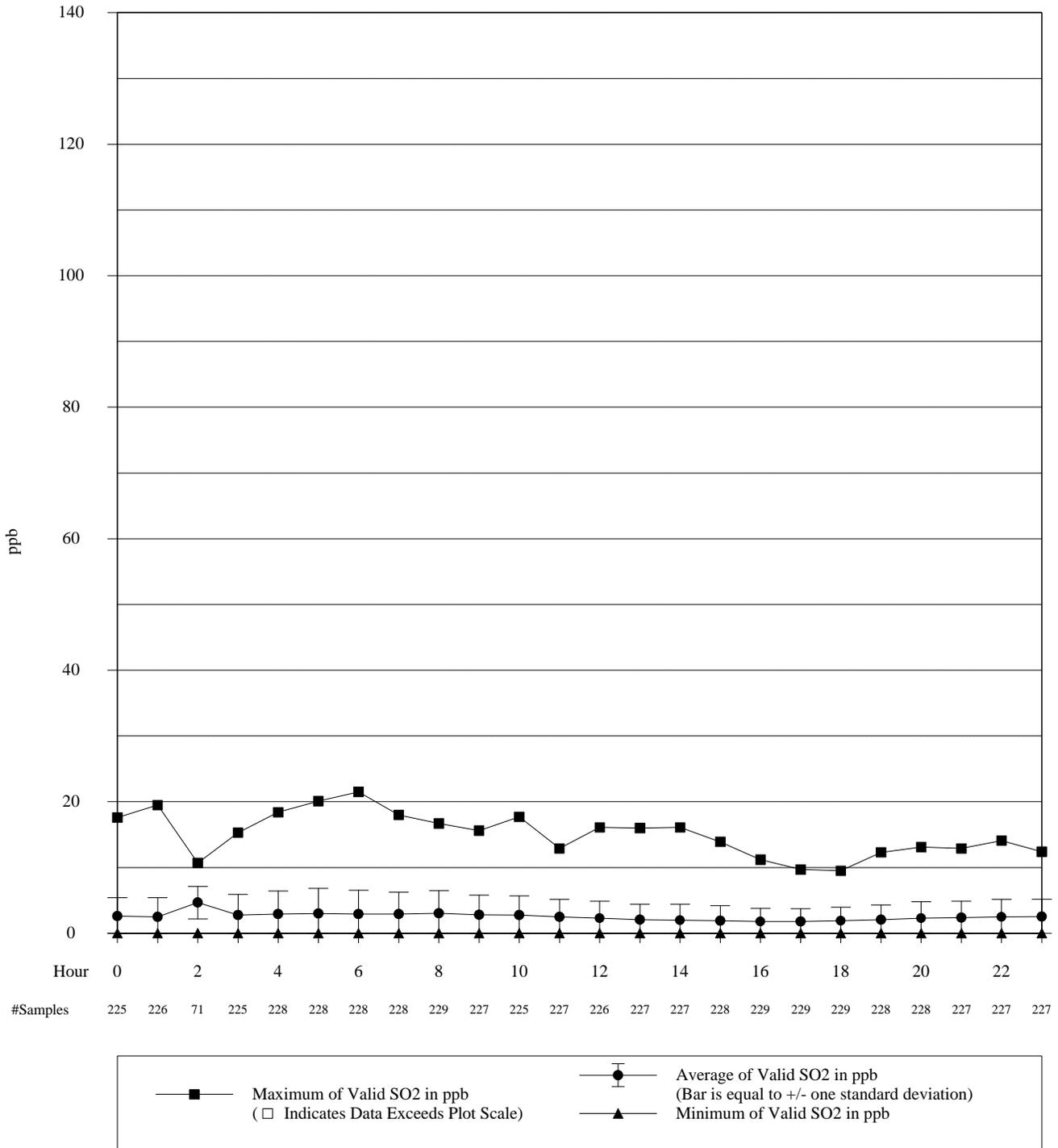
THIRD QUARTER (JUL-SEP)



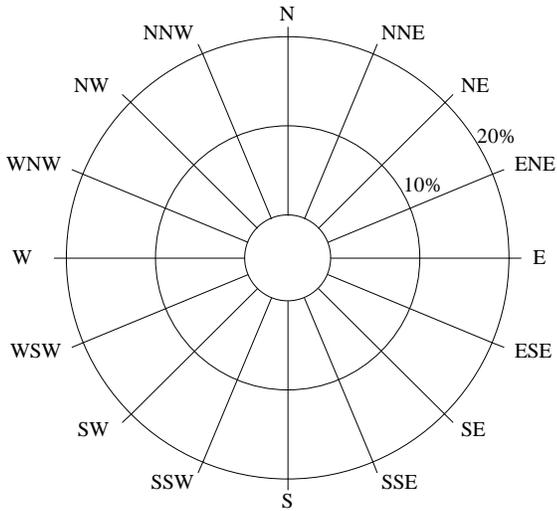
FOURTH QUARTER (OCT-DEC)



Maximum of Valid SO2 in ppb  
 Average of Valid SO2 in ppb (Bar is equal to +/- one standard deviation)  
 Minimum of Valid SO2 in ppb  
 Indicates Data Exceeds Plot Scale

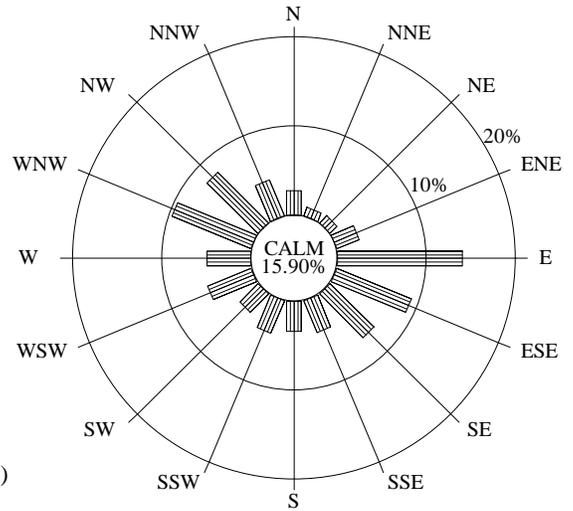


FIRST QUARTER (JAN-MAR)



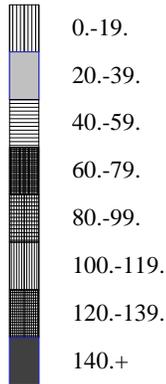
100.0% Collected 0.0% Valid  
2160 Possible /2160 Collected /0 Valid

SECOND QUARTER (APR-JUN)

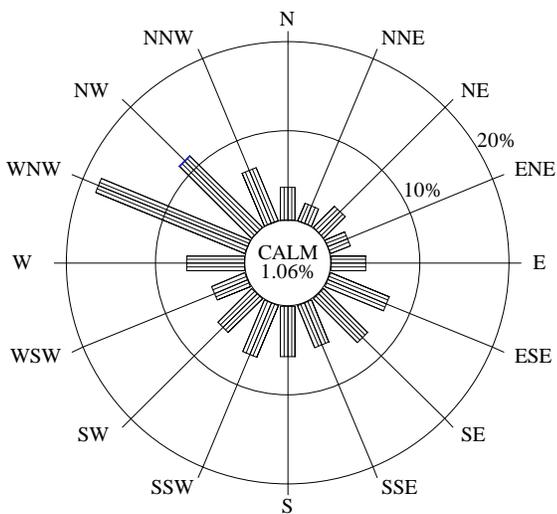


100.0% Collected 48.7% Valid  
2184 Possible /2184 Collected /1063 Valid

Sulfur Dioxide (ppb)

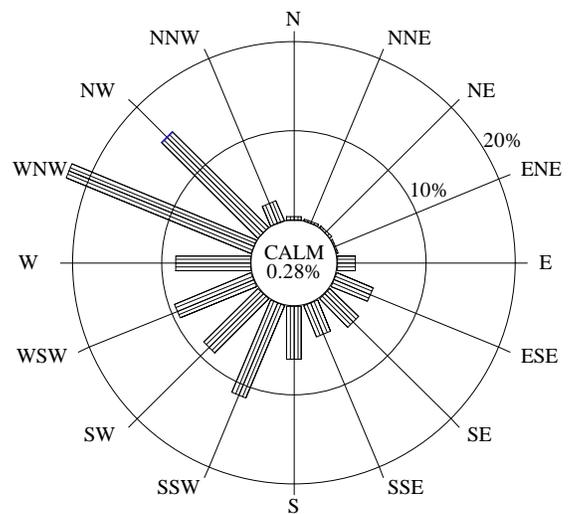


THIRD QUARTER (JUL-SEP)

