FAR PART 150 STUDY UPDATE

Seattle-Tacoma International Airport
Seattle, Washington

JULY 2002

The preparation of this document was financed in part through a planning grant from the Federal Aviation Administration (FAA) as provided under Section 505 of the Airport and Airway Improvement Act of 1982 as amended by the Airport and Airway Safety and Capacity Expansion Act of 1987. The contents do not necessarily reflect the official views or policy of the FAA. Acceptance of this report by the FAA does not in any way constitute a commitment on the part of the United States to participate in any development depicted herein, nor does it indicate that the proposed development is environmentally acceptable in accordance with appropriate public law.

The Noise Exposure Map and accompanying documentation for the Noise Exposure Map for Seattle-Tacoma International Airport, submitted in accordance with FAR Part 150 with the best available information, are hereby certified as true and complete to the best of my knowledge and belief. In addition, it is hereby certified that interested persons were afforded adequate opportunity to submit their views, data, and comments concerning the correctness and adequacy of the draft maps and description of forecasts of aircraft operations.

Seattle-Tacoma International Airport

FAR Part 150 Study Update

The Barnard Dunkelberg & Company Team

RECORD OF APPROVAL

FEDERAL AVIATION REGULATION PART 150
NOISE COMPATIBILITY PROGRAM

SEATTLE- TACOMA INTERNATIONAL AIRPORT
SEATTLE, WASHINGTON

INTRODUCTION

The Noise Compatibility Plan (NCP) for Seattle-Tacoma International Airport (Sea-Tac) includes measures to abate aircraft noise, control land development, mitigate the impact of noise on non-compatible land uses, and implement and update the program. Federal Aviation Regulation (FAR) Part 150 requires that the plan apply to a period of no less than five years into the future, although it may apply to a longer period if the sponsor so desires. The airport sponsor has requested that the program measures be applied to the current conditions NEM (Figure C40) because it covers a larger area for potential mitigation. The NCP discusses the possibility of the third runway becoming operational but neither the current conditions nor the 2004 NEM (figure F1) shows this runway layout. However, there is a measure in the NCP to reevaluate the NCP measures once the runway becomes operational.

The objective of the noise compatibility planning process has been to improve the compatibility between aircraft operations and noise-sensitive land uses in the area, while allowing the airport to continue to serve its role in the community, state, and nation. The approval actions listed herein include all those that the airport sponsor recommends be taken by the Federal Aviation Administration (FAA). It should be noted that the approvals indicate only that the actions would, if implemented, be consistent with the purposes of Part 150. These approvals do not constitute decisions to implement the actions. Subsequent decisions concerning possible implementation of these actions may be subject to applicable environmental procedures or aeronautical study requirements.

The program elements below summarize as closely as possible the airport operator's recommendations in the noise compatibility program and are cross-referenced to the program. The statements contained within the summarized program elements and before the indicated FAA approval, disapproval, or other determination, do not represent the opinions or decisions of the FAA.

The FAA has evaluated the "current conditions" noise exposure map identified as "year 1998" and found it to be representative of the "year 2000", the date of submission.

PROGRAM ELEMENTS

1. Measure A-6: Establish Follow-up Public Committee The 1985 Part 150 established a public committee to address noise issues, which was transitioned into the SeaTac Noise Advisory Committee subsequent to the Mediation process that generated some of the original noise mitigations actions at the airport. This action is to convene a committee to monitor programs implemented as a result of the Part 150 Study after its completion. Page F.6

FAA Determination: Approved

2. Measure A-7: Establish Noise Barriers/Run-Up Enclosure The 1985 Part 150 recommended the use of airport facilities for noise buffering of ground noise. This measure supplements the 1985 recommendation, and recommends constructing a noise barrier in the north cargo hardstand area. This action also calls for the completion of a siting/feasibility study for a Ground Run-up Enclosure by December 31, 2001. Pages E-37-E-57, page F-7.

FAA Determination: Approved in part; Disapproved pending submission of additional information to make an informed analysis. A siting/feasibility study for a ground run up enclosure is approved. Placement of any future GRE will be subject to additional FAA review determined by the results of the study. Construction of a noise barrier is disapproved pending submission of additional information regarding non-compatible land uses impacted and benefits to those non-compatible land uses from construction of the noise barrier.

3. Measure A-9: Encourage Voluntary Phase Out of Stage 2 Jet Aircraft Under 75,000 Lbs. The 1985 Part 150 recommended compliance with FAR Part 36 standards. This Action amends that through the voluntary phase out of Stage 2 jet aircraft operating at the Airport. Aircraft operating at Sea-Tac and meeting this criteria are currently older business jets and the F-28 commercial jet. Jet aircraft weighing less than 75,000 lbs. were exempt from the Stage 2 aircraft phase out mandated under the Airport Noise and Capacity Act of 1990. This Action involves working with the operators and airlines to voluntarily limit operations by aircraft weighing less than 75,000 lbs., noise certified under FAR Part 36 as Stage 2, especially between the hours of 10 p.m. and 7 a.m. Pages E-70, F.9

FAA Determination: Disapproved pending submission of additional information to make an informed analysis. It is not clear from the NCP documentation the contribution these aircraft have to the overall noise environment at Sea-Tac or the expected benefit from voluntary compliance. It is recognized that some aircraft operators are working with the airport to voluntarily limit operations by these aircraft types.

4. Measure A-10: Maintenance Run-Up Regulations This action addresses maintenance run-ups and recommends several changes to run-up related activities. Pages E-25 through E-33 and F.11.

These include:

a. Prohibiting run-ups during the overnight hours of midnight to 6:00 a.m.
b. Include language that allows run-ups in the shoulder hours of 10:00 p.m. to midnight and 6:00 a.m. to 7:00 a.m. only if necessary for a departure within two-and-a-half hours from scheduled run-up.
c. Increase fines for violations to the run-up regulations to $1,000 for the first violation. Doubling each time thereafter, within a 12-month timeframe, to a maximum of $8,000 per occurrence.
d. Implement new fine structure once new noise monitoring system has been fully installed and tested for reliability.
e. Include run-up monitoring in Fly-quiet program.
f. Work with airlines to restrict run-ups on weekend mornings before 9:00 a.m. unless needed for a departure within two-and-a-half hours of scheduled departure.

FAA Determination: Disapproved pending submission of additional information to make an informed analysis. Implementation of revised run up procedures (a. b., f. above) is disapproved pending submission of additional information regarding how the changes compare to the existing run-up procedures in their effect on aircraft operators. This measure differs from the one proposed and analyzed in the Part 150 documentation; there is no analysis of how this measure affects the non-compatible land uses impacted and benefits to those non-compatible land uses from changing the run up procedures.

The present nighttime restriction on run-ups is "grandfathered" from notice and analysis requirements of the Airport Noise and Capacity Act of 1990 and implementing regulations Part 161. Without additional information, the FAA cannot determine whether the proposed changes would reduce or limit the total number or hours of Stage 2 or Stage 3 aircraft operations (Part 161, section 161.7). Such an effect would make the changes to the run-up procedures subject to Part 161.

Monitoring equipment may not be used for enforcement purposes of aircraft in flight by in situ measurement of any present noise thresholds, for reasons of aviation safety.

5. Measure A-11: Preferential Runway Use This action implements a preferential runway system, during the nighttime hours, for those aircraft equipped with flight management system (FMS), to operate through the North Flow Nighttime Noise Abatement Corridor. This would be operational when traffic and other conditions permit as determined by the FAA. When conditions permit, during nighttime hours, departures can be shifted from south to the north, thus utilizing the established noise abatement corridor. This would be at the discretion of the FAA and would be premised on safe and efficient operating conditions. Pages E-52-E-59, E-89-E-92, F .15

FAA Determination: Approved as voluntary. Several sub-alternatives of a preferred nighttime north flow were evaluated in the NCP. Use of this procedure could impact on airspace capacity and therefore will be limited to those times when it can be done safely and efficiently. This measure will have no effect on the DNL noise contour, but would avoid West Seattle and Magnolia and would reduce over flights in the northern sections of Beacon Hill when it can be used. This measure is associated with the Fly Quiet Measure A-12, and includes "Nighttime Elliott Bay flight path compliance", which is an over-the-water route.

6. Measure A-12: Development/Implementation of Fly Quiet Program Pages E.60-E.64, F.16

The Fly Quiet Program should be developed to:

a. Monitor adherence to ideal noise abatement flight tracks
b. Evaluate success of airlines, aircraft types and other variables
c. Establish goals and track level of improvement over time
d. Offer incentives for improvement

The Fly Quiet Program should include the following elements:

e. Aircraft noise should be related to its effects on people including such factors as annoyance, speech interference and sleep disturbance
f. Comparative fleet quality between airlines should also be included
g. The program should utilize measured data from the Airport's noise monitoring system
h. A method of normalizing data to account for airlines that most efficiently serve the region's air transportation needs should be developed
i. Incentives of sufficient importance that airlines will take notice of the results

j. Pilots and air traffic controllers should be included, if possible.

FAA Determination: Approved as voluntary. None of the measures in the NCP would affect the DNL noise contour because Sea-Tac has in place a mitigation program that has provided significant noise benefit over the last 10+years. The NCP proposes to analyze the effectiveness of a Fly Quiet Program using supplemental metrics to compare benefits of alternative corridors, altitudes, etc. It should be understood that compliance with this program can occur only to the extent that safe, efficient aircraft operation and airspace management is not jeopardized; the pilot in command has final authority regarding safe operation of his/her aircraft. For reasons of aviation safety, this approval does not extend to use of the monitoring equipment for enforcement purposes of aircraft in flight by in situ measurement of any present noise thresholds.

7. Measure A-13: Evaluate increased use of the Duwamish/Elliott Bay Corridor with Flight Management Systems (FMS) This measure involves the Port of Seattle (Port) encouraging the FAA to pursue options for determining the feasibility of increased use of the Duwamish/Elliott Bay corridor. FAA conducted a feasibility study and provided a report and its findings to the Port on December 19, 2000. See attached Port letter of April 19, 2001, and Page F. 18.

FAA Determination: Disapproved. Implementing this action would greatly impact the efficiency of the air traffic system in the region and degrade safety, which would not be consistent with 14 C.F.R. part 150, section 150.35(b)(3)(iii).

8. Measure A-14: Nighttime Use of Commencement Bay Departure This action recommends further study and that FAA defer implementation until the Port coordinates with representatives of Pierce County. The Port has chosen to not include this item in the NCP and to pursue this separately from the remainder of the Part 150 process. Page F.20

FAA Determination: No FAA action required.

9. **Measure A-15: Use of FMS Procedures** This action involves the Port requesting that FAA evaluate potential FMS procedures for use over non-populated areas, and to discourage FAA development of new FMS procedures over populated areas. The Port would support the development of FMS procedures for all north flow departures turning west to improve compliance with the identified noise abatement corridor. Pages E.89-92, F.22

FAA Determination: Approved. The Port is responsible for initiating coordination with the FAA and airlines on evaluating potential new FMS procedures. The FAA will work with the Port and airlines to determine if any other FMS procedures are feasible and would provide noise mitigation. The NCP analysis and preliminary FAA evaluation determined that FMS procedures and corridors recommended in the NCP were not feasible, and could severely impact on airspace capacity in the area. Approval of this measure does not commit the FAA to implementing new procedures.

10. Measure A-16: Use of Ground Equipment This action will be to install power and conditioned air in existing and newly constructed gates to minimize use of auxiliary power units/ground power units. Once power and conditioned air are installed at gates, airlines should be required to use these services. Page F.23. Also reference analysis used for barrier and ground run-up enclosure (pages E.36-E.45).

FAA Determination: Disapproved pending submission of additional information to make an informed analysis. Intuitively, to install units at newly constructed gates where aircraft can use alternative sources of power would minimize ground equipment noise. However, the NCP analysis is insufficient to determine present ground equipment impacts to the closest noise-sensitive sites, including duration, dB(A) levels at the receiver, and time of day.

11. Measure A-17: Raise Altitude Where Aircraft Intercept Glide Slope Through the Fly Quiet Program, the subsequent Follow-On Committee will work with the operators and the FAA toward a goal of having aircraft on the glide slope as far out as possible while not adversely impacting capacity. Pages E.136, F.25.

FAA Determination: Disapproved. Moving aircraft further out on the glide slope would negatively impact airspace capacity and efficiency. The current procedures are needed to maintain operational efficiency at the airport.

12. Measure M-2a: Noise Compatibility Program Boundary The 1985 Part 150 identified the existing Noise Remedy Boundary. In this action, the Port will focus efforts on more highly impacted residential uses located within the revised "current conditions" (1998) 70 DNL with this revised program. This will allow the Port to accurately mitigate the noise impacts based on the current noise environment for the next 5-7 years. These will be reevaluated when the next Part 150 Study Update occurs. As a separate effort outside of the Part 150 process, the Port will continue to work with King County International Airport on addressing combined noise impacts of both airports. Page F .27

FAA Determination: Approved. The revised program boundary is limited to airport layout and operations for the current conditions and forecast 5-year NEM conditions. Neither the 1998 nor forecast 2004 NEMs show the proposed third runway configuration. At such time as the noise environment changes significantly, this measure should be reevaluated to determine its currency. (Program Guidance Letter 01-1, 3/29/01, and Part 150, section 150.21.) Also see Measure M-10 of this NCP.

13. Measure M-2b: Insulation of Schools The action is to sound attenuate schools within the 1998 (current conditions) DNL 65 dB(A) noise contour. The Port and the FAA are working with the Highline School District on developing a sound attenuation program for that District. Once an agreement is reached, the program elements should apply for all schools within the 65 DNL. The Port has already insulated several private schools within the contours where agreements were reached on criteria and continues to insulate classrooms at Highline Community College. Page F.28

FAA Determination: Approved. Insulation of schools within 65 DNL will be based upon negotiated agreements between the Port, school districts/education facilities, and FAA.

14. Measures M-2c: Multi-Family Developments The 1993 Part 150 recommended a pilot project to sound attenuate a multi-family (greater than four units) structure. That pilot project was completed and this action is to sound attenuate all owner-occupied multi-family structures within the 1998 (current conditions) 70 DNL noise contour. Amend subdivision regulations to require dedication of avigation easements and recording of fair disclosure agreements for new subdivisions. Page F.29

FAA Determination: Approved. This measure will result in the treatment of approximately 300 owner-occupied multi-family units.

15. Measure M-2d: Manufactured (Mobile) Homes The 1993 Part 150 recommended that the Port offer financial assistance for the removal of mobile homes for those residents that are living in a mobile home park (park) where the owner has decided to close the park. In exchange for this assistance, the park owner would sign an avigation easement to ensure that a noise compatible use would replace the park.

This action will amend that measure in two ways: first, the Port will purchase manufactured/mobile home parks within the 1998 (current conditions) 70 DNL noise contour and provide relocation assistance to the residents of those parks in accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act, as amended; and second, the Port will continue to offer financial assistance for the removal of mobile homes to those residents residing in parks, where the park owner has decided to close the park, located in the 1998 65 to 70 DNL noise contour. Page F.31

FAA Determination: Approved. This measure has the potential to remove approximately 425 mobile home units from within the 70 DNL noise contour. The FAA requires that the land use must be changed to, and remain compatible, once it is purchased for airport compatibility purposes. When using Federal financial assistance, the assistance provided the property owner would be a "displacing activity" defined at 49 CFR 24.2(g)(42 USC 4601(6)(A)) and the mobile home tenants are displaced persons entitled to the relocation benefits prescribed under 49 CFR 24.

16. Measure M-10: Operations Review and Noise Exposure Map Updates The FAR Part 150 Study is a five-year program recommended to be reevaluated prior to the end of the five-year time period. In addition, if the airport operator determines there is a significant change in either aircraft types or numbers of operations, or significant new facilities, the Study may be reevaluated prior to the end of the five-year time frame. The proposed third runway may be operational shortly beyond the timeframe of this Part 150 Study. As soon as that runway is operational, an update of this Part 150 should be initiated. Page F.33

FAA Determination: Approved.

17. Measure M-11 : Approach Transition Zone Acquisition Residential properties experiencing noise levels of 65 DNL or greater, and located within the Approach Transition Zones (ATZ) of the proposed third runway should be purchased. The ATZ's are within the DNL 65 contour shown in Figure C39. The Port will work with the cities of Burien and SeaTac on the purchase of these properties and to prepare compatible land use plans for the areas consistent with both community and Port goals. Page F.35

FAA Determination: Approved for part 150 purposes with respect to those areas located within the most recent official Part 150 NEMs. The FAA requires that the land use must be changed to, and remain compatible, once it is purchased for airport compatibility purposes. When using Federal financial assistance, the requirements of the 49 CFR Part 24 must be met.

18. Measure M-12: Prepare Cooperative Development Agreements The Port and the surrounding jurisdictions should work towards development of cooperative development agreements concerning land use, redevelopment, and infrastructure of the ATZ's, as well as other redevelopment areas as necessary. Page F.37

FAA Determination: Approved. This is consistent with the purpose of Part 150.

