Addressing Community Health Concerns Around SeaTac Airport:

Second Report on the Work Plan Proposed in August 1998

December 1999

Washington State Department of Health
Public Health – Seattle & King County
Community Representatives

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Background

In response to community concerns about health around SeaTac International Airport, Senator Julia Patterson arranged meetings with community residents, the Washington State Department of Health (DOH), Public Health – Seattle & King County (PHSKC) and other interested parties. As a result of these meetings and preliminary DOH findings related to glioblastoma rates in an area approximately three miles around the airport, Senator Patterson requested that DOH work with the PHSKC and the community to develop a work plan addressing the community's concerns.

Community representatives presented a list of 18 questions they wanted addressed in the work plan. The work plan was divided into two phases. Phase 1 activities addressed ten of the questions. Answers to the questions in Phase 1 are necessary in determining the value and feasibility of proceeding to the remaining questions included in Phase 2.

DOH and PHSKC issued a progress report in February 1999 that included full reports for questions 1, 2, 7, 8 and 10 (part 1). This document contains

- summaries for questions 1, 2, 7, 8 and 10 (part 1);
- full reports for questions for questions 3, 4, 5, and 6; and
- progress reports for questions 9 and 10 (part 2).

Summaries of Previous Reports and Reports for Questions Not Previously Answered

Questions One - Six: Descriptive Epidemiology

1. What types of cancer are the most prevalent in the proximity of the airport, and what are their risk factors?
2. Are rates of breast cancer elevated in the proximity of the airport?

The full report for answers to these questions was released in February 1999.

Summary: State health department researchers looked at the occurrence of more than 25 categories of cancer between 1992 and 1996 in areas within one mile, three miles and five miles of SeaTac Airport. We found that the 10 most prevalent cancers around the airport were consistent with the 10 most prevalent cancers in both King County and in Washington State as a whole. Findings regarding cancers of specific interest to SeaTac area residents were:

- Glioblastoma showed a statistically significant elevation in the three-mile zone around the airport. The elevation for the 1992 – 1996 time period was caused by the large number of cases diagnosed in 1992. The numbers of people diagnosed with glioblastoma from 1993 through 1996 were within expected range.

- All leukemia, including the specific category of acute myeloid leukemia (AML), was not elevated in any of the three areas around the airport.
- Breast cancer was not elevated in any of the three areas around the airport.

Table 1 from the February 1999 report describes the findings in more detail. We have provided that table in Attachment 1.

3. Do we know of all cases of glioblastoma in the proximity of the airport?
4. Can we confirm that all of the suspected cases of glioblastoma have been properly diagnosed as such?

As was recommended in the original work plan, we combined information from available registries and community reports to identify glioblastoma among people living or working in the area around SeaTac Airport. At a meeting on August 10, 1998, we agreed to include people who were diagnosed with glioblastoma in 1985 or later and who lived within three miles of the airport at the time of diagnosis. We also agreed to include people with glioblastoma who lived in the 1990-1993 buyout area whether or not they were living there at the time of diagnosis. We agreed to try to identify cases among people who worked at SeaTac Airport.

In assessing cancer in a community, it is standard epidemiologic practice to exclude people who have been diagnosed after leaving the community. There are several reasons for this practice.

- Depending on how long ago the person moved and the interval between exposure and disease, the exposure may not have caused the cancer.[1] For, example, if a specific type of cancer becomes apparent two years after an exposure and the person moved away five years ago, the exposure would not have caused the cancer.
- If we add people who were diagnosed within a certain time period after moving from the community, we need to exclude people who were diagnosed in the community, but had not lived there for a certain length of time. This requires special study, since our databases do not have length of time at residence of diagnosis.
- The population at risk (i.e., the population used to estimate the rate or the expected number of cases) is estimated for the number of permanent residents. If we add people who have moved away to the number of observed cases or the rate for the area, we would also need to add people who moved away to the estimate of the area's population. We have no way of doing this. Why not?

Despite this common practice, we agreed to include people who had lived in the SeaTac buyout area even if they were diagnosed after having moved. Our reason for including people from the buyout area was that had the buyout not occurred, many of the people

[1] For any disease, there is a lag between an exposure and the development of disease. For most infectious diseases, the time period is relatively short, such as days or weeks. For most types of cancer, the interval is relatively long, such as several years to several decades. The time period for the development of glioblastoma is unknown.

would have continued living near SeaTac Airport and so the moves did not represent the normal movement of a population. Additionally, an analysis of the population estimates for the area around SeaTac Airport did not indicate that people from the buyout area were excluded after 1993. Therefore, the people in the buyout area continued to be counted in the population used in determining how many people would get glioblastoma if rates around the airport were the same as in King County or Washington State.

How strange

We confirmed many of the community's reports. These reports did not identify additional people with glioblastoma who were diagnosed while they lived in the SeaTac Airport area. There were three people diagnosed with glioblastoma after they moved from the SeaTac Airport area. We did not include these people in our analyses for reasons described above. However, the addition of these people in the analyses for questions 1, 5, and 6 would not change the findings.

Why not? 3 more cases of GB

Our follow-up with people living in the 1990-1993 buyout area revealed one person with glioblastoma who was not living in the SeaTac Airport area at the time of diagnosis. Since this person was identified before the February 1999 report, the person was included in the analyses for question 1 presented as part of the February report. The person is also included in the analyses for questions 5 and 6 described below. The two other people with glioblastoma from the buyout area were identified in the cancer registries as living in the buyout area at the time of diagnosis and so they were also included in the analyses for the year in which they were diagnosed.

6 cases altogether from the buyout area 2400 households

Details of our findings are presented below.

Community Reports

We received 34 reports of suspected cases of glioblastoma and other brain tumors from the community, including individuals who called the Washington State Department of Health and lists compiled by KIRO TV and by community members. Table 1 summarizes these reports.

We were able to confirm 16 of the reports as malignant brain tumors through the Washington State Cancer Registry (WSCR) or the Fred Hutchinson Cancer Research Center's Cancer Surveillance System (CSS).

- Eleven people were diagnosed when they lived in the SeaTac area.
  - ✓ Ten of these people were diagnosed before 1992 or after 1996 and so they were not included in the analyses described for question 1 above. The person diagnosed in 1996 was included in the analysis for question 1.
  - ✓ The person diagnosed in 1996 and two people diagnosed in 1997 are included in the analyses for questions 5 and 6 below.
  - ✓ The people with glioblastoma diagnosed before 1992 are included in the analyses described for question 6 below.

Table 1. Community Reports of Brain Tumors

		Included as SeaTac area resident in analyses for questions:		
Number (%)	Status	1 (above)	5 (below)	6 (below)
16 (47%)	Confirmed as brain cancer by WSCR or CSS			
11	**In SeaTac area at time of diagnosis**			
	3 glioblastoma before 1992	NE[1]	NE	**yes**
	1 glioblastoma in 1996	**yes**	**yes**	**yes**
	2 glioblastoma in 1997	NE	**yes**	**yes**
	3 glioblastoma in 1998	NE	NE	NE
	2 other brain cancer in 1997	NE	NE	NE
5	**Not in SeaTac area at time of diagnosis and not from buyout area**			
	3 glioblastomas (1989, 1994, 1997)	**no***	**no***	**no***
	2 astrocytoma (1991, 1993)	**no***	NE	NE
7 (21%)	Confirmed as non-brain cancer by WSCR or CSS			
	3 diagnosed between 1992-1996	**yes**	NE	NE
	4 diagnosed before 1992 or after 1996	NE	NE	NE
3 (9%)	Possible or confirmed benign brain tumor	NE	NE	NE
7 (21%)	Unable to confirm by WSCR, CSS or death certificate			
	4 names not provided	UE[2]	UE	UE
	3 names not found in databases	UE	UE	UE
1 (3%)	Suspected non brain cancer, 1990[3]	NE	NE	NE
Total: 34				

[1] NE indicates the people were **not eligible** to be included in the analysis either because of the date of diagnosis or the type of cancer.

[2] UE **(unknown eligibility)** indicates that we do not know whether the people were eligible to be included in the analyses.

[3] Reported by neighbor as brain cancer, reported by family member as pancreatic cancer.

* Inclusion of these cases would not alter the conclusions.

- Five people were diagnosed with brain cancer after they moved from the area and we have no record of these people living in the buyout area. While they were not included in the SeaTac area for the analyses for questions 1, 5 and 6, the addition of these people would not alter the conclusions drawn from these analyses. The three people with glioblastoma were diagnosed in 1989, 1994 and 1997.
  - ✓ Question 1: The person diagnosed in 1994 lived in the three-mile zone. Since the observed number of glioblastomas in that area was already more than expected, the addition of one person increases the expected number, but does not change the conclusion. This person would also be added to the five-mile zone. The addition of another person to the five-mile zone does not alter the conclusion. The people diagnosed in 1989 and 1997 would not be included in the analyses for question 1, since the time period covered in question 1 was 1992–1996.
  - ✓ Question 5: The geospatial analysis presented below includes people diagnosed between 1992–1997. The person diagnosed with glioblastoma in 1994 lived in the area north of the airport. The person diagnosed in 1997 lived in the area west of the airport. As can be seen from table 3 on page 8, adding

one person to the areas north and west of the airport does not change the conclusions of the geospatial analysis.

- ✓ Question 6: The people diagnosed with glioblastoma in 1989 and 1994 lived in the three-mile zone. The person diagnosed in 1997 lived in the one-mile zone. The addition of these people in the appropriate years to the charts in figures 3-14, beginning on page 12, does not change the findings.

Using information from WSCR and CSS, we confirmed that seven people who were reported as having brain cancer had a different type of cancer. Because several types of cancer may spread to the brain, it is not unusual that some brain cancers reported by the community are not primary brain tumors. A variety of cancers were reported, including three lymphomas (two non-Hodgkin's, one Hodgkin's), two lung cancers, one cancer of the nasopharnyx, and one cancer of the meninges. Three of these cancers occurred in the 1992 – 1996 time period among people living in the SeaTac area at the time of diagnosis and so these people were included in the analyses conducted for question 1. The remaining four people were diagnosed before 1992 or after 1996 and so they were not included in the analyses.

We confirmed one of three reports of benign brain tumors.[2] Since the cancer registries do not have complete reporting of benign brain tumors, we would need to look at medical records to confirm the other two reports. Some cancer experts believe that benign brain tumors have the same causes as malignant brain tumors. However, since benign brain tumors are not completely reported to the cancer registries, we cannot include benign brain tumors in our analysis of brain cancer. Therefore, we do not plan to request medical records to confirm these diagnoses.

We have been unable to find information for seven people.

- There were four reports of brain tumors from one person who was unable to provide names. We were unable to get names or additional information about the specific type of cancer, date of diagnosis or address at diagnosis.
- For the remaining three reports,
  - ✓ One person was reported as being diagnosed in 1998 and one in 1997. Both of these people were reported as being alive. One explanation for our inability to confirm these diagnoses using the cancer registries is that the people have benign brain tumors[2] that are not recorded in the registries. Both of the reports were of "brain tumors" and did not specify glioblastoma or other types of malignant tumors.
  - ✓ The date of diagnosis was not reported for one person whom a neighbor reported as having died in 1990. Although we do not have Washington specific data, studies have shown that death registration in the US is more than

[2] The term "benign brain tumor" indicates that the tumor results from growth of non-malignant cells. Although the cells are not considered cancer, the growth of "benign" tumors in the brain is usually life-threatening.

99% complete.[3] Our inability to find this person's death certificate is most likely because we have an incorrect name.

One person, who was reported by a neighbor as having brain cancer, was reported in the buyout reports (see below) as having a different type of cancer. While we were not able to confirm cancer for this person, we suspect that the person had the type of cancer indicated in the buyout report. The cancer may have spread to the brain. This person was not included in the analyses for questions 1, 5 and 6.

Buyout Area

We tried to find people with cancer among those who left the SeaTac Airport area between 1990 - 1993 during the buyout by the Port of Seattle. The 1990–1993 buyout included 92 residential properties. In September 1998, we sent packets to people who had lived in the buyout area using address information provided by community members. The packets included a letter explaining why we were contacting them, forms requesting information on the number of people who had lived in the house and whether any of those people had cancer, and a postage-paid return envelope. In November 1998, we sent another letter requesting the same information to those who had not responded to our first mailing. In April and May of 1999, we made two phone attempts to reach all the households for which we had phone numbers. Table 2 summarizes the results.

Table 2. Reports from residents in 1990-1993 buyout area.

Number	Result
92 properties	
52	unable to contact
40	report on 127 household members
127 people	
114	no reported cancer
13	reports of cancer
13 cancer reports	
3	glioblastoma: all included in analyses
10	other types of cancer, not included in analyses

We received information from 40 households, representing 43% of the number of properties in the buyout area. The 40 households reported for 123 household members, of whom 13 were reported to have had cancer since 1985. Three of these cancers were glioblastoma. Two of the people were diagnosed when they lived in the buyout area. They were also in the cancer registries and so they were included as SeaTac area residents in the analyses for questions 1, 5 and 6, depending on the date of diagnosis. One person was diagnosed after moving from the buyout area. This

[3] National Center for Health Statistics. Vital statistics of the United States, vol II, mortality, part A. Washington: Public Health Sevice. 1996.

person was added to the data from the cancer registries and was included as a SeaTac area resident for the analyses in questions 1, 5 and 6.

Of the remaining ten people reported as having lived in the buyout area and having been diagnosed with cancer in 1985 or later, there were two reports of breast cancer, two reports of colorectal cancer and two reports of skin cancer (one specified as melanoma). No other type of cancer was reported more than once. Since the conclusions related to questions 1 and 2 would not change if we added these people as SeaTac area residents, we did not attempt to confirm these diagnoses.

We did not receive information for 52 (57%) of the households. For 43 of these households, we had insufficient contact information (for example, the initial list contained no address or phone; mail was returned as undeliverable; phones were disconnected.) Nine of these households seemed to receive the packets in that they were not returned by the post office, but no one returned a questionnaire or responded to two telephone calls.

Employment at SeaTac Airport

As was reported at the February 1999 meeting, in November 1998, we sent letters to 111 businesses located around SeaTac Airport. The letter asked for information regarding cancer among employees from 1985 until the present. We received responses from 15 (14%) businesses. Given the poor response rate, we did not continue trying to ascertain cases of cancer among employees at SeaTac Airport. Rather, we recommended that businesses or employees with specific concerns contact the Washington State Department of Labor and Industries at 360-902-5800 to file a complaint or request consultation. They could also contact the National Institute for Occupational Safety and Health (NIOSH) at 800-356-4674 for information on the Health Hazard Evaluation Program or to speak to a technical representative.

5. Are incidence rates of glioblastoma elevated in the area west of the airport?

We used several geo-spatial analytical techniques to answer this question. The different methods consistently identified the area south of SeaTac Airport as an area with slightly elevated rates of glioblastoma compared to King County. The areas west, north and east of the airport did not have elevated rates compared to King County. Detail on two of the analyses is provided below.

The following map (figure 1) shows the area around SeaTac Airport divided into four sectors: north, south, east and west. The dots represent where people lived who were diagnosed with glioblastoma between 1992 and 1997. To protect confidentiality, the dots are within ½ mile of the person's residence. However, no dots have been moved from one sector to another.

Figure 1. Approximate location of people with glioblastoma within five miles of SeaTac Airport, 1992-1997.

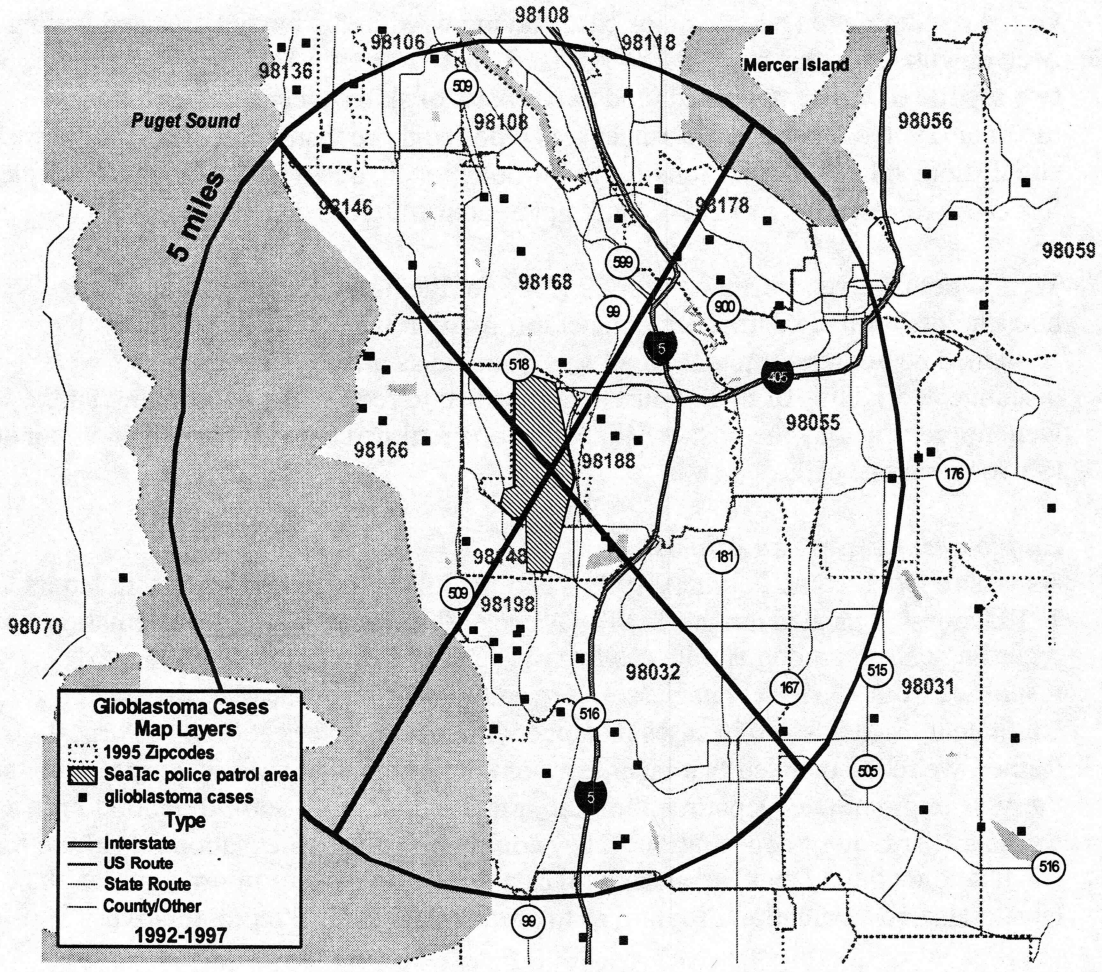

Table 3 shows the number of people diagnosed with glioblastoma between 1992 and 1997 in each sector and the number of people expected to be diagnosed if the rate of glioblastoma in the sector was the same as the rate in King County and the same as the rate in Washington State.

Table 3. Geospatial analysis, 1992-1997.

Sector	People diagnosed with glioblastoma		
	Observed	Expected-King	Expected-State
North	13	18.07	16.01
South	17*	9.80	8.87
East	11	12.50	11.05
West	7	8.06	7.19

*statistically significantly more people with glioblastoma than expected ($p < 0.05$)

To calculate the expected number of cases for each sector, we multiplied the number of people in a specific age range and sex category in the sector by the rate of glioblastoma for the same age range and sex category in King County or Washington. In developing the rates for King County and Washington, we did not include the area around SeaTac Airport. We then added the results for all the age and sex categories together to get the total number of expected cases.

As can be seen from Table 3, in the sector south of the airport, there were 17 cases of glioblastoma, compared to an expected number of less than 10. This results in a statistically significant elevation in people diagnosed with glioblastoma between 1992 and 1997 in the area south of the airport. (As an estimate of statistical significance, we developed a 95% Poisson confidence interval around the observed number of cases. Generally, if the confidence interval does not include the expected number of cases, we conclude that the observed is statistically significantly different from the expected.[4] In this case, the confidence interval around the 17 observed cases is 9.90 – 27.22. Since the confidence interval does not include the expected number of cases, we conclude that the elevation is statistically significant.) No single year accounts for the elevation.

A second geospatial analysis utilized SaTScan software developed by the National Cancer Institute.[5] This software develops an almost infinite number of distinct geographical circles, each being a potential candidate for a cluster. The large number of circles is developed by varying the size of each circle around a center point (usually referred to as a centroid). By varying the size of the circles and combining circles around different center points, the program seeks to maximize the probability of finding clusters. SaTScan can adjust for a number of factors in determining whether a cluster exists.

For this analysis, we used the center of each census block and census block group in King County and adjusted for age. As can be seen from figure 2, the area south of the airport was identified as an area where the number of people with glioblastoma was higher than expected, with the expected number based on the overall rate in King County. However, using this technique, the elevation was not statistically significant. SaTScan did not identify other areas around SeaTac Airport as having more glioblastoma than expected.

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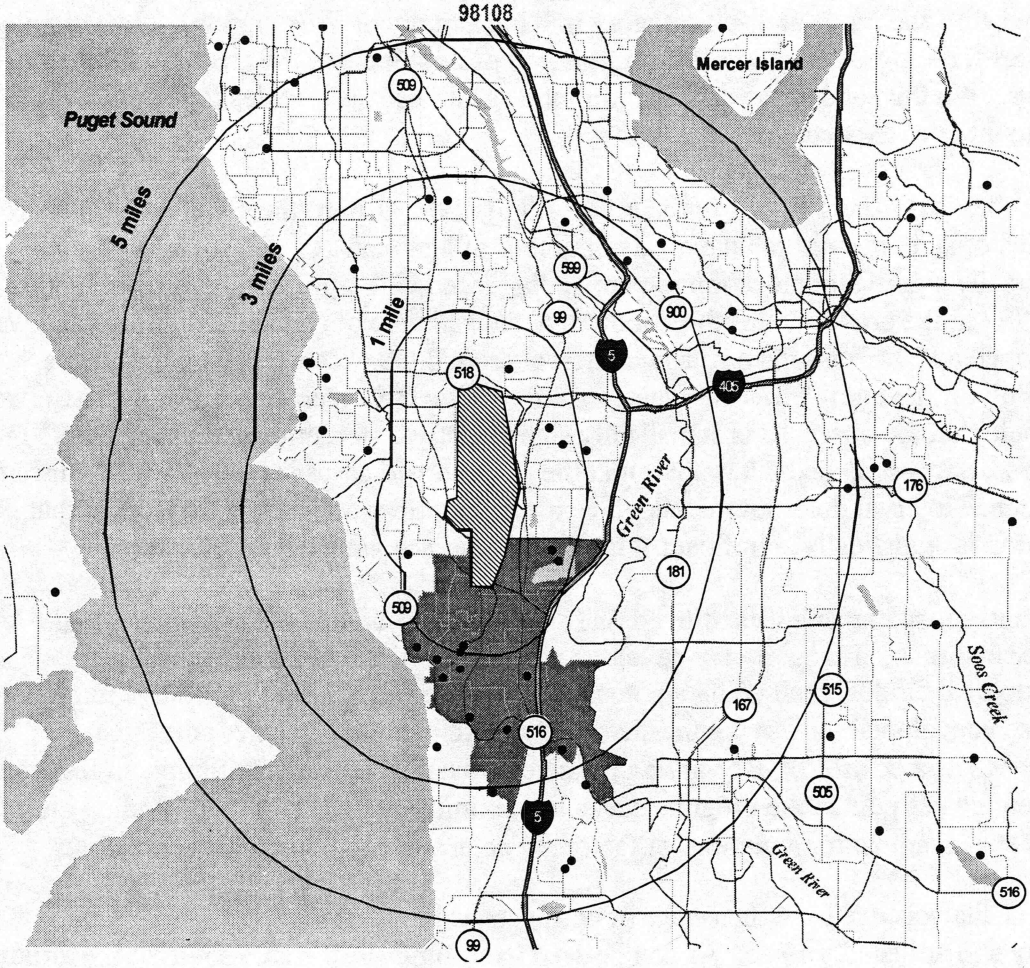
[4] Breslow NE and Day NE. *Statistical Methods in Cancer Research: Volume II – The Design and Analysis of Cohort Studies.* Oxford University Press: New York, NY, 1987.

[5] Kulldorff M. A spatial scan statistic. *Communications in Statistics: Theory and Methods, 26*: 1481-1496, 1997.

Figure 2. Areas identified as having a non-statistically significant elevation in the number of people with glioblastoma using SaTScan software.



6. Is this elevation in glioblastoma incidence rates continuing presently, or did it only occur in the past?

The February 1999 report provided information on glioblastoma for 1992 – 1996. Information presented in that report indicated that the elevated rate of glioblastoma in the area three miles around SeaTac Airport was caused by a high number of cases in 1992. In conjunction with answering the question about whether the elevation is continuing or occurred only in the past, the community asked that we look at information from 1985 – 1991 and for years after 1996. As the figures below indicate, there are not elevations in the number of people with glioblastoma in the area around SeaTac Airport for years before or after 1992. In all analyses, the elevation is seen only in 1992 for the area within three miles of the airport.

We obtained data on the incidence of glioblastoma from the Fred Hutchinson Cancer Research Center, Cancer Surveillance System (CSS) for people diagnosed between 1974 and 1991. We obtained similar data from the Washington State Cancer Registry for 1992-1997. We used the data from these two sources and we added one person identified with glioblastoma who had previously lived in the 1990-1993 buyout area (see questions 3 and 4) to prepare four sets of graphs showing the observed and expected number of people with glioblastoma for each year.

To calculate the expected number of cases, we developed rates of glioblastoma for three comparison groups: King County, Washington State, and the 13 counties in northwest Washington that are included in CSS. In determining the rates for the comparison groups, we excluded the area around SeaTac Airport. We multiplied the population in a specific age range and sex category in the SeaTac Airport area by the rate of glioblastoma for the same age range and sex category in the comparison groups. We then added the results for all the age and sex categories together to get a total number of expected cases.

Figures 3-8 below show the observed and expected number of people with glioblastoma for 1985-1995. For figures 3-5, we based expected rates on the rates in King County. For figures 6-8, we based the expected rates on the rates for the 13 northwestern counties included in CSS. Since we do not have statewide data before 1992, we could not use Washington State as a comparison group in these analyses.

- We could not obtain reliable population data before 1990. Therefore, for these analyses, we used the 1990 population of the SeaTac Airport area as the basis for calculating expected numbers for each year from 1985 – 1995. 1990 is the mid-point of the time period and all years are within 5 years of 1990. If the population in the SeaTac Airport area has been growing, this method will overestimate the expected number of people with glioblastoma before 1990 and underestimate the expected number of people with glioblastoma after 1990.
- Information on the number of people with glioblastoma from 1985-1991 is from the Fred Hutchinson Cancer Research Center's (FHCRC) Cancer Surveillance System. FHCRC has policies and procedures to assure that they maintain the confidentiality of the people in their database. To comply with these procedures and to receive the data in a timely fashion, we obtained the data by census tract, rather than exact address. Therefore, in figures 3-8, the boundaries for the area around SeaTac are approximated using census tracts.

Figure 3. Observed number of people with glioblastoma within **one mile** of SeaTac Airport and expected number based on rates in **King County.**

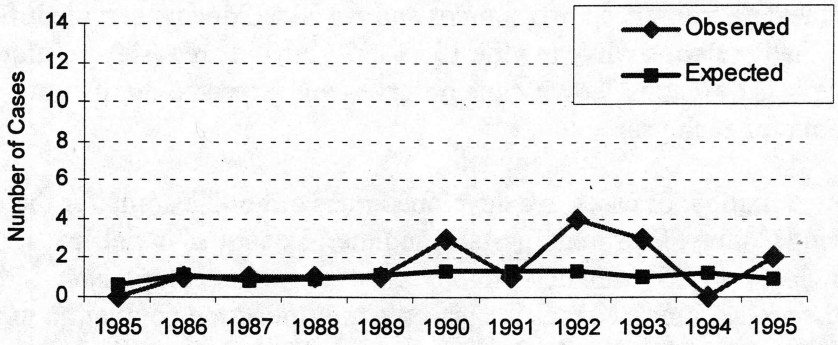
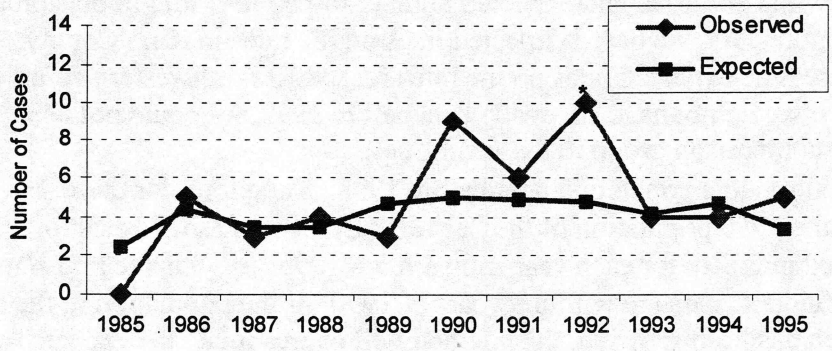


Figure 4. Observed number of people with glioblastoma within **three miles** of SeaTac Airport and expected number based on rates in **King County.**



* Statistically significant elevation in the number of cases ($p \leq 0.05$)

Figure 5. Observed number of people with glioblastoma within **five miles** of SeaTac Airport and expected number based on rates in **King County.**

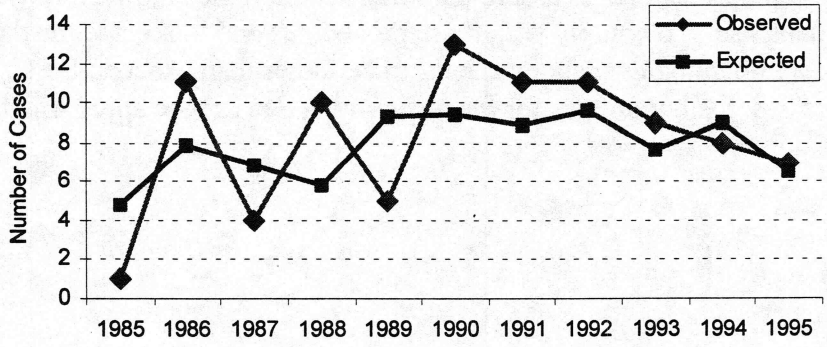


Figure 6. Observed number of people with glioblastoma within **one mile** of SeaTac Airport and expected number based on rates in **13 counties in Northwest Washington.**

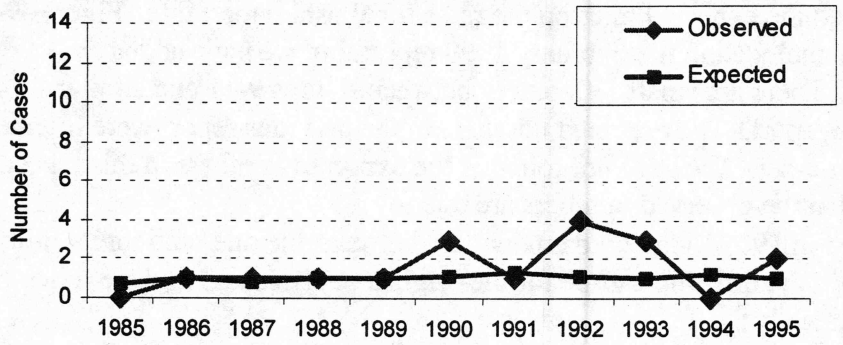
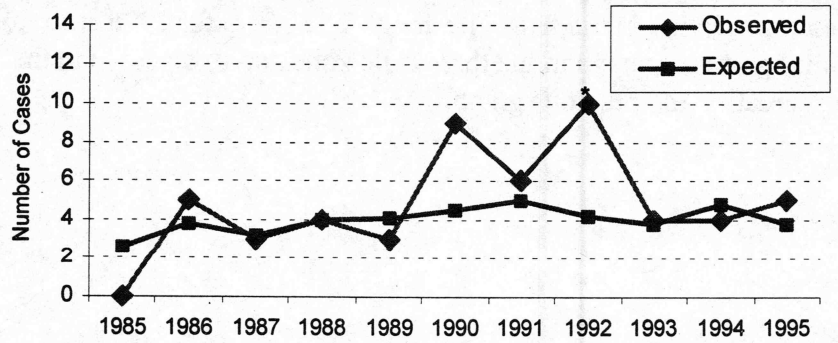
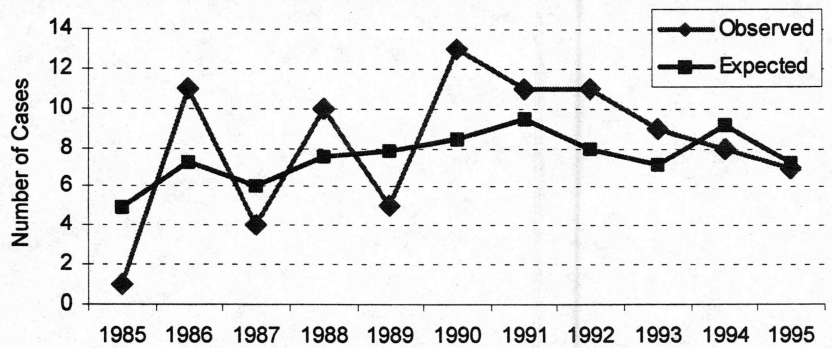


Figure 7. Observed number of people with glioblastoma within **three miles** of SeaTac Airport and expected number based on rates in **13 counties in Northwest Washington.**



* Statistically significant elevation in the number of cases ($p \leq 0.05$)

Figure 8. Observed number of people with glioblastoma within **five miles** of SeaTac Airport and expected number based on rates in **13 counties in Northwest Washington.**



Figures 9-14 show the observed and expected number of people with glioblastoma for 1992-1997. For figures 9-11, we based expected rates on the rates in King County. For figures 12-14, we based the expected rates on the rates for Washington State. Figures 9-11 are similar to those included in the February 1999 report, but we have added information for 1997. There are small differences between figures 9-11 and similar graphs in the previous report. The expected numbers in the previous report were rounded to the nearest whole number. We have not rounded the expected numbers in this report. The small differences in the observed numbers are due to

- a person diagnosed in 1995 living on the boundary between the one- and three- mile zones was placed in the three-mile zone for the original analysis and the one-mile zone in the current analysis;
- a person diagnosed in 1994 living on the boundary of the three- and five-mile zones was placed in the five-mile zone for the original analysis and the three-mile zone in the current analysis; and
- errors in the original analysis affecting the observed number of people with glioblastoma for 1993 and 1996. The error for 1993 resulted from the omission from the database of one person living in the five-mile zone. The errors for 1996 seem to reflect an undercounting of one person in the three-mile zone and two people in the five-mile zone when creating the previous graph.

Figure 9. Observed number of people with glioblastoma within **one mile** of SeaTac Airport and expected number based on rates in **King County.**

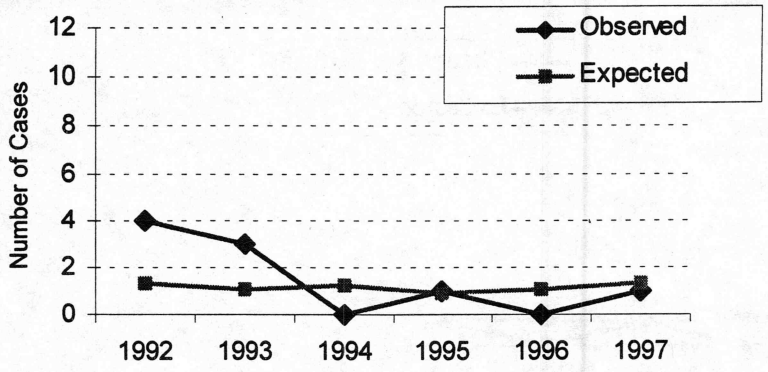
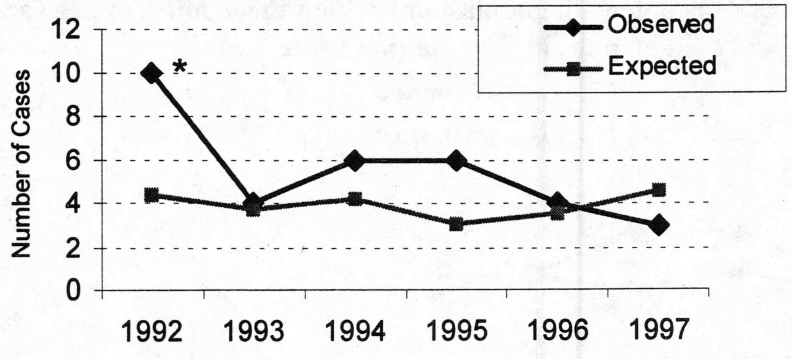


Figure 10. Observed number of people with glioblastoma within **three miles** of SeaTac Airport and expected number based on rates in **King County.**



* Statistically significant elevation in the number of cases ($p \leq 0.05$)

Figure 11. Observed number of people with glioblastoma within **five miles** of SeaTac Airport and expected number based on rates in **King County.**

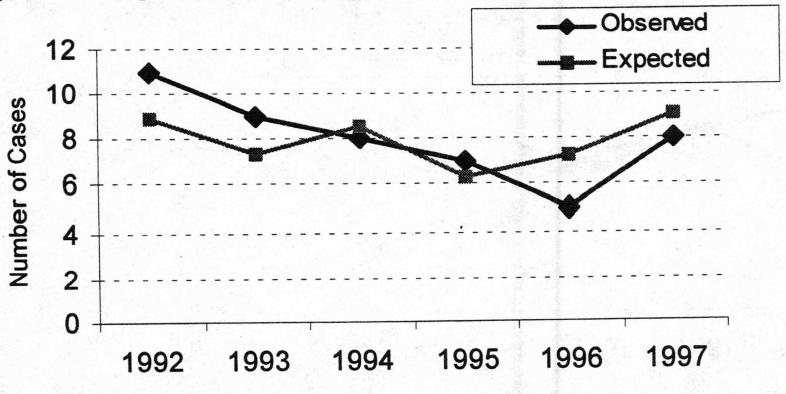


Figure 12. Observed number of people with glioblastoma within **one mile** of SeaTac Airport and expected number based on rates in **Washington State.**

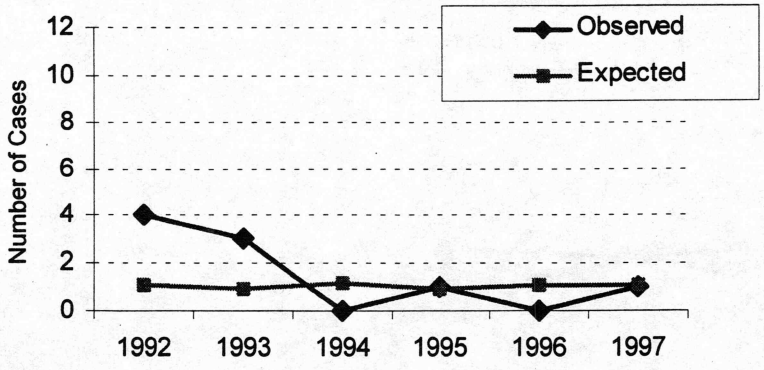
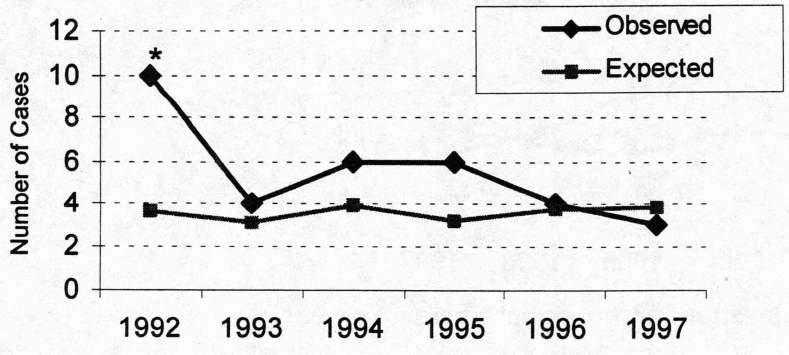


Figure 13. Observed number of people with glioblastoma within **three miles** of SeaTac Airport and expected number based on rates in **Washington State.**



* Statistically significant elevation in the number of cases ($p \leq 0.05$)

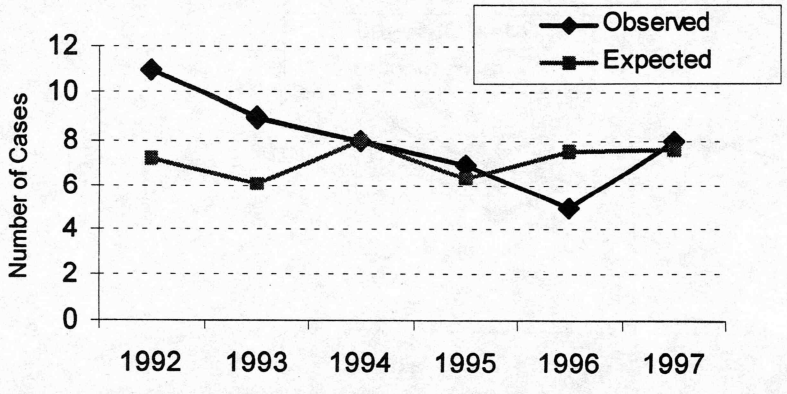


Figure 14. *Observed number of people with glioblastoma within* ***five miles*** *of SeaTac Airport and expected number based on rates in* ***Washington State.***

Questions Seven and Eight: Literature Review

7. What are the risk factors for glioblastoma?

The full report for this question was released in February 1999.

Summary: An extensive review of the scientific literature related to environmental causes of glioblastoma found that no proven risk factors for this disease in people have been identified. There are relatively few studies focusing on causes of glioblastoma, but some studies have evaluated environmental and occupational risk factors. Those factors include employment in the petrochemical industry, agriculture and at airfields. Most of these studies were designed to generate questions for further research. At this time, there is a consensus among researchers that causal factors for glioblastoma in people have not yet been found.

8. What are the chemicals in jet engine exhaust emissions and what happens to them after they are emitted?

The full report for this question was released in February 1999. We are continuing to investigate whether there are chemicals or ratios of chemicals unique to jet engine emissions. Although outside the original scope of this question, we are also investigating whether there are chemicals or ratios of chemicals unique to evaporation or release of unburned fuel, since these products may contribute to air pollution around the airport.

Summary: To date, we have not identified published studies in which pollutants unique to aircraft emissions have been identified. Cars and trucks emit the same pollutants as airplanes. The following are the major emission products released from the evaporation of jet fuel or emitted from jet aircraft engines. This list names general classes of compounds. Within a given class, there are numerous chemicals. The general classes and examples of specific chemicals are:

- **Inorganic gases**, including carbon monoxide (CO), carbon dioxide (CO_2) and nitrogen oxides (NO, NO_2, NO_X);
- **Volatile Organic Compounds (VOCs)**, including hydrocarbon compounds such as alkanes, cycloalkanes, alkenes and aromatic hydrocarbons, which include compounds such as pentane, butane, acetylene, naphthalene, 1,3-butadiene, benzene, toluene, and xylene;
- **Oxygenated organics** including a variety of carbonyl compounds such as aldehydes which include compounds such as formaldehyde and acetaldehyde; and
- **Aromatic hydrocarbons**, including polycyclic aromatic hydrocarbons (PAHs), such as benzo(a)pyrene, chrysene, benzo(a)anthracene, and fluoranthene.

At this point, we have a limited understanding of what happens to these products after emission or evaporation. For example, we know that they contribute to the formation of ozone, generally in areas east of and somewhat distant from the airport. We know that the area adjacent to the airport has higher levels of these pollutants on low or no wind

days compared to days with high wind. We may gain a better understanding of what happens to these pollutants through answering question 9 below.

Questions Nine and Ten: Potential Field Studies

9. Is it possible to monitor jet engine exhaust emissions, or to model their path using data on prevailing winds and takeoff patterns?

As indicated in the February 1999 report, DOH collected and initiated a review of studies relevant to health and air quality issues at or near SeaTac International Airport. To assist in this review, help answer questions regarding air quality, and recommend methods and procedures for possible future studies, DOH convened an advisory committee. The committee includes representatives from the SeaTac Airport community and experts from state and local agencies and institutions, including Washington State Department of Health, Washington State Department of Ecology, Public Health – Seattle & King County, Puget Sound Clean Air Agency, and the University of Washington. We have also talked with a representative from the US Environmental Protection Agency.

We are currently focusing on the six studies, five of which are summarized below. The sixth study involves residue sampling by Puget Sound Clean Air Agency and follow-up sampling by the Port of Seattle. This study was cited in the second study summarized below. We need to obtain the original documents before commenting on the findings. We believe this work may be relevant to the community's concern about black residues that are found in the environment around the airport.

We are aware of two studies from the 1970s (Air Pollution by Jet Aircraft at SeaTac Airport. Department of Commerce 1970 and ESL Incorporated SeaTac Air Quality – Final report ESL-ET59, June 28,1973). The group did not review these studies, since these studies most likely do not reflect current conditions.

Below, we have provided draft summaries of the five studies and preliminary conclusions about previous air monitoring around SeaTac Airport. We continue to have unanswered questions about several of the studies. We welcome questions and comments about the draft summaries and conclusions that follow.

- **SeaTac Airport Spatial Nitrogen Dioxide Study. Doug Urry and Tim Larson, University of Washington, 1999, (Unpublished)**
  This study assessed whether areas near SeaTac exceed the National Ambient Air Quality Standards (NAAQS) for nitrogen dioxide (NO_2); whether there are NO_2 concentration gradients in the SeaTac area; and whether aircraft operations impact local NO_2 concentrations. The researchers measured NO_2 using passive badge samplers. They sampled at 16 locations with the majority of the samplers placed north and south of the airport. They sampled continuously for an entire year. During the time period of the study, the average annual NO_2 level did not exceed the NAAQS; there were only small NO_2 concentration gradients (concentration levels

generally decreased with distance from the airport and from heavily trafficked areas, and from east to west); and NO_2 levels near the airport were highly affected by regional levels (i.e., NO_2 from many sources contributing to levels in a wider area) and did not differ greatly from concentrations measured in a separate study in other Seattle urban areas.[6] Overall, the data did not support the hypothesis that operations at SeaTac Airport significantly impact local NO_2 concentrations.

- **EIS – Master Plan Update Final and Final Supplemental Environmental Impact Statement. Port of Seattle/Department of Transportation (DOT)/Federal Aviation Agency (FAA), 1997.**
  The purpose of this study was to determine the impact of increased air traffic at SeaTac Airport on ambient air pollution. The study focused on three areas:
  - the development of an emissions inventory by using modeling to determine the sources and relative contribution of emissions from aircraft, road traffic and parking lot activities;
  - an area dispersion analysis to model the effect of pollutants related to airport activities on the area immediately around the airport; and
  - a roadway intersection dispersion analysis that modeled air pollution related to changes in traffic patterns and volumes over time.

  The emissions inventory modeling indicated that all aircraft emissions are expected to increase with increased air traffic. However, the modeling predicted that emissions increases related to additional air traffic would not exceed the levels allowed in the 1995 state implementation plan. The state implementation plan provides for implementation, maintenance, and enforcement of the NAAQS. The report states that the addition of a runway was expected to reduce emissions by 2005 and 2010 since an additional runway would lessen time currently spent queued up waiting to take off.

  The area dispersion analysis included pollutants from a broader range of airport activities than the emission inventory analysis. It also included a sampling study in which levels of particulate matter 10 microns in diameter (PM_{10}) and sulfur dioxide (SO_2) were measured. The area dispersion analysis concluded that increased activity at the airport would not create violations of the NAAQS.

  The roadway intersection modeling concluded that in a worst case scenario, four intersections near the airport would exceed the 8-hour caarbon monoxide (CO) NAAQS. However, current measured levels of CO were below those predicted by the model.

  This study looked only at criteria pollutants (i.e., those covered by the NAAQS) and did not model levels of volatile organic compounds (VOCs). Additionally, modeling is only accurate to the extent that the underlying assumptions are accurate. Since we

[6] Norris G and Larson T. Spatial and temporal measurements of NO_2 in an urban area using continuous mobile monitoring and passive samplers. *Journal of Exposure Analysis and Environmental Epidemiology* 9(6): 1-8, 1999.

do not have the resources to verify all of the assumptions, it is difficult for us to assess the accuracy of the predictions. We have not relied on this study as a primary source in drawing the conclusions stated below, except where the study included actual measurements of pollutants.

- **1996-1997 Carbon Monoxide Saturation Study Sea-Tac International Airport Area. Washington State Department of Ecology (WSDOE) ,1997.**
  This study evaluated the impacts of increasing population and traffic congestion on CO levels in the Puget Sound area. WSDOE sampled at 27 locations for 60 days during the winter of 1996-1997. They located portable bag samplers near major roadways and near intersections with high traffic density and poor atmospheric ventilation. Air was blown through the samplers for 8-hours at a time. The 8-hour level of CO in the SeaTac area did not exceed the NAAQS. The highest CO concentration was 7.2 parts per million (ppm). The 8-hour NAAQS is 9 ppm.

- **Air Quality Survey Sea-Tac International Airport. McCulley, Frick & Gillman, Inc., 1995.**
  This study looked at airborne toxic compounds and CO in the vicinity of SeaTac International Airport. Samples were collected during four late fall to early winter days in 1993 at locations within the airport operations area and outside the airport including, upwind of the airport, downwind of the airport, near International Boulevard, and at a residential location in Normandy Park. The sampling periods were selected to evaluate different meteorological conditions, which result in different modes of airport operations. CO levels were below the 8-hour NAAQS. VOC monitoring showed:
  - Mean concentrations of several VOCs were higher than acceptable source impact levels (acetaldehyde, formaldehyde, acrolein, benzene, carbon tetrachloride, 1,2-dichloroethane and dichloromethane). Acceptable source impact levels (ASILs) are screening levels that Department of Ecology, Puget Sound Clean Air Agency and other clean air agencies use in permitting new facilities. They are based on criteria intended to protect health. Because of the protective assumptions used to develop most ASILs, exceeding an ASIL does not necessarily indicate a health concern. However, ASIL analysis is chemical and facility specific and does not take into account the total exposure of individuals the area impacted by specific emissions.
  - Benzene was found in every sample collected. The highest levels were collected at Gate B3 and next to International Boulevard. The lowest levels. were observed at the residential location.
  - Monitoring could not discern significant differences in upwind versus downwind levels of VOCs. However, we do not know whether this would be true if more extensive sampling had been performed.
  - Levels of VOCs were within a range exhibited in other similarly sized urban areas. We would need to do additional research to interpret this finding. For example, we would need to understand how and where the measurements in the other urban areas were obtained.

- Chemicals or ratios of several key VOCs were indicative of automobile exhaust and did not resemble the VOC profiles associated with aircraft emissions. We are currently trying to determine how the authors arrived at this conclusion, since published studies indicate that there are no pollutants unique to aircraft emissions.

Because this study only collected samples on four days, we have not relied on this study as a primary source of information in drawing the conclusions summarized below.

- **Mobile Source Hazardous Air Pollutant Emissions in the Sea-Tac Urban Area. Radian Corp., 1994.**
  This study was contracted by the US Environmental Protection Agency and Puget Sound Clean Air Agency to develop a hazardous air pollutant (HAP) emissions inventory (mainly VOCs) for mobile polluters in the Seattle-Tacoma area. A HAP emissions inventory shows which hazardous pollutants and how much of each pollutant comes from each mobile source of pollution. Mobile polluters include on-road vehicles, aircraft and other non-road vehicles and equipment. The study concluded that on-road vehicles are a primary source of HAP emissions in the Seattle-Tacoma area. Results for aircraft indicate that they are not a significant area-wide source of HAP. However, airport facilities may be more significant contributors to overall HAP emissions in areas near these facilities. The study suggested the need for additional information on VOC emissions from aircraft.

The group has drawn preliminary conclusions based on the documents summarized above and their expertise in the area of air quality.

- Previous monitoring for CO (WDOE, 1997; Port of Seattle/DOT/FAA, 1997; Radian Corp, 1994) NO_2 (Urry and Larson, 1999; Port of Seattle/DOT/FAA, 1997), and PM_{10} (Port of Seattle/DOT/FAA, 1997) in the vicinity of the airport does not suggest the need for additional monitoring. Monitored levels of these pollutants did not exceed the NAAQS.
- There is not a compelling reason to monitor for SO_2 in the vicinity of the airport. One sampling study indicated that concentrations of SO_2 are below NAAQS (Port of Seattle/DOT/FAA, 1997). Airports are not significant sources of SO_2 and SO_2 levels in the Puget Sound area are generally well below the NAAQS. (Data on SO_2 measurement in the Puget Sound area are available through Puget Sound Clean Air Agency's annual Air Quality Data Summary. To request a copy contact Mary Hoffman at 206-689-4006.)
- There has not been monitoring for ozone (O_3) in the vicinity of the airport. O_3 develops from a reaction of nitrogen oxides (NO_x) and hydrocarbons. The reaction is facilitated by ultraviolet radiation from the sun. In areas where nitrogen oxide (NO) is present, such as urban areas with high traffic, O_3 is rapidly converted to NO_2 and oxygen. As NO_x drifts away from areas with relatively high NO, O_3 forms and is not converted to NO_2 and oxygen. Thus, in the Puget Sound region, the highest levels of O_3 are found well south and east of the major urban areas (personal communication, Dr. Tim Larson, University of Washington,

August 1999). This being the case, we do not feel that there is a compelling reason to monitor for O_3 in the vicinity of the airport.

- There has not been adequate monitoring for VOCs, such as benzene and 1,3 butadiene; carbonyl compounds, such formaldehyde and acrolein; polycyclic aromatic hydrocarbons (PAHs); or specific compounds within the PM class. EPA has identified these classes of compounds as major combustion and evaporation products associated with jet fuels (personal communication, John Williamson, Department Ecology, Seattle Air Toxics Monitoring Project, August 1999).
- We did not review documents that reported on monitoring of $PM_{2.5}$ in the vicinity of the airport. The group needs to determine whether there has been monitoring and if not, the group needs to determine whether there is a compelling reason to monitor $PM_{2.5}$ around the airport.

The group also noted that:

- Winds blow predominantly from either the north or the south and that airport operations and traffic patterns affect the air quality north, south and east of the airport.
- The airport sits relatively high compared to the surrounding area and therefore, pollutant concentrations tend to be fairly low when wind speeds are high.
- Poor air quality in the vicinity of the airport is most likely to develop on days with low wind speeds.

The group is continuing to meet to discuss the feasibility and utility of monitoring and/or modeling to determine the levels of pollutants for which we were unable to locate data. We had originally planned to make recommendations on the usefulness and feasibility of modeling or monitoring flight path emissions by December 1999. We now anticipate having preliminary recommendations by February 2000.

10. Are there other important health problems, such as respiratory disease, in this community, particularly in schools located under the flight path?

Part 1. Previously Collected Data

As a first step in answering this question, Public Health – Seattle & King County conducted a general community health assessment. The full report of this assessment was released in February 1999.

Summary: At the community's request, Public Health – Seattle & King County conducted a general community health assessment. A broad range of health outcomes, including deaths, hospitalizations, physician reports and behavioral risks were examined. In the following six bullets, all comparisons involve statistically significant differences between the SeaTac Airport Community and King County, except where noted in the data on adult smoking.

This assessment showed:

- Death rates for lung cancer and chronic obstructive pulmonary disease were higher in the SeaTac Airport community compared to King County as a whole.
- Hospital admissions for asthma, were elevated in all age groups.
- Hospital admissions for pneumonia and influenza were elevated for people less than age 65.
- AIDS incidence and mortality rates are decreasing and are lower than the rates for the county as a whole.
- Late entry into prenatal care as well as rates of smoking were more common among mothers giving birth in the SeaTac Airport community.
- There is no adult smoking data specifically for the SeaTac community. However, in 1995, the percent of adults in South County as a whole (including the SeaTac community) who were smokers was somewhat higher compared to King County (24% and 19%, respectively). This elevation, however, was not statistically significant.

Part 2. Field study

As noted in the original work plan, the usefulness of collecting new health data depends, in part, on information developed in answering question 9. Available data do not indicate high levels of US Environmental Protection Agency criteria pollutants (carbon monoxide, nitrogen oxides, ozone, particulate matter 10 microns in diameter, sulfur dioxide and lead) and there is not adequate information on other potential pollutants. Therefore, we cannot currently design a health study consistent with available air pollution data.

Attachment 1

Table 1. Cancer in the Proximity of SeaTac International Airport, 1992-1996

This table was originally included in the February 1999 report "Addressing Community Health Concerns around SeaTac Airport: Progress Report on the Work Plan Proposed in August 1998." As we explained in that report, the expected number of cases is the number of cases expected in the SeaTac Airport area if the rate around the airport is the same as the rate in King County or Washington State. To calculate the expected number of cases, we multiplied the population in a specific age range in the SeaTac Airport area by the rate of glioblastoma for the same age range in King County or Washington State. (Since the area around the airport is part of King County and comprises more than 10% of its population, we subtracted the SeaTac area of interest from both numerator and denominator in calculations of expected cases when using King County as the comparison group.) We then added the results for all the age ranges together and rounded to the nearest whole number to get a total number of expected cases.

Table 1. Cancer in the Proximity of SeaTac International Airport, 1992-1996									
	Area 1 = Within 1 Miles of Airport			Area 2 = Within 3 Miles of Airport			Area 3 = Within 5 Miles of Airport		
	Observed	Expected (County Rate)	Expected (State Rate)	Observed	Expected (County Rate)	Expected (State Rate)	Observed	Expected (County Rate)	Expected (State Rate)
All Cancer[1]	797	783	771	2,794	2,874	2,827	† 5,334	5,575	5,455
Bladder	32	32	33	117	123	127	217	238	244
Brain, All Types	15	11	11	48	39	37	73	79	73
Brain, All Gliomas	15	11	10	48	38	36	73	77	72
Brain, Astrocytomas	1	2	3	7	8	9	13	17	18
Brain, Glioblastomas	7	5	5	*** 28	19	18	37	38	34
Breast	134	142	134	490	510	480	† 889	1,005	930
Cervix	5	7	8	22	23	26	45	46	52
Colorectal	86	80	79	284	306	301	564	580	573
Endometrium	*** 39	22	23	93	82	83	167	158	160
Esophagus	9	8	8	34	28	28	62	53	54
Kidney / Renal	20	17	17	73	60	63	* 138	114	122
Larynx	9	6	7	* 34	23	25	*** 67	42	49
Leukemia, All Types	16	19	18	65	69	67	137	133	131
Leukemia, Acute Myeloid (AML)	3	5	5	19	19	17	40	36	33
Liver	6	6	5	** 27	20	17	** 50	38	33
Lung	*** 132	104	108	406	386	399	779	738	767
Lymphoma, Hodgkin's	6	6	5	16	20	17	30	42	35
Lymphoma, non-Hodgkin's	28	33	30	106	120	109	222	233	212
Melanoma	36	46	42	141	163	146	††† 242	330	286
Multiple Myeloma	5	8	8	24	31	31	57	58	59
Oral / Pharynx	** 29	20	19	82	74	68	140	144	131
Ovary	16	17	16	60	62	58	117	121	113
Pancreas	18	16	16	58	63	59	122	118	112
Prostate	99	113	119	†† 393	429	448	††† 762	827	860
Stomach	6	11	11	35	42	40	82	78	77
Testis	6	6	6	16	20	20	42	39	41
Thyroid	9	11	10	32	37	35	† 59	76	70
All Other Cancer Categories	60	66	63	238	240	230	451	469	445

* Higher than expected using King County rate
** Higher than expected using State rate
*** Higher than expected using both King County and State rates
† Lower than expected using King County rate
†† Lower than expected using State Rate
††† Lower than expected using both King County and State rates

[1] The totals of cancers broken into categories are greater than "All Cancer" because some individuals have multiple cancers. The "All Cancer" category counts only the total number of individuals with any type of cancer during the study period.