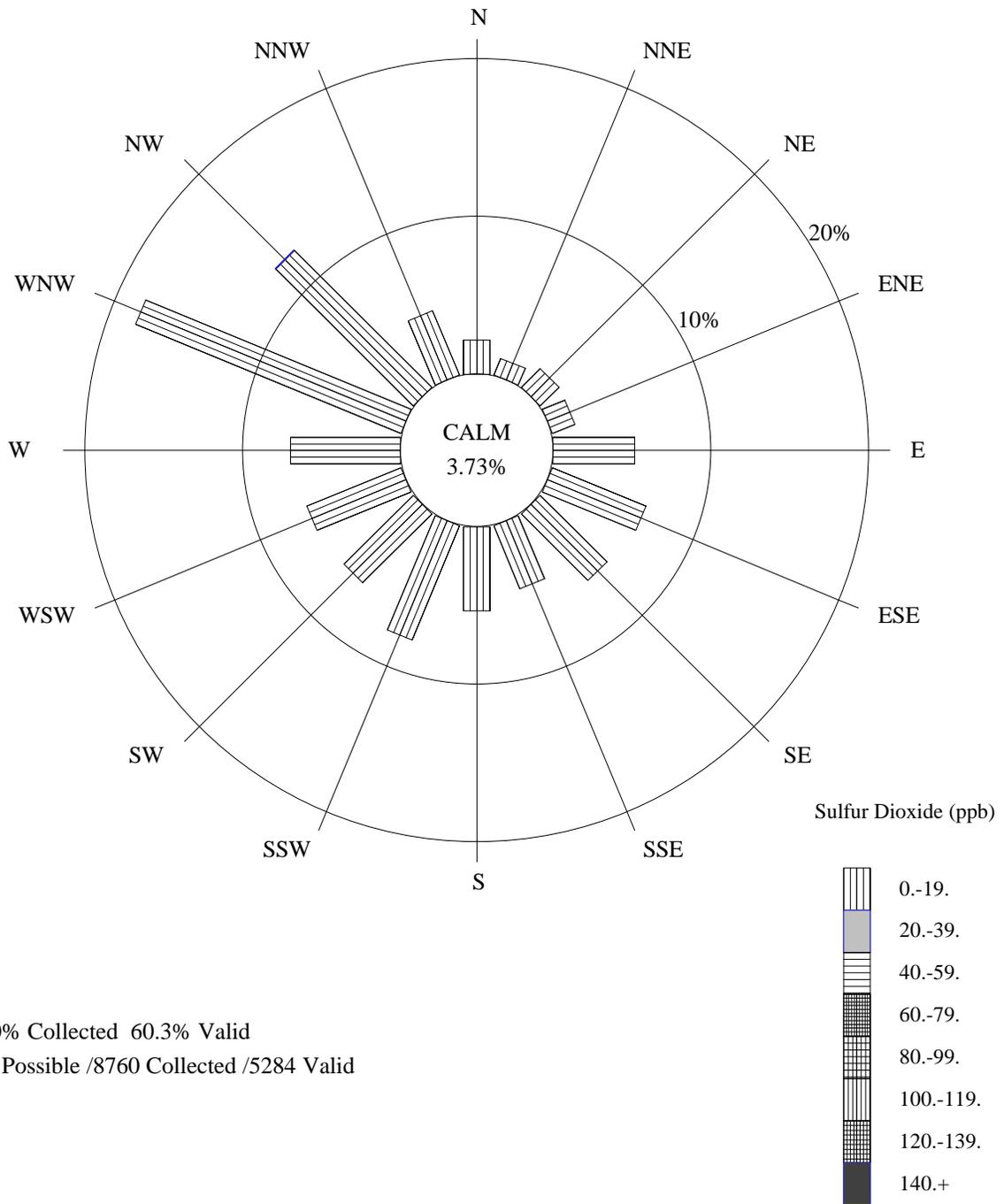


100.0% Collected 93.8% Valid  
2208 Possible /2208 Collected /2072 Valid

FOURTH QUARTER (OCT-DEC)



100.0% Collected 97.3% Valid  
2208 Possible /2208 Collected /2149 Valid



100.0% Collected 60.3% Valid  
8760 Possible /8760 Collected /5284 Valid

## **2.4 METEOROLOGICAL DATA SUMMARY**

Summary of Selected Meteorological Data

Shenandoah National Park

Big Meadows

Final Data

01/01/99 - 12/31/99

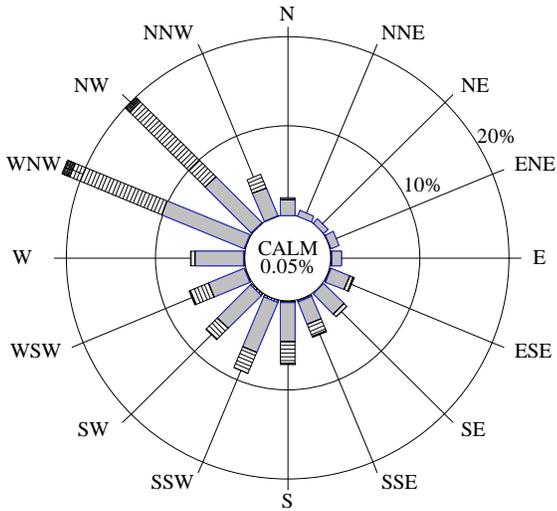
Parameter	Value	Units	Number	Std Dev
<b>SCALAR WIND SPEED</b>				
Average	2.7	m/s	8641	1.4
Maximum	9.3	m/s		
Percent calm = 2.55				
<b>AMBIENT TEMPERATURE</b>				
Average	8.5	degC	8656	9.0
Maximum	29.0	degC		
Minimum	-17.3	degC		
<b>RELATIVE HUMIDITY</b>				
Average	78	percent	7099	16
Maximum	100	percent		
Minimum	26	percent		
<b>PRECIPITATION (Rainfall or Snow melt)</b>				
Average non-zero rate	2.1	mm/hr	633	3.1
Maximum non-zero rate	24.1	mm/hr		
Minimum non-zero rate	.3	mm/hr		
Accumulated during period	1320.3	mm		
<b>SOLAR RADIATION</b>				
Average Daily Total	12,796,262	joules/m2day	365	7,227,289
Maximum Daily Total	26,896,000	joules/m2day		
Minimum Daily Total	505,600	joules/m2day		

Note: Calms are included in the average scalar wind speed and are defined as winds less than 0.5 m/s (1.0 mph).

Solar radiation terms are based on the calculation of the total amount of solar energy incident on a unit area during each day. The maximum and minimum daily totals are selected from the list of daily totals. The totals for all days are then added and divided by the number of days to yield the average daily total. Only days with 24 valid values are included in these statistics.

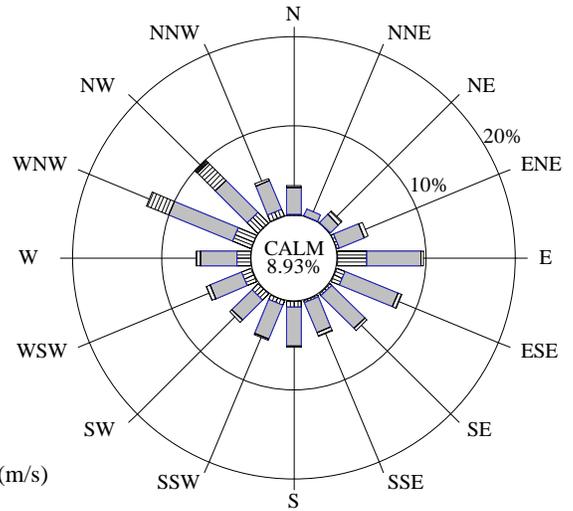
NA indicates instrument not available.

FIRST QUARTER (JAN-MAR)



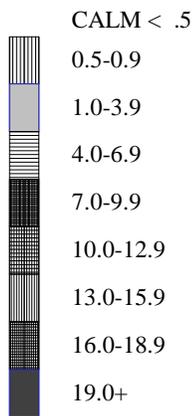
100.0% Collected 99.7% Valid  
2160 Possible /2160 Collected /2153 Valid

SECOND QUARTER (APR-JUN)

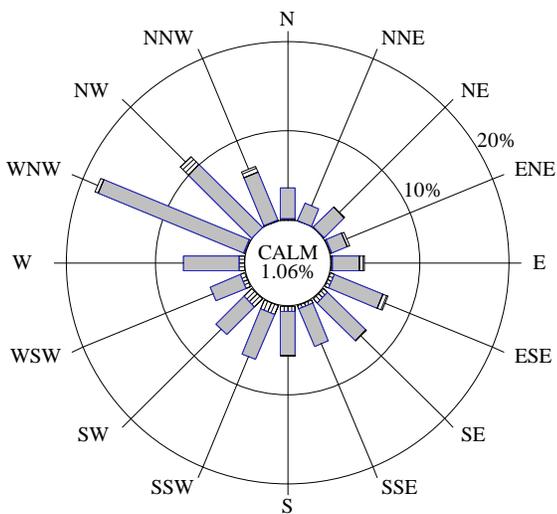


100.0% Collected 96.4% Valid  
2184 Possible /2184 Collected /2106 Valid

Scalar Wind Speed (m/s)

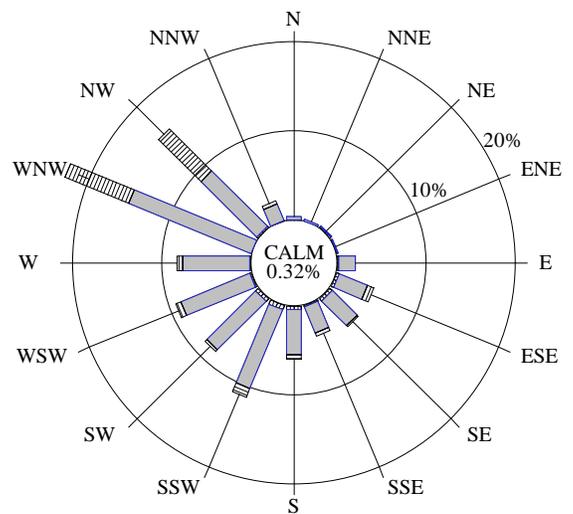


THIRD QUARTER (JUL-SEP)

