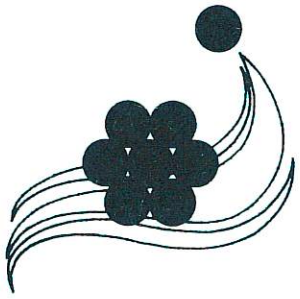
1986 AIR QUALITY DATA SUMMARY

Counties Of

King
Kitsap
Pierce
Snohomish



Puget Sound
Air Pollution Control Agency

Puget Sound Air Pollution Control Agency

Serving King, Kitsap, Pierce and Snohomish Counties

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1986
AIR QUALITY
DATA SUMMARY

Measured and Compiled by the
Technical Services Division

Emission Inventory Developed by the
Engineering Division

PUGET SOUND
AIR POLLUTION CONTROL AGENCY
200 West Mercer Street, Room 205
Seattle, Washington 98119-3958

1986 AIR QUALITY DATA SUMMARY

Contents

Reference copies of this summary have been placed in public and college libraries within the Puget Sound region. Individual copies are for sale at the Puget Sound Air Pollution Control Agency Seattle headquarters office.

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Technical Services Division
(206) 344-7326

EXECUTIVE SUMMARY

Introduction

This fifteenth annual data summary reviews 1986 air quality, meteorological and air contaminant emission data for the Puget Sound Region. The report begins with illustrations of two sampling stations, a table outlining the sampling network (with addresses) and a map of the network. Within the report are summaries of pollutant measurements together with interpretive comments. Sections near the back present meteorological data consisting of lower atmosphere temperature soundings, wind speed averages and wind roses. New at the end of this summary is the tabulation of the air contaminant emission inventory by county followed by the four county totals for the Puget Sound Region. The last page outlines the National, Washington State, and Puget Sound Region ambient air quality standards for the six principal air pollutants.

The standards are not yet attained for the pollutants carbon monoxide and particulate matter. A major revision to the national standards for particulate matter was published during July, 1987. The Puget Sound Region was redesignated as attainment for the pollutant ozone early in 1987. The Region is in attainment of the standards for sulfur dioxide and nitrogen dioxide. For the pollutant lead, a single station recorded a level exceeding the standard during the first quarter of 1986 due to site cleanup activities following closure of a secondary lead smelter, but the lead standard has been attained for all other locations.

Carbon Monoxide

The carbon monoxide nonattainment areas are located in Seattle (downtown and the University district), in Bellevue (downtown), and in Tacoma (downtown). The following table summarizes 1986 carbon monoxide data for areas measuring values exceeding the level of the primary (health related) standard of 9 ppm averaged over eight hours.

Location	Number of Days 8 hr Avg Exceeded 9 ppm	Highest 8 hr Avg (ppm)	Date	2nd Highest 8 hr Avg (ppm)	Date
Bellevue, Bellevue Wy	5	12	Jan 7	12	Dec 17
Seattle, Northgate	2	11	Dec 10	11	Dec 17
Seattle, Univ Dist	8	12	Jan 12	12	Dec 17
Seattle, 4th & Pike	1	11	Jan 31	9	Dec 16
Seattle, 5th & James	1	10	Jan 31	9	Oct 6
Tacoma, 942 Pacific	5	13	Oct 23	12	Dec 17

Particulate Matter

The areas which exceed the Total Suspended Particulate (TSP) standards are the industrialized Seattle Harbor Island-Duwamish area and the industrialized Tacoma Port area. The following table summarizes data for all stations measuring at least one TSP value exceeding the level of the 24 hour standard of 260 micrograms per cubic meter (ug/m^3) during 1986. The 1986 annual geometric mean is also shown for each of these locations. No station exceeded the annual standard of 75 ug/m^3 for calendar year 1986.

Location	Maximum TSP Value (ug/m^3)	Date	Number of TSP Values Exceeding 260 ug/m^3	Number of TSP Values Exceeding 150 ug/m^3	Annual Geometric Mean (ug/m^3)
Duwamish, Seattle	391	Jan 7	2	23	71
27th St NE, Tacoma	322	Oct 14	1	4	57
Taylor Way, Tacoma	261	Oct 23	1	6	69
Willard School, Tacoma	263	Dec 10	1	2	50
Mt Tahoma HS, Tacoma	268	Dec 10	1	1	--

Of the 30 stations measuring TSP in the Puget Sound area, 22 locations measured at least one value exceeding the 24 hour standard of 150 ug/m^3 during 1986.

The particulate matter situation is complicated by the revision to the national standards. The new standards adopted by the U. S. Environmental Protection Agency (EPA) in July, 1987 measure only the component of TSP known as PM_{10} (particles 10 micrometers or less in diameter). The level of the new national primary and secondary PM_{10} standards is 150 ug/m^3 for a 24 hour average and 50 ug/m^3 annual arithmetic mean. In most cases this revision relaxes the national standards for particulate matter when compared to the TSP standards. The following table summarizes PM_{10} data acquired in the Puget Sound Region during 1986 for locations with at least one value exceeding a 24 hour average of 150 ug/m^3. The 1986 annual arithmetic mean is also presented for each of those sites.

Location	Maximum PM_{10} Value (ug/m^3)	Date	Number of PM_{10} Values Exceeding 150 ug/m^3	Annual Arithmetic Mean (ug/m^3)
Duwamish, Seattle	201	Jan 7	2	43
South Park, Seattle	152	Dec 10	1	39
N Central Ave, Kent	153	Dec 10	1	39
Taylor Way, Tacoma	152	Oct 23	1	45
East 11th St, Tacoma	175	Jan 7	3	42

Ozone

The Puget Sound Region was redesignated as in attainment of the ozone standard by EPA's formal action early in 1987. None of the ozone values measured from 1982 through 1984 exceeded the level of the national primary standard, which is 0.12 ppm for a single day maximum one hour average. One day with a maximum hourly value exceeding the level of the standard occurred at one station in 1985 and at two stations in 1986. Because of EPA's statistical form for the standard, no standard violation occurred. The following table lists the locations where measurements equaled or exceeded the level of the ozone standard during 1986.

Location	Maximum 1 hr Avg (ppm)	Date(s)
Lake Sammamish State Park	.13	June 13
Enumclaw	.12	May 31, June 13
Pack Forest, Pierce County	.14	June 13

Daily Air Quality and Weather Variables

The Agency reports on daily air quality by using the national Pollutant Standards Index. The Index value is calculated directly from the actual concentration for each of the pollutants, and the report includes the descriptive air quality category associated with the daily Index value. These categories describe the air quality (in progressively more polluted stages) as "Good", "Moderate", "Unhealthful", or "Very Unhealthful". Any pollutant concentration exceeding the short term national primary standard results in an Index value placing the daily air quality in the unhealthful or a worse category.

The daily Pollutant Standards Index values provide an easy way to summarize the air quality for the entire year. The following table compiles the daily Index values during 1986 for Everett, Seattle, and Tacoma.

	Number of Days in Each Category During 1986		
	Everett	Seattle	Tacoma
Good	324	130	161
Moderate	41	226	197
Unhealthful	0	8	7
Very Unhealthful	0	1	0

Finally, another variable 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 people's 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 each year poor dispersion persists for 24 or more hours. These cases are often associated with the higher pollutant levels. During 1986 in western Washington, the Department of Ecology formally declared the Forecast Stage of an air pollution episode on three occasions because of stagnant weather conditions. The dates with the Forecast Stage in effect were October 15-17, October 20-24, and December 10-11. This was about average for the number of such cases each year looking back over the historical frequency of occurrence since 1971.

Air Contaminant Emission Inventory

The air contaminant emission inventory is compiled each year by the Agency's Engineering Division from registered source information, Notice of Construction permit data, published emission factors, census statistics and source test results. The air contaminants tabulated include: total suspended particulate matter (TSPM), particulate matter less than 10 micrometers (PM_{10}), sulfur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOC), carbon monoxide (CO) and toxic air contaminants (TAC). The Puget Sound Region emission inventory for 1986 is summarized below.

Emissions in Thousands of Tons (1986)

Source Category	TSPM	PM_{10}	SO_x	NO_x	VOC	CO	TAC
Transportation	206	81	7	71	106	686	5
Fuel Combustion	8	7	25	10	12	42	2
Industrial Processes	6	2	4	4	7	22	7
Miscellaneous	5	5	-	2	28	33	15
Totals	225	95	36	87	153	783	29

Other Information Sources

All data collected are reported to the Washington State Department of Ecology; some of it is forwarded from there to the National Aerometric Data Bank maintained by the EPA. The Department of Ecology conducts air monitoring within the Puget Sound area 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 State Department of Ecology - PV11, Office of Air Programs, Olympia, Washington 98504-8711.

Anyone may also obtain the current Pollutant Standards Index from the American Lung Association of Washington in Seattle by dialing 441-5100 or by dialing 1-800-732-9339 from outside Seattle.

SAMPLING SYSTEM ILLUSTRATED

Air quality and wind measurements are conducted at a variety of different locations as tabulated on the following page.

To the right is the main Seattle industrial area station located at 4752 E Marginal Way South. Real time data is telemetered to the Seattle central station from the continuous measurements of wind, sulfur dioxide and atmospheric particles at this site. An array of high volume samplers on the roof provide for almost daily sampling using this manual method. Data from this station and others are used to report the daily Pollutant Standards Index to the public.

The monitoring station above is the main Tacoma industrial area station located at 2316 E 11th Street. Real time data from continuous sampling is telemetered from this station, however the picture is focused on some of the manual particulate matter samplers on the roof. In the center foreground is a dichotomous low volume sampler.

One of the TSP high volume samplers is on the left. Three PM_{10} high volume samplers with the mushroom-like size selective inlets appear in the background center and to the right. Values for TSP and PM_{10} are computed after a sampled filter from each instrument is removed and transported to the Seattle laboratory where it is conditioned and weighed.

PUGET SOUND AIR POLLUTION CONTROL AGENCY

Atmospheric Sampling Network

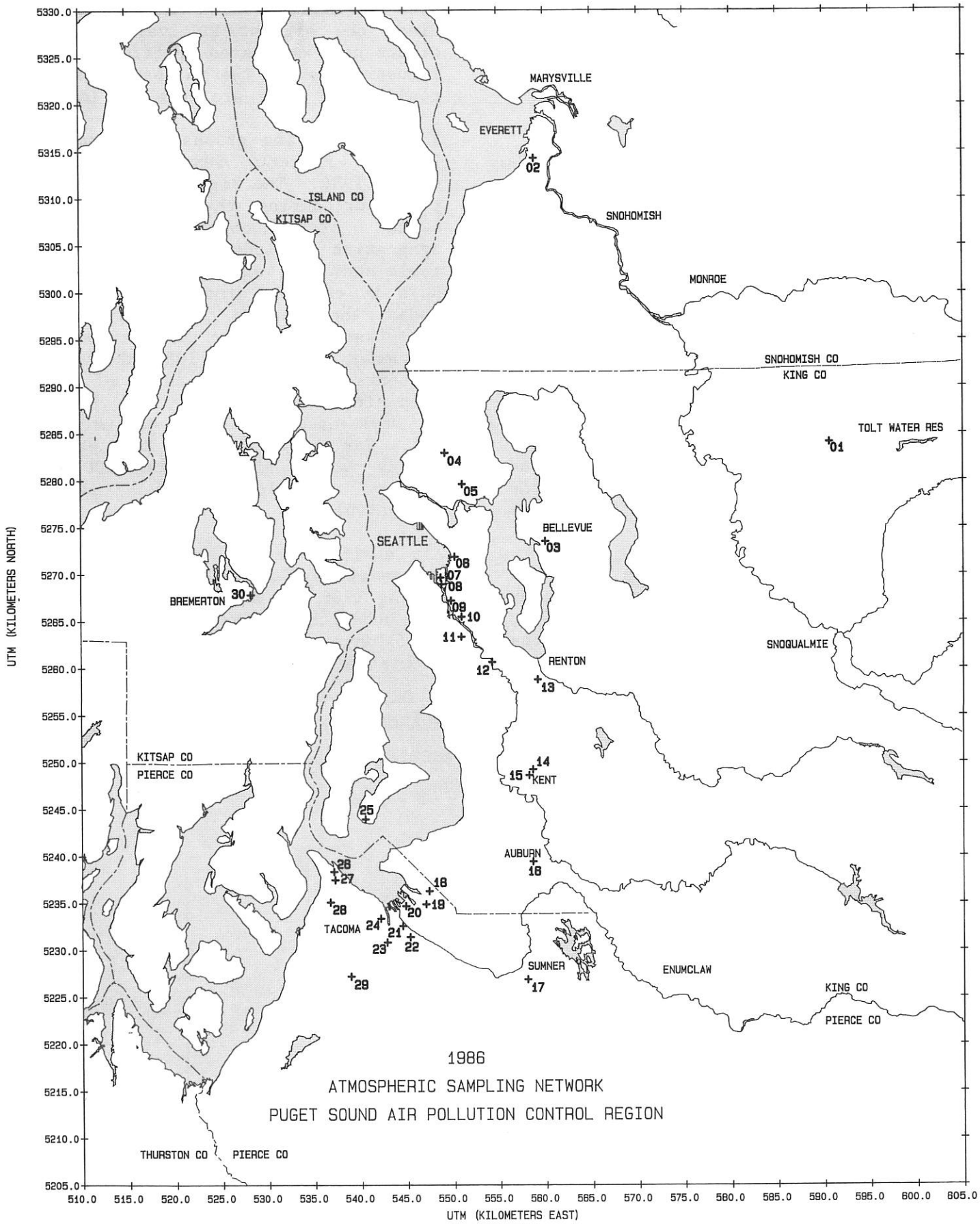
1986

	Location	Type of Sampling[a] A	B	C	D	E	F	G	H	I
01	Tolt River Watershed, King County, Wa	A								
02	Medical-Dental Bldg, 2730 Colby, Everett, Wa	A	B	C	D					I
*03	504 Bellevue Way NE, Bellevue, Wa	A						G		I
04	North 98th St & Stone Ave N, Seattle, Wa	A	B		D		F	G		I
*05	5701 8th Ave NE, Seattle, Wa	A						G		
*06	Fire Station #10, 301 2nd Ave S, Seattle, Wa	A								I
07	Harbor Island, 2555 13th Ave SW, Seattle, Wa	A						G	H	
08	Harbor Island, 3400 13th Ave SW, Seattle, Wa	A						G	H	I
09	Duwamish, 4752 E Marginal Way S, Seattle, Wa	A	B	C	D		F			I
*10	Georgetown, 6431 Corson Ave S, Seattle, Wa	A								
11	South Park, 723 S Concord St, Seattle, Wa	A						G	H	I
12	Duwamish Valley, 12026 42nd Ave S, King Co, Wa	A								
13	200 South 2nd St, Renton, Wa	A								
14	22916 86th Ave S, Kent, Wa	A			D	E	F			
15	Memorial Park, 850 N Central Ave, Kent, Wa	A								I
16	115 E Main St, Auburn, Wa	A								
17	Sumner Jr HS, 1508 Willow St, Sumner, Wa	A			D	E		G	H	
18	27th St NE & 54th Ave NE, Northeast Tacoma, Wa	A	B		D		F			I
19	2340 Taylor Way, Tacoma, Wa	A								I
20	Fire Station #12, 2316 E 11th St, Tacoma, Wa	A		C	D		F			I
21	Treatment Plant, 1241 Cleveland Wy, Tacoma, Wa	A								
22	Cascadia, 2002 E 28th St, Tacoma, Wa	A								
23	Willard School, S 32nd & S 'D' St, Tacoma, Wa	A								
24	Hess Bldg, 901 Tacoma Ave S, Tacoma, Wa	A								
25	SW 283rd & 101st Ave SW, Maury Island, Wa	A	B					G	H	
26	Ruston School, 5219 N Shirley St, Tacoma, Wa	A						G	H	
27	4716 North Baltimore St, Tacoma, Wa	A						G	H	
28	North 26th & Pearl Sts, Tacoma, Wa	A	B		D			G	H	
*29	Mt Tahoma HS, 6404 S Adams St, Tacoma, Wa	A								
30	City Hall, 239 4th St, Bremerton, Wa	A								

* Station operated by Washington State Department of Ecology (Additional ozone and all nitrogen dioxide and carbon monoxide sampling is performed by the Department of Ecology. Summaries of these data are included in this publication).

[a] Type of Sampling

A Suspended Particulates (Total)
B Sulfur Dioxide (SO2)
C Suspended Particulates-COH'S
D Wind Direction & Speed
E Ozone (O3)
F Atmospheric Particles (b - scattering)
G Lead
H Arsenic
I Suspended Particulates (PM10)


MARYSVILLE
EVERETT
02
ISLAND CO
KITSAP CO
SNOHOMISH
MONROE
SNOHOMISH CO
KING CO
TOLT WATER RES
01
04
05
SEATTLE
BELLEVUE
03
06
07
08
09
10
11
12
BREMERTON
30
RENTON
13
SNOQUALMIE
KITSAP CO
PIERCE CO
14
15
KENT
25
AUBURN
16
26
27
18
19
20
28
TACOMA
24
21
23
22
SUMNER
17
29
ENUMCLAW
KING CO
PIERCE CO
THURSTON CO
PIERCE CO
1986
ATMOSPHERIC SAMPLING NETWORK
PUGET SOUND AIR POLLUTION CONTROL REGION
UTM (KILOMETERS NORTH)
UTM (KILOMETERS EAST)
5330.0
5325.0
5320.0
5315.0
5310.0
5305.0
5300.0
5295.0
5290.0
5285.0
5280.0
5275.0
5270.0
5265.0
5260.0
5255.0
5250.0
5245.0
5240.0
5235.0
5230.0
5225.0
5220.0
5215.0
5210.0
5205.0
510.0
515.0
520.0
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555.0
560.0
565.0
570.0
575.0
580.0
585.0
590.0
595.0
600.0
605.0

POLLUTANT STANDARDS INDEX

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

The PSI places pollutant levels during a 24 hour period on a scale indicating whether there are potential health effects. The PSI scale of zero to 500 classifies the air quality by the following descriptions:

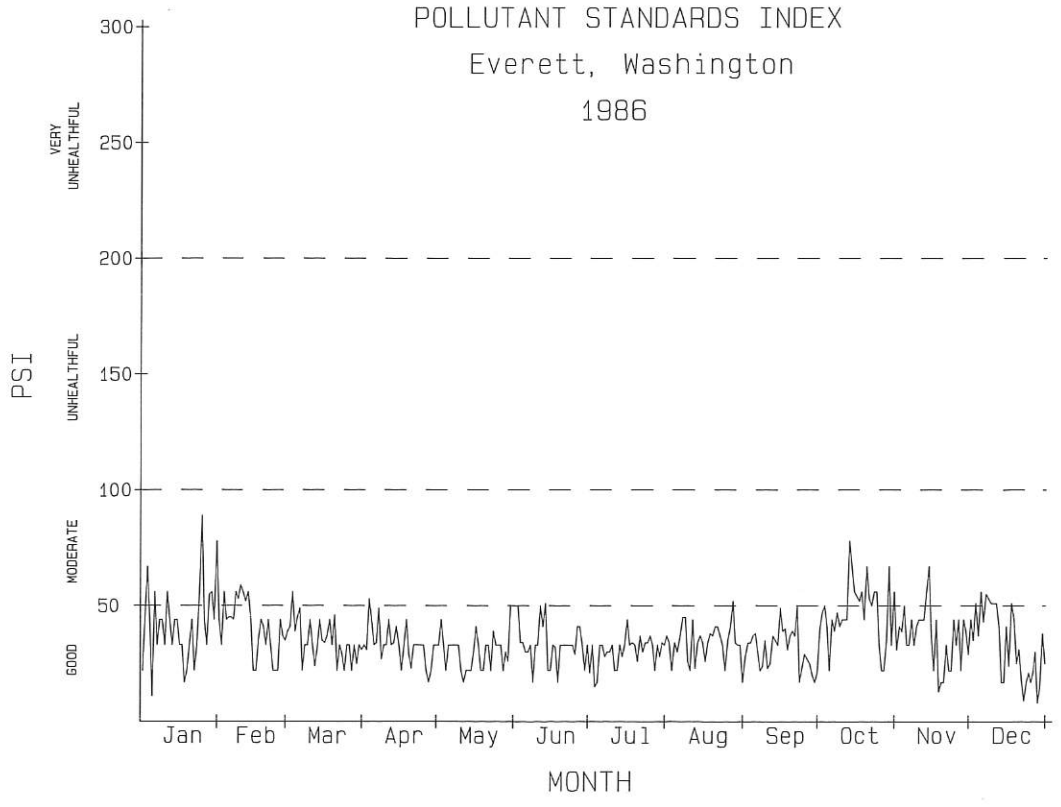
from 0 to 50, Good;
from 51 to 100, Moderate;
from 101 to 199, Unhealthful;
from 200 to 299, Very Unhealthful;
from 300 to 500, Hazardous.

