Report No. NPS D-457

Annual Data Summary

GRAND CANYON NATIONAL PARK

1999

National Park Service
Gaseous Air Pollutant Monitoring Network

AIR RESOURCES DIVISION
RESEARCH AND MONITORING BRANCH
12795 West Alameda Parkway
P.O. Box 25287
Lakewood, Colorado 80225
Telephone: (303) 969-2820
Fax: (303) 969-2822

This Annual Data Summary was prepared under NPS Contract CX-1270-96-007 by:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525
Telephone: (970) 484-7941
Fax: (970) 484-3423

For additional copies of this report or reports for other NPS units, contact:

National Park Service 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

or

National Park Service
Air Resources Division
P.O. Box 25287
Lakewood, Colorado 80225-02587
Telephone: (303) 969-2130
E-Mail: AQ_INFO@AQD.NPS.GOV

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At Grand Canyon National Park, the ARD specifically recognizes Carl Bowman 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
OLYMPIC
NORTH CASCADES
MOUNT RAINIER
GLACIER
VOYAGEURS
Theodore Roosevelt
Acadia (2)
Cape Cod
YELLOWSTONE
CRATERS OF THE MOON
LASSEN VOLCANIC
YOSEMITE
GREAT BASIN
ROCKY MOUNTAIN
CANYONLANDS
PINNACLES
DEATH VALLEY
SEQUOIA AND KINGS CANYON (3)
MESA VERDE
SHENANDOAH
MAMMOTH CAVE
GRAND CANYON
Channel Islands
GREAT SMOKY MOUNTAINS (4)
Cowpens
JOSHUA TREE
Congaree Swamp
Saguaro
CHIRICAHUA
Chamizal
HAWAII
HAWAII VOLCANOES (3)
BIG BEND
DENALI
EVERGLADES
ALASKA
VIRGIN ISLANDS
Parameters Monitored
Ozone Only
Ozone and Meteorology
Sulfur Dioxide and Meteorology
Ozone, Sulfur Dioxide and Meteorology
Ozone and Sulfur Dioxide
Enhanced Gaseous and Meteorology
Site Operator (12/99)
DENALI Operated by National Park Service
Acadia Operated by Other Agency

1.2 GRAND CANYON NATIONAL PARK

Grand Canyon National Park, a Class I area, is located in northwestern Arizona some 180 miles north of Phoenix. Its location and site specifications are presented on the following page.

Grand Canyon National Park was officially established as a "public park for the benefit and enjoyment of the people" in 1919. In 1975, the park was significantly enlarged "in order to further protect and interpret the outstanding scenic, natural, and scientific values." The park was designated a World Heritage Site in 1979. In all there are about 20 pieces of legislation contributing to the establishment of Grand Canyon National Park and the protection of wild animals, objects of unusual scientific interest, and geologic and paleontologic features and objects and other scientific and natural values.

Best known for its geologic significance, the Grand Canyon offers a geologic record covering the first 2.5 billion years of geological time, making it one of the most complete records of geological history anywhere in the world. Canyon significance, however, is not limited to geology.

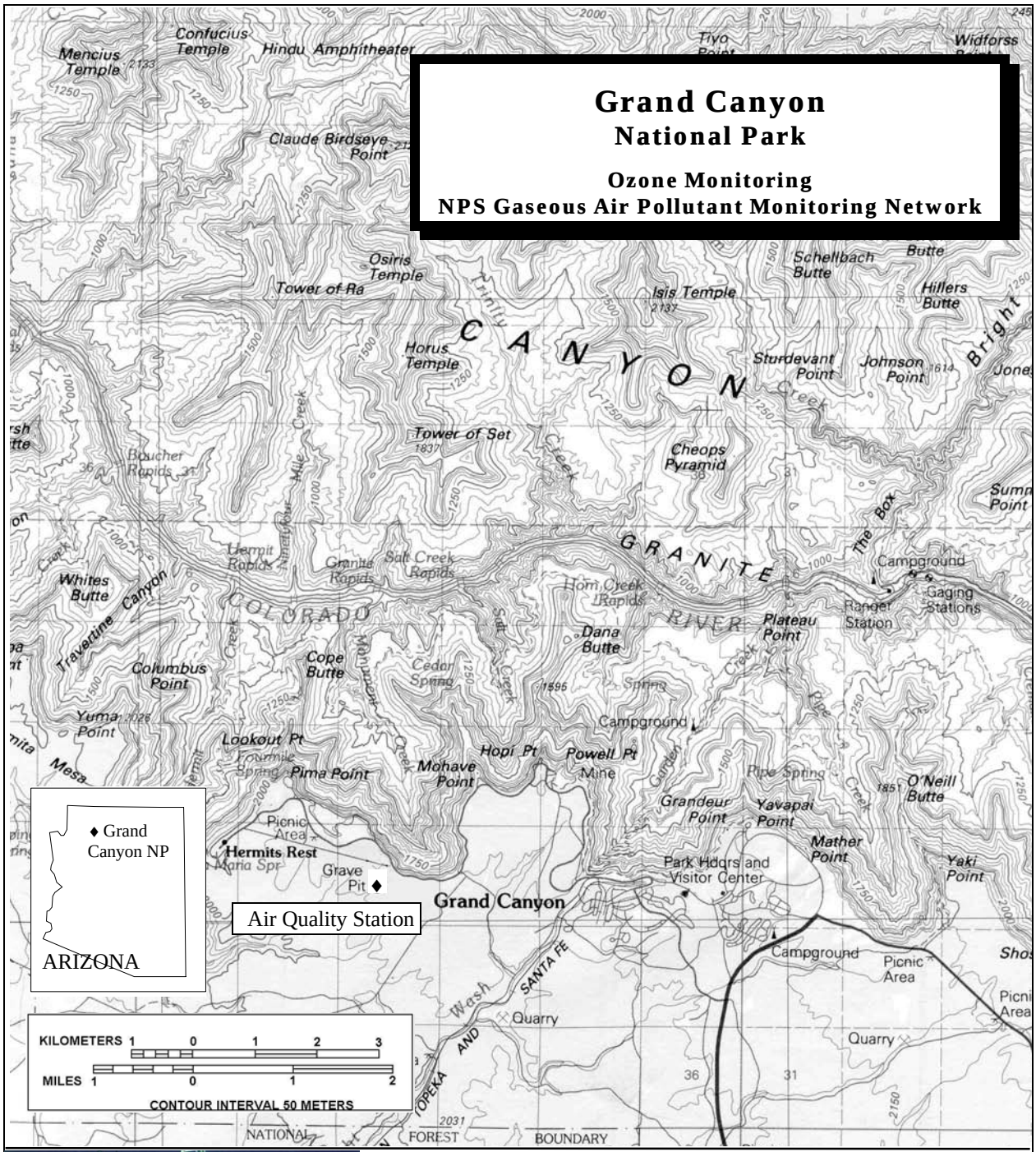
The park includes 277 miles of the Colorado River. With 160 recognized rapids, it is one of the longest and most challenging recreational white water rivers in the world.

Within the park, there are over 1,500 plant species, 287 bird species, 88 species of mammals, 58 reptile and amphibian species, and 26 native species of fish.

Grand Canyon contains more than 2,500 known archeological sites with artifacts indicating 4,000 years of human habitation. It also includes 312 buildings determined eligible for the List of Classified Structures or on the National Register of Historic Places and at least another 138 structures considered potentially eligible.

From the Canyon rim to the Colorado River, one passes from subalpine to desert environments. Normally, a person would have to travel from northern Mexico (Sonoran desert environment) to southern Canada (ponderosa pine environment) to pass through as many different climatic zones.

During the summer season, air quality and visibility in Grand Canyon National Park are affected by the long range transport of pollutants from southern California urban areas and southern Arizona smelters. Transport of air pollution from local sources, such as a nearby coal fired power plant, affects air quality and visibility in the park during the winter months.



SITE IDENTIFICATION		MAP INFORMATION	
Site Abbreviation:	GRCA	Mean Elevation:	2073 m
AIRS ID NO.:	04-005-2003	Longitude:	112° 10' 56"W
		Latitude:	36° 03' 35"N
		UTM Zone:	12
		Easting:	393527 m
		Northing:	3991219 m
		Map Reference:	Grand Canyon 36112-A1-TM 100 1:100,000

INSTRUMENTATION	
O_3 Analyzer	Delta Temperature
Calibrator	Temperature
Wind Speed	Solar Radiation
Wind Direction	Precipitation
Relative Humidity	

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
Grand Canyon National Park

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	7970	91.0	7955	90.8
Scalar Wind Speed	SWS	8760	8592	98.1	8579	97.9
Vector Wind Speed	VWS	8760	8592	98.1	8567	97.8
Vector Wind Direction	VWD	8760	8591	98.1	8567	97.8
Standard Deviation for Wind Direction	SDWD	8760	8591	98.1	8578	97.9
Ambient Temperature (aspirated)	TMP	8760	8602	98.2	8602	98.2
Delta Temperature	DTP	8760	8592	98.1	8592	98.1
Relative Humidity	RH	8760	8602	98.2	8533	97.4
Precipitation	RNF	8760	8580	97.9	8580	97.9
Wetness Sensor	WET	8760	8609	98.3	8448	96.4
Solar Radiation	SOL	8760	8608	98.3	8597	98.1
Filter Pack Flow Rate	FLOW	8760	8588	98.0	8588	98.0

Notes: All statistics are for hourly averages.

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

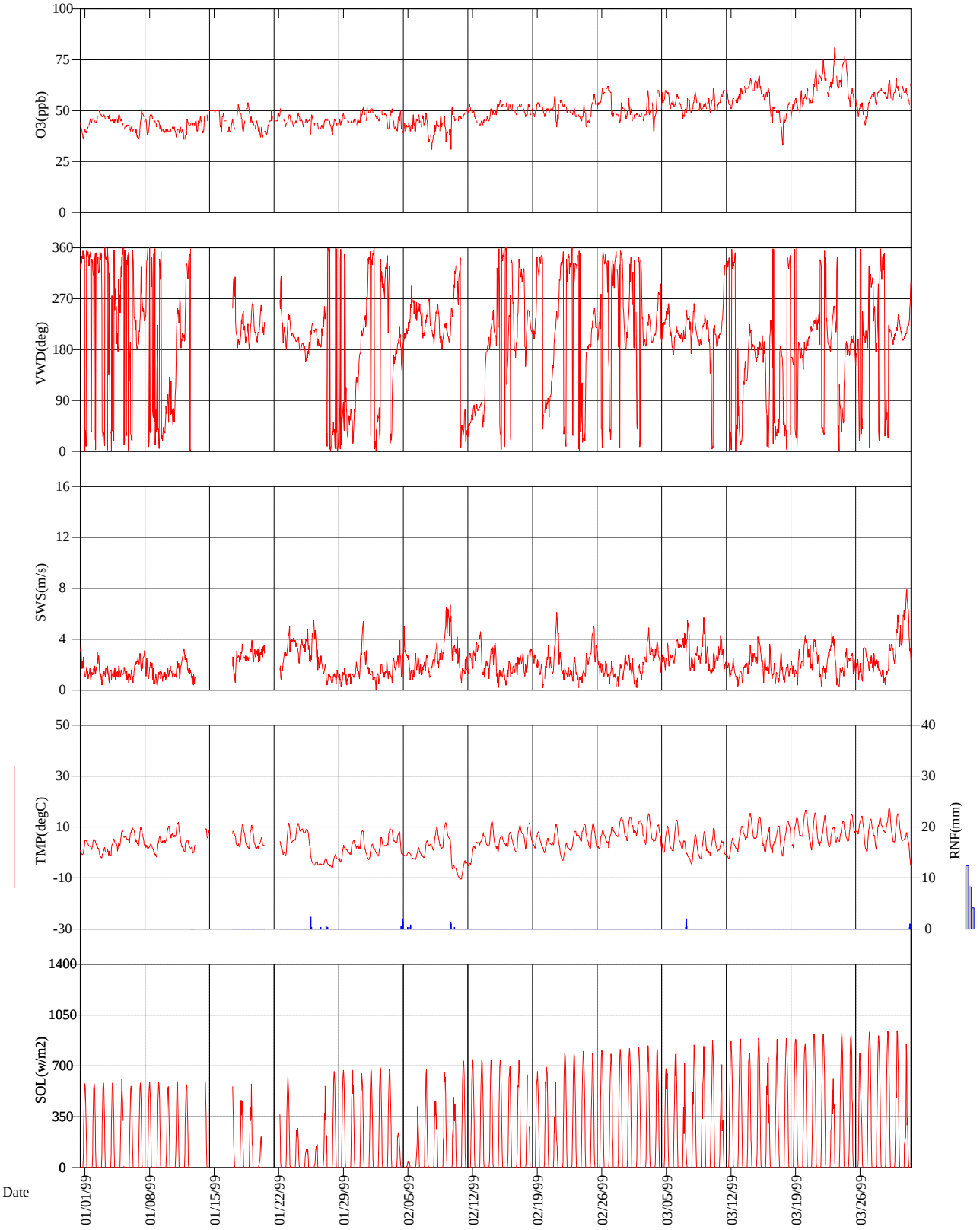
The percent valid is calculated against the number possible.

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:	Monthly Criteria:
100% of sites, >= 85% valid data capture	100% of sites, >= 60% valid data capture
90% of sites, >= 90% valid data capture	90% of sites, >= 75% valid data capture
80% of sites, >= 95% valid data capture	80% of sites, >= 85% valid data capture

Grand Canyon National Park

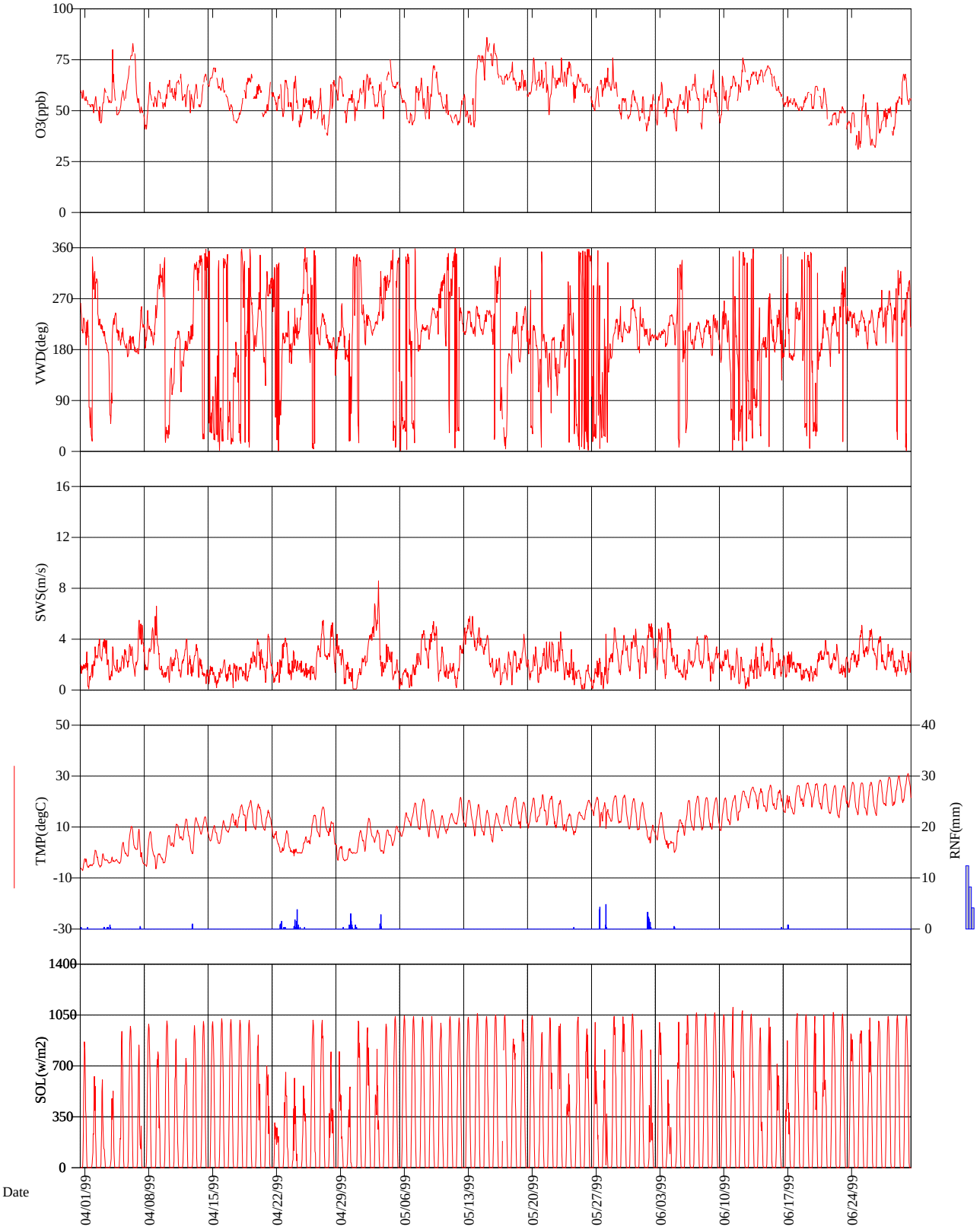


Final Validation

First Quarter 1999

grca-as.stk - grca99.dat 06-06-2000

Grand Canyon National Park

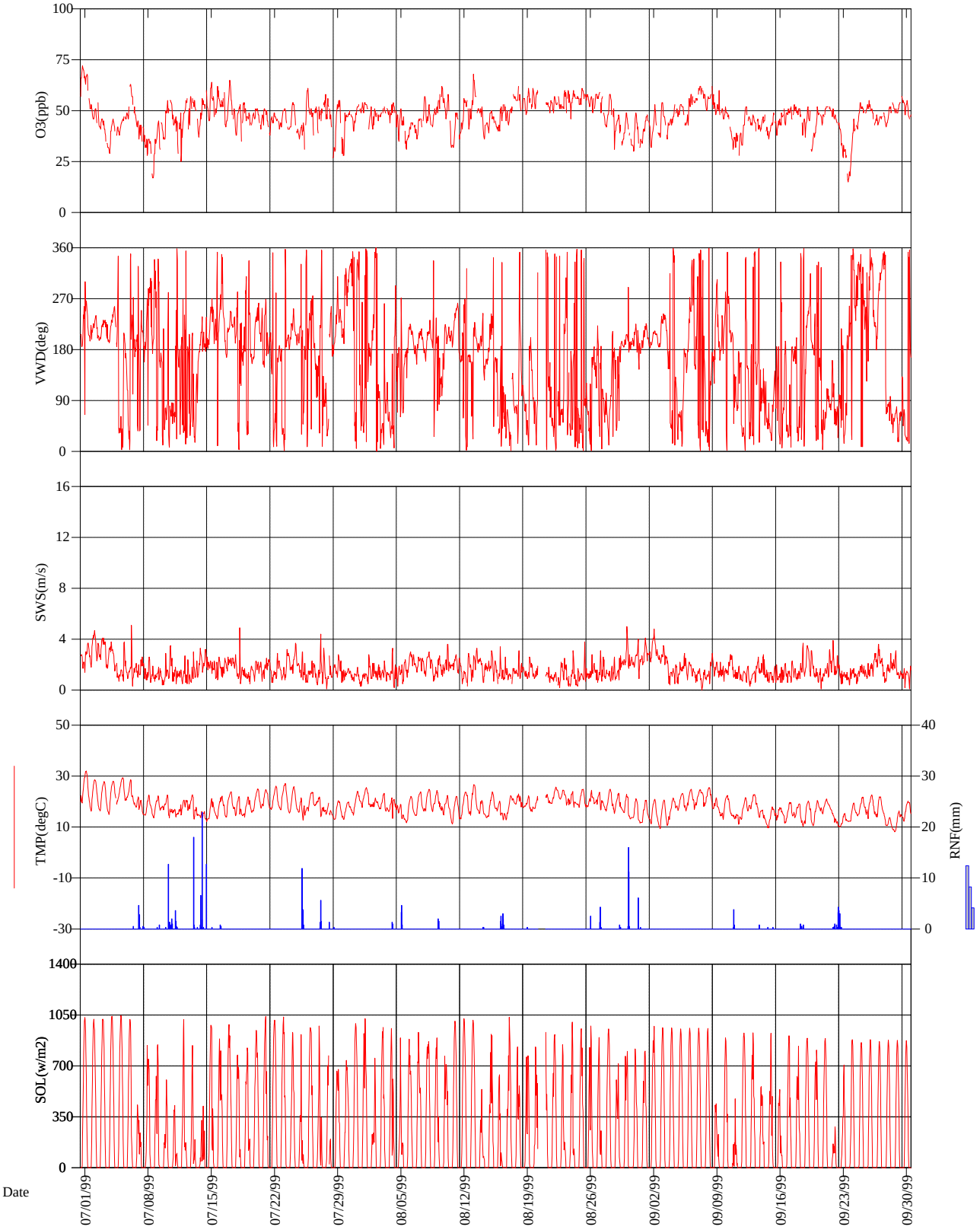


Final Validation

Second Quarter 1999

grca-as.stk - grca99.dat 06-06-2000

Grand Canyon National Park

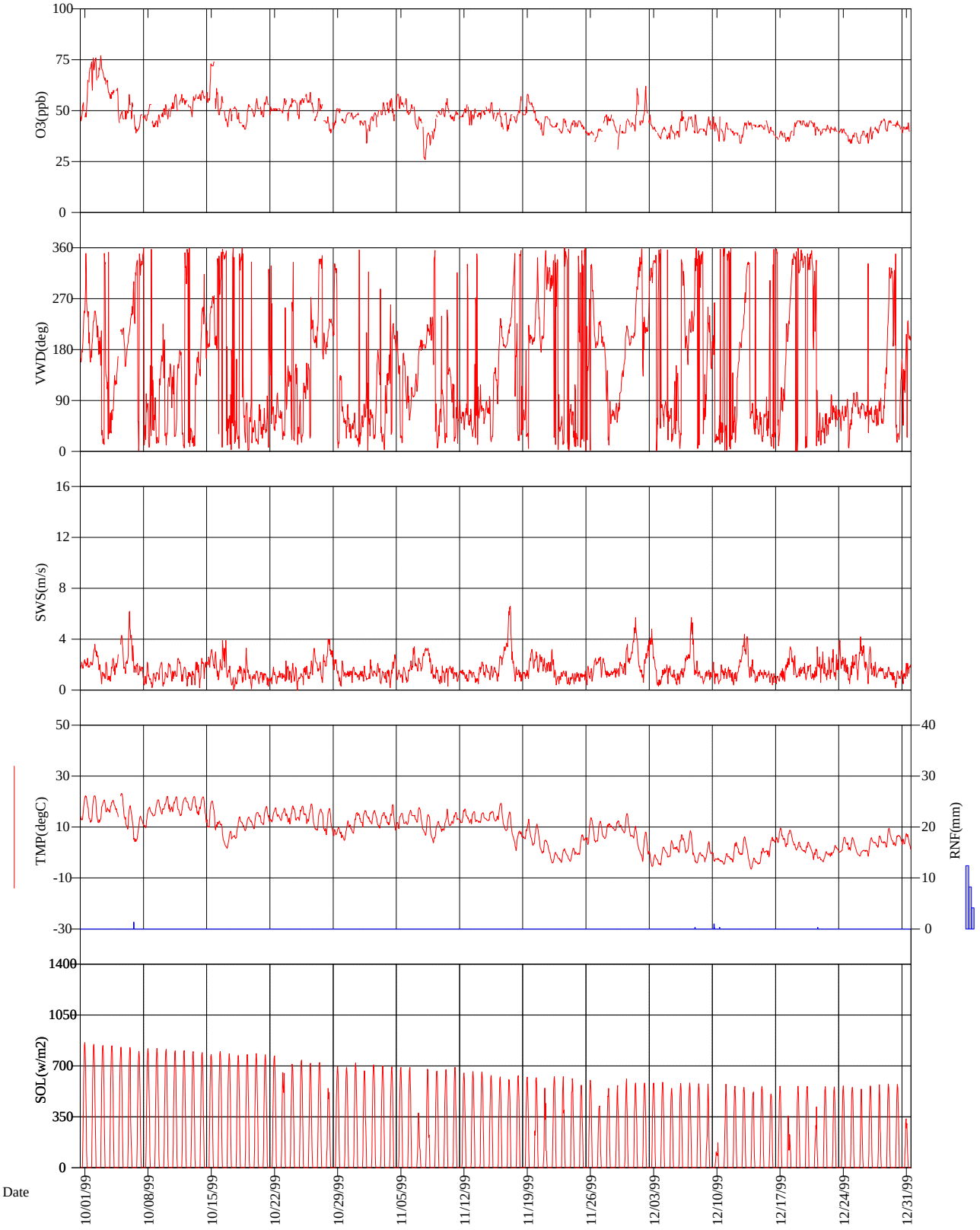


Final Validation

Third Quarter 1999

grca-as.stk - grca99.dat 06-06-2000

Grand Canyon National Park



Final Validation

Fourth Quarter 1999

grca-as.stk - grca99.dat 06-06-2000

2.2 OZONE DATA SUMMARY

Ozone Quick Look Annual Summary Statistics
Grand Canyon National Park

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	54	62	81	83	86	76	72	68	62	77	58	62	86	86
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(30)	(31)	(30)	(31)	(153)	(365)
AVERAGE DAILY MAXIMUM	48	52	62	65	69	61	54	55	52	57	50	45	58	56
NO. OF DAYS	(31)	(28)	(31)	(30)	(31)	(30)	(31)	(31)	(30)	(31)	(30)	(31)	(153)	(365)
MAXIMUM DAILY MEAN	50	56	68	72	77	69	66	57	58	70	55	49	77	77
NO. OF DAYS	(30)	(28)	(31)	(30)	(31)	(30)	(31)	(28)	(30)	(31)	(30)	(31)	(150)	(361)
AVERAGE DAILY MEAN	44	48	56	56	60	54	47	49	46	52	46	41	51	50
NO. OF DAYS	(30)	(28)	(31)	(30)	(31)	(30)	(31)	(28)	(30)	(31)	(30)	(31)	(150)	(361)
MAX PEAK:MIN RATIO	1.417	1.677	1.636	1.711	1.833	1.871	2.647	1.659	3.067	1.444	1.538	1.525	3.067	3.067
NO. OF DAYS	(30)	(28)	(31)	(30)	(31)	(30)	(31)	(28)	(30)	(31)	(30)	(31)	(150)	(361)
AVERAGE PEAK:MIN RATIO	1.180	1.218	1.245	1.336	1.329	1.353	1.553	1.360	1.426	1.216	1.219	1.192	1.405	1.302
NO. OF DAYS	(30)	(28)	(31)	(30)	(31)	(30)	(31)	(28)	(30)	(31)	(30)	(31)	(150)	(361)
MAX 9AM-4PM AVERAGE	50	58	70	76	81	70	67	59	61	73	55	53	81	81
NO. OF DAYS	(29)	(28)	(31)	(30)	(31)	(30)	(31)	(29)	(30)	(31)	(30)	(31)	(151)	(361)
MONTHLY 9AM-4PM AVERAGE	45	49	57	58	61	56	49	50	47	53	46	42	53	51
NO. OF DAYS	(29)	(28)	(31)	(30)	(31)	(30)	(31)	(29)	(30)	(31)	(30)	(31)	(151)	(361)
MAX 7AM-7PM AVERAGE	50	57	69	76	79	70	67	57	59	71	54	51	79	79
NO. OF DAYS	(30)	(28)	(31)	(30)	(31)	(30)	(31)	(30)	(30)	(31)	(30)	(31)	(152)	(363)
MONTHLY 7AM-7PM AVERAGE	44	49	57	58	61	56	48	50	47	53	46	42	52	51
NO. OF DAYS	(30)	(28)	(31)	(30)	(31)	(30)	(31)	(30)	(30)	(31)	(30)	(31)	(152)	(363)
MONTHLY MEAN	44	48	56	56	60	54	47	49	46	52	46	41	51	50
NO. OF HOURS	(681)	(614)	(680)	(657)	(676)	(657)	(674)	(654)	(656)	(674)	(654)	(678)	(3317)	(7955)
SUM0 EXPOSURE INDEX	30036	29535	37998	36947	40722	35549	31357	31998	30130	35050	29910	27980	169756	397212
NO. OF HOURS	(681)	(614)	(680)	(657)	(676)	(657)	(674)	(654)	(656)	(674)	(654)	(678)	(3317)	(7955)
SUM60 EXPOSURE INDEX	-	850	11519	12711	25423	11687	2450	1348	611	4842	-	183	41519	71624
NO. OF HOURS	(0)	(14)	(180)	(197)	(383)	(180)	(38)	(22)	(10)	(71)	(0)	(3)	(633)	(1098)
SUM80 EXPOSURE INDEX	-	-	161	325	1064	-	-	-	-	-	-	-	1064	1550
NO. OF HOURS	(0)	(0)	(2)	(4)	(13)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(13)	(19)
W126 EXPOSURE INDEX	1853	3154	9450	9672	15209	8707	3723	4249	2965	6606	2507	1297	34853	69392
NO. OF HOURS	(681)	(614)	(680)	(657)	(676)	(657)	(674)	(654)	(656)	(674)	(654)	(678)	(3317)	(7955)

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

* Statistics defined in the Quick Look subsection of the Glossary

Final Validation

05/15/2000

Frequency Distribution
Ozone Analyzer

Grand Canyon National Park

Monitoring Season: 01/01/99 - 12/31/99[1]

Averaging Period	% Obs.[3]	# Obs.[2]	Min. Obs.[4]	Percentile[5] 10	30	50	70	90	95	99	Max. Obs.	2nd Max.	Arith. Mean	Geo. Mean	Geo. Stdv.
1-Hour	99	7955	0.039	0.045	0.051	0.054	0.060	0.068	0.074	0.081	0.086	0.083	0.0559	0.0552	1.17

Concentrations in parts per million (ppm)

[1] 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.

[2] The number of observations (# Obs.) includes all valid observations recorded within the Monitoring Season.

[3] 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..

[4] The minimum observation value (Min. Obs.) is the minimum daily maximum recorded during the Monitoring Season.

[5] The percentiles and other statistics are derived from the daily maximums.

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

Grand Canyon National Park

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	.044	F	.052	M	.056	M	.062	T	.061	S	.057	T	.072	T	.054	S	.048	W	.065	F	.045	M	.061	W
2	.050	S	.050	T	.049	T	.057	F	.068	S	.058	W	.055	F	.052	M	.053	T	.076	S	.049	T	.062	T
3	.050	S	.051	W	.060	W	.061	S	.064	M	.064	T	.049	S	.052	T	.054	F	.077	S	.054	W	.048	F
4	.048	M	.050	T	.060	T	.080	S	.075	T	.056	F	.046	S	.054	W	.053	S	.065	M	.056	T	.042	S
5	.048	T	.047	F	.060	F	.060	M	.072	W	.058	S	.047	M	.051	T	.053	S	.061	T	.058	F	.043	S
6	.043	W	.048	S	.058	S	.083	T	.062	T	.062	S	.063	T	.044	F	.058	M	.058	W	.056	S	.050	M
7	.051	T	.049	S	.056	S	.077	W	.062	F	.068	M	.052	W	.046	S	.062	T	.048	T	.051	S	.047	T
8	.048	F	.045	M	.059	M	.064	T	.066	S	.061	T	.041	T	.057	S	.062	W	.053	F	.040	M	.048	W
9	.045	S	.047	T	.054	T	.060	F	.072	S	.070	W	.045	F	.058	M	.060	T	.048	S	.050	T	.047	T
10	.042	S	.052	W	.061	W	.065	S	.069	M	.067	T	.055	S	.062	T	.052	F	.053	S	.056	W	.047	F
11	.042	M	.051	T	.060	T	.066	S	.058	T	.067	F	.055	S	.049	W	.041	S	.058	M	.050	T	.044	S
12	.046	T	.053	F	.060	F	.068	M	.056	W	.076	S	.056	M	.056	T	.052	S	.058	T	.053	F	.041	S
13	.045	W	.046	S	.062	S	.063	T	.058	T	.069	S	.057	T	.068	F	.048	M	.058	W	.051	S	.045	M
14		T	.051	S	.066	S	.068	W	.077	F	.070	M	.060	W	.052	S	.048	T	.060	T	.052	S	.044	T
15	.050	F	.055	M	.067	M	.071	T	.086	S	.072	T	.064	T	.050	S	.049	W	.074	F	.054	M	.045	W
16	.050	S	.054	T	.061	T	.066	F	.083	S	.067	W	.062	F	.053	M	.051	T	.061	S	.051	T	.045	T
17	.047	S	.053	W	.052	W	.057	S	.068	M	.057	T	.065	S	.058	T	.052	F	.051	S	.049	W	.040	F
18	.053	M	.053	T	.054	T	.060	S	.074	T	.056	F	.053	S	.062	W	.053	S	.052	M	.057	T	.040	S
19	.054	T	.054	F	.056	F	.068	M	.070	W	.059	S	.054	M	.061	T	.052	S	.053	T	.058	F	.045	S
20	.045	W	.052	S	.061	S	.063	T	.076	T	.062	S	.051	T		F	.052	M	.056	W	.054	S	.045	M
21	.050	T	.057	S	.071	S	.064	W	.073	F	.061	M	.051	W		S	.052	T	.057	T	.047	S	.044	T
22	.051	F	.055	M	.075	M	.063	T	.074	S	.049	T	.049	T	.057	S	.052	W	.052	F	.045	M	.043	W
23	.048	S	.051	T	.081	T	.065	F	.076	S	.052	W	.051	F	.060	M	.044	T	.056	S	.046	T	.042	T
24	.049	S	.053	W	.077	W	.067	S	.074	M	.049	T	.054	S	.060	T	.046	F	.056	S	.045	W	.041	F
25	.046	M	.058	T	.072	T	.056	S	.068	T	.058	F	.044	S	.061	W	.054	S	.057	M	.045	T	.039	S
26	.048	T	.061	F	.056	F	.057	M	.063	W	.054	S	.061	M	.058	T	.055	S	.059	T	.040	F	.040	S
27	.046	W	.062	S	.058	S	.061	T	.063	T	.054	S	.053	T	.059	F	.049	M	.056	W	.044	S	.042	M
28	.046	T	.054	S	.061	S	.065	W	.071	F	.052	M	.058	W	.058	S	.054	T	.047	T	.048	S	.045	T
29	.049	F			.065	M	.067	T	.076	S	.057	T	.055	T	.051	S	.057	W	.051	F	.045	M	.046	W
30	.046	S			.066	T	.060	F	.056	S	.068	W	.050	F	.049	M	.057	T	.049	S	.046	T	.045	T
31	.052	S			.063	W			.060	M			.053	S	.049	T			.049	S			.044	F
Valid Days	30		28		31		30		31		30		31		29		30		31		30		31	
Maximum	.054		.062		.081		.083		.086		.076		.072		.068		.062		.077		.058		.062	
Violations	0		0		0		0		0		0		0		0		0		0		0		0	

7955 Total Samples
90.8 % Possible
362 Valid daily maxima

0 Daily-maxima exceeding the standard of .12 ppm (starred[*])
1 Missing days assumed to be less than the standard
0 Daily maximas exceed the alert level of .200 ppm

Concentrations in parts per million (ppm)

Final Validation

5/15/2000

Grand Canyon National Park

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

Ozone Season: January through December

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	74	98%	Yes	82	80	80	77	76

Ozone
Ten Highest Daily 1-Hour Average Maximum Concentrations

Grand Canyon National Park

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

Rank	Date	Hour	Concentration (ppb)
1	05/15/99	13	86*
2	04/06/99	18	83*
3	05/16/99	8	83*
4	03/23/99	18	81*
5	04/04/99	13	80
6	03/24/99	20	77
7	04/07/99	0	77
8	05/14/99	14	77*
9	10/03/99	6	77
10	05/20/99	16	76**

* 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
Grand Canyon National Park

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

Date	Beginning Hour	No. Hours > 100 ppb	No. Hours >124 ppb	Max (ppb)
No values exceeded 100 ppb during this period				
Total		0	0	

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^3 exceeds the standard.) (40 CFR 50.9 with reference to Appendix D and H.)

Episodes with 8-Hour Average Ozone Concentrations > 84 ppb Grand Canyon National Park 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
No values exceeded 84 ppb during this period			
0	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^3). (40 CFR 50.10.)

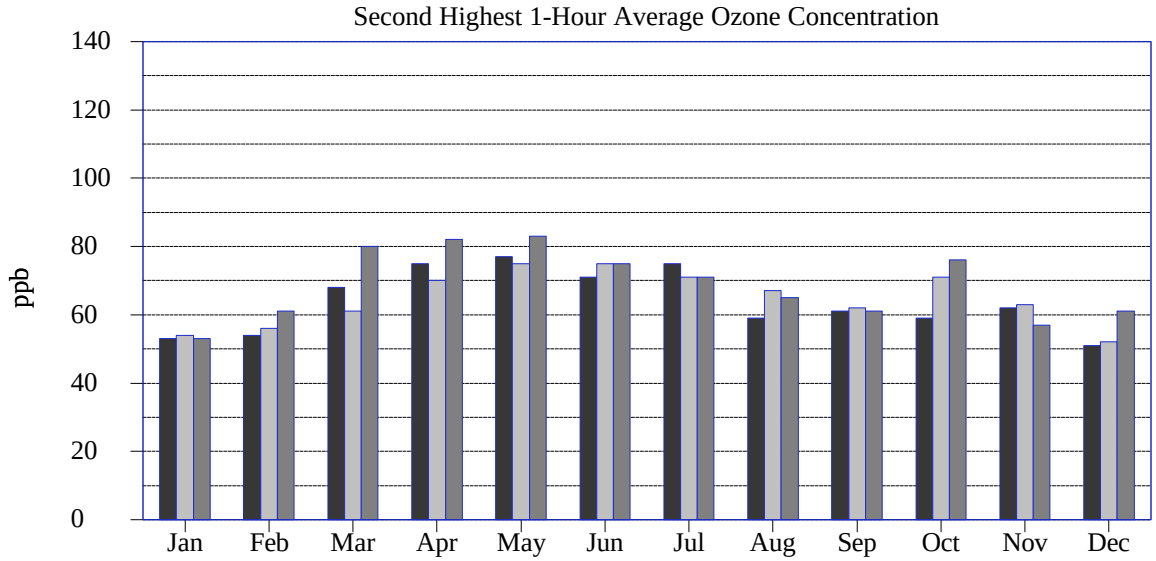
Ozone Rank Listings of Second Highest 1-Hour Average Concentrations, 4th Highest 8-Hour Average Concentrations, and Annual SUM60 Exposure Index for All NPS Monitoring Sites

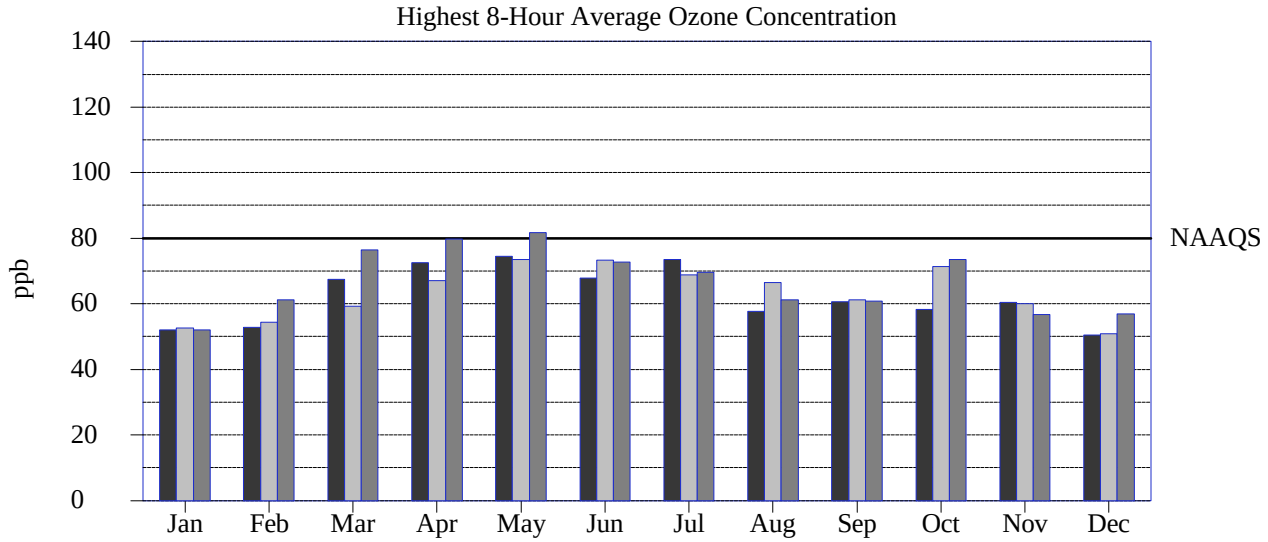
01/01/99 - 12/31/99

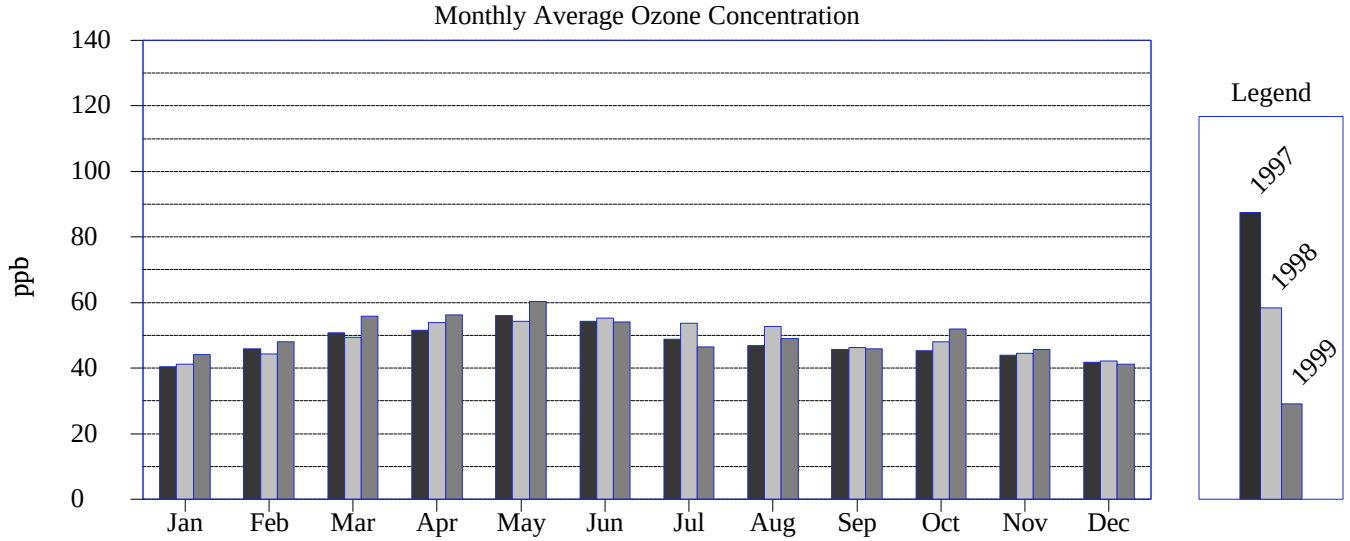
Second Highest 1-Hour Average Concentration		
Site	Rank	Concentration (ppb)
JOTR-YV	1	134
CACO-XX	2	127
GRSM-CM	3	126
SEKI-AS	4	125
ACAD-CM	5	123
GRSM-LR	6	123
MACA-HM	7	123
SEKI-LP	8	122
GRSM-CC	9	114
GRSM-CD	10	114
COWP-XX	11	111
SEKI-LK	12	111
SHEN-BM	13	110
CHAM-XX	14	108
LAVO-ML	15	108
COSW-XX	16	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

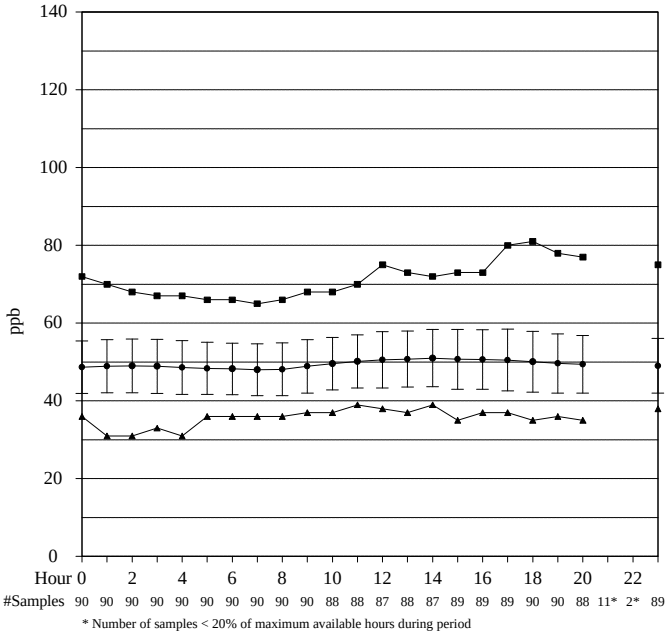

Second Highest 1-Hour Average Ozone Concentration
ppb
140
120
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Highest 8-Hour Average Ozone Concentration
ppb
140
120
100
80
60
40
20
0
NAAQS
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

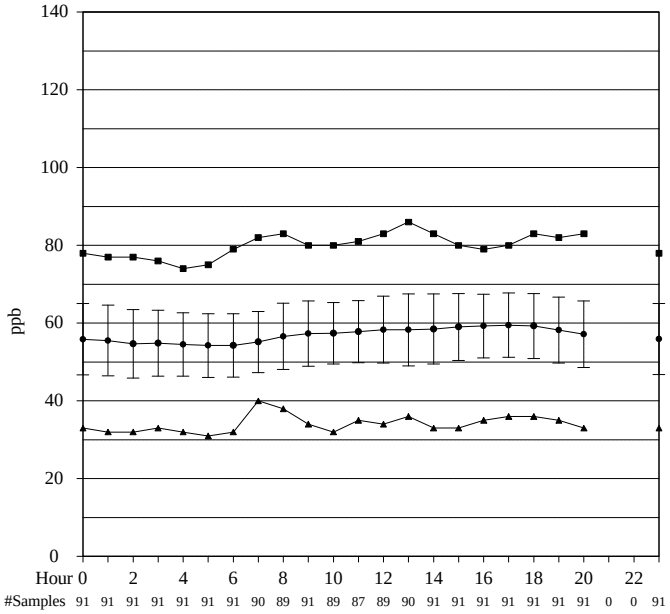

Monthly Average Ozone Concentration
ppb
140
120
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Legend
1997
1998
1999

NATIONAL PARK SERVICE
GASEOUS POLLUTANT MONITORING NETWORK
1999 Second Highest 1-Hour Ozone Concentrations
OLYMPIC
47
62
NORTH CASCADES
90
MOUNT RAINIER
67
GLACIER
VOYAGEURS
82
63
Theodore Roosevelt
Acadia
123
127
Cape Cod
78
YELLOWSTONE
80
CRATERS OF THE MOON
LASSEN VOLCANIC
108
YOSEMITE
95
PINNACLES
105
125
92
SEQUOIA AND KINGS CANYON
82
Channel Islands
134
DEATH VALLEY
83
GREAT BASIN
CANYONLANDS
82
98
ROCKY MOUNTAIN
75
MESA VERDE
83
GRAND CANYON
JOSHUA TREE
Saguaro
89
81
CHIRICAHUA
108
Chamizal
74
BIG BEND
MAMMOTH CAVE
123
GREAT SMOKY MOUNTAINS
126
111
Cowpens
106
Congaree Swamp
110
SHENANDOAH
EVERGLADES
95
HAWAII
42
HAWAII VOLCANOES
DENALI
57
ALASKA
52
VIRGIN ISLANDS

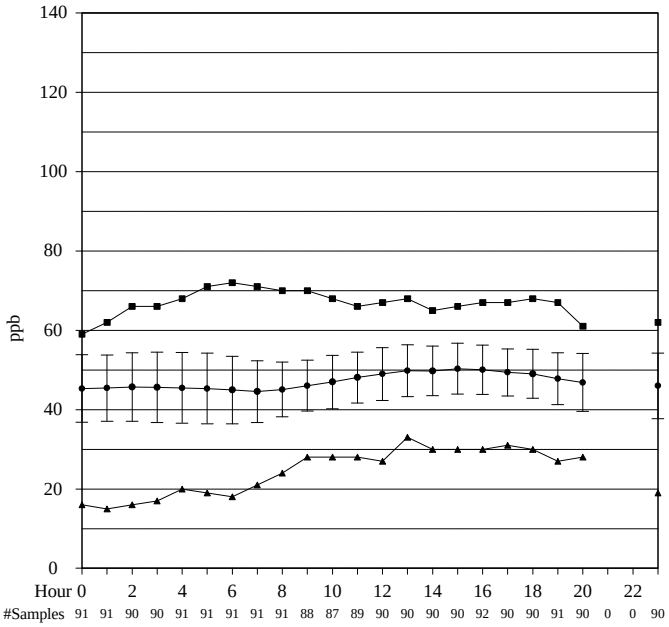
FIRST QUARTER (JAN-MAR)



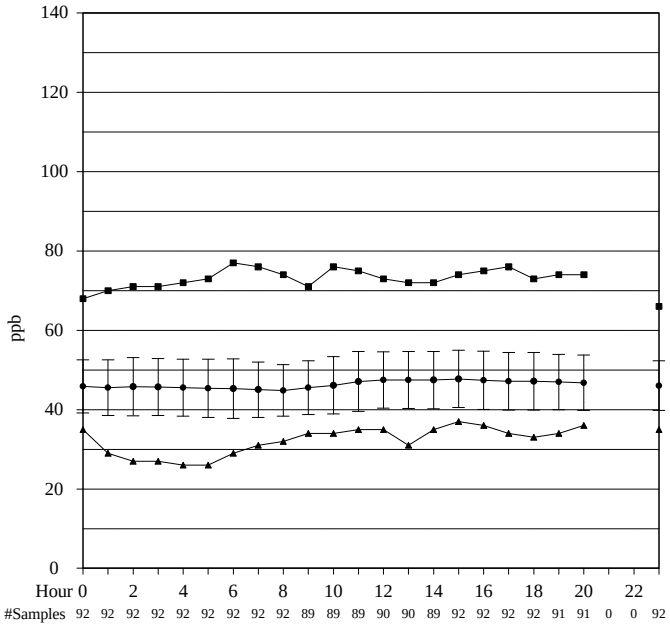
SECOND QUARTER (APR-JUN)



THIRD QUARTER (JUL-SEP)



FOURTH QUARTER (OCT-DEC)



Maximum of Valid O3 in ppb
(□ Indicates Data Exceeds Plot Scale)

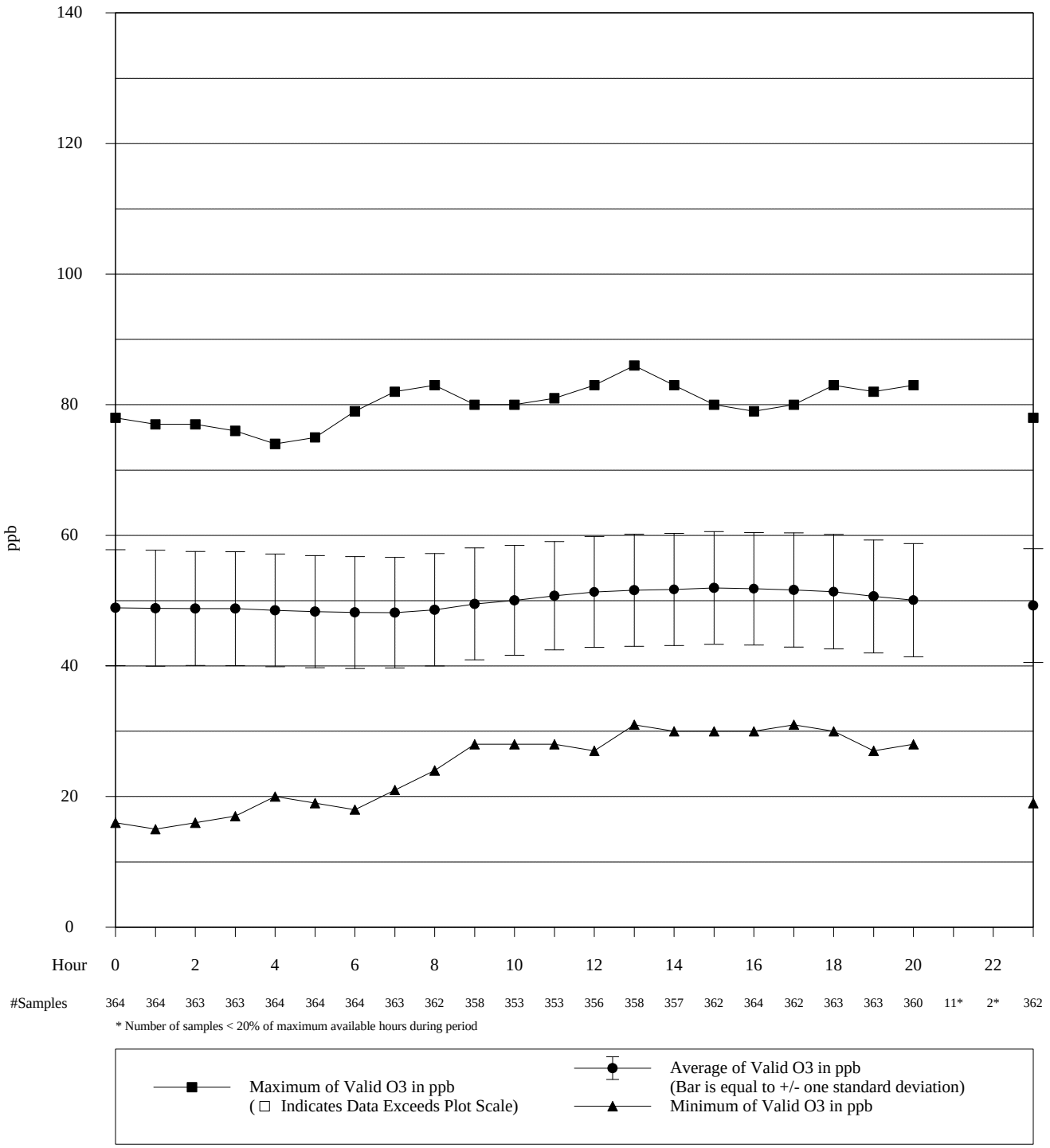
Average of Valid O3 in ppb
(Bar is equal to +/- one standard deviation)

Minimum of Valid O3 in ppb

Grand Canyon National Park

Annual Diurnal Ozone Plot

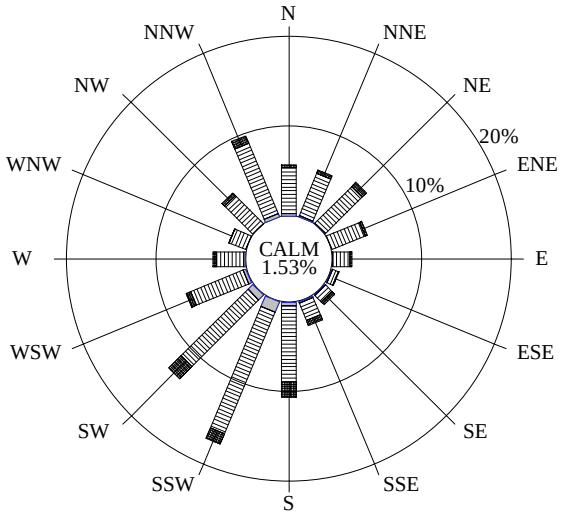
1999



Final Validation

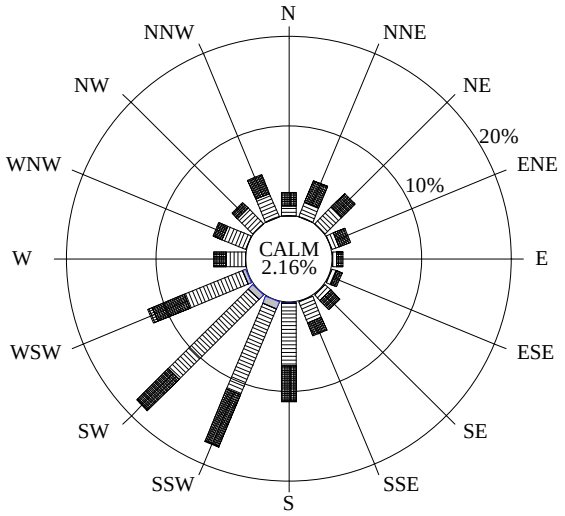
05-18-2000

FIRST QUARTER (JAN-MAR)



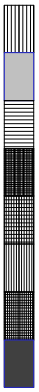
100.0% Collected 84.8% Valid
2160 Possible /2160 Collected /1832 Valid

SECOND QUARTER (APR-JUN)



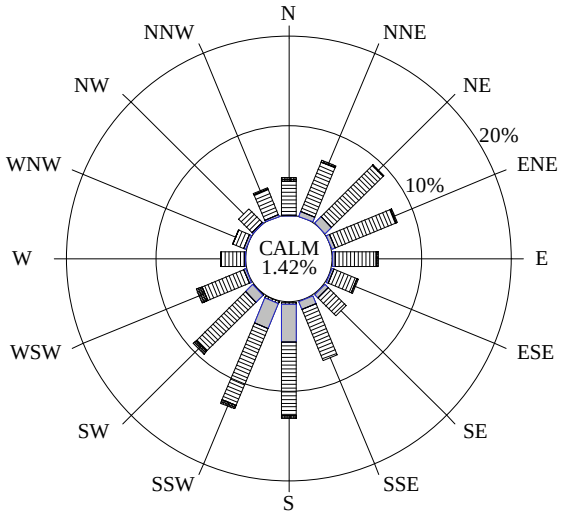
100.0% Collected 91.1% Valid
2184 Possible /2184 Collected /1990 Valid

Ozone (ppb)



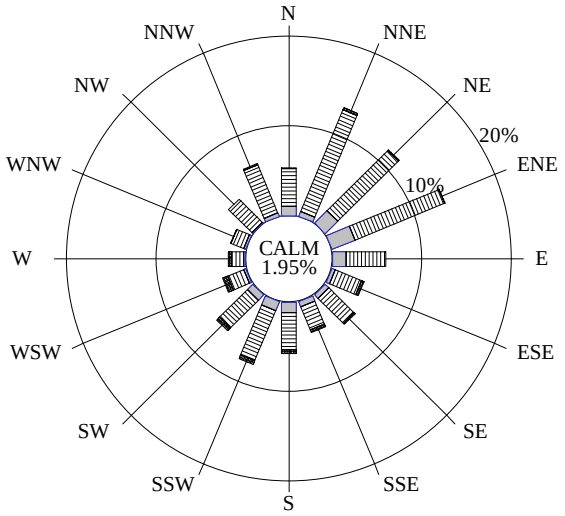
0-19
20-39
40-59
60-79
80-99
100-119
120-139
140+

THIRD QUARTER (JUL-SEP)

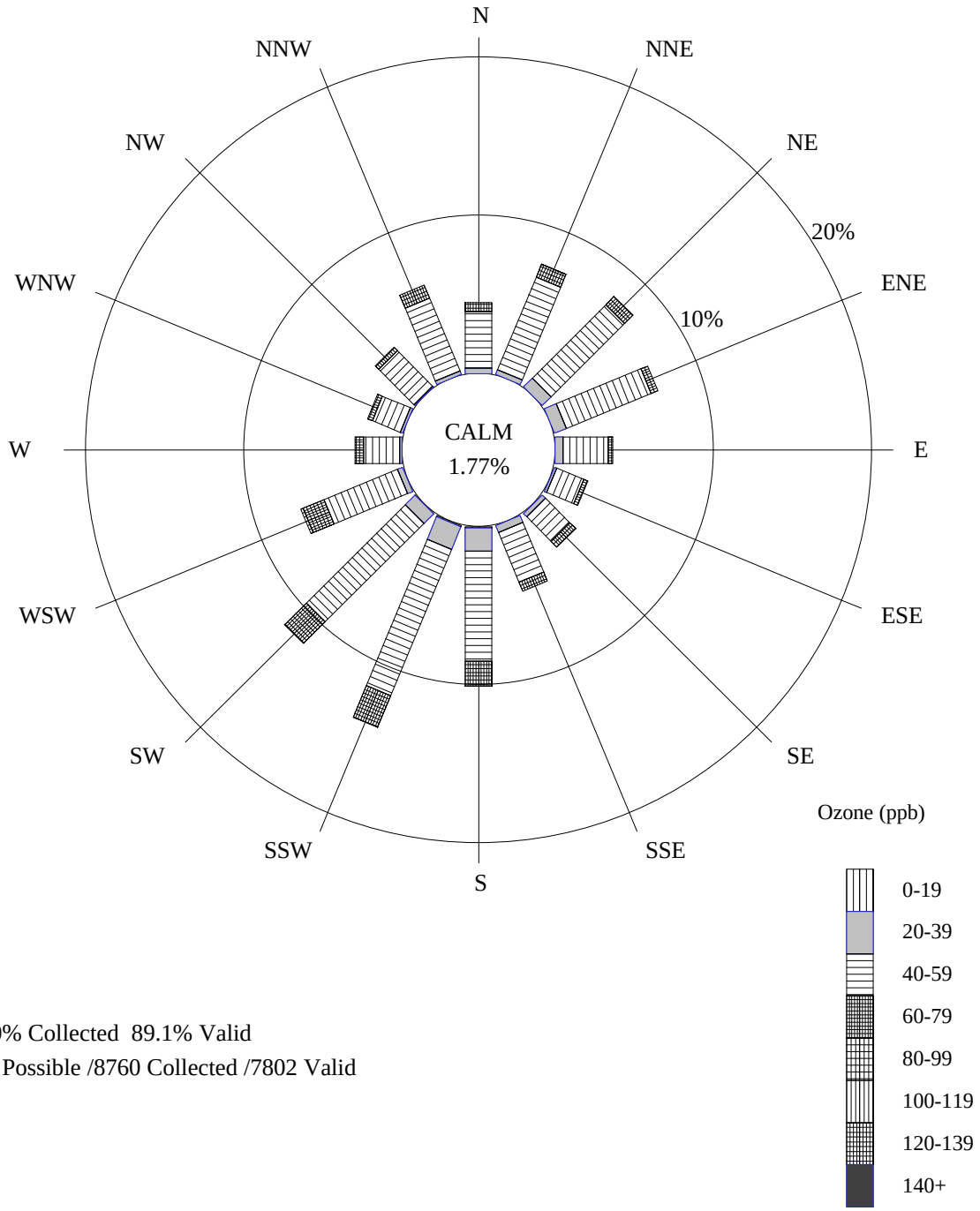


100.0% Collected 89.6% Valid
2208 Possible /2208 Collected /1978 Valid

FOURTH QUARTER (OCT-DEC)



100.0% Collected 90.7% Valid
2208 Possible /2208 Collected /2002 Valid



100.0% Collected 89.1% Valid
8760 Possible /8760 Collected /7802 Valid

Ozone Precision Check Summary
Grand Canyon National Park

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.[1] According to NPS Standard Operating Procedures, the pollutant analyzer must respond within 10% of the transfer standard.[2] 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[3] 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 [1] [2]	Lower 95% Probability Limit [3]	Upper 95% Probability Limit [3]
1	71	-1.50	-3.75	0.76
2	91	-0.50	-2.66	1.66
3	91	-1.53	-4.71	1.65
4	90	-1.24	-5.16	2.69

[1] Percent Difference= $\frac{\text{analyzer - transfer std}}{\text{transfer std}}$ X 100.

[2] Average Percent Difference is the mean of all individual precision check percent differences during the quarter.

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

2.3 METEOROLOGICAL DATA SUMMARY

Summary of Selected Meteorological Data

Grand Canyon National Park

Final Data

01/01/99 - 12/31/99

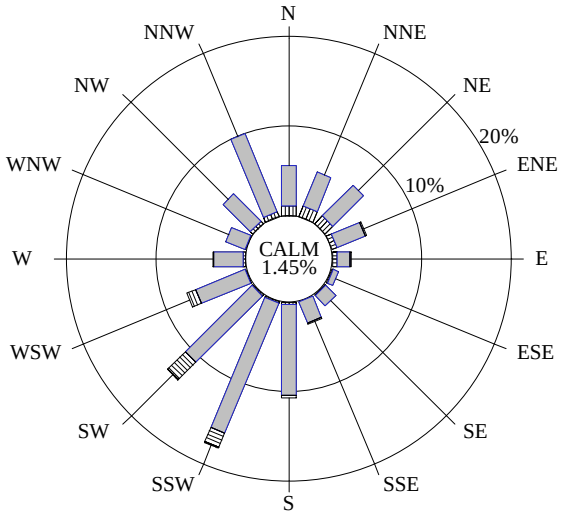
Parameter	Value	Units	Number	Std Dev
SCALAR WIND SPEED				
Average	1.9	m/s	8579	1.0
Maximum	8.6	m/s		
Percent calm = 1.84				
AMBIENT TEMPERATURE				
Average	10.9	degC	8602	8.0
Maximum	32.0	degC		
Minimum	-10.5	degC		
RELATIVE HUMIDITY				
Average	39	percent	8533	24
Maximum	100	percent		
Minimum	2	percent		
PRECIPITATION (Rainfall or Snow melt)				
Average non-zero rate	1.6	mm/hr	204	2.9
Maximum non-zero rate	22.9	mm/hr		
Minimum non-zero rate	.3	mm/hr		
Accumulated during period	330.4	mm		
SOLAR RADIATION				
Average Daily Total	17,200,693	joules/m2day	365	6,632,198
Maximum Daily Total	29,827,200	joules/m2day		
Minimum Daily Total	816,000	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.

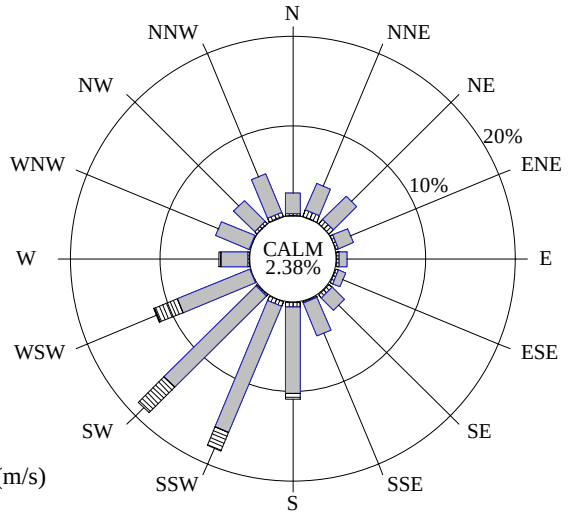
NA indicates instrument not available.

FIRST QUARTER (JAN-MAR)



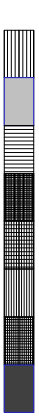
100.0% Collected 92.7% Valid
2160 Possible /2160 Collected /2002 Valid

SECOND QUARTER (APR-JUN)



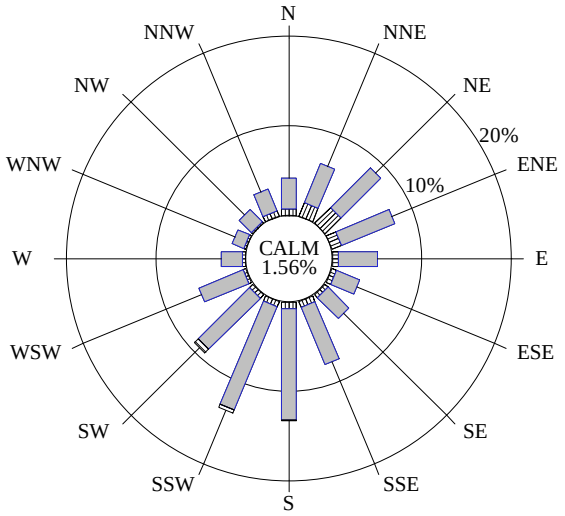
100.0% Collected 99.9% Valid
2184 Possible /2184 Collected /2182 Valid

Scalar Wind Speed (m/s)



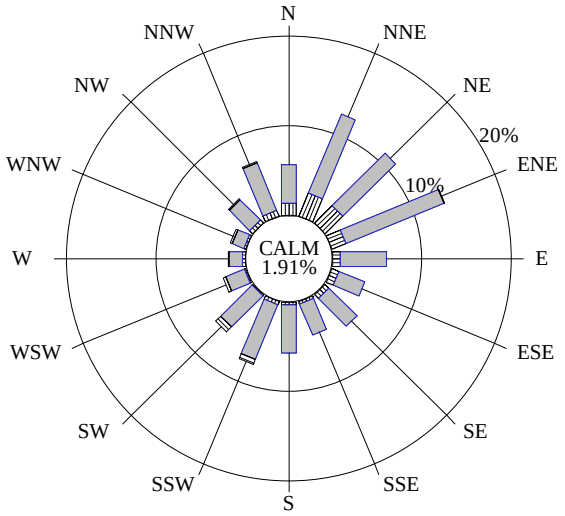
CALM < .5
0.5-0.9
1.0-3.9
4.0-6.9
7.0-9.9
10.0-12.9
13.0-15.9
16.0-18.9
19.0+

THIRD QUARTER (JUL-SEP)



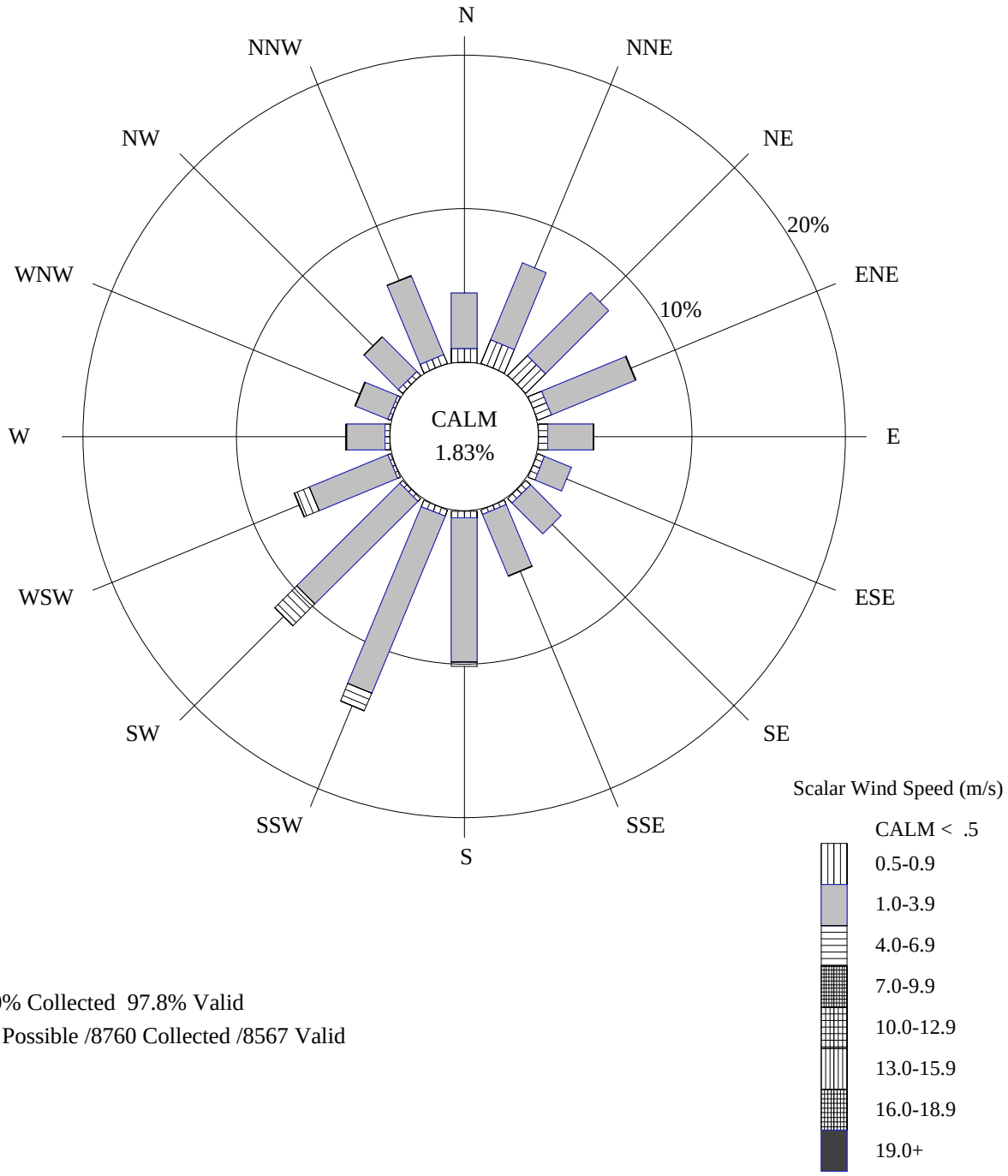
100.0% Collected 98.7% Valid
2208 Possible /2208 Collected /2180 Valid

FOURTH QUARTER (OCT-DEC)



100.0% Collected 99.8% Valid
2208 Possible /2208 Collected /2203 Valid

Annual Wind Rose



100.0% Collected 97.8% Valid
8760 Possible /8760 Collected /8567 Valid

2.4 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 (SO_4^{2-}), particulate nitrate (NO_3^-), particulate ammonium (NH_4^+), sulfur dioxide (SO_2), and nitric acid (HNO_3). In some cases, the positive ions Na^+, K^+, Ca^{2+}, and 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/ardpublc/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
Grand Canyon National Park
01/01/1999-12/31/1999

Quarter	No.Valid Samples	p-NO_3 (ug/m^3)	HNO_3 (ug/m^3)	Total NO_3 (ug/m^3)	NH_4 (ug/m^3)	p-SO_4 (ug/m^3)	SO_2 (ug/m^3)	SO_4 /SO_2 Ratio
1	13	0.403	0.723	1.115	0.203	0.538	0.438	1.228
2	13	0.481	0.821	1.289	0.313	1.030	0.324	3.179
3	13	0.235	1.186	1.402	0.375	1.181	0.308	3.837
4	13	0.162	1.193	1.336	0.246	0.623	0.707	0.881
Annual Average		0.320	0.981	1.285	0.284	0.843	0.444	1.898
Standard Deviation		0.234	0.426	0.456	0.123	0.388	0.243	

Data Recovery Table

Total No. Filters	No. Invalidated	Data Capture	No. Valid Hours
52	0	100.0%	8553.0

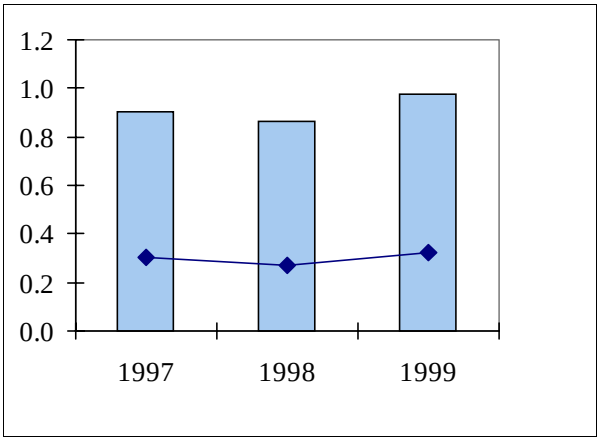
CASTNet Dry Deposition Monitoring Weekly Concentrations Report
Grand Canyon National Park
01/01/1999 - 12/31/1999

On Date	Off Date	p-NO_3 (ug/m^3)	HNO_3 (ug/m^3)	Total NO_3 (ug/m^3)	NH_4 (ug/m^3)	p-SO_4 (ug/m^3)	SO_2 (ug/m^3)	SO_4/SO_2 Ratio
12/29/98	01/05/99	0.048	0.362	0.405	0.099	0.273	0.487	0.561
01/05/99	01/12/99	0.094	0.719	0.802	0.101	0.210	0.468	0.449
01/12/99	01/19/99	0.978	1.760	2.710	0.378	0.660	0.937	0.705
01/19/99	01/26/99	0.280	0.531	0.802	0.110	0.347	0.343	1.011
01/26/99	02/02/99	0.154	0.563	0.708	0.143	0.353	0.371	0.950
02/02/99	02/09/99	0.371	0.551	0.913	0.215	0.321	0.173	1.858
02/09/99	02/16/99	0.180	0.639	0.809	0.133	0.394	0.402	0.981
02/16/99	02/23/99	0.159	0.592	0.742	0.153	0.441	0.336	1.312
02/23/99	03/02/99	0.222	0.680	0.891	0.122	0.426	0.312	1.368
03/02/99	03/09/99	0.941	0.802	1.730	0.273	0.710	0.482	1.472
03/09/99	03/16/99	0.544	0.706	1.239	0.346	1.049	0.501	2.095
03/16/99	03/23/99	0.459	0.703	1.151	0.255	0.783	0.436	1.796
03/23/99	03/30/99	0.807	0.794	1.588	0.309	1.021	0.444	2.301
03/30/99	04/06/99	0.663	0.291	0.949	0.169	0.673	0.212	3.171
04/06/99	04/13/99	0.424	0.826	1.237	0.168	0.535	0.375	1.428
04/13/99	04/20/99	0.225	0.935	1.145	0.283	0.804	0.407	1.978
04/20/99	04/27/99	0.326	0.624	0.940	0.159	0.724	0.205	3.533
04/27/99	05/04/99	0.633	0.328	0.956	0.152	0.899	0.223	4.038
05/04/99	05/11/99	0.428	0.598	1.017	0.302	0.972	0.277	3.504
05/11/99	05/17/99	0.793	0.844	1.623	0.400	1.321	0.411	3.214
05/17/99	05/25/99	0.707	0.948	1.640	0.397	1.258	0.442	2.846
05/25/99	06/01/99	0.377	0.864	1.227	0.438	1.272	0.275	4.625
06/01/99	06/08/99	0.427	0.883	1.296	0.370	1.225	0.296	4.134
06/08/99	06/15/99	0.525	1.196	1.702	0.327	1.012	0.366	2.763
06/15/99	06/22/99	0.387	1.350	1.715	0.566	1.681	0.420	4.000
06/22/99	06/29/99	0.342	0.987	1.313	0.339	1.013	0.302	3.350
06/29/99	07/06/99	0.469	1.555	1.999	0.385	1.275	0.381	3.347
07/06/99	07/13/99	0.128	0.992	1.104	0.243	0.785	0.114	6.915
07/13/99	07/20/99	0.285	1.301	1.565	0.465	1.376	0.246	5.585
07/20/99	07/27/99	0.373	1.286	1.639	0.383	1.330	0.293	4.538
07/27/99	08/03/99	0.104	1.083	1.170	0.331	0.937	0.272	3.439
08/03/99	08/10/99	0.281	1.198	1.460	0.498	1.401	0.315	4.445
08/10/99	08/17/99	0.418	0.792	1.198	0.322	1.227	0.343	3.573
08/17/99	08/24/99	0.140	1.759	1.871	0.495	1.528	0.393	3.888
08/24/99	08/31/99	0.101	1.359	1.438	0.446	1.315	0.219	6.018
08/31/99	09/07/99	0.390	0.678	1.058	0.298	0.909	0.334	2.723
09/07/99	09/14/99	0.086	1.386	1.450	0.339	1.319	0.524	2.519
09/14/99	09/21/99	0.182	1.048	1.214	0.354	1.018	0.204	4.978
09/21/99	09/27/99	0.094	0.984	1.063	0.314	0.932	0.363	2.569
09/27/99	10/05/99	0.195	1.703	1.870	0.313	0.805	0.635	1.269
10/05/99	10/12/99	0.157	1.247	1.385	0.315	0.817	0.603	1.354
10/12/99	10/19/99	0.164	1.384	1.526	0.354	0.829	0.674	1.229
10/19/99	10/26/99	0.090	1.647	1.711	0.245	0.624	0.678	0.921
10/26/99	11/02/99	0.150	1.327	1.456	0.216	0.605	0.510	1.186
11/02/99	11/09/99	0.252	1.760	1.984	0.383	0.959	1.287	0.745
11/09/99	11/16/99	0.159	2.172	2.296	0.469	1.254	1.378	0.910
11/16/99	11/23/99	0.429	0.712	1.130	0.227	0.554	0.386	1.437
11/23/99	11/30/99	0.068	0.969	1.022	0.126	0.302	0.758	0.398
11/30/99	12/07/99	0.121	0.705	0.814	0.154	0.341	0.604	0.565
12/07/99	12/14/99	0.197	0.639	0.826	0.169	0.443	0.534	0.830
12/14/99	12/21/99	0.053	0.362	0.410	0.065	0.159	0.379	0.421
12/21/99	12/28/99	0.065	0.884	0.935	0.161	0.408	0.768	0.532

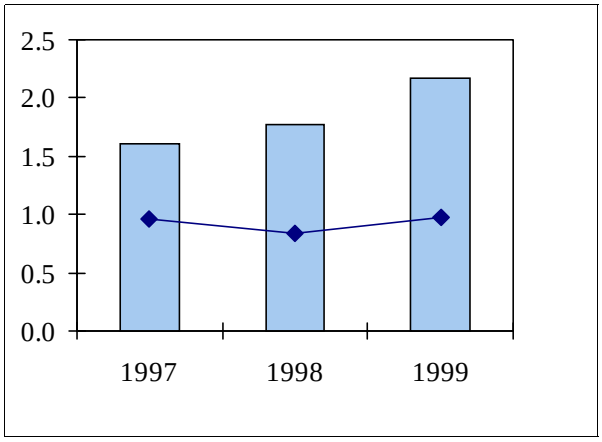
Grand Canyon National Park

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

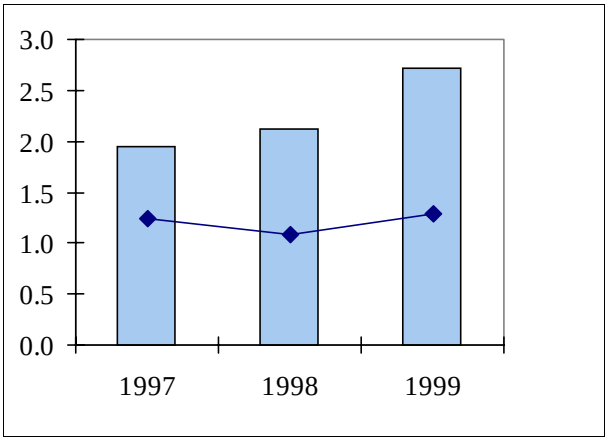
p-NO_3



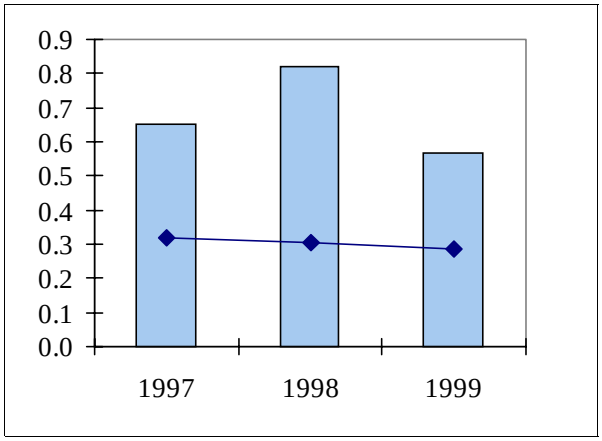
HNO_3



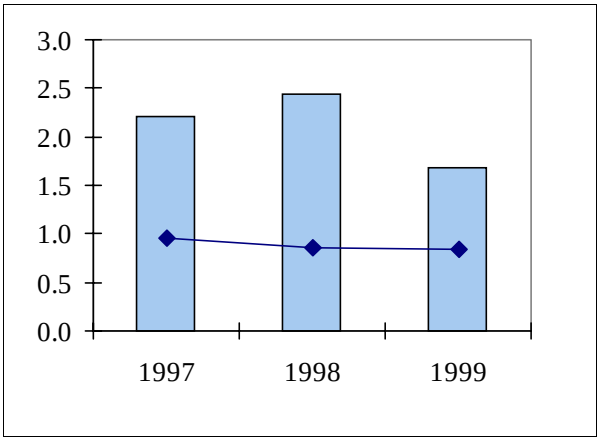
Total NO_3



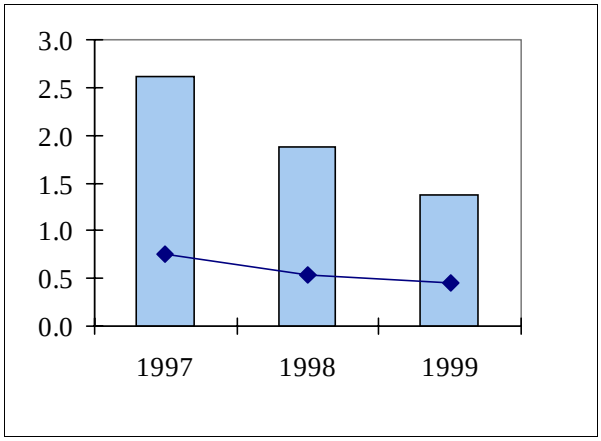
NH_4



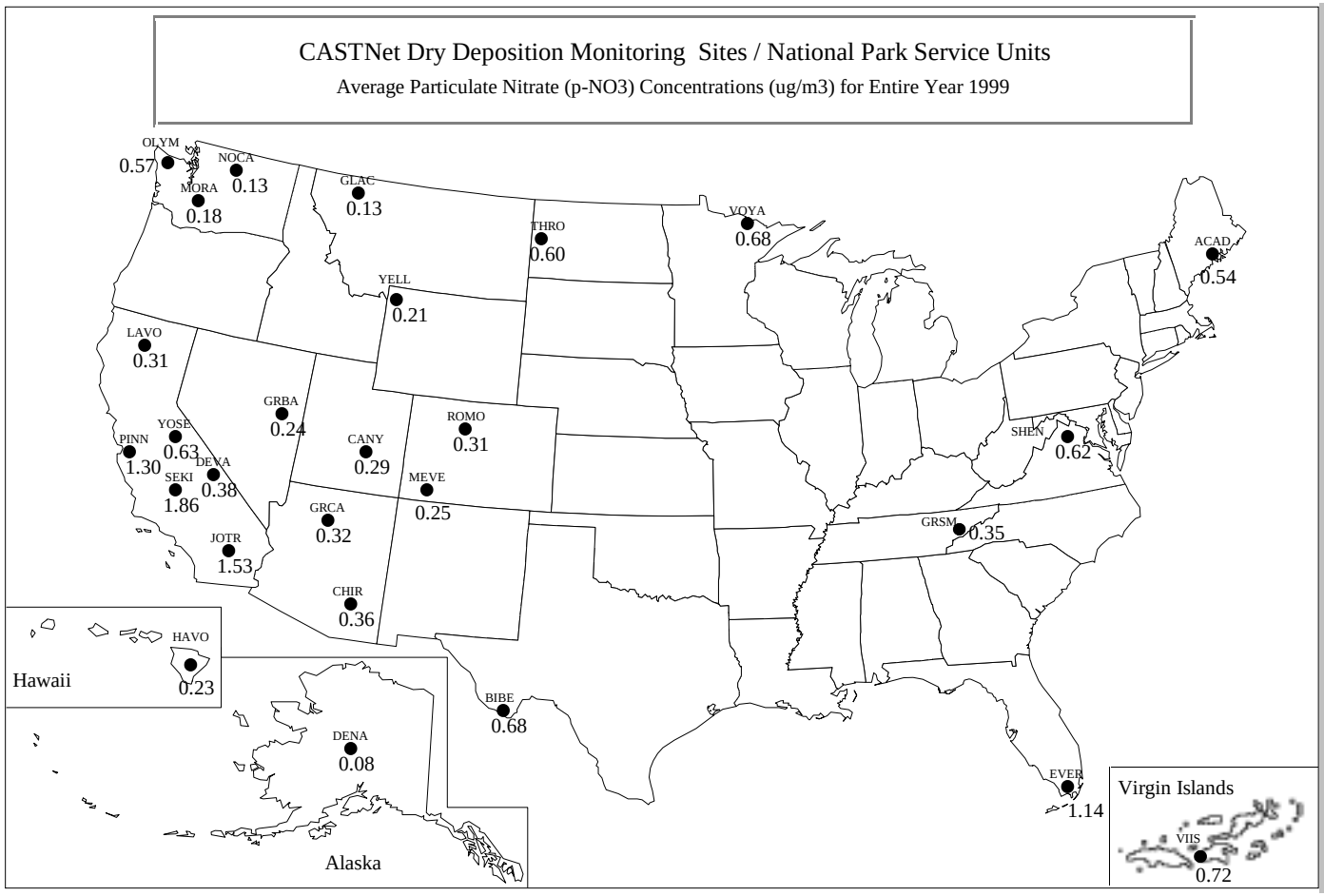
p-SO_4



SO_2

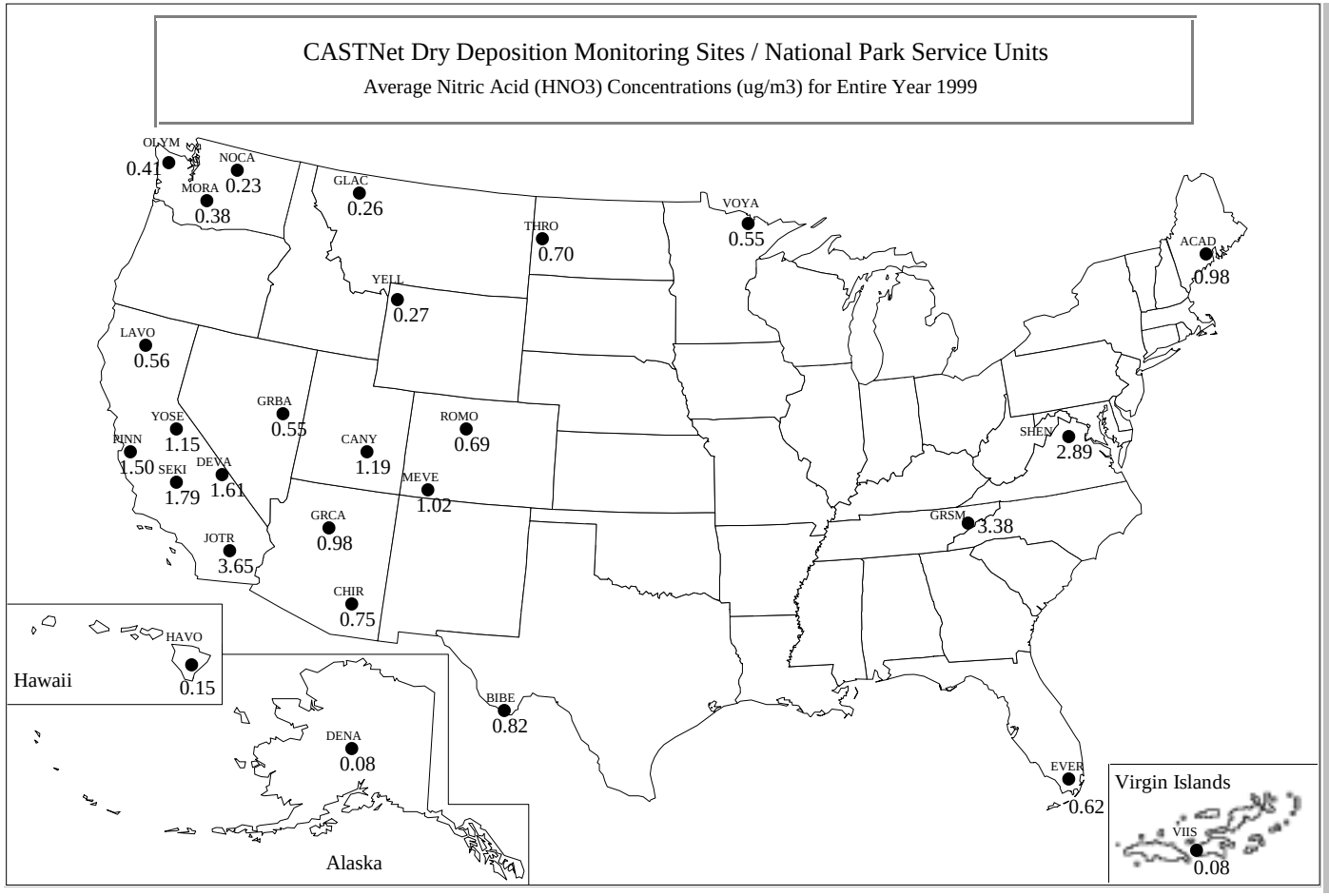


Maximum Concentration (ug/m^3) Average Concentration (ug/m^3)



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 NM
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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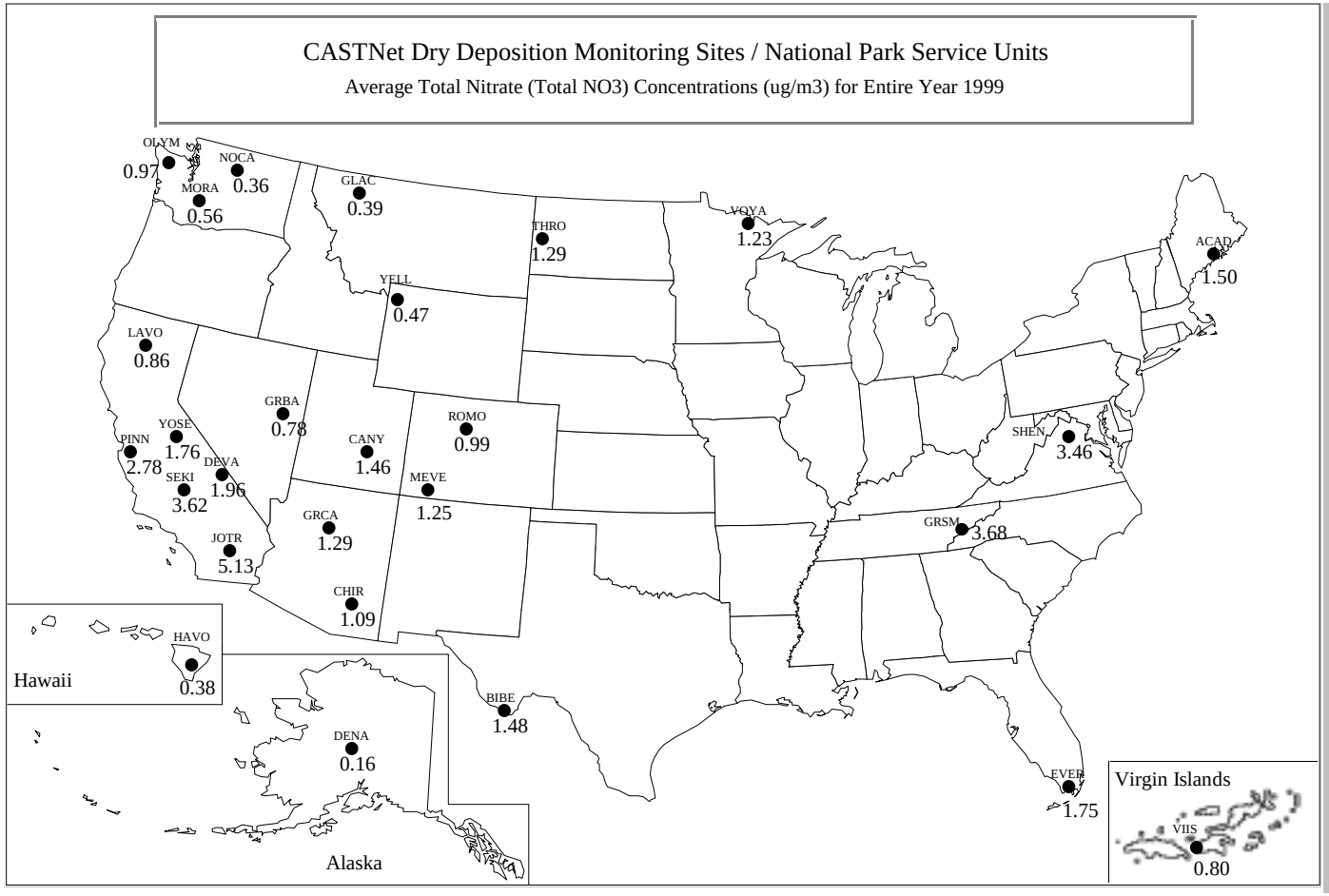

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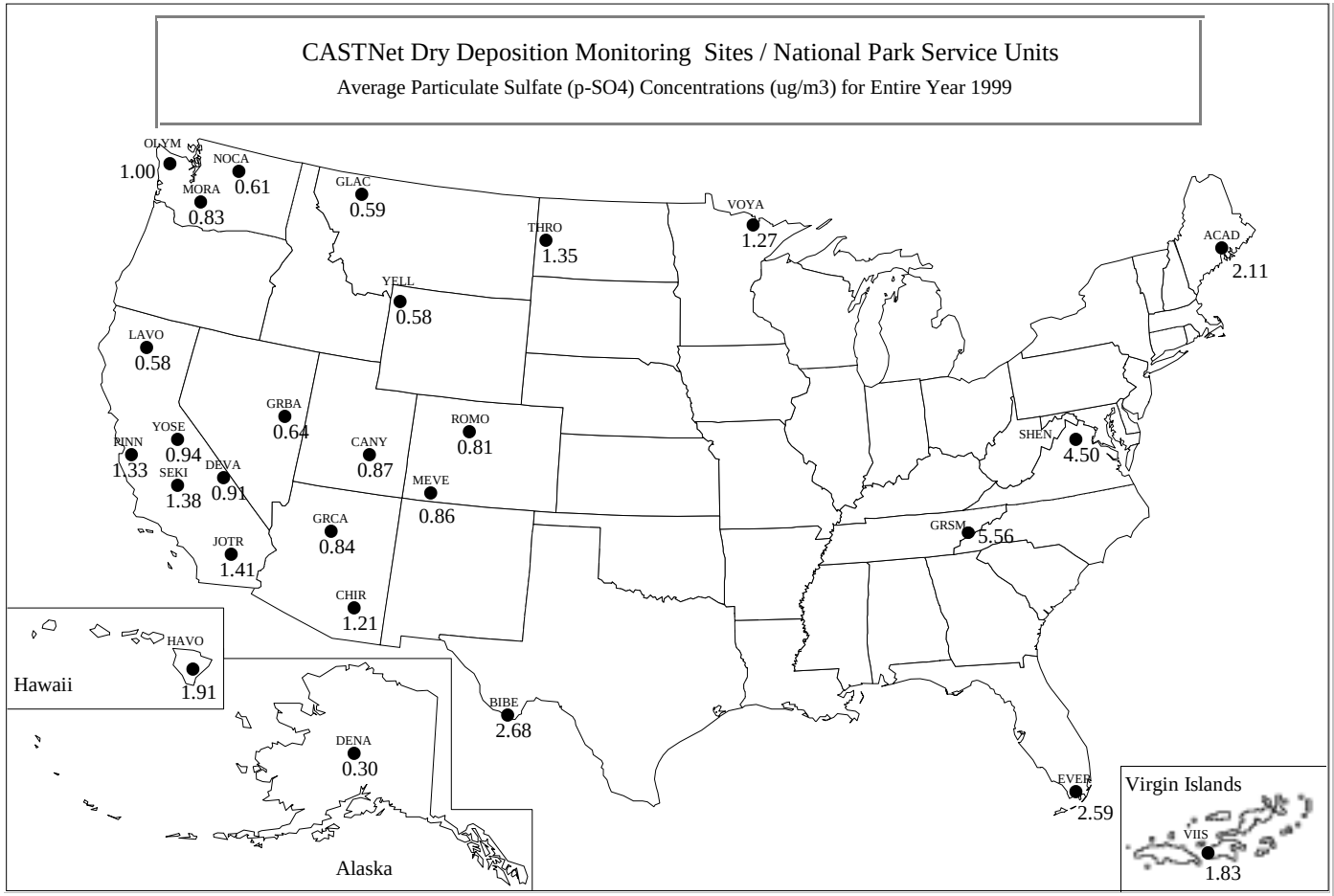

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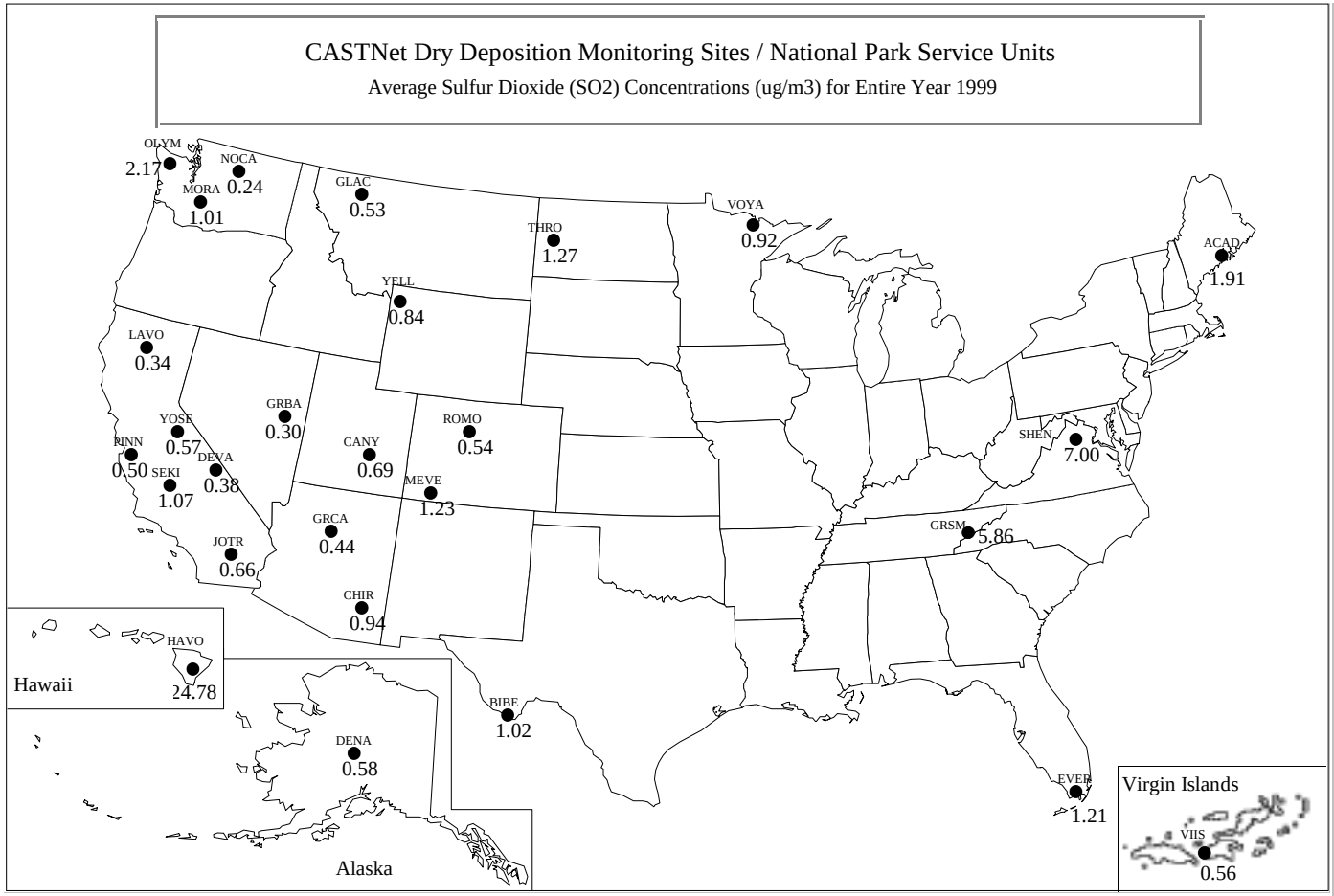

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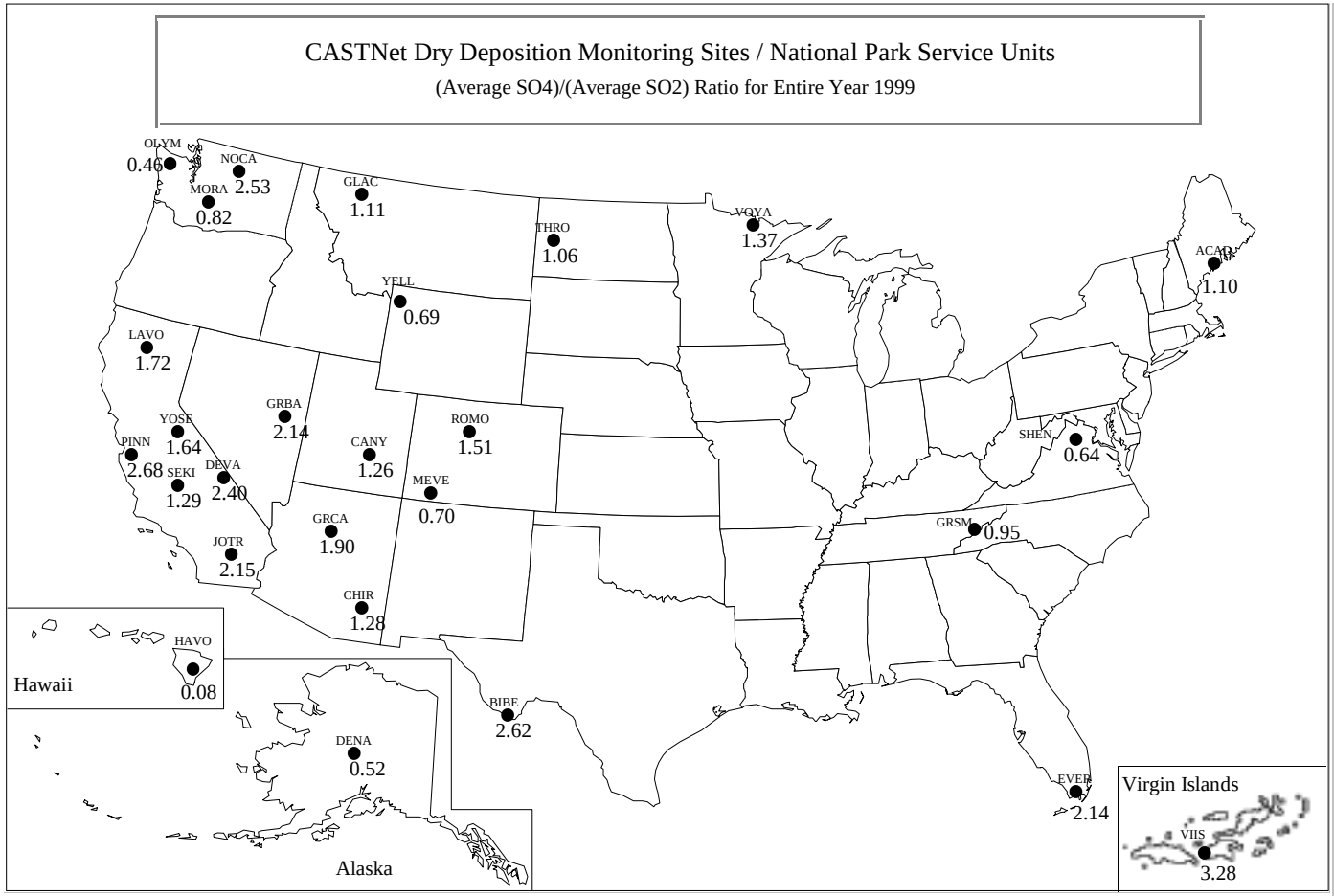

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3.0 NATIONAL PARK SERVICE AIR RESOURCES DIVISION DATA SOURCES

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

Data Disk Contents Summary	
File Name (s)	Description
Hourly	
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	

CASTNet Weekly Species Summary Data	
File Name (s)	Description
CASTNet	
ssssCNyr.ASC	Weekly averages
Where: ssss = site code CN = CASTNet yr = year asc = ascii file	

NPS IMC and AIRS Invalid Data Codes			
NPS IMC VAL CODE	REASON	AIRS CODE	AIRS REASON
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.

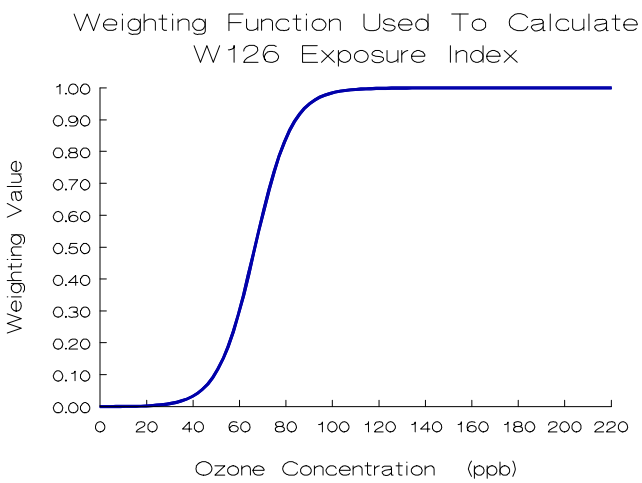
(13) **SUM60 Exposure Index**. The monthly sum of all hourly ozone concentrations equaling or exceeding 60 PPB. Units are PPB-HR. The "MAY-SEP" column sums across the months of May through September to give the cumulative exposure for the growing season. The "ANNUAL" column sums across every month to 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[1] is:

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

where



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 <u>not</u> 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

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_2, NO_2, PM_{10}, Pb, CO, O_3).

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_3): 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_2): 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.

4.3 GLOSSARY OF AIR QUALITY UNITS

Units Conversion Table			
Parameter Type	Multiply	By	To Obtain
Pollutant	ppm	1000	ppb
	ppm	1960	$\mu g/m^3$ Ozone (at 25°C)
	ppm	2615	$\mu g/m^3$ Sulfur Dioxide (at 25°C)
	ppb	0.001	ppm
	ppb	1.960	$\mu g/m^3$ Ozone (at 25°C)
	ppb	2.615	$\mu g/m^3$ Sulfur Dioxide (at 25°C)
	$\mu g/m^3$ Ozone (25°C)	0.0005102	ppm
	$\mu g/m^3$ Ozone (25°C)	0.5102	ppb
	$\mu g/m^3$ Sulfur Dioxide (25°C)	0.0003824	ppm
	$\mu g/m^3$ Sulfur Dioxide (25°C)	0.3824	ppb
Wind Speed	m/s	2.05	mph
	mph	0.489	m/s
Solar Radiation	ly/min	697	w/m^2
	w/m^2	0.00143	ly/min
Precipitation	mm/hr	0.0394	in/hr
	in/hr	25.4	mm/hr
Temperature	°C + 17.78	1.8	°F
	°F - 32	5/9	°C

Where:
ppm = parts per million
ppb = parts per billion
$\mu g/m^3$ = micrograms per cubic meter (at 25°C)
m/s = meters per second
mps = miles per hour
ly/min = langleys per minute
w/m^2 = watts per square meter
mm/hr = millimeters per hour
in/hr = inches per hour
°C = degrees centigrade
°F = degrees fahrenheit