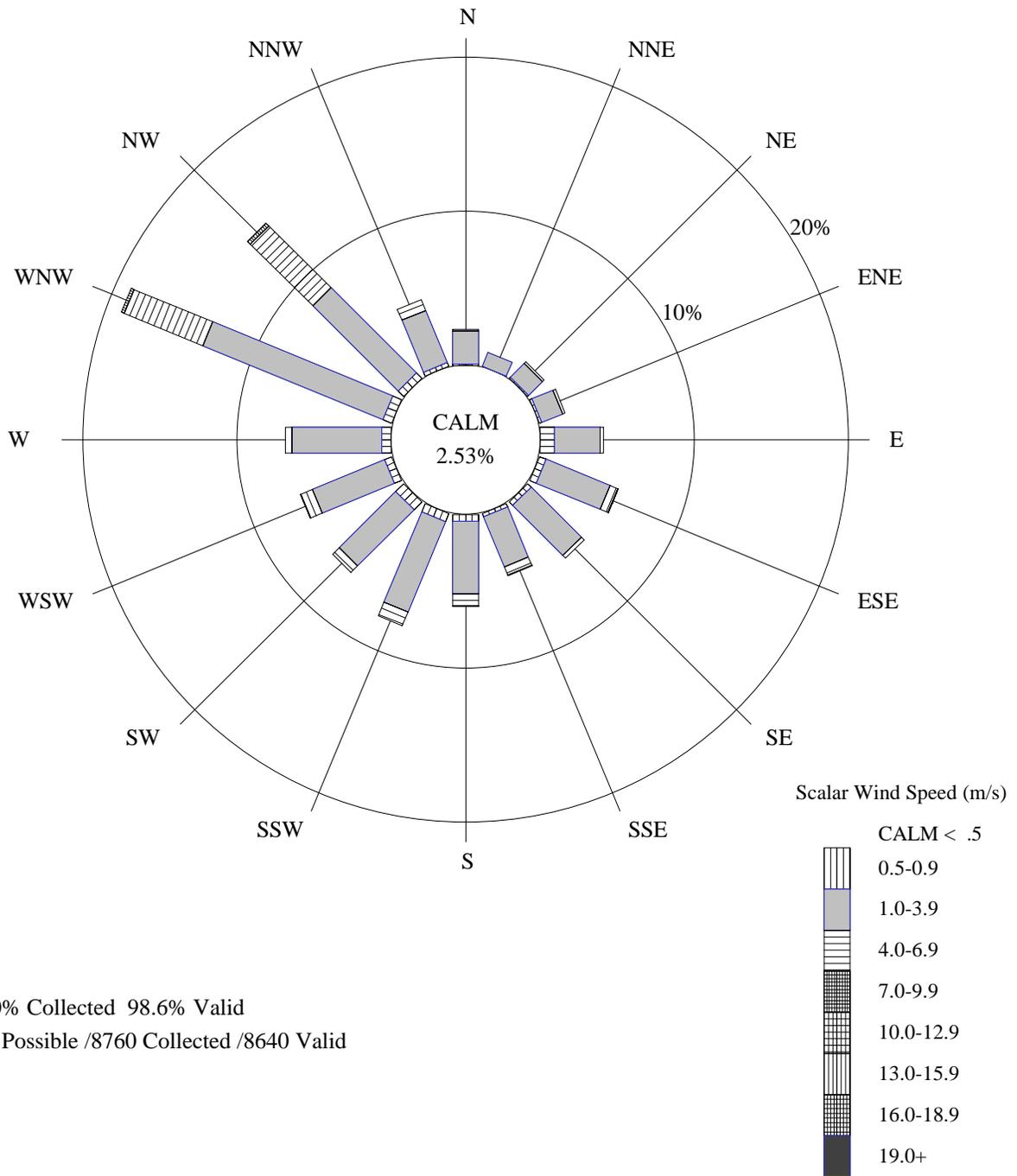


100.0% Collected 98.5% Valid  
2208 Possible /2208 Collected /2174 Valid

FOURTH QUARTER (OCT-DEC)



100.0% Collected 100.0% Valid  
2208 Possible /2208 Collected /2207 Valid



100.0% Collected 98.6% Valid  
8760 Possible /8760 Collected /8640 Valid

## 2.5 DRY DEPOSITION DATA SUMMARY

### Clean Air Status and Trends Network (CASTNet) Dry Deposition Monitoring

In 1995, the National Park Service (NPS) and the Environmental Protection Agency (EPA) entered a partnership to jointly measure dry deposition in park units, mostly in the West. A portion of the 1997, 1998, and 1999 data collected from this partnership is presented in this section.

Atmospheric deposition of acidic species takes two pathways: wet deposition and dry deposition. Wet deposition is the result of precipitation events (rain, snow, or fog) that remove particles and gases from the atmosphere. Dry deposition is less event driven, but still involves the transfer of particles and gases from the atmosphere to surfaces and plants. Wet deposition has been well documented for many years. In the national parks, the National Acidic Deposition Program (NADP) measures and reports wet deposition (see the web site at <http://nadp.sws.uiuc.edu> for further information). Dry deposition is much harder to measure and a smaller network of monitoring stations is involved. The method used to measure dry deposition is sometimes called the "inferential method" because air quality concentration data are combined with meteorological measurements and land use functions to compute deposition velocities. The CASTNet program provides long-term estimates of total acidic deposition by adding dry deposition values to wet deposition values.

This annual summary report presents the air quality concentration portion of the dry deposition inferential method, which is the only currently available data set. These data were compiled from the analyses of filters collected by CASTNet deposition filter pack systems in the parks. The filter pack analyses yielded weekly average concentrations of particulate sulfate ( $\text{SO}_4^{2-}$ ), particulate nitrate ( $\text{NO}_3^-$ ), particulate ammonium ( $\text{NH}_4^+$ ), sulfur dioxide ( $\text{SO}_2$ ), and nitric acid ( $\text{HNO}_3$ ). In some cases, the positive ions  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Mg}^{2+}$  were also measured from the filter samples. These concentration data for the individual ionic species are presented as weekly bar charts and summarized by quarter and by year in this report. Concentration data can be used to compare sites and to indicate the amount of acidic species available for deposition. As with the continuous analyzer data, the filter pack concentration data are included on a computer diskette that accompanies this report.

Estimated dry deposition values derived from EPA modeling will be reported at a later time to complete the inferential analyses. When available, these modeling results will be posted on the NPS Air Resources Division Internet web site at <http://www.aqd.nps.gov/ard1> or on the EPA CASTNet site (<http://www.epa.gov/ardpublic/acidrain/castnet/about.html>). Initial CASTNet results have shown that dry deposition can be a significant portion of total acidic deposition.

CASTNet Dry Deposition Monitoring  
 Quarterly and Annual Average Concentrations  
 Shenandoah National Park  
 01/01/1999-12/31/1999

Quarter	No. Valid Samples	p-NO <sub>3</sub> (ug/m <sup>3</sup> )	HNO <sub>3</sub> (ug/m <sup>3</sup> )	Total NO <sub>3</sub> (ug/m <sup>3</sup> )	NH <sub>4</sub> (ug/m <sup>3</sup> )	p-SO <sub>4</sub> (ug/m <sup>3</sup> )	SO <sub>2</sub> (ug/m <sup>3</sup> )	SO <sub>4</sub> /SO <sub>2</sub> Ratio
1	13	0.862	2.373	3.197	1.050	2.544	9.374	0.271
2	13	0.541	3.395	3.882	1.542	4.837	4.957	0.976
3	13	0.189	3.525	3.658	2.146	8.144	6.356	1.281
4	13	0.868	2.261	3.092	0.921	2.479	7.325	0.338
Annual Average		0.615	2.888	3.458	1.415	4.501	7.003	0.643
Standard Deviation		0.564	1.014	1.010	0.705	3.107	3.584	

Data Recovery Table			
Total No. Filters	No. Invalidated	Data Capture	No. Valid Hours
52	0	100.0%	8605.0

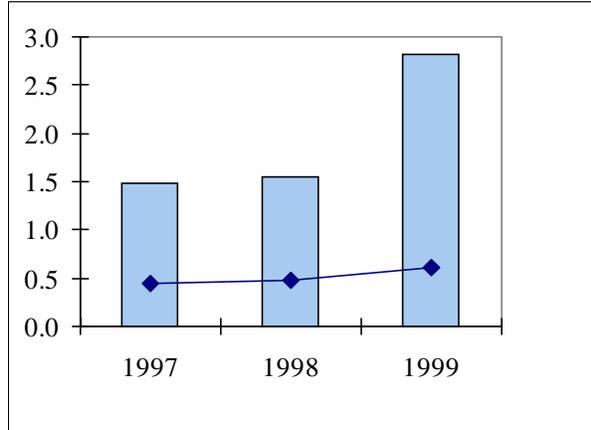
CASTNet Dry Deposition Monitoring Weekly Concentrations Report  
 Shenandoah National Park  
 01/01/1999 - 12/31/1999