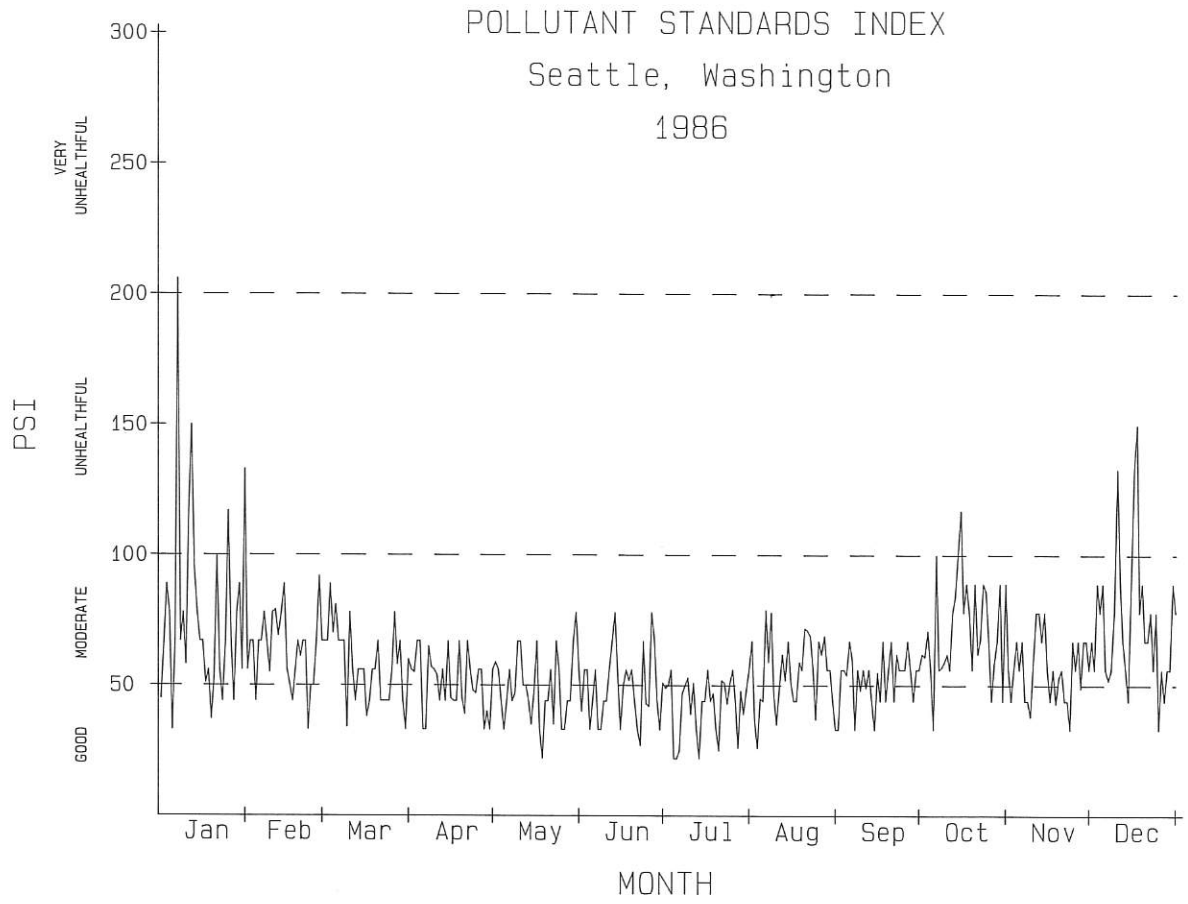
Whenever the PSI is above 100, a measured pollutant level exceeds the national primary air quality standard. An index value of 200 means the pollutant concentration has reached the "Alert" level in the Washington Episode Avoidance Plan.

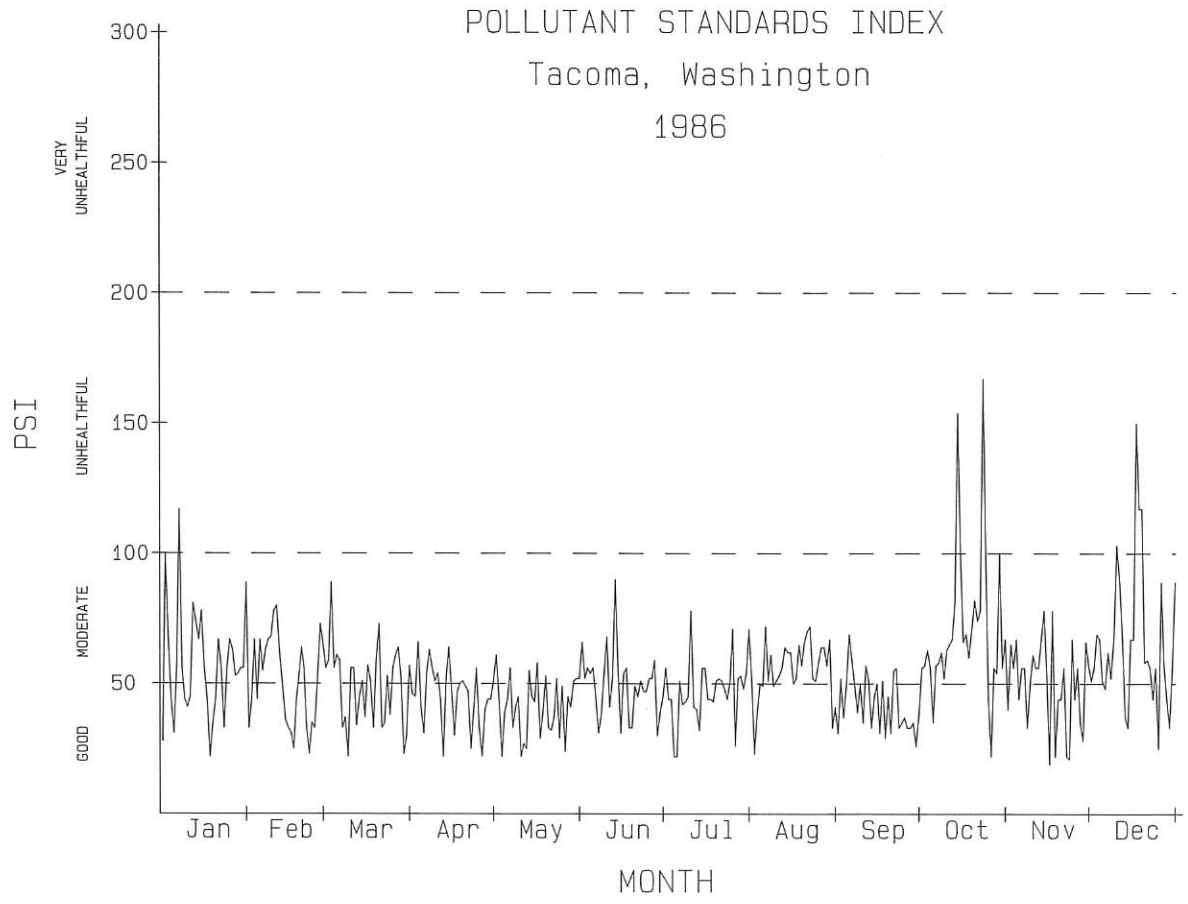
The Agency reviews carbon monoxide, suspended particulates, and sulfur dioxide within the cities of Everett, Seattle and Tacoma to calculate the Index. The Index value for each day in each city is determined by the pollutant with the highest value on the PSI scale. Since the highest PSI value generally occurs near congested traffic or near an industrial area, the values for suburban residential areas are normally lower.

The accompanying graphs plot each daily PSI for Everett, Seattle, and Tacoma during 1986. The higher PSI values tend to occur during the fall and winter months often coinciding with air stagnation periods. A 1986 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 summary table for 1980 through 1986 presents by year the number of days in each air quality category and the number of days each pollutant determined the PSI. For the unhealthful days each year (Index values greater than 100), this summary tabulates the pollutant responsible.

Air quality in Bellevue is principally determined by levels of carbon monoxide. During 1986 the air quality in Bellevue was unhealthful due to carbon monoxide on 5 days during January and December with a maximum PSI of 150.




POLLUTANT STANDARDS INDEX
Seattle, Washington
1986
PSI
300
250
200
150
100
50
VERY UNHEALTHFUL
UNHEALTHFUL
MODERATE
GOOD
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
MONTH


POLLUTANT STANDARDS INDEX
Tacoma, Washington
1986
PSI
300
250
200
150
100
50
VERY UNHEALTHFUL
UNHEALTHFUL
MODERATE
GOOD
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
MONTH

POLLUTANT STANDARDS INDEX

1986

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)	23	21	30	29	31	29	31	30	30	19	28	23	324
MODERATE	(51 to 100)	8	7	1	1	0	1	0	1	0	12	2	8	41
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		89	59	56	53	50	51	44	52	50	78	67	56	89
Date		25th	10th	3rd	3rd	30th#	13th	16th	27th	22nd	13th	14th	5th	Jan 25
Pollutant		CO	TSP	TSP	TSP	SO2	TSP	CO	TSP	TSP	CO	CO	TSP	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)	5	6	10	14	19	16	22	12	10	3	10	3	130
MODERATE	(51 to 100)	21	22	21	16	12	14	9	19	20	27	20	25	226
UNHEALTHFUL	(101 to 199)	4	0	0	0	0	0	0	0	0	1	0	3	8
VERY UNHEALTHFUL	(200 to 299)	1	0	0	0	0	0	0	0	0	0	0	0	1
Maximum PSI each month		206	92	89	67	78	78	56	79	67	117	78	150	206
Date		7th	27th	3rd	3rd#	30th	13th#	3rd#	6th	5th#	15th	11th#	17th	Jan 7
Pollutant		TSP	TSP	TSP	CO	CO	CO	CO	TSP	CO	CO	CO	CO	TSP

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)	11	13	12	19	22	14	17	8	22	3	13	7	161
MODERATE	(51 to 100)	19	15	19	11	9	16	14	23	8	26	17	20	197
UNHEALTHFUL	(101 to 199)	1	0	0	0	0	0	0	0	0	2	0	4	7
VERY UNHEALTHFUL	(200 to 299)	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum PSI each month		117	80	89	66	61	90	78	72	69	167	78	150	167
Date		7th	11th	3rd	3rd	1st	13th	10th	6th#	5th	23rd	14th#	17th	Oct 23
Pollutant		CO	TSP	CO	TSP	TSP	TSP	CO	TSP	TSP	CO	CO	CO	CO

TSP = Total Suspended Particulates; CO = Carbon Monoxide; SO2 = Sulfur Dioxide.

Earliest date of occurrence

POLLUTANT STANDARDS INDEX

1980 - 1986

EVERETT

	Days in Each Air Quality Category				Pollutant Determining the PSI						Highest Value		
					All Days			Unhealthful Days					
	Good	Moderate	Unhealthful	Very Unhealthful	TSP	CO	SO2	TSP	CO	SO2	PSI	Date	Pollutant
1980	340	19	0	0	356	-	3	0	-	0	60	Jan 23	TSP
1981	350	11	0	0	340	-	21	0	-	0	62	Jan 16	TSP
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	TSP
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
Totals	2265	278	3	0	1590	751	205	0	3	0			

SEATTLE

	Days in Each Air Quality Category				Pollutant Determining the PSI						Highest Value		
					All Days			Unhealthful Days					
	Good	Moderate	Unhealthful	Very Unhealthful	TSP	CO	SO2	TSP	CO	SO2	PSI	Date	Pollutant
1980	73	275	18	0	95	270	1	1	17	0	194	Jan 23	TSP
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	TSP
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	TSP
1985	150	202	10	3	156	206	3	6	7	0	204	Dec 12	TSP
1986	130	226	8	1	113	246	6	1	8	0	206	Jan 7	TSP
Totals	752	1714	85	6	781	1743	33	16	75	0			

TACOMA

	Days in Each Air Quality Category				Pollutant Determining the PSI						Highest Value		
					All Days			Unhealthful Days					
	Good	Moderate	Unhealthful	Very Unhealthful	TSP	CO	SO2	TSP	CO	SO2	PSI	Date	Pollutant
1980	83	271	12	0	256	107	3	4	8	0	160	Apr 12	TSP
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	TSP
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	TSP
1986	161	197	7	0	247	114	4	2	5	0	167	Oct 23	CO
Totals	879	1621	54	3	1667	845	45	9	48	0			

Earliest date of occurrence

SUSPENDED PARTICULATES

Introduction

Suspended Particulates as a general term includes small particles of dust, soot, organic matter and compounds containing sulfur, nitrogen, and metals. Particulate matter measured by the federal reference high volume method is termed Total Suspended Particulates (TSP). TSP samplers collect all particles up to 25 to 50 micrometers in diameter, an upper limit somewhat broad with respect to size.

During July, 1987, the U.S. Environmental Protection Agency revised the national primary and secondary particulate matter standards. The revision: (1) defines a size specific method to measure only those particulates smaller than or equal to 10 micrometers in diameter (PM_{10}); (2) sets the same levels for the national primary and secondary standards, 150 ug/m^3 for a 24 hour average and 50 ug/m^3 annual arithmetic mean and (3) adopts statistical calculation formulas for determining whether the standards are attained. During 1986, measurements of PM_{10} continued at eleven stations using the size selective inlet high volume sampler. PM_{10} data is summarized in this section along with the analysis of TSP from the larger network.

Particulate Sources and Air Quality

Particulates directly enter the air from industrial operations, from fuel combustion, from auto and truck traffic, from construction, and from other sources. These emissions may change from day to day due to intermittent industrial operations, equipment upset or breakdown and traffic variations. Gaseous transformation products such as sulfates, nitrates, and some organics are also a component of particulate matter, principally adding particles smaller than 2.5 micrometers in diameter.

Once present in the air particulate matter disperses and is transported by the wind. Lower atmosphere stability influences how readily particulates are dispersed by low level air motions. Measured 24 hour particulate levels often differ significantly from day to day responding to how much enters the air and how quickly meteorological processes disperse the particulates. Tables in this section summarize 24 hour measurements and document that high 24 hour levels often occur at many stations on the same day.

Annual Particulate Matter Maps

Maps of annual average particulate matter values for calendar year 1986 appear on pages 14 and 15. One map presents annual geometric mean TSP values and another map presents annual arithmetic mean values of PM_{10}. Actual values at each sampling station, together with a particulate emission inventory, local wind roses and topography, provide the basis for these maps.

The annual particulate matter concentration at a location may be determined by interpolating between adjacent isopleths (lines connecting points of equal concentration). The highest levels occur in the Tacoma Port area and the Harbor Island-Duwamish Valley area of Seattle.

Particulate Trends

A continuous plot of 12 month averages for a site provides a picture of the levels over time, but to depict any trend such a plot requires many years of data. Moving geometric mean plots of the TSP levels for several stations follow the maps. The plotted line representing the ambient levels is referenced to dashed lines marking the levels of the annual standards. The TSP levels at the Tolt Water Reservoir are consistently low, apparently not affected by the urban area. TSP levels in the industrialized Seattle Duwamish Valley and Tacoma Port area exceeded the annual 75 ug/m^3 standard prior to 1975, from 1977 through 1981 and again at year end 1985. The levels fell between the 75 and 60 ug/m^3 standards for the period 1982-1984 and at year end 1986. A trend is not evident in these data.

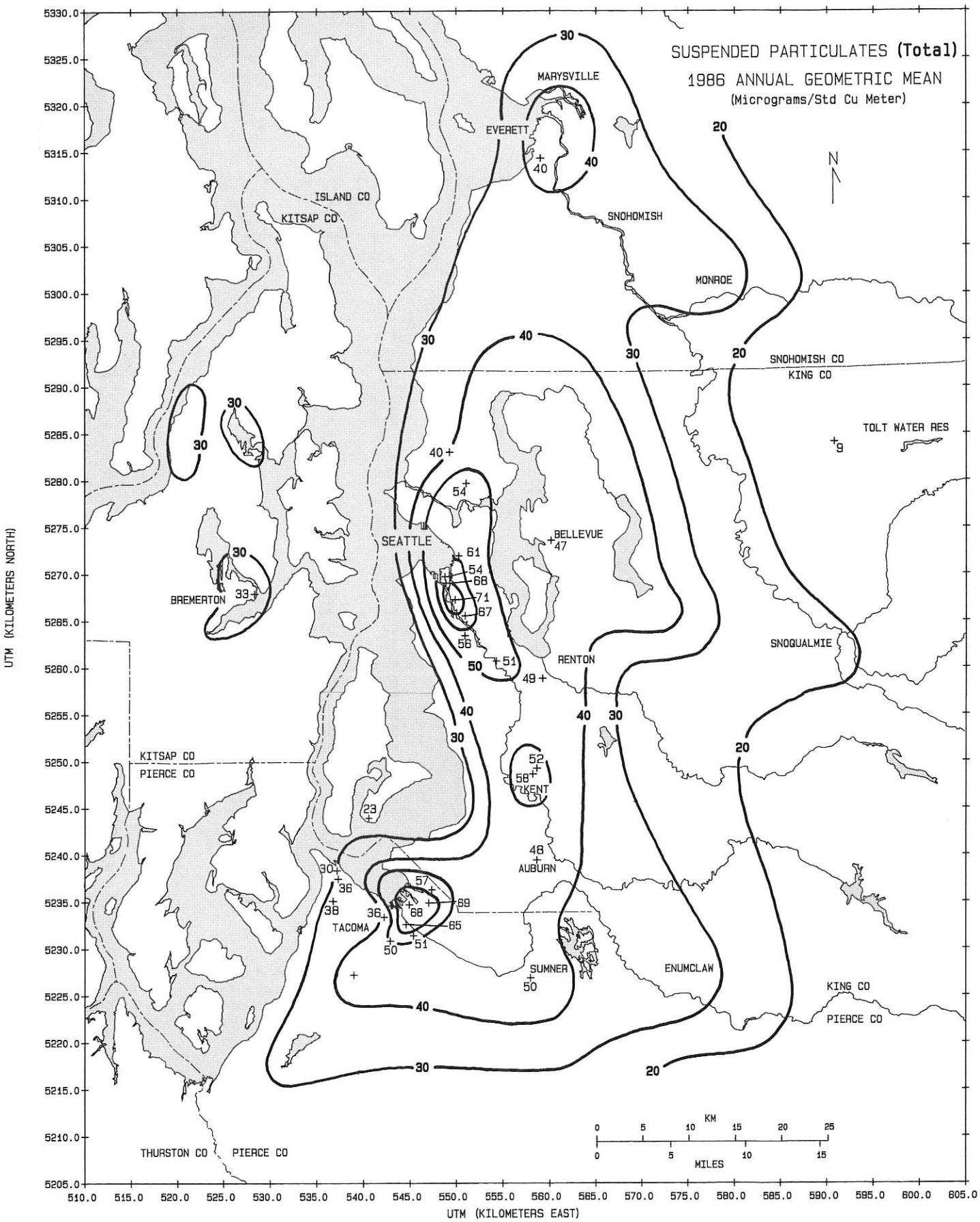
SUSPENDED PARTICULATES (Total)
Micrograms per Standard Cubic Meter

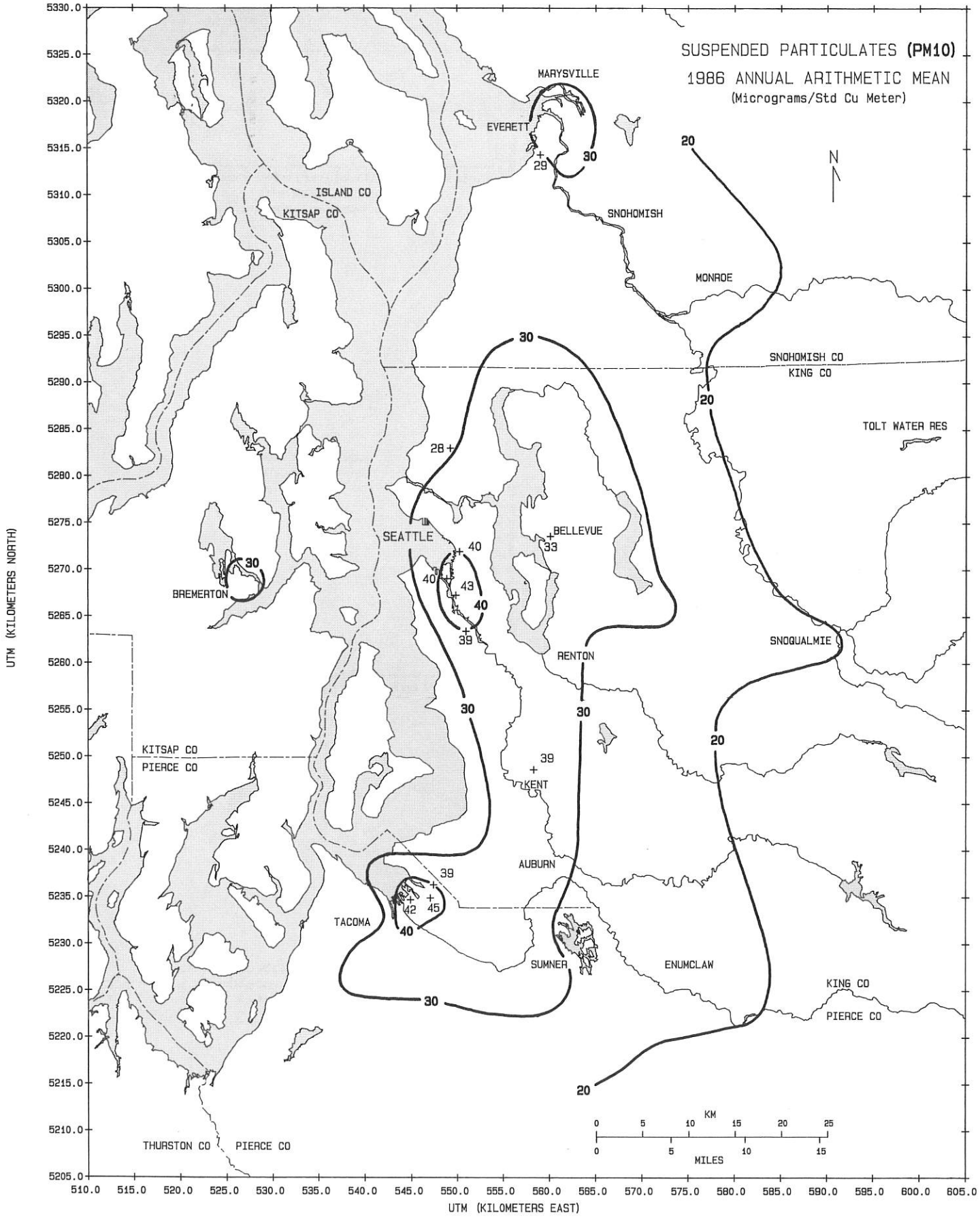
Sampled by Standard High Volume Glass Fiber filters

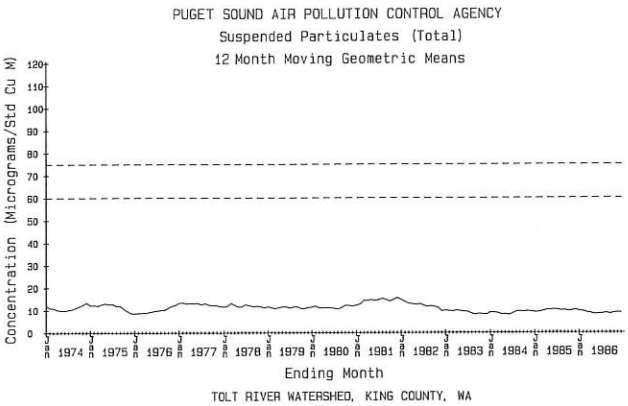
1986

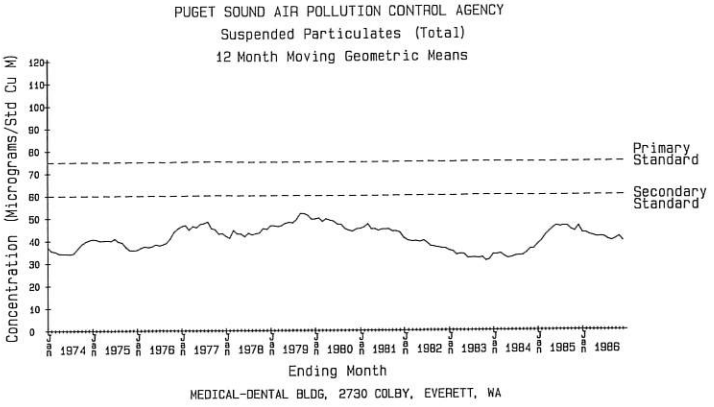
Location	Number of Values	Quarterly Arithmetic Averages				Year Arith Mean	Year Geom Mean
		1st	2nd	3rd	4th		
Tolt River Watershed, King County, Wa	59	5	12	20	9	12	9
Medical-Dental Bldg, 2730 Colby, Everett, Wa	58	49	40	41	46	44	40
504 Bellevue Way NE, Bellevue, Wa	54	65	40	45	61	53	47
North 98th St & Stone Ave N, Seattle, Wa	61	49	34	44	50	44	40
5701 8th Ave NE, Seattle, Wa	55	71	41	-	67	60	54
Fire Station #10, 301 2nd Ave S, Seattle, Wa	52	84	51	-	73	69	61
Harbor Island, 2555 13th Ave SW, Seattle, Wa	61	75	45	50	76	62	54
Harbor Island, 3400 13th Ave SW, Seattle, Wa	61	87	57	72	89	76	68
Duwamish, 4752 E Marginal Way S, Seattle, Wa	338	91	61	72	98	81	71
Georgetown, 6431 Corson Ave S, Seattle, Wa	50	80	67	-	85	77	67
South Park, 723 S Concord St, Seattle, Wa	61	68	49	64	87	67	56
Duwamish Valley, 12026 42nd Ave S, King Co, Wa	61	65	42	53	75	59	51
200 South 2nd St, Renton, Wa	61	69	40	47	63	55	49
22916 86th Ave S, Kent, Wa	61	68	54	55	62	60	52
Memorial Park, 850 N Central Ave, Kent, Wa	61	94	53	54	70	68	58
115 E Main St, Auburn, Wa	58	68	40	48	65	55	48
Sumner Jr HS, 1508 Willow St, Sumner, Wa	58	60	43	58	64	56	50
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	121	55	73	62	82	68	57
2340 Taylor Way, Tacoma, Wa	59	79	64	82	109	84	69
Fire Station #12, 2316 E 11th St, Tacoma, Wa	298	82	68	72	92	78	68
Treatment Plant, 1241 Cleveland Wy, Tacoma, Wa	61	71	60	75	90	74	65
Cascadia, 2002 E 28th St, Tacoma, Wa	60	60	51	57	80	62	51
Willard School, S 32nd & S 'D' St, Tacoma, Wa	59	58	49	53	87	62	50
Hess Bldg, 901 Tacoma Ave S, Tacoma, Wa	59	45	29	34	68	44	36
SW 283rd & 101st Ave SW, Maury Island, Wa	59	27	21	19	40	27	23
Ruston School, 5219 N Shirley St, Tacoma, Wa	60	35	25	27	60	37	30
4716 North Baltimore St, Tacoma, Wa	117	41	31	36	57	41	36
North 26th & Pearl Sts, Tacoma, Wa	61	46	47	43	50	47	38
Mt Tahoma HS, 6404 S Adams St, Tacoma, Wa	45	50	-	-	73	-	-
City Hall, 239 4th St, Bremerton, Wa	59	39	28	32	41	35	33

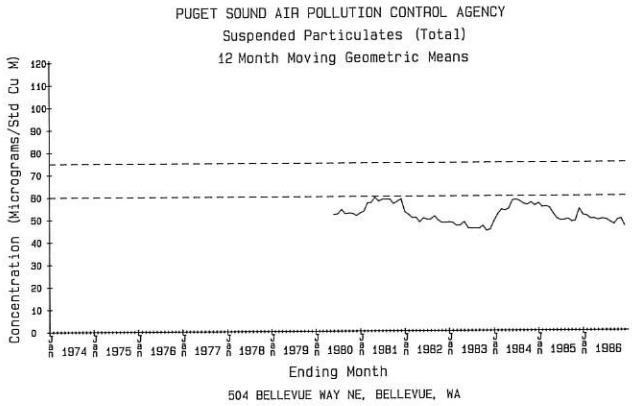
Notes
(1) Nationally scheduled particulate matter sampling occurs each sixth day. Quarterly averages are shown only when at least one data value exists for 75 percent or more of the six day intervals.
(2) Annual averages are shown only if there are at least three quarterly averages.

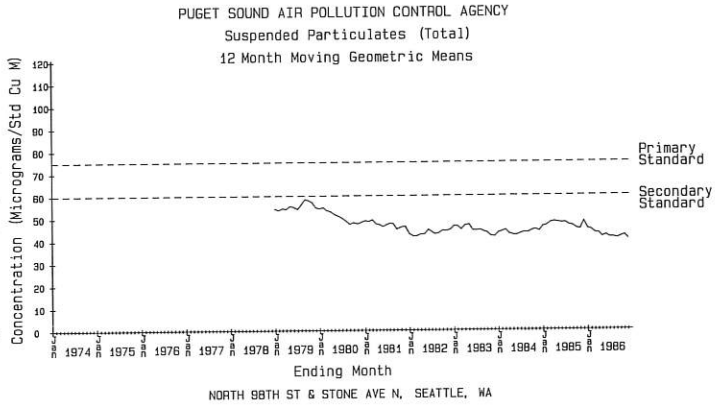

SUSPENDED PARTICULATES (Total)
1986 ANNUAL GEOMETRIC MEAN
(Micrograms/Std Cu Meter)
N
MARYSVILLE
EVERETT
ISLAND CO
KITSAP CO
SNOHOMISH
MONROE
SNOHOMISH CO
KING CO
TOLT WATER RES
SEATTLE
BELLEVUE
BREMERTON
RENTON
SNOQUALMIE
KITSAP CO
PIERCE CO
KENT
AUBURN
TACOMA
SUMNER
ENUMCLAW
KING CO
PIERCE CO
THURSTON CO
PIERCE CO
KM
MILES
UTM (KILOMETERS NORTH)
UTM (KILOMETERS EAST)

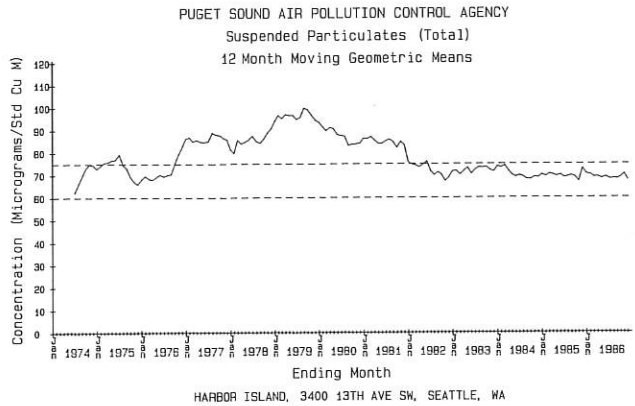

SUSPENDED PARTICULATES (PM10)
1986 ANNUAL ARITHMETIC MEAN
(Micrograms/Std Cu Meter)
N
MARYSVILLE
EVERETT
29
30
20
ISLAND CO
KITSAP CO
SNOHOMISH
MONROE
SNOHOMISH CO
KING CO
TOLT WATER RES
28
SEATTLE
BELLEVUE
33
40
43
39
BREMERTON
RENTON
SNOQUALMIE
KITSAP CO
PIERCE CO
KENT
AUBURN
42
45
TACOMA
SUMNER
ENUMCLAW
KING CO
PIERCE CO
THURSTON CO
PIERCE CO
KM
MILES
UTM (KILOMETERS NORTH)
UTM (KILOMETERS EAST)

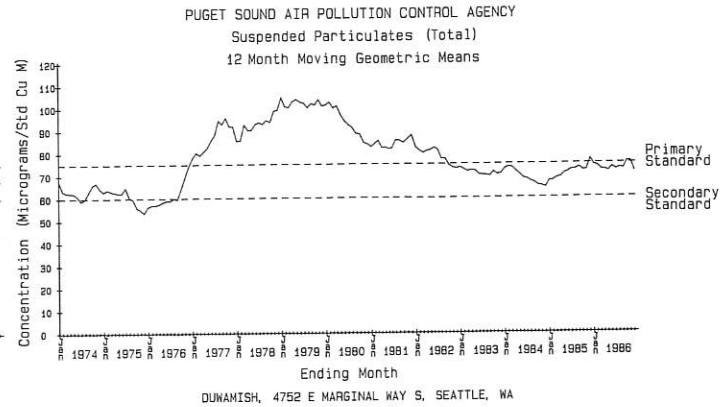

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Ending Month
TOLT RIVER WATERSHED, KING COUNTY, WA

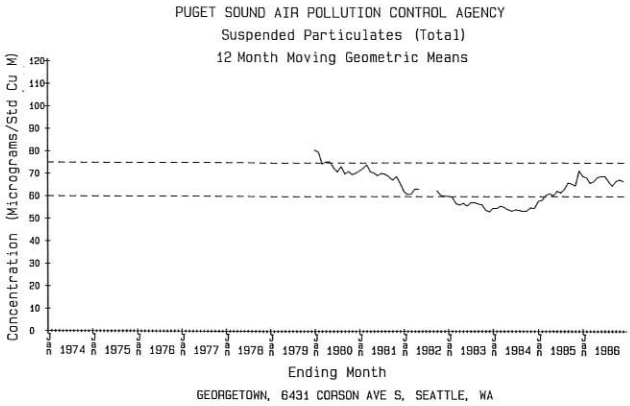

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Primary Standard
Secondary Standard
Concentration (Micrograms/Std Cu M)
Ending Month
MEDICAL-DENTAL BLDG, 2730 COLBY, EVERETT, WA

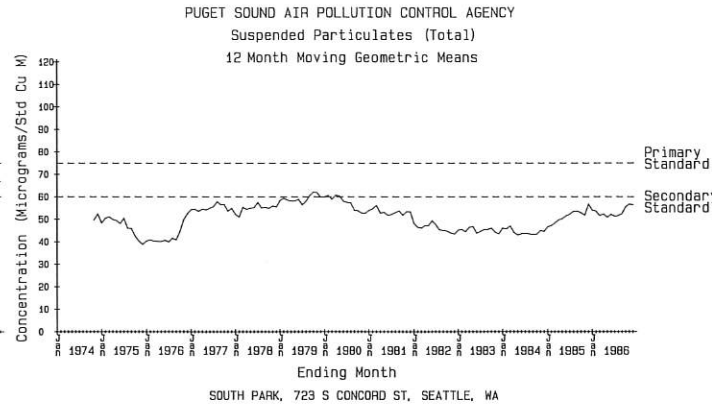

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Ending Month
504 BELLEVUE WAY NE, BELLEVUE, WA

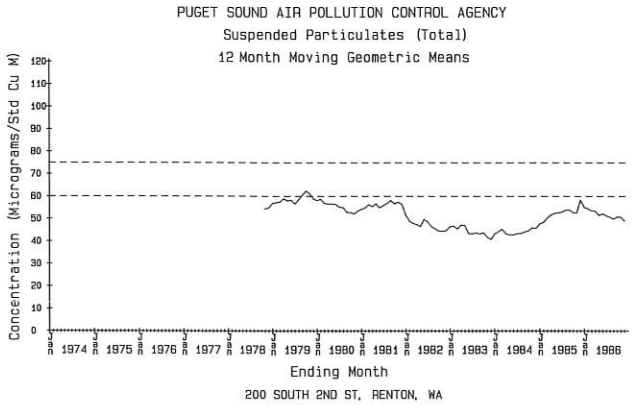

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Primary Standard
Secondary Standard
Concentration (Micrograms/Std Cu M)
Ending Month
NORTH 98TH ST & STONE AVE N, SEATTLE, WA

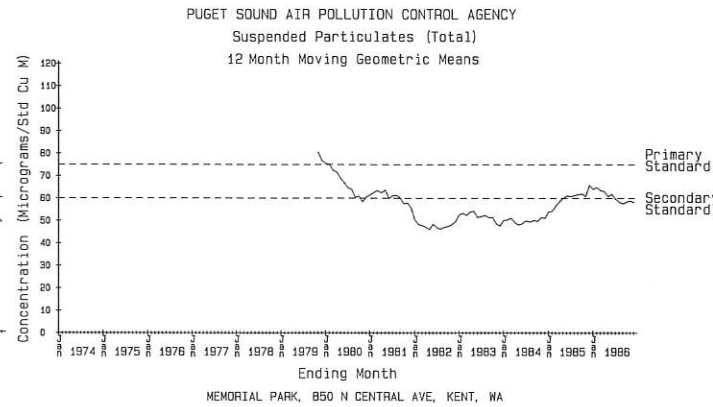

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Ending Month
HARBOR ISLAND, 3400 13TH AVE SW, SEATTLE, WA

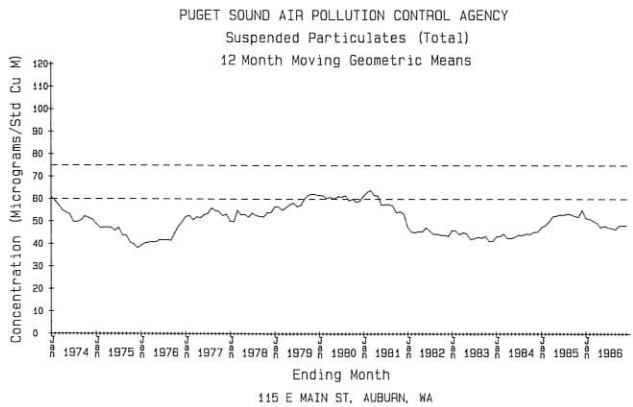

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Primary Standard
Secondary Standard
Concentration (Micrograms/Std Cu M)
Ending Month
DUWAMISH, 4752 E MARGINAL WAY S, SEATTLE, WA

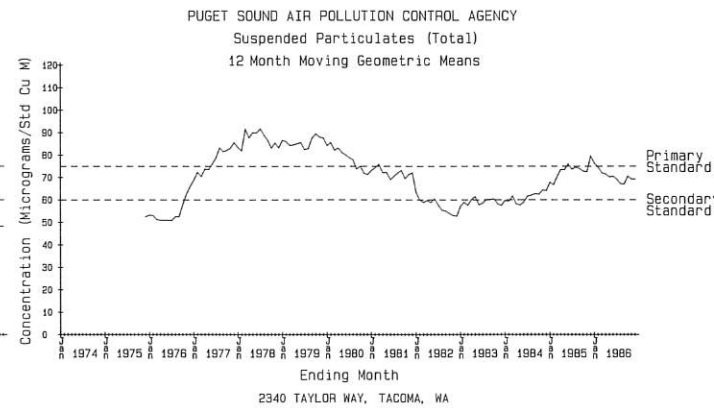

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Ending Month
GEORGETOWN, 6431 CORSON AVE S, SEATTLE, WA

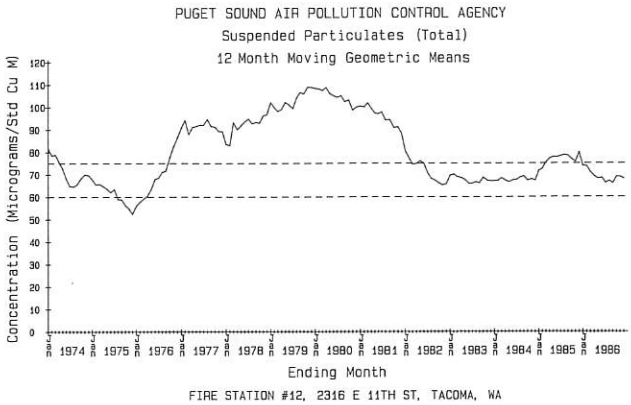

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Primary Standard
Secondary Standard
Ending Month
SOUTH PARK, 723 S CONCORD ST, SEATTLE, WA

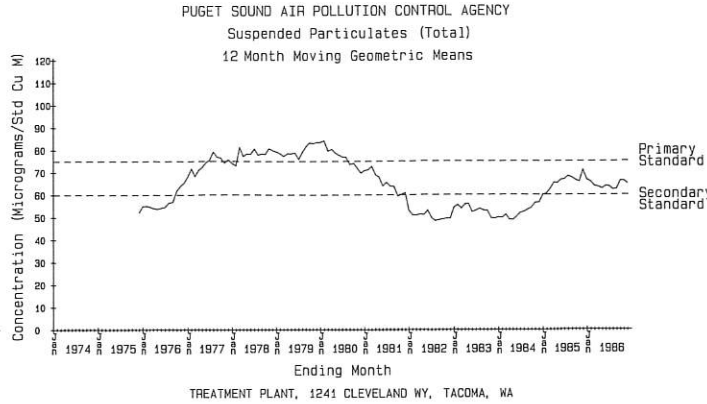

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Ending Month
200 SOUTH 2ND ST, RENTON, WA

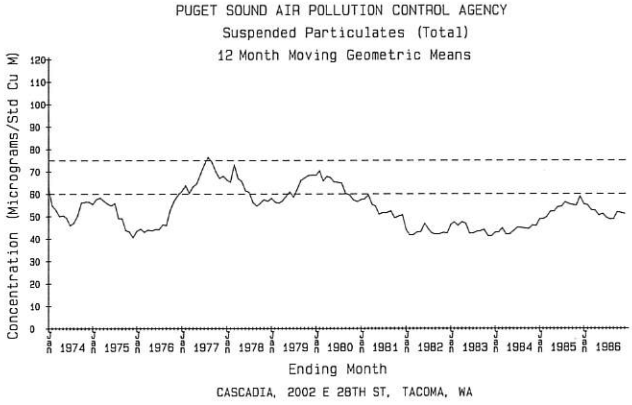

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Primary Standard
Secondary Standard
Ending Month
MEMORIAL PARK, 850 N CENTRAL AVE, KENT, WA

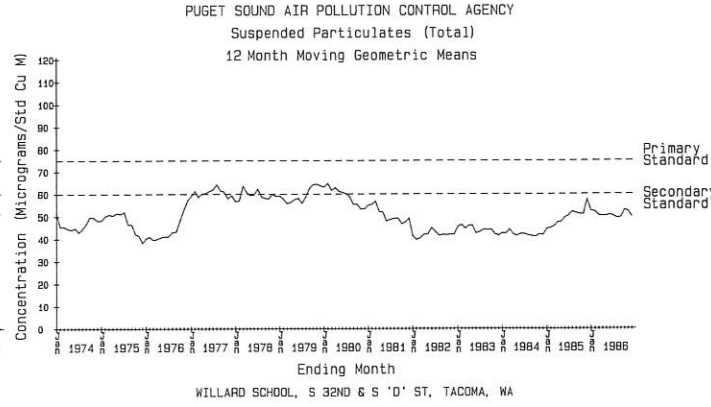

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Ending Month
115 E MAIN ST, AUBURN, WA

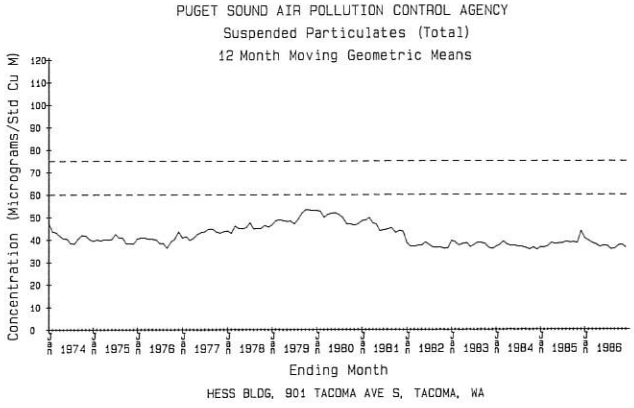

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Primary Standard
Secondary Standard
Ending Month
2340 TAYLOR WAY, TACOMA, WA

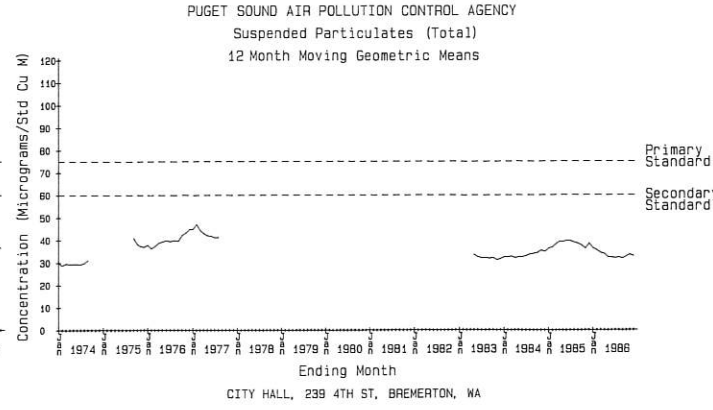

PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Ending Month
FIRE STATION #12, 2316 E 11TH ST, TACOMA, WA


PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Primary Standard
Secondary Standard
Concentration (Micrograms/Std Cu M)
Ending Month
TREATMENT PLANT, 1241 CLEVELAND WY, TACOMA, WA


PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Ending Month
CASCADIA, 2002 E 28TH ST, TACOMA, WA


PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Primary Standard
Secondary Standard
Concentration (Micrograms/Std Cu M)
Ending Month
WILLARD SCHOOL, S 32ND & S 'D' ST, TACOMA, WA


PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Concentration (Micrograms/Std Cu M)
Ending Month
HESS BLDG, 901 TACOMA AVE S, TACOMA, WA


PUGET SOUND AIR POLLUTION CONTROL AGENCY
Suspended Particulates (Total)
12 Month Moving Geometric Means
Primary Standard
Secondary Standard
Concentration (Micrograms/Std Cu M)
Ending Month
CITY HALL, 239 4TH ST, BREMERTON, WA

SUSPENDED PARTICULATES (Total)
Micrograms per Standard Cubic Meter

Sampled by Standard High Volume Glass Fiber filters

1986

Summary of Maximum and 2nd High Observed Concentrations

Location	Jan 7 Tue	Jan 14 Tue	Jan 26 Sun	Feb 7 Fri	Mar 3 Mon	Jun 13 Fri	Jul 25 Fri	Aug 18 Mon	Oct 14 Tue	Oct 15 Wed	Oct 23 Thu	Oct 24 Fri	Nov 10 Mon	Dec 10 Wed	Dec 16 Tue
Tolt River Watershed, King County, Wa	--				--		35	40	--	--		--			
Medical-Dental Bldg, 2730 Colby, Everett, Wa	--				96				--	--	94	--			
504 Bellevue Way NE, Bellevue, Wa	--				156				--	--		--		130	
North 98th St & Stone Ave N, Seattle, Wa	--				98				--	--		--		95	
5701 8th Ave NE, Seattle, Wa	--				149				--	--		--			139
Fire Station #10, 301 2nd Ave S, Seattle, Wa	--	200							--	--		--		180	
Harbor Island, 2555 13th Ave SW, Seattle, Wa	--				181				--	--		--		182	
Harbor Island, 3400 13th Ave SW, Seattle, Wa	--				199				--	--		--		204	
Duwamish, 4752 E Marginal Way S, Seattle, Wa	391					--								263	
Georgetown, 6431 Corson Ave S, Seattle, Wa	--				188				--	--		--		221	
South Park, 723 S Concord St, Seattle, Wa	--				161				--	--		--		201	
Duwamish Valley, 12026 42nd Ave S, King Co, Wa	--				125				--	--		--		226	
200 South 2nd St, Renton, Wa	--				146				--	--		--		200	
22916 86th Ave S, Kent, Wa	--				160				--	--		--		168	
Memorial Park, 850 N Central Ave, Kent, Wa	--			182					--	--		--		212	
115 E Main St, Auburn, Wa	--	--			147				--	--		--		161	
Sumner Jr HS, 1508 Willow St, Sumner, Wa	--	--			108				--	--		--		116	
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	--					222			322	--		--			
2340 Taylor Way, Tacoma, Wa	--								--	--	261	--		221	
Fire Station #12, 2316 E 11th St, Tacoma, Wa	247											256			
Treatment Plant, 1241 Cleveland Wy, Tacoma, Wa	--								--	--	207	--		187	
Cascadia, 2002 E 28th St, Tacoma, Wa	--					174			--	--	184	--			
Willard School, S 32nd & S 'D' St, Tacoma, Wa	--						--		--	--	180	--		263	
Hess Bldg, 901 Tacoma Ave S, Tacoma, Wa	--								--	--	138	--		181	
SW 283rd & 101st Ave SW, Maury Island, Wa	--				71				--	--		--		122	
Ruston School, 5219 N Shirley St, Tacoma, Wa	--								--	--		--	87	189	
4716 North Baltimore St, Tacoma, Wa	--								--	110		--		161	
North 26th & Pearl Sts, Tacoma, Wa	--					126			--	--		--		148	
Mt Tahoma HS, 6404 S Adams St, Tacoma, Wa	--					--			--	--	129	--		268	
City Hall, 239 4th St, Bremerton, Wa	--		77		79				--	--		--			

-- Indicates no sample on specified day

SUSPENDED PARTICULATES (Total)
Micrograms per Standard Cubic Meter

Sampled by Standard High Volume Glass Fiber filters

Jan - Jul, 1986

Summary of Observations Greater Than 150

Location	Jan 7 Tue	Jan 12 Sun	Jan 13 Mon	Jan 14 Tue	Jan 28 Tue	Feb 7 Fri	Feb 10 Mon	Feb 11 Tue	Feb 27 Thu	Mar 3 Mon	Mar 5 Wed	Mar 20 Thu	Jun 13 Fri	Jul 25 Fri	Jul 31 Thu
504 Bellevue Way NE, Bellevue, Wa	--	--	--		--		--	--	--	156	--	--			
Fire Station #10, 301 2nd Ave S, Seattle, Wa	--	--	--	200	--		--	--	--	175	--	--			
Harbor Island, 2555 13th Ave SW, Seattle, Wa	--	--	--		--		--	--	--	181	--	--			
Harbor Island, 3400 13th Ave SW, Seattle, Wa	--	--	--		--		--	--	--	199	--	--			
Duwamish, 4752 E Marginal Way S, Seattle, Wa	391	154	243	154	170			183	231	221	188		--		
Georgetown, 6431 Corson Ave S, Seattle, Wa	--	--	--		--		--	--	--	188	--	--			
South Park, 723 S Concord St, Seattle, Wa	--	--	--		--		--	--	--	161	--	--			
Duwamish Valley, 12026 42nd Ave S, King Co, Wa	--	--	--		--		--	--	--		--	--			
200 South 2nd St, Renton, Wa	--	--	--		--		--	--	--		--	--			
22916 86th Ave S, Kent, Wa	--	--	--		--		--	--	--	160	--	--			
Memorial Park, 850 N Central Ave, Kent, Wa	--	--	--		--	182	--	--	--		--	--			
115 E Main St, Auburn, Wa	--	--	--	--	--		--	--	--		--	--			
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	--	--	--		--		--	--	--		--	--	222		
2340 Taylor Way, Tacoma, Wa	--	--	--		--		--	--	--	195	--	--	167		151
Fire Station #12, 2316 E 11th St, Tacoma, Wa	247	--	163				177	187	159	202		161	224	151	
Treatment Plant, 1241 Cleveland Wy, Tacoma, Wa	--	--	--		--		--	--	--	181	--	--			
Cascadia, 2002 E 28th St, Tacoma, Wa	--	--	--		--		--	--	--		--	--	174		
Willard School, S 32nd & S 'D' St, Tacoma, Wa	--	--	--		--		--	--	--		--	--		--	
Hess Bldg, 901 Tacoma Ave S, Tacoma, Wa	--	--	--		--		--	--	--		--	--			
Ruston School, 5219 N Shirley St, Tacoma, Wa	--	--	--		--		--	--	--		--	--			
4716 North Baltimore St, Tacoma, Wa	--	--			--		--	--	--		--	--			
Mt Tahoma HS, 6404 S Adams St, Tacoma, Wa	--	--	--		--		--	--	--		--	--	--		

-- Indicates no sample on specified day

SUSPENDED PARTICULATES (Total)
Micrograms per Standard Cubic Meter

Sampled by Standard High Volume Glass Fiber filters

Aug - Dec, 1986

Summary of Observations Greater Than 150

Location	Aug 6 Wed	Aug 20 Wed	Aug 21 Thu	Aug 22 Fri	Oct 3 Fri	Oct 13 Mon	Oct 14 Tue	Oct 15 Wed	Oct 16 Thu	Oct 20 Mon	Oct 21 Tue	Oct 23 Thu	Oct 24 Fri	Dec 3 Wed	Dec 10 Wed	Dec 11 Thu	Dec 17 Wed	Dec 18 Thu	Dec 19 Fri
504 Bellevue Way NE, Bellevue, Wa		--	--	--	--	--	--	--	--	--	--		--	--		--	--	--	--
Fire Station #10, 301 2nd Ave S, Seattle, Wa		--	--	--	--	--	--	--	--	--	--		--	--	180	--	--	--	--
Harbor Island, 2555 13th Ave SW, Seattle, Wa		--	--	--	--	--	--	--	--	--	--		--	--	182	--	--	--	--
Harbor Island, 3400 13th Ave SW, Seattle, Wa	182	--	--	--	--	--	--	--	--	--	--	160	--	--	204	--	--	--	--
Duwamish, 4752 E Marginal Way S, Seattle, Wa		156	154		153	201	197	203	162			194	209	172	263	220	237	172	
Georgetown, 6431 Corson Ave S, Seattle, Wa	--	--	--	--	--	--	--	--	--	--	--		--	--	221	--	--	--	--
South Park, 723 S Concord St, Seattle, Wa		--	--	--	--	--	--	--	--	--	--		--	--	201	--	--	--	--
Duwamish Valley, 12026 42nd Ave S, King Co, Wa		--	--	--	--	--	--	--	--	--	--		--	--	226	--	--	--	--
200 South 2nd St, Renton, Wa		--	--	--	--	--	--	--	--	--	--		--	--	200	--	--	--	--
22916 86th Ave S, Kent, Wa		--	--	--	--	--	--	--	--	--	--		--	--	168	--	--	--	--
Memorial Park, 850 N Central Ave, Kent, Wa		--	--	--	--	--	--	--	--	--	--		--	--	212	--	--	--	--
115 E Main St, Auburn, Wa		--	--	--	--	--	--	--	--	--	--		--	--	161	--	--	--	--
27th St NE & 54th Ave NE, Northeast Tacoma, Wa			--	--	--	--	322	--	--		--	164	--	--	180	--	--		--
2340 Taylor Way, Tacoma, Wa	158	--	--	--	--	--	--	--	--	--	--	261	--	--	221	--	--	--	--
Fire Station #12, 2316 E 11th St, Tacoma, Wa				156		190	188	172		195	162	236	256		190			185	161
Treatment Plant, 1241 Cleveland Wy, Tacoma, Wa		--	--	--	--	--	--	--	--	--	--	207	--	--	187	--	--	--	--
Cascadia, 2002 E 28th St, Tacoma, Wa		--	--	--	--	--	--	--	--	--	--	184	--	--	155	--	--	--	--
Willard School, S 32nd & S 'D' St, Tacoma, Wa		--	--	--	--	--	--	--	--	--	--	180	--	--	263	--	--	--	--
Hess Bldg, 901 Tacoma Ave S, Tacoma, Wa	--	--	--	--	--	--	--	--	--	--	--		--	--	181	--	--	--	--
Ruston School, 5219 N Shirley St, Tacoma, Wa		--	--	--	--	--	--	--	--	--	--		--	--	189	--	--	--	--
4716 North Baltimore St, Tacoma, Wa		--		--		--	--		--	--			--	--	161	--	--	--	
Mt Tahoma HS, 6404 S Adams St, Tacoma, Wa		--	--	--	--	--	--	--	--	--	--		--	--	268	--	--	--	--

-- Indicates no sample on specified day

SUSPENDED PARTICULATES (PM10)
Micrograms per Standard Cubic Meter

Sampled by Size Selective Inlet - Hi Vol SA321A Quartz Fiber filters

1986

Location	Number of Values	Quarterly Arithmetic Averages 1st	2nd	3rd	4th	Year Arith Mean
Medical-Dental Bldg, 2730 Colby, Everett, Wa	57	28	24	26	37	29
504 Bellevue Way NE, Bellevue, Wa	132	41	19	26	44	33
North 98th St & Stone Ave N, Seattle, Wa	61	31	20	22	41	28
Fire Station #10, 301 2nd Ave S, Seattle, Wa	51	42	28	-	48	40
Harbor Island, 3400 13th Ave SW, Seattle, Wa	61	46	29	33	54	40
Duwamish, 4752 E Marginal Way S, Seattle, Wa	338	48	29	36	58	43
South Park, 723 S Concord St, Seattle, Wa	61	42	26	31	57	39
Memorial Park, 850 N Central Ave, Kent, Wa	61	50	28	28	50	39
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	60	38	35	36	48	39
2340 Taylor Way, Tacoma, Wa	59	47	32	38	64	45
Fire Station #12, 2316 E 11th St, Tacoma, Wa	353	47	30	33	60	42

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 7 Tue	Jan 14 Tue	Feb 7 Fri	Feb 8 Sat	Mar 3 Mon	Jun 13 Fri	Oct 14 Tue	Oct 17 Fri	Oct 23 Thu	Dec 6 Sat	Dec 10 Wed
Medical-Dental Bldg, 2730 Colby, Everett, Wa	--			--			--	73	68	--	
504 Bellevue Way NE, Bellevue, Wa	--		--	121	--		115			--	
North 98th St & Stone Ave N, Seattle, Wa	--			--			--		70	--	70
Fire Station #10, 301 2nd Ave S, Seattle, Wa	--	98		--			--			130	
Harbor Island, 3400 13th Ave SW, Seattle, Wa	--			--	96		--			--	134
Duwamish, 4752 E Marginal Way S, Seattle, Wa	201					--					163
South Park, 723 S Concord St, Seattle, Wa	--			--			--		86	--	152
Memorial Park, 850 N Central Ave, Kent, Wa	--		84	--			--			--	153
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	--			--		120	--		110	--	--
2340 Taylor Way, Tacoma, Wa	--			--			--		152	--	141
Fire Station #12, 2316 E 11th St, Tacoma, Wa	175										157

Summary of Observations Greater Than 150

Location	Jan 7 Tue	Oct 23 Thu	Dec 10 Wed
Duwamish, 4752 E Marginal Way S, Seattle, Wa	201		163
South Park, 723 S Concord St, Seattle, Wa	--		152
Memorial Park, 850 N Central Ave, Kent, Wa	--		153
2340 Taylor Way, Tacoma, Wa	--	152	
Fire Station #12, 2316 E 11th St, Tacoma, Wa	175	151	157

-- Indicates no sample on specified day

SUSPENDED PARTICULATES
Description of Methods

Manual Methods

For many years the federal reference method to determine particulate matter in the air has measured Total Suspended Particulates (TSP). This is often termed the high volume method. The method is completely specified in Title 40, Code of Federal Regulations, Part 50, Appendix B, as amended, December 6, 1982.

Briefly the method prescribes use of a small shelter with overhanging roof with gaps for air sampling between the roof and shelter walls. The sampler draws ambient air through a filter at a flow rate between 39 and 55 cubic feet per minute. Following conditioning to remove moisture effects, the filter is weighed in the laboratory before and after sampling to determine the net weight of particulate collected on the filter. The volume of air sampled, corrected to standard temperature and pressure conditions, is calculated from the flow rate and sampling time. The ambient particulate matter concentration is the weight (mass) of the particulate collected divided by the volume of air sampled.

The new national standards measure only that fraction of particulate matter with particle diameters less than or equal to 10 micrometers (PM_{10}). The new method continues the procedure of collecting particulates on a filter and computing the PM_{10} concentration from the mass collected divided by the volume of air sampled. The principal difference from the TSP method is the use of an ambient air inlet which traps particulates larger than 10 micrometers so that only PM_{10} is collected on the filter. Such an inlet installed on a high volume sampler in place of the roof is called a size selective inlet.

All of these methods are manual methods which "integrate a sample" for the duration of sampling on a filter, usually for 24 hours from midnight to midnight. The particulate concentration measured by these methods is reported in micrograms per standard cubic meter of air.

Continuous Methods

An instrument called an integrating nephelometer continuously measures the light scattering extinction coefficient. A component of the scattering coefficient, (b_{sp}), is a measure of atmospheric particles. This particle scattering coefficient is inversely related to visibility and has shown high correlation to fine particulate mass concentration. The particulate level measured by this method is reported as a scattering coefficient per meter times 10^{-4}. The Agency preheats the sample air stream 6 to 10° C above ambient air temperature to remove moisture effects. The integrating nephelometer method is documented in a paper by Michael G. Ruby published in the "Journal of the Air Pollution Control Association", March, 1985.

Coefficient of Haze (COH) is a measure of suspended particulates derived from the decrease in light transmission through a cellulose filter tape as particulates filtered from an ambient air stream accumulate on the tape. The sampling cycle automatically repeats every 30 minutes to provide continuous sampling. The measurement results are reported in COH-units per thousand linear feet of air.

Data and Method Relationships

For stations with collocated sampling methods the table on the next page presents correlation coefficients calculated between the "continuous" and "integrated" methods. In general the results are site specific with better correlation between "continuous" and "integrated" sampling for the PM_{10} data than for the TSP data.

Summaries on page 25 present particulate levels measured by the integrating nephelometer. A table on the bottom of page 25 presents ratios of PM_{10} to TSP for Puget Sound area sites. These ratios vary between sites and months. The new PM_{10} standard is based on information placing the PM_{10} to TSP ratio within the range of .45 to .60.

SUSPENDED PARTICULATES
1986

Correlation between Continuous and Integrated Sampling Methods

	Jan Feb Mar	Apr May Jun	Jul Aug Sep	Oct Nov Dec	Annual
Medical-Dental Bldg, 2730 Colby, Everett, Wa					
24 Hour COH Vs TSP Corr. Coeff.	.72	.71	.75	.94	.80
Number of Common Samples	14	12	16	13	55
Medical-Dental Bldg, 2730 Colby, Everett, Wa					
24 Hour COH Vs PM10 Corr. Coeff.	.84	.78	.89	.94	.87
Number of Common Samples	14	13	15	12	54
North 98th St & Stone Ave N, Seattle, Wa					
24 Hour bsp Vs TSP Corr. Coeff.	.96	.58	.19	.87	.75
Number of Common Samples	15	15	16	14	60
North 98th St & Stone Ave N, Seattle, Wa					
24 Hour bsp Vs PM10 Corr. Coeff.	.99	.85	.57	.95	.96
Number of Common Samples	15	15	16	14	60
Duwamish, 4752 E Marginal Way S, Seattle, Wa					
24 Hour COH Vs TSP Corr. Coeff.	.78	.70	.79	.88	.81
24 Hour bsp Vs TSP Corr. Coeff.	.76	.68	.47	.77	.74
Number of Common Samples	82	62	88	86	318
Duwamish, 4752 E Marginal Way S, Seattle, Wa					
24 Hour COH Vs PM10 Corr. Coeff.	.89	.74	.85	.89	.89
24 Hour bsp Vs PM10 Corr. Coeff.	.88	.84	.64	.88	.88
Number of Common Samples	82	61	88	85	316
22916 86th Ave S, Kent, Wa					
24 Hour bsp Vs TSP Corr. Coeff.	.85	.68	.46	.95	.69
Number of Common Samples	15	15	16	15	61
27th St NE & 54th Ave NE, Northeast Tacoma, Wa					
24 Hour bsp Vs TSP Corr. Coeff.	.86	.76	.22	.82	.59
Number of Common Samples	30	30	30	30	120
27th St NE & 54th Ave NE, Northeast Tacoma, Wa					
24 Hour bsp Vs PM10 Corr. Coeff.	.96	.91	.13	.83	.71
Number of Common Samples	15	15	16	14	60
Fire Station #12, 2316 E 11th St, Tacoma, Wa					
24 Hour bsp Vs TSP Corr. Coeff.	.75	.64	.54	.88	.72
Number of Common Samples	70	73	73	74	290
Fire Station #12, 2316 E 11th St, Tacoma, Wa					
24 Hour bsp Vs PM10 Corr. Coeff.	.94	.79	.71	.96	.93
Number of Common Samples	83	89	86	85	343

Note: The 24 Hour period is a calendar day.

ATMOSPHERIC PARTICLES
(bsp (X 10 Exp-4)/M)
1986

Statistical Summary

Location	No. of 1 Hour Samples	Frequency Distribution - Percent												Arith Mean	Geom Mean	Geom Std Dev	Arith Std Dev
		5	10	20	30	40	50	60	70	80	90	95	99				
North 98th St & Stone Ave N, Seattle, Wa	8715	.1	.1	.2	.2	.3	.3	.4	.5	.8	1.3	1.8	2.8	.54	.34	2.57	.59
Duwamish, 4752 E Marginal Way S, Seattle, Wa	7991	.1	.2	.3	.3	.4	.5	.6	.8	1.1	1.7	2.4	3.8	.78	.54	2.33	.77
22916 86th Ave S, Kent, Wa	8708	.1	.2	.2	.3	.4	.5	.6	.9	1.3	2.0	2.8	4.8	.86	.54	2.59	.96
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	8688	.1	.1	.2	.3	.4	.5	.6	.8	1.2	2.0	2.7	4.6	.81	.49	2.71	.94
Fire Station #12, 2316 E 11th St, Tacoma, Wa	8550	.1	.2	.2	.3	.4	.5	.6	.8	1.3	2.3	3.2	5.5	.89	.52	2.75	1.11

Location	Monthly Arithmetic Averages												No. of 1 Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
North 98th St & Stone Ave N, Seattle, Wa	.71	.73	.49	.35	.24	.24	.25	.31	.37	1.16	.74	.89	8715	.54
Duwamish, 4752 E Marginal Way S, Seattle, Wa	1.00	.88	.68	.50			.39	.52	.56	1.68	.91	1.17	7991	.78
22916 86th Ave S, Kent, Wa	1.11	1.04	.73	.53	.39	.38	.41	.63	.57	1.88	1.03	1.55	8708	.86
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	1.18	.90	.65	.47	.39	.42	.41	.57	.51	1.75	1.01	1.41	8688	.81
Fire Station #12, 2316 E 11th St, Tacoma, Wa	1.41	1.01	.73	.48	.33	.36	.38	.53	.50	1.93	1.11	2.02	8550	.89

PARTICULATE MATTER RATIOS
(PM10)/(Total)

1986

Particulate Matter Fraction	Method	Filter Medium
PM10	Size Selective Inlet - Hi Vol SA321A	Quartz Fiber
DIVIDED BY		
Total	Standard High Volume	Glass Fiber

Location	Average Monthly Ratios												No. of Obs	Year Ratio
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Medical-Dental Bldg, 2730 Colby, Everett, Wa	.62	.57	.50	.64	.60	.61	.68	.60	.75	.86	.90	.91	56	.685
504 Bellevue Way NE, Bellevue, Wa	.81				.55		.49	.52	.63	.79	.74	.73	32	.660
North 98th St & Stone Ave N, Seattle, Wa	.70	.64	.51	.63	.58	.53	.54	.46	.66	.75	.91	.85	61	.646
Fire Station #10, 301 2nd Ave S, Seattle, Wa	.55	.45	.43	.57	.61			.54	.74	.71	.73	.63	42	.598
Harbor Island, 3400 13th Ave SW, Seattle, Wa	.59	.51	.46	.53	.48	.49	.51	.42	.56	.63	.59	.64	61	.534
Duwamish, 4752 E Marginal Way S, Seattle, Wa	.57	.52	.51	.51	.50	.46	.50	.50	.52	.61	.61	.60	336	.534
South Park, 723 S Concord St, Seattle, Wa	.66	.65	.54	.58	.59	.48	.56	.47	.55	.58	.77	.68	61	.593
Memorial Park, 850 N Central Ave, Kent, Wa	.60	.49	.49	.61	.54	.47	.55	.50	.57	.74	.78	.66	61	.584
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	.80	.63	.63	.53	.51	.46	.53	.59	.51	.63	.64	.71	60	.597
2340 Taylor Way, Tacoma, Wa	.63	.60	.53	.57	.42	.51	.50	.48	.47	.54	.63	.60	59	.540
Fire Station #12, 2316 E 11th St, Tacoma, Wa	.75	.57	.50	.53	.46	.46	.50	.47	.54	.64	.68	.74	294	.570

The ambient air quality standard for lead is 1.5 micrograms per cubic meter averaged over one calendar quarter. Lead emissions to the air across 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.

The tables below present the results of lead sampling in the Puget Sound area during 1986. The Harbor Island station at 2555 13th Ave SW measured a level exceeding the standard during the first quarter of 1986 due to site cleanup activities following closure of a secondary lead smelter just south of the station. Lead concentrations measured at all other stations were lower than the ambient standard. Current lead air quality levels compared to levels prior to 1980 show significant improvement due primarily to the phase down of lead in gasoline.

LEAD
Micrograms per Standard Cubic Meter

Sampled by Standard High Volume Glass Fiber filters

1986

Location	Monthly Arithmetic Averages												No. Of Obs.	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
504 Bellevue Way NE, Bellevue, Wa	.13	.01	.07	.07	.05	.09	.06	.07					#	.07
North 98th St & Stone Ave N, Seattle, Wa	.12	.08	.07	.08	.05	.07	.05	.07	.06	.16	.10	.16	#	.09
5701 8th Ave NE, Seattle, Wa	.23	.15	.13	.17	.45	.16	.14	.16		.25	.17	.31	#	.21
Harbor Island, 2555 13th Ave SW, Seattle, Wa	3.45	.98	1.02	.36	.79	.76	1.40	.32	.34	.31	.17	.31	61	.85
Harbor Island, 3400 13th Ave SW, Seattle, Wa	.17	1.66	.14	.17	.33	.25	.18	.51	.25	.20	.18	.28	61	.36
South Park, 723 S Concord St, Seattle, Wa	.17	.11	.08	.10	.05	.12	.07	.10	.11	.20	.11	.28	61	.12
Sumner Jr HS, 1508 Willow St, Sumner, Wa	.12	.09	.06	.05	.05	.07	.06	.06	.04	.16	.07	.13	58	.08
SW 283rd & 101st Ave SW, Maury Island, Wa	.03	.03	.02	.02	.01	.03	.02	.02	.03	.05	.04	.08	58	.03
Ruston School, 5219 N Shirley St, Tacoma, Wa	.11	.06	.04	.05	.02	.06	.03	.05	.03	.11	.06	.16	60	.06
4716 North Baltimore St, Tacoma, Wa	.12	.08	.03	.05	.04	.06	.03	.07	.04	.14	.08	.13	117	.07
North 26th & Pearl Sts, Tacoma, Wa	.10	.10	.04	.05	.03	.06	.03	.05	.04	.11	.09	.18	61	.07

# indicates a composite monthly average was used.

Location	Quarterly Arithmetic Averages			
	1st	2nd	3rd	4th
504 Bellevue Way NE, Bellevue, Wa	.07	.07	.06	
North 98th St & Stone Ave N, Seattle, Wa	.09	.07	.06	.14
5701 8th Ave NE, Seattle, Wa	.17	.26	.15	.24
Harbor Island, 2555 13th Ave SW, Seattle, Wa	1.82	.64	.69	.26
Harbor Island, 3400 13th Ave SW, Seattle, Wa	.66	.25	.31	.22
South Park, 723 S Concord St, Seattle, Wa	.12	.09	.09	.20
Sumner Jr HS, 1508 Willow St, Sumner, Wa	.09	.06	.05	.12
SW 283rd & 101st Ave SW, Maury Island, Wa	.03	.02	.02	.06
Ruston School, 5219 N Shirley St, Tacoma, Wa	.07	.04	.04	.11
4716 North Baltimore St, Tacoma, Wa	.08	.05	.05	.12
North 26th & Pearl Sts, Tacoma, Wa	.08	.05	.04	.13

ARSENIC

Under the federal Clean Air Act the U.S. EPA has designated inorganic arsenic as a hazardous air pollutant. The principal source of arsenic in the Puget Sound area is the closed Tacoma Smelter site at Ruston. Smelting ceased in March, 1985 and arsenic processing ended in January, 1986. Site dismantling and reclamation continues under EPA supervision. The Washington Department of Ecology has set community exposure standards for arsenic as follows:

Maximum 24 hour concentration - 2.0 micrograms per cubic meter

Maximum annual arithmetic mean - 0.3 micrograms per cubic meter

The tables below summarize arsenic measurements during 1986 from eight stations. The Ruston School and North Baltimore stations are less than one mile from the Tacoma Smelter site.

ARSENIC
Micrograms per Standard Cubic Meter

Sampled by Standard High Volume Glass Fiber filters

1986

Location	Monthly Arithmetic Averages												No. Of Obs.	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Harbor Island, 2555 13th Ave SW, Seattle, Wa	.02	<.01	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	61	<.01
Harbor Island, 3400 13th Ave SW, Seattle, Wa	.01	<.01	.01	<.01	<.01	<.01	<.01	.01	<.01	<.01	<.01	<.01	61	<.01
South Park, 723 S Concord St, Seattle, Wa	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.05	61	.01
Sumner Jr HS, 1508 Willow St, Sumner, Wa	<.01	<.01	<.01	<.01	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	58	<.01
SW 283rd & 101st Ave SW, Maury Island, Wa	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	58	<.01
Ruston School, 5219 N Shirley St, Tacoma, Wa	.34	.04	.03	.04	.01	.04	.02	.15	.01	.21	.29	.06	60	.10
4716 North Baltimore St, Tacoma, Wa	.15	.11	.01	.15	.04	.04	.02	.05	.03	.06	.03	.07	117	.06
North 26th & Pearl Sts, Tacoma, Wa	.01	.01	<.01	.01	.01	.01	<.01	<.01	<.01	<.01	<.01	.01	61	.01

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

Summary of Individual 24 Hour Average Arsenic Values

Location	Highest Value		Values Higher than .50	
	Value	Date	Value	Date
Harbor Island, 2555 13th Ave SW, Seattle, Wa	.07	20 Jan		
Harbor Island, 3400 13th Ave SW, Seattle, Wa	.02	6 Aug		
South Park, 723 S Concord St, Seattle, Wa	.22	16 Dec		
Sumner Jr HS, 1508 Willow St, Sumner, Wa	.01	20 Jan		
SW 283rd & 101st Ave SW, Maury Island, Wa	.02	26 Jan		
Ruston School, 5219 N Shirley St, Tacoma, Wa	1.42	10 Nov	1.42	10 Nov
			1.00	14 Jan
			.83	17 Oct
			.60	18 Aug
4716 North Baltimore St, Tacoma, Wa	1.14	30 Apr	1.14	30 Apr
			.87	21 Jan
			.53	19 Feb
North 26th & Pearl Sts, Tacoma, Wa	.03	19 Feb		

SULFUR DIOXIDE

Sulfur dioxide is a common air pollutant for which standards have been established nation-wide. 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 area 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. In the air, reactions occur to partially convert sulfur dioxide to other sulfur compounds such as sulfuric acid and various sulfate salts. Local sulfur dioxide standards have been in effect since 1968. The tables below and on the following page summarize sulfur dioxide data collected during 1986. There were no violations of the national standards, but in Everett there were three consecutive periods where measured 5 minute averages exceeded 1.00 ppm. This same case measured 0.62 ppm for a 1 hour average thus exceeding the 1 hour standard of 0.40 ppm.

SULFUR DIOXIDE
(Parts per Million)
1986

Location	Monthly Arithmetic Averages												No. of 1 Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Medical-Dental Bldg, 2730 Colby, Everett, Wa	.011	.012	.011	.012	.013	.016	.013		.010	.010	.007	.009	8131	.011
North 98th St & Stone Ave N, Seattle, Wa	.008	.006	.004	.004	.006		.003	.005	.003	.006	.006	.008	7853	.005
Duwamish, 4752 E Marginal Way S, Seattle, Wa	.008	.012	.011	.008			.009	.008	.008	.010	.006	.009	7959	.009
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	.011	.010	.010	.007	.006	.006	.006	.009	.010	.012	.009	.014	8420	.009
SW 283rd & 101st Ave SW, Maury Island, Wa	.005	.005	.004	.004									2812	.005
North 26th & Pearl Sts, Tacoma, Wa	.009	.008	.006	.006	.006	.006	.006	.007	.006	.007	.006		8318	.007

SULFUR DIOXIDE
(Parts per Million)
1986

Number of Concentrations Exceeding Selected Values
for Various Averaging Periods

Location	5 Minute Average	1 Hour Average		3 Hour Average	24 Hour Average	
	1.00 ppm	0.40 ppm	0.25 ppm	0.50 ppm	0.10 ppm	0.14 ppm
Medical-Dental Bldg, 2730 Colby, Everett, Wa	3	1	2	0	0	0
North 98th St & Stone Ave N, Seattle, Wa	0	0	0	0	0	0
Duwamish, 4752 E Marginal Way S, Seattle, Wa	0	0	0	0	0	0
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	0	0	0	0	0	0
SW 283rd & 101st Ave SW, Maury Island, Wa	0	0	0	0	0	0
North 26th & Pearl Sts, Tacoma, Wa	0	0	0	0	0	0

Summary of Maximum and Second Highest Concentrations
for Various Averaging Periods

Location / Continuous Sampling Period(s)	5 Minute Average			1 Hour Average			3 Hour Average			24 Hour Average		
	Value	Date	End Time	Value	Date	End Time	Value	Date	End Time	Value	Date	End Time
Medical-Dental Bldg, 2730 Colby, Everett, Wa	2.00	28 Jan	1515	.62	28 Jan	1600	.227	28 Jan	1600	.043	29 Jan	1200
1 Jan-1 Aug; 21 Aug-31 Dec	2.00	28 Jan	1520	.16	31 May	0400	.077	13 Feb	0500	.038	31 May	1700
North 98th St & Stone Ave N, Seattle, Wa				.06	9 Dec	0900	.033	14 Jan	1000	.017	22 Jan	0200
3 Jan-20 Jun; 7 Jul-31 Dec				.04	14 Jan	0900	.030	9 Dec	0900	.015	10 Dec	2400
Duwamish, 4752 E Marginal Way S, Seattle, Wa				.14	28 Jun	2200	.090	29 Dec	2100	.041	25 Feb	1300
1 Jan-20 May; 13 Jun-31 Dec				.13	29 Dec	2100	.080	11 Jul	1600	.037	16 Feb	2000
27th St NE & 54th Ave NE, Northeast Tacoma, Wa				.16	17 Dec	0300	.100	17 Dec	0500	.050	13 Jan	1000
1 Jan-31 Dec				.14	13 Oct	0400	.090	13 Jan	0400	.045	14 Oct	0200
SW 283rd & 101st Ave SW, Maury Island, Wa				.05	13 Jan	0700	.040	20 Apr	0500	.017	20 Apr	0600
1 Jan-30 Apr				.04	11 Feb	0300	.030	13 Jan	0800	.015	13 Jan	1500
North 26th & Pearl Sts, Tacoma, Wa				.06	13 Oct	1500	.047	23 Oct	0900	.021	14 Oct	1200
1 Jan-17 Dec				.05	10 Mar	0900	.043	13 Oct	1500	.020	10 Dec	2100

Notes
(1) 5 minute average reported only for concentrations exceeding 1.00 ppm.
(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 sulfur dioxide was measured using the continuous ultraviolet fluorescence method.

Introduction

The principal oxidant found in photochemical smog is ozone, a very reactive form of oxygen. Most photochemical oxidants are products of chemical reactions in the ambient air between nitrogen oxides and volatile organic compounds (VOC) under the effect of radiant energy. The more intense radiant energy of summer sunlight suggests why the highest ozone levels occur on hot summer days.

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 area 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 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 Pollutant Standards Index

The U. S. EPA has set the level of the ozone standard at a value of 0.12 ppm. The federal regulation says the standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than one.

If an "exceedance" is defined to be 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. In the case of a complete data set, the expected number of exceedances is simply the average number of observed exceedances at a particular location during the most recent 3 years.

When the data set for a given year is incomplete, the number of exceedances in that year must be adjusted to estimate the true number. This estimate is based upon the observed number of exceedances, the number of required monitoring days, the number of days upon which a valid maximum was recorded, and the number of days assumed to be less than the standard level.

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

A 1 hour average ozone level 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, but may occasionally cause unhealthful air quality for outlying locations such as Lake Sammamish, Sumner or Graham.

The 1986 ozone summary table opposite this page lists the four highest daily maximum 1 hour ozone averages for each monitoring location. For the three year period ending with 1986, the number of ozone exceedances is 1.0 or less and this completes five years without measurements exceeding the ozone standard more than once per year per location. On January 2, 1987, the EPA formally redesignated the Puget Sound area as in attainment of the ozone standard.

OZONE
(Parts per Million)
1986

Location / Continuous Sampling Period(s)	Four 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	1984	1985	1986	
Snohomish FD #22, 9921 84th NE, Arlington, Wa*	.09	26 Aug	1800	0.0	0.0	0.0	0.0
23 Apr-7 Oct	.09	27 Aug	1600				
	.08	13 Jun	1600				
	.08	1 Aug	1600				
Tolt River Watershed, King County, Wa*	.07	18 Aug	1700		0.0	0.0	0.0
15 May-29 Jun; 12 Aug-31 Oct	.07	27 Aug	1800				
	.06	17 Aug	1500				
	.06	21 Aug	1500				
20050 SE 56th, Lake Sammamish State Park, Wa*	.13	13 Jun	1500	0.0	0.0	1.0	0.3
1 Jan-16 Oct	.11	31 May	1400				
	.11	7 Aug	1500				
	.10	9 Aug	1700				
22916 86th Ave S, Kent, Wa	.08	13 Jun	1700	0.0	0.0	0.0	0.0
1 Jan-28 Oct	.08	7 Aug	1500				
	.07	1 Aug	1600				
	.07	2 Aug	1600				
Enumclaw, Wa*	.12	31 May	1500		0.0	0.0	0.0
30 May-22 Jul; 2 Sep-23 Sep	.12	13 Jun	1800				
	.09	10 Jun	1700				
	.09	27 Jun	1600				
Sumner Jr HS, 1508 Willow St, Sumner, Wa	.11	13 Jun	1600	0.0	0.0	0.0	0.0
1 Jan-30 Jun; 18 Jul-20 Oct	.10	7 Aug	1600				
	.09	31 May	1800				
	.09	26 Aug	1600				
Firwood Fire Sta, 4418 Freeman Rd, Fife, Wa*	.10	13 Jun	1500	0.0	0.0	0.0	0.0
1 Jan-31 Oct	.08	7 Aug	1400				
	.07	29 May	1700				
	.07	31 May	1300				
Pierce Co Fire D #21, 8102 304th, Graham, Wa*	.11	13 Jun	1600	0.0	0.0	0.0	0.0
18 Apr-31 Oct	.09	31 May	1500				
	.09	1 Aug	1700				
	.09	7 Aug	1500				
Charles L Pack Forest, La Grande, Wa*	.14	13 Jun	1700		1.0	1.1	1.0
7 May-9 Oct	.11	30 May	1700				
	.11	27 Jun	1700				
	.11	1 Aug	1800				
Mount Rainier National Park, Longmire, Wa*	.10	7 Aug	1700			0.0	0.0
24 Jun-15 Oct	.09	27 Jun	1900				
	.09	1 Aug	1700				
	.09	2 Aug	1700				

Notes
(1) * Station 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.

Nitric oxide (NO) and nitrogen dioxide (NO2) are released to the atmosphere as the result of high temperature fuel combustion. Motor vehicles and power plants are the most common fuel combustion sources emitting oxides of nitrogen. Nitric oxide oxidizes rather quickly to nitrogen dioxide. Nitrogen dioxide plays an important role in the photochemical reactions which produce ozone. The nitrogen dioxide standard is an annual arithmetic average of 0.05 ppm. Nitrogen dioxide levels exceeding this annual standard would be termed unhealthful, but this has never occurred in the Puget Sound area.

NITROGEN DIOXIDE
(Parts per Million)
1986

Location	Monthly Arithmetic Averages												No. of 1 Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
4th Ave South & Jackson St, Seattle, Wa*	.035			.035	.036						.023		3718	.033
15th Ave S & Charlestown St, Seattle, Wa*						.022	.014	.030			.014	.013	3677	.018

Notes
(1) * Station operated by the Washington State Department of Ecology.
(2) Monthly averages are shown only for months with 75 percent or higher data completeness.
(3) Year arithmetic means are calculated from all valid samples; the number of samples shows how completely the year mean represents the full year.
(4) At both stations nitrogen dioxide was measured using the continuous gas phase chemiluminescence method.

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 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 notable during late afternoon commuting and around shopping centers particularly during holiday shopping. A contributing factor during some periods when levels are high is the presence of stable weather and light wind, thus temporarily reducing the means to disperse carbon monoxide 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. Pollutant Standards 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 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 1986 Data

The tables on the next two pages summarize the six highest 1 hour and 8 hour average carbon monoxide levels at each station during 1986. These data were obtained from Department of Ecology data summaries. One Seattle station was discontinued on March 31 and a new station in Bremerton began operation November 7.

Measurements at four stations exceeded an 8 hour average of 9 ppm at least twice. Therefore all of these four stations, one located in Bellevue, two located in Seattle, and one located in Tacoma, violated the 8 hour average carbon monoxide standard. The 1 hour carbon monoxide standard of 35 ppm was not exceeded at any station.

Multi-Year Summary

A multi-year summary following the 1986 tables presents data and column graphs which help to show the long term historical trend. For 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 and list in the bottom row the value which was the 2nd high 8 hour average. This summary includes stations with several years of data.

The first complete year of carbon monoxide data for one Seattle station was 1972. The results at this station have improved from over 100 days exceeding the primary standard in 1972 & 73 to one day exceeding the standard in 1986. Two other Seattle stations which began in 1978 confirm the same trend.

A review of the data if begun with 1980 shows the decrease (improvement) in carbon monoxide values has leveled off. To show the standard has been attained, the EPA requires that the average number of cases exceeding the standard over a two year period at a station not exceed one; therefore for Seattle, Bellevue and Tacoma, attaining the carbon monoxide standard is yet in the future. The significant improvement from levels existing in the mid 1970's is due mainly to the federal emission standards for new motor vehicles and the program to test emissions of in use vehicles for compliance with these standards.

CARBON MONOXIDE
(Parts per Million)
1986

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		
2005 Hewitt Avenue, Everett, Wa	13	31 Jan	0900	8	26 Jan	0100	0	0
1 Jan-31 Aug; 1 Oct-8 Dec	12	31 Jan	1800	7	31 Jan	1500		
	11	25 Jan	2000	7	13 Oct	2300		
	11	25 Jan	2200	6	3 Jan	1900		
	11	31 Jan	1700	6	31 Jan	2300		
	10	3 Feb	1800	6	14 Oct	2300		
622 Bellevue Way NE, Bellevue, Wa	16	7 Jan	1700	12	7 Jan	2100	6	5
1 Jan-2 Aug; 16 Aug-31 Dec	15	10 Dec	1800	12	17 Dec	2300		
	15	10 Dec	2000	11	10 Dec	2400		
	14	10 Dec	1900	11	16 Dec	2400		
	14	17 Dec	2000	10	19 Dec	2400		
	13	7 Jan	1000	9	12 Jan	2200		
Northgate, 310 NE Northgate Way, Seattle, Wa	15	10 Dec	0900	11	10 Dec	2400	3	2
11 Jan-16 Oct; 10 Nov-31 Dec	15	10 Dec	1900	11	17 Dec	2300		
	15	17 Dec	0900	10	17 Dec	1300		
	15	17 Dec	1000	9	12 Jan	2200		
	14	10 Feb	0900	9	21 Jan	2300		
	14	11 Dec	1800	8	31 Jan	1900		
4511 University Way NE, Seattle, Wa	21	12 Jan	1800	12	12 Jan	2000	8	8
1 Jan-31 Dec	19	31 Jan	1900	12	17 Dec	2400		
	18	31 Jan	1800	11	12 Jan	0200		
	17	29 Jan	2100	11	31 Jan	1900		
	15	23 Oct	1800	11	16 Dec	2400		
	15	16 Dec	2100	10	26 Jan	0100		
3921 Linden Ave N, Seattle, Wa	10	17 Dec	0900	6	12 Jan	2300	0	0
1 Jan-31 Aug; 1 Oct-31 Dec	9	12 Jan	1800	6	10 Dec	2400		
	9	10 Dec	1000	5	16 Dec	2400		
	8	12 Jan	1700	5	17 Dec	1200		
	8	31 Jan	1800	5	17 Dec	2400		
	8	27 Feb	0800	4	6 Jan	2300		
1424 4th Ave, Seattle, Wa	17	31 Jan	1800	11	31 Jan	1800	1	1
8 Jan-12 Jan; 28 Jan-27Jul; 12 Nov-31 Dec	16	31 Jan	1600	9	16 Dec	1900		
	14	16 Dec	1800	8	29 Jan	1900		
	13	31 Jan	1300	8	14 Feb	1900		
	12	31 Jan	1700	8	3 Dec	1800		
	12	10 Dec	2000	8	5 Dec	1800		

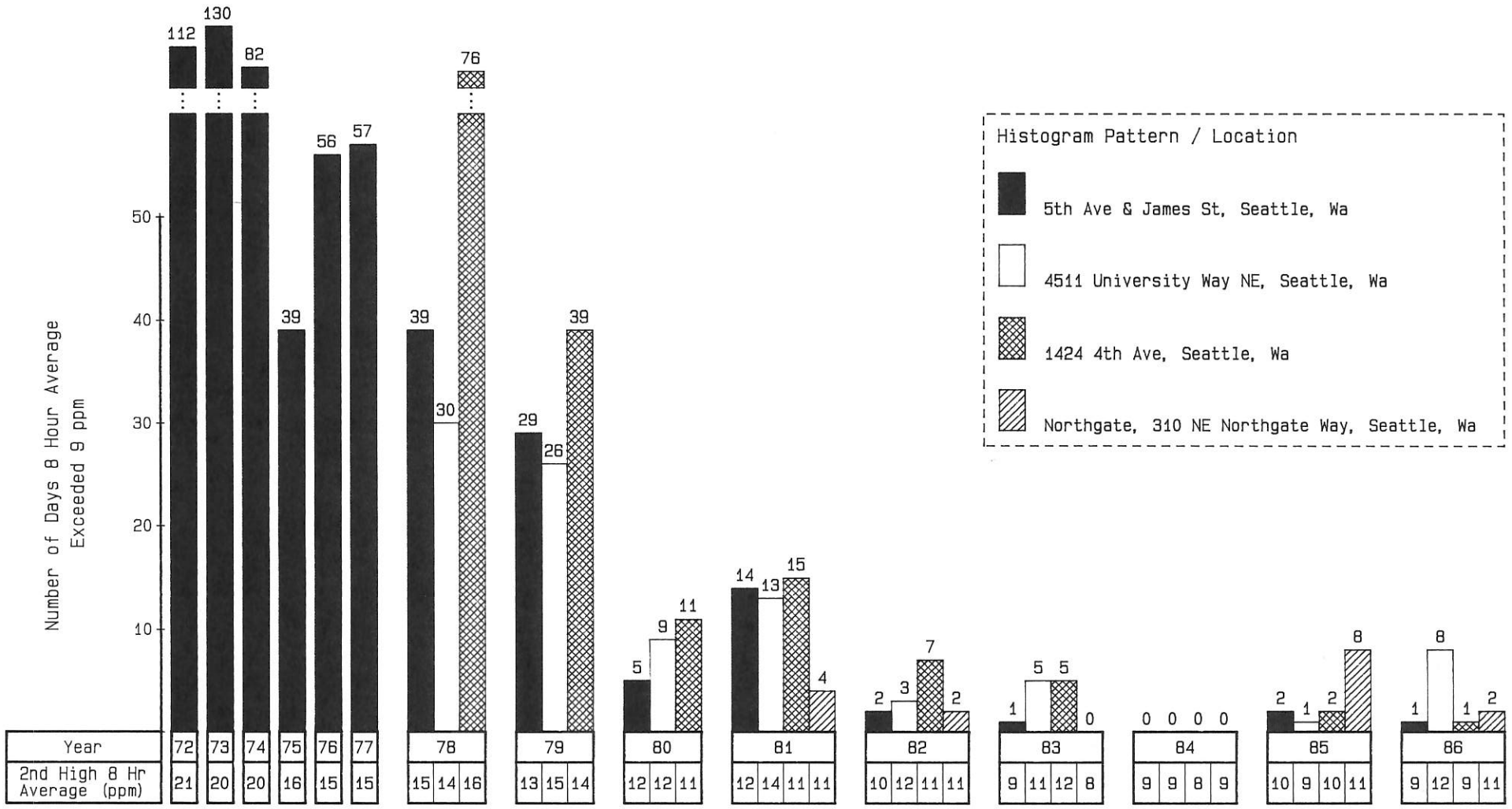
Notes
(1) Ending times are reported in Pacific Standard Time.
(2) For equal concentration values the date and time refer to the earliest occurrences.
(3) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(4) At all stations carbon monoxide was measured using the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

CARBON MONOXIDE
(Parts per Million)
1986

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		
5th Ave & James St, Seattle, Wa	16	3 Jan	1800	10	31 Jan	1800	1	1
1 Jan-18 Nov; 10 Dec-31 Dec	15	31 Jan	1800	9	6 Oct	1700		
	14	14 Feb	1800	8	3 Jan	2000		
	14	6 Oct	1600	8	7 Jan	1400		
	13	6 Oct	1700	8	29 Jan	1900		
	12	31 Jan	1600	8	14 Feb	1800		
Courthouse, 4th Ave & James St, Seattle, Wa	15	25 Aug	1100	8	7 Jan	1700	0	0
1 Jan-15 Jan; 27 Jan-26 Mar; 11 Apr-30 Apr;	11	31 Jan	1800	8	31 Jan	1900		
13 Aug-31 Aug; 1 Oct-31 Dec	11	23 Nov	1700	8	16 Dec	2400		
	11	17 Dec	0800	8	17 Dec	1000		
	11	17 Dec	1000	7	23 Oct	1900		
	10	7 Jan	1000	7	10 Dec	2000		
Fire Station #10, 301 2nd Ave S, Seattle, Wa	12	31 Dec	0600	9	16 Dec	2400	0	0
1 Jan-31 Aug; 1 Oct-31 Dec	11	16 Dec	1800	8	17 Dec	0800		
	11	17 Dec	0800	7	10 Dec	2200		
	11	17 Dec	1000	7	31 Dec	0700		
	10	16 Dec	2300	6	11 Jan	2300		
	10	20 Dec	1700	6	21 Jan	2300		
2809 26th Ave S, Seattle, Wa	13	7 Jan	1700	9	7 Jan	1400	0	0
1 Jan-31 Mar	12	7 Jan	1000	7	7 Jan	2200		
	12	7 Jan	1100	7	26 Jan	0100		
	11	7 Jan	0900	5	9 Jan	1600		
	10	7 Jan	1800	5	14 Jan	2100		
	9	7 Jan	1200	5	21 Jan	2200		
942 Pacific Ave, Tacoma, Wa	22	23 Oct	1700	13	23 Oct	1800	6	5
1 Jan-31 Aug; 1 Oct-26 Nov; 11 Dec-31 Dec	22	17 Dec	1800	12	17 Dec	2300		
	21	23 Oct	1600	10	7 Jan	1500		
	20	2 Jan	1800	10	18 Dec	1800		
	16	17 Dec	1700	10	19 Dec	2400		
	14	15 Jan	1800	9	2 Jan	1800		
Burwell St & Pacific Ave, Bremerton, Wa	18	27 Dec	2400	7	17 Dec	2200	0	0
7 Nov-31 Dec	14	27 Dec	2300	7	28 Dec	0100		
	12	28 Dec	0100	6	28 Nov	2300		
	10	1 Dec	1700	6	5 Dec	1800		
	10	17 Dec	2000	6	8 Dec	2400		
	8	28 Nov	2200	5	14 Nov	2000		

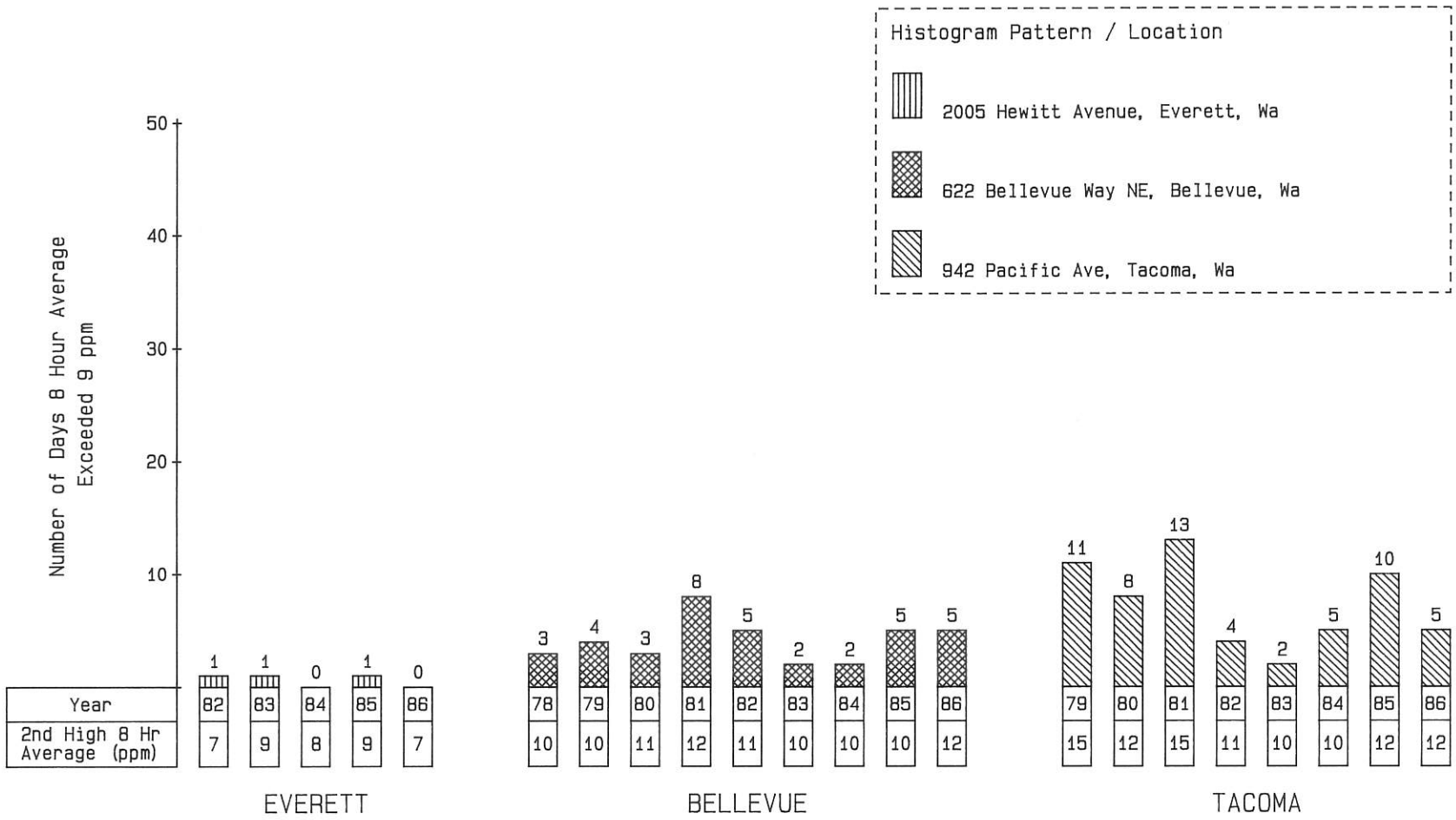
Notes
(1) Ending times are reported in Pacific Standard Time.
(2) For equal concentration values the date and time refer to the earliest occurrences.
(3) Continuous sampling periods are those with fewer than 10 consecutive days of missing data.
(4) At all stations carbon monoxide was measured using the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

CARBON MONOXIDE
Multi-Year Summary



SEATTLE

CARBON MONOXIDE
Multi-Year Summary



Introduction

Quality Assurance (QA) includes all activities for the purpose of 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) an annual on-site audit of some Agency instruments by EPA or their designated representative, and (2) Agency participation in EPA's national performance audits as they are announced. The Department of Ecology also independently selects and audits Agency instruments on-site such that a part of the network is audited each quarter.

Precision and Accuracy Audits

The documentation for the QA program is established in Title 40, Code of Federal Regulations, Part 58, published May 10, 1979, and amended November 9, 1979, September 3, 1981, and March 19, 1986. 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 of the reference sample 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 differences, 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 and they document 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 many Agency monitoring locations precision audits are performed each week and accuracy audits are completed each six months or each quarter. The table opposite this page summarizes the precision and accuracy probability limits by quarter for all air quality data which the Agency originated in 1986. For each pollutant the type of audit (accuracy or precision) is followed by a brief phrase description of the audit method. For each quarter the number of audits and the resulting lower and upper probability limits are presented. Audits for the integrating nephelometer, which measures atmospheric particles, are conducted only as a one point precision check.

DATA QUALITY ASSESSMENT
1986

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
Suspended Particulates (Total, Hi Vol)	26												
Accuracy													
Flow Rate		35	-6	+4	25	-5	+5	22	-5	+7	35	-6	+5
Precision													
Collocated Samples		40	-3	+14	38	-1	+14	38	-1	+13	43	-2	+8
Suspended Particulates (PM10, SSI Hi Vol)	9												
Accuracy													
Flow Rate		30	-4	+3	28	-5	+4	18	-5	+2	22	-3	+4
Precision													
Collocated Samples		23	-7	+5	18	-5	+4	25	-5	+5	28	-5	+6
Sulfur Dioxide	7												
Accuracy													
Level 1		19	-13	+12	13	-11	+17	12	-9	+8	16	-8	+11
Level 2		19	-12	+11	13	-10	+12	12	-5	+9	16	-6	+10
Level 3		19	-12	+10	13	-8	+10	12	-6	+10	15	-6	+8
Level 4		19	-13	+12	13	-10	+9	10	-7	+10	3	-2	+1
Precision													
One point check		90	-8	+9	70	-8	+8	64	-9	+9	59	-9	+8
Ozone	2												
Accuracy													
Level 1								2	-14	+5			
Level 2								2	-9	+4			
Level 3								2	-6	+3			
Precision													
One point check		13	-5	+10	24	-3	+7	24	-14	+13	7	+2	+10
Atmospheric Particles (Nephelometer)	5												
Precision													
One point check		36	-6	+5	33	-6	+5	34	-5	+4	35	-6	+5

AIR STAGNATION ADVISORY and WASHINGTON EPISODE AVOIDANCE PLAN

The National Weather Service issues an **Air Stagnation Advisory** when poor atmospheric dispersion conditions exist and are forecast to persist for 24 hours or more. 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 is 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. Outdoor fires are prohibited during any declared stage of the Washington Episode Plan. A new section added to the Washington Clean Air Act by the 1987 Legislature says that any person who has an adequate source of heat without burning wood shall not burn wood in any solid fuel heating device during any declared stage of the Washington Episode Plan.

In 1986 the Forecast stage was in effect in the Puget Sound region during the following periods:

2 pm, Wednesday, October 15 -
12 noon, Friday, October 17

9 am, Monday, October 20 -
12 noon, Friday, October 24

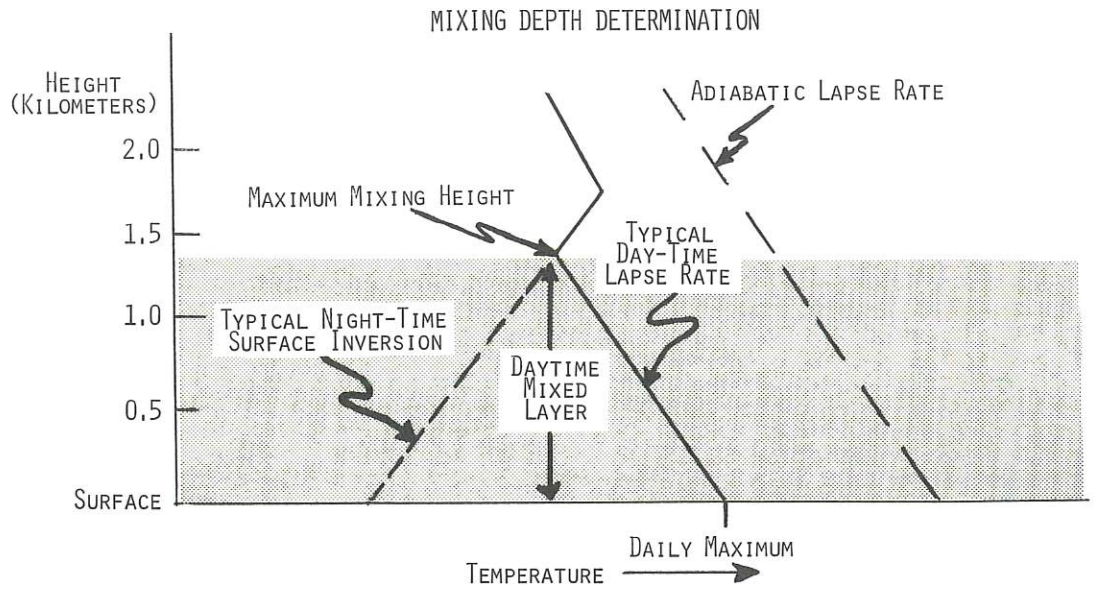
2 pm, Wednesday, December 10 -
10 am, Thursday, December 11

LOWER ATMOSPHERE TEMPERATURE SOUNDINGS

The Washington State Department of Ecology operates a lower atmosphere sounding unit on the east shore of Portage Bay in Seattle. Normal operation provides one sounding to 700 millibars about 7 am local time each Monday through Friday except holidays. This sounding provides the primary lower atmosphere data in the Puget Sound region and is an essential basis for many forecasts including Air Stagnation Advisories. The Agency regularly uses the sounding to evaluate and interpret air quality data and also enters the sounding in a computerized data base.

The figure on the top of the opposite page illustrates some key concepts. Temperature increasing with height is termed a **Temperature Inversion**. A temperature inversion limits the height to which pollutants are mixed or dispersed vertically. The **Mixing Depth** is the height from the surface to the temperature inversion base. The mixing depth continuously changes in response to diurnal surface temperature changes and to other processes. On days with no temperature inversion the mixing depth is unlimited, and this contributes to rapid pollutant dispersion and good air quality. In contrast, a temperature inversion near the surface which is too thick to be reversed during the daytime significantly restricts vertical dispersion. This stable condition is associated with higher pollutant levels.

Five soundings from 1986 appear on the opposite and following pages. These soundings all reveal stagnant conditions on days when some pollutant values exceeded the level of an ambient standard. On each sounding, temperature is represented by a solid line connecting actual data values enclosed by circles. The dewpoint temperature is represented by a dashed line connecting actual data values enclosed by triangles. The wind at regular altitude intervals is plotted and also printed in degrees/knots to the right of the temperature sounding.

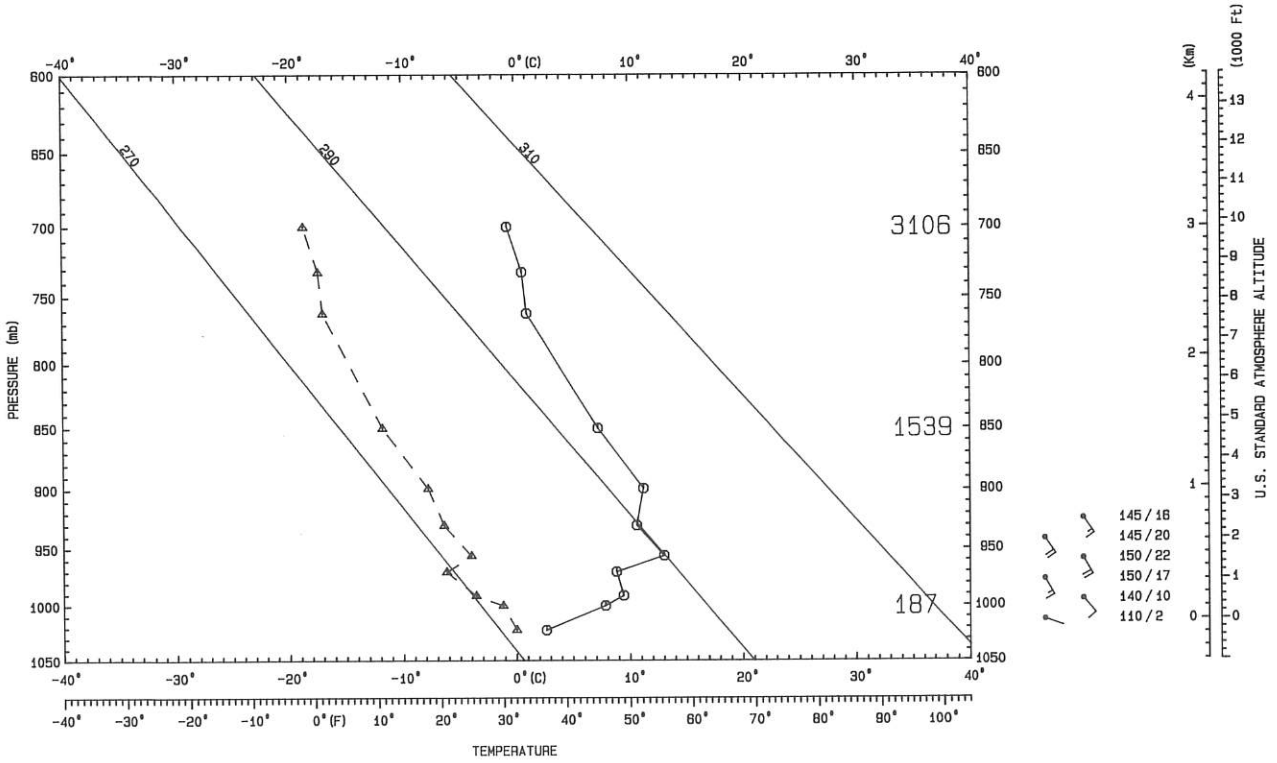


PUGET SOUND AIR POLLUTION CONTROL AGENCY

PSEUDO-ADIABATIC CHART

0700 PST Jan 7, 1986

Portage Bay, 2725 Montlake Blvd E, Seattle, WA

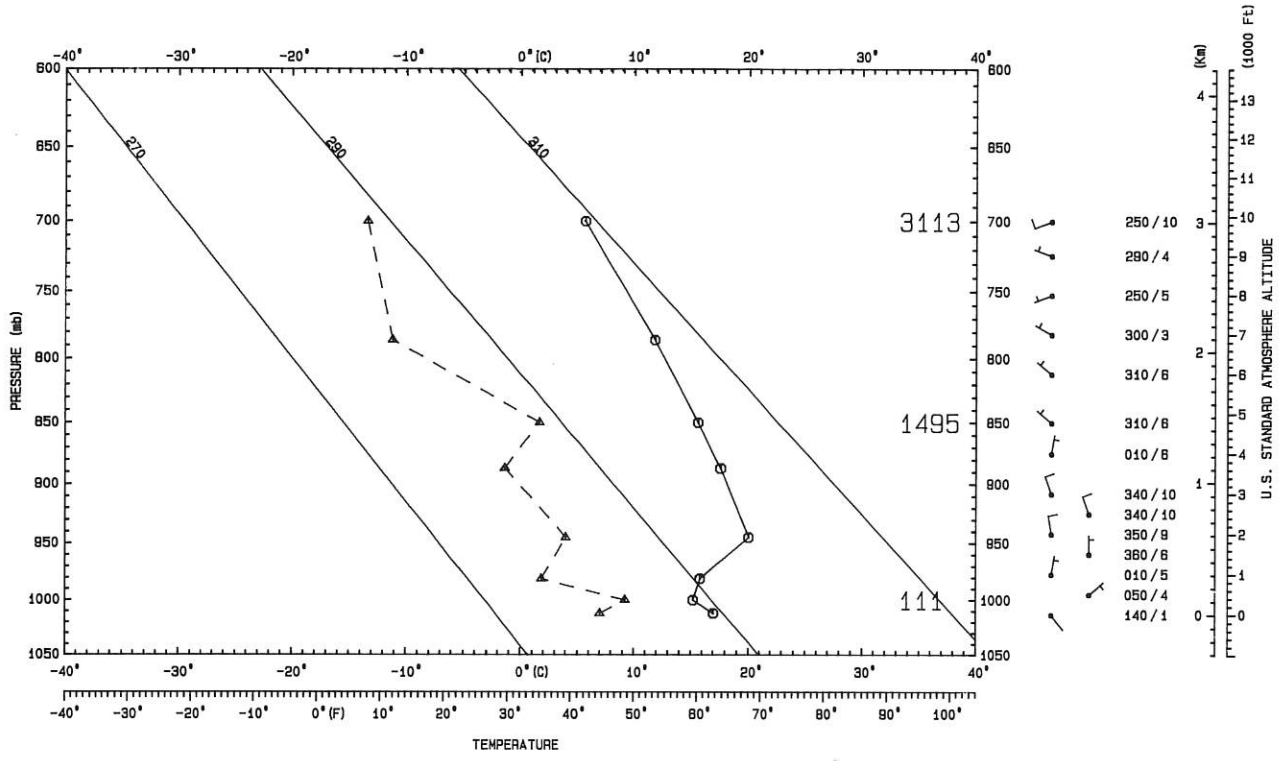


PUGET SOUND AIR POLLUTION CONTROL AGENCY

PSEUDO-ADIABATIC CHART

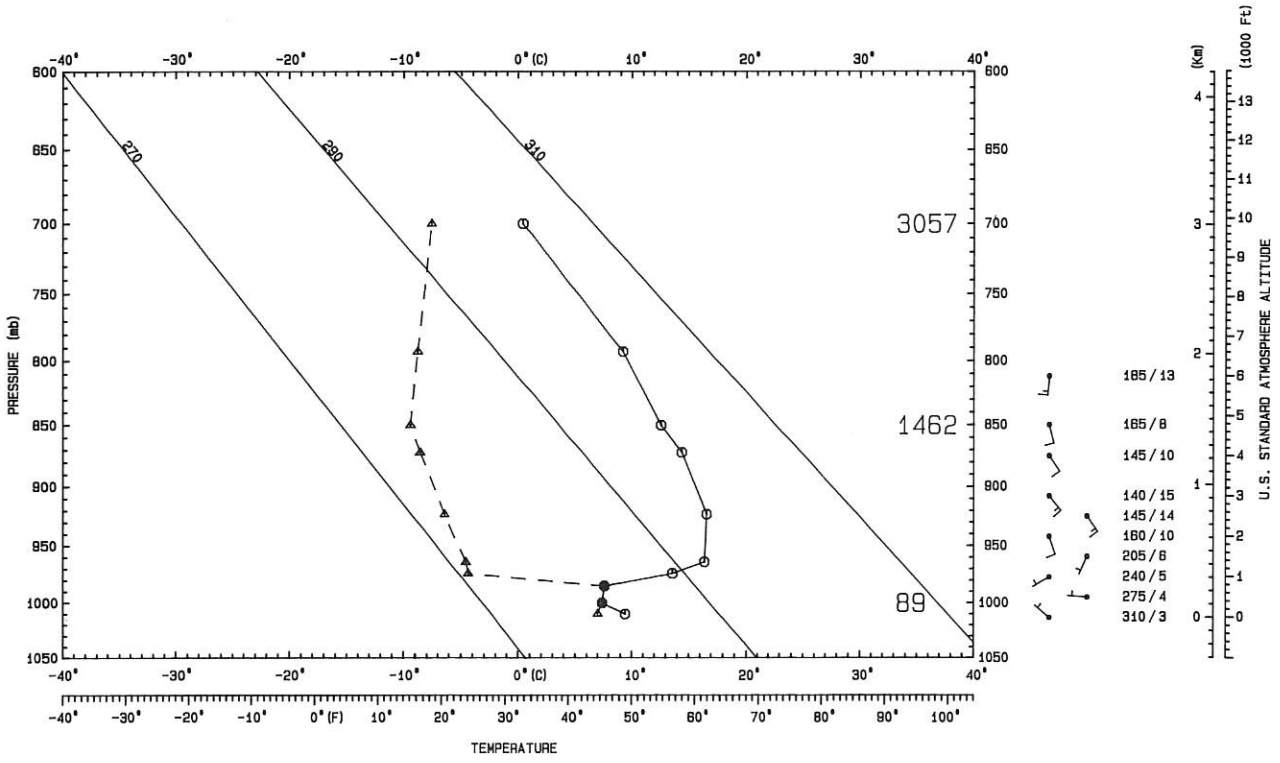
0600 PST Jun 13, 1986

Portage Bay, 2725 Montlake Blvd E, Seattle, WA



0600 PST Oct 23, 1986

Portage Bay, 2725 Montlake Blvd E, Seattle, WA

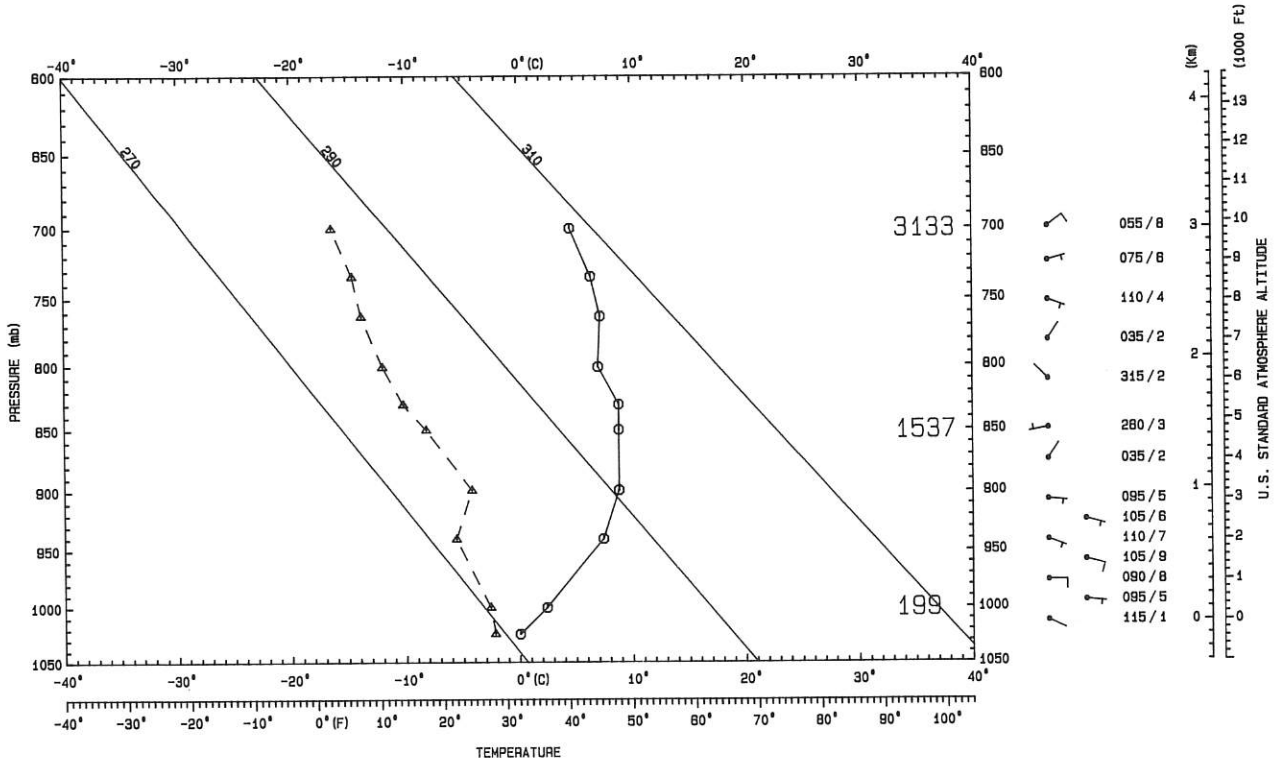


PUGET SOUND AIR POLLUTION CONTROL AGENCY

PSEUDO-ADIABATIC CHART

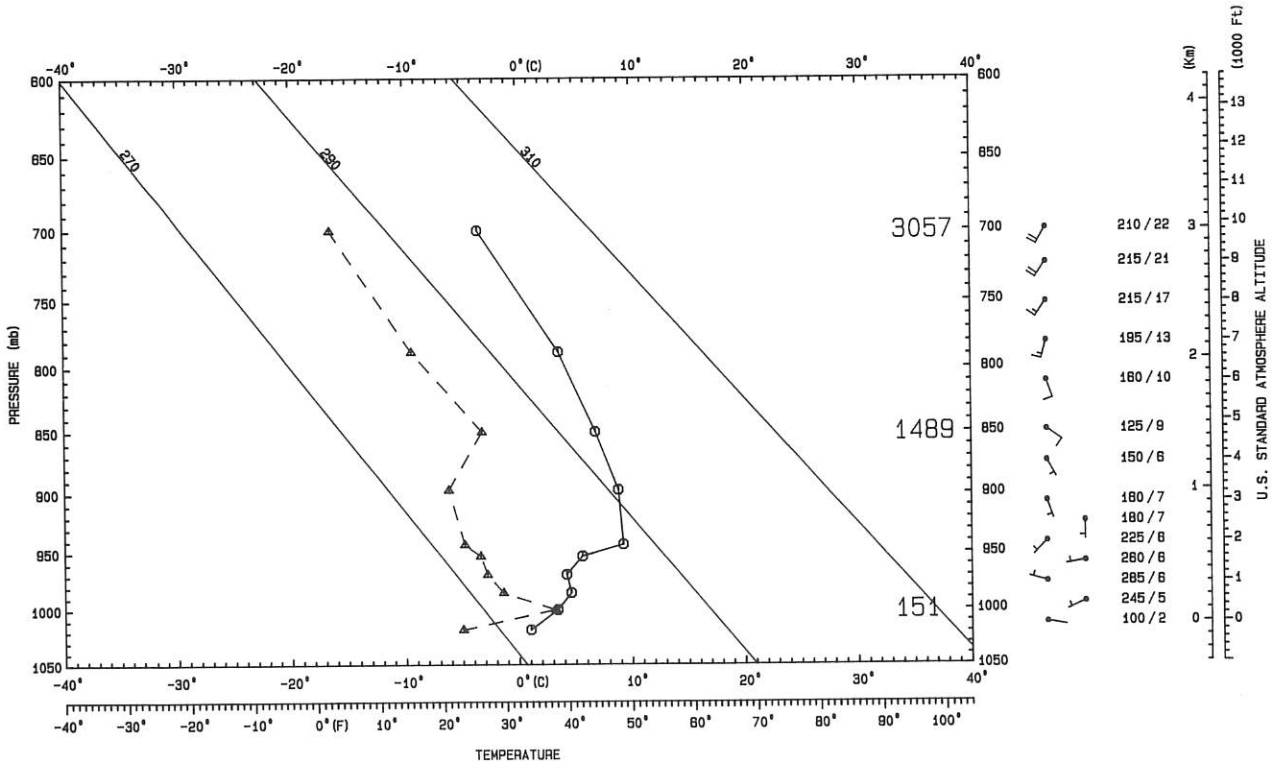
0700 PST Dec 10, 1986

Portage Bay, 2725 Montlake Blvd E, Seattle, WA



0700 PST Dec 17, 1986

Portage Bay, 2725 Montlake Blvd E, Seattle, WA



WIND ANALYSIS

Wind Data

Everyone has a qualitative sense of surface wind and some effects produced by the wind. From an air pollution standpoint, low wind speed slowly dilutes and transports pollutants and is therefore associated with higher air pollutant concentrations near urban or industrialized areas. Light or calm surface wind is a concurrent feature with stable, temperature inversion conditions; when these conditions persist, the natural process which effectively disperses pollutants is greatly diminished and pollutant levels are higher near the source areas. The wind direction data suggests which sources or source areas affect a specific location.

Wind Speed Averages

The table below presents monthly and annual average wind speed computed from hour average surface wind speed at wind monitoring locations. These average values are sometimes used to compare locations and months and also in calculations needing average speed values. Individual air stagnation episodes are not exposed by this analysis unless episode conditions predominate during most of a month.

Wind Roses

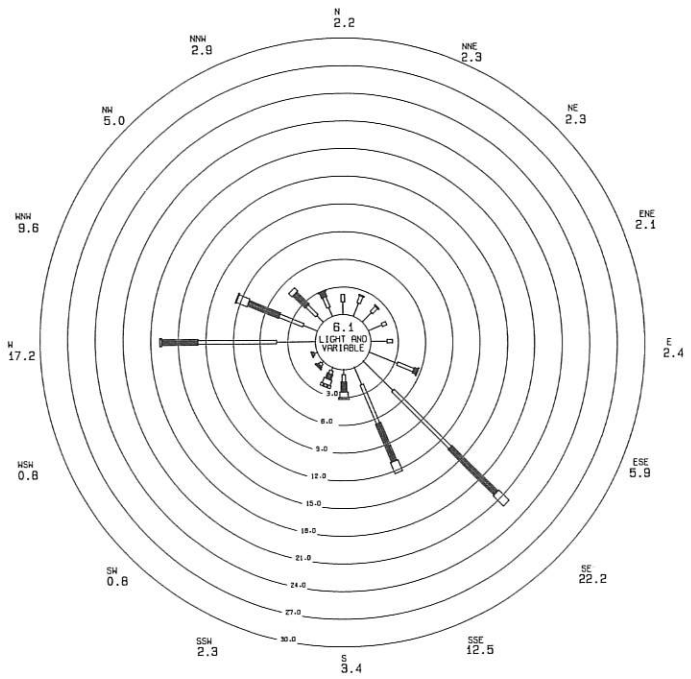
A wind rose is a quantitative graphical means to summarize the wind direction and speed for a given time period. It is essentially a count, expressed on the following graphs as a percentage frequency, of the number of observations or hours which had a particular direction and speed during the summary period.

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

The length of each segment of a spoke represents the frequency of wind within a speed category. From this frequency and the total observations, the number of hours within each speed category may be determined. The percentage frequency of light and variable winds (winds less than 1.5 knots) is printed in the center of the rose.

WIND SPEED
(Knots)
1986

Location	Monthly Arithmetic Averages												No. of 1 Hour Samples	Year Arith Mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Medical-Dental Bldg, 2730 Colby, Everett, Wa	7.5	5.5	6.2	5.8	6.1	6.0	5.3	5.1	4.7	4.3	5.9	6.4	8619	5.7
North 98th St & Stone Ave N, Seattle, Wa	3.2	2.9	3.3	3.5	3.3	3.1	3.1	2.4	2.4	1.9	2.9	1.9	8561	2.8
Duwamish, 4752 E Marginal Way S, Seattle, Wa	3.7	4.0	3.8	4.2			4.2	3.1	3.3	2.6	4.5	2.9	7905	3.7
22916 86th Ave S, Kent, Wa	4.0	3.6	3.4	3.8	3.5	3.2	3.3	2.3	2.7	2.0	3.8	2.8	8593	3.2
Sumner Jr HS, 1508 Willow St, Sumner, Wa	2.8	2.7	2.7	3.0	2.8	2.5	2.6	2.1	2.4	1.6			7640	2.6
27th St NE & 54th Ave NE, Northeast Tacoma, Wa	3.6	3.7	3.0	2.9	2.8	3.0	2.7	2.3	2.2	2.3	3.2	2.8	8553	2.9
Fire Station #12, 2316 E 11th St, Tacoma, Wa	3.9	4.5	4.1	4.4	4.5	4.4	4.4	3.4	3.7	2.8	4.2	2.7	8594	3.9
North 26th & Pearl Sts, Tacoma, Wa	4.2	4.8	3.9	4.2	4.0	4.1	3.9	3.2	3.3	2.8	4.3	3.4	8616	3.8



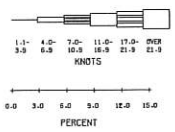
HOUR AVERAGE SURFACE WINDS

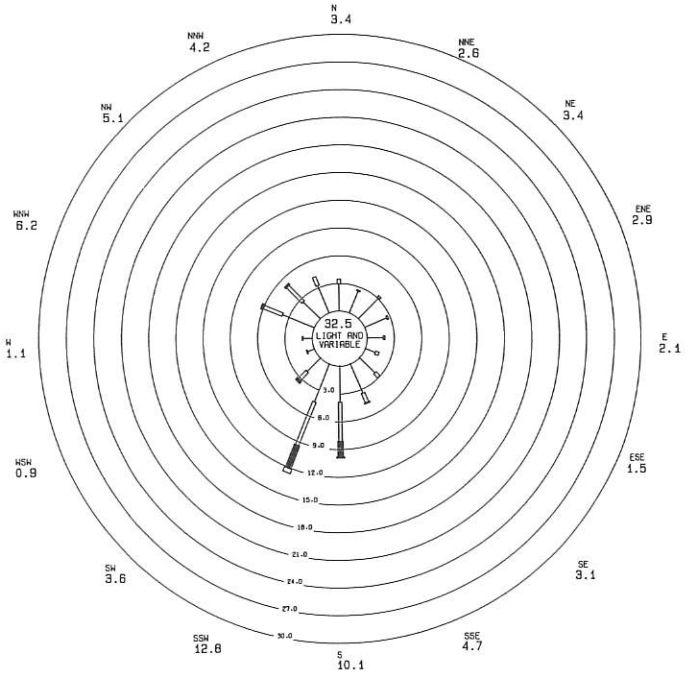
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Medical-Dental Bldg, 2730 Colby, Everett, Wa

INCLUSIVE DATES- ALL MONTHS 1986

TOTAL OBSERVATIONS- 8,619





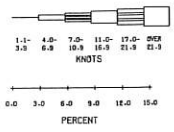
HOUR AVERAGE SURFACE WINDS

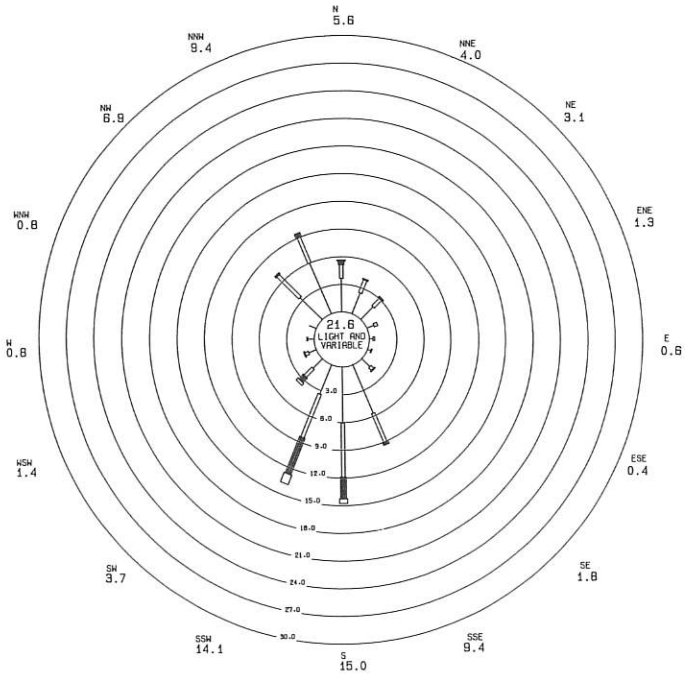
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
North 98th St & Stone Ave N, Seattle, Wa

INCLUSIVE DATES- ALL MONTHS 1986

TOTAL OBSERVATIONS- 8,561





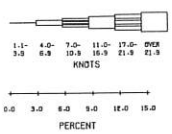
HOUR AVERAGE SURFACE WINDS

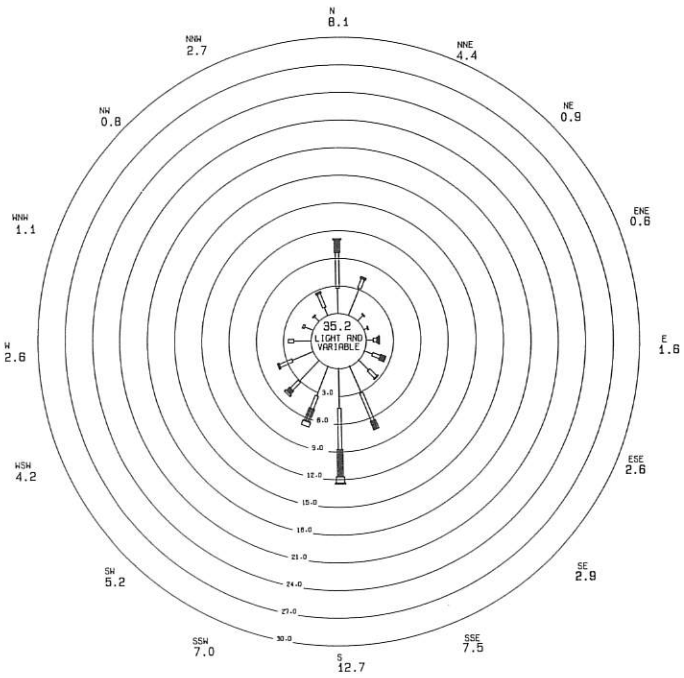
PERCENTAGE FREQUENCY OF OCCURRENCE

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

INCLUSIVE DATES- ALL MONTHS 1986

TOTAL OBSERVATIONS- 7,905





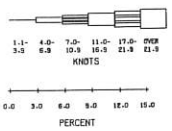
HOUR AVERAGE SURFACE WINDS

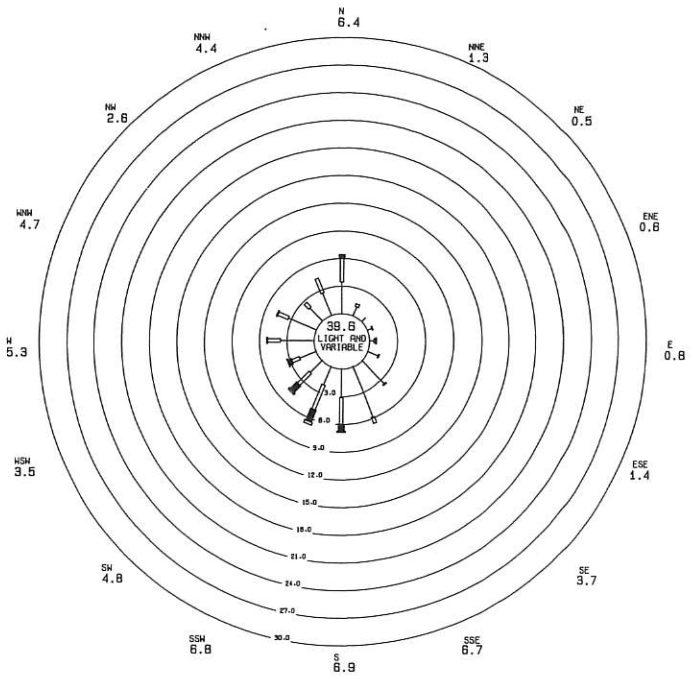
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
22916 88th Ave S, Kent, Wa

INCLUSIVE DATES- ALL MONTHS 1986

TOTAL OBSERVATIONS- 8,593





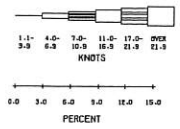
HOUR AVERAGE SURFACE WINDS

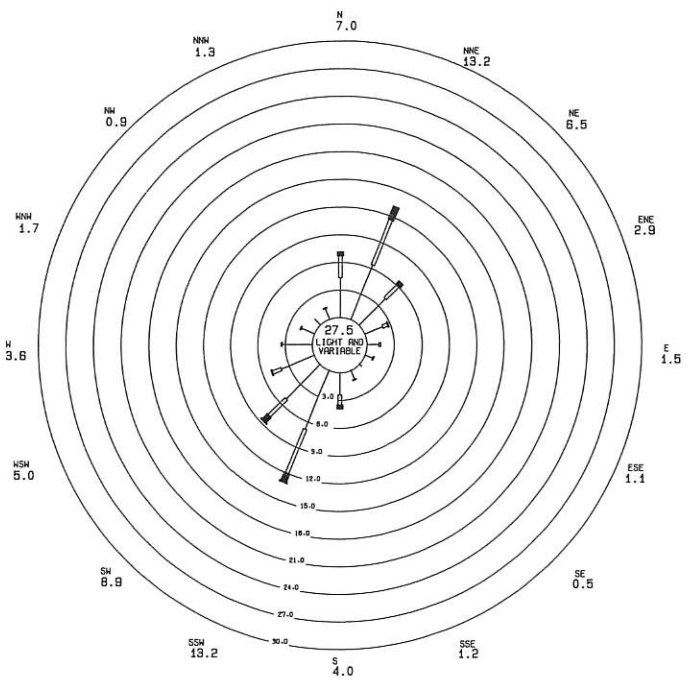
PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
Sumner Jr HS, 1508 Willow St, Sumner, Wa

INCLUSIVE DATES- JAN - NOV, 1986

TOTAL OBSERVATIONS- 7,640





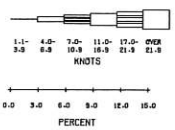
HOUR AVERAGE SURFACE WINDS

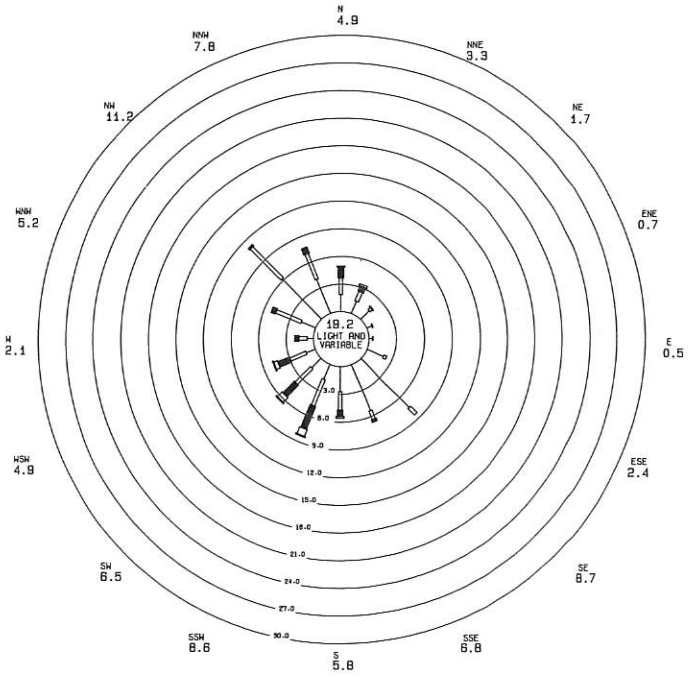
PERCENTAGE FREQUENCY OF OCCURRENCE

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

INCLUSIVE DATES- ALL MONTHS 1986

TOTAL OBSERVATIONS- 8,553





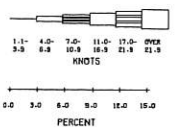
HOUR AVERAGE SURFACE WINDS

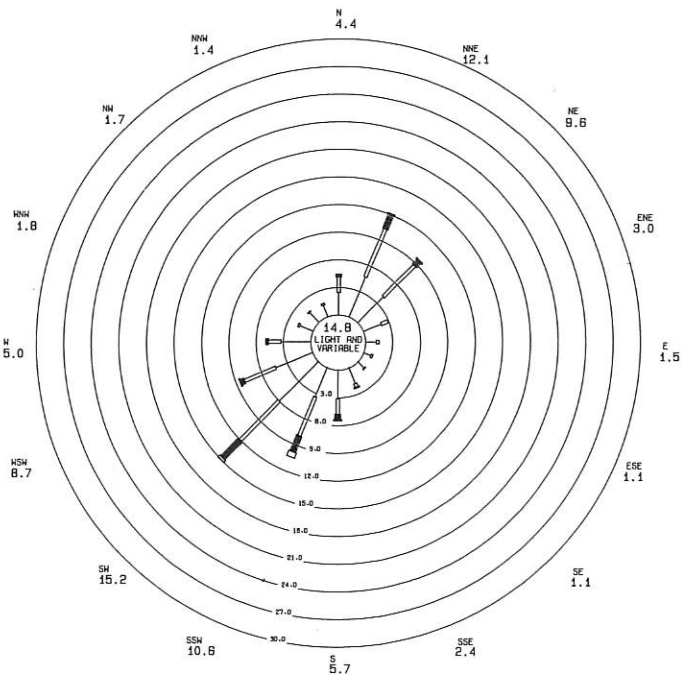
PERCENTAGE FREQUENCY OF OCCURRENCE

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

INCLUSIVE DATES- ALL MONTHS 1986

TOTAL OBSERVATIONS- 8,594





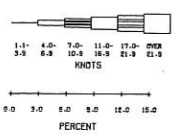
HOUR AVERAGE SURFACE WINDS

PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
North 26th & Pearl Sts, Tacoma, Wa

INCLUSIVE DATES- ALL MONTHS 1986

TOTAL OBSERVATIONS- 8,616



AIR CONTAMINANT EMISSION INVENTORY

Introduction

Registered facilities within the Puget Sound Agency's control region are required to report annually the process quantities which enable calculation of air contaminant emissions from published emission factors. These emissions have been tabulated by county and by source category in the pages which follow.

Definitions

Area sources: County-wide categories of sources.

Emission factor: A value derived from source tests, material balance, engineering comparison with similar processes or other published data which is used to estimate annual emissions from process quantities.

Off road transportation: Farm vehicles, construction/industrial vehicles, logging/governmental vehicles, small marine craft, railroads, vessels, tugs, and ferries.

On road transportation: Motor vehicle fuel combustion by-products and resuspended roadway particulate matter.

Other area sources: Architectural surface coating, automobile surface coating, cold solvent degreasing, commercial/consumer solvents, cutback asphalt, dry cleaning, graphic arts, waste incineration, fireplaces without inserts, stationary diesel engines, and small utility engines.

Point sources: Facilities which have an air contaminant annual emission exceeding twenty-five tons.

Process quantity: An indicator of air contaminant emitting activities used to calculate emissions, such as amount of fuel burned, materials handled, coatings applied, etc.

Registered facility: The sum total of all the pollutant emitting activities located on one or more contiguous or adjacent properties, which is owned or operated by the same person and includes buildings, structures, equipment, control apparatus and storage piles.

Residential heating: Natural gas and distillate fuel oil combustion in homes; wood combustion in stoves and fireplaces with inserts.

Slash burns: Prescribed burning on private, state and federal land.

Small boilers: Commercial natural gas and distillate fuel oil combustion.

Volatile organic compound (VOC): A hydrocarbon or derivative with a vapor pressure exceeding 0.002 pounds per square inch (psi) at 20° C and 14.7 psi excluding methane,
ethane,
trichlorotrifluoroethane (CFC-113),
methylene chloride,
1,1,1-trichloroethane,
chlorodifluoromethane (CFC-22),
dichlorodifluoromethane (CFC-12),
trifluoromethane (FC-23),
dichlorotetrafluoroethane (CFC-114),
trichlorofluoromethane (CFC-11) and
chloropentafluoroethane (CFC-115).

Comments

It should be noted that the air contaminant categories are not necessarily mutually exclusive. Toxic air contaminants may also be tabulated under TSPM, PM_{10} or VOC; and PM_{10} is a subset of TSPM. Estimates for toxic air contaminants have come primarily from source calculated emissions or evaporation estimates of substances which were reported as hazardous ingredients on material safety data sheets. Toxic air contaminants represent a wide range of toxicity.

AIR CONTAMINANT EMISSION INVENTORY SUMMARY

King County
Tons per Year
1986

	TSPM	PM10	SOx	NOx	VOC	CO	TAC
POINT SOURCES							
1-INDUSTRIAL BOILERS	257	223	697	614	87	1534	206
2-FOREST PRODUCTS							
A-PULP MILLS							
B-WOOD PRODUCTS	52	52			2		
3-PRIMARY METALS							
A-ALUMINUM							
B-COPPER							
C-OTHER	124	70		32		1258	14
4-PETROLEUM REFINERIES							
5-ELECTRIC UTILITIES	1	1	5	1	0	0	0
6-CHEMICAL PRODUCTION					25		29
7-CEMENT PRODUCTION	82	53	287	477			2
8-OTHER POINTS							
A-POLLUTANT >25 T/Y	1572	429	775	1182	4093	255	3533
B-POLLUTANT <25 T/Y	105	51	3	16	196	4	122
POINT SOURCE TOTAL	2193	879	1767	2322	4403	3051	3906
AREA SOURCES							
1-TRANSPORTATION							
A-ON ROAD	119232	46467	3094	35716	56030	386554	3046
B-OFF ROAD	426	392	784	4992	2827	12889	8
2-SMALL BOILERS	504	359	10897	3371	105	702	0
3-SLASH BURNS	185	185	0	18	110	1144	
4-RESIDENTIAL HEATING	2650	2596	3593	2012	6070	16015	163
5-OTHER AREA SOURCES	1906	1906	92	871	15243	13990	8685
AREA SOURCE TOTAL	124903	51905	18460	46980	80385	431294	11902
GRAND TOTAL	127096	52784	20227	49302	84788	434345	15808

Notes
(1) TSPM=Total Suspended Particulate Matter
PM10=Particulate Matter <10 Micrometers
SOx =Sulfur Oxides
TAC =Toxic Air Contaminants
NOx=Nitrogen Oxides
VOC=Volatile Organic Compounds
CO =Carbon Monoxide
(2) Unit Conversion: 1 Ton=907.18 kg

AIR CONTAMINANT EMISSION INVENTORY SUMMARY

Kitsap County
Tons per Year
1986

	TSPM	PM10	SOx	NOx	VOC	CO	TAC
POINT SOURCES							
1-INDUSTRIAL BOILERS	79	61	1160	228	5	29	2
2-FOREST PRODUCTS							
A-PULP MILLS							
B-WOOD PRODUCTS	38	19					
3-PRIMARY METALS							
A-ALUMINUM							
B-COPPER							
C-OTHER							
4-PETROLEUM REFINERIES							
5-ELECTRIC UTILITIES							
6-CHEMICAL PRODUCTION							
7-CEMENT PRODUCTION							
8-OTHER POINTS							
A-POLLUTANT >25 T/Y	394	86	120	73	121	26	162
B-POLLUTANT <25 T/Y	0	0	0	2	13	0	13
POINT SOURCE TOTAL	511	166	1280	303	139	55	177
AREA SOURCES							
1-TRANSPORTATION							
A-ON ROAD	11702	4561	304	3505	5977	37940	317
B-OFF ROAD	50	50	232	225	106	870	2
2-SMALL BOILERS	6	5	67	48	2	8	0
3-SLASH BURNS	34	34	0	3	20	208	
4-RESIDENTIAL HEATING	447	444	184	106	1053	2748	26
5-OTHER AREA SOURCES	300	300	9	86	1907	2074	1090
AREA SOURCE TOTAL	12539	5394	796	3973	9065	43848	1435
GRAND TOTAL	13050	5560	2076	4276	9204	43903	1612

Notes
(1) TSPM=Total Suspended Particulate Matter
PM10=Particulate Matter <10 Micrometers
SOx =Sulfur Oxides
TAC =Toxic Air Contaminants
NOx=Nitrogen Oxides
VOC=Volatile Organic Compounds
CO =Carbon Monoxide
(2) Unit Conversion: 1 Ton=907.18 kg

AIR CONTAMINANT EMISSION INVENTORY SUMMARY

Pierce County
Tons per Year
1986

	TSPM	PM10	SOx	NOx	VOC	CO	TAC
POINT SOURCES							
1-INDUSTRIAL BOILERS	1327	1151	2181	1346	319	5745	522
2-FOREST PRODUCTS							
A-PULP MILLS	408	388	674	164	4	2464	54
B-WOOD PRODUCTS	194	104			1		
3-PRIMARY METALS							
A-ALUMINUM	816	626	1719		42	10422	391
B-COPPER				8	0	2	
C-OTHER							
4-PETROLEUM REFINERIES	4	0	139	254	801	111	0
5-ELECTRIC UTILITIES							
6-CHEMICAL PRODUCTION					3	42	3
7-CEMENT PRODUCTION							
8-OTHER POINTS							
A-POLLUTANT >25 T/Y	1066	185	59	157	516	100	367
B-POLLUTANT <25 T/Y	76	30	20	12	207	1	168
POINT SOURCE TOTAL	3891	2484	4792	1941	1893	18887	1505
AREA SOURCES							
1-TRANSPORTATION							
A-ON ROAD	40958	15962	1063	12269	20254	132788	1074
B-OFF ROAD	458	458	332	2946	3059	6736	4
2-SMALL BOILERS	68	53	1197	477	18	91	0
3-SLASH BURNS	672	672	0	64	400	4160	
4-RESIDENTIAL HEATING	939	903	2386	946	2079	5540	55
5-OTHER AREA SOURCES	627	627	33	282	5828	4629	3364
AREA SOURCE TOTAL	43722	18675	5011	16984	31638	153944	4497
GRAND TOTAL	47613	21159	9803	18925	33531	172831	6002

Notes
(1) TSPM=Total Suspended Particulate Matter
PM10=Particulate Matter <10 Micrometers
SOx =Sulfur Oxides
TAC =Toxic Air Contaminants
NOx=Nitrogen Oxides
VOC=Volatile Organic Compounds
CO =Carbon Monoxide
(2) Unit Conversion: 1 Ton=907.18 kg

AIR CONTAMINANT EMISSION INVENTORY SUMMARY

Snohomish County
Tons per Year
1986

	TSPM	PM10	SOx	NOx	VOC	CO	TAC
POINT SOURCES							
1-INDUSTRIAL BOILERS	609	521	1306	675	197	3564	505
2-FOREST PRODUCTS							
A-PULP MILLS	506	241	594	934		1032	43
B-WOOD PRODUCTS	67	34					
3-PRIMARY METALS							
A-ALUMINUM	186						
B-COPPER							
C-OTHER							
4-PETROLEUM REFINERIES							
5-ELECTRIC UTILITIES							
6-CHEMICAL PRODUCTION							
7-CEMENT PRODUCTION							
8-OTHER POINTS							
A-POLLUTANT >25 T/Y	564	99	93	215	1286	5851	1207
B-POLLUTANT <25 T/Y	13	6	8	4	10		6
POINT SOURCE TOTAL	1945	901	2001	1828	1493	10447	1761
AREA SOURCES							
1-TRANSPORTATION							
A-ON ROAD	32678	12735	848	9789	17833	105944	891
B-OFF ROAD	138	138	182	1766	421	2546	4
2-SMALL BOILERS	23	14	591	261	9	58	0
3-SLASH BURNS	315	315	0	30	188	1950	
4-RESIDENTIAL HEATING	913	909	261	214	2156	5624	55
5-OTHER AREA SOURCES	641	641	28	251	4367	4472	2452
AREA SOURCE TOTAL	34708	14752	1910	12311	24974	120594	3402
GRAND TOTAL	36653	15653	3911	14139	26467	131041	5163

Notes
(1) TSPM=Total Suspended Particulate Matter
PM10=Particulate Matter <10 Micrometers
SOx =Sulfur Oxides
TAC =Toxic Air Contaminants
NOx=Nitrogen Oxides
VOC=Volatile Organic Compounds
CO =Carbon Monoxide
(2) Unit Conversion: 1 Ton=907.18 kg

AIR CONTAMINANT EMISSION INVENTORY SUMMARY

All Counties
Tons per Year
1986

	TSPM	PM10	SOx	NOx	VOC	CO	TAC
POINT SOURCES							
1-INDUSTRIAL BOILERS	2272	1956	5344	2863	608	10872	1235
2-FOREST PRODUCTS							
A-PULP MILLS	914	629	1268	1098	4	3496	97
B-WOOD PRODUCTS	351	209			3		
3-PRIMARY METALS							
A-ALUMINUM	1002	626	1719		42	10422	391
B-COPPER				8		2	
C-OTHER	124	70		32		1258	14
4-PETROLEUM REFINERIES	4		139	254	801	111	
5-ELECTRIC UTILITIES	1	1	5	1			
6-CHEMICAL PRODUCTION					28	42	32
7-CEMENT PRODUCTION	82	53	287	477			2
8-OTHER POINTS							
A-POLLUTANT >25 T/Y	3596	799	1047	1627	6016	6232	5269
B-POLLUTANT <25 T/Y	194	87	31	34	426	5	309
POINT SOURCE TOTAL	8540	4430	9840	6394	7928	32440	7349
AREA SOURCES							
1-TRANSPORTATION							
A-ON ROAD	204570	79725	5309	61279	100094	663226	5328
B-OFF ROAD	1072	1038	1530	9929	6413	23041	18
2-SMALL BOILERS	601	431	12752	4157	134	859	
3-SLASH BURNS	1206	1206		115	718	7462	
4-RESIDENTIAL HEATING	4949	4852	6424	3278	11358	29927	299
5-OTHER AREA SOURCES	3474	3474	162	1490	27345	25165	15591
AREA SOURCE TOTAL	215872	90726	26177	80248	146062	749680	21236
GRAND TOTAL	224412	95156	36017	86642	153990	782120	28585

Notes
(1) TSPM=Total Suspended Particulate Matter
PM10=Particulate Matter <10 Micrometers
SOx =Sulfur Oxides
TAC =Toxic Air Contaminants
NOx=Nitrogen Oxides
VOC=Volatile Organic Compounds
CO =Carbon Monoxide
(2) Unit Conversion: 1 Ton=907.18 kg

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 mm Hg and a temperature of 25 degrees C.

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

POLLUTANT STANDARDS INDEX

The Pollutant Standards Index values are indexed to actual concentrations of pollutants for which a national primary standard has been set. The following table shows the averaging period and the pollutant concentration for each break-point of the Index. Values between break-points are determined by linear interpolation.

Pollutant	Averaging Period & Units
Carbon Monoxide (CO)	8 hour average in parts per million
Total Suspended Particulates (TSP)	24 hour average in micrograms per cubic meter
Sulfur Dioxide (SO_2)	24 hour average in parts per million
Ozone (OZ)	1 hour average in parts per million

PSI Break-points and Pollutant Concentrations

PSI value	CO (8 hrs)	TSP (24 hrs)	SO_2 (24 hrs)	OZ (1 hr)
50	4.5	75	0.03	0.06
100	9.0	260	0.14	0.12
200	15.0	375	0.30	0.20
300	30.0	625	0.60	0.40
400	40.0	875	0.80	0.50
500	50.0	1000	1.00	0.60

AMBIENT AIR QUALITY STANDARDS

SULFUR OXIDES

The presence of sulfur oxides in the ambient air has been associated with a variety of respiratory diseases and increased mortality rates. They represent a significant economic burden and have a nuisance impact. When sulfur oxides are inhaled with small particles, the effect on health is increased. Inhalation of sulfur dioxide can cause increased airway resistance by constricting lung passages.

PARTICULATES

Small discrete masses of solid or liquid matter dispersed in the atmosphere, especially those of one micron or less in diameter, are associated with a variety of adverse effects on public health and welfare. Particulate matter in the respiratory tract may produce injury by itself, or it may act in conjunction with gases to increase the effect on the body. Small particles suspended in the air are chiefly responsible for reduced visibility in the Puget Sound area. Soiling of buildings and other property is a common effect of high particulate levels.

CARBON MONOXIDE

Carbon monoxide reacts with the hemoglobin in red blood cells to decrease the oxygen-carrying capacity of the blood. The national primary standard for carbon monoxide was based on evidence that levels of carboxyhemoglobin in human blood as low as 2.5% may be associated with impairment of ability to discriminate time intervals. The national ambient air quality standards for carbon monoxide are intended to protect against the occurrence of carboxyhemoglobin levels above 2%. Smoking 2 packs of cigarettes a day raises carboxyhemoglobin levels to 5%.

	NATIONAL			WASHINGTON STATE		PUGET SOUND REGION	
	PRIMARY	SECONDARY	*		*		*
SULFUR OXIDES	ppm	ppm		ppm		ppm	
Annual Average	0.03		a	0.02	a	0.02	a
30 day Average						0.04	a
24 hour Average	0.14		b	0.10	b	0.10	a
3 hour Average		0.50	b				
1 hour Average				0.25	c	0.25	c
1 hour Average				0.40	b	0.40	a
5 min Average						1.00	d
SUSPENDED PARTICULATES	ug/cubic meter	ug/cubic meter		ug/cubic meter		ug/cubic meter	
Annual Geometric Mean	75	60	a	60	a	60	a
24 hour Average	260	150	b	150	b	150	b
CARBON MONOXIDE	ppm			ppm		ppm	
8 hour Average	9		b	9	b	9	b
1 hour Average	35		b	35	b	35	b
OZONE	ppm	ppm		ppm		ppm	
1 hour Average	0.12	0.12	e	0.12	e	0.12	e
NITROGEN DIOXIDE	ppm	ppm		ppm		ppm	
Annual Average	0.05	0.05	a	0.05	a	0.05	a
LEAD	ug/cubic meter	ug/cubic meter				ug/cubic meter	
Calendar Quarter Average	1.5	1.5	a			1.5	a

ppm = parts per million ug/cubic meter = micrograms per cubic meter

*

a Never to be exceeded
b Not to be exceeded more than once per year
c Not to be exceeded more than twice in seven days
d Not to be exceeded more than once in eight hours
e Standard attained when expected number of days per year with maximum hourly average above 0.12 ppm is equal to or less than one

OZONE

Oxidants are produced in the atmosphere when nitrogen oxides and some hydrocarbons are exposed to sunlight. Ozone is the oxidant found in largest amounts. 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, produced in smaller amounts than ozone, cause eye irritation. Persons with chronic respiratory problems such as asthma seem most sensitive to changes in ozone concentration.

NITROGEN DIOXIDE

Nitric oxide results from the fixation of nitrogen and oxygen at high temperatures as in fuel combustion. There are several atmospheric reactions which lead to the oxidation of nitric oxide to nitrogen dioxide, and the presence of nitrogen dioxide in ambient air is essential to the production of photochemical oxidants. The presence of nitrogen dioxide in ambient air has been associated with a variety of respiratory diseases.

LEAD

Lead affects humans in numerous ways, but the greatest effects appear to be on the blood-forming system, the nervous system, and the kidneys. It affects some persons more than others. Young children (ages 1-5) 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.

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