19. Measure M-13: Amend Community Plans and Zoning Ordinances The Port will work with the jurisdictions to amend zoning Maps, as necessary to reflect ATZ and mobile/manufactured home park recommendations that may not be consistent with existing zoning maps and to take into consideration FAR Part 77 height requirements. Such changes shall work towards discouraging the location of additional mobile/manufactured homes that cannot be insulated, within the 1998 (current conditions) NEM 65 DNL contour. It is also recommended that jurisdictions that do not have code requirements adopt them. Pages F.39 and 40.

FAA Determination: Approved. This measure, for the Port to work with surrounding land use jurisdictions to promote airport-compatible land uses, is consistent with the intent of Part 150.

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Introduction

Introduction

The Seattle-Tacoma International Airport (Sea-Tac) Federal Aviation Regulation (FAR) Part 150 Study is an update of an existing program that was adopted by the Port of Seattle in 1994. That Study recommended specific noise abatement and mitigation measures, many of which were developed through the mediation process of 1989/90.

This FAR Part 150 Study Update is a five-year program. The baseline year for this update is 1998 with the future baseline being 2004. The purposes of an FAR Part 150 Program are: to assess the noise environment, to prepare forecasts of aviation operations, to identify land uses within the airport environs, and to explore ways to mitigate land use compatibility conflicts.

FAR Part 150 requires the development of Noise Exposure Maps that depict the existing aircraft noise levels, expressed in terms of the Day-Night Noise Level (DNL) metric, and the five year future noise levels in terms of DNL. Thus the Study has a five-year planning horizon. The threshold DNL used for compatibility purposes is the 65 DNL noise contour. In addition to the Noise Exposure Maps, a Noise Compatibility Program (NCP) can also be prepared. The NCP contains the recommendations for noise mitigation and abatement that the sponsoring agency, the Port of Seattle in this case, is recommending for implementation. A schedule for implementation, along with the parties responsible for that implementation, is also presented.

Summary

This document contains a review of the existing land use controls, available for implementation, future land uses, and existing zoning in the airport environs. A review of historical aviation activity is also presented and a forecast of activity for the study period. The information contained in this document relating to aviation forecast was derived from the forecast of aviation activity, developed and approved for the Airport Master Plan and Environmental Impact Statement. The existing and future noise contours associated with the aviation activity is presented along with the noise measurement program and analysis used to develop these contours. Using these contours as a base, the noise compatibility process discusses the development of realistic and effective operational alternatives to mitigate the noise exposure. In addition to operational alternatives, a wide range of feasible land use alternatives, noise control actions, and noise impact patterns are evaluated and potential solutions which accommodate both airport users and inhabitants of the airport's environs within acceptable safety, economic and environmental parameters are discussed.

The various measures are listed and described, and each is evaluated in terms of its appropriateness with, and relationship to, Sea-Tac. In addition, recommendations are made as to which alternatives should be implemented at the Airport. The document then presents a schedule for review and updating of the elements contained in this FAR Part 150 Plan and Program to ensure success of the program.

This document, in terms of content and recommendations, has culminated from many meetings, with the Citizens Advisory Committee, the Technical Advisory Committee, Airport Staff and Management, the Commissioners of the Port of Seattle, the Federal Aviation Administration and other interested parties.

All proposals contained in this document are consistent with the Approved Airport Layout Plan and the Airport Master Plan, the State System Plan, and the Puget Sound Regional Council Resolutions and plans.

FAR Part 150 Noise Exposure Map Checklist
July, 2002

		Page Number
I.	**IDENTIFICATION AND SUBMISSION OF MAP DOCUMENT:**	
	A. Is this submittal appropriately identified as one of the following, submitted under FAR Part 150:	Cover, Cover Letter
	1. A NEM only	N/A
	2. A NEM and NCP	Yes
	3. A revision to NEMs which have previously been determined by FAA to be in compliance with Part 150?	N/A
	B. Is the airport name and the qualified airport operator identified?	Cover
	C. Is there a dated cover letter from the airport operator which indicates the documents are submitted under Part 150 for appropriate FAA determination?	Yes
II.	**CONSULTATION:** [150.21 (b), A150.(a)]	
	A. Is there a narrative description of the consultation accomplished, including opportunities for public review and comment during map development?	G.1-G.7, Appendix
	B. Identification:	
	1. Are the consulted parties identified?	G.1-G.7, Appendix
	2. Do they include all those required by 150.21 (b) and A150.105 (a)?	Yes, G.1-G.7, Appendix
	C. Does the documentation include the airport operator's certification, and evidence to support it, that interested persons have been afforded adequate opportunity to submit their view, data, and comments during map development and in accordance with 150.21 (b)?	Cover Letter, G.1-G.7, Appendix

D. Does the document indicate whether written comments were received during consultation and, if there were comments, that they are on file with the FAA region? — G.1-G.7, Appendix

III. **GENERAL REQUIREMENTS:** [150.21]

A. Are there two maps, each clearly labeled on the face with year (existing condition year and 5-year)? — C.88, F.5

B. Map currency:

1. Does the existing condition map year match the year on the airport operator's submittal letter? — No, Chapter C
2. Is the 5-year map based on reasonable forecasts and other planning assumptions and is it for the fifth calendar year after the year of submission? — No, F.5 and Chapter C
3. If the answer to 1 and 2 above is no, has the airport operator verified in writing that data in the documentation are representative of existing condition and 5-year forecast conditions as of the date of submission? — Cover Letter, Yes

C. If the NEM and NCP are submitted together:

1. Has the airport operator indicated whether the 5-year map is based on 5-year contours without the program vs. contours if the program is implemented? — Cover Letter
2. If the 5-year map is based on program implementation:
   a. are the specific program measures which are reflected on the map identified? — Yes, F.1F.37
   b. does the documentation specifically describe how these measures affect land use compatibilities depicted on the map? — Yes, F.1-F.37
3. If the 5-year NEM does not incorporate program implementation, has the airport operator included an additional NEM for FAA determination after the program is approved which show program implementation conditions and which is intended to replace the 5-year NEM as the new official 5-year map? — N/A

IV. **MAP SCALE, GRAPHICS, AND DATA REQUIREMENTS:** [A150.101, A150.105, 150.21 (a)]

A. Are the maps of sufficient scale to be clear and readable (they must not be less than 1" to 8,000') and is the scale indicated on the maps? — Yes, C.88, F.5

B. Is the quality of the graphics such that required information is clear and readable?	Yes, C.88, F.5
C. Depiction of the airport and its environs.	
1. Is the following graphically depicted to scale on both the existing condition and 5-year maps:	
a. Airport boundaries	Yes, C.88, F.5
b. Runway configurations with runway end numbers	Yes, C.88, F.5
2. Does the depiction of the off-airport data include:	
a. A land use base map depicting streets and other identifiable geographic features	Yes
b. The area within the 65 Ldn (or beyond, at local discretion)	Yes
c. Clear delineation of geographic boundaries and the names of all jurisdictions with the 65 Ldn (or beyond, at local discretion)	Yes
D. 1. Continuous contours for at least the Ldn 65, 70, and 75?	Yes, C.88, F.5
2. Based on current airport and operational data for the existing condition year NEM, and forecast data for the 5-year NEM?	C.88, F.5
E. Flight tracks for the existing condition and 5-year forecast time frames (these may be on supplemental graphics which must use the same land use base map as the existing conditioned and 5-year NEM), which are numbered to correspond to accompanying narrative?	C.68, C.69
F. Locations of any noise monitoring sites (these may be on supplemental graphics which must use the same land use base map as the official NEMs)	C.34-C.36
G. Noncompatible land use identification:	
1. Are noncompatible land uses within at least the 65 Ldn depicted on the maps?	Yes, C.88, F.5
2. Are noise sensitive public buildings identified?	Yes
3. Are the noncompatible uses and noise sensitive public buildings readily identifiable and explained on the map legend?	Yes
4. Are compatible land uses, which would normally be considered noncompatible, explained in the	

accompanying narrative? — Yes, F.2

V. **NARRATIVE SUPPORT OF MAP DATA:**
[150.21 (a), A150.1, A150.103]

A. 1. Are the technical data, including data sources, on which the NEMs are based adequately described in the narrative? — Yes,A.4-A.48
2. Are the underlying technical data and planning assumptions reasonable? — F.1-F.3

B. Calculation of Noise Contours:
1. Is the methodology indicated? — Cover Letter, C.30-C.86
   a. Is it FAA approved? — C.57
   b. Was the same model used for both maps? — Yes
   c. Has AEE approval been obtained for use of a model other than those which have previous blanket FAA approval? — N/A
2. Correct use of noise models:
   a. Does the documentation indicate the airport operator has adjusted or calibrated FAA-approved noise models or substituted one aircraft type for another? — No
   b. If so, does this have written approval from AEE? — N/A
3. If noise monitoring was used, does the narrative indicate that Part 150 guidelines were followed? — C.31
4. For noise contours below 65 Ldn, does the supporting documentation include explanation of local reasons? (Narrative explanation is highly desirable but not required by the Rule.) — N/A

C. Noncompatible Land Use Information:
1. Does the narrative give estimates of the number of people residing in each of the contours (Ldn 65, 70 and 75, at a minimum) for both the existing condition and 5-year maps? — D.1-D.5, F.3
2. Does the documentation indicate whether Table 1 of Part 150 was used by the airport operator? — Cover Letter, C.25, D.3
   a. If a local variation to Table 1 was used:
      (1) does the narrative clearly indicate which adjustments were made and the local reasons for doing so? — N/A
      (2) does the narrative include the airport operator's

complete substitution for Table 1?	N/A
3. Does the narrative include information of self-generated or ambient noise where compatible/ noncompatible land use identifications consider non-airport/aircraft sources?	N/A
4. Where normally noncompatible land uses are not depicted as such on the NEMs, does the narrative satisfactorily explain why, with reference to the specific geographic areas?	N/A
5. Does the narrative describe how forecasts will affect land use compatibility?	D.2, F.3

VI. **MAP CERTIFICATIONS:** [150.21 (b), 150.21 (e)]

A. Has the operator certified in writing that interested persons have been afforded adequate opportunity to submit views, data, and comments concerning the correctness and adequacy of the draft maps and forecasts?	Cover Letter
B. Has the operator certified in writing that each map and description of consultation and opportunity for public comment are true and complete?	Cover Letter, C.88, F.5

FAR Part 150 Noise Compatibility Program Checklist
July, 2002

	Page Number
I. **IDENTIFICATION AND SUBMISSION OF PROGRAM:**	
A. Submission is properly identified:	
1. FAR 150 NCP? Cover, Cover Letter	
2. NEM and NCP together?	Yes
3. Program revision?	N/A
B. Airport and Airport Operator's name identified?	Cover, Flysheet
C. NCP transmitted by airport operator cover letter?	Yes
II. **CONSULTATION:**	
A. Documentation includes narrative of public participation and consultation process?	G.1-G.7, Appendix
B. Identification of consulted parties:	
1. All parties in 150.23(c) consulted?	G.1-G.7, Appendix
2. Public and planning agencies identified?	G.1-G.7, Appendix
3. Agencies in 2., above, correspond to those indicated on the NEM?	G.1-G.7, Appendix
C. Satisfies 150.23(d) requirements:	
1. Documentation shows active and direct participation of parties in B, above?	G.1-G.7, Appendix
2. Active and direct participation of general public?	G.1-G.7, Appendix
3. Participation was prior to and during development of NCP and prior to submittal to FAA?	G.1-G.7, Appendix
4. Indicates adequate opportunity afforded to submit views, data, etc.?	G.1-G.7, Appendix

D. Evidence included of notice and opportunity for a public hearing on NCP?	Appendix
E. Documentation of comments:	
1. Includes summary of public hearing comments, if hearing was held?	G.1-G.7, Appendix
2. Includes copy of all written material submitted to operator?	Appendix
3. Includes operator's responses/disposition of written and verbal comments?	Appendix
F. Informal agreement received from FAA on flight procedures?	No
III. **NOISE EXPOSURE MAPS:** [150.23, B150.35 (f)] (This section of the checklist is not a substitute for the Noise Exposure Map checklist. It deals with maps in the context of the Noise Compatibility Program submission.)	
A. Inclusion of NEMs and supporting documentation:	
1. Map documentation either included or incorporated by reference?	C.88, F.5
2. Maps previously found in compliance by FAA?	N/A
3. Compliance determination still valid?	N/A
4. Does 180-day period have to wait for map compliance finding?	N/A
B. Revised NEMs submitted with program: (Review using NEM checklist if map revisions included in NCP submittal)	N/A
1. Revised NEMs included with program?	
2. Has airport operator requested FAA to make a determination on the NEM(s) when NCP approval is made?	
C. If program analysis used noise modeling:	
1. INM or HNM, or FAA-approved equivalent?	C.57
2. Monitoring in accordance with A150.5?	C.31
D. Existing condition and 5-year maps clearly identified as the official NEMs?	C.88, F.5

IV. **CONSIDERATION OF ALTERNATIVES:**
[B150.7, 150.23 (e)]

A. At a minimum, are the alternatives below considered?	
1. Land acquisition and interest therein, including air rights, easements, and development rights?	E.5-E.10
2. Barriers, acoustical shielding, public building soundproofing	E.11-E.12
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[150.23 (e), B150.35 (b), B150.5]

A. Document clearly indicates:	
1. Alternatives recommended for implementation?	F.1-F.37
2. Final recommendations are airport operator's, not those of consultant or third party?	Cover Letter
B. Do all program recommendations:	
1. Relate directly or indirectly to reduction of noise	

and noncompatible land uses?	F.1-F.37
2. Contain description of contribution to overall effectiveness of program?	F.1-F.37
3. Noise/land use benefits quantified to extent possible?	F.3
4. Include actual/anticipated effect on reducing noise exposure within noncompatible area shown on NEM?	F.1-F.37
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Supporting documentation includes provision for revision? N/A

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A Inventory

Seattle-Tacoma International Airport

FAR Part 150 Study Update

Inventory

Introduction

Seattle-Tacoma International Airport (Sea-Tac) is the primary air transportation hub of Washington State and the Northwest United States. The Airport is located within King County and the City of SeaTac, approximately 12 miles south of downtown Seattle and approximately 20 miles north of the City of Tacoma. In 1997, the Airport was served by 54 airlines, with scheduled passenger service provided by 10 major carriers. There are 14 scheduled all-cargo carriers serving the Airport. The Airport provides non-stop air service to 67 cities within the United States and 15 additional cities worldwide, with direct flights to an additional six international cities. In terms of passenger activity, Sea-Tac Airport is the 18th busiest airport in the United States and is the primary commercial service airport for the Pacific Northwest. In terms of operations, it is the 23rd busiest airport in the United States. It is the only airport that provides primary scheduled commercial service in the Puget Sound Region. The generalized airport location is illustrated on Figure A1, *AIRPORT LOCATION MAP.*

Sea-Tac is owned and operated by the Port of Seattle (Port), which is lead by a five-member governing body called the Port of Seattle Commission (Commission). The Commission is elected at large to direct Port policy. The Port district boundaries are contiguous with those of King County. The Managing Director of the Aviation Division is responsible for the day-to-day operations of the Airport. While state enabling legislation provides the Port with a broad range of municipal powers over the Airport property and operations, the Port does not have jurisdiction over land use and zoning requirements to ensure compatible development in the noise-affected areas around the Airport. The Port of Seattle, as operator of the Airport, has enacted a comprehensive program of noise abatement and mitigation measures through Port Commission Resolutions. These Resolutions are outlined in subsequent sections of this chapter.

In 1997, the Port of Seattle completed and adopted an Airport Master Plan for Seattle-Tacoma International Airport. That Master Plan contained many recommendations, including the construction of a third parallel runway. The new runway is to be constructed approximately 1,700 feet west of the existing west runway, is to be 8,500 feet in length and 150 feet in width, and will include precision instrument approaches on both ends. During the preparation of the Airport Master Plan, an Environmental Impact Statement (EIS) was initiated to address the environmental impacts of the new runway, along with other Master Plan recommendations. Subsequent to the EIS and prior to a Record of Decision, a Supplemental EIS was prepared to address the projects contained in the Airport Master Plan. The Federal Aviation Administration (FAA) issued a favorable Record of Decision on the environmental documentation on July 5, 1997.

In addition to these airport-planning projects, the Puget Sound Regional Council (PSRC) conditionally approved the addition of a third runway at Sea-Tac as an element of the area's Metropolitan Transportation Plan. The PSRC conditioned this approval with requirements to study additional noise-reduction measures. Due to the regional nature of this process, areas beyond traditional Part 150 neighborhoods have an interest in this Part 150 Study. This FAR Part 150 Study will evaluate traditional FAR Part 150 elements and time frames, which generally includes evaluating aircraft operations and noise measures within the five-year time frame dictated by Part 150. However, this Study will also evaluate the noise affects, in general, that are anticipated to result from the addition of the third runway. These elements will not be evaluated or illustrated on the Noise Exposure Maps or within the Noise Compatibility Program, but will be addressed on a more general basis for the long-term time frame. Noise-exposure contours will be presented that not only are associated with aircraft operations beyond the five-year time frame but that also present Day-Night Noise Levels (DNL) lower than the traditional 65 DNL noise-exposure contour.

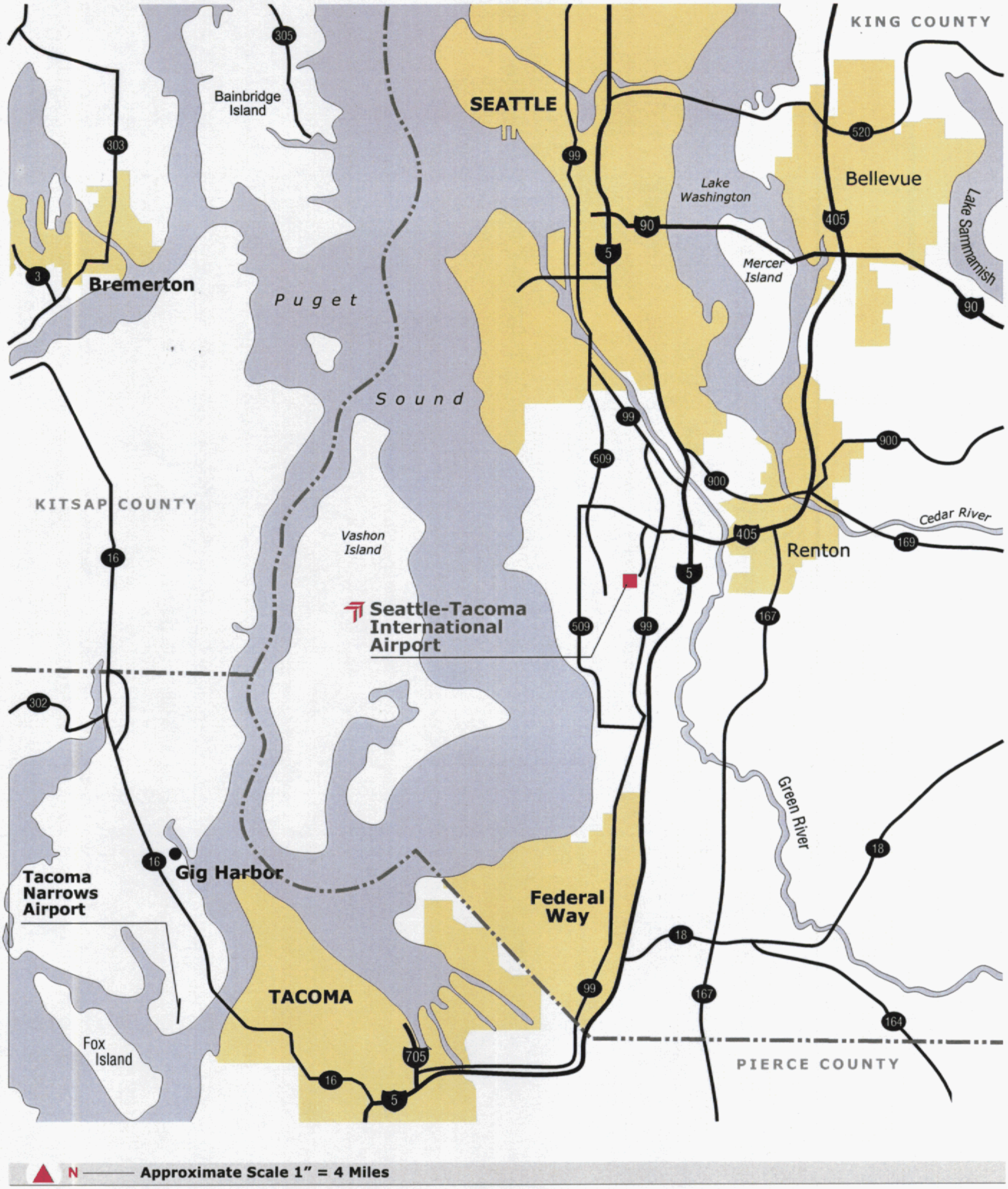
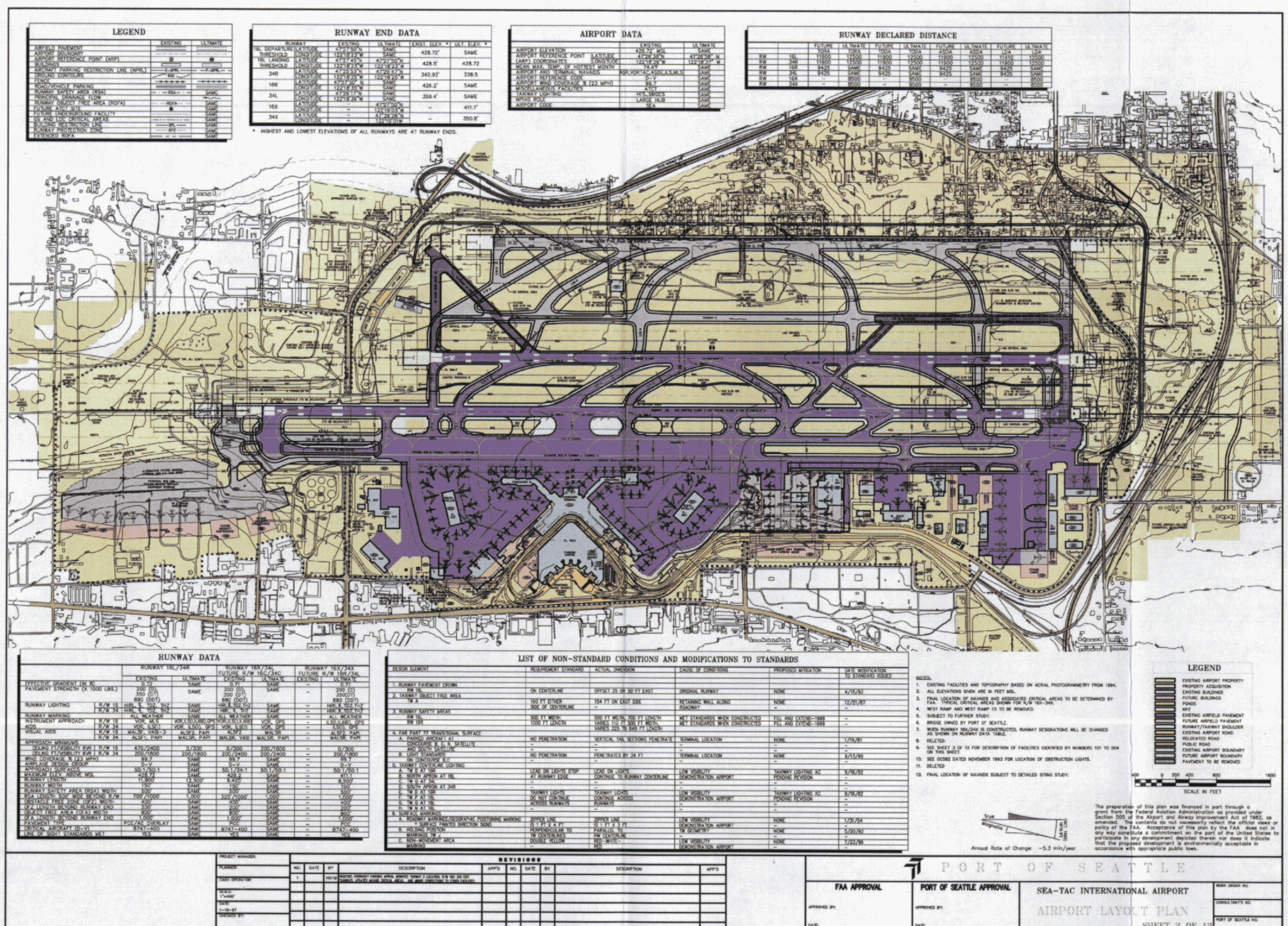


Figure A1 **Airport Location Map**

Airport Physical Facilities

The Airport currently consists of two parallel runways: Runways 16L/34R and 16R/34L. Runway 16L/34R is the longer runway, at 11,900 feet in length and 150 feet in width. Runway 16R/34L is 800 feet to the west and is 9,425 feet in length and 150 feet in width. Runway 16L/34R has an instrument approach to Runway 34R, while Runway 16R/34L has instrument approaches to both Runways 16R and 34L. There is an existing parallel taxiway on the east side of the east runway (Runway 16L/34R) with high-speed connecting taxiways connecting the east runway to the west runway (Runway 16R/34L). The west runway has a partial parallel taxiway on the west side of the north end of the runway. Aircraft using Runway 16R/34L must cross Runway 16L/34R in either an approach or departure operation. Most ancillary landside facilities are located on the east side of the Airport, with the passenger terminal complex located approximately in the center of the Airport east of Runway 16L/34R. Existing cargo and other support facilities are located north of the terminal. The terminal itself consists of one main terminal building with two satellite terminals, referred to as the north and south satellites. Major ground access is provided by International Boulevard (Highway 99) or State Highway 518 from the north. State Highway 518 connects to Interstates 5 and 405.

The FAA-approved Airport Layout Plan (ALP) indicates the construction of a third parallel runway approximately 1,700 feet west of Runway 16R/34L. This runway would be 8,500 feet long with a full parallel taxiway and high-speed connecting taxiways on the east side of the runway. The runway would have precision instrument approaches to both ends. The ALP also indicates both terminal and parking structure expansion, with long-term satellite terminal development occurring north of the existing terminal, along with an associated parking structure. The South Aviation Support Area is shown south of the terminal complex, south of 188th Street. This is an area adjacent the southeast end of the airfield which will be developed for aviation uses requiring aircraft and airfield access, such as aircraft maintenance or air cargo handling. During the noise monitoring period, the Airport operated in a south-flow configuration (arrivals from the north and departures to the south) approximately 70 percent of the time. Historically over a number of years, the operations are in north flow approximately 35 percent of the time and south flow approximately 65 percent of the time. This is graphically presented in Figure A2, *SCHEMATIC AIRPORT LAYOUT PLAN.*



N —— Not to Scale

Figure A2 **Existing Airport Layout**

Air Traffic Operations Activity

Sea-Tac has shown steady growth in operations over the past several years. As shown in the following table, overall operations (an operation is either a take-off or a landing) have increased from approximately 260,000 in 1986 to approximately 385,000 in 1997. As can be seen, a significant increase in air-taxi (commuter) operations occurred in 1987 and 1988, and then leveled off, resulting in continued high levels of air-taxi operations.

Table A1
SUMMARY OF HISTORICAL OPERATIONS, 1986-1996
Sea-Tac International Airport FAR Part 150 Study

Year	Air Carrier	Air Taxi	General Aviation	Military	Total Operations
1986	187,870	54,977	16,806	286	259,939
1987	178,682	95,337	17,671	355	292,045
1988	176,732	124,245	14,520	447	315,944
1989	182,460	139,215	12,865	384	334,924
1990	193,482	150,376	10,844	305	355,007
1991	186,717	142,828	8,773	289	338,607
1992	196,141	140,744	8,800	310	345,995
1993	200,000	131,046	7,929	444	339,459
1994	212,016	132,160	8,358	518	353,052
1995	226,190	149,444	10,244	658	386,536
1996	239,063	149,882	6,077	194	395,216
1997	235,447	143,513	6,180	158	385,298

Source: 1997 Airport Activity Report

In terms of overall operations, the Airport was the 23rd busiest airport in the United States in 1997. The airlines with the largest percentage of overall operations at Sea-Tac during 1997 were Alaska (29.2%), United (15%), Horizon (10.3%), Northwest (9.3%), Delta (7.2%), Southwest (7.0%), and American (4.6%). The remainder of the airlines had less than three percent of overall operations.

The aircraft with the greatest number of operations in 1997 were Boeing 737 models (22.8%), Douglas MD-80 (18.9%), de Havilland Dash 8 (16.7%), Beech 1900 (8.1%), Boeing 757 (6.7%), Fokker F-28 (5.9%), Piper PA31 (3.2%), DC-10 (2.4%), Airbus A-310 (2.3%), and Boeing 727 (2.3%). All other aircraft types generated the remaining 10.7 percent of operations.

Operations are further broken down by the time of day they occurred. Based on the recently completed Airport Master Plan, the majority of operations occur between 7:00 a.m. and 10:00 p.m., as shown in the following table.

Table A2
SUMMARY OF OPERATIONS BY TIME OF DAY, In Percent
Sea-Tac International Airport FAR Part 150 Study

Type of Operation	Day 7:00 a.m. to 10:00 p.m.	Night 10:00 p.m. to 7:00 a.m.
Air Carrier	85.6	14.4
Air Taxi/Commuter	89.7	10.3
Air Cargo		
Under 60,000 lbs.	72.2	27.8
Over 60,000 lbs.	53.1	46.9
Military	100	00.0
General Aviation	90.6	09.4

Source: 1997 Airport Master Plan Revised Unconstrained Aviation Forecast Update

These time-of-day allocations will be verified and updated as necessary prior to generating the DNL noise-exposure contours for this Part 150 Study.

In 1997, approximately 24,738,476 passengers were accommodated at the Airport. This compares to approximately 24,324,596 passengers in 1996. The 1997 passenger figures include 22,887,340 domestic passengers and 1,851,136 international passengers. The number of passengers has been increasing steadily since 1986 when there were 13,642,666 total passengers. Sea-Tac was ranked the 18th busiest airport in the United States for total passengers in 1997.

The domestic passenger market, which accounts for approximately 93 percent of the total passenger market, was dominated by the contiguous United States, which accounted for 84 percent of the domestic passengers. Alaska passengers accounted for 6.6 percent and Hawaii passengers accounted for the remaining 2.1 percent of the domestic passengers. The top five domestic destination markets were the Bay Area in California (12.7%), Los Angeles (11.5%), Spokane (4.1%), Las Vegas (3.8%), and Phoenix (3.2%).

The international passenger market, which accounted for approximately seven percent of the total passenger markeet, was almost evenly split between Asia (2.9%) and Canada (2.6%). Europe accounted for 1.4 percent with Mexico accounting for less then one percent (0.6%) of the market. The top five international destination markets were London (11.3%), Vancouver (10.6%), Tokyo (6.4%), Taipei (5.5%), and Seoul (5.1%).

In 1997 the Airport provided for the transportation of 393,786 metric tons of cargo. Approximately 53.0 percent of this cargo, 208,828 metric tons, was domestic freight, and approximately 18.4 percent, 72,319 metric tons, was international freight. The remaining 28.6 percent was air mail, at 112,639 metric tons. Federal Express accounted for 29.3 percent of all the air freight, with Alaska Airlines accounting for 11.6 percent, Northwest Airlines for 8.9 percent, United Airlines for 5.7 percent, Cargolux for 5.6 percent, and Emery for 5.2 percent. The remaining airlines all account for less then five percent each.

Airspace/Air Traffic Control

The FAA is responsible for the safe and efficient use of the national air space. This airspace is divided into three specific types; enroute, terminal, and tower. When an aircraft departs an airport it is located in the airspace being handled by air traffic controllers working in an air traffic control tower. When the aircraft is approximately one mile away from the airport, the aircraft is handed off to controllers working the Terminal Radar Approach Control Facility (TRACON). These controllers are responsible for the airspace extending out 25 to 30 miles from the airport in all directions. The aircraft then enters the third type of airspace and becomes the responsibility of enroute controllers working in an Air Route Traffic Control Center (ARTCC). The enroute controllers retain control until the aircraft nears it intended destination. The air-traffic control process is then reversed for landings. For aircraft operating at Sea-Tac, the controlling facilities responsible for the terminal and tower airspace are located in the main terminal building.

There are several airports located in the Seattle area that are under the control of Seattle TRACON. Although Sea-Tac accounts for a significant percentage of all area aircraft operations, the cumulative number of aircraft operations at the other airports also adds a significant workload for controllers in the Seattle TRACON. There are also other general aviation airports without operational control towers or published instrument procedures that contribute to the total number of area-wide aircraft operations. While aircraft using these other general aviation airports operate under visual flight rules (VFR), they must utilize the Seattle terminal airspace, and aircraft using Sea-Tac must be separated from them. Seattle TRACON provides full arrival and departure services for Sea-Tac, as well as for King County International Airport/Boeing Field, Gray Army Air Field, McChord Air Force Base, Olympia Airport, Renton Municipal, Tacoma Narrows, Bremerton National Airport, and Shelton/Sanderson Field.

Sea-Tac has a 24-hour, continuously operating Air Traffic Control Tower (ATCT) that has a designated Airport Traffic Area (ATA). Aircraft which operate within an ATA must be in contact, at all times, with the tower controllers, especially to receive approval for take-offs and landings. Standard ATAs are designated to include all airspace within five miles of the Airport from the surface of the ground up to (but not including) 3,000 feet. Because of its proximity to other airports in the area, especially the King County International Airport, the Sea-Tac ATA is not completely circular. Airspace operational activities are explained in greater detail in the following paragraphs.

Air Space Configuration [1]

The Sea-Tac Terminal area airspace is shown in Figure A3. This airspace has been delegated to the Sea-Tac TRACON facility by the Seattle ARTCC or Center. The Center provides Air Traffic Control (ATC) services to aircraft between terminal areas. The Seattle TRACON provides approach/departure control services within its delegated airspace. Eight of the busiest airports within the Seattle TRACON's airspace have ATCTs or "towers." These towers provide control within the TRACON's airspace. These eight airports are listed below:

[1] The following information concerning airspace and air traffic control is summarized from the Airport Master Plan, Technical Report Four, *FACILITIES INVENTORY*.

- Boeing Field/King County International
- Gray Army Air Field
- McChord Air Force Base
- Olympia Airport
- Renton Municipal
- Seattle-Tacoma International
- Tacoma Narrows
- Paine Field

The Center and TRACON provide control primarily to aircraft operating under instrument flight rules (IFR). In addition, TRACON provides control or service to aircraft operating under VFR within the Seattle Class B Airspace, (Formerly TCA). An ATC clearance and control is mandatory for VFR aircraft operating within Class B airspace. The Seattle Class B Airspace Area is depicted on Figure A3.

Published instrument approach procedures exist for nine airports within the Seattle TRACON airspace as listed in Table A3. Table A3 differentiates between precision and non-precision approaches. A precision approach, by definition, provides electronic vertical guidance to the pilot as well as horizontal (azimuth) guidance. A non-precision approach provides horizontal guidance only. Generally the azimuth guidance for a precision approach is more precise. For an Instrument Landing System (ILS) approach procedure, a localizer transmitter provides the azimuth guidance and a glide-slope transmitter provides the vertical guidance.

N — Approximate Scale 1" = 7 Nautical Miles

Figure A3 **Airspace/NAVAIDS Summary**

Source: Seattle Sectional Aeronautical Chart, January 1998. Not Intended for Navigational Purposes.

Table A3
PUBLISHED IFR APPROACH PROCEDURES
Sea-Tac International Airport FAR Part 150 Study

Airport Name	Runway	Procedure
King County Int./Boeing Field	13R	ILS (CAT I)
	31L	LOC BC
Bremerton National	1	NDB
	19	ILS (CAT I)
Gray Army Field	15	ILS, NDB
	33	VOR, NDB
McChord Air Force Base	34	ILS, HI-TACAN
	16	ILS, TACAN
Olympia	17	ILS (CAT I)
	34	VOR/DME
	To airport	VOR-A
Renton Municipal	15	NDB
Seattle-Tacoma International	16R	ILS (CAT IIIB), NDB
	34L	ILS (CAT I)
	34R	ILS (CAT I), NDB
	16L/R	VOR
	34L/R	VOR
Shelton/Sanderson Field	To airport	NDB-A
Tacoma Narrows	17	ILS (CAT I)
	35	NDB

Guide to Abbreviations: DME=Distance Measuring Equipment; ILS=Instrument Landing System; LOC BC=Localizer Back Course; NDB=Nondirectional (radio) Beacon; TACAN=Tactical Air Navigation; VOR=Very High Frequency Omnidirectional Range.

Air Space Usage

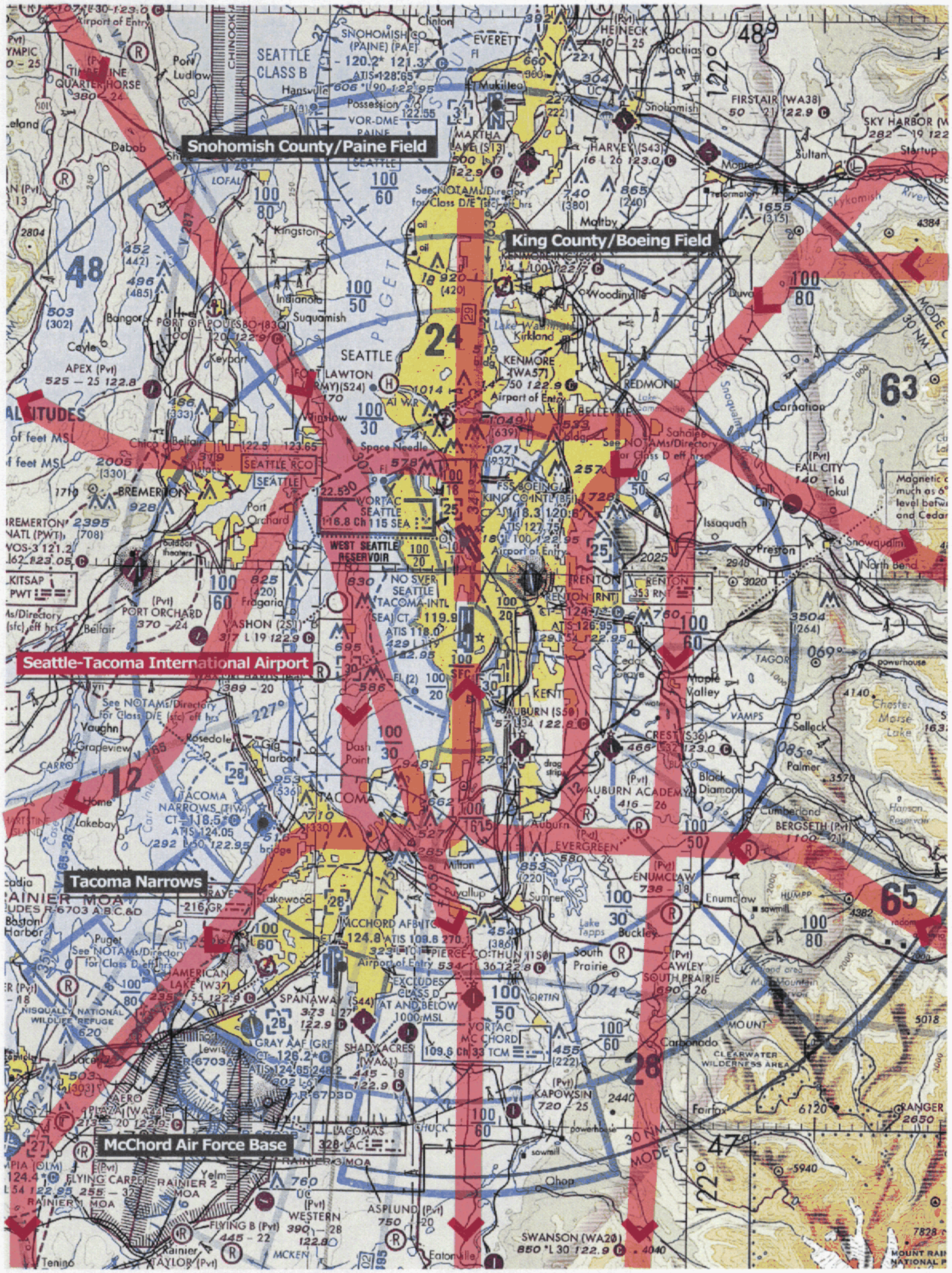
All aircraft flights are governed by either visual flight rules (VFR) or instrument flight rules (IFR). Definitions are contained in FAR Part 91 and summarized below. The basic difference between VFR and IFR is that the pilot maintains spatial orientation of an aircraft by reference to the earth's surface for VFR and by reference to aircraft instruments for IFR. Under IFR rules, apilot can operate in poor visibility conditions within controlled airspace. Flight under VFR rules requires good visibility and maintenance of specified distances from clouds.

During poor weather conditions, Sea-Tac is restricted to a single arrival stream. This is because of the proximity of the existing parallel runways. Sea-Tac operates with a single arrival stream approximately 44percent of the time.

The Seattle Terminal Airspace area includes nine IFR airports and approximately 30 VFR airports. Two of the IFR airports are military (McChord AFB and Gray AAF), and 10 of the VFR airports are private or restricted and generally are not available to the public.

IFR Operations

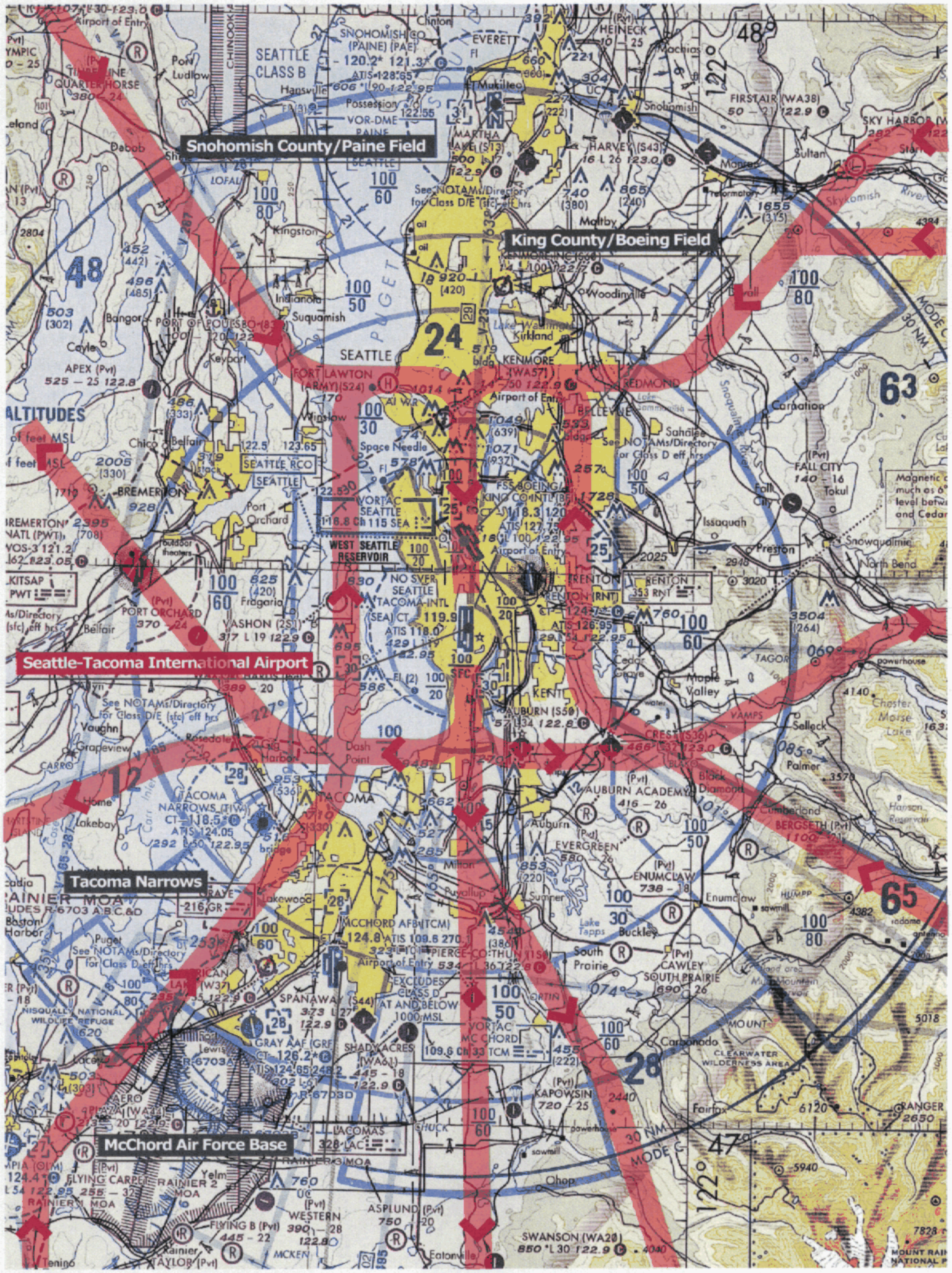
Air carrier and many turbojet general aviation and military aircraft operating to or from the Airport under IFR, are reassigned coded flight routes and procedures referred to as Standard Instrument Departures (SIDs) and Standard Arrival Routes (STARs). These SID and STAR routes are depicted on Figure A4 for north flow and on Figure A5 for south flow. These figures also depict arrival and departure gates. Navigation of IFR aircraft within the Seattle TRACON airspace is generally provided by radar vectors to achieve efficient sequencing, spacing, and separation between aircraft. Therefore, actual aircraft flight tracks, particularly closer in to the Airport, will not conform exactly with the SIDS, and STARS depicted.



N —— Approximate Scale 1" = 7 Nautical Miles

Figure A4 **Standard Instrument Departure and Arrival Routes, North Flow**

Source: Seattle Sectional Aeronautical Chart, January 1998. Not Intended for Navigational Purposes.



N — Approximate Scale 1" = 7 Nautical Miles

Figure A5 **Standard Instrument Departure and Arrival Routes, South Flow**

Source: *Seattle Sectional Aeronautical Chart, January 1998. Not Intended for Navigational Purposes.*

In general, however, IFR arrival aircraft are cleared to the Airport by the Seattle Center via these STARs while descending from enroute altitudes. These aircraft arrivals are "handed off" via radar from the Seattle Center to the Seattle TRACON at various entry points, referred to as "gates". In other words, there are established arrival routes that aircraft utilize and the pilots are in contact with different controllers as they approach the Airport.

In April 1990 the FAA standardized the air traffic patterns for jet aircraft flying in and out of Sea-Tac. The new air traffic plan, referred to as the "4-Post Plan," changed the arrival and departure procedures used by the air-traffic controllers to transfer the aircraft from the enroute to the terminal environment. The FAA determined that safety and efficiency could be improved if the procedures used to route air traffic to the terminal airspace area were designed to be the same regardless of the direction of traffic flow. Depending on the city of origin, aircraft enter the terminal airspace from one of the four "posts," or corners of the terminal airspace area. These procedures helped to alleviate difficulties associated with having two different sets of patterns that were wind dependent.

The TRACON assumes responsibility for guiding the arrival aircraft to the final approach course at the destination airport and for separating it from other aircraft. Lower performance aircraft, and some commuter/air-taxi aircraft, operate at lower altitudes below or clear of the jet aircraft routes. The lower performance aircraft are "laced" into the arrival routes closer in to the Airport to minimize the effects of the speed differentials.

When arrival aircraft are in the vicinity of their destination airport they are given descent instructions by TRACON until they are approximately 1,500 feet above the destination airport and approximately five nautical miles from the runway threshold on the final approach. TRACON then clears them for the approach and instructs the pilot to contact the destination airport's tower.

Similarly, departing IFR aircraft are guided by the Seattle TRACON through its delegated airspace and separated from other aircraft. Shortly after departure aircraft are airborne, the tower clears the aircraft to contact the TRACON for departure control. The TRACON then directs departing aircraft toward the departure gates. Similar to arrivals, departing low performance aircraft are turned immediately after take-off to separate them from the jet departure stream and to keep tham at lower altitudes. As soon as departing aircraft either pass the departure gate or climb out of the TRACON airspace, they are transferred to ARTCC for enroute control.

Unless visual separation is applied, TRACON provides all IFR aircraft with a radar separation of at least three nautical miles longitudinally, or 1,000 feet of vertical separation, throughout their terminal airspace. Additional longitudinal separation to avoid wake turbulence is provided for various combinations of aircraft sizes. The minimum longitudinal separation in terminal airspace is listed below:

Table A4
AIRCRAFT LONGITUDINAL SEPARATIONS
Sea-Tac International Airport FAR Part 150 Study

Lead Aircraft Classification	Aircraft Classification	Separation (NM)
Heavy	Heavy	4
Heavy	Large	5
Large	Small	4
Heavy	Small	6

Source: FAA Handbook 7110.65L, "Air Traffic Control" with changes.

For the purpose of wake turbulence separation minims, FAA classifies aircraft as Heavy, Large and Small as follows:

Heavy: Aircraft capable of take-off weights of 300,000 pounds or more whether or not they are operating at this weight during a particular phase of flight (Examples: B-747, B-777, DC-10).

Large: Aircraft of more than 12,500 pounds, maximum certified take-off weight, up to 300,000 pounds (Examples: B-737, MD-80, Business jets).

Small: Aircraft of 12,500 pounds or less maximum certified take-off weight (Twin and single piston/turboprops).

Within the Seattle Class B airspace, the Seattle TRACON provides all VFR aircraft a radar separation of one-half nautical mile longitudinally, or 500 feet of vertical separation, from all IFR and VFR aircraft.

VFR Operations

Flights conducted under VFR, unlike IFR flights, are not always under ATC jurisdiction. Under VFR, pilots may normally operate without an ATC clearance, except when operating within Class B airspace. When operating in visual meteorological conditions, all pilots, regardless of type of airspace flight plan or ATC clearance, are ultimately responsible to see and avoid other aircraft.

The lower altitudes of airspace to the east and west of the Seattle area are restricted by the Cascade and Olympic Mountains. These mountains and the Class B Airspace tend to channel north/south VFR traffic. One north/south channel or VFR flyway exists at approximately five-to-six miles east of Sea-Tac and below 4,000 or 5,000 feet above mean sea level (MSL). The other north/south VFR flyway is somewhat wider and close to the Olympic Mountains. Those transiting under Class B Airspace in the vicinity of Sea-Tac and over the Puget Sound are below 3,000 feet. Some VFR aircraft fly over the tops of Class B Airspace. The top of the Class B Airspace is at 10,000 feet above MSL.

Flow Control

During peak air traffic periods of the day, especially during inclement weather, arrival aircraft traffic demand exceeds the arrival capacity of Sea-Tac. In the past, when demand exceeded capacity, TRACON would advise ARTCC to place arrivals in holding patterns at the edge of TRACON airspace. Because it is more efficient for delays to be absorbed enroute, a procedure called Flow Control has been developed. In extreme conditions, aircraft destined for Sea-Tac may be held on the ground at the departure airport prior to take-off.

In general, Flow Control refers to a procedure allowing TRACON to determine the maximum hourly rate of arrivals to Sea-Tac. The TRACON advises Seattle Center so that adjustments can be made to the rate of entries into TRACON airspace. This hourly rate of arrivals is known as the Airport Acceptance Rate (AAR). The AAR varies according to several conditions including number of runways available for landings, weather conditions, direction of traffic flow, types of approach in use, and runway operational conditions.

Existing Conditions

Interactions are situations requiring special controller and/or pilot attention to ensure that adequate separation or sequencing is accomplished. Although this broad definition could include random occurrences that do not affect capacity, there are two interactions which affect Sea-Tac capacity that occur regularly during IFR weather conditions and one that occurs regularly when visual approaches are in progress. These three interactions occur during: (1) IFR south-flow conditions; (2) IFR north-flow conditions; and (3) visual approaches in south-flow conditions.

IFR Weather Conditions-South Flow

During IFR weather conditions, when Sea-Tac and KCIA (King County International Airport/Boeing Field) are operating with south flows, interactions exist between the arrivals to the two airports. Although a minimum of 1,000 feet of altitude separation exists between the published Instrument Landing System (ILS) approaches, a need exists to protect KCIA missed approach possibilities. In weather conditions that allow KCIA air traffic controllers to see the Sea-Tac arriving aircraft, visual separation is provided by the controllers and no loss in capacity is experienced. This operating arrangement is known as Plan Alpha. Cloud ceilings at KCIA must be at least 2,500 feet for KCIA ATC personnel to see Sea-Tac arrivals. The yearly frequency of occurrence of south-flow conditions, with ceilings below 2,500 feet (no Plan Alpha) is approximately 17 percent. Based on observations, this is estimated to drop to about 16 percent during the busiest part of the day, 7:00 a.m. to 9:00 p.m. Additionally, weather conditions below minimums (closed conditions) at Sea-Tac would reduce the occurrence of the interaction by another 1 or 2 percent.

Weather statistics indicate this interaction should occur approximately 15 percent of the time. However, the actual time of this impact to capacity is less because of special ATC procedures. Under these procedures, during certain weather conditions and with pilots who are familiar with KCIA, aircraft approaching Sea-Tac will be advised to maintain 3,000 feet MSL until KCIA Tower advises TRACON that the landing of the other aircraft at KCIA is assured. At this point, the Sea-Tac approaching aircraft pilot is given a final approach clearance and authorization to land. If the KCIA approaching pilot executes a missed approach, TRACON will vector the Sea-Tac approach back into the arrival stream and one arrival interval or slot is lost in arrival capacity at Sea-Tac. However, this situation occurs very rarely.

IFR Weather Conditions - North Flow

During north-flow IFR conditions, interactions exist between the arrivals to KCIA and departures from Sea-Tac. Sea-Tac departures are held on the ground from the time a KCIA arrival nears the final approach fix located just east of Sea-Tac until KCIA Tower reports the landing is assured or until visual separation can be provided. This situation can affect Sea-Tac's departure capacity. If a Sea-Tac arrival is within two nautical miles of the Runway 34R threshold, a departure from Sea-Tac, in certain IFR conditions, cannot be released. As a result one to three intervals could be lost.

Visual Approaches - South Flow

Visual approaches can normally be conducted to Sea-Tac when the cloud ceiling is at least 5,000 feet over the Puget Sound and pilots have visual contact with the preceding aircraft or the Airport.

When visual approaches are being conducted, the TRACON will radar vector aircraft on three arrival routes and sequence them into a common arrival stream over Elliott Bay. This activity occurs over the top of straight-in arrivals to KCIA.

During peak periods, both Runways 16L and 16R at Sea-Tac are used if visual approach conditions exist. Two common arrival streams are formed over Elliott Bay. This situation requires special attention on the part of both controllers and pilots. When pilots are making the turns into Elliott Bay from the north and south, visibility from the cockpit is reduced. If two aircraft are about to make the turn at about the same time onto different arrival streams, one pilot often tends to reduce speed and fall back, in order to keep the other aircraft in sight. This reduction of speed will increase the longitudinal spacing in the arrival stream and reduce the arrival rate.

ANOMS Radar Data

The Port of Seattle Noise Abatement Office has a flight track data collection and analysis program called ANOMS (Airport Noise and Operational Monitoring System). This program collects and processes radar data from the FAA's ARTS (Aircraft Radar Tracking System). Once collected, the ANOMS program performs a number of processes, including determining if the track is a departure or arrival and assigning a runway to the track. With this system, the Port is able to analyze compliance with the Port's noise abatement program and investigate particular incidents concerning aircraft operations.

The ANOMS program exports a file that includes flight information about the aircraft that is operating on each track as well as position information as to the location of the flight. The flight information includes data such as the ARTS aircraft type, ARTS airline code, flight number, and type of operation and runway. The position information includes the X and Y position of each radar strike for the flight track for every four seconds of the flight as well as the altitude of the aircraft at each point and the time that the aircraft was at that point. The position information is given in distance relative to the ARTS radar antenna that is on Airport property.

These files have been successfully exported to the Bridge Reports programs for analysis in the FAR Part 150 Study. Note that the data used is based upon the information from ANOMS, which is derived from the FAA's radar system. There is always the possibility that some data are lost in these radar systems; however, every possible step is taken to ensure this does not occur. When data are lost or when gaps occur in the data, the data are typically not recoverable.

Current Noise Abatement Program

Sea-Tac has a long history of implementing noise abatement programs. These programs include both physical and operational programs. In 1976, the Port prepared the Sea-Tac Community Plan, which addressed for the first time the relationship of aircraft noise to land use development and contained recommendations for land use compatibility. This Plan was updated in 1985 when the Port completed its first FAR Part 150 Study. This Study recommended many of the existing noise mitigation programs currently adopted by the Port and established the Noise Remedy Program Boundaries. That FAR Part 150 Study was updated in 1993. The Updated FAR Part 150 Study contained measures which amended some of the programs adopted in the first study and produced an updated set of Noise Exposure Maps. This FAR Part 150 Study Update is the third Part 150 Study that the Port has voluntarily undertaken.

Following the first FAR Part 150 Study, in 1989 the Port undertook a new and innovative process to address the aircraft noise issue at the Airport. This was called the Sea-Tac Noise Mediation process, which was a consensus-based approach that was used to address aircraft noise issues. Through that process several measures for noise abatement and noise mitigation were recommended and adopted, resulting in a package of noise-reduction measures for the Airport. Many diverse interests were represented in this process, including Airport users, tenants, citizens from throughout the area, the FAA, and pilots. The package contained both short-term and long-term measures to reduce aircraft noise by at least 50 percent by 2001. In 1990, the Port Commission adopted these recommendations.

The "package" contains many elements for noise reduction, including:

- Implementing a "noise budget" or allocation of noise for the Airport and airlines that will decrease over time. The budget limits and controls aircraft noise and accelerates the use of the new Stage III aircraft.

- Restricting nighttime use of Stage II aircraft. For the first two years of the program, no new Stage II aircraft flights were introduced between midnight and 6:00 a.m. On October 1, 1995, the restriction became fully implemented with no Stage II flights between 10:00 p.m. and 7:00 a.m.

- Doubling the rate of the Port's existing sound-insulation program (The Noise Remedy Program) and changing the "cost-share" insulation area to 100-percent Port funded.

- Control of aircraft ground noise by restricting use of engine power for backing aircraft away from gates, improving run-up regulations, investigating the reduction of reverse thrusts, limiting use of auxiliary power units, and erecting a "hush" facility if a maintenance base is built at the Airport.

- Implementation of a state-of-the-art flight track monitoring system to better monitor compliance with noise abatement flight track procedures.

- Improvement of flight procedures through the Elliott Bay corridor and over Puget Sound to minimize jet noise to adjacent residential areas, with special attention to nightime flights.

- Control of noise from "single-event" aircraft operations that are particularly annoying by improving the Port's complaint hotline and monitoring system.

- Establishment of a Noise Abatement Committee to ensure implementation of the agreement.

Since the adoption of the Noise Mediation recommendations and the last FAR Part 150 Update, the Noise Acquisition Program, now completed, has resulted in the acquisition of approximately 1,328 homes and 103 vacant lots at a cost of approximately $119 million. The Noise Remedy Program offers soundproofing to the 10,000 homes within the existing program boundaries. There have been approximately 6,228 homes insulated for a cost of approximately $125 million. The Noise Remedy Boundary Map is shown on the following illustration, Figure A6, *NOISE REMEDY BOUNDARY MAP.*

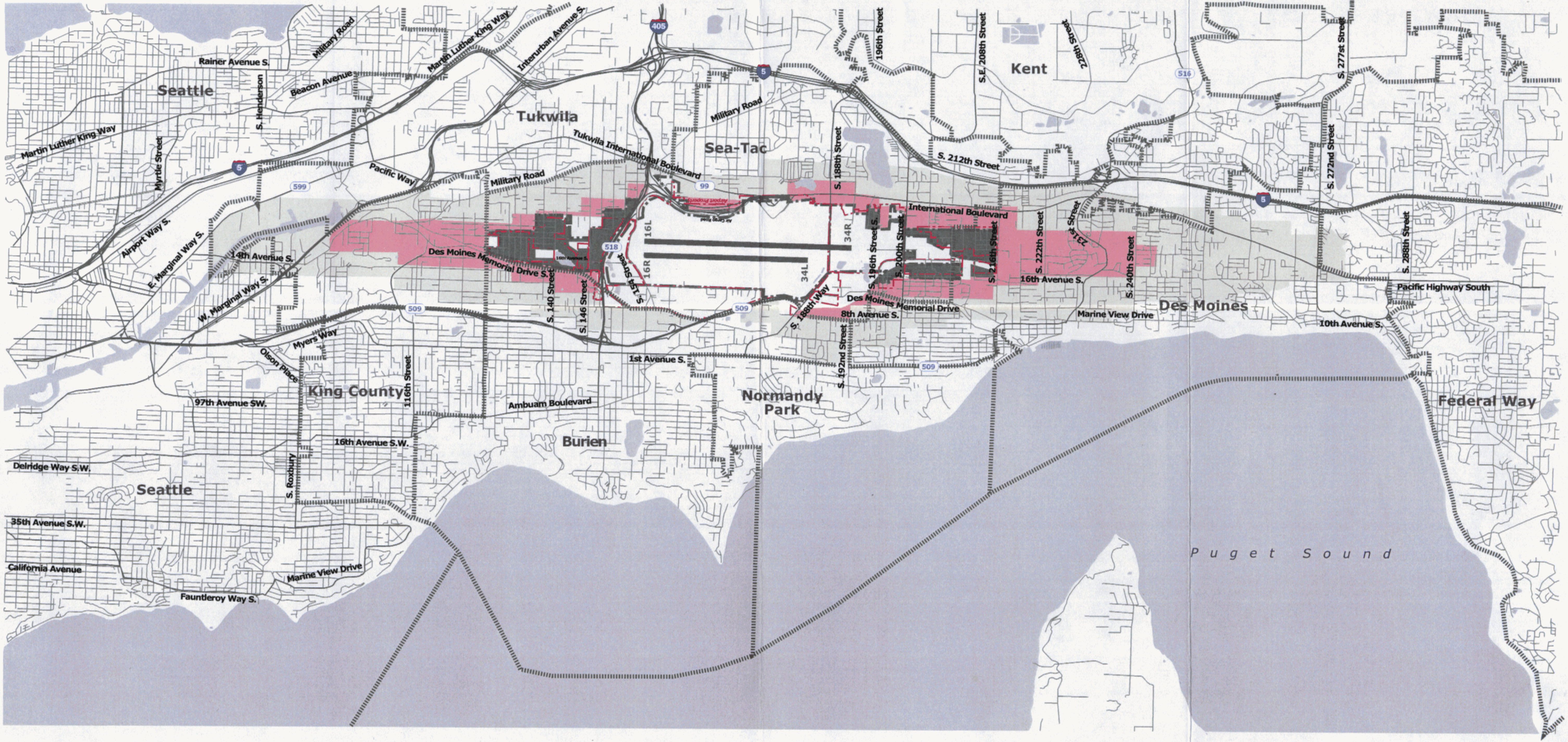
More detailed information concerning these programs is found in the Appendix. Based on the programs developed through the Noise Mediation Project, various airlines have been fined for violating the Agreement. These fines have generally been a result of two types of violations, engine run-ups and exceeding nighttime Stage II aircraft limitations.

Noise Complaint History

The Port of Seattle Noise Abatement Office has been operating a noise complaint hotline since 1987. The purpose of the complaint hotline is to provide the public with a means of contacting the Port concerning aircraft noise and giving Port staff insight into the issues that are important to the community. Citizens may call concerning particular incidents or about aircraft noise in general.

A recent sampling of the noise complaint data, which has been collected since 1987, has been reviewed in order to help identify current issues that are important to the citizens who have contacted the hotline. Noise complaint hotline calls between January 1, 1996 and March 30, 1998 were obtained from the Port in electronic format. The complaint data were then processed in order to map each complaint address, to categorize the complaints, and to correlate the complaint data with flight track data during the time period that flight track data are being analyzed.

The complaint data have been analyzed according to several variables;. location, primary reason, time of day, and the day of week for each call. The hotline calls between January 1, 1996 and March 30, 1998 are summarized in the following tables and figure.



GRAPHIC SCALE IN FEET

0 2,000 4,000 6,000 8,000 10,000

N Approximate Scale 1" = 6,000 '

Figure A6 **Generalized Noise Remedy Boundary Map**

- Airport Boundary
- Acquired Noise Property (Program completed : 1,400 parcels)
- Custom Insulation (Neighborhood Reinforcement Area)
- Standard Insulation

Source: Basemap compiled from Tiger Line Data, 1994.
Port of Seattle, Noise Remedy Program Map

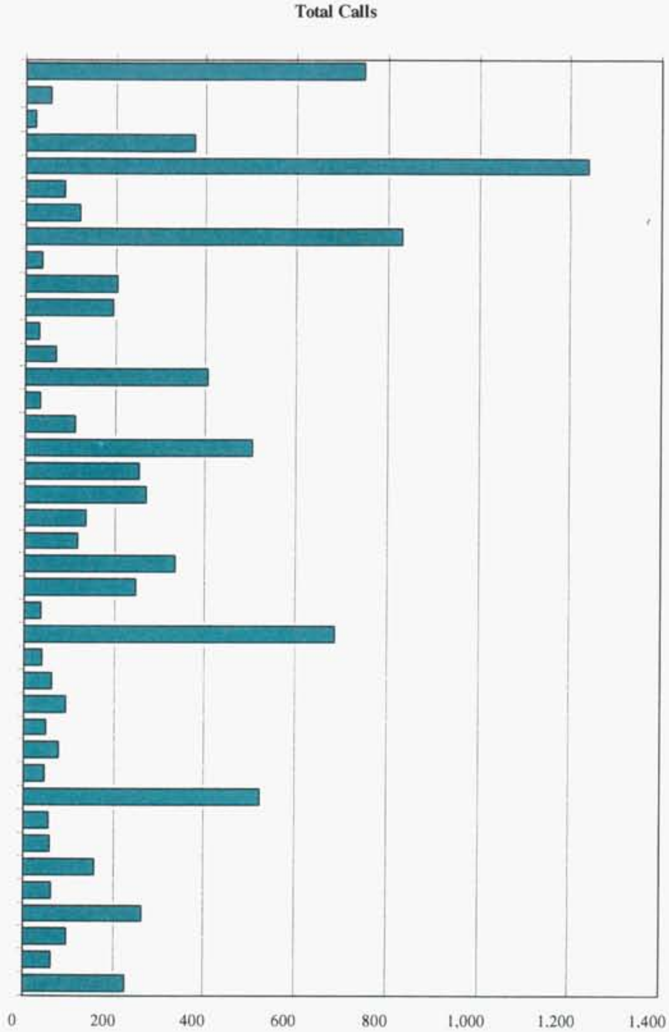
Table A5 presents the total calls received per community as well as the number of individual callers during this 27-month time frame. As is depicted, many of the complaints come from areas not directly under the approach/departure paths of the Airport. The graph at the bottom of the table illustrates the general nature of the disturbance that the caller identified. As can be seen, 42 percent of the complaints were for aircraft being too loud, with complaints of low-flying aircraft accounting for 23 percent, complaints of aircraft being off track accounting for 11 percent, and the remaining complaints concerning nighttime operations, engine run-ups, frequency of operations, and other complaints. For that same period, Figure A7 presents a plot of the location of the noise complaints. Please note that not all callers provide an address, or sufficient information from which an exact position can be determined. This map displays only those calls for which the locations could be determined.

Table A6 presents the number of calls by hour of the day. The hour with the highest number of calls begins at 7:00 a.m. (799 calls), and the hours with the second highest number of calls begin at 8:00 a.m. and 9:00 p.m. (600 calls and 604 calls, respectively). These hours generally correspond to the times that most people are at home.

Table A-5
Noise Complaint Summary
Seattle-Tacoma International Airport
January 1996 through March 1998

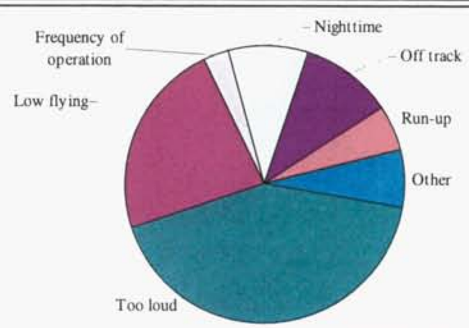
Hotline Calls by Community

Community	Total Calls	Number of Callers
Auburn	747	67
Bainbridge Island	56	12
Ballard	23	12
Beacon Hill/Mt Baker/Leschi	374	116
Burien/Normandy Park	1,240	321
Capitol Hill	86	16
Dash Point	121	9
Des Moines	831	323
Bellevue/East Bellevue	38	26
East Federal Way	204	102
Georgetown	196	60
Highpoint/Delridge	30	14
Issaquah/Cougar Mtn.	67	17
Kent	405	127
Lake City	33	12
Madison Park/Mountlake	111	59
Madrona/Leschi	505	105
Magnolia/Queen Anne	252	92
McMicken Hts/Southcenter	269	134
Medina	137	10
Mercer Island	118	33
North Burien	333	123
Northgate	248	60
Queen Anne Hill/Interbay	38	25
Riverton Heights	686	228
Renton	39	29
Seattle/Pike Place Market	61	32
Seward Park/Mt Baker	94	32
Shilshole Bay/N Ballard	50	18
Skyway	77	9
South Bellevue	45	17
Sunnydale/North Hill	521	145
University District	57	34
Vashon Island	58	25
Wallingford	157	15
West Bellevue/Medina	61	25
West Federal Way	262	68
West Seattle	96	41
White Center/Delridge	61	30
Other	225	139
Total	**9,012**	**2,762**



Nature of Hotline Call Noise Complaint

Nature of Complaint	Total Calls	Percent
Too loud	2,807	42%
Low flying	1,531	23%
Frequency of operation	196	3%
Nighttime	618	9%
Off track	730	11%
Run-up	351	5%
Other	437	7%
Not Reported	2,342	
Total	**9,012**	



N Scale 1"=12,000' Approximately

Figure A7 **Noise Complaint Map**

Noise Commplaint Location

Table A6
TOTAL HOTLINE CALLS, per hour of the day
Sea-Tac International Airport FAR Part 150 Study

Hour of Day	Total Calls	Percent of Total
12 am	277	3.1%
1 am	144	1.6%
2 am	185	2.1%
3 am	238	2.6%
4 am	244	2.7%
5 am	246	2.7%
6 am	349	3.9%
7 am	799	8.9%
8 am	600	6.7%
9 am	429	4.8%
10 am	422	4.7%
11 am	430	4.8%
12 pm	334	3.7%
1 pm	413	4.6%
2 pm	372	4.1%
3 pm	407	4.5%
4 pm	260	2.9%
5 pm	257	2.9%
6 pm	397	4.4%
7 pm	408	4.5%
8 pm	477	5.3%
9 pm	604	6.7%
10 pm	398	4.4%
11 pm	322	3.6%
Total	**9,012**	**100%**

Table A7 presents the number of calls per day of the week. Typically one might expect more calls on the weekends when most people are at home, however, that is not the case for Sea-Tac. All days are about equal, with Monday having the highest number of calls and Saturday the lowest.

Table A7
TOTAL HOTLINE CALLS PER DAY OF THE WEEK
Sea-Tac International Airport FAR Part 150 Study

Day of Week	Total Calls	Percent of Total
Sunday	1,287	14
Monday	1,393	15
Tuesday	1,203	13
Wednesday	1,315	15
Thursday	1,344	15
Friday	1,314	15
Saturday	1,159	13
Total	**9,012**	**100**

Table A8 presents an analysis of how often individual people called. The data show that 1,727 people called once, while there was one person who called 349 times. This information helps illustrate that 63 percent of the individuals that called the hotline during that time period called only once. Based on the data analysis, it appears that a small number of individuals called repeatedly.

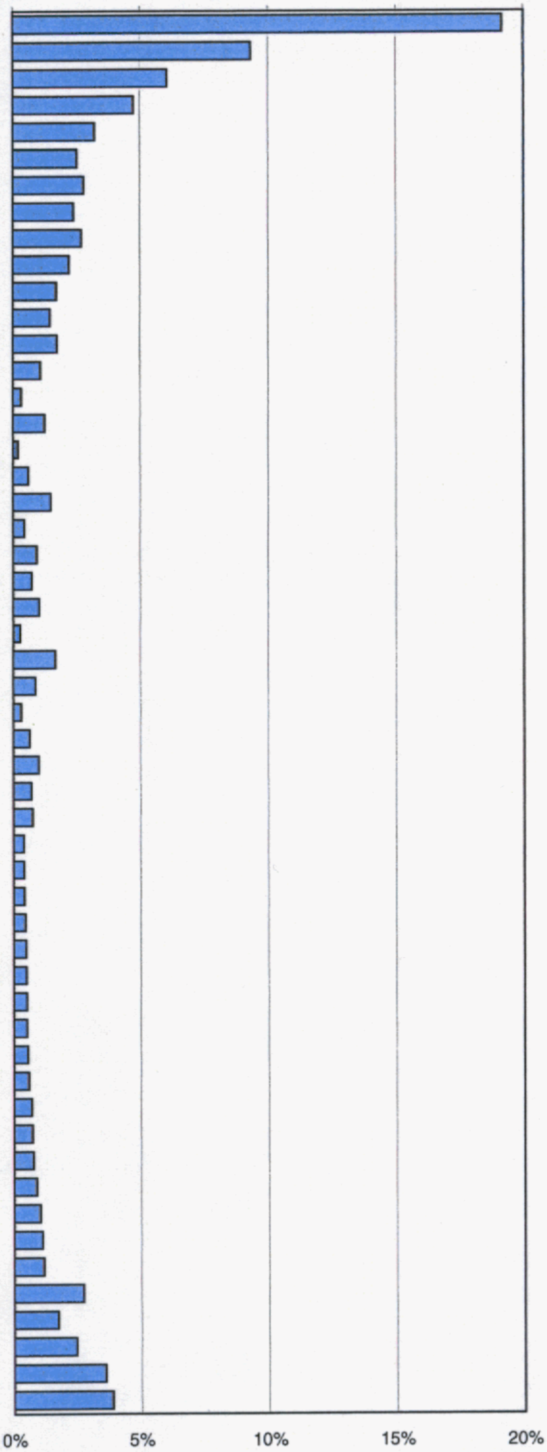
Airport Environs

Sea-Tac is within the city limits of the City of SeaTac. Several other incorporated communities adjoin the City of SeaTac or are, or could be, within the 65 DNL noise-exposure contour associated with aircraft operations at Sea-Tac. These communities include Seattle, Tukwila, Des Moines, Normandy Park, Federal Way, Burien, and Kent, along with portions of unincorporated King County. This Study will utilize a variety of graphics to present information, and two different base maps will be used. The Study Area map depicts the entire region on an aerial photo at a small scale, and the Detailed

Table A-8
Noise Complaint Statistics Report
Seatac International Airport
Period: January 1, 1996 to March 31, 1998

Complaints per Caller	Number of Callers	Total Number of Complaints	% of All Callers	% of All Complaints
1	1727	1727	63%	19%
2	420	840	15%	9%
3	182	546	7%	6%
4	107	428	4%	5%
5	58	290	2%	3%
6	38	228	1%	3%
7	36	252	1%	3%
8	27	216	1%	2%
9	27	243	1%	3%
10	20	200	1%	2%
11	14	154	1%	2%
12	11	132	0%	1%
13	12	156	0%	2%
14	7	98	0%	1%
15	2	30	0%	0%
16	7	112	0%	1%
17	1	17	0%	0%
18	3	54	0%	1%
19	7	133	0%	1%
20	2	40	0%	0%
21	4	84	0%	1%
22	3	66	0%	1%
23	4	92	0%	1%
24	1	24	0%	0%
25	6	150	0%	2%
26	3	78	0%	1%
28	1	28	0%	0%
29	2	58	0%	1%
30	3	90	0%	1%
32	2	64	0%	1%
34	2	68	0%	1%
36	1	36	0%	0%
37	1	37	0%	0%
39	1	39	0%	0%
42	1	42	0%	0%
44	1	44	0%	0%
45	1	45	0%	0%
46	1	46	0%	1%
47	1	47	0%	1%
50	1	50	0%	1%
53	1	53	0%	1%
64	1	64	0%	1%
66	1	66	0%	1%
69	1	69	0%	1%
81	1	81	0%	1%
93	1	93	0%	1%
100	1	100	0%	1%
105	1	105	0%	1%
123	2	246	0%	3%
157	1	157	0%	2%
221	1	221	0%	2%
324	1	324	0%	4%
349	1	349	0%	4%

Percent of All Complaints



Study Area map presents land use information at a larger scale for more detailed analysis. The Detailed Study Area map will be used for detailed analysis within the 65 DNL noise-exposure contour. The Study Area map will be used for larger contour and supplementary noise metric analysis, and is presented at the conclusion of this Chapter, as Figure A12.

Existing Land Use

The recently completed Environmental Impact Statement for the proposed new runway documented existing land uses for the area surrounding the Airport. This information will be used for this Part 150 Study Update, however, generalized land use information will be presented and evaluated within a larger area for this Study. Within the detailed study area, there is a significant number of residential developments (single-family, multi-family, and mobile home units), in addition to other noise-sensitive land uses including schools, churches, hospitals, nursing homes, and libraries. Preliminary existing land use is presented in Figure A8, *GENERALIZED EXISTING LAND USE, DETAILED STUDY AREA*. The area beyond the 65 DNL noise-exposure contour will be evaluated to a more generalized extent.

Existing land use to the north of the Airport is a mixture of airport-related development, including some commercial and some residential development. To the south of the Airport, there is open space, single-family residential, a large number of multi-family residential, and public facilities uses. To the east of the Airport, especially along International Boulevard, there is intensive commercial development with residential development, both single- and multi-family, east of the commercial strip on International Boulevard. West of the Airport is primarily single-family residential development with commercial and public facility uses to the southwest. A more detailed evaluation of land use and population will be presented as it relates to the noise-exposure contours where the contours are presented.

In summary, there are significant areas of existing, and some potential, non-compatible land uses within the immediate airport environs. These non-compatible uses include, for the most part, residential development off the ends of the existing runways. Many of these residential structures are being addressed by the existing Noise Remedy Program.

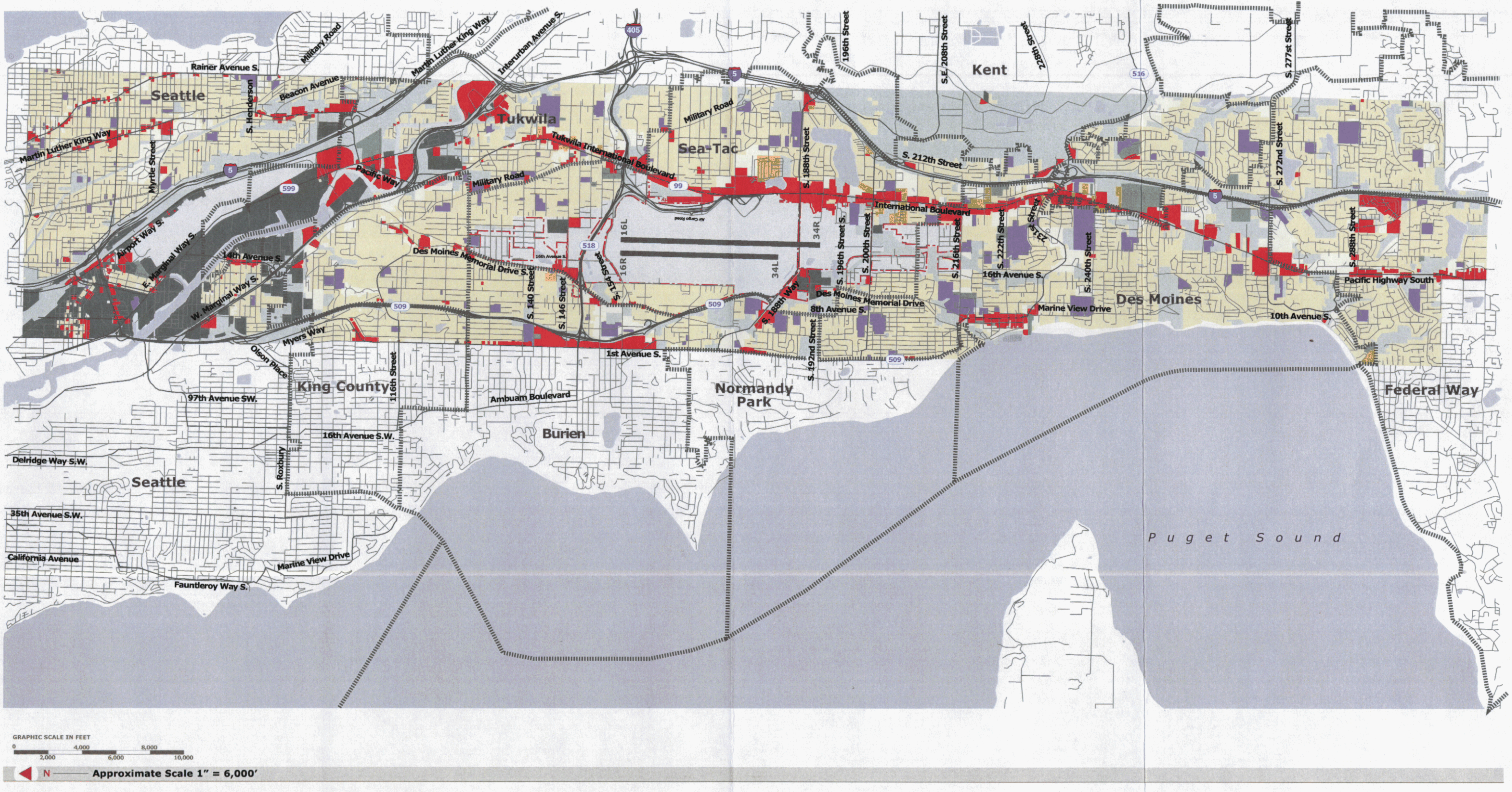


Figure A8 **Generalized Existing Land Use Detailed Study Area**

- Single-Family Residential
- Multi-Family residential
- Mobile Home Park
- Commercial
- Public Facilities
- Governmental Services
- Water Resources and Recreation
- Airport
- Industrial
- Open Space, Parks, Cemeteries
- Agricultural Land and Freeways

Source: Basemap compiled from Tiger Line Data, 1994.
Generalized Existing Land Use, Gambrell Urban, Inc., EIS Master Plan, 1997.

Future Land Use

Each of the jurisdictions within the vicinity of Sea-Tac has adopted future land use plans or guidelines, pursuant to the Washington State Growth Management Act. Generally, the Act directs the surrounding jurisdictions to develop future land use plans compatible with airport operations. The future land use plans for each of these communities are discussed in the following paragraphs.

City of SeaTac

The City of SeaTac adopted its Comprehensive Plan in December 1994, with subsequent amendments in December 1995 and December 1996. The existing Plan has been in effect since December 1996 and contains land use and transportation policies for the area immediately surrounding Sea-Tac Airport. It also identifies the Airport as an essential public facility. The Plan also contains the following Goal and Policy language related to the Airport

> **Goal**: To achieve a reasonable level of compatibility between airport activities and adjacent land uses.
>
> **Policy**: Encourage land uses adjacent to Sea-Tac International Airport that are compatible with airport operations.

The Plan includes a set of noise-exposure contours associated with aircraft operations at Sea-Tac Airport that have been used to guide the future land use plan. The adopted Future Land Use Plan is illustrated in Figure A9, *GENERALIZED FUTURE LAND USE.*

City of Des Moines

The City of Des Moines adopted the Greater Des Moines Comprehensive Plan in December 1995 by Ordinance 1160, with portions amended by Ordinance 1176. The Plan contains several policies addressing Sea-Tac and presents several Preferred Land Use Plans for specific areas within the City of Des Moines.

> **Policy 8-03-01 (3):** Adopt appropriate plans, zoning, development and building regulations and review procedures to ensure that designated residential neighborhoods will not be exposed to environmental noise levels that exceed an Ldn of 55 dBA [more commonly referred to as 55 DNL], or existing noise levels as of April 20, 1995, whichever is greater. A reduction in the environmental noise level (greater than 55 DNL) that existed as of April 20, 1995 should become the new maximum environmental level.

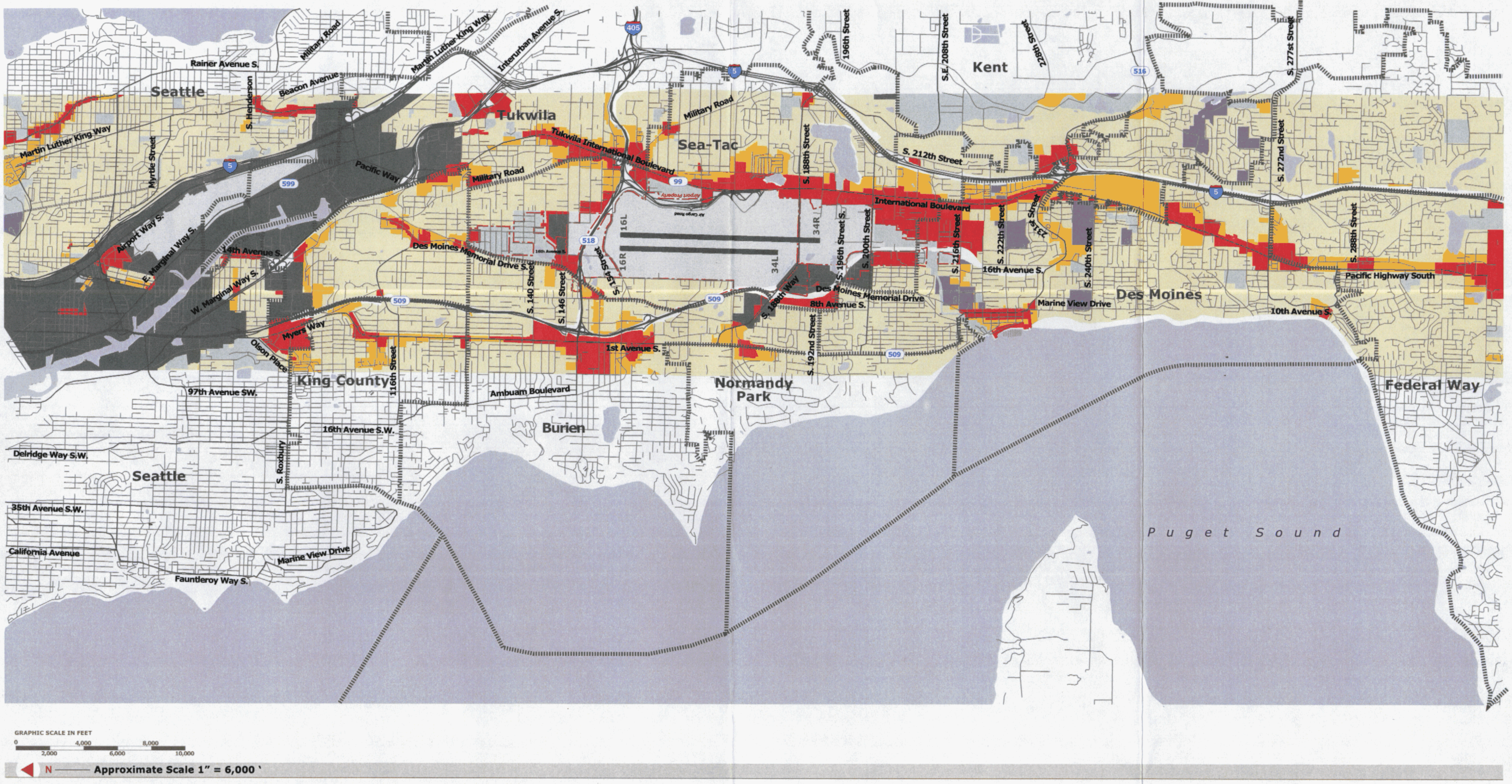


Figure A9 **Generalized Future Land Use Detailed Study Area**

- Low Density Residential
- Medium/High Density Residential
- Commercial
- Industrial
- Airport
- Parks and Open Space
- Institutional

Source: Basemap compiled from Tiger Line Data, 1994.
Generalized Future Land Use, Gambrell Urban, Inc., EIS Master Plan, 1997

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Policy 8-03-02 (3): In order to minimize adverse impacts related to noise, protect historic properties and archaeological sites of local significance from environmental noise-exposure levels that exceed an Ldn of 55 dBA, or existing levels as of April 20, 1995, whichever is greater. A reduction in the environmental noise level (greater than 55 DNL) that existed as of April 20, 1995 should become the new maximum environmental level.

Policy 6-03-23: In order to minimize adverse impacts related to noise, Des Moines' parks and recreation areas of local significance should be protected from exterior noise-exposure levels that exceed an Ldn of 55 dBA, or the Ldn in existence on the effective date of this Element, whichever is higher; except that golf courses, ball fields, outdoor spectator sports areas, amusement areas, riding stables, nature trails, and wildlife refuges should be protected from exterior noise exposure levels that exceed an Ldn of 60 dBA, or the Ldn in existence on the effective date of this Element, whichever is higher. A reduction in the exterior noise level (greater than 55 dBA or 60 dBA as applicable) that existed as of April 20, 1995 shall become the new maximum exterior noise level.

Policy 8-03-04:

(1) Discourage the introduction of noise levels that are incompatible with current or planned land uses. Encourage the reduction of incompatible noise levels, and discourage the introduction of new land uses into areas where existing noise levels are incompatible with such land uses.
(2) Encourage the reduction of noise from Seattle-Tacoma International Airport.
(3) Campaign aggressively for the development of new and quieter aircraft engines as well as modifications and/or retrofitting programs that promote the greatest reductions possible in aircraft noise emission levels.
(4) Require that noise levels generated from all land uses be restricted to the most stringent of federal, state and local standards.
(5) Require buffering of noise and cleansing of air from land uses that are highly noise generating and air polluting through substantial berming, landscaping, setbacks, tree planting, and building construction and siting methods.
(7) Within the North Central Neighborhood, encourage land uses and construction techniques that are tolerant of and compatible with the high noise and vibration levels generated by aircraft.

As an integral part of these Policies, the City has adopted various Strategies to help implement the Policies. In addition, the City has also adopted a specific set of Policies and Strategies for the North Central Neighborhood, which contains a portion of the Port's home acquisition area. The City does not directly identify Sea-Tac as an Essential Public Facility, but addresses the Airport in Policy 5-03-05.

Policy 5-03-05: City plans and development regulations should identify, and provide a process for consideration of, the siting of essential public facilities. Essential public facilities should include: A) domestic water, sanitary sewer, public schools, and fire protection; B) difficult-to-site facilities such as those identified by RCW 36.70A.200 and County-wide Planning Policies; and C) essential state facilities specified by the office of financial management. Des Moines should not accept a disproportionate share of the adverse impacts resulting from air transportation.

City of Normandy Park

The City of Normandy Park adopted the City of Normandy Park Comprehensive Plan in December 1995 by Ordinance 623. The Plan contains Policies that address Sea-Tac and presents a Future Land Use Map, which is illustrated on Figure A4. The Policies presented in the Normandy Park Plan are very similar to those of the City of Des Moines Policies.

Policy 1.6.3: The city shall adopt appropriate plans, zoning, development and building regulations and review procedures to ensure that designated residential neighborhoods will not be exposed to exterior noise levels which exceed an Ldn of 55 dBA, or existing noise levels as of the date of adoption, whichever is greater.

Policy 1.7.3: In order to minimize adverse impacts related to noise, historic properties and sites of local significance shall be protected from exterior noise exposure levels which exceed an Ldn of 55 dBA, or existing levels as of the date of adoption, whichever is greater.

Policy 1.9.1: Discourage the introduction of noise levels which are incompatible with current or planned land uses, encourage the reduction incompatible noise levels, and discourage the introduction of new land uses into areas where existing noise levels are incompatible with such land uses.

Policy 1.9.2: Encourage the reduction of noise from Seattle-Tacoma International Airport.

Policy 1.9.3: Aggressively campaign for the development of new and quieter aircraft engines as well as modifications and/or retrofitting programs which promote the greatest reductions possible in aircraft noise emission levels.

Policy 1.9.4: Take advantage of every opportunity to work with the Port of Seattle and the Federal Aviation Administration to promote the development and implementation of airport operational procedures that will decrease the adverse noise effects of airport operations on the city and its residents.

Policy 1.9.5: Enact city-wide land use compatibility guidelines and criteria for the consideration of noise impacts in all planning and zoning decisions.

Policy 1.9.6: Take appropriate legislative and regulatory action to require noise levels generated from all sources be restricted to the most stringent of federal, state and local standards.

Policy 1.9.7: Take appropriate legislative and regulatory action to require buffering of noise generating land uses through substantial berming, landscaping, setbacks, tree planting, and building construction and siting methods.

Policy 1.9.9: Aggressively seek the support of Congressional representatives to secure Federal Aviation Administration agreement to develop and implement airport operational procedures that will decrease the adverse noise effects of airport operations on the city and its residents.

Policy 1.10.4: In order to minimize adverse impacts related to noise, Normandy Park's park and recreation areas of local significance shall be protected from exterior noise exposure levels which exceed an Ldn of 55 dBA, or the Ldn in existence as of the date of adoption, whichever is higher; except that golf courses, ball fields, outdoor spectator sports areas, amusement areas, riding stables, nature trails, and wildlife refuges shall be protected from exterior noise exposure levels which exceed an Ldn of 60 dBA, or the Ldn in existence as of the date of adoption, whichever is higher.

City of Burien

The City of Burien adopted The Burien Plan in November 1997. The Plan contains policies that address Sea-Tac and presents a Future Land Use Map, which is illustrated on Figure A9. Some of the policies presented in the Burien Plan are very similar to, if not exactly like, the City of Des Moines and the City of Normandy Park policies. In addition, the Burien Plan is based on the forecast that the third runway at Sea-Tac would not be built. The Policies are presented below.

Policy LU 1.9: The City is aware that under the Growth Management Act the City may not preclude through its comprehensive plan the siting of the third runway if a runway (as opposed to an existing airport) is determined to be an "essential public facility." The City also notes that the Growth Management Act, the Central Puget Sound Growth Management Hearings Board, the Countywide Planning Policies, and the State Environmental Policy Act require that there be appropriate and reasonable mitigation for communities adversely impacted by the siting of an essential public facility. Consequently, this plan may need to be amended if the legal issues raised by the City are resolved in favor of construction of the third runway, and provided that appropriate and reasonable mitigation for the adverse impacts of the project on the community are furnished. Such an amendment should only be considered as part of a program by the Port of Seattle to appropriately and reasonable mitigate the impacts of the project on the community. The Sea-Tac International Airport Impact Mitigation Study shall be used as the primary starting point for this mitigation program. In addition, the City will adopt development regulations which will incorporate appropriate and reasonable mitigation requirements to assure that, if the proposed third runway is constructed, it will be consistent with the policies of the Burien Plan..

Policy NO 1.1: The City shall;

- **a.** discourage the introduction of noise levels which are incompatible with current or planned land uses;
- **b.** encourage the reduction incompatible noise levels; and
- **c.** discourage the introduction of new land uses into areas where existing noise levels are incompatible with such land uses.

Policy NO 1.2: The City shall work with other jurisdictions and agencies to encourage the reduction of noise from Seattle-Tacoma International Airport.

Policy NO 1.3: The City shall aggressively campaign for the development of new and quieter aircraft engines as well as modifications and/or retrofitting programs which promote the greatest reductions possible in aircraft noise emission levels.

Policy NO 1.4: The City shall take advantage of every opportunity to work with the Port of Seattle and the Federal Aviation Administration to promote the development and implementation of airport operational procedures that will decrease the adverse noise effects of airport operations on the City and its residents.

Policy HT 1.5: In order to minimize adverse impacts related to noise, historic properties and sites of local significance shall be protected from exterior noise exposure levels that exceed a Ldn of 55 dBA.

City of Tukwila

The City of Tukwila adopted a Comprehensive Land Use Plan in December 1995. The Plan contains a Comprehensive Land Use Plan, illustrated on Figure A4, that depicts future land uses. The City has adopted several policies addressing aircraft noise, very similar to other communities.

Policy 7.2.5: Encourage the reduction of noise from Seattle-Tacoma International Airport and King County Airport, by promoting the development of new or the retrofit and modification of existing aircraft engines which are quieter, and operational procedures that help reduce aircraft noise emission levels.

Policy 7.2.6: Work with the Port of Seattle, King County Airport and the Federal Aviation Administration to promote the development and implementation of airport operational procedures that will decrease the adverse noise effects of airport operations on Tukwila and its residents.

City of Federal Way

The City of Federal Way adopted the City of Federal Way Comprehensive Plan Draft in November 1995. The Plan contains a Comprehensive Plan Land Use Map reflecting future land use designations and is reflected on Figure A4. The Plan contains an Aviation section of the Transportation Element. However, it pertains mostly to helicopters and placement of heliports in the City. There is one policy that addresses the regional airport.

Policy TP76: Continue to represent the community in matters pertaining to the regional airport(s).

City of Kent

The City of Kent adopted the City of Kent Comprehensive Plan in April 1995 by Ordinance Number 3222. The Plan contains goals and policies for community development, and a Land Use Plan Map that depicts generalized future land uses. The Plan does not contain any goals or policies addressing Sea-Tac or any noise-exposure contours associated with the Airport. The Plan does not address the Airport as an essential public facility.

King County

King County adopted the King County Comprehensive Plan in November 1994 and updated it in 1997. The Plan contains several policies pertaining to new essential public facilities or the expansion of existing essential public facilities. However, the Plan does not address aircraft-related noise issues or how such noise affects land use development in the county. The Plan contains one policy addressing aviation under Chapter Nine, Transportation, Section H Aviation, Freight, and Ferries;

Policy T-540: Regional aviation facilities play a foundational role in promoting a strong regional economy as well as providing significant direct and indirect employment opportunities to residents of the County and Puget Sound region. Consistent with this plan's policies concerning the siting of essential public facilities, King County should work with the Puget Sound Regional Council and its members to ensure that any regional projected capacity problems, and the air transportation needs of the region's residents and economy are addressed in a timely manner. Siting decisions must be consistent with the Regional Airport System Plan, the Countywide Planning Policies and this Plan.

City of Seattle

The City of Seattle adopted a comprehensive plan, Seattle's Comprehensive Plan, Toward a Sustainable Seattle, in July 1994 and amended it in November 1997. The Plan contains a future land use plan. The Plan is a goals and policy plan. The Transportation Element contains a policy on air transportation:

Policy T5: Work with the state Department of Transportation, public transportation providers, and the public to identify, design, and incorporate noise mitigation measures into existing and planned traffic and transit operations and capital improvements. Encourage air and rail transport operations to reduce and mitigate their noise impact.

Zoning

All of the jurisdictions in the vicinity of Sea-Tac have adopted traditional land use zoning ordinances to control the types of land uses on specific parcels. The ordinances divide a jurisdiction into districts and prescribe certain requirements for allowable uses within those districts. The various zoning codes pertaining to airport-related activities, are presented in the following paragraphs. Figure A10, *GENERALIZED EXISTING ZONING*, presents the zoning districts for the various jurisdictions.

The area immediately surrounding the Airport within the jurisdiction of the City of SeaTac is generally zoned Industrial, Commercial along SR 99, Urban High to Medium Density adjacent to SR 99 and Airport Use and Aviation Business Center in areas adjacent to the Airport. Single-family development is currently zoned as Urban Low, and is mostly west of the Airport.

Burien has generally zoned the majority of its jurisdiction as single- and multi-family residential, with Commercial zoning along First Avenue South.

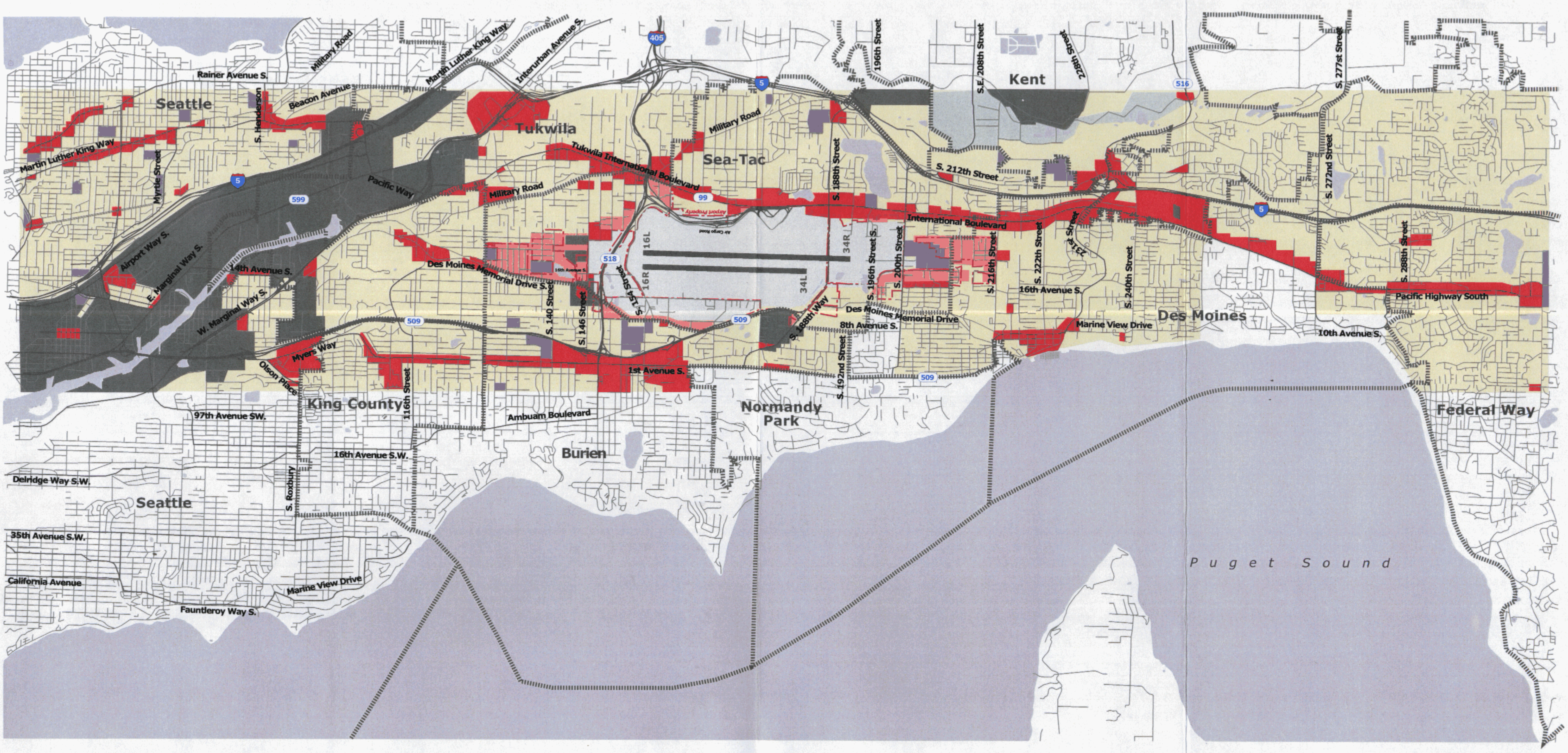
Des Moines is generally zoned for single-family housing except for the downtown and marina areas, and along Pacific Highway South, I-5, and arterial streets where commercial and multi-family development is permitted.

Tukwila permits a variety of business, industrial and residential development at various densities.

The zoning for each of these communities is discussed in the following paragraphs.

City of SeaTac

The City of SeaTac has an adopted zoning ordinance revised in October 1996 that controls the type of land uses allowed on specific parcels. The ordinance contains two use zones that address the Airport directly, Airport Use Zone and Aviation Business Center Zone.



GRAPHIC SCALE IN FEET
0 2,000 4,000 6,000 8,000 10,000

N —— Approximate Scale 1" = 6,000 '

Figure A10 **Generalized Existing Zoning Detailed Study Area**

- Residential/Mobile Home Park
- Commercial/Office
- Industrial
- Public/Parks
- Aviation Operations
- Aviation Commercial
- Open Space, Parks, Cemeteries
- Agricultural Land and Freeways

Source: Basemap compiled from Tiger Line Data, 1994.
Generalized Existing Zoning, Various Communities Zoning Maps.

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Airport Use Zone. The purpose of this zoning designation is to provide for the Seattle-Tacoma International Airport, and for various airport-related facilities, operations, businesses and activities that support airport operations.

Aviation Business Center Zone. The purpose of this zone is to promote a major commercial center supporting high concentrations of customers, visitors, employees, and pedestrian activity; to create a quality development in which people can work, shop and access child care; and to create a market geared toward a business orientation to the Airport which is compatible with airport operations.

These purposes are accomplished by encouraging flexible development programs to improve the design, character, and quality of new development; facilitating the provisions of streets and utilities; preserving natural and scenic features; establishing minimum lot sizes to encourage projects of sufficient scale to increase the viability of high capacity transit and encourage ride-share alternatives; and promoting a balanced multi-modal transportation network consisting of motor vehicle transportation, public transportation, pedestrian circulation, and integrated parking.

The Code also contains the following General Performance Standard provision addressing noise.

15.18.020: Due to the proximity of the Airport facilities, residential construction shall have sound attenuated or limited as consistent with adopted Port of Seattle/FAA noise remedy programs within significant LDN contours.

In addition to the above provisions, the City of SeaTac and the Port of Seattle entered into an Interlocal Agreement concerning several issues of importance to both entities, one of which was land use and zoning. The Port and the City adopted the planning, land use and zoning provisions set forth in the Agreement in Exhibit A. The Agreement was dated September 4, 1997. The following Zoning/Land use/Development Regulations statement is included in the Agreement:

2.1 **Land Use/Zoning Map**. The Port Commission and City Council each shall adopt a coordinated land use map that (a) shall be implemented by the City's zoning map; (b) is updated to recognize the Port's Master Plan; (c) resolves any discrepancies on the permitted uses of Port-owned property on the perimeter of the Airport; and (d) reflects the City land use decisions that affect the Airport. Both the City Council and the Port Commission shall adopt the coordinated land use map on or before December 31, 1997.

2.2 **Zoning Uses.** The Port and City agree upon the two zones and uses for Port-owned Property as set forth in Attachment A-2: "Aviation Operation" and "Aviation Commercial".

The Agreement contains many other land use and development standards and procedures, along with many other areas of shared concerns, including Surface Water Management, Critical Areas, Transportation, State Environmental Policy Act, Police, Material Haul, and Master Plan Community Relief.

City of Des Moines

The City of Des Moines has an adopted zoning ordinance, with the latest revision being in February 1997. The code contains a Noise Levels Chapter, 18.38 with two sections dealing with noise levels in residential neighborhoods.

> **18.38.020:** Residential neighborhoods shall not be subject to adverse land uses, activities or traffic that generate exterior noise exposure levels exceeding 55 Ldn dBA, or existing levels as of April 20, 1995, whichever is greater. A reduction in the exterior noise level (greater than 55 Ldn) that existed as of April 20, 1995 shall become the new maximum exterior noise level.

> **18.38.030:** Proponents of projects that will increase exterior noise levels to which residential areas are exposed to levels exceeding those existing on April 20, 1995, or to levels exceeding an Ldn of 55 dBA, which ever is greater, must submit a noise mitigation plan to the community development department of the city for review and approval before required permits are issued to allow the project to proceed.

City of Normandy Park

The City of Normandy Park has an adopted zoning ordinance which addresses noise levels in three chapters; Chapter 18.68 Residential Neighborhoods-Noise Protection, Chapter 18.72 Landmark Protection and Preservation, and Chapter 18.76 Parks of Local Significance.

18.68.030: Residential neighborhoods shall not be subject to adverse land uses, activities or traffic that generate exterior noise exposure levels exceeding 55 Ldn dBA, or existing levels as of the effective date of the ordinance codified in this chapter, whichever is greater.

18.68.040: Proponents of projects that will increase exterior noise levels to which residential areas are exposed to levels exceeding those existing on the effective date of the ordinance codified in this chapter, or above an Ldn of 55 dBA, which ever is higher, must submit a noise mitigation plan to the city planning department for review and approval before required permits are issued to allow the project to proceed.

18.72.040: Significant sites, districts, buildings, structures and objects shall not be subject to adverse land uses which generate exterior noise exposure levels exceeding an Ldn of 55dbA, or existing levels as of the effective date of the ordinance codified in this chapter, whichever is greater.

18.72.050: Proponents of projects that will increase exterior noise levels to which significant sites, districts, buildings, structures are exposed to levels exceeding those existing on the effective date of the ordinance codified in this chapter, or above an Ldn of 55 dBA, which ever is higher, must submit a noise mitigation plan to the city planning department for review and approval before required permits are issued to allow the project to proceed.

City of Tukwila

The City of Tukwila has adopted a zoning ordinance that does not address aircraft-related noise issues in relationship to land uses.

City of Federal Way

The City of Federal Way has adopted a zoning ordinance with various updates and amendments. The ordinance addresses noise in two sections.

> **Section 22-956. Maximum environmental noise levels.**
>
> The city adopts by reference the maximum environmental noise levels established pursuant to the Noise Control Act of 1974.
>
> **Section 22-957. Noise Level Bonds.**
>
> The city may require a bond under section 22-146 et seq. to insure compliance with the provisions of section 22-956.

City of Kent

The City of Kent has an adopted zoning ordinance which addresses noise in general but does not specifically address aircraft noise levels.

> **Section 15.08.050. Performance Standards.**
>
> **D. Restrictions on dangerous and objectionable elements.**
>
> 1. *Noise.* At the points of measurement specified in Subsection C. of this section, the maximum sound pressure level radiated in each standard octave band by any use or facility, other than transportation facilities or temporary construction work, shall not exceed the values for octave bands lying within the several frequency limits given in table I after applying the corrections shown in table II...

The section goes on to identify certain noise levels that cannot be emitted by land uses and specific functions within those uses. Aircraft and airports are not mentioned and appear to be exempt.

King County

King County has an adopted zoning ordinance that addresses land use development within King County, the King County Zoning Code, Title 21A. The Code was last amended in March 1998. The Code contains provisions for Special District Overlay Zones.

21A.38.160. Special District Overlay-Aviation Facilities. A. The purpose of the aviation facilities special district overlay is to protect existing non-commercial airports from encroaching residential development. Aviation facilities special district overlay shall only be established in the area up to ¼ mile around airports and shall be zoned UR or RA.

B. The following development standards shall apply to uses locating in aviation facilities special overlay districts: On the title of all properties within pending short subdivisions or subdivisions and binding site plans, the following statement shall be recorded and be shown to all prospective buyers of lots or homes: "This property is located near the (name of airport) which is recognized as a legitimate land use by King County. Air traffic in this area, whether at current or increased levels, is consistent with King County land use policies provided it confirms to all applicable state and federal laws."

Sound Attenuation Requirements

The Cities of Des Moines and SeaTac have building code provisions for sound attenuation of new structures within noise-exposure contours. King County also has sound attenuation requirements for new construction within the noise-exposure contours. Copies of these provisions are in the Appendix.

The City of Des Moines has two different sound transmission control areas. Area 1 is all portions of the city north of South 252^{nd} Street or its extension and Area 2 is all of the city south of South 252^{nd} Street. Area 1 requires a 35-decibel reduction and Area 2 requires a 30-decibel reduction. The City has adopted specific requirements to achieve these reductions.

The City of SeaTac refers to the Port's Noise Remedy Area Boundaries to define areas of sound attenuation. The requirements are for new construction and additions to structures. The requirements in the Neighborhood Reinforcement Area are for bedrooms to achieve a 35-decibel reduction and all other areas must achieve a 30-decibel reduction. In the Standard Insulation Area, bedrooms must achieve a 30-decibel reduction and all other areas must achieve a 25-decibel reduction. King County requirements are the same as the City of SeaTac and reference the same Noise Remedy Boundaries.

Land Use Controls Evaluation

Land use planning and development controls offer ways through which the county, cities, and the Airport may achieve certain objectives. These measures involve the various opportunities and options that are available for influencing, directing, managing, and controlling the type and sequence of development within the Airport environs. The various techniques and mechanisms range from fee simple land acquisition programs to more advanced regulatory mechanisms and advisory programs. Each different mechanism is useful in accomplishing desired objectives and can be used separately or in concert with others as the situation dictates. The following is a discussion of the land use planning and control measures available for consideration.

Fee Simple Land Acquisition

Fee simple land acquisition is often the most effective means available to an airport or community for controlling land use development and ensuring compatibility, however, it is also the most expensive. Land acquisition can be accomplished through negotiation and purchase from the owner or through condemnation proceedings. Although it is the most expensive, resale for a compatible use or joint purchase with another government agency for a compatible public use may help reduce the net cost of the property.

Condemnation of property is available to the Port as a means of acquiring property. Condemnation is subject to the legal finding that it is for a public purpose, although this has traditionally been broadly defined by the courts. In fact, the acquisition of airspace by eminent domain is a proper use (*Port of Olympia v. Deschutes Animal Clinic, Inc.*, 1978, 19 Wash. App. 317). Washington Statutes specifically state that land for airports can be acquired by eminent domain (RCWA 14.08.030). If condemnation is used or outright purchase is made with the assistance of federal funds, provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (URARPAPA, P.L. 91-646) would apply. The Act stipulates that homeowners be granted a payment of up to $22,500 to compensate for any differential between the value of the condemnation unit and the cost of comparable replacement housing. Renters are granted up to three-and-a-half years of rent differential. Renters and owners alike are eligible for moving expenses. The federal assistance portion of relocation costs is in the same proportion as whatever grant is involved with the condemnation procedure.

The acquisition of property affected or potentially affected by airport operations is the most effective and efficient means of controlling land use in noise-impacted areas. It is possible that compatible public use could compensate for the direct expenditure of purchasing the property. It should be noted that the acquisition of property is used more often than not in circumstances where the noise situation is critical for the continuation of existing uses or where such preventive measures as comprehensive planning and zoning are not working.

Zoning

Zoning is the most traditional approach, and the most common and widely used legal device to control land use development. It can be defined as "the division of a city (*or county*) by legislative regulation into districts and the prescription and application in each district of regulations having to do with structural and architectural design of buildings and of regulations prescribing use to which buildings within designated districts may be put." This is accomplished through the adoption of a zoning ordinance, which specifies the use, size, height, and bulk of structures within each district. The regulation of land through a zoning ordinance is premised as part of the police power inherent in the state and delegated to the local jurisdiction through state enabling legislation. The county and various communities surrounding the Airport do have the statutory authority to adopt zoning ordinances and maps (RCWA 36.70.010, 36.70A.040 and 35.63.080, and Washington State Constitution, Article 11, §11). As stated earlier, the communities surrounding Sea-Tac have adopted such zoning ordinances, and do control land use within their respective boundaries.

Zoning is a useful tool for controlling land use development and promoting compatibility while supporting private land ownership. Zoning cannot be relied upon as a "corrective measure" as it can only be applied prospectively and not retroactively. Also, because zoning is a creature of a political body and subject to changing conditions and situations, the zoning classification of any particular tract of land is always subject to change.

Zoning can also be used to regulate the height of objects around airports to prevent hazards to navigation. Washington Statutes specifically allow airport sponsors to implement height hazard zoning in certain designated areas within an airport's environs to prevent the establishment of hazards (RCWA 14.12) and the Attorney General has stated that zoning of building heights near an airport is a proper use of police power (Op. Att. Gen. 1953-55, No. 298). The State of Washington has no specific enabling legislation to allow airports or airport sponsors to enact zoning ordinances based on aircraft noise or noise contours. Several states have enacted such enabling legislation, which prevents the encroachment of incompatible land uses within the Airport environs.

In summary, zoning is the most widely used land use control mechanism and offers an acceptable tool for implementing a land use compatibility plan. There are several state statutes that grant zoning authority, which can have an effect on the area around the Airport: RCWA 36.70.10, 36.70A.040, 14.12 and 35.63.060. Zoning can be a time-consuming effort in that the designation of zoning classifications and their implementation must be closely monitored to ensure continuing compatibility.

Comprehensive Planning

A comprehensive plan is an expression of the community's policies and goals toward land use and development, and serves as a guide for policy implementation. As stated earlier, the county and the communities surrounding the Airport have adopted future land use plans to guide development based on Washington Statutes.

In 1990, Washington State enacted the Growth Management Act to address problems caused by rapid population growth and uncoordinated planning efforts throughout the state. The legislation seeks to ensure that population growth and planning for transportation, housing, