At the first meeting I showed you the environmental impact statement for the third runway EIS and then talked about how the air quality model input had not been included in that document. After opening up the model input I found the figures did not agree with published data taken from certification of aircraft engines or standard calculations from EPA. Examples of differences in the EIS were:

1) Time in mode was lower
2) Aircraft emission factors were lower
3) All particulate data for all jet aircraft had been eliminated from the model

EPA data from new engine certification is published in AP-42 with engine type and corresponding emission factors in kilograms or pounds per hour per engine. Accordingly, the FAA's standard airport emissions model called EDMS uses this data as input. I am supplying you with a letter from FAA explaining how the FAA takes the data from EPA and also explains how the default settings within the model are open for users to enter airport specific data. Please notice that the figures the FAA used for the third runway project are smaller in every case for aircraft when compared to AP-42. Please also note that the recommended taxi in/out queue time in mode for all aircraft was set at 11 minutes rather than the recommended 26 minutes. Two experienced pilots who have flown Sea-Tac and other airports both assert this is not realistic and the 11 minutes would only happen if there is no other traffic on the airfield.

I made the claim that all particulate data for all jet aircraft had been removed from the model prior to the third runway's use of EDMS. I asked FAA for an explanation of this removal and received a response that the data was found to be inaccurate. At the end of the third runway EIS process, no data had ever been entered to estimate particulate emissions from jet aircraft and the total predicted impact through 2020 for the project for all jet aircraft operations remained at zero which is false.

In 1991 Department of Ecology ran a screening analysis using the same model and found the particulate inventory to be over 60 tons per year for just jets. Contrast this to 3 years later for the draft EIS for the third runway at a tiny fraction of 0.23. In 1991 DOE had predicted violations of the federal Clean Air Act for particulate matter. In 1994 the FAA and Port of Seattle estimated zero impact.

Unlike the EIS, Department of Ecology had included their input into the model in their document and I've enclosed a sample that shows it agrees with EPA's AP-42 and EPA's recommendations for time in mode.

Please know that if the model input had not been dramatically altered, the third runway project would never have been able to be approved, funded or supported by FAA. Even with the drastically underestimated impacts, it still violated the federal standards. So we have been living with a terrible threat to our public health because of manipulated and falsified data and now we are sick. This is a public outrage and tragedy.

Debi Wagner

U.S. Department
of Transportation

Federal Aviation Administration

Northwest Mountain Region
Colorado, Idaho, Montana
Oregon, Utah, Washington
Wyoming

1601 Lind Avenue, S. W.
Renton, Washington 98055-4056

December 13, 1995

Mrs. Debi L. DesMarais
24322 22nd Ave. S.
Des Moines, WA 98198

Dear Mrs. DesMarais:

This is in response to your letter of November 13, 1995. I will address your questions in the order asked.

1. This is the type of question that should have been asked as part of your comments on the draft EIS. I believe it would be improper to answer this question since the draft EIS comment period has long since closed. Addressing this type of question, at this time, would be viewed by many as preferential treatment or selectively re-opening the comment period.

2. through 5: Are general technical questions about EDMS. The following answers have been provided by the Office of Environment and Energy in our Washington, D. C. Headquarters office:

Have the emission rates contained within the model been approved by EPA? If not, were previous rates approved? When? Is the EDMS model approved by EPA?

On July 20, 1993, the Environmental Protection Agency (EPA) formally accepted EDMS as a "Preferred Guideline" model for use at civil airports and military air bases. The emission rates contained within EDMS come from EPA's AP-42 Compilation of Air Pollutant Emission Factors and the FAA Engine Emission Database (FAEED).

If the emission rates come from manufacturers specifications, who exempted aircraft engine manufacturers from estimating particulate matter (smoke number)? If FAA exempted, do manufacturers estimates exist? Are they available for viewing?

The particulate matter (PM-10) come from EPA's AP-42 database. The aircraft engine manufacturers are required to estimate smoke number for certification purposes. For further information, please contact Richard Wilcox at EPA, Ann Arbor, Michigan.

Does FAA update emission data periodically with newer aircraft engine emission rates? If so, can those rates be substantiated with appropriate documentation?

The FAA updates aircraft emission data as information becomes available. The EDMS model is flexible in allowing users to add new aircraft emission data into the database and to override defaults for more detailed or site specific values.

Since there is such disparity between the 1985 EPA AP-42 engine emission rates and today FAA EDMS rates, can the reduction in CO and HC by approximately 2/3 be substantiated?

The emission rate in EPA's AP-42 and EDMS are very close. We are in the process of updating the EDMS database to incorporate data from the recent update of the AP-42 database. If Ms DeMarais can specify how she used the EDMS model to calculate the emission rate, then we would be willing to look at the cause of any disparities.

A further contact for EDMS questions is Ms Diana Liang at 202-267-3494.

Sincerely,

Dennis Ossenkop
Environmental Protection Specialist

As indicated on page D-38, a separate analysis also confirmed that even if the average annual fleet (i.e., all aircraft types in use) and the highest peak hour level of departures, maximized peak hour departure queue time could occur at the same time, the change in pollutant levels would be minimal. This analysis was also conducted for the future annual aircraft fleet. Except at South 154th Street, all pollutant concentrations would still be below the AAQS.

The test case analysis indicated that increased departure queue time would result in increased CO levels, while increased aircraft departures would result in increased NO_2 levels. However, as observed by historic FAA data, peak hour departures and peak hour queuing are mutually exclusive and do not occur at the same time. Nonetheless, the analysis indicates that all concentrations except at South 154th Street would be below the AAQS.

Comment 14: Commentor questioned the time-in-mode/taxi and requested a clarification of these assumptions.

Response: Appendix D, page D-5 discusses the determination of taxi-in and taxi-out times. Actual field observations were used to estimate the amount of time an aircraft spends in different modes, such as apron idling, taxiing, and idling at the end of the runway. Taxi-in and taxi-out times were based on a determination of existing airfield taxi distances and aircraft speed for seven different points on the airfield. The addition of the South Aviation Support Area (SASA) and the proposed terminal improvements were modeled in combination with the proposed third parallel runway. The average taxi distance was then calculated by applying the existing or future runway end use based on a constant aircraft taxi speed of 15 knots.

The use of the proposed new parallel runway for departures is expected to be limited for the reasons discussed in the Final EIS. Accordingly, taxi times are not expected to be substantially different over existing conditions (i.e., taxi times take into consideration runway use). For the existing conditions, each aircraft operation is expected to experience approximately 8.11 minutes of taxi-time (for both arrival and departure operations).

Comment 15: Commentor stated that the EDMS write-up in the EIS should have noted that all particulate data for jet aircraft had been removed.

Response: As stated in the EIS in Appendix R, response to comment R-10-2, the aircraft emission rates included in the EDMS for particulates was revised by the FAA to include only that data for which reliable particulate information is known. Accordingly, the most current EPA approved version of the EDMS model (which was used in preparing the analysis for the Final EIS) includes little information on particulates in comparison to older versions of the model. The FAA has not updated the particulate data because no reliable data on aircraft particulate emissions is available.

Comment 16: Requested an explanation of why the aircraft emissions in the Final EIS are less than those presented in the Draft EIS.

Response: As noted in Appendix D, page D-34, in re-evaluating the air quality analysis, all input assumptions used in preparation of the Draft EIS were re-examined. As part of that review, the hourly aircraft temporal factors used in the Final EIS analysis for the existing condition were revised to reflect hourly departure activity based on the FAA's Capacity Enhancement Study. The revised

AIRCRAFT EMISSIONS RATES OR TOTAL GSE EMISSION PER LANDING/TAKEOFF CYCLE

Aircraft	AIRCFT	747	Geomode 1 - Takeoff (kg/hr/eng)
Geographic mode	GEOMODE		Geomode 2 - Runway Queue (kg/hr/eng)
		2	Geomode 3 - Touch & Go (kg/hr/eng)
			Geomode 4 - Taxi in/out (kg/hr/eng)
Fuel	FUEL.CD	13	Geomode 5 - Grnd supp equip (kg/LTO)
Number of engines	ENG.NUM	4	Geomode 6 - Test (kg/hr/eng)
			Geomode 7 - Climb (kg/hr/eng)
			Geomode 8 - Approach (kg/hr/eng)

Time in mode TIMEMOD 2.89 minutes

Sum of GSE costs per LTO GSE .00 dollars/hours

Aircraft engine emissions per unit time (kg/hr/eng) or
emissions from all ground support equipment per aircraft LTO (kg/LTO)