On Date	Off Date	p-NO <sub>3</sub> (ug/m <sup>3</sup> )	HNO <sub>3</sub> (ug/m <sup>3</sup> )	Total NO <sub>3</sub> (ug/m <sup>3</sup> )	NH <sub>4</sub> (ug/m <sup>3</sup> )	p-SO <sub>4</sub> (ug/m <sup>3</sup> )	SO <sub>2</sub> (ug/m <sup>3</sup> )	SO <sub>4</sub> /SO <sub>2</sub> Ratio
12/29/98	01/05/99	0.766	1.071	1.820	0.944	2.001	7.409	0.270
01/05/99	01/12/99	0.325	2.193	2.483	0.778	1.918	8.966	0.214
01/12/99	01/19/99	0.500	1.811	2.282	0.724	1.754	5.627	0.312
01/19/99	01/26/99	0.149	2.207	2.321	0.942	2.921	4.486	0.651
01/26/99	02/02/99	0.847	2.089	2.902	0.849	2.074	5.860	0.354
02/02/99	02/09/99	0.866	2.441	3.268	1.209	2.560	6.212	0.412
02/09/99	02/16/99	0.479	2.409	2.850	0.781	2.243	7.486	0.300
02/16/99	02/23/99	0.916	3.171	4.037	1.470	3.782	16.115	0.235
02/23/99	03/02/99	1.216	3.893	5.048	1.609	3.831	10.064	0.381
03/02/99	03/09/99	0.767	1.749	2.488	0.818	1.678	8.415	0.199
03/09/99	03/16/99	0.556	2.947	3.456	0.867	2.471	22.165	0.111
03/16/99	03/23/99	1.006	1.916	2.892	0.944	2.680	6.785	0.395
03/23/99	03/30/99	2.819	2.946	5.718	1.721	3.154	12.272	0.257
03/30/99	04/06/99	0.096	5.322	5.334	1.911	6.307	5.611	1.124
04/06/99	04/13/99	0.788	2.527	3.275	0.974	2.822	4.606	0.613
04/13/99	04/20/99	0.472	2.336	2.770	0.923	2.526	7.099	0.356
04/20/99	04/27/99	0.335	3.512	3.791	1.362	3.901	7.564	0.516
04/27/99	05/04/99	1.548	3.257	4.754	0.775	1.828	4.360	0.419
05/04/99	05/11/99	0.432	3.826	4.197	1.934	5.778	4.961	1.165
05/11/99	05/18/99	1.192	4.021	5.149	1.398	5.591	4.748	1.178
05/18/99	05/25/99	0.314	2.260	2.539	1.510	4.567	3.432	1.331
05/25/99	06/01/99	0.783	3.942	4.662	1.831	5.183	8.589	0.603
06/01/99	06/08/99	0.573	3.394	3.914	2.322	7.576	4.939	1.534
06/08/99	06/15/99	0.112	3.952	4.001	2.061	7.209	4.457	1.618
06/15/99	06/22/99	0.163	2.914	3.031	1.468	4.323	2.267	1.907
06/22/99	06/29/99	0.227	2.874	3.055	1.576	5.273	1.808	2.916
06/29/99	07/06/99	0.374	2.853	3.181	2.480	9.226	3.490	2.643
07/06/99	07/13/99	0.094	3.168	3.212	2.246	7.421	5.879	1.262
07/13/99	07/20/99	0.119	4.157	4.210	2.325	11.589	5.034	2.302
07/20/99	07/27/99	0.121	4.337	4.389	3.006	11.565	10.168	1.137
07/27/99	08/03/99	0.135	4.532	4.595	2.819	9.929	12.161	0.816
08/03/99	08/10/99	0.087	4.517	4.533	2.364	7.389	8.414	0.878
08/10/99	08/17/99	0.095	4.523	4.546	2.867	12.970	8.450	1.535
08/17/99	08/24/99	0.060	4.244	4.236	2.400	10.721	7.614	1.408
08/24/99	08/31/99	0.114	3.613	3.670	2.305	9.183	5.433	1.690
08/31/99	09/07/99	0.075	2.140	2.181	0.205	0.415	2.498	0.166
09/07/99	09/14/99	0.479	2.956	3.387	2.021	6.470	4.629	1.398
09/14/99	09/21/99	0.126	2.671	2.755	1.655	5.275	4.350	1.213
09/21/99	09/28/99	0.583	2.110	2.660	1.209	3.723	4.502	0.827
09/28/99	10/05/99	0.081	1.928	1.979	0.259	0.671	3.449	0.195
10/05/99	10/12/99	0.077	3.726	3.744	1.468	4.605	5.699	0.808
10/12/99	10/19/99	0.574	2.095	2.636	0.819	2.585	5.860	0.441
10/19/99	10/26/99	0.586	3.125	3.661	0.995	2.561	10.660	0.240
10/26/99	11/02/99	1.492	3.955	5.384	1.301	3.576	8.572	0.417
11/02/99	11/09/99	1.091	2.202	3.258	0.835	2.179	10.431	0.209
11/09/99	11/16/99	1.764	2.703	4.424	1.912	5.550	7.657	0.725
11/16/99	11/23/99	1.456	1.747	3.175	0.868	2.161	6.518	0.332
11/23/99	11/30/99	1.176	0.955	2.116	0.725	1.667	4.534	0.368
11/30/99	12/07/99	0.809	1.416	2.202	0.557	1.609	5.468	0.294
12/07/99	12/14/99	0.250	1.456	1.683	0.541	1.456	5.445	0.267
12/14/99	12/21/99	0.305	2.604	2.868	0.529	1.563	8.254	0.189
12/21/99	12/28/99	1.622	1.474	3.073	1.169	2.041	12.681	0.161

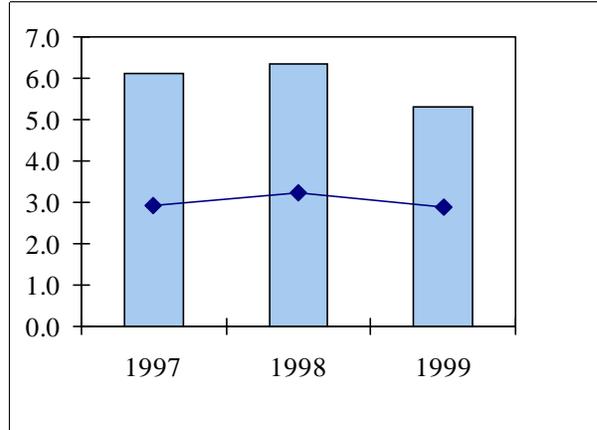
Shenandoah National Park

CASTNet Dry Deposition Monitoring  
Three Year Comparison of Maximum and Average Concentrations

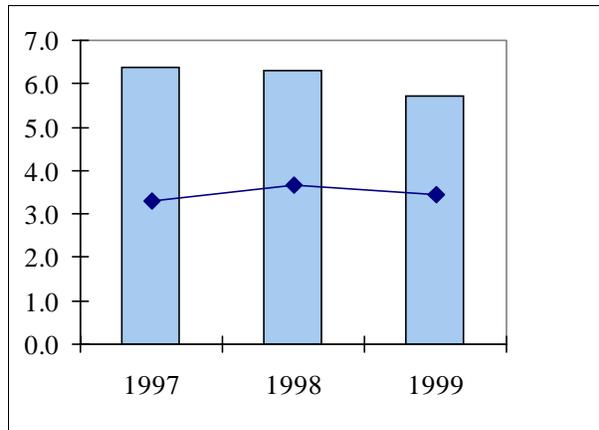
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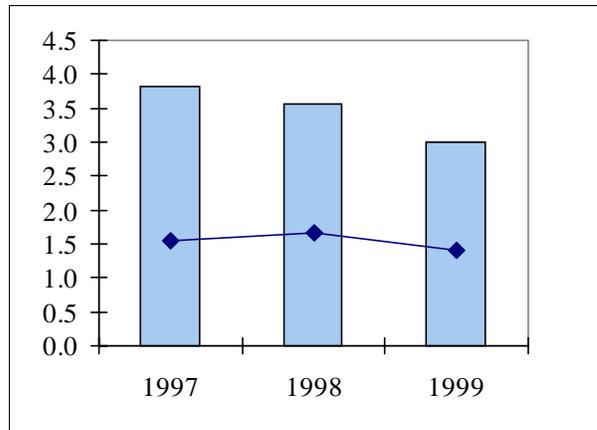
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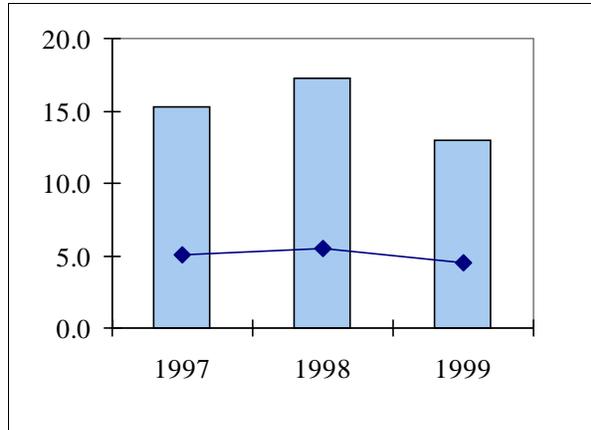
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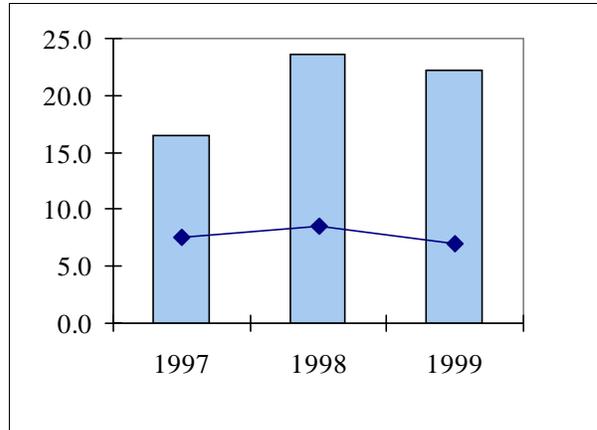
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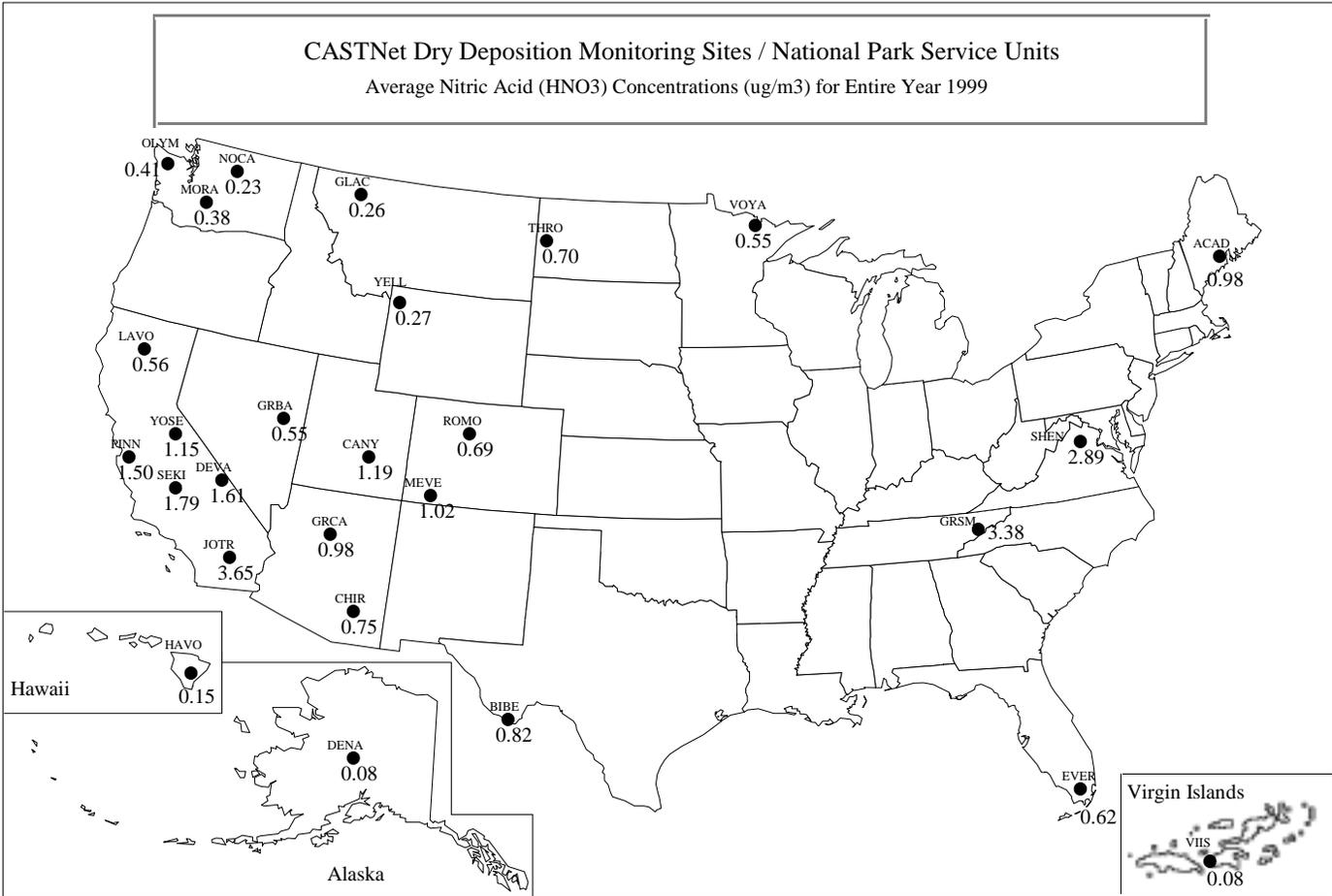
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SO<sub>2</sub>

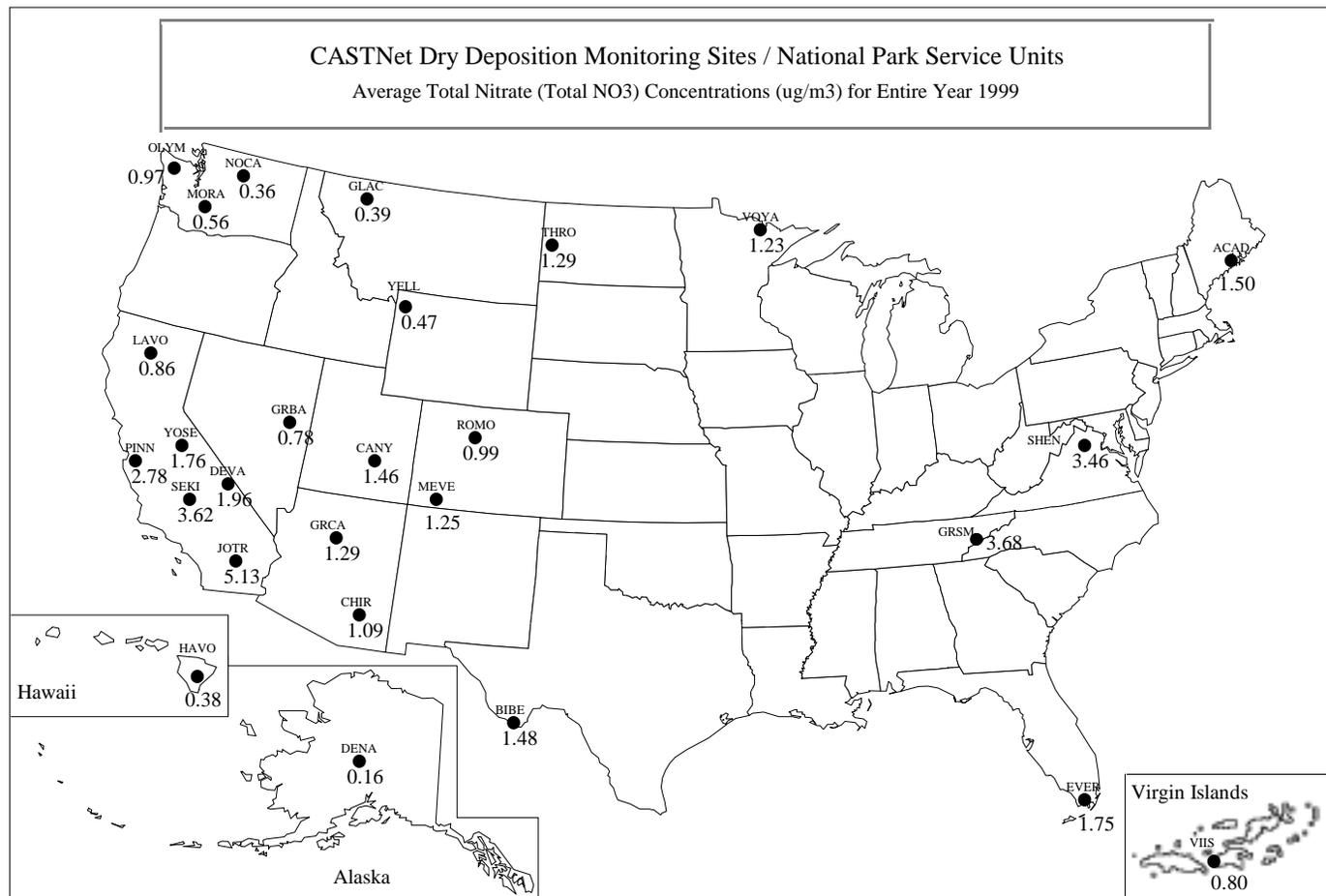






### Key:

ACAD	Acadia NP
BIBE	Big Bend NP
CANY	Canyonlands NP
CHIR	Chiricahua NM
DENA	Denali NP
DEVA	Death Valley NP
EVER	Everglades NP
GLAC	Glacier NP
GRBA	Great Basin NP
GRCA	Grand Canyon NP
GRSM	Great Smokies NP
JOTR	Joshua Tree NP
LAVO	Lassen Volcanic NP
MEVE	Mesa Verde NP
MORA	Mount Rainier NP
NOCA	North Cascades NP
OLYM	Olympic NP
PINN	Pinnacles NP
ROMO	Rocky Mountain NP
SEKI	Sequoia NP
SHEN	Shenandoah NP
THRO	Th. Roosevelt NP
VIIS	Virgin Islands NP
VOYA	Voyageurs NP
YELL	Yellowstone NP
YOSE	Yosemite NP



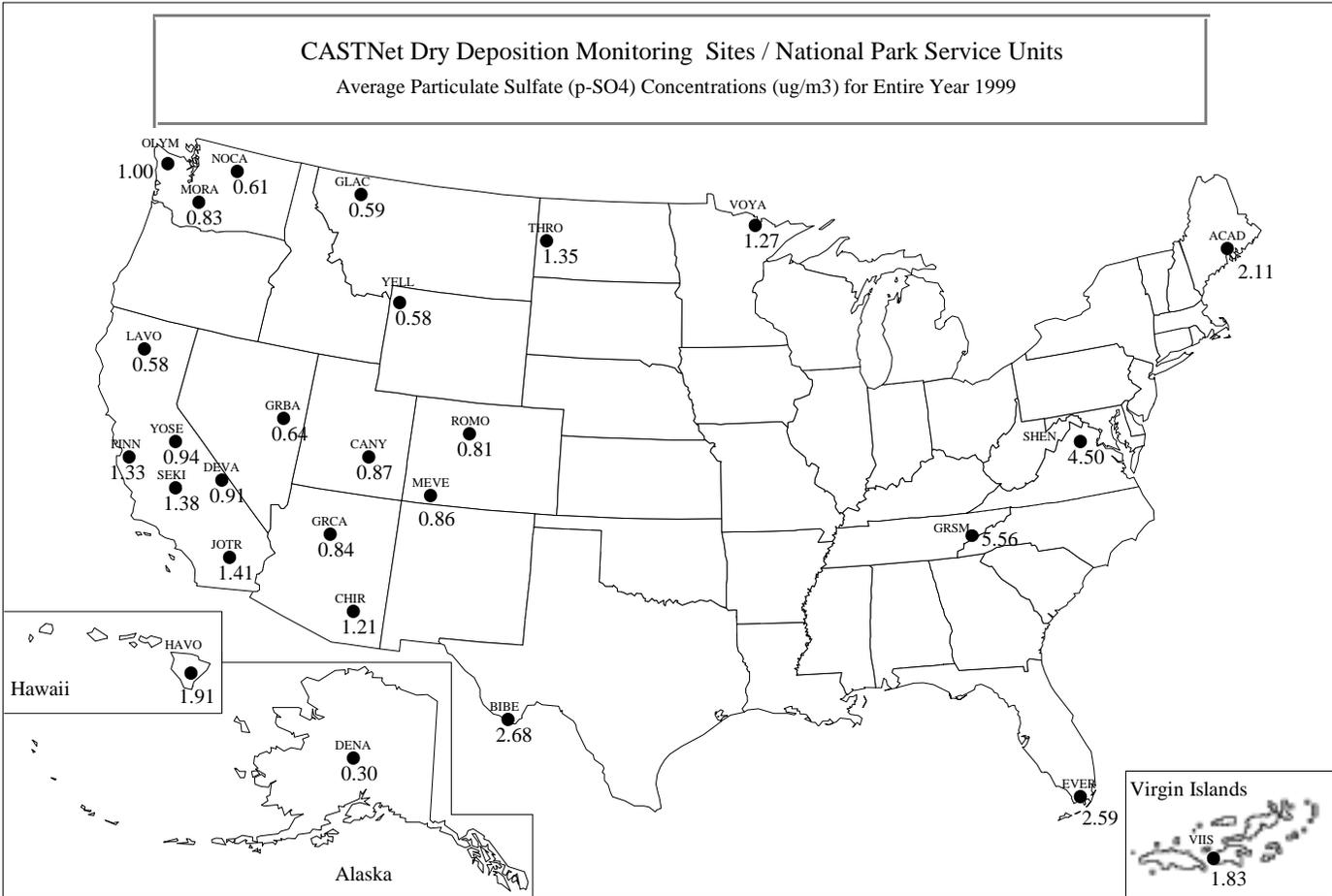
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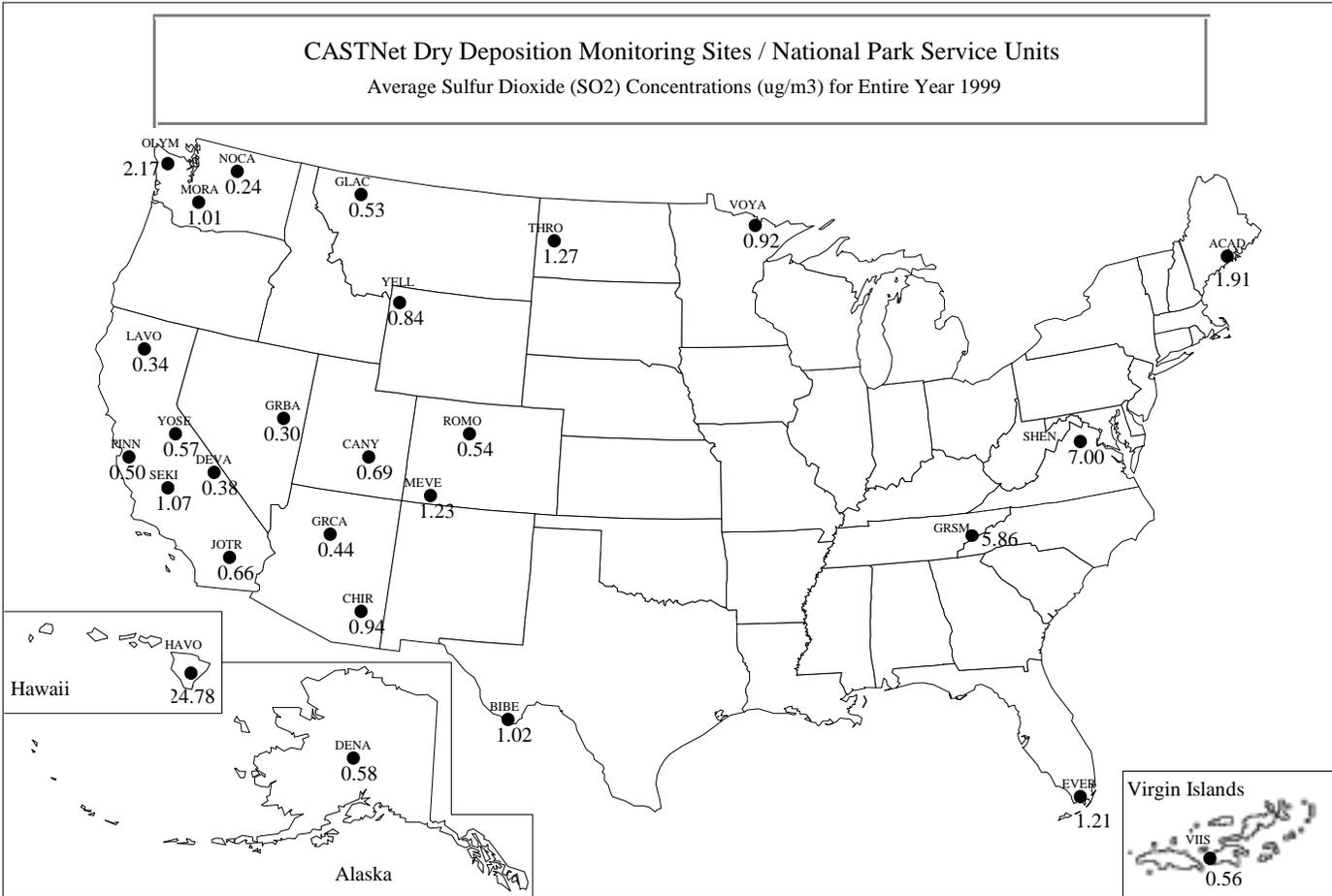
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- JOTR Joshua Tree NP
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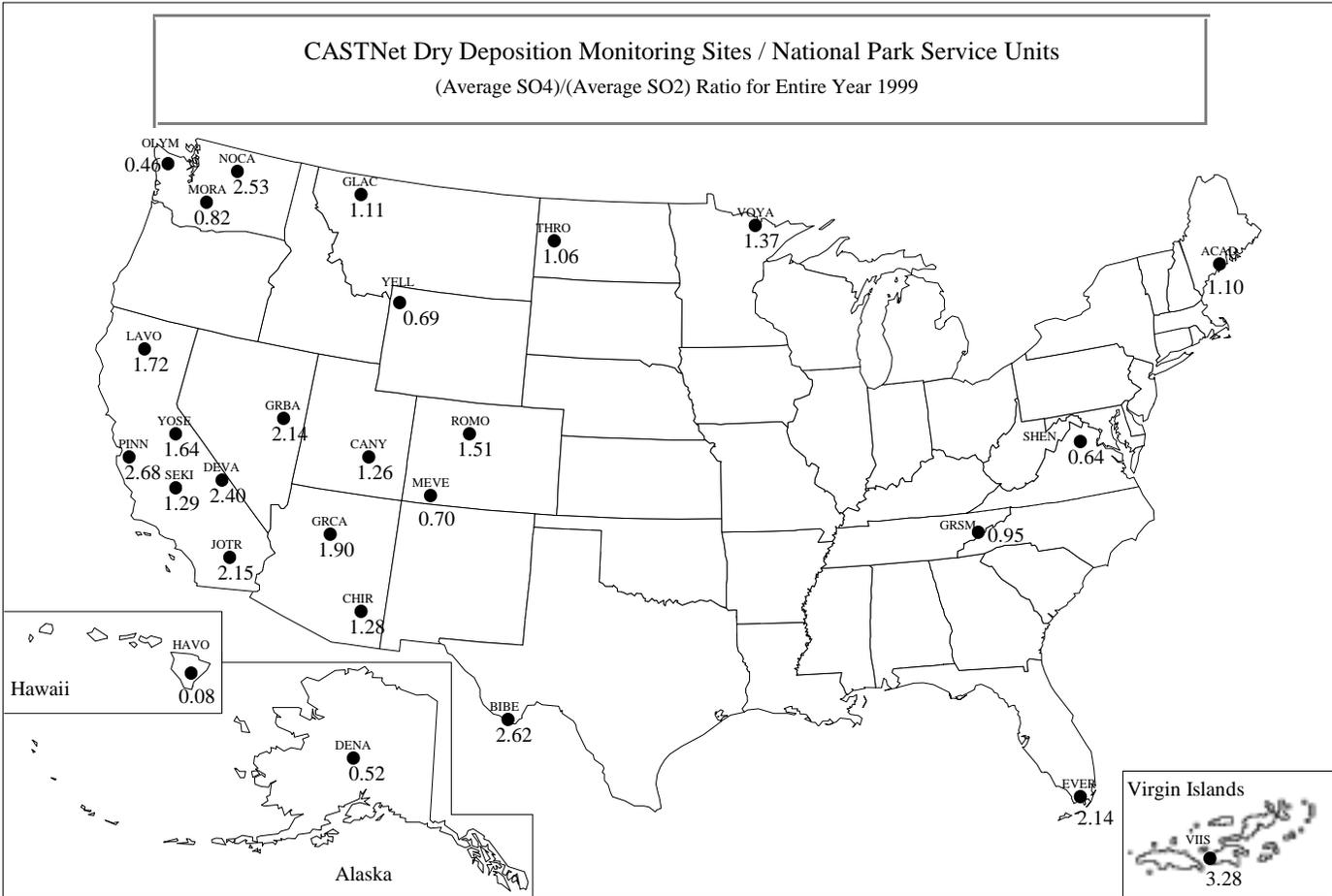
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### **3.0 NATIONAL PARK SERVICE AIR RESOURCES DIVISION DATA SOURCES**

#### **3.1 GUIDE TO ATTACHED DATA DISKS**

Data disks containing ASCII files of the validated hourly data, as shown in the following table are available. Please return the enclosed postcard or contact the address below. These data may be imported into other programs to perform additional data processing and analysis. The data format of each file is included within each file. The second table describes the validation codes used in the data tables to indicate why data are missing or invalid. Wind and pollutant frequency distribution tables in ASCII format are also included on the diskette if available for this site.

Data users should acknowledge the National Park Service Air Resources Division whenever using these data or any portion of this report.

#### **3.2 OTHER SOURCES FOR RETRIEVING NATIONAL PARK SERVICE GASEOUS POLLUTANT DATA**

The data contained in this report may also be obtained from the following sources:

- National Park Service AIRWeb (<http://www.aqd.nps.gov/natnet/ard>) - available after last quarter 1997
- EPA AIRS database
- Data requests directed to:

NPS Air Resources Division  
Information Management Center  
c/o Air Resource Specialists, Inc.  
1901 Sharp Point Drive, Suite E  
Fort Collins, Colorado 80525  
Telephone: (970) 484-7941  
Fax: (970) 484-3423  
E-Mail: AIR-IMC@AIR-RESOURCE.COM

<b>Data Disk Contents Summary</b>	
File Name (s)	Description
<b>Hourly</b>	
ssssyy.DAT	All Validated Air Quality Data
ssssyymm.ppp	Monthly Data Summary Tables
ssssAN95.Rpp	Annual Wind and Pollutant Frequency Distribution
ssssQ195.Rpp	Quarter 1 Wind and Pollutant Frequency Distribution
ssssQ295.Rpp	Quarter 2 Wind and Pollutant Frequency Distribution
ssssQ395.Rpp	Quarter 3 Wind and Pollutant Frequency Distribution
ssssQ495.Rpp	Quarter 4 Wind and Pollutant Frequency Distribution
Where: ssss = site code yy = year mm = month ppp = air quality data parameter code AN = Annual Qn = Quarter 1-4 R = Wind Frequency distribution table	
<b>CASTNet Weekly Species Summary Data</b>	
File Name (s)	Description
<b>CASTNet</b>	
ssssCNyr.ASC	Weekly averages
Where: ssss = site code CN = CASTNet yr = year asc = ascii file	

<b>NPS IMC and AIRS Invalid Data Codes</b>			
<b>NPS IMC VAL CODE</b>	<b>REASON</b>	<b>AIRS CODE</b>	<b>AIRS REASON</b>
TO	Sample time out of limits	9973	Sample time out of limits
IW	Instrument warmup	9978	Voided by operator
OE	Operator error	9978	
BM	Begin monitoring	9979	Miscellaneous void
TL	Station temp low	9979	
OS	Off scale	9979	
EM	End monitoring	9979	
LI	Local interference	9979	
TH	Station temp high	9979	
IM	Instrument malfunction	9980	Machine malfunction
IN	Interference	9981	Bad weather
RF	Recording system failure	9983	Collection error
NA	No data	9987	Monitoring waived
PF	Power failure	9988	Power Failure
PC	Precision check	9990	Precision Check
ZS	Instrument zero/span check	9991	QC Control Points (Zero/Span)
SA	System audit	9992	QC Audit
PA	Performance audit	9992	
MT	Maintenance	9993	Maintenance/Routine Repairs
OR	Out for repair	9993	
CA	Calibration	9995	Multipoint calibration
SC	Station check	9998	Precision/zero/span

## 4.0 GLOSSARY

### 4.1 DEFINITIONS AND COMPUTATIONAL PROCEDURES FOR NATIONAL PARK SERVICE QUICK LOOK ANNUAL SUMMARY STATISTICS REPORT

The National Park Service Quick Look Annual Summary Statistics Table (Page 2-8) provides ozone summary statistics for various indices computed on a monthly basis for an entire year. Growing season (generically defined to be May 1 - September 30) and annual statistics are also presented under the "MAY-SEP" and "ANNUAL" columns, respectively. All concentrations are expressed in the units of parts per billion (PPB) and exposures in parts per billion-hours (PPB-HR). The definitions for each of the statistics appearing on the Quick Look Annual Summary Table are given below.

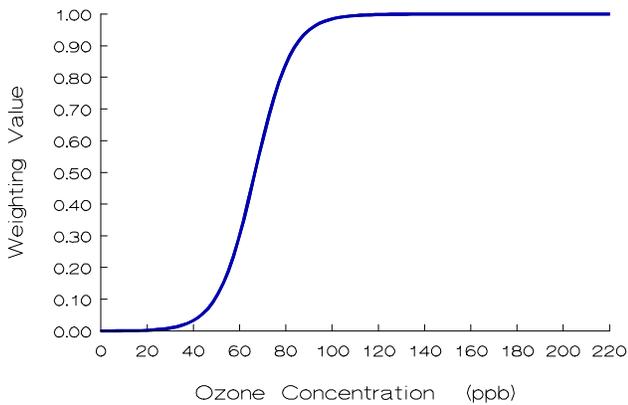
- (1) **Daily 1-Hr Maximum.** The maximum 1-hour average concentration recorded during each month, the growing season or the year regardless of the number of valid hourly observations recorded during a given day. The number in parentheses below this statistic, (N), indicates the number of days in the month, growing season, or year with valid data.
- (2) **Average Daily Maximum.** The average of all Daily 1-Hr Maxima during the month regardless of the number of Daily 1-Hr Maxima recorded during the month. For the "MAY-SEP" column the average of all the Daily Maxima recorded during the growing season is given. For the "ANNUAL" column the average of all the Daily Maxima is given. N is as in (1) above.
- (3) **Maximum Daily Mean.** The maximum of the valid daily means computed for each month, the growing season ("MAY-SEP" column), and the year ("ANNUAL" column). A valid daily mean is one for which 75% of the observations are available for each day, i.e., 18 hours. N is the number of days during each month, growing season, and year with at least 18 observations.
- (4) **Average Daily Mean.** The average of all valid daily means for the month, the growing season ("MAY-SEP" column), and the year ("ANNUAL" column). N is as in (3) above.
- (5) **Max Peak:Min Ratio.** The ratio of the Daily 1-Hr Maximum to the Daily 1-Hr Minimum. A ratio is computed only if a valid Daily Mean is computed and if the Daily 1-Hr Minimum is not equal to zero. N is the number of days with a valid Peak:Min ratio.
- (6) **Average Peak:Min Ratio.** The average of all Peak:Min ratios for the month, growing season, or year. N is as in (5) above.
- (7) **Max 9AM-4PM Average.** The maximum of all valid 9AM-4PM Averages computed for the month, growing season, or year. A valid 9AM-4PM Average is one which has 75% of the observations available during that time period (i.e., 6 hours. N is the number of days with valid averages.)

- (8) **Monthly 9AM-4PM Average.** The average of all valid 9AM-4PM Averages for the month, growing season, or year. N is as in (7) above.
- (9) **Max 7AM-7PM Average.** The maximum of all valid 7AM-7PM Averages computed for the month, growing season, or year. A valid 7AM-7PM Average is one which has 75% of the observations available during that time period, i.e., 9 hours. N is the number of days with valid averages.
- (10) **Monthly 7AM-7PM Average.** The average of all valid 7AM-7PM averages for the month, growing season, or year. N is as in (9) above.
- (11) **Monthly Mean.** The average of all 1-Hr ozone concentrations recorded during the month, growing season, or year. A mean is computed regardless of the number of hours with valid data. N is the number of hours with valid observations.
- (12) **SUM0 Exposure Index.** The monthly sum of all hourly ozone concentrations. Units are PPB-HR. The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to give the cumulative exposure for the year. N is the number of hours with valid observations and is the same N as in (11) above.
- (13) **SUM60 Exposure Index.** The monthly sum of all hourly ozone concentrations equaling or exceeding 60 PPB. Units are PPB-HR. The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to give the cumulative exposure for the year. N is the number of hours equaling or exceeding 60 PPB during the month, growing season, or year.
- (14) **SUM80 Exposure Index.** The monthly sum of all hourly ozone concentrations equaling or exceeding 80 PPB. Units are PPB-HR. The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to give the cumulative exposure for the year. N is the number of hours equaling or exceeding 80 PPB during the month, growing season, or year.
- (15) **W126 Exposure Index.** The monthly sum of all hourly ozone concentrations where each concentration is weighted by a function that gives greater emphasis to the higher hourly concentrations while still including the lower ones. This weighting function provides a weighting value that is unique for each hourly ozone concentration. The weighting function, as described by Lefohn, Laurence, and Kohut<sup>1</sup> is:

$$w_i = \frac{1}{1 + 4403 \exp(-.126c_i)}$$

where

Weighting Function Used To Calculate W126 Exposure Index



$w_i$  = weighting value for hourly concentration  $i$ ,  
and  
 $c_i$  = hourly concentration  $i$  in PPB.

The graph of weighting value versus ozone concentration, in the figure to the left, illustrates the greater weights given to higher hourly ozone concentrations.

Each hour's weighting value is multiplied by its corresponding hourly concentration. This product is summed over all the valid hours in each month to calculate the monthly W126 exposure.

Thus, the monthly W126 exposure is:

$$W126 = \sum_{i=1}^n w_i c_i$$

where

- W126 = monthly W126 exposure index,
- $w_i$  = weighting value for hourly concentration  $i$ ,
- $c_i$  = hourly concentration  $i$  in PPB, and
- $n$  = number of hours in the month with valid ozone concentrations.

The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to give the cumulative exposure for the year. The exposure units are PPB-HR.

Because each hour contributes to this exposure index,  $N$  is the number of hours with valid observations and is the same  $N$  as in (11) and (12) above.

The U.S. Environmental Protection Agency usually considers air quality statistics, such as a mean, to be "valid" (i.e., representative of the parameter being estimated for the time interval in question) only if 75% or more of the total possible observations have been measured during that time interval. Therefore, one should exercise caution when comparing these statistics between months and sites, particularly those that are not averages (e.g., maxima and exposures) whenever the number of valid observations is less than 75% of the total possible.

## References

1. Lefohn, A.S., J. A. Laurence, and R. J. Kohut. 1988. A Comparison of Indices That Describe the Relationship Between Exposure to Ozone and Reduction in the Yield of Agricultural Crops. *Atmospheric Environment* 22, 1229-1240.

## 4.2 AIR QUALITY GLOSSARY

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**Acid Deposition:** Air pollution produced when acid chemicals are incorporated into rain, snow, fog, or mist.

**Aerometric Information Retrieval System (AIRS):** A computer-based database of U.S. air pollution information administered by the EPA Office of Air Quality Planning and Standards (U.S. Environmental Protection Agency).

**AIRWeb:** Air Resources Web, an air quality information retrieval system for U.S. parks and wildlife refuges developed by the Air Resources Division of the National Park Service and the Air Quality Branch of the Fish and Wildlife Service.

**Air Pollutant:** An unwanted chemical or other material found in the air.

**Air Pollution:** Degradation of air quality resulting from unwanted chemicals or other materials occurring in the air.

**Air Quality:** The properties and degree of purity of air to which people and natural and heritage resources are exposed (in the context of national parks).

**Air Pollution Control Permitting Process:** Process by which facilities are permitted to emit specified types and quantities of air pollutants.

**Air Quality Related Values (AQRVs):** Values including visibility, flora, fauna, cultural and historical resources, odor, soil, water, and virtually all resources that are dependent upon and affected by air quality. "These values include visibility and those scenic, cultural, biological, and recreation resources of an area that are affected by air quality." (43 Fed. Reg. 15016)

**Ambient Air:** Air that is accessible to the public.

**Class I:** Areas of the country set aside under the Clean Air Act to receive the most stringent degree of air quality protection.

**Class II:** Areas of the country protected under the Clean Air Act but identified for somewhat less stringent protection from air pollution damage than Class I, except in specified cases.

**Clean Air Act:** Originally passed in 1963, our current national air pollution control program is based on the 1970 version of the law. Substantial revisions were made by the 1990 Clean Air Act Amendments.

**Continuous Sampling Device:** An air analyzer that measures air quality components continuously.

**Criteria:** Information on health and/or environmental effects of pollution (in the context of criteria air pollutants).

**Criteria Air Pollutant:** A group of very common air pollutants regulated by EPA on the basis of criteria and for which a National Ambient Air Quality Standard is established (SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub>, Pb, CO, O<sub>3</sub>).

**Emissions:** Release of pollutants into the air from a source.

**Environmental Protection Agency (EPA):** The federal agency responsible for regulating air quality.

**Monitoring:** Measurement of air pollution.

**National Ambient Air Quality Standards (NAAQS):** Permissible levels of criteria air pollutant established to protect public health and welfare.

**Ozone (O<sub>3</sub>):** A criteria air pollutant that is a strong oxidizing agent, reactive with many other compounds and surfaces, and a health hazard in high concentrations. Ozone is formed by nitrogen oxides and organic compounds reacting in sunlight.

**Source:** Any place or object from which air pollutants are released. Sources that are fixed in space are stationary sources; sources that move are mobile sources.

**Sulfur Dioxide (SO<sub>2</sub>):** A criteria air pollutant that is a gas produced by burning coal and some industrial processes.

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\* Recent updates to this glossary may be found on the NPSARD AIRWeb - <http://www.aqd.nps.gov/natnet/ard/glossary.htm>.

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### 4.3 GLOSSARY OF AIR QUALITY UNITS

Units Conversion Table			
Parameter Type	Multiply	By	To Obtain
Pollutant	ppm	1000	ppb
	ppm	1960	$\mu\text{g}/\text{m}^3$ Ozone (at 25°C)
	ppm	2615	$\mu\text{g}/\text{m}^3$ Sulfur Dioxide (at 25°C)
	ppb	0.001	ppm
	ppb	1.960	$\mu\text{g}/\text{m}^3$ Ozone (at 25°C)
	ppb	2.615	$\mu\text{g}/\text{m}^3$ Sulfur Dioxide (at 25°C)
	$\mu\text{g}/\text{m}^3$ Ozone (25°C)	0.0005102	ppm
	$\mu\text{g}/\text{m}^3$ Ozone (25°C)	0.5102	ppb
	$\mu\text{g}/\text{m}^3$ Sulfur Dioxide (25°C)	0.0003824	ppm
	$\mu\text{g}/\text{m}^3$ Sulfur Dioxide (25°C)	0.3824	ppb
Wind Speed	m/s	2.05	mph
	mph	0.489	m/s
Solar Radiation	ly/min	697	$\text{w}/\text{m}^2$
	$\text{w}/\text{m}^2$	0.00143	ly/min
Precipitation	mm/hr	0.0394	in/hr
	in/hr	25.4	mm/hr
Temperature	$^{\circ}\text{C} + 17.78$	1.8	$^{\circ}\text{F}$
	$^{\circ}\text{F} - 32$	5/9	$^{\circ}\text{C}$
<p>Where:</p> <ul style="list-style-type: none"> <li>ppm = parts per million</li> <li>ppb = parts per billion</li> <li><math>\mu\text{g}/\text{m}^3</math> = micrograms per cubic meter (at 25°C)</li> <li>m/s = meters per second</li> <li>mps = miles per hour</li> <li>ly/min = langley's per minute</li> <li><math>\text{w}/\text{m}^2</math> = watts per square meter</li> <li>mm/hr = millimeters per hour</li> <li>in/hr = inches per hour</li> <li><math>^{\circ}\text{C}</math> = degrees centigrade</li> <li><math>^{\circ}\text{F}</math> = degrees fahrenheit</li> </ul>			