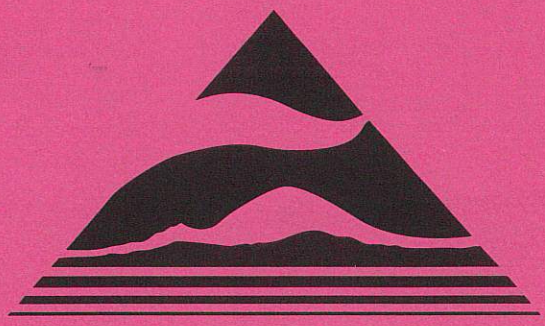
KNECHTEL

1990 Air Quality Data Summary

for the counties

King
Kitsap
Pierce
Snohomish



PUGET SOUND AIR POLLUTION CONTROL AGENCY
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PUGET SOUND AIR POLLUTION CONTROL AGENCY

Serving King, Kitsap, Pierce and Snohomish Counties

1990 AIR QUALITY DATA SUMMARY

Contents

Reference copies of this summary have been placed in public and college libraries within the Puget Sound Region. Copies are available at the Puget Sound Air Pollution Control Agency Seattle headquarters office. A single copy picked up at the Seattle office is free; otherwise the price for each copy is: $4.00 (plus $2.00 postage and handling if mailed).

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EXECUTIVE SUMMARY

Introduction

This nineteenth annual data summary reviews 1990 air quality and meteorological data for the Puget Sound Region. The report begins with sampling network tables providing the address and type of sampling at each location. Summaries of pollutant measurements and information to assist in interpretation appear within the report. Sections near the back provide a summary of air pollution episodes and impaired air quality periods and meteorological analyses consisting of wind speed averages and wind roses.

Air pollution consists of a complex mixture of compounds that are often difficult to quantify. National ambient air quality standards have been established for the six common pollutants known as carbon monoxide, particulate matter, ozone, sulfur dioxide, lead and nitrogen dioxide. For these pollutants Federal law requires meeting the national primary standards which protect health by certain dates.

The Washington Department of Ecology and the Puget Sound Air Pollution Control Agency have established state and local ambient air quality standards for the same six pollutants which are at least as stringent as the national standards. The state and the local ambient sulfur dioxide standard pre-dates the national standard and is also more stringent than the national standard. A table of all these ambient air quality standards and a discussion of the characteristics and effects of each of those air pollutants appear on the last two facing pages of this report.

For the Puget Sound Region, the standards are not yet attained in specific areas for the pollutants carbon monoxide and particulate matter. Though the Puget Sound Region was redesignated as attainment for the pollutant ozone early in 1987, monitoring data during the summer of 1990 indicates the Region may again be out of compliance with the standard. The Region is in attainment of the standards for sulfur dioxide, lead and nitrogen dioxide.

Daily Air Quality

The Agency uses the national Pollutant Standards Index to report daily air quality. The Index value is calculated directly from measurements for each of the pollutants, and the report includes a descriptive term for the daily Index value.

These terms describe the air quality (in progressively more polluted stages) as "Good", "Moderate", "Unhealthful", or "Very Unhealthful". Any pollutant measurement exceeding the short term national primary standard causes the Index value to be in the Unhealthful or a worse category.

The daily Pollutant Standards Index values provide a way to summarize the air quality for the entire year. In 1990:

Everett had 166 Good, 197 Moderate, and 2 Unhealthful days;
Seattle had 239 Good, 126 Moderate, and zero Unhealthful days;
Tacoma had 289 Good, 75 Moderate, and 1 Unhealthful days.

Carbon Monoxide

The carbon monoxide nonattainment areas are located in Seattle (downtown and the University district), in Bellevue (downtown), and in Tacoma (downtown). During 1990 only the station in downtown Everett measured carbon monoxide values which exceeded the level of the primary (health related) standard of 9 ppm averaged over eight hours. These cases for Everett are summarized below.

Location	Number of Days 8 hr Avg Exceeded 9 ppm	Highest 8 hr Avg (ppm)
Everett, Broadway	2	10

Particulate Matter

The particulate matter standards adopted by the U. S. EPA in July 1987 measure only PM_{10} (particles 10 micrometers or less in diameter). The levels for the national primary and secondary PM_{10} standards are 150 ug/m^3 for a 24 hour average and 50 ug/m^3 for an annual arithmetic mean. Washington State and Puget Sound Region PM_{10} standards were established at the same level as the national PM_{10} standards.

For 1990, none of the daily or annual average PM_{10} values exceeded the level of the standard except for one daily value in Tacoma. The following table summarizes the maximum daily PM_{10} value and the annual PM_{10} arithmetic average by monitoring location for the year 1990.

1990 PM_{10} Summary

Location	Maximum Daily PM_{10} Value (ug/m^3)	Annual PM_{10} Arith Avg (ug/m^3)
Marysville, City Hall	120	28.5
Everett, Hoyt & 26th	50	24.2
Bellevue, Bellevue Wy NE	64	21.1
Lake Forest Pk, City Hall	103	26.7
Seattle, Harbor Is	100	34.9
Seattle, Duwamish	134	36.2
Seattle, South Park	108	27.9
Kent, James & Central	103	30.2
NE Tacoma, 27th & 54th	72	29.2
Tacoma, Taylor Way	89	32.6
Tacoma, Alexander	85	30.9
Tacoma, E 11th St	186	33.7

None of the annual PM_{10} values for the past three calendar years exceeded the annual PM_{10} standard of 50 ug/m^3, so the Puget Sound Region is in compliance with the annual PM_{10} standard.

The last three years of data must also be used to determine compliance with the 24 hour average PM_{10} standard. The U. S. EPA requires attainment to be determined by statistically adjusting for days without data and then calculating the average number of days per year exceeding the standard at a particular location for the last three years. If this "expected" number of days above the standard exceeds one, then the PM_{10} standard has not been attained.

This calculation shows one area within the Puget Sound Region where the "expected" number of days above the standard exceeds one per year. This area is the industrialized Tacoma Port area. The following table shows the monitoring locations where the "expected" number of days per year with daily values exceeding 150 ug/m^3 is more than zero; for two Tacoma Port area sites this "expected" number exceeds one.

Location	Number of Days Expected to Exceed 150 ug/m^3
Seattle, Duwamish	0.7
Tacoma, Taylor Way	2.0
Tacoma, Alexander	0.7
Tacoma, E 11th St	1.4

The long record of Total Suspended Particulates (TSP) measurements provides the best information as to any trend. The following table shows the TSP annual geometric mean beginning with 1972 for the industrialized Seattle Harbor Island-Duwamish area and the industrialized Tacoma Port area as well as for a background location at Tolt in the foothills of the Cascades. PM_{10} annual arithmetic mean values are shown in parenthesis after these measurements began.

Annual Particulate Matter Averages
(ug/m³)

Year	Seattle--Duwamish TSP	(PM10)	Tacoma---Port area TSP	(PM10)	Tolt TSP
1972	81		71		14
1973	68		82		12
1974	68		69		13
1975	53		53		9
1976	75		87		12
1977	94		91		11
1978	100		98		10
1979	101		107		10
1980	83		101		10
1981	85		88		15
1982	74		66		10
1983	71	(49)	67	(48)	9
1984	64	(45)	66	(47)	9
1985	77	(54)	80	(55)	10
1986	71	(43)	68	(42)	9
1987	80	(45)	79	(48)	9
1988	73	(39)	69	(43)	9
1989	73	(40)	64	(39)	8
1990	68	(36)	54	(34)	10

These data show the two separate industrialized areas are similar, while both are quite different from the background site outside the urban area. The Tolt site shows a low, reasonably steady value during this nineteen year period.

The two industrial areas appeared to achieve the 60 ug/m³ annual TSP standard in 1975, but values considerably exceeded the standard in the late 70's and then decreased to a level just above the standard in Seattle and just below the standard in Tacoma by the end of 1990. The PM10 levels in these same two areas exceeded the 50 ug/m³ annual standard only in 1985 and are now clearly better than the standard requires.

In an effort to determine if wood smoke was threatening the PM10 standard in some residential areas, survey sampling was conducted during the winters from late 1986 through early 1989 under a special project grant from the U. S. EPA to the University of Washington Department of Civil Engineering. The study identified marked variations in the smoke levels in residential areas determined to a large extent by topography.

As a result, in early June 1989, the Puget Sound Air Pollution Control Agency installed a fully instrumented PM10 monitoring station in an identified wood smoke impacted area near the City Hall in Lake Forest Park. The study suggested this location would be similar to and could be representative of many other wood smoke impacted valleys in the Puget Sound Region.

None of the Lake Forest Park PM10 values have exceeded the national PM10 standard since monitoring began there. The highest PM10 value measured at Lake Forest Park during 1990 was 103 ug/m³.

Ozone

Ozone is a photochemical pollutant with highest levels measured on hot days from mid May to mid September. In 1987 the Puget Sound Region attained the ozone standard, but monitoring data during the summer of 1990 indicates the Region may again be out of compliance with the standard.

If a particular location shows more than one (1.0) daily maximum hour per year, averaged over the last three years, which is in excess of 0.12 ppm, then the ozone standard has been violated. At the Enumclaw monitoring location, for the three year period ending with 1990, the "expected" number of days per year with an hourly average above 0.12 ppm calculated to be 1.3 days; all other ozone monitoring locations showed 1.0 or fewer days.

The following table summarizes the maximum 1 hour average ozone value during 1990 for each ozone monitoring site.

1990 Ozone Summary

Location	Maximum 1 hr Avg (ppm)
Lake Sammamish State Park	0.126
Ravensdale	0.102
Enumclaw, Highway 410	0.149
La Grande, Pack Forest	0.130

Weather and Air Quality

One of the variables that influences the air quality on a given day is the weather. Weather never causes high pollutant levels, but sometimes under stable conditions the pollutants emitted from human activities are not quickly dispersed.

Poor dispersion exists on about one-third of the days during nighttime and early morning hours, but the weather effectively disperses pollutants by afternoon on most of these days. A few times during the months of January, February, October, November or December each year, poor dispersion persists for 24 or more hours and may result in the declaration of an "air pollution episode" or local "impaired air quality". These cases are often associated with the higher pollutant levels. During 1990, the Department of Ecology did not declare any stage of an air pollution episode in the Puget Sound Region.

For 1990, revisions to the Washington Clean Air Act which were effective for the fall heating season changed the criteria for determining "impaired air quality" as well as defining two stages of "impaired air quality". This is discussed in a section near the back of this report. During 1990 the Puget Sound Air Pollution Control Agency declared a local condition of "impaired air quality" resulting in a burn ban on three occasions. These three periods with a burn ban in effect for the four counties of King, Kitsap, Pierce and Snohomish were:

2:30 pm, Friday, January 19 - 2:30 pm, Sunday, January 21;

2:30 pm, Friday, December 7 - 9:30 am, Saturday, December 8;

2:30 pm, Tuesday, December 25 - 8:15 am, Thursday, December 27.

Other Information Sources

All data collected are reported to the Washington State Department of Ecology; some of it is forwarded from there to the Aerometric Information Retrieval System maintained by the U. S. EPA. The Department of Ecology conducts air monitoring within the Puget Sound Region in addition to that done by our Agency. The Department publishes an annual summary of data for the entire state. Requests for the state summary should be directed to the Washington Department of Ecology - PV11, Air Program, Olympia, WA 98504-8711.

The current daily Index is available toll free from the Puget Sound Air Pollution Control Agency by dialing 1-800-433-2215.

1990 SAMPLING NETWORK

Location	Type of Sampling			
Tolt River Watershed, King County, Wa		TSP		
City Hall, 514 Delta Ave, Marysville, Wa	PM10			
Hoyt Ave & 26th St, Everett, Wa	PM10			bsp, SO_2, Wind
* Broadway & Hewitt Ave, Everett, Wa			CO	
* 622 Bellevue Way NE, Bellevue, Wa			CO	
* 504 Bellevue Way NE, Bellevue, Wa	PM10			
* 20050 SE 56th, Lake Sammamish State Park, Wa (seasonal)				O_3
17711 Ballinger Way NE, Lake Forest Park, Wa	PM10			bsp, Wind
* Northgate, 310 NE Northgate Way, Seattle, Wa			CO	
* Sand Point, 7600 Sand Pt Way NE, Seattle, Wa				Wind, Temp, dT
* 5701 8th Ave NE, Seattle, Wa		TSP		Pb
* University Dist, 1307 NE 45th St, Seattle, Wa (began Aug 01)			CO	
* 1960 NE Pacific St, Seattle, Wa (discontinued Jun 19)			CO	
* 1424 4th Ave, Seattle, Wa			CO	
* 5th Ave & James St, Seattle, Wa			CO	
* Beacon Hill, 15th S & Charlestown, Seattle, Wa				Wind, Temp
Harbor Island, 2555 13th Ave SW, Seattle, Wa		TSP		Pb
Harbor Island, 3400 13th Ave SW, Seattle, Wa	PM10			
Duwamish, 4752 E Marginal Way S, Seattle, Wa	PM10	TSP		PM2.5, bsp, SO_2, Wind

Notes- (1) Type of Sampling:

PM10	= Particulate Matter 10 micrometers or smaller	bsp	= Atmospheric Particles (by nephelometer)
TSP	= Total Suspended Particulates	O_3	= Ozone
CO	= Carbon Monoxide	SO_2	= Sulfur Dioxide
PM2.5	= Particulate Matter 2.5 micrometers or smaller	Pb	= Lead
		Temp	= Air Temperature
Wind	= Wind Direction & Speed	dT	= delta Temperature

(2) * Station operated by Washington State Department of Ecology.

1990 SAMPLING NETWORK

Location	Type of Sampling			
South Park, 723 S Concord St, Seattle, Wa	PM_{10}			
Duwamish Valley, 12026 42nd Ave S, King Co, Wa		TSP		
James St & Central Ave, Kent, Wa	PM_{10}			$PM_{2.5}$, bsp, Wind
* Ravensdale, Wa (seasonal)				O_3
115 E Main St, Auburn, Wa		TSP		
* Highway 410, 2 miles east of Enumclaw, Wa (seasonal)				O_3
Sumner Jr HS, 1508 Willow St, Sumner, Wa		TSP		
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	PM_{10}			bsp, SO_2, Wind
2340 Taylor Way, Tacoma, Wa	PM_{10}			
2301 Alexander Ave, Tacoma, Wa	PM_{10}			SO_2, Wind
Fire Station #12, 2316 E 11th St, Tacoma, Wa	PM_{10}	TSP		$PM_{2.5}$, bsp, Wind
* 951 Portland Ave, Tacoma, Wa				SO_2
Cascadia, 2002 E 28th St, Tacoma, Wa		TSP		
Willard School, S 32nd & S 'D' St, Tacoma, Wa		TSP		
* 1101 Pacific Ave, Tacoma, Wa			CO	
Ruston School, 5219 N Shirley St, Tacoma, Wa		TSP		Pb, As
* Charles L Pack Forest, La Grande, Wa (seasonal)				O_3

Notes- (1) Type of Sampling:

PM_{10}	= Particulate Matter 10 micrometers or smaller	bsp	= Atmospheric Particles (by nephelometer)
TSP	= Total Suspended Particulates	O_3	= Ozone
CO	= Carbon Monoxide	SO_2	= Sulfur Dioxide
$PM_{2.5}$	= Particulate Matter 2.5 micrometers or smaller	Pb	= Lead
Wind	= Wind Direction & Speed	As	= Arsenic

(2) * Station operated by Washington State Department of Ecology.

POLLUTANT STANDARDS INDEX

The Pollutant Standards Index (PSI) provides a nationally uniform method to report daily air quality levels. In cooperation with the Washington State Department of Ecology, the Puget Sound Air Pollution Control Agency began reporting the PSI in 1980 for the Everett, Seattle, and Tacoma areas.

Measured pollutant levels during each day are converted to a scale that shows if there are potential health effects. This PSI scale of zero to 500 categorizes air quality by the following descriptions:

from 0 to 50, Good;
from 51 to 100, Moderate;
from 101 to 199, Unhealthful;
from 200 to 299, Very Unhealthful;
from 300 to 500, Hazardous.

The table below shows the pollutant concentration and specific averaging period for each PSI category break-point value. Values between break-points are determined by linear interpolation.

Whenever the PSI is above 100, a measured pollutant level has exceeded the national primary air quality standard established to protect health. An index value of 200 means the pollutant concentration has reached the "Alert" level in the Washington Episode Avoidance Plan.

Each day the pollutant levels within the cities of Everett, Seattle and Tacoma determine the Index. The daily Index value for each city comes from the pollutant with the highest value on the PSI scale. The highest values usually occur near congested traffic or an industrial area.

Since high ozone levels occur some distance downwind of Everett, Seattle or Tacoma on hot summer afternoons, the Agency reports the ozone PSI value in a downwind area during the months from May through September. For 1990 a maximum ozone PSI value of 136 was measured near Enumclaw on August 11. Ozone PSI values also exceeded 100 on two additional summer days during 1990 at this same Enumclaw station.

Tables which follow summarize the daily PSI values for Everett, Seattle, and Tacoma. The 1990 summary table shows for each month the number of days in each PSI interval, the maximum Index, the date of the maximum and the pollutant determining the maximum value.

A 1980 through 1990 summary table shows annually the number of days in each air quality category and the number of days each pollutant determined the PSI. For all the unhealthful days each year (Index values greater than 100), this summary also tabulates the pollutant responsible. The right-hand columns list the highest PSI value.

Pollutant Concentration for Each PSI Break-point Value

PSI Value	CO *8 hr Avg (ppm)*	PM10 *24 hr Avg (ug/m^3)*	SO_2 *24 hr Avg (ppm)*	O_3 *1 hr Avg (ppm)*
50	4.5	50	0.03	0.06
100	9.0	150	0.14	0.12
200	15.0	350	0.30	0.20
300	30.0	420	0.60	0.40
400	40.0	500	0.80	0.50
500	50.0	600	1.00	0.60

POLLUTANT STANDARDS INDEX

1990

EVERETT

Number of Days in Each PSI Interval during Each Month

AIR QUALITY	(PSI Interval)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
GOOD	(0 to 50)	17	14	12	11	14	13	11	5	5	19	24	21	166
MODERATE	(51 to 100)	14	14	18	19	17	17	20	26	24	12	6	10	197
UNHEALTHFUL	(101 to 199)	0	0	1	0	0	0	0	0	1	0	0	0	2
VERY UNHEALTHFUL	(200 to 299)	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum PSI each month		89	89	117	100	78	100	100	100	117	78	78	89	117
Date		12th	23rd#	2nd	16th	3rd#	21st	10th	10th	21st	5th	7th	11th	Mar 2
Pollutant		CO	CO	CO	CO	CO	CO	CO	CO	CO	CO	CO	CO	CO

SEATTLE

Number of Days in Each PSI Interval during Each Month

AIR QUALITY	(PSI Interval)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
GOOD	(0 to 50)	21	17	18	22	28	29	27	25	14	14	12	12	239
MODERATE	(51 to 100)	10	11	13	8	3	1	4	6	16	17	18	19	126
UNHEALTHFUL	(101 to 199)	0	0	0	0	0	0	0	0	0	0	0	0	0
VERY UNHEALTHFUL	(200 to 299)	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum PSI each month		100	85	92	63	57	51	59	67	67	89	67	89	100
Date		18th	28th	1st	6th	5th	21st	12th	9th	22nd	26th	2nd#	7th	Jan 18
Pollutant		CO	PM	PM	PM	PM	PM	PM	CO	CO	CO	CO	CO	CO

TACOMA

Number of Days in Each PSI Interval during Each Month

AIR QUALITY	(PSI Interval)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
GOOD	(0 to 50)	23	20	18	23	30	27	28	26	17	25	28	24	289
MODERATE	(51 to 100)	8	8	13	7	0	3	3	5	13	6	2	7	75
UNHEALTHFUL	(101 to 199)	0	0	0	0	1	0	0	0	0	0	0	0	1
VERY UNHEALTHFUL	(200 to 299)	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum PSI each month		89	73	95	65	118	57	63	68	65	89	56	78	118
Date		19th	23rd	2nd	10th	5th	21st	5th	10th	28th	24th	2nd	6th#	May 5
Pollutant		CO	PM	PM	PM	PM	PM	PM	PM	PM	CO	PM	CO	PM

PM = Particulate Matter; CO = Carbon Monoxide; SO2 = Sulfur Dioxide.

Earliest date of occurrence

POLLUTANT STANDARDS INDEX

1980 - 1990

EVERETT

	Days in Each Air Quality Category				Pollutant Determining the PSI						Highest Value		
					All Days			Unhealthful Days					
	Good	Moderate	Unhealthful	Very Unhealthful	PM	CO	SO2	PM	CO	SO2	PSI	Date	Pollutant
1980	340	19	0	0	356	-	3	0	-	0	60	Jan 23	PM
1981	350	11	0	0	340	-	21	0	-	0	62	Jan 16	PM
1982	334	30	1	0	277	70	18	0	1	0	117	Dec 30	CO
1983	308	56	1	0	191	150	24	0	1	0	117	Nov 30	CO
1984	309	57	0	0	105	217	44	0	0	0	92	Sep 28	PM
1985	300	64	1	0	152	166	47	0	1	0	117	Dec 11	CO
1986	324	41	0	0	169	148	48	0	0	0	89	Jan 25	CO
1987	203	158	3	0	96	250	18	0	3	0	117	Jun 26#	CO
1988	174	184	8	0	15	345	6	0	8	0	133	Sep 13#	CO
1989	150	213	2	0	26	338	1	0	2	0	133	Feb 10	CO
1990	166	197	2	0	29	335	1	0	2	0	117	Mar 2#	CO
Totals	2958	1030	18	0	1756	2019	231	0	18	0			

SEATTLE

	Days in Each Air Quality Category				Pollutant Determining the PSI						Highest Value		
					All Days			Unhealthful Days					
	Good	Moderate	Unhealthful	Very Unhealthful	PM	CO	SO2	PM	CO	SO2	PSI	Date	Pollutant
1980	73	275	18	0	95	270	1	1	17	0	194	Jan 23	PM
1981	69	267	28	1	109	254	2	5	24	0	213	Jan 15	CO
1982	86	268	10	1	96	264	5	1	10	0	214	Feb 6	PM
1983	98	258	9	0	101	261	3	0	9	0	183	Jan 28	CO
1984	146	218	2	0	111	242	13	2	0	0	103	Dec 6	PM
1985	150	202	10	3	156	206	3	6	7	0	204	Dec 12	PM
1986	130	226	8	1	113	246	6	1	8	0	206	Jan 7	PM
1987	120	238	7	0	119	246	0	3	4	0	184	Feb 6	PM
1988	215	146	5	0	67	298	1	2	3	0	150	Dec 3	CO
1989	231	134	0	0	129	233	3	0	0	0	100	Jan 19#	CO
1990	239	126	0	0	141	218	6	0	0	0	100	Jan 18	CO
Totals	1557	2358	97	6	1237	2738	43	21	82	0			

TACOMA

	Days in Each Air Quality Category				Pollutant Determining the PSI						Highest Value		
					All Days			Unhealthful Days					
	Good	Moderate	Unhealthful	Very Unhealthful	PM	CO	SO2	PM	CO	SO2	PSI	Date	Pollutant
1980	83	271	12	0	256	107	3	4	8	0	160	Apr 12	PM
1981	74	278	10	3	222	137	6	1	12	0	227	Jan 12	CO
1982	119	242	4	0	255	101	9	0	4	0	167	Dec 30	CO
1983	140	222	3	0	228	128	9	1	2	0	137	Dec 23	PM
1984	162	198	6	0	207	149	10	0	6	0	117	Jan 19#	CO
1985	140	213	12	0	252	109	4	1	11	0	165	Dec 13	PM
1986	161	197	7	0	247	114	4	2	5	0	167	Oct 23	CO
1987	173	177	13	2	227	136	2	5	10	0	220	Feb 5	CO
1988	226	132	8	0	184	175	7	3	5	0	183	Jan 27	CO
1989	260	103	2	0	217	121	27	0	2	0	117	Nov 30#	CO
1990	289	75	1	0	237	87	41	1	0	0	118	May 5	PM
Totals	1827	2108	78	5	2532	1364	122	18	65	0			

Earliest date of occurrence

PARTICULATE MATTER

Introduction

Particulate Matter as a general term includes small particles of dust, soot, organic matter and compounds containing sulfur, nitrogen, and metals. In July 1987, the U. S. EPA changed the national particulate matter standards from the measurement of Total Suspended Particulates (TSP) to the measurement of only that portion of particulate matter with particle diameters smaller than or equal to 10 micrometers (PM_{10}). The levels for the national primary and secondary standards are identical, 150 ug/m^3 for a 24 hour average and 50 ug/m^3 annual arithmetic mean. The PM_{10} standards also include calculation formulas for statistically determining whether the standards are attained (40 CFR Part 50, Appendix K).

Particulate Sources and Air Quality

Particulates directly enter the air from industrial operations, from auto, bus and truck traffic, from fuel combustion including wood stoves and fireplaces, from construction, and from other sources. The emission levels change daily due to intermittent industrial operations, equipment upset or breakdown, traffic cycles and building heating requirements. Gaseous transformation products like sulfates, nitrates, and some organics are also components of particulate matter. In the air, particulate matter disperses and is transported by the wind. Ambient levels change from day to day in response to what enters the air and to the variations in weather conditions.

Manual Sampling Methods

The reference methods designated by the U. S. EPA to measure PM_{10} all draw outside air first through an inlet which traps particulates larger than 10 micrometers and then through a filter which collects the remaining particulate matter (PM_{10}). Sampling for a single measurement continues for 24 hours usually from midnight to midnight. After sampling, the pre-weighed filter is manually removed and, following conditioning in a controlled atmosphere to remove moisture effects, the sampled filter is weighed on a precise balance to calculate the weight of particulate matter collected. The volume of air sampled, corrected to standard temperature and pressure conditions, is calculated from the flow rate and sampling time. The ambient PM_{10} concentration is the weight (mass) of the particulate collected divided by the volume of air sampled, and is reported in micrograms per standard cubic meter.

The TSP method measures the total particulate concentration following a procedure essentially like the PM_{10} reference method except that the inlet is not size selective. For TSP, outside air reaches the collection filter after being drawn under the roof covering a small rectangular shelter containing the high volume sampler.

Continuous Sampling

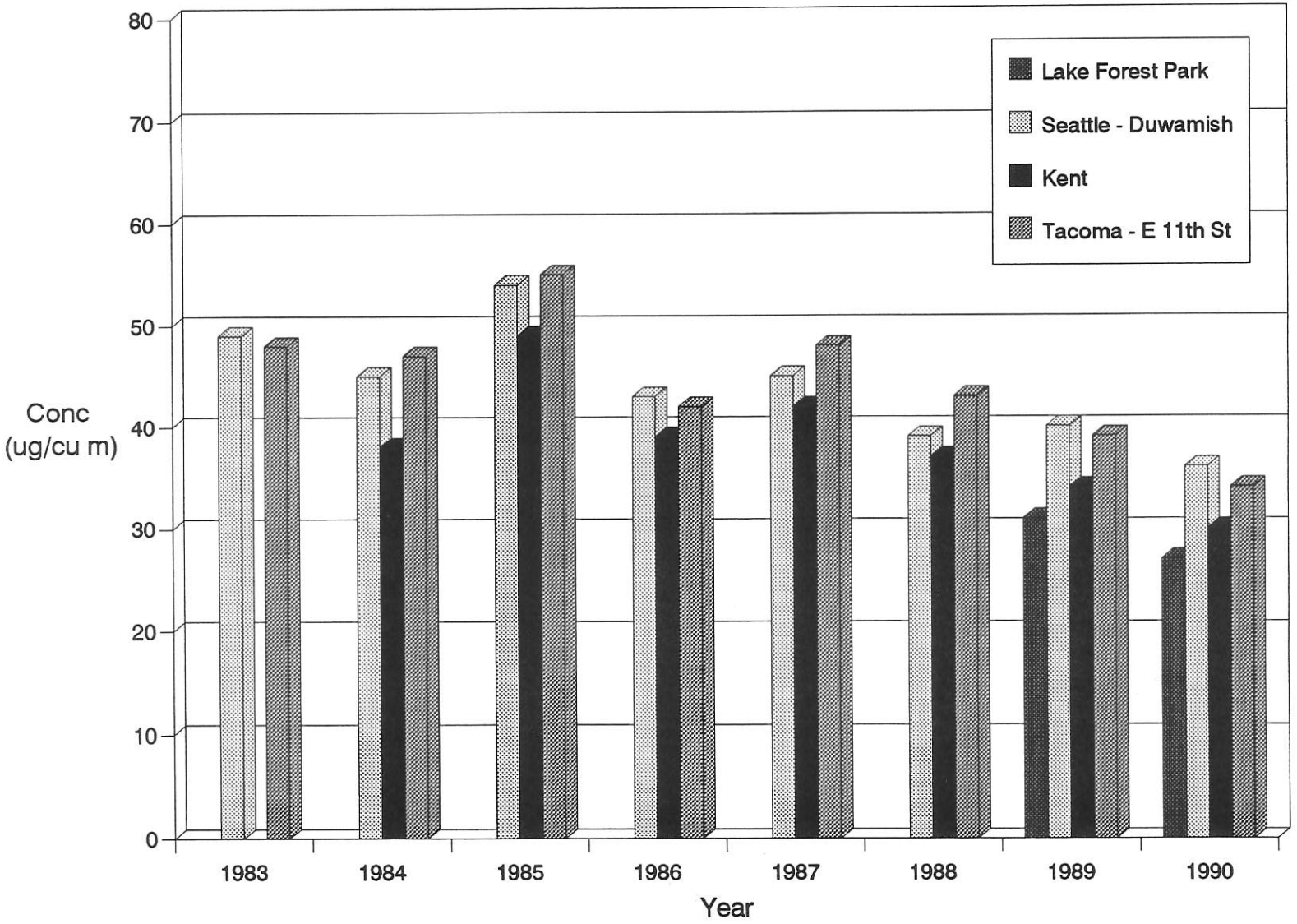
An integrating nephelometer continuously measures the light scattering extinction coefficient. A component of the scattering coefficient due to dry particles, (b_{sp}), generally shows good correlation to PM_{10} values. The b_{sp} values are reported as a scattering coefficient per meter times 10^{-4}. When operated at a site concurrent with the reference method, a relationship between the two methods may be developed for that site. Each relationship (multiple regression equation) enables use of the continuous nephelometer measurement to provide a satisfactory real-time estimate of the manual reference PM_{10} value.

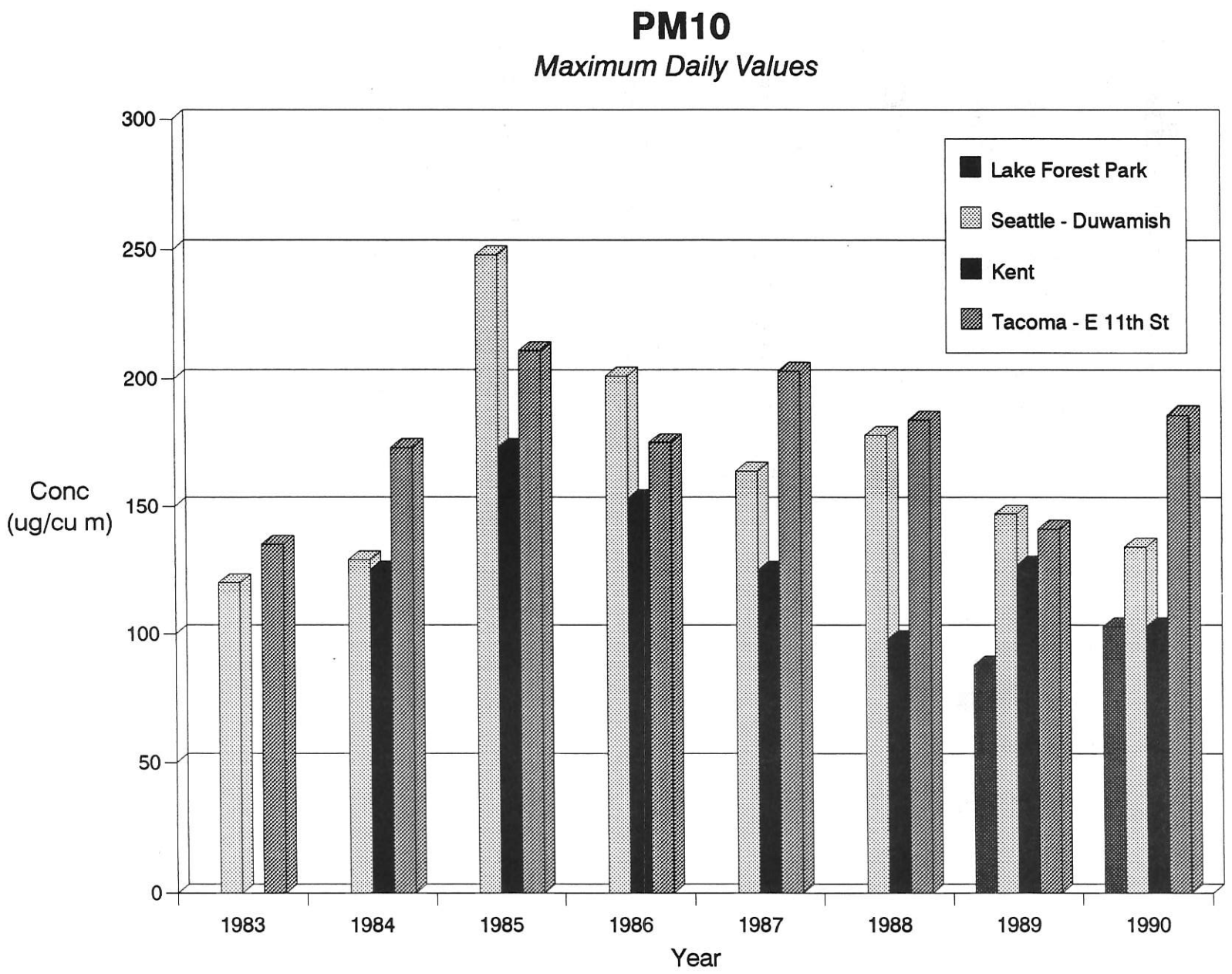
Graphs and Summaries of Data

The following graphs and tables summarize PM_{10}, TSP, and nephelometer measurements. Column graphs for selected stations present a PM_{10} history from the beginning of PM_{10} measurements. None of the annual PM_{10} values for the past three calendar years exceeded the annual PM_{10} standard of 50 ug/m^3. Though the number of daily PM_{10} values exceeding the level of the 150 ug/m^3 standard has decreased, the Tacoma Port area station (E 11th St) has not yet attained this short term standard.

PM10

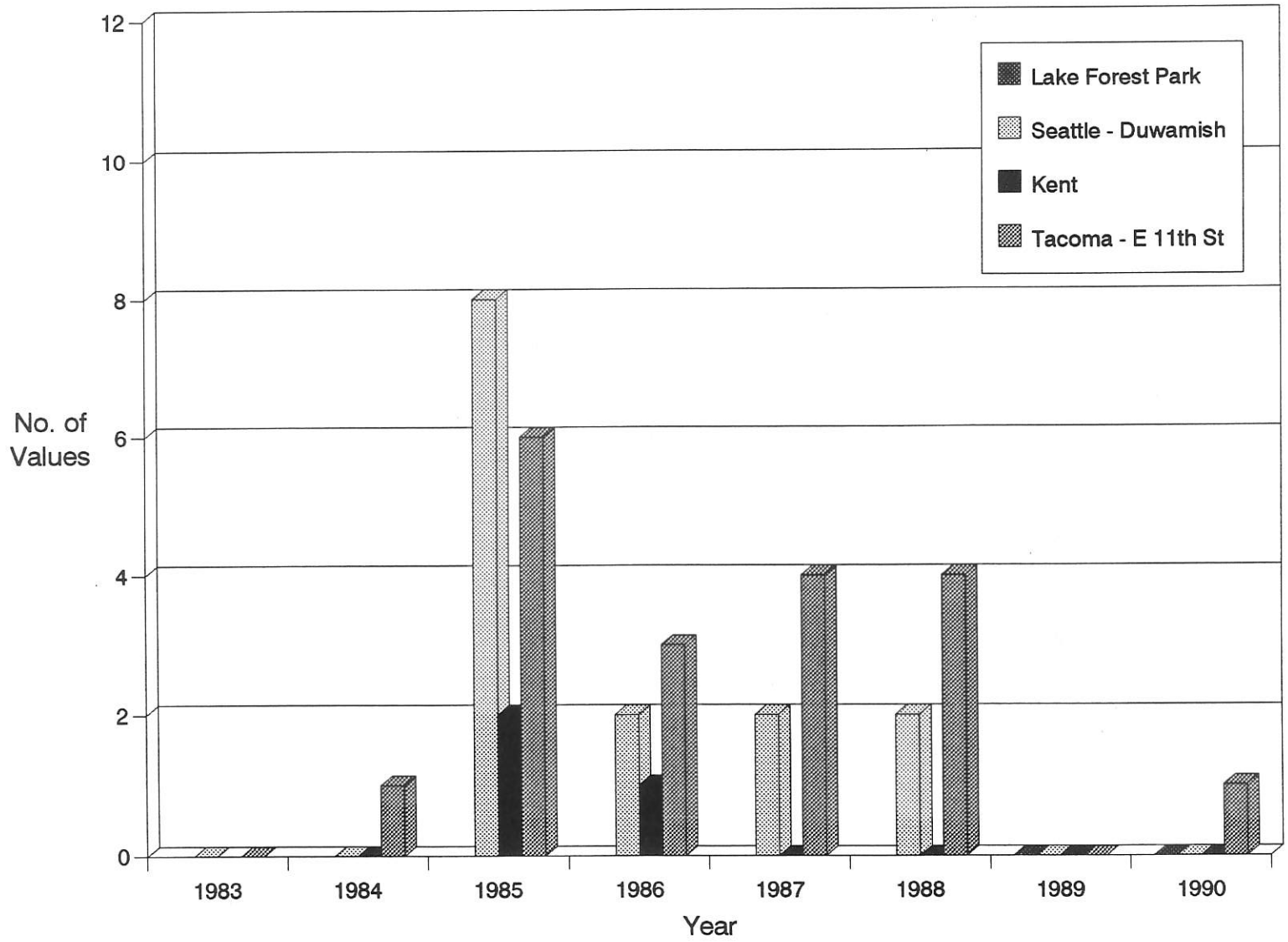
Annual Arithmetic Averages




PM10
Maximum Daily Values
Conc
(ug/cu m)
300
250
200
150
100
50
0
Lake Forest Park
Seattle - Duwamish
Kent
Tacoma - E 11th St
1983
1984
1985
1986
1987
1988
1989
1990
Year

PM10

No. of Daily Values Greater than 150 ug/cu m



PARTICULATE MATTER (PM10)
Micrograms per Standard Cubic Meter

Sampled by Size Selective Inlet - Hi Vol SA1200 Quartz Fiber filters

1990

Location	Number of Values	Quarterly Arithmetic Averages 1st	2nd	3rd	4th	Year Arith Mean
City Hall, 514 Delta Ave, Marysville, Wa	110	33.2	23.2	30.7	26.8	28.5
Hoyt Ave & 26th St, Everett, Wa	58	23.9	21.9	30.8	20.0	24.2
504 Bellevue Way NE, Bellevue, Wa	264	22.3	19.0	24.4	18.8	21.1
17711 Ballinger Way NE, Lake Forest Park, Wa	346	38.2	20.2	22.3	25.9	26.7
Harbor Island, 3400 13th Ave SW, Seattle, Wa	58	37.5	32.3	34.7	35.0	34.9
Duwamish, 4752 E Marginal Way S, Seattle, Wa	350	40.5	31.6	36.7	36.1	36.2
South Park, 723 S Concord St, Seattle, Wa	59	32.5	19.5	34.5	25.1	27.9
James St & Central Ave, Kent, Wa	354	33.3	25.6	34.8	27.0	30.2
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	59	27.3	23.0	39.6	26.8	29.2
2340 Taylor Way, Tacoma, Wa	57	36.2	25.3	39.1	29.7	32.6
2301 Alexander Ave, Tacoma, Wa	145	33.7	24.9	34.1	30.9	30.9
Fire Station #12, 2316 E 11th St, Tacoma, Wa	353	36.9	32.1	35.2	30.7	33.7

Notes
(1) Nationally scheduled particulate matter sampling occurs each sixth day. Quarterly averages are shown only when at least one data value exists for 75 percent or more of the six day intervals.
(2) Annual averages are shown only if there are at least three quarterly averages.

Summary of Maximum and 2nd High Observed Concentrations

Location	Jan 19 Fri	Jan 20 Sat	Feb 27 Tue	Feb 28 Wed	Mar 1 Thu	Mar 2 Fri	Mar 28 Wed	Mar 30 Fri	Apr 5 Thu	May 5 Sat	Sep 26 Wed	Oct 23 Tue	Dec 7 Fri	Dec 22 Sat
City Hall, 514 Delta Ave, Marysville, Wa	--	--	--	90	--	--		--	--					120
Hoyt Ave & 26th St, Everett, Wa	--	--	--	--	--	--	50	--	--	--	48	--		--
504 Bellevue Way NE, Bellevue, Wa	--	53	--		--	--	--	64				--		
17711 Ballinger Way NE, Lake Forest Park, Wa			99	103										--
Harbor Island, 3400 13th Ave SW, Seattle, Wa	--	--	--	100	--	--	--					--	95	--
Duwamish, 4752 E Marginal Way S, Seattle, Wa			--	119	134									
South Park, 723 S Concord St, Seattle, Wa	--	--	--	108	--	--	--					--	72	--
James St & Central Ave, Kent, Wa	103				95									
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	--	--	--		--	--	--	67	72		67	--		--
2340 Taylor Way, Tacoma, Wa	--	--	--	89	--	--	--					--	72	--
2301 Alexander Ave, Tacoma, Wa	--			--	85	--	--	--			--	84	--	
Fire Station #12, 2316 E 11th St, Tacoma, Wa						140				186				

-- Indicates no sample on specified day

PARTICULATE MATTER (PM10)
Micrograms per Standard Cubic Meter

Sampled by Size Selective Inlet - Hi Vol SA1200 Quartz Fiber filters

Jan - Mar, 1990

Summary of Observations Equal To or Greater Than 75

Location	Jan 12 Fri	Jan 18 Thu	Jan 19 Fri	Jan 20 Sat	Feb 18 Sun	Feb 19 Mon	Feb 22 Thu	Feb 23 Fri	Feb 26 Mon	Feb 27 Tue	Feb 28 Wed	Mar 1 Thu	Mar 2 Fri	Mar 28 Wed
City Hall, 514 Delta Ave, Marysville, Wa	--	--	--	--		--	--	--		--	90	--	--	
17711 Ballinger Way NE, Lake Forest Park, Wa		96	78	83	92		98	80	82	99	103	87	91	
Harbor Island, 3400 13th Ave SW, Seattle, Wa	--	--	--	--	--	--		--	--	--	100	--	--	--
Duwamish, 4752 E Marginal Way S, Seattle, Wa	93		111	82				--		--	119	134	111	81
South Park, 723 S Concord St, Seattle, Wa	--	--	--	--	--	--		--	--	--	108	--	--	--
James St & Central Ave, Kent, Wa		82	103		87	89						95	93	
2340 Taylor Way, Tacoma, Wa	--	--	--	--	--	--		--	--	--	89	--	--	--
2301 Alexander Ave, Tacoma, Wa	--	83	--	80	--	--		--	--		--	85	--	--
Fire Station #12, 2316 E 11th St, Tacoma, Wa	76	85	111	84		79		95		82	89	97	140	

-- Indicates no sample on specified day

Mar - Dec, 1990

Summary of Observations Equal To or Greater Than 75

Location	Mar 31 Sat	Apr 6 Fri	Apr 10 Tue	May 5 Sat	Jul 5 Thu	Aug 10 Fri	Sep 28 Fri	Oct 23 Tue	Oct 24 Wed	Dec 6 Thu	Dec 7 Fri	Dec 22 Sat	Dec 23 Sun	Dec 25 Tue
City Hall, 514 Delta Ave, Marysville, Wa	--	--	--		--	--	--		--	--		120	--	
17711 Ballinger Way NE, Lake Forest Park, Wa											79	--	--	--
Harbor Island, 3400 13th Ave SW, Seattle, Wa	--	--	--		--	--	--	--	--	--	95	--	--	--
Duwamish, 4752 E Marginal Way S, Seattle, Wa	75	75					78		78	78	86			
South Park, 723 S Concord St, Seattle, Wa	--	--	--		--	--	--	--	--	--		--	--	--
James St & Central Ave, Kent, Wa	86													89
2340 Taylor Way, Tacoma, Wa	--	--	--		--	--	--	--	--	--		--	--	--
2301 Alexander Ave, Tacoma, Wa		--			--	--	--	84	--		--		--	79
Fire Station #12, 2316 E 11th St, Tacoma, Wa			80	186	75	86	79		79	75	77		93	83

-- Indicates no sample on specified day

SUSPENDED PARTICULATES (TSP)
Micrograms per Standard Cubic Meter

Sampled by Standard High Volume Quartz Fiber filters

1990

Location	Number of Values	Quarterly Arithmetic Averages 1st	2nd	3rd	4th	Year Arith Mean	Year Geom Mean
Tolt River Watershed, King County, Wa	55	8.5	15.8	25.6	5.8	13.9	9.9
5701 8th Ave NE, Seattle, Wa	58	51.8	40.8	45.9	39.6	44.5	41.4
Harbor Island, 2555 13th Ave SW, Seattle, Wa	58	54.8	54.3	59.5	52.4	55.3	48.7
Duwamish, 4752 E Marginal Way S, Seattle, Wa	352	86.4	73.6	75.8	68.0	76.0	67.5
Duwamish Valley, 12026 42nd Ave S, King Co, Wa	59	53.2	31.6	50.7	35.9	42.9	35.5
115 E Main St, Auburn, Wa	59	49.6	39.5	50.9	35.1	43.8	38.0
Sumner Jr HS, 1508 Willow St, Sumner, Wa	59	37.5	26.9	44.1	24.4	33.2	27.0
Fire Station #12, 2316 E 11th St, Tacoma, Wa	301	71.1	76.5	71.4	48.5	66.9	54.0
Cascadia, 2002 E 28th St, Tacoma, Wa	59	47.9	39.4	72.0	32.2	47.9	36.6
Willard School, S 32nd & S 'D' St, Tacoma, Wa	59	50.1	32.5	54.1	32.4	42.3	33.1
Ruston School, 5219 N Shirley St, Tacoma, Wa	59	25.1	21.1	30.6	22.2	24.8	21.4

Notes
(1) Nationally scheduled particulate matter sampling occurs each sixth day. Quarterly averages are shown only when at least one data value exists for 75 percent or more of the six day intervals.
(2) Annual averages are shown only if there are at least three quarterly averages.

Summary of Maximum and 2nd High Observed Concentrations

Location	Feb 22 Thu	Feb 28 Wed	Mar 1 Thu	Mar 2 Fri	Mar 12 Mon	Mar 30 Fri	May 5 Sat	Aug 3 Fri	Sep 20 Thu
Tolt River Watershed, King County, Wa			--	--			55	40	
5701 8th Ave NE, Seattle, Wa		--	--	--	101	100			
Harbor Island, 2555 13th Ave SW, Seattle, Wa		132	--	--			151		
Duwamish, 4752 E Marginal Way S, Seattle, Wa		279	321						
Duwamish Valley, 12026 42nd Ave S, King Co, Wa		167	--	--		109			
115 E Main St, Auburn, Wa		116	--	--			105		
Sumner Jr HS, 1508 Willow St, Sumner, Wa		73	--	--		78			
Fire Station #12, 2316 E 11th St, Tacoma, Wa				302			555		
Cascadia, 2002 E 28th St, Tacoma, Wa		125	--	--					105
Willard School, S 32nd & S 'D' St, Tacoma, Wa	102	133	--	--					
Ruston School, 5219 N Shirley St, Tacoma, Wa		72	--	--			49		

-- Indicates no sample on specified day

SUSPENDED PARTICULATES (TSP)
Micrograms per Standard Cubic Meter

Sampled by Standard High Volume Quartz Fiber filters

Jan - Mar, 1990

Summary of Observations Greater Than 150

Location	Jan 12 Fri	Jan 19 Fri	Feb 13 Tue	Feb 23 Fri	Feb 27 Tue	Feb 28 Wed	Mar 1 Thu	Mar 2 Fri	Mar 12 Mon	Mar 13 Tue	Mar 16 Fri	Mar 27 Tue	Mar 28 Wed
Harbor Island, 2555 13th Ave SW, Seattle, Wa	--	--	--	--	--		--	--		--	--	--	--
Duwamish, 4752 E Marginal Way S, Seattle, Wa	161	191		183	210	279	321	252	167	160	159	165	196
Duwamish Valley, 12026 42nd Ave S, King Co, Wa	--	--	--	--	--	167	--	--		--	--	--	--
Fire Station #12, 2316 E 11th St, Tacoma, Wa		168	152	169	176	166	183	302					

-- Indicates no sample on specified day

Apr - Dec, 1990

Summary of Observations Greater Than 150

Location	Apr 5 Thu	Apr 6 Fri	Apr 9 Mon	Apr 10 Tue	Apr 16 Mon	May 4 Fri	May 5 Sat	Jul 5 Thu	Aug 10 Fri	Aug 15 Wed	Dec 6 Thu
Harbor Island, 2555 13th Ave SW, Seattle, Wa		--	--	--	--	--	151	--	--		--
Duwamish, 4752 E Marginal Way S, Seattle, Wa	152	178	165				198			156	174
Duwamish Valley, 12026 42nd Ave S, King Co, Wa		--	--	--	--	--		--	--		--
Fire Station #12, 2316 E 11th St, Tacoma, Wa				167	192	155	555	163	197		

-- Indicates no sample on specified day

ATMOSPHERIC PARTICLES
(bsp (X 10 Exp-4)/M)
1990

Location	Monthly Arithmetic Averages												No. of 1 Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Hoyt Ave & 26th St, Everett, Wa	.55	.71	.66	.51	.45	.38	.47	.49	.87	.44	.37	.61	8664	.54
17711 Ballinger Way NE, Lake Forest Park, Wa	1.04	1.01	1.01	.71	.49	.35	.38	.37	.82	.84	.62	1.15	8224	.73
Duwamish, 4752 E Marginal Way S, Seattle, Wa	.66	.55	.77	.56	.43	.34	.43	.49	.91	.60	.50	.81	8651	.59
James St & Central Ave, Kent, Wa		.81	.92	.63	.41	.31	.39	.35	.87	.61	.52	1.06	8281	.60
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	.58	.52	.67	.47	.33		.37	.38	.69	.51	.40		8029	.49
Fire Station #12, 2316 E 11th St, Tacoma, Wa	.73	.68	.80	.53		.36	.45	.44	.82	.67	.52	.99	8307	.62

Statistical Summary

Location	No. of 1 Hour Samples	Frequency Distribution - Percent												1 Hour Max	Arith Mean	Arith Std Dev
		5	10	20	30	40	50	60	70	80	90	95	99			
Hoyt Ave & 26th St, Everett, Wa	8664	.1	.2	.2	.3	.4	.4	.5	.6	.8	1.1	1.4	2.0	4.58	.54	.42
17711 Ballinger Way NE, Lake Forest Park, Wa	8224	.1	.2	.2	.3	.4	.4	.6	.7	1.0	1.6	2.3	4.2	8.85	.73	.84
Duwamish, 4752 E Marginal Way S, Seattle, Wa	8651	.2	.2	.2	.3	.4	.4	.5	.6	.8	1.2	1.6	2.8	5.35	.59	.52
James St & Central Ave, Kent, Wa	8281	.1	.1	.2	.2	.3	.4	.5	.7	.9	1.3	1.8	3.2	6.39	.60	.63
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	8029	.1	.1	.2	.2	.3	.3	.4	.5	.7	1.0	1.4	2.4	5.15	.49	.47
Fire Station #12, 2316 E 11th St, Tacoma, Wa	8307	.1	.1	.2	.3	.3	.4	.5	.7	.9	1.4	1.9	3.5	5.86	.62	.66

PM_{10} SITE SPECIFIC RELATIONSHIPS and ANALYSIS FOR DAYS WITH THE HIGHEST PM_{10} VALUES

Introduction

The reference methods designated by the U. S. EPA to measure PM_{10} all collect particulate matter on a filter for a 24 hour period. The actual PM_{10} value is not available until sampling ends and each sampled filter is manually removed, transported to the Seattle laboratory, conditioned for at least 24 hours and then processed. This may not be completed for several days.

Since these PM_{10} reference methods provide only historic data, an alternate, acceptable real-time technique is needed to provide the PM_{10} value for the daily Pollutant Standards Index since the Federal Regulations indicate the Index should be based on data obtained during the 24 hour period immediately preceding the time of the report. Additionally, under the Washington Clean Air Act and Department of Ecology implementing regulations, real-time PM_{10} values are needed to declare an "impaired air quality" condition. The declaration of "impaired air quality" prohibits outdoor fires and bans most indoor burning.

During September and October 1990, the U. S. EPA certified two different continuous PM_{10} monitors as equivalent to the reference method. When sited and operated according to approved procedures, these new monitors can directly provide approved PM_{10} values which are immediately available to report the daily Index or determine a condition of "impaired air quality". For other real-time monitoring techniques, site specific relationships may be developed to provide a real-time estimate of the 24 hour average PM_{10} value at specific locations.

Site Specific Relationships

The Federal Regulations (40 CFR Part 58, Appendix G) provide that particulate measurements from samplers other than reference or equivalent method samplers may be included in Pollutant Standards Index calculations, if such measurements can be quantitatively related to reference or equivalent method measurements. The Puget Sound Air Pollution Control Agency used multiple linear regression to quantitatively relate continuous nephelometer particulate measurements of dry particle light scattering (b_{sp}) to the PM_{10} measurements during 1990 for specific sites in Everett, Lake Forest Park, Seattle-Duwamish, Kent, Northeast Tacoma and the Tacoma tideflats.

A summary of the 1990 statistics and results of the multiple regression analysis appears in the table subtitled, "Site Specific PM_{10}, b_{sp} Statistics and Equations". Review of the partial correlation coefficients for all the sites reveals correlations from .75 to .88 between the collocated continuous particulate measurement (b_{sp}) and the PM_{10} value. As documented in the table, two other independent variables, precipitation and day of week, are not correlated to the PM_{10} value, but when included in the multiple regression analysis the resulting equation predicts a PM_{10} value which correlates to the actual PM_{10} value even better than if based on the continuous particulate measurement alone. The multiple correlation coefficient improves to within a range of .82 to .90 for all the sites.

Four of the sites obtained over 320 paired observations providing a significant statistical basis for the multiple regression relationships developed for these locations. The table presents an equation for each site which estimates the actual PM_{10} value as a function of the 24 hour average dry particle light scattering measured by nephelometer (b_{sp}), the logarithm of the 24 hour precipitation (LPR) and the day of week variable (DAY). For real-time use, the 24 hour average PM_{10} estimate at each site may be calculated for any 24 hour period from the appropriate equation, given the real-time nephelometer measurement and values for the precipitation and day of week variables. Since the most weight in each equation comes from the b_{sp} value, b_{sp} is measured at each site. The precipitation value is obtained from an official National Weather Service station representing the entire area.

Analysis of Highest PM_{10} Values

The periods of stagnant weather which can sometimes lead to an "impaired air quality" condition occur during fall and winter, primarily during the months of January, February, November and December. The higher PM_{10} values also occur most often during the fall and winter, however industrial stations affected by local industrial emissions sometimes also measure higher PM_{10} values during other times of the year. Revisions in the Washington Clean Air Act lowered the PM_{10} value for determining "impaired air quality" from 90 ug/m^3 to 75 ug/m^3 beginning in the fall of 1990.

For the four stations which operated almost daily during 1990 all of the dates when the PM_{10} value was 75 ug/m^3 or greater are included in a table covering January to March on one page and April to December on the following page. Also included are all of the dates during which an "impaired air quality" condition was in effect. The Department of Ecology did not declare the "Forecast" stage of an air pollution episode in the Puget Sound region during 1990.

The data show that only one of the measured values exceeded the level of the 24 hour average PM_{10} standard of 150 ug/m^3. A PM_{10} value of 186 ug/m^3 was measured at the Tacoma Fire Station #12 industrial site on Saturday, May 5. This day began as a somewhat stable day, but conditions changed dramatically in the Tacoma tideflats industrial area as the wind increased and persistently averaged 14 to 21 miles per hour from the west-southwest for the 9 hour period from about noon to 9:00 p.m. Since the TSP value at this station for the same day was also very high, 555 ug/m^3, this suggests the excessive particulate level contained a significant amount of coarse particulate matter and likely came from source emissions originating a short distance west-southwest of the monitoring station. All other PM_{10} values on this day were significantly lower than the standard.

The site specific equation significantly underestimated the PM_{10} value measured at Tacoma Fire Station #12 on May 5. The nephelometer is more responsive to particles smaller than 2.5 micrometers than to larger particles, so the dramatic increase in the coarse component on this day may explain the underprediction in the PM_{10} estimate.

Review of the data shows that most of the measured values exceeding 75 ug/m^3 during 1990 occurred in the months of January, February, March and December. For the first quarter the "impaired air quality" trigger value was 90 ug/m^3, and the PM_{10} estimates compare satisfactorily with the reference method PM_{10} values until late February. The PM_{10} estimates during the last two days of February and first two days of March were lower than the reference method PM_{10} values. On these days the fact that the nephelometer based real-time PM_{10} estimates were low compared to the actual PM_{10} values suggests the coarse component, particles from 2.5 to 10 micrometers in size, was larger than usual. This coarse fraction commonly consists of crustal material (road and fugitive dust) and plant pollens, whereas the combustion particles from wood smoke are primarily fine particles smaller than 2.5 micrometers. If on a given day, the proportions of fine and coarse particles are different from usual for a site, the site specific PM_{10} estimates are likely to vary from the reference method PM_{10} values.

For the last quarter of 1990 the "impaired air quality" trigger value was lowered to 75 ug/m^3. The PM_{10} estimates satisfactorily tracked the reference method PM_{10} values for this period also. Essentially all of the significant PM_{10} values during this quarter occurred during December. The PM_{10} estimates overpredicted on December 25 and 26, but reference method PM_{10} values at two stations did exceed 75 ug/m^3.

In conclusion, since reference method PM_{10} values are never available except for an historic review such as done here, site specific relationships provide real-time PM_{10} estimates which enable satisfactory management of the "impaired air quality" program. The PM_{10} estimates also provide a real-time value needed to report the Pollutant Standards Index.

PARTICULATE MATTER (PM_{10})

Site Specific PM_{10}, b_{sp} Statistics and Equations
(Developed from Data Collected During Calendar Year 1990)

Sta	Partial Correlation Coefficients: PM_{10} b_{sp}	PM_{10} LPR	PM_{10} DAY	b_{sp} LPR	Mult Corr Coef: PM_{10} all	No. Obs	Equation	Std Err Est
EVT	.83	-.59	.21	-.35	.90	56	$PM_{10} = 4.1 + \mathbf{22.1}\, b_{sp} - \mathbf{3.1}\, LPR + \mathbf{2.7}\, DAY$	4.2
LFP	.88	-.37	.05	-.26	.89	322	$PM_{10} = 2.1 + \mathbf{25.4}\, b_{sp} - \mathbf{2.5}\, LPR + \mathbf{2.8}\, DAY$	8.0
DWM	.79	-.45	.32	-.33	.86	347	$PM_{10} = 4.1 + \mathbf{30.4}\, b_{sp} - \mathbf{3.4}\, LPR + \mathbf{10.9}\, DAY$	9.3
KNT	.82	-.54	.15	-.25	.90	336	$PM_{10} = 1.3 + \mathbf{23.5}\, b_{sp} - \mathbf{5.6}\, LPR + \mathbf{5.0}\, DAY$	7.3
TNE	.75	-.70	.25	-.48	.85	53	$PM_{10} = -1.5 + \mathbf{27.4}\, b_{sp} - \mathbf{7.4}\, LPR + \mathbf{3.7}\, DAY$	9.6
TDF	.77	-.45	.14	-.29	.82	332	$PM_{10} = 3.5 + \mathbf{26.9}\, b_{sp} - \mathbf{4.9}\, LPR + \mathbf{5.8}\, DAY$	12.3

Abbreviations

- PM_{10} : 24 hour average particulate matter 10 micrometers or less in diameter (ug/m^3).
- b_{sp} : 24 hour average light scattering due to dry particles ($\times 10^{-4}$ per meter).
- LPR : the common logarithm of the 24 hour precipitation with .001 substituted for Zero and .005 substituted for Trace.
- DAY : set to 1 for Mon, Tue, Wed, Thu or Fri; set to 0 for Sat or Sun.
- No. Obs : number of collocated data observations in the regression analysis.

Station Addresses		(Record Period during 1990)
EVT :	Hoyt Ave & 26th St, Everett	(Jan - Dec)
LFP :	17711 Ballinger Way NE, Lake Forest Park	(Jan - Dec)
DWM :	Duwamish, 4752 E Marginal Way S, Seattle	(Jan - Dec)
KNT :	James St & Central Ave, Kent	(Jan - Dec)
TNE :	27th St NE & 54th Ave NE, Northeast Tacoma	(Jan - Dec)
TDF :	Fire Station #12, 2316 E 11th St, Tacoma	(Jan - Dec)

PARTICULATE MATTER (PM_{10})

Site Specific Analysis for Days when any PM_{10} Value was 75 ug/m^3 or Greater and for Episode or Impaired Air Quality Days

(Jan - Mar 1990)

			LkFrstPk (LFP)			Seattle (DWM)			Kent (KNT)			Tacoma (TDF)		
Day	Date		Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %
	Jan 90													
Fri	12		67	**67**	0	76	**93**	-18		**64**		70	**76**	-8
Thu	18		110	**96**	15	76	**70**	9		**82**		97	**85**	14
Fri	19	I	86	**78**	10	99	**111**	-11		**103**		104	**111**	-6
Sat	20	I	86	**83**	4	80	**82**	-2		**67**		83	**84**	-1
Sun	21	I	61	**55**	11	53	**53**	0		**40**		46	**45**	2
	Feb 90													
Sun	18		109	**92**	18	69	**56**	23	92	**87**	6	68	**59**	15
Mon	19		82	**72**	14		**73**		77	**89**	-13	83	**79**	5
Thu	22		47	**98**	-52	52	**52**	0	53	**53**	0	49	**53**	-8
Fri	23		56	**80**	-30	78			64	**64**	0	86	**95**	-9
Mon	26		45	**82**	-45	52	**57**	-9	43	**43**	0	43	**53**	-11
Tue	27		54	**99**	-45	43			38	**35**	9	58	**82**	-29
Wed	28		53	**103**	-49	61	**119**	-49	43	**60**	-28	63	**89**	-29
	Mar 90													
Thu	01		48	**87**	-45	68	**134**	-49	62	**95**	-35		**97**	
Fri	02		59	**91**	-35	64	**111**	-42	62	**93**	-33		**140**	
Wed	28		38	**48**	-21	56	**81**	-31	46	**55**	-16	55	**68**	-19
Sat	31		81	**70**	16	93	**75**	24	98	**86**	14	87	**74**	18

Notes

I: A condition of "impaired air quality" was in effect during the following times in King, Kitsap, Pierce and Snohomish counties ....

2:30 pm, Fri, **Jan 19** - 2:30 pm, Sun, **Jan 21**.

Est: Estimated 24 hour average PM_{10} using site specific equation.

Val: 24 hour average PM_{10} value measured by reference method.

Err: Error in PM_{10} estimate compared to measured value.

PARTICULATE MATTER (PM_{10})

Site Specific Analysis for Days when any PM_{10} Value was 75 ug/m^3 or Greater
and for Episode or Impaired Air Quality Days
(Apr - Dec 1990)

			LkFrstPk (LFP)			Seattle (DWM)			Kent (KNT)			Tacoma (TDF)		
Day	Date		Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %	Est ug/m^3	Val ug/m^3	Err %
	Apr 90													
Fri	06		47	**40**	18	59	**75**	-21	50	**56**	-11	47	**50**	-6
Tue	10		34	**37**	-8	45	**58**	-22	44	**61**	-28	47	**80**	-41
	May 90													
Sat	05		28	**29**	-3	38	**63**	-40	35	**52**	-33	43	**186**	-77
	Jul 90													
Thu	05		17	**15**	13	26	**29**	-10	19	**25**	-24	26	**75**	-65
	Aug 90													
Fri	10		27	**31**	-13	48	**54**	-11	35	**50**	-30	49	**86**	-43
	Sep 90													
Fri	28		48	**40**	20	86	**78**	10	62	**74**	-16	73	**79**	-8
	Oct 90													
Wed	24		49	**44**	11	68	**78**	-13	51	**50**	2	73	**79**	-8
	Dec 90													
Thu	06		51	**51**	0	57	**78**	-27	64	**58**	10	72	**75**	-4
Fri	07	I	80	**79**	1	97	**86**	13	80	**69**	16	93	**77**	21
Sat	08	I	31	**30**	3	35	**36**	-3	37	**45**	-18	39	**41**	-5
Sun	23		70			53	**48**	10		**61**		109	**93**	17
Tue	25	I	81			95	**66**	44	103	**89**	16	107	**83**	29
Wed	26	I	60	**43**	40	85	**65**	31	66	**46**	43	75	**47**	60
Thu	27	I	17			25	**20**	25	16	**16**	0	19	**15**	27

Notes

I: A condition of "impaired air quality" was in effect during the following times in King, Kitsap, Pierce and Snohomish counties ....

2:30 pm, Fri, **Dec 7** - 9:30 am, Sat, **Dec 8**;
2:30 pm, Tue, **Dec 25** - 8:15 am, Thu, **Dec 27**.

Est: Estimated 24 hour average PM_{10} using site specific equation.

Val: 24 hour average PM_{10} value measured by reference method.

Err: Error in PM_{10} estimate compared to measured value.

LEAD

The ambient air quality standard for lead is 1.5 ug/m^3 averaged over one calendar quarter. Lead emissions to the air in urban areas come principally from automobile exhaust. In some places localized industrial emissions of lead come from stationary sources such as primary and secondary nonferrous smelters. As shown below, lead concentrations measured at all stations in the Puget Sound Region during 1990 were lower than the ambient standard. These current ambient lead levels are significantly lower than levels existing during the 70's due primarily to the phase down of lead in gasoline. The lead levels at the Harbor Island station still document some effect from the nearby site of a secondary lead smelter which ceased operation several years ago.

LEAD
Micrograms per Standard Cubic Meter
1990

Location	Monthly Arithmetic Averages												No. Of Obs.	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
5701 8th Ave NE, Seattle, Wa	.05	.04	.06	.04	.07	.04	.04	.06	.03	.02	.03	.05	58	.04
Harbor Island, 2555 13th Ave SW, Seattle, Wa	.34	.24	.20	.77	.53	.25	.07	1.63	.22	.21	.76	.50	58	.48
Ruston School, 5219 N Shirley St, Tacoma, Wa	.04	.03	.02	.02	.04	.01	.01	.02	.03	.02	.01	.02	59	.02

Location	Quarterly Arithmetic Averages			
	1st	2nd	3rd	4th
5701 8th Ave NE, Seattle, Wa	.05	.05	.04	.03
Harbor Island, 2555 13th Ave SW, Seattle, Wa	.26	.52	.64	.49
Ruston School, 5219 N Shirley St, Tacoma, Wa	.03	.02	.02	.02

ARSENIC

The U. S. EPA has designated inorganic arsenic as a hazardous air pollutant. The principal source of arsenic in the Puget Sound Region is the closed Tacoma Smelter site at Ruston. Smelting ceased in March 1985 and arsenic processing ended in January 1986. Site reclamation has proceeded under U. S. EPA supervision. Measurements during 1990 at the Ruston School, just west of the smelter site, document low ambient arsenic levels.

ARSENIC
Micrograms per Standard Cubic Meter
1990

Location	Monthly Arithmetic Averages												No. Of Obs.	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Ruston School, 5219 N Shirley St, Tacoma, Wa	.01	.01	.01	.01	.01	.01	.01	.02	.03	.01	<.01	<.01	59	.01

Yearly arithmetic mean calculated using .0025 as a substitute for each <.01 value.

SULFUR DIOXIDE

Sulfur dioxide is a common air pollutant regulated under a national standard. Local sulfur dioxide standards have been in effect since 1968. The national, state and local sulfur dioxide standards are summarized on page 44. Sulfur dioxide enters the air mainly from industrial processes and from the combustion of sulfur-containing fuels such as coal and oil. In the Puget Sound Region, the four main industrial areas with sulfur dioxide point sources are the Everett Port area, Seattle Harbor Island-Duwamish Valley area, Tacoma Port area and the Bremerton Naval Shipyard. Reactions in the air partially convert sulfur dioxide to other sulfur compounds such as sulfuric acid and various sulfate salts. The tables below summarize sulfur dioxide data collected during 1990.

SULFUR DIOXIDE
(Parts per Million)
1990

Location	Monthly Arithmetic Averages												No. of 1 Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Hoyt Ave & 26th St, Everett, Wa	.005	.006	.008	.009	.006	.006	.010	.009	.008	.006	.004	.005	8672	.007
Duwamish, 4752 E Marginal Way S, Seattle, Wa	.007	.009	.008	.010	.009	.007	.010	.011	.009	.008	.007	.011	8584	.009
27th St NE & 54th Ave NE, Northeast Tacoma, Wa		.008	.010	.006	.008	.006	.006	.008	.006	.010	.009	.010	8099	.008
2301 Alexander Ave, Tacoma, Wa	.009	.007	.009	.007	.009	.008	.008	.009	.009	.011	.012	.009	8585	.009
951 Portland Ave, Tacoma, Wa	.007	.005	.005	.006	.006	.004	.005	.004	.005	.004	.002	.006	8540	.005

Summary of Maximum and Second Highest Concentrations
for Various Averaging Periods

Location / Continuous Sampling Period(s)	1 Hour Average			3 Hour Average			24 Hour Average		
	Value	Date	End Time	Value	Date	End Time	Value	Date	End Time
Hoyt Ave & 26th St, Everett, Wa	.160	14 Jul	1700	.071	30 Nov	0300	.026	17 Apr	0100
1 Jan-31 Dec	.150	29 Jan	0300	.068	14 Jul	1800	.021	14 Jul	1700
Duwamish, 4752 E Marginal Way S, Seattle, Wa	.114	27 Jan	1400	.092	27 Jan	1500	.030	28 Jan	1100
1 Jan-31 Dec	.111	27 Jan	1500	.055	13 Mar	1700	.027	25 Dec	0300
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	.111	23 Dec	2300	.083	20 Jan	1000	.044	20 Jan	2100
1 Jan-28 Dec	.098	20 Jan	0800	.076	20 Jan	0200	.034	24 Dec	2000
2301 Alexander Ave, Tacoma, Wa	.089	20 Oct	1100	.058	19 Jan	0500	.027	19 Jan	2300
1 Jan-31 Dec	.080	19 Jan	0400	.057	10 Aug	1000	.024	8 Nov	0900
951 Portland Ave, Tacoma, Wa	.079	8 May	2200	.050	24 Dec	1700	.023	25 Dec	0500
1 Jan-31 Dec	.073	3 May	2300	.043	21 Jun	0300	.021	20 Jan	0100

Notes
(1) Ending times are reported in Pacific Standard Time.
(2) For equal concentration values the date and time refer to the earliest occurrences.
(3) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(4) At all stations sulfur dioxide was measured using the continuous ultraviolet fluorescence method.

OZONE

Introduction

The principal oxidant found in photochemical smog is ozone, a very reactive form of oxygen. Most photochemical oxidants result from sunlight driven chemical reactions in the ambient air between nitrogen oxides and volatile organic compounds (VOC). The highest ozone levels occur on hot summer afternoons since this is the period of most intense radiant energy from sunlight. However, even with strong sunlight, ozone levels would be low without the precursor nitrogen oxide and VOC pollutants emitted from human activities.

On any given day the photochemical reactions proceed for several hours and generally produce maximum ozone levels between noon and early evening at locations several miles away from the sources of nitrogen oxides and VOC. Each day after nightfall the high ozone levels diminish because the photochemical effect ends. However, the photochemical smog is such a complex mixture that significant ozone levels sometimes continue for hours into the night.

In the Puget Sound Region the highest ozone levels occur from mid May to mid September on the few days favorable for significant photochemical activity. These high values develop when urban area emissions are trapped beneath a nighttime and morning temperature inversion followed during the day by very high temperatures. Light northerly winds often develop on these hot days. As a result, the highest ozone values normally occur south to southeast of the major cities or source areas.

Ozone Standard and Summary of Data

The U. S. EPA has set the level of the ozone standard at a value of 0.12 ppm. According to the Federal regulation (40 CFR Part 50), the standard is attained when the expected number of days per calendar year with a maximum hourly average concentration above 0.12 ppm is one day or less. If an "exceedance" means a day on which the maximum 1 hour average is higher than 0.12 ppm, the standard is attained when the expected number of exceedances is equal to or less than one. If no data are missing, the expected number of exceedances is the average number of measured exceedances per year at a particular location for the last three years.

When some data for a given year are missing, the number of exceedances in that year must be adjusted to estimate the true number. The estimate is calculated using the number of measured exceedances, the number of required monitoring days, the number of days with a measured maximum value and the number of days determined to be less than the level of the standard.

For each year the estimated number of exceedances is always equal to or greater than the measured number of exceedances. For stations where no exceedances are measured, the estimate is zero. The expected number of exceedances is then the average of the annual estimates for the last three years.

The 1990 ozone summary table on the following page lists the six highest daily maximum 1 hour averages for each monitoring location. For the three year period ending with 1990, the expected number of ozone exceedances calculates to be 1.3 days for the Enumclaw location; all other ozone monitoring locations calculate to be 1.0 or fewer days. Though the Puget Sound Region was redesignated as in attainment of the ozone standard in 1987, the ozone measurements during the summer of 1990 indicate the region may again be out of compliance with the standard.

Pollutant Standards Index

A one hour average ozone value of 0.12 ppm is equivalent to 100 on the Pollutant Standards Index scale. Since the high ozone levels occur some distance downwind of major cities, ozone never determines the Index for Everett, Seattle or Tacoma. However, at outlying locations such as Lake Sammamish, Enumclaw and La Grande, ozone caused unhealthful air quality on four days during July and August 1990.

OZONE
(Parts per Million)
1990

Location / Continuous Sampling Period(s)	Six Highest Daily Maximum 1 Hour Averages			Estimated No. of Days Daily Maximum 1 Hour Average Exceeded .12 ppm			No. of Days Daily Maximum 1 Hour Average Expected To Exceed .12 ppm
	Value	Date	End Time	1988	1989	1990	
20050 SE 56th, Lake Sammamish State Park, Wa 1 Jan-31 Oct	.126	12 Jul	1600	1.0	0.0	1.0	0.7
	.123	11 Aug	1400				
	.108	12 Aug	1500				
	.096	20 Jul	1500				
	.096	21 Jul	1500				
	.095	4 Aug	1500				
Ravensdale, Wa 25 Apr-24 May; 16 Jun-31 Jul; 22 Aug-31 Oct	.102	20 Jul	1600			0.0	0.0
	.100	21 Jul	1600				
	.097	11 Jul	1500				
	.093	12 Jul	1300				
	.081	30 Jul	1500				
	.080	14 Jul	1700				
Highway 410, 2 miles east of Enumclaw, Wa 1 Apr-2 Oct	.149	11 Aug	1500	0.0	0.0	3.8	1.3
	.131	21 Jul	1500				
	.126	10 Aug	1800				
	.118	20 Jul	1700				
	.116	12 Aug	1600				
	.115	4 Aug	1700				
Charles L Pack Forest, La Grande, Wa 5 Apr-18 Apr; 18 May-31 Oct	.130	11 Aug	1600	0.0	0.0	2.9	1.0
	.127	21 Jul	1600				
	.107	4 Aug	1600				
	.105	11 Jul	1700				
	.103	20 Jul	1700				
	.099	29 Jul	1700				

Notes
(1) All ozone stations operated by the Washington State Department of Ecology.
(2) Ending times are reported in Pacific Standard Time.
(3) For equal concentration values the date and time refer to the earliest occurrences.
(4) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(5) At all stations ozone was measured using the continuous ultraviolet photometric detection method.

CARBON MONOXIDE

Introduction

As a group, motor vehicles emit more carbon monoxide than any other source. For Puget Sound area cities, motor vehicles are the principal source of carbon monoxide causing the ambient levels to exceed air quality standards.

The occasions with high ambient levels of carbon monoxide occur mainly during autumn and winter months. The highest levels are measured in the vicinity of congested motor vehicle traffic present during late afternoon commuting and around shopping centers particularly during holiday shopping.

A contributing factor during some periods when levels are high is the existence of stable weather and light wind. Such a condition temporarily reduces the means to disperse carbon monoxide which is emitted into the air.

Pollutant Standards Index and Washington State Episode Levels

The level of the 8 hour average standard is 9 parts per million (ppm), and this is equivalent to 100 on the Pollutant Standards Index scale. PSI values exceeding 100 are termed "Unhealthful". An 8 hour average of 15 ppm equals 200 on the PSI scale. Index values of 200 to 299 are described as "Very Unhealthful".

Episode criteria are specified in the Washington Episode Plan (Washington Administrative Code 173-435). The Alert stage is reached when the ambient carbon monoxide concentration reaches 15 ppm for an 8 hour average, and meteorological conditions are such that the carbon monoxide concentration can be expected to remain at or above that level for 12 or more hours, or to recur within 24 hours unless control actions are taken. Correspondingly, the carbon monoxide concentration for the Warning stage is 30 ppm for an 8 hour average, and for the Emergency stage is 40 ppm for an 8 hour average.

Summary of 1990 Data

The table on the next page summarizes the six highest 1 hour and 8 hour average carbon monoxide levels at each station during 1990. These data were obtained from Department of Ecology data summaries.

Only the station in downtown Everett measured carbon monoxide values which exceeded the level of the 8 hour average standard. Since this occurred twice, the Everett station violated the 8 hour average standard.

Multi-Year Summary

A multi-year summary following the 1990 table presents data and column graphs to show the long term historical trend. For the longest term sampling sites in the cities of Seattle, Everett, Bellevue and Tacoma, the summary charts show by year the number of days on which the 8 hour average exceeded 9 ppm. The bottom row lists the value that was the second high 8 hour average for each year.

The first complete year of carbon monoxide data for one Seattle station was 1972. The results at this station have improved from exceeding the primary standard over 100 days in 1972 and 1973, to zero exceedances during 1987 through 1990. Two other Seattle stations which began in 1978 confirm the same trend. The significant improvement from levels in the mid 1970's is due mainly to the Federal emission standards for new motor vehicles and to the program requiring regular testing of vehicle emissions to assure compliance with these standards.

For all cities, the data acquired since 1979 show the decrease (improvement) in carbon monoxide values has leveled off. To show the standard has been attained for any station, the U. S. EPA requires that the number of cases exceeding the level of the standard averaged over a two year period not exceed one per year.

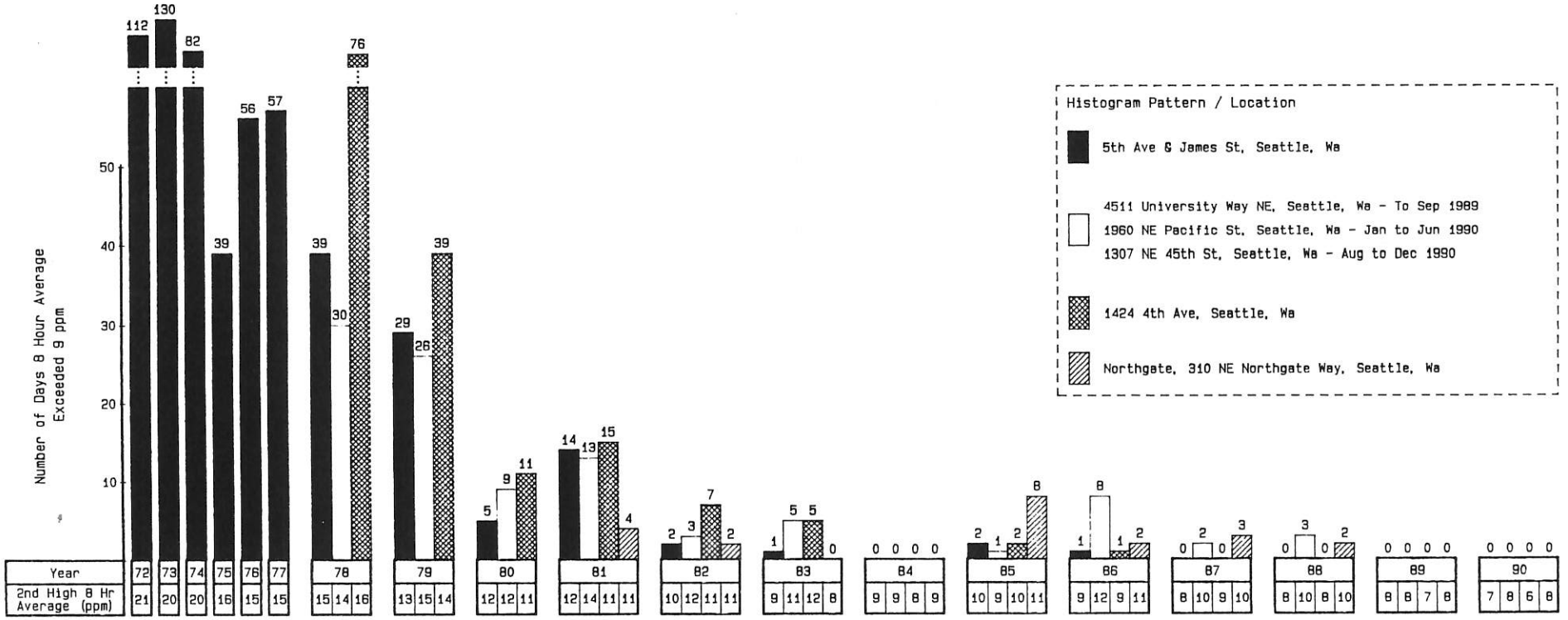
CARBON MONOXIDE
(Parts per Million)
1990

Location / Continuous Sampling Period(s)	Six Highest Concentrations						Number of 8 Hour Averages Exceeding 9 ppm	Number of Days 8 Hour Average Exceeded 9 ppm
	1 Hour Average			8 Hour Average				
	Value	Date	End Time	Value	Date	End Time		
Broadway & Hewitt Ave, Everett, Wa	13.1	2 Mar	1600	10.0	2 Mar	1800	2	2
1 Jan-31 Dec	12.8	27 Feb	0800	9.6	21 Sep	1800		
	12.6	2 Mar	1700	9.1	10 Aug	1800		
	11.8	28 Feb	1700	8.8	10 Jul	1700		
	11.6	10 Aug	1400	8.7	21 Jun	1900		
	11.6	6 Dec	1600	8.6	16 Apr	1700		
622 Bellevue Way NE, Bellevue, Wa	9.5	19 Jan	0900	6.5	20 Jan	0100	0	0
1 Jan-31 Dec	8.6	12 Jan	0900	6.2	6 Dec	2400		
	8.6	19 Jan	1000	6.1	12 Jan	2300		
	8.4	28 Feb	2200	6.0	21 Jan	0100		
	8.1	19 Jan	1800	5.9	7 Dec	2200		
	8.1	6 Dec	2200	5.7	12 Jan	1400		
Northgate, 310 NE Northgate Way, Seattle, Wa	15.8	19 Jan	0900	8.1	12 Jan	1400	0	0
1 Jan-31 Dec	12.9	19 Jan	0800	7.6	19 Jan	0100		
	12.4	2 Mar	0800	7.5	21 Jan	0200		
	12.3	12 Jan	0900	7.3	19 Jan	1400		
	12.1	12 Jan	1000	6.2	20 Jan	0100		
	10.8	1 Mar	0800	6.1	23 Oct	2300		
University Dist, 1307 NE 45th St, Seattle, Wa	10.4	15 Dec	0100	7.8	7 Dec	2200	0	0
1 Aug-31 Dec	10.3	23 Oct	2100	7.5	27 Oct	0200		
	10.3	26 Oct	2200	7.4	23 Oct	2200		
	9.6	26 Oct	2100	7.3	14 Dec	2100		
	9.6	26 Oct	2300	6.4	11 Oct	1900		
	9.2	11 Dec	1800	6.3	16 Nov	2000		
1960 NE Pacific St, Seattle, Wa	11.3	18 Jan	2200	8.8	19 Jan	0200	0	0
1 Jan-19 Jun	9.7	18 Jan	2300	7.0	21 Jan	0200		
	9.5	18 Jan	2400	5.2	12 Jan	1500		
	8.8	18 Jan	2000	5.2	20 Jan	0100		
	8.6	20 Jan	2200	5.0	19 Jan	1000		
	8.5	18 Jan	2100	5.0	1 Mar	0300		
1424 4th Ave, Seattle, Wa	10.3	14 Dec	1800	6.3	12 Jan	2100	0	0
1 Jan-31 Dec	10.3	18 Dec	1600	6.3	21 Jan	0400		
	9.4	22 Sep	1800	6.1	18 Dec	1900		
	9.0	19 Jan	1800	6.0	6 Dec	2000		
	8.6	6 Dec	1800	5.5	19 Jan	2400		
	8.0	31 Jan	1200	5.4	19 Jan	0100		
5th Ave & James St, Seattle, Wa	9.4	19 Jan	0800	7.0	19 Jan	0900	0	0
1 Jan-31 Dec	9.2	1 Oct	1700	6.8	12 Jan	2000		
	9.1	1 Oct	1600	6.4	11 Jan	2000		
	9.1	6 Dec	1700	6.3	21 Jan	0300		
	9.0	23 Feb	1600	6.1	1 Oct	1700		
	8.7	11 Jan	1800	5.8	19 Jan	0100		
1101 Pacific Ave, Tacoma, Wa	10.2	24 Oct	1700	8.1	24 Oct	2200	0	0
1 Jan-30 Sep; 12 Oct-26 Oct; 19 Nov-31 Dec	10.0	17 Jan	0900	8.0	19 Jan	2300		
	9.4	6 Dec	2100	7.1	12 Jan	1800		
	9.2	19 Jan	2000	6.9	6 Dec	2300		
	9.2	28 Feb	0900	6.7	7 Dec	2300		
	9.2	1 Mar	0800	6.6	2 Mar	2400		

Notes
(1) All carbon monoxide stations operated by the Washington State Department of Ecology.
(2) Ending times are reported in Pacific Standard Time.
(3) For equal concentration values the date and time refer to the earliest occurrences.
(4) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(5) At all stations carbon monoxide was measured using the continuous nondispersive infrared method.

CARBON MONOXIDE

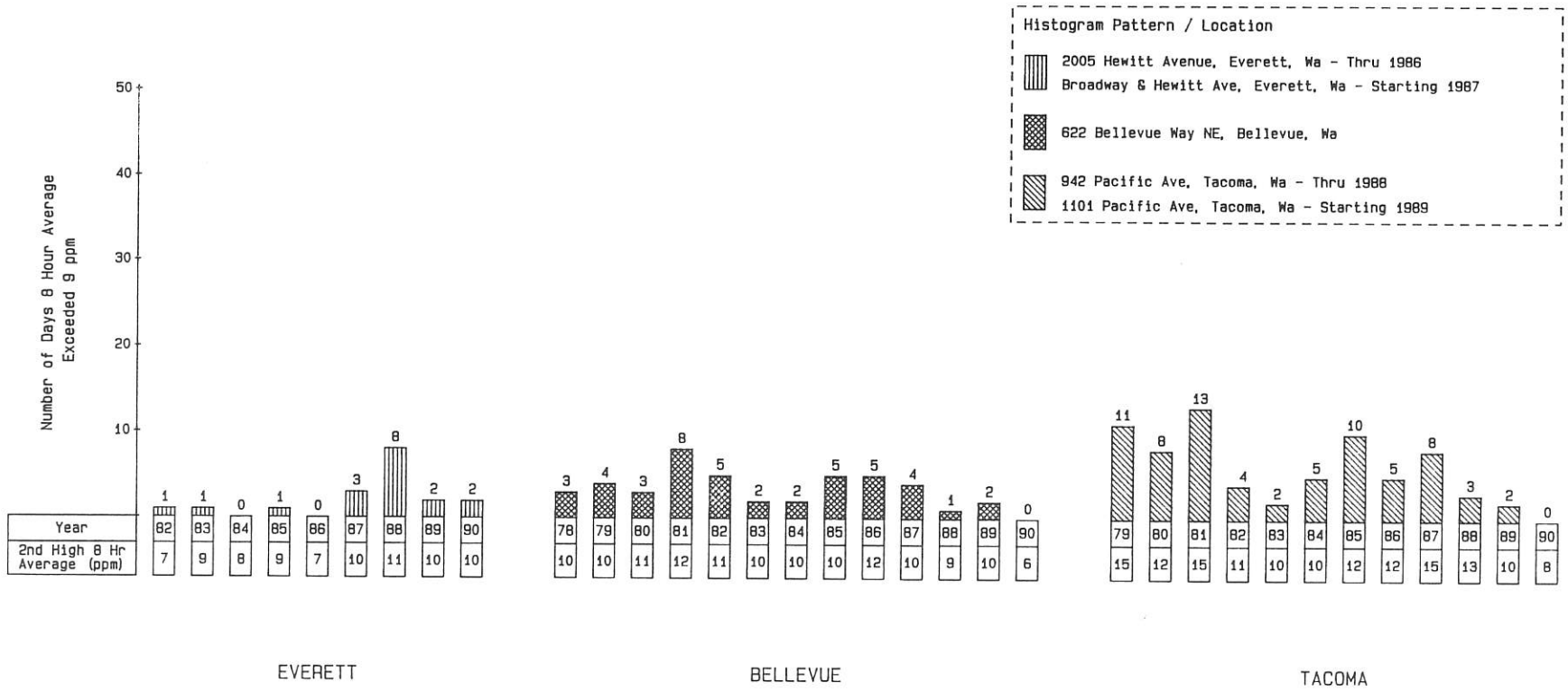
Multi-Year Summary



SEATTLE

CARBON MONOXIDE

Multi-Year Summary



QUALITY ASSURANCE

Introduction

Quality Assurance (QA) includes all activities involved with obtaining valid data and documenting the quality of the data. Quality Assurance is an integral part of all monitoring activities. Some specific QA activities are: selection of methods and analyzers; installation of equipment; calibration; zero and span checks and adjustments; control checks, limits and corrective actions; maintenance; recording and validating data; and documentation of quality control information.

The Agency participates in audit programs conducted independently by the U. S. Environmental Protection Agency and the Washington State Department of Ecology. For the EPA, this consists of (1) on-site audits of some Agency monitoring equipment by EPA or their designated representative, and (2) Agency participation in EPA's national performance audits as they are announced. Each quarter the Department of Ecology also independently audits some Agency monitoring equipment in operation at various stations.

Precision and Accuracy Audits

The QA program requirements are established in Title 40, Code of Federal Regulations, Part 58. The important QA characteristics which the regulations require to be developed and reported are *precision* and *accuracy*. In simple terms, *precision* means the ability to repeat a measurement of the same, known sample at a different time; *accuracy* means the agreement between a measurement and the true value.

Each instrument measuring a pollutant at a location must be audited for precision at least every two weeks and for accuracy at least once per year. For each audit, the percentage difference between the instrument indicated concentration and the true concentration is calculated. For each calendar quarter the average and the standard deviation of these percentage differences are calculated. These two statistics are then pooled for all audits involving the same pollutant.

Probability Limits

The Federal regulation requires summary of the precision and accuracy audit results by computing the 95 percent probability limits for each pollutant from the weighted average percent difference, D, and the pooled standard deviation, S_a, as follows:

$$\text{Upper 95 Percent Probability Limit} = D + 1.96\,(S_a)$$

$$\text{Lower 95 Percent Probability Limit} = D - 1.96\,(S_a)$$

These upper and lower limits reflect data quality by establishing that, with 95 percent probability, the pollutant measurements during the audit period are within the limits. As an example, if the average of the percent differences is zero and the standard deviation of the percent differences is 4.1 percent, the upper and lower 95 percent probability limits are respectively +8 and -8 percent.

Agency Precision and Accuracy

For most Agency monitoring locations precision audits are performed each week and accuracy audits are completed each month or each quarter. The table following this page summarizes the precision and accuracy probability limits by quarter for all air quality data which the Agency originated in 1990. For each pollutant the type of audit (accuracy or precision) is followed by a brief phrase description of the audit method. The number of audits and the lower and upper probability limits are presented for each quarter.

DATA QUALITY ASSESSMENT
1990

Lower and Upper 95 Percent Probability Limits
of Percent Differences

Pollutant & Type of Audit	Number of Stations	Audit Results by Quarter											
		1st			2nd			3rd			4th		
		No. of Audits	Prob. Limits Lwr	Upr	No. of Audits	Prob. Limits Lwr	Upr	No. of Audits	Prob. Limits Lwr	Upr	No. of Audits	Prob. Limits Lwr	Upr
Particulate Matter (TSP, Hi-Vol)	11												
Accuracy													
Flow Rate		9	-9	+6	2	-2	+14	4	-5	+7	20	-3	+3
Precision													
Collocated Samples		25	-4	+14	27	-8	+11	29	-4	+7	25	-7	+15
Particulate Matter (PM10, SSI Hi Vol)	11												
Accuracy													
Flow Rate		88	-4	+5	75	-3	+2	87	-4	+3	84	-3	+4
Precision													
Collocated Samples		38	-8	+5	38	-7	+3	47	-10	+8	34	-9	+9
Sulfur Dioxide	4												
Accuracy													
Level 1		11	-4	+11	13	-3	+10	9	-4	+11	9	-8	+11
Level 2		11	-5	+10	13	-5	+8	9	-2	+9	9	-4	+9
Level 3		11	-5	+9	13	-6	+9	9	-2	+8	9	-4	+9
Level 4					4	-8	+8	2	-2	+3	2	-10	+11
Precision													
One point check		41	-5	+12	48	-7	+10	52	-4	+7	55	-5	+9
Atmospheric Particles (Nephelometer)	6												
Precision													
One point check		50	-4	+7	55	-7	+8	55	-4	+5	64	-2	+7

AIR POLLUTION EPISODES and IMPAIRED AIR QUALITY PERIODS

Introduction

The policy and rules for air pollution episode avoidance and for restrictions on the use of solid fuel burning devices during periods of "impaired air quality" are established by the Washington Clean Air Act and implemented by state and local regulations. The 1990 Washington Legislature amended the Clean Air Act sections dealing with solid fuel burning devices, "impaired air quality" and air pollution episode avoidance. These revisions were effective for the fall 1990 heating season.

Air Pollution Episodes

The Washington Clean Air Act defines air pollution episodes and the policy for establishing an avoidance plan in RCW 70.94.710 through 70.94.730. The Washington State Department of Ecology has adopted WAC 173-435 which implements an episode avoidance plan.

The "First" or "Forecast" stage of the Episode Plan may be declared by the Department of Ecology when an air stagnation advisory is issued by the National Weather Service or there is equivalent indication of stagnant atmospheric conditions and conditions are forecast to persist for 24 hours. During 1990, the Department of Ecology did not declare any stage of an air pollution episode in the Puget Sound Region.

Impaired Air Quality Periods

Under the law and regulations applicable for the first part of 1990, "impaired air quality" meant a condition declared by the Department of Ecology or an air pollution control agency whenever meteorological conditions were conducive to an accumulation of air contamination concurrent with PM_{10} at an ambient level of 90 ug/m^3 measured on a 24 hour average. During the first part of 1990, a condition of "impaired air quality" was in effect as follows in the four counties of King, Kitsap, Pierce and Snohomish:

2:30 pm, Friday, January 19 -
2:30 pm, Sunday, January 21.

Revisions to the Washington Clean Air Act effective before fall 1990 included changes regarding the use of solid fuel burning devices. Specifically, RCW 70.94.473 was amended to define two stages of "impaired air quality". During a first stage of "impaired air quality", any person in a residence or commercial establishment which has an adequate source of heat without burning wood shall not burn wood in any solid fuel burning device except those which meet the standards set forth in RCW 70.94.457 or a pellet stove either certified or issued an exemption certificate by the U.S. Environmental Protection Agency. A first stage of "impaired air quality" is reached when PM_{10} is at an ambient level of 75 ug/m^3 measured on a 24 hour average or when carbon monoxide is at an ambient level of 8 ppm measured on an 8 hour average. During the last part of 1990, a first stage of "impaired air quality" was in effect during the following times in the four counties of King, Kitsap, Pierce and Snohomish:

2:30 pm, Friday, December 7 -
9:30 am, Saturday, December 8;

2:30 pm, Tuesday, December 25 -
2:30 pm, Wednesday, December 26.

A second stage of "impaired air quality" is reached when PM_{10} is at an ambient level of 105 ug/m^3 measured on a 24 hour average. When a second stage of "impaired air quality" is in effect, any person in a residence or commercial establishment which has an adequate source of heat without burning wood shall not burn wood in any solid fuel burning device, including those which meet the standards set forth in RCW 70.94.457. During the last part of 1990 a second stage of "impaired air quality" was in effect as follows in the four counties of King, Kitsap, Pierce and Snohomish:

2:30 pm, Wednesday, December 26 -
8:15 am, Thursday, December 27.

In addition to the restrictions on the use of solid fuel burning devices as outlined above, all outdoor fires are prohibited during any period of "impaired air quality".

WIND ANALYSIS

Wind Data

Everyone has a qualitative sense of surface wind and some effects produced by the wind. The wind direction helps identify the sources or source areas affecting a specific location.

From an air pollution standpoint, low wind speed poorly dilutes pollutants and is therefore associated with higher air pollutant concentrations. During a stable, temperature inversion condition, the wind is often light or calm. When this condition persists, the natural process which effectively disperses pollutants is greatly diminished, and pollutant levels are higher near the source areas.

Wind Speed Averages

The table below presents monthly and annual average wind speed computed from hour average wind speed at various locations. These average values are sometimes used to compare locations or different months. Air stagnation episodes are not exposed by this analysis unless episode conditions predominate during most of a month.

Wind Roses

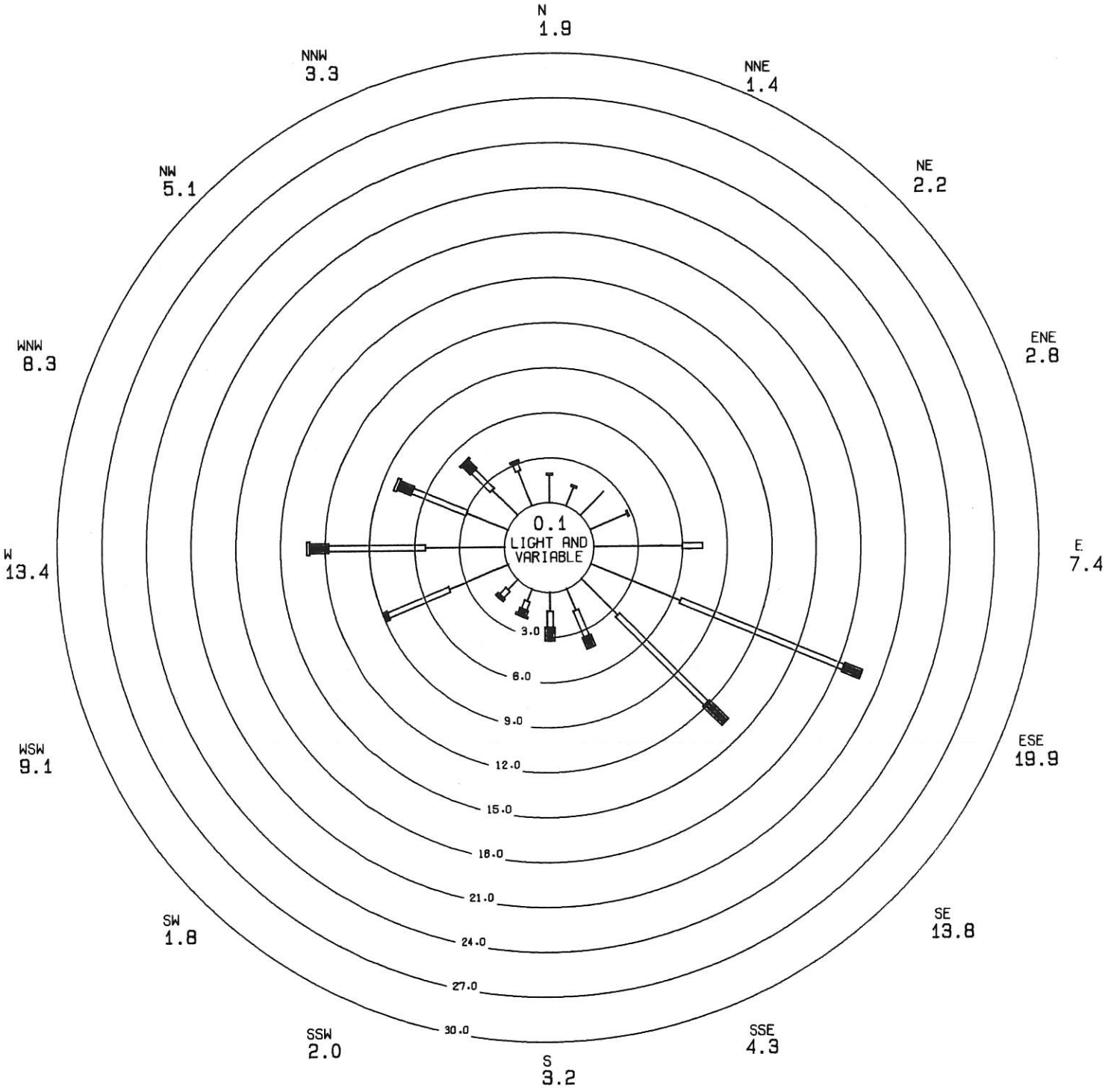
A wind rose is a quantitative graphical summary of the wind direction and speed for a given time period. The following wind rose graphs show the number of observations or hours, expressed as a percentage, that had a particular direction and speed during the summary period.

The wind rose spokes or arms represent 16 points of the compass and are labeled by wind direction. The percentage of time the wind blew *from* a given direction (without regard to speed) is expressed numerically beneath that direction on the perimeter of each rose.

For a particular wind direction the length of each segment of a spoke represents the percentage of time the wind speed was within a specific speed interval. If summed for all wind directions, the result would provide the percentage of all hours the wind speed was measured within a particular interval. The percentage of time during which the wind was light and variable shows in the center of the rose.

WIND SPEED
(Miles per Hour)
1990

Location	Monthly Arithmetic Averages												No. of 1 Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Hoyt Ave & 26th St, Everett, Wa	5.5	4.9	4.8	4.6	4.8	5.1	4.7	4.5	4.2	5.4	5.9	5.8	8647	5.0
17711 Ballinger Way NE, Lake Forest Park, Wa	3.9	4.4	2.9	3.0	3.1	3.4	2.7	2.9	2.3	3.0	4.6	3.3	8710	3.3
Duwamish, 4752 E Marginal Way S, Seattle, Wa	6.2	6.2	4.5	4.6	4.8	4.9	4.5	4.3	3.6	6.0	7.1	6.0	8561	5.2
James St & Central Ave, Kent, Wa	5.2	5.6	3.9	4.0	4.0	4.2	3.9	3.7	3.1	4.1	5.7	4.9	8748	4.4
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	5.0	5.6	4.4	4.0	3.6	4.3	3.7	3.5	3.5	3.6	5.0	4.7	8584	4.2
2301 Alexander Ave, Tacoma, Wa	6.3	6.6	4.7	5.3	5.6	5.9	5.4	4.8	4.2	5.2	6.5		8404	5.5
Fire Station #12, 2316 E 11th St, Tacoma, Wa	6.5	7.0	4.7	5.3	5.6	5.8	5.6	5.8	5.1	6.1	7.9	7.2	8727	6.0



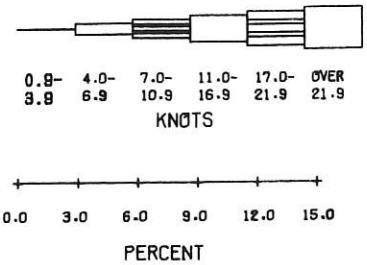
HØUR AVERAGE SURFACE WINDS

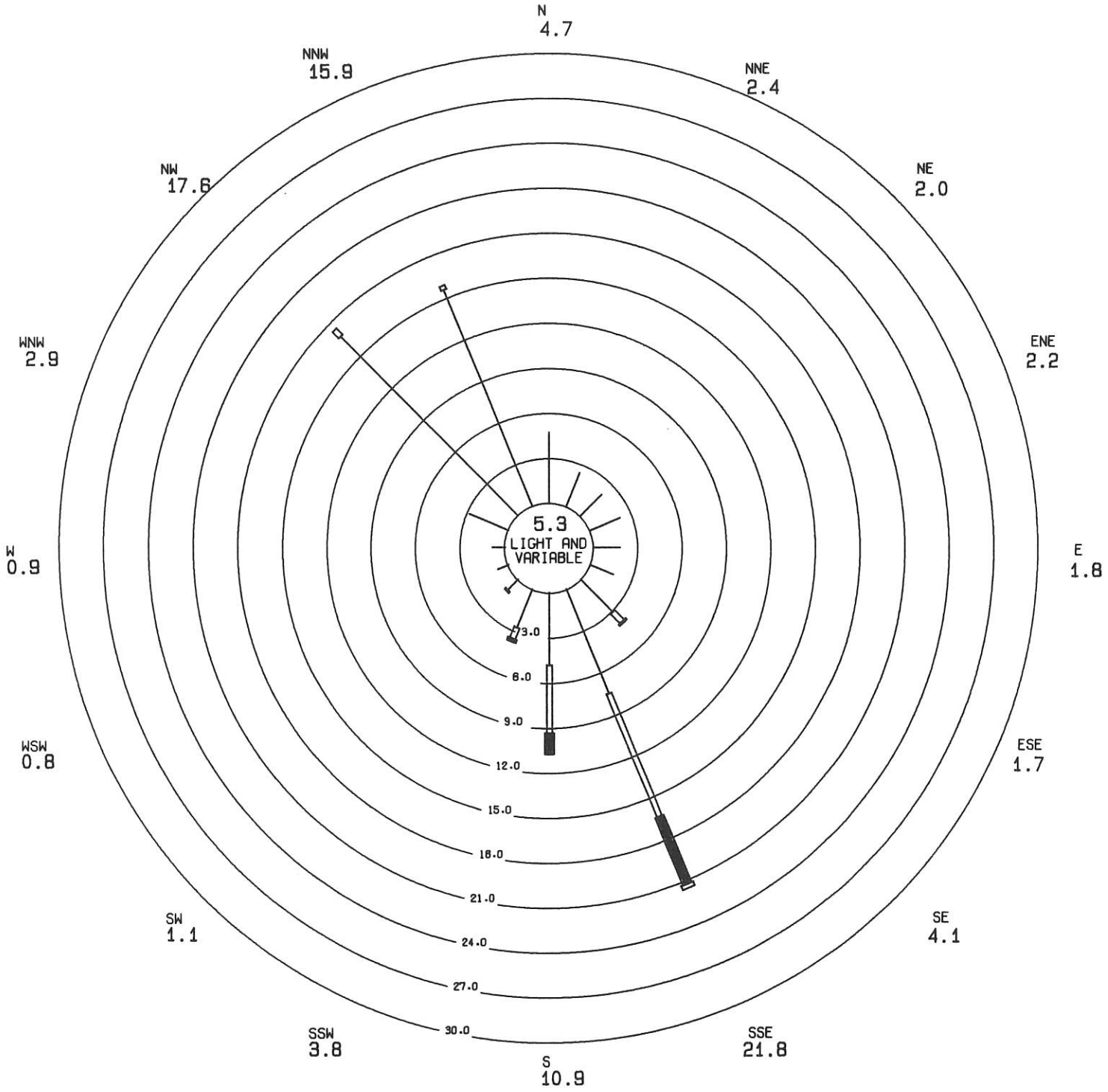
PERCENTAGE FREQUENCY ØF ØCCURRENCE

STATION LØCATIØN- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Hoyt Ave & 26th St, Everett, Wa

INCLUSIVE DATES- ALL MONTHS 1990

TØTAL ØBSERVATIØNS- 8,647





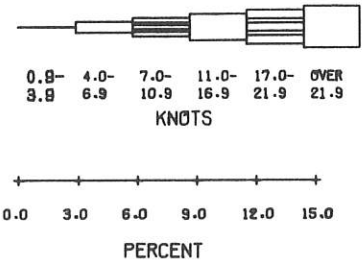
HOUR AVERAGE SURFACE WINDS

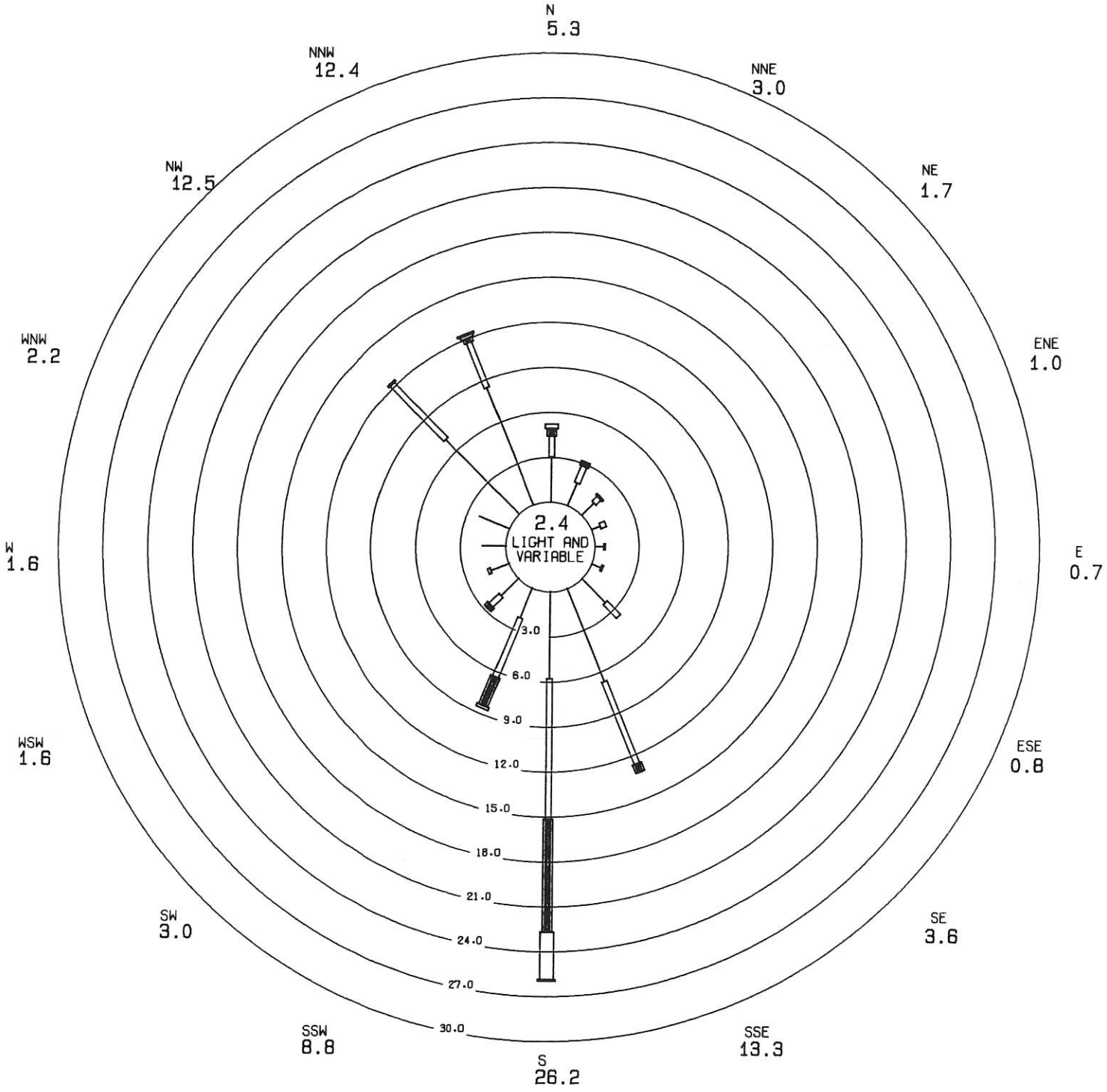
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
17711 Ballinger Way NE, Lake Forest Park, Wa

INCLUSIVE DATES- ALL MONTHS 1990

TOTAL OBSERVATIONS- 8,710





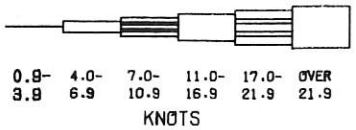
HOUR AVERAGE SURFACE WINDS

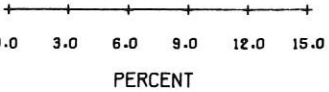
PERCENTAGE FREQUENCY OF OCCURRENCE

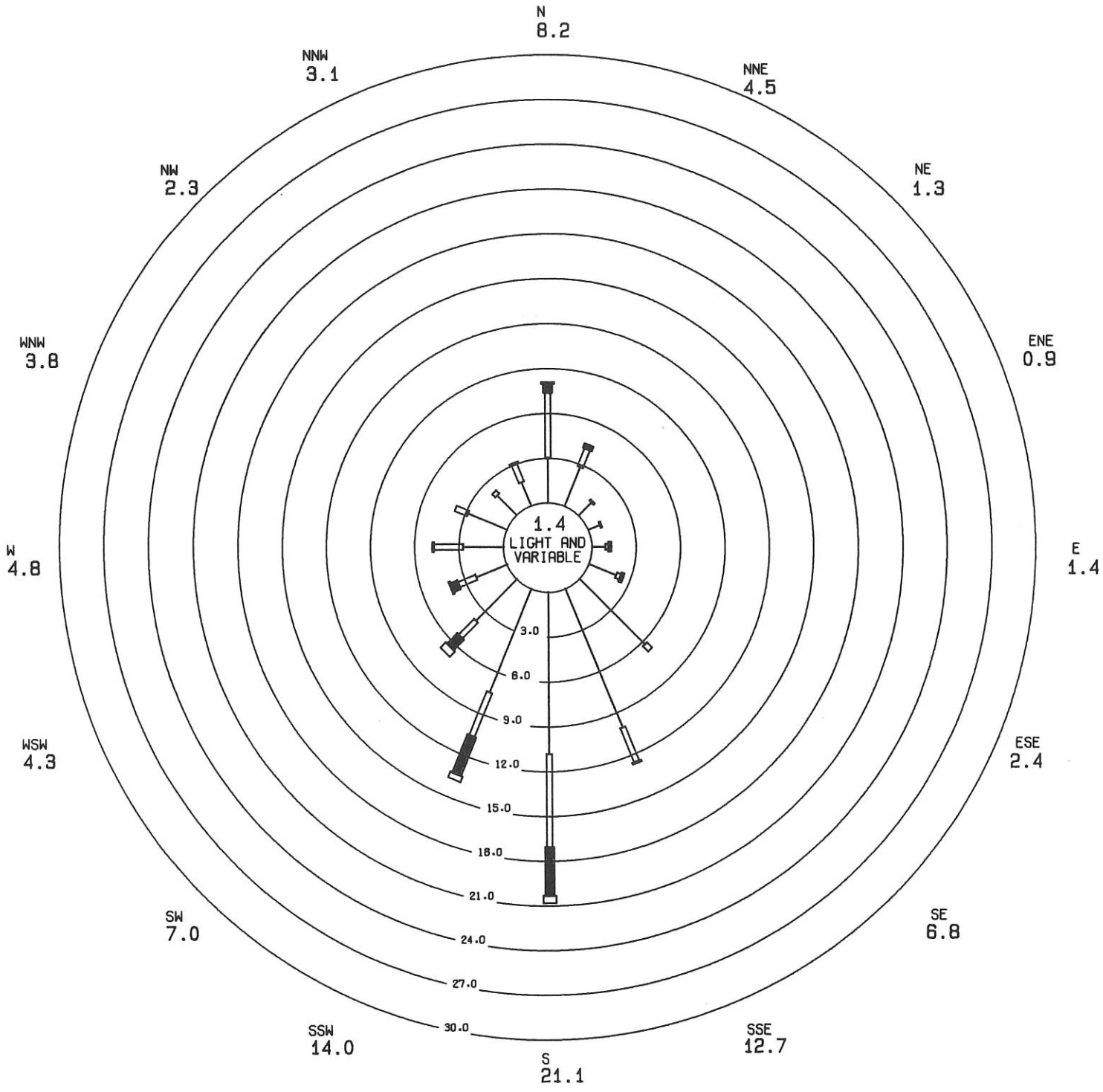
STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Duwamish, 4752 E Marginal Way S, Seattle, Wa

INCLUSIVE DATES- ALL MONTHS 1990

TOTAL OBSERVATIONS- 8,561







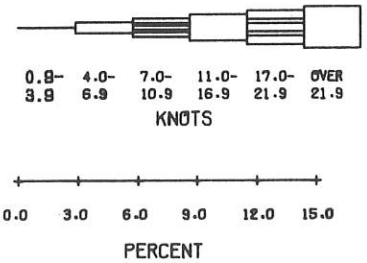
HØUR AVERAGE SURFACE WINDS

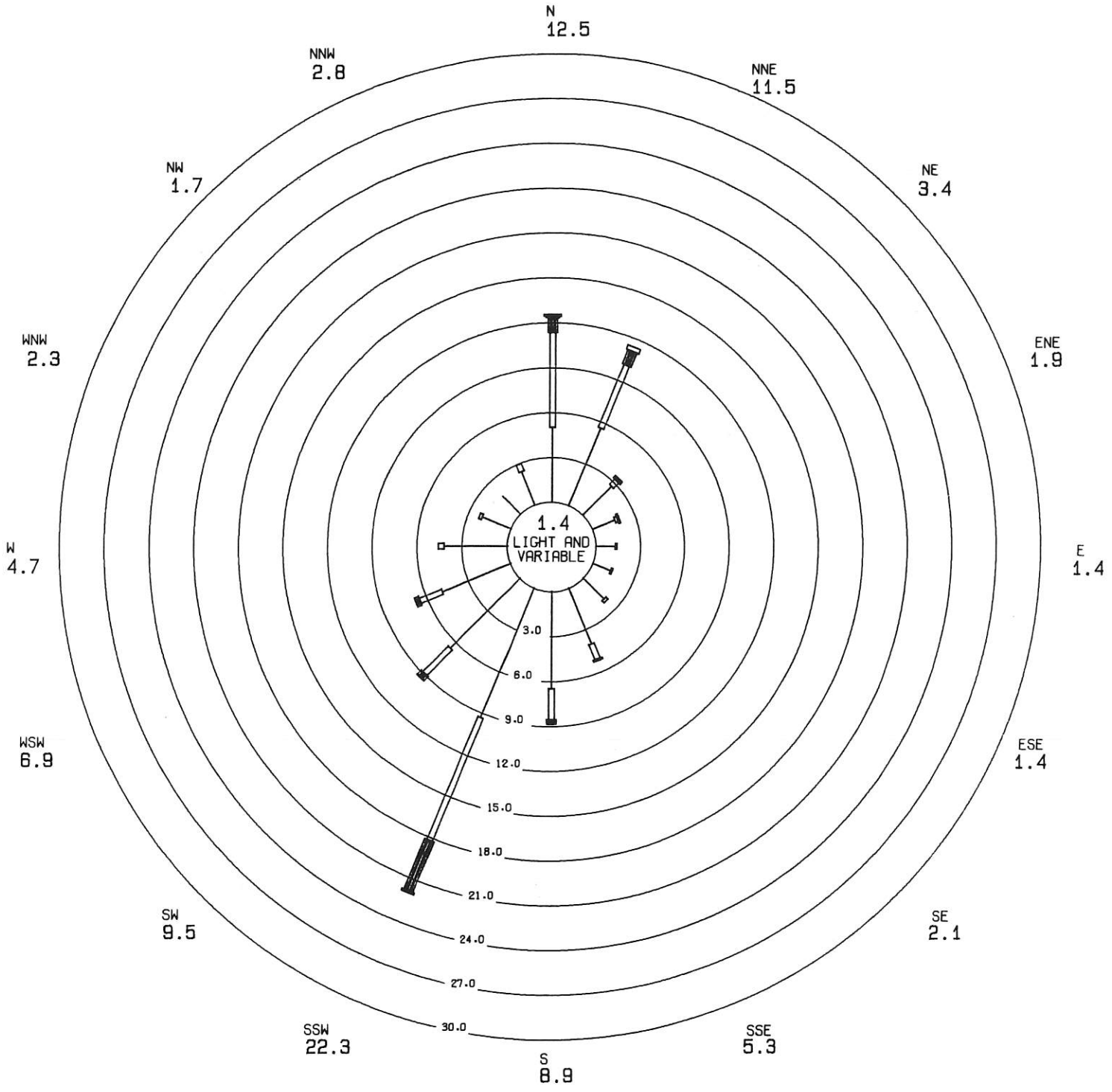
PERCENTAGE FREQUENCY ØF ØCCURRENCE

STATIØN LØCATIØN- PUGET SOUND AIR POLLUTION CONTROL AGENCY
James St & Central Ave, Kent, Wa

INCLUSIVE DATES- ALL MONTHS 1990

TØTAL ØBSERVATIØNS- 8,748





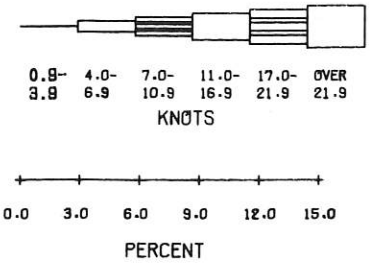
HOUR AVERAGE SURFACE WINDS

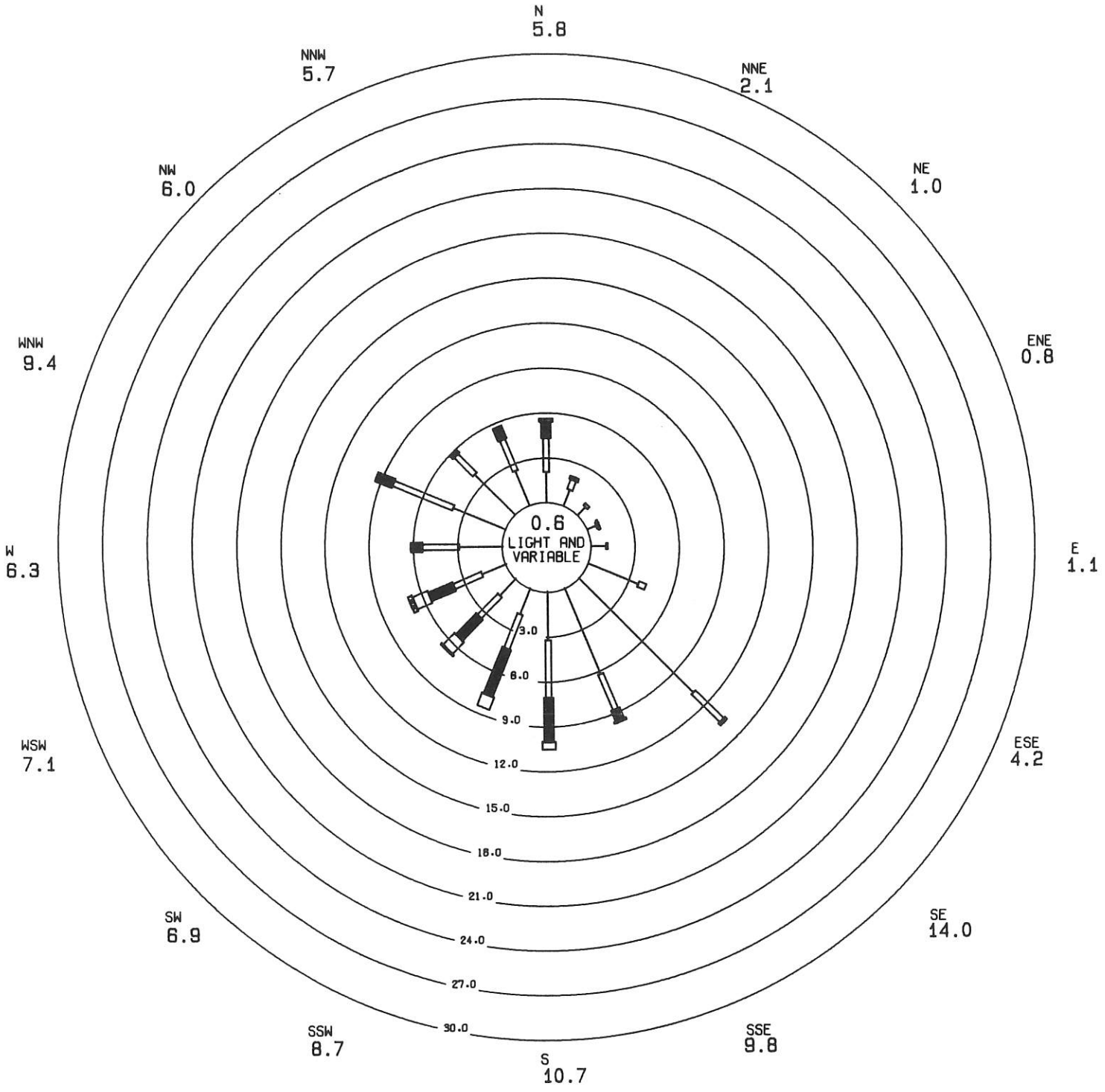
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
27th St NE & 54th Ave NE, Northeast Tacoma, Wa

INCLUSIVE DATES- ALL MONTHS 1990

TOTAL OBSERVATIONS- 8, 584





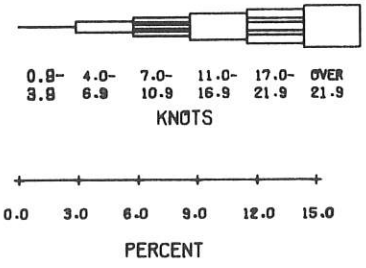
HOUR AVERAGE SURFACE WINDS

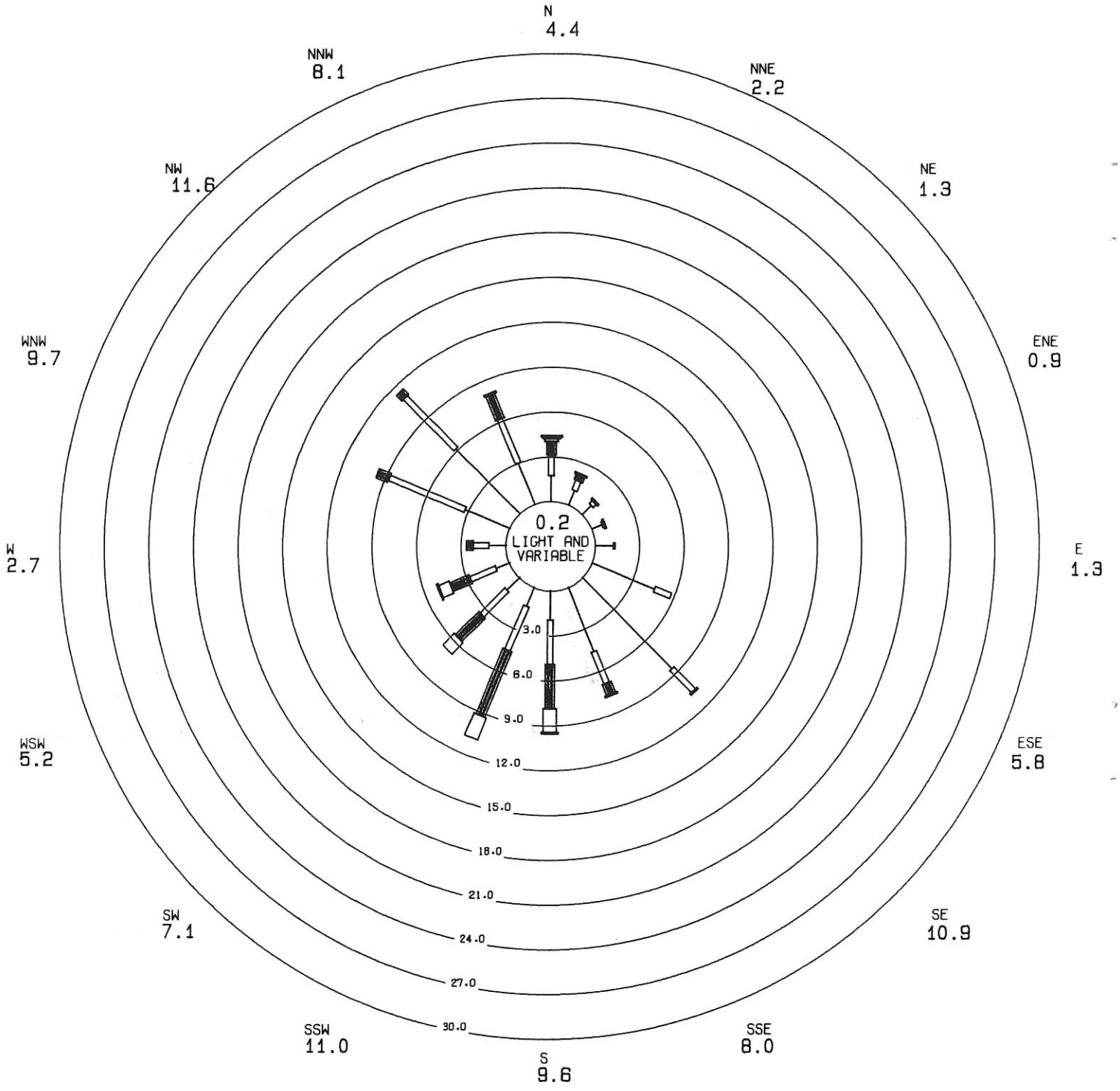
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
2301 Alexander Ave, Tacoma, Wa

INCLUSIVE DATES- ALL MONTHS 1990

TOTAL OBSERVATIONS- 8, 404





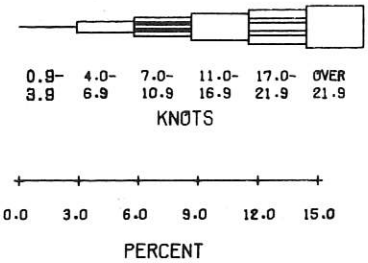
HOUR AVERAGE SURFACE WINDS

PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Fire Station #12, 2316 E 11th St, Tacoma, Wa

INCLUSIVE DATES- ALL MONTHS 1990

TOTAL OBSERVATIONS- 8,727



AIR QUALITY UNITS CONVERSION TABLE

Air quality standards for gases are defined in terms of micrograms (ug) or milligrams (mg) per cubic meter as well as in parts per million (ppm). As this data summary expresses measurements for gaseous pollutants in terms of ppm, the following conversion table is for the convenience of those who wish to interpret our results in terms of ug/cubic meter or mg/cubic meter. These conversion factors from the Federal Register assume a pressure of 760 millimeters Hg and a temperature of 25 degrees C.

Pollutant	*Multiply ppm by*	*To Obtain*
Carbon Monoxide	1.145	mg/cubic meter
Ozone	1961	ug/cubic meter
Sulfur Dioxide	2619	ug/cubic meter
Nitrogen Dioxide	1880	ug/cubic meter

AMBIENT AIR QUALITY STANDARDS

POLLUTANT	NATIONAL Primary	NATIONAL Secondary	WASHINGTON STATE	PUGET SOUND REGION
CARBON MONOXIDE				
8 Hour Average	9 ppm		9 ppm	9 ppm
1 Hour Average	35 ppm		35 ppm	35 ppm
PARTICULATE MATTER (PM_{10})				
Annual Arithmetic Average	50 ug/m^3	50 ug/m^3	50 ug/m^3	50 ug/m^3
24 Hour Average[a]	150 ug/m^3	150 ug/m^3	150 ug/m^3	150 ug/m^3
TOTAL SUSPENDED PARTICULATES				
Annual Geometric Average			60 ug/m^3	60 ug/m^3
24 Hour Average			150 ug/m^3	150 ug/m^3
OZONE				
1 Hour Average[b]	0.12 ppm	0.12 ppm	0.12 ppm	0.12 ppm
SULFUR DIOXIDE				
Annual Average	0.03 ppm		0.02 ppm	0.02 ppm
30 Day Average				0.04 ppm
24 Hour Average	0.14 ppm		0.10 ppm	0.10 ppm[c]
3 Hour Average		0.50 ppm		
1 Hour Average[d]			0.25 ppm	0.25 ppm
1 Hour Average			0.40 ppm	0.40 ppm[c]
5 Minute Average[e]				1.00 ppm
LEAD				
Calendar Quarter Average	1.5 ug/m^3	1.5 ug/m^3		1.5 ug/m^3
NITROGEN DIOXIDE				
Annual Average	0.05 ppm	0.05 ppm	0.05 ppm	0.05 ppm

Notes

(1) ppm = parts per million

(2) ug/m^3 = micrograms per cubic meter

(3) Annual, Quarter and 30 Day standards never to be exceeded, shorter term standards not to be exceeded more than once per year unless noted.

a - Standard attained when expected number of days per year with a 24 hour concentration above 150 ug/m^3 is equal to one or less.

b - Standard attained when expected number of days per year with an hourly average above 0.12 ppm is equal to one or less.

c - Sulfur Dioxide short-term standard never to be exceeded.

d - Not to be exceeded more than twice in seven days.

e - Not to be exceeded more than once in eight hours.

CHARACTERISTICS AND EFFECTS OF AMBIENT AIR POLLUTANTS

Carbon Monoxide

Carbon monoxide is a colorless, odorless, toxic gas commonly formed when carbon-containing fuel is not burned completely. The automobile internal combustion engine is a principal source of carbon monoxide. Carbon monoxide chemically combines with the hemoglobin in the red blood cells to decrease the oxygen-carrying capacity of the blood. It also weakens the contractions of the heart, thus reducing the amount of blood pumped throughout the body. People with heart disease and pregnant women are particularly at risk because of the effects of carbon monoxide.

Particulate Matter (PM_{10} and TSP)

Particulate matter consists of small discrete solid or aerosol particles dispersed in the air. Particulate matter with an aerodynamic diameter of less than or equal to 10 micrometers is referred to as PM_{10}. Total Suspended Particulates (TSP) includes PM_{10} and larger suspended particulates. Transportation, industrial activity and wood burning are major sources of particulate matter. Particulates one micrometer or less in diameter are especially associated with a variety of adverse effects on public health and welfare. Particulate in the respiratory tract may produce injury by itself, or it may act in conjunction with gases to increase the effect on the body. The elderly, those suffering from respiratory illness, and young children are especially prone to the deleterious effects of particulates. Soiling of buildings and other property, and reduced visibility are further results of high particulate matter levels.

Ozone

Ozone is a pungent-smelling, colorless gas produced in the atmosphere when nitrogen oxides and some hydrocarbons chemically react under the effect of strong sunlight. It is a pulmonary irritant that affects lung tissues and respiratory functions. Ozone impairs the normal function of the lung and, at concentrations between 0.15 and 0.25 ppm, causes lung tightness, coughing and wheezing. Other oxidants that often accompany ozone cause eye irritation. Persons with chronic respiratory problems, such as asthma, seem most sensitive to increases in ozone concentration.

Sulfur Dioxide

Sulfur dioxide is a colorless, corrosive gas, that has a bitter taste, but no appreciable smell between 0.3 - 1.0 ppm. Industrial sites such as smelters, paper mills, power plants and steel manufacturing plants are the main sources of sulfur dioxide pollution. The presence of sulfur dioxide in the ambient air has been associated with a variety of respiratory diseases and increased mortality rates. When sulfur dioxide is inhaled with small particles, the effect on health is increased. Inhalation of sulfur dioxide can cause increased airway resistance by constricting lung passages.

Lead

Lead particles or its compounds enter the air from vehicle exhaust and from industries that smelt or process the metal. Lead affects humans in numerous ways, but the greatest impacts appear to be on the blood-forming system, the nervous system, and the kidneys. It affects some people more than others. Young children from one to five years old are particularly sensitive to lead exposure. The standard for lead in air is intended to prevent most children from exceeding blood lead levels of 30 micrograms per deciliter of blood.

Nitrogen Dioxide

Nitrogen dioxide is a poisonous, brownish gas which, in addition to being a strong oxidizing agent, quickly reacts with water vapor to form corrosive nitric acid. Nitrogen dioxide is formed as the result of high temperature fuel combustion and subsequent atmospheric reactions. The presence of nitrogen dioxide in ambient air has been connected with a range of respiratory diseases. Further, nitrogen dioxide plays an essential role in the production of ozone.