CO	42.575443	64.59
HC	20.499287	24.99
NOx	2.444146	2.6
SOx	.425754	.84
Part	.000000	1.0

AIRCRAFT EMISSIONS RATES OR TOTAL GSE EMISSION PER LANDING/TAKEOFF CYCLE

Aircraft	AIRCFT	747	Geomode 1 - Takeoff (kg/hr/eng)
Geographic mode	GEOMODE		Geomode 2 - Runway Queue (kg/hr/eng)
		4	Geomode 3 - Touch & Go (kg/hr/eng)
			Geomode 4 - Taxi in/out (kg/hr/eng)
Fuel	FUEL.CD	13	Geomode 5 - Grnd supp equip (kg/LTO)
Number of engines	ENG.NUM	4	Geomode 6 - Test (kg/hr/eng)
			Geomode 7 - Climb (kg/hr/eng)
			Geomode 8 - Approach (kg/hr/eng)

Time in mode TIMEMOD 8.11 minutes

Sum of GSE costs per LTO GSE .00 dollars/hours

Aircraft engine emissions per unit time (kg/hr/eng) or
emissions from all ground support equipment per aircraft LTO (kg/LTO)

CO	42.575443
HC	20.499287
NOx	2.444146
SOx	.425754
Part	.000000

AIRCRAFT EMISSIONS RATES OR TOTAL GSE EMISSION PER LANDING/TAKEOFF CYCLE

Aircraft	AIRCFT	757	Geomode 1 - Takeoff (kg/hr/eng)
Geographic mode	GEOMODE		Geomode 2 - Runway Queue (kg/hr/eng)
		2	Geomode 3 - Touch & Go (kg/hr/eng)
			Geomode 4 - Taxi in/out (kg/hr/eng)
Fuel	FUEL.CD	13	Geomode 5 - Grnd supp equip (kg/LTO)
Number of engines	ENG.NUM	2	Geomode 6 - Test (kg/hr/eng)
			Geomode 7 - Climb (kg/hr/eng)
			Geomode 8 - Approach (kg/hr/eng)

Time in mode TIMEMOD 2.89 minutes

Sum of GSE costs per LTO GSE .00 dollars/hours by 2020 will there be a substitute for fossil fuel ??!!

where did the particulates go

TABLE II.3-1
Page 2 of 2

Environmental Impact Statement
Master Plan Update

PRELIMINARY AIRSIDE SCREENING ANALYSIS

	Master Plan Update Airside Options						
	1A	1B	3	4A	4C	5	6
Air Inventory (tons per day in year 2020)							
Carbon Monoxide	13.86	13.86	10.18	6.82	6.82	5.86	4.86
Nitrogen Oxides	6.82	6.82	6.49	6.19	6.19	6.11	6.02
Particulate Matter (PM10)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sulfur Oxides	0.33	0.33	0.28	0.23	0.23	0.22	0.20
Wetland Impacts (acres)	0	0	4.2	5.4	5.0	5.4	27.7
100-Year Floodplain Impacts (acres)	0	0	1	7	2	7	30
Stream Relocation (linear feet)	0	0	2,760	2,970	2,760	2,970	12,240
Earth Impacts (million cubic yards)	0	0	12	17	13	17	28
Construction Impact (units displaced):							
Properties	0	0	330	410	400	420	700
Homes	0	0	260	330	300	320	500
Parks	0	0	0	0	0	0	1
Historic/Cultural sites	0	0	1	1	1	1	3
Schools	0	0	0	0	0	0	1

Impacts presented in this table were prepared as a part of a preliminary screening, based on initial data collection. As was noted in presenting this data in July 1994, the base information was later updated by this Environmental Impact Statement.

Source: Landrum & Brown, Shapiro & Associates, and Gambrell Urban - Population and dwelling units using 1990 census.

- Option 1A/B – Do-Nothing
- Option 2 - Commuter Close Spaced - this option was not evaluated due to its similarity to Option 3.
- Option 3 – Commuter Dependent
- Option 4A - Programmatic Baseline
- Option 4B - Programmatic Staggered - this option was not evaluated due to its similarity to Options 4A, 4C and 5.
- Option 4C - 7,500 Foot – Staggered
- Option 5 - Dependent–Maximum Length
- Option 6 - Independent – Maximum Length

Seattle - Tacoma International Airport
Environmental Impact Statement

EMISSION INVENTORY
1994 EXISTING CONDITIONS
TONS/YEAR

1994 Do-Nothing SOURCES	CO	VOC'S	NOx	SOx	PM10	TOTAL
Roadways	16,676.00	1,402.50	2,163.70	1.37	9.12	20,252.69
Parking Lots	175.78	14.07	12.30	0.01	0.05	202.21
Heating Plants	3.25	0.53	13.00	0.06	0.28	17.12
Training Fires	42.72	24.48	0.32	9.79	0.08	77.38
Surf. Coating	0.00	3.58	0.00	0.00	0.00	3.58
Tank Farms	0.00	27.51	0.00	0.00	0.00	27.51
Grnd. Sup. Equip.	548.35	120.78	105.85	2.30	6.67	783.95
Aircraft	1,365.10	406.89	1,378.30	54.67	0.23	3,205.19
TOTALS	18,811.20	2,000.34	3,673.47	68.20	16.42	24,569.63

Source: Emission Dispersion Modeling System (EDMS) Version 944
Landrum & Brown Inc., March, 1995

Box # 3

SEATTLE TACOMA INTERNATIONAL AIRPORT:

AIR POLLUTANT CONTRIBUTION

May 1991

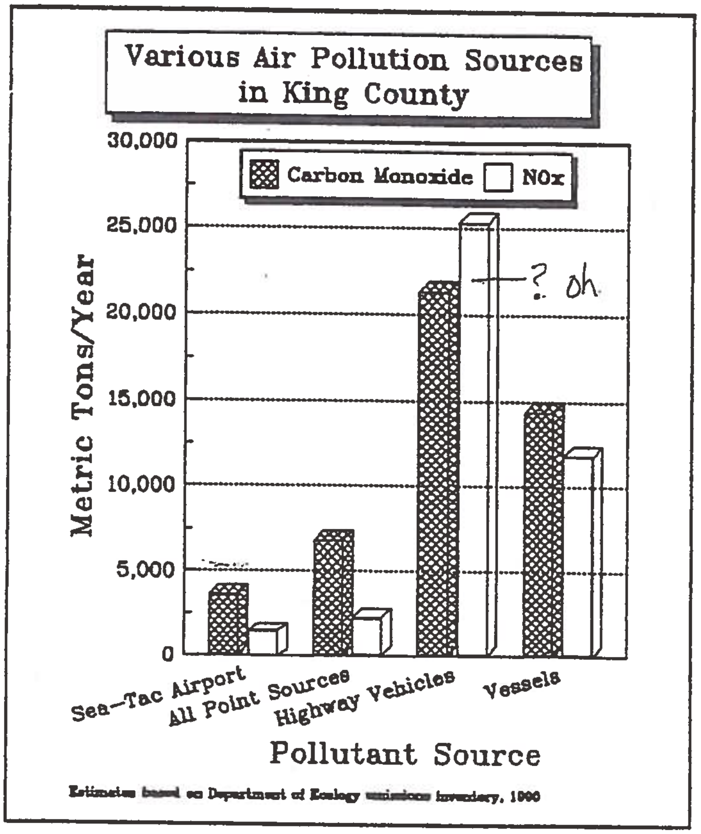
Air Quality Program

Department of Ecology

Olympia, Washington

This is the report Greg Fisher worked for.

1991 EDMS
D.O.E. STUDY



Estimates based on Department of Ecology emissions inventory, 1990

FIGURE 2

constitute a small source compared to motor vehicle and aircraft emissions. The boiler, which is powered with natural gas, is also a minor source. The rest of the figures pertaining to emissions will include only the major sources: aircraft and motor vehicles.

TABLE 1. AIR POLLUTION SOURCES AT SEA-TAC AIRPORT

Source	CO	HC	NOx	SOx	TSP
Tank Farms	0	0.006	0	0	0
Motor Vehicles	502	37.2	23.03	0.018	0.118
Aircraft	3121	1277	1874	162	61.44
Boiler	3.36	2.77	0.012	0.003	0.371
Total	3628	1315	1897	163	62

Units - metric tons per year

507

2 T/O

Aircraft	AIRCFT	747	Geomode 1 - Takeoff
Geographic mode	GEOMODE	1	Geomode 2 - Runway Queue
Fuel	FUEL.CD	13	Geomode 3 - Touch & Go
Number of engines	ENG.NUM	4	Geomode 4 - Taxi in/out
Time in mode	TIMEMOD	.70 minutes	Geomode 5 - Aircraft Parkin
Takeoff speed	TOSPEED	.00 meters/sec	Geomode 6 - Engine Testing
			Geomode 7 - Aircraft Climb
			Geomode 8 - Aircraft Approa

(NOTE: Queueing Times in mode, Geomode 2, are entered in the runway screen)
(it has meaning only for geomode #1, it is ignored otherwis

Emission rates in kg/hr (per engine)

CO	1.470000
HC	.360000
NOx	215.300000
SOx	7.320000
Part	1.700000

Aircraft	AIRCFT	747	Geomode 1 - Takeoff
Geographic mode	GEOMODE	2	Geomode 2 - Runway Queue
Fuel	FUEL.CD	13	Geomode 3 - Touch & Go
Number of engines	ENG.NUM	4	Geomode 4 - Taxi in/out
Time in mode	TIMEMOD	20.00 minutes	Geomode 5 - Aircraft Parkin
Takeoff speed	TOSPEED	.00 meters/sec	Geomode 6 - Engine Testing
			Geomode 7 - Aircraft Climb
			Geomode 8 - Aircraft Approa

(NOTE: Queueing Times in mode, Geomode 2, are entered in the runway screen)
(it has meaning only for geomode #1, it is ignored otherwis

Emission rates in kg/hr (per engine)

CO	64.590000
HC	24.990000
NOx	2.600000
SOx	.840000
Part	1.000000

Aircraft	AIRCFT	747	Geomode 1 - Takeoff
Geographic mode	GEOMODE	3	Geomode 2 - Runway Queue
Fuel	FUEL.CD	13	Geomode 3 - Touch & Go
Number of engines	ENG.NUM	4	Geomode 4 - Taxi in/out
Time in mode	TIMEMOD	2.00 minutes	Geomode 5 - Aircraft Parking
Takeoff speed	TOSPEED	.00 meters/sec	Geomode 6 - Engine Testing
			Geomode 7 - Aircraft Climb
			Geomode 8 - Aircraft Approach

(NOTE: Queueing Times in mode, Geomode 2, are entered in the runway screen)
(it has meaning only for geomode #1, it is ignored otherwise)

Emission rates in kg/hr (per engine)

CO	64.590000
HC	24.990000
NOx	2.600000
SOx	.840000
Part	1.000000

Aircraft	AIRCFT	747	Geomode 1 - Takeoff
Geographic mode	GEOMODE	4	Geomode 2 - Runway Queue
Fuel	FUEL.CD	13	Geomode 3 - Touch & Go
Number of engines	ENG.NUM	4	Geomode 4 - Taxi in/out
Time in mode	TIMEMOD	6.00 minutes	Geomode 5 - Aircraft Parking
Takeoff speed	TOSPEED	.00 meters/sec	Geomode 6 - Engine Testing
			Geomode 7 - Aircraft Climb
			Geomode 8 - Aircraft Approach

(NOTE: Queueing Times in mode, Geomode 2, are entered in the runway screen)
(it has meaning only for geomode #1, it is ignored otherwise)

Emission rates in kg/hr (per engine)

CO	64.590000
HC	24.990000
NOx	2.600000
SOx	.840000
Part	1.000000

Aircraft	AIRCFT	747	Geomode 1 - Takeoff
Geographic mode	GEOMODE	5	Geomode 2 - Runway Queue
Fuel	FUEL.CD	13	Geomode 3 - Touch & Go
Number of engines	ENG.NUM	4	Geomode 4 - Taxi in/out
Time in mode	TIMEMOD	3.00 minutes	Geomode 5 - Aircraft Parking
Takeoff speed	TOSPEED	.00 meters/sec	Geomode 6 - Engine Testing
			Geomode 7 - Aircraft Climb
			Geomode 8 - Aircraft Approach

(NOTE: Queueing Times in mode, Geomode 2, are entered in the runway screen)
(it has meaning only for geomode #1, it is ignored otherwise)

Emission rates in kg/hr (per engine)

CO	64.590000
HC	24.990000

III. CONCLUSIONS AND RECOMMENDATIONS

A. Results and Conclusions

EDMS calculated emission rates for all the criteria pollutants plus hydrocarbons for Sea-Tac Airport's typical activity on an annual basis. Those emission reported in figures 2 through 8 and in Appendix 4.

After calculating emission rates, EDMS was used to calculate ambient concentrations during peak-hour activity. This dispersion output was contoured with an interpolating and plotting package called SURFER. The interpolating technique used was Krigning. The results obtained from the plotting exercise are shown in figures 9 through 22 found in Appendix 5, and, although they serve the purpose of providing a graphical illustration of the results, they must be used with caution. Because of the low density of points in certain data sets, some contours were not completed. Other contours contain waves and other artifacts that are not a true reflection of the data, but rather reflect weaknesses of the interpolating algorithm in handling the steep gradients in regions with few data points. Practical considerations relating to computer run time precluded using more calculation points.

1. Sea-Tac Airport is a major indirect source of air pollutants. It contributes approximately 8% of the carbon monoxide and 5% of the nitrogen oxide emissions in King County. Refer to Figure 2.

2. The emission inventory obtained for Sea-Tac Airport shows that the boilers, tank farms, and training fire are minor, even insignificant, sources compared to aircraft and motor vehicles which together comprise 99.9% of the emissions.

Refer to Table 1 and Figure 3. Note that Figure 3 depicts the airport's hydrocarbon emissions in a logarithmic scale. Appendix 4 contains Sea-Tac's emission inventory in more detail.

The tank farms contribute only hydrocarbons from evaporation loses. The training fires take place quarterly, at night, and particular run EDMS predicted a concentration of 19 ppm NO_2 in a receptor location right on 154th street. With the wind blowing directly from the north (0 degrees) the Tyee Golf Course can be getting as much as 12 ppm NO_2 one-hour average during worst-case conditions.

6. Predicted maximum one-hour concentrations of carbon monoxide during worst-case conditions are about 20 ppm in the terminal area, due almost entirely to traffic, and range up to 59 ppm at the runway, rapidly decreasing to about 15 ppm one kilometer downwind of the maximum concentration. In the case where the wind direction is zero degrees, the plume spreads out around the queuing area, and 1 km south of the queue the impact is still about 10 ppm. In figure 9 an island of zero concentration is located next to the 2 ppm contour. As expected, due to the meteorology chosen and the nature of the source, there is a steep gradient in the east-west direction and a more moderate one along the north-south axis. In the 345 degree case illustrated in figure 11, a one-hour average contribution to the housing development immediately east of the Tyee Golf Course, Angle Lake School and Seattle Christian School of approximately 9-5 ppm was predicted.

The one-hour standard for CO is 35 ppm. It is predicted that the maximum one-hour concentration of CO due to aircraft alone is about 20 ppm, or 57% of the standard, in an area of public access during a peak hour and low-dispersive meteorological conditions.

7. EDMS revealed localized hot-spots of particulate concentrations in the range of 800 micrograms per cubic meter, particularly in the 170 degree case illustrated in figure 22. Note that 154th. Street is located at the hot spot. At approximately 1 km north of the runway, the concentration has decreased to 157 micrograms per cubic meter.

The 24-hour standard for fine particulate matter (PM-10) is 150 micrograms per cubic meter. Measurements have shown that all of the particulate matter from aircraft exhaust can be classified as fine, ranging in diameter from 0.03 to 0.1 micrometers.[17]

dangerous level of small particulates

8. The airport is also a significant source of hydrocarbons contributing up to 5 ppm worst-case, ground-level concentrations. The housing development around Seattle Christian School and the school itself may get around 4 ppm of hydrocarbons as illustrated in figure 14, the 345

degree case. From a toxics standpoint that may be quite significant depending on the actual composition of the hydrocarbons. For example, assuming that 4% (based on the Radian estimates) of the hydrocarbon emissions are benzene, the benzene contribution to the hourly average from the airport would be of about 0.16 *parts per million* (or 24000 *parts per trillion* annual average). As a point of reference, the acceptable source impact level (ASIL) for new sources proposed in WAC 173-460 is 0.063 *parts per trillion*.

9. The contribution of traffic to sulfur oxide pollution is minimal. A high of 0.5 ppm SO_2 was predicted on the runway in the 0 degree case on figure 18 decreasing to 0.1 ppm 1 km south of the queuing area, in the vicinity of 200th Street. A one-hour average national standard for SO_2 does not exist, Washington's one-hour average standard is 0.4 ppm.

10. It is important to mention the conclusions that the FAA/EPA team reached in their 1980 report *Impact of Aircraft Emissions on Air Quality in the Vicinity of Airports* mentioned earlier. This report compiled both monitoring and modeling analyses of airports throughout the country: Washington National, Los Angeles International, Dulles International, Lakeland, John F. Kennedy, and Chicago O'Hare. They summarized their conclusions in the following manner:

" * Maximum hourly average CO concentrations from aircraft are unlikely to exceed 5 ppm in areas of public exposure and are thus small in comparison to the NAAQS of 35 ppm.

* Maximum hourly HC concentrations from aircraft can exceed 0.25 ppm over an area several times the size of the airport.

* While annual average NO_2 concentrations from aircraft are estimated to contribute only 10 to 20 percent of the NAAQS limit level, these concentrations, when averaged over a one hour time period are estimated to produce concentrations as high as 0.5 ppm if one assumes that all engine produced NO is converted to NO_2 by the time these emissions reach public exposure. This value is at the upper end of the concentration range being considered for the short term NO_2 standard presently under review and cannot be ignored."

The above excerpt identifies nitrogen oxides and hydrocarbons as two pollutants to be concerned about at airports; however, this screening study of Sea-Tac's emissions showed that the airport's contribution to ground-level pollutant concentrations is higher than expected.

EPA AP-42 1994

TABLE II-1-7 (CONTINUED)

Model-Series Mfg.[b] Type[b]	Mode	Fuel Rate lb/hr	Fuel Rate kg/hr	CO lb/hr	CO kg/hr	NO_x[c] lb/hr	NO_x[c] kg/hr	Total HC[d] lb/hr	Total HC[d] kg/hr	SO_x[e] lb/hr	SO_x[e] kg/hr	Particulates[f] lb/hr	Particulates[f] kg/hr
JT3D-7 P&W TF (DC-8-63F)	Idle	1013	459.5	140.8	63.87	2.23	1.01	124.6	56.52	1.01	0.46	0.45[g]	0.20[g]
	Takeoff	9956	4516	8.96	4.06	126.4	57.34	4.98	2.26	9.96	4.52	8.25	3.7
	Climbout	8188	3714	15.56	7.06	78.6	35.65	3.28	1.49	8.19	3.71	8.5	3.9
	Approach	3084	1399	60.14	27.28	16.35	7.42	6.48	2.94	3.08	1.40	8.0	3.6
JT8D-17 P&W TF (DC-9-30, 727, 737-200)	Idle	1150	521.6	39.10	17.74	3.91	1.77	10.10	4.58	1.15	0.52	0.36[g,h]	0.16[g,h]
	Takeoff	9980	4527	6.99	3.17	202.6	91.90	.50	0.227	9.98	4.53	3.7	1.7
	Climbout	7910	3588	7.91	3.59	123.4	55.97	.40	0.181	7.91	3.59	2.6	1.2
	Approach	2810	1275	20.23	9.18	19.39	8.80	1.41	0.640	2.81	1.28	1.5	0.68
JT9D-7 P&W TF (747-100, 200)	Idle	1849	838.7	142.4	64.59	5.73	2.60	55.10	24.99	1.85	0.84	2.2[i]	1.0
	Takeoff	16142	7322	3.23	1.47	474.6	215.3	0.81	0.367	16.14	7.32	3.75	1.7
	Climbout	13193	5984	6.60	2.99	282.3	128.0	1.32	0.599	13.19	5.98	4.0	1.8
	Approach	4648	2108	44.62	20.24	36.25	16.44	4.65	2.11	4.65	2.11	2.3	1.0
JT9D-70 P&W TF	Idle	1800	816.5	61.20	27.76	5.76	2.61	12.24	0.55	1.80	0.82	(assume JT9D-7 data)	
	Takeoff	19380	8791	3.88	1.76	600.8	272.5	2.91	1.32	19.38	8.79		
	Climbout	15980	7248	4.79	2.17	386.7	175.4	2.40	1.09	15.98	7.25		
	Approach	5850	2654	7.61	3.45	47.39	21.50	2.63	1.19	5.85	2.65		
JT15D-1 PWC TF	Idle	215	97.52	19.46	8.83	0.54	0.245	7.48	3.39	0.22	0.10		
	Takeoff	1405	637.3	1.41	0.640	14.19	6.44	0	0	1.41	0.64		
	Climbout	1247	565.6	1.25	0.567	11.35	5.15	0	0	1.25	0.57		
	Approach	481	218.2	11.45	5.19	2.45	1.11	1.59	0.721	0.48	0.22		
PT6A-27 PWC TP	Idle	115	52.16	7.36	3.34	0.28	0.127	5.77	2.62	0.12	0.05		
	Takeoff	425	192.8	0.43	0.195	3.32	1.51	0	0	0.43	0.19		
	Climbout	400	181.4	0.48	0.218	2.80	1.27	0	0	0.40	0.18		
	Approach	215	97.52	4.95	2.24	1.80	0.816	0.47	0.213	0.22	0.10		
PT6A-41 PWC TP	Idle	147	66.63	16.95	7.69	0.29	0.132	14.94	6.78	0.15	0.07		
	Takeoff	510	231.3	2.60	1.18	4.07	1.85	0.89	0.404	0.51	0.23		
	Climbout	473	214.6	3.07	1.39	3.58	1.62	0.96	0.435	0.47	0.21		
	Approach	273	123.8	9.50	4.31	1.27	0.576	6.20	2.81	0.27	0.12		
Spey 555-15[i] RR TF	Idle	915	415	83.2	37.7	1.6	0.7	86.0	43.5	0.92	0.42		
	Takeoff	5734	2600	6.5	3.0	109.2	49.5	29.5	13.4	5.73	2.60		
	Climbout	4677	2121	0.0	0.0	68.7	31.2	2.5	1.1	4.68	2.12		
	Approach	1744	791	34.8	15.8	10.2	4.6	14.3	6.5	1.74	0.79		
Spey MK511[g,i] RR TF (1-11-400)	Idle	946	429.1	104.4	47.36	0.785	0.356	80.03	36.30	0.95	0.43	0.17	0.077
	Takeoff	7057	3201	16.16	7.33	156.7	71.08	13.97	6.34	7.06	3.20	16.0	7.3
	Climbout	5752	2609	0.0	0.0	116.8	52.98	0.0	0.0	5.75	2.61	10.0	4.5
	Approach	2204	999.7	48.71	22.09	16.00	7.26	20.56	9.33	2.20	1.00	1.5	0.68
M45H-01[i] RR (Bristol) TF	Idle	366	166.0	55.63	25.23	0.622	0.282	11.53	5.23	0.37	0.17		
	Takeoff	3590	1628	7.18	3.26	32.31	14.66	0.718	0.326	3.59	1.62		
	Climbout	3160	1433	9.48	4.30	25.28	11.47	0.632	0.287	3.16	1.43		
	Approach	1067	484.0	53.56	24.29	3.57	1.62	6.61	3.00	1.07	0.48		

g, h: smokeless engine

Table II-1-3. TYPICAL DURATION FOR CIVIL LTO CYCLES AT LARGE CONGESTED METROPOLITAN AIRPORTS[a]

ircraft	Mode					
	Taxi/ Idle out	Takeoff	Climbout	Approach	Taxi/ Idle in	Total
ommercial carrier						
Jumbo, long and medium range jet[b]	19.0	0.7	2.2	4.0	7.0	32.9
Turboprop[c]	19.0	0.5	2.5	4.5	7.0	33.5
Transport-piston	6.5	0.6	5.0	4.6	6.5	23.2
General aviation						
Business jet	6.5	0.4	0.5	1.6	6.5	15.5
Turboprop[c]	19.0	0.5	2.5	4.5	7.0	33.5
Piston[d]	12.0	0.3	5.0	6.0	4.0	27.3
Helicopter	3.5	-	6.5	6.5	3.5	20.0

[a]Reference 3. Data given in minutes.
[b]Same times as EPA Classes T2, T3 and T4 (Note b, Table II-1-5).
[c]Same times as EPA Classes T1 and P2 (Note b, Table II-1-5).
[d]Same times as EPA Class P1 (Note b, Table II-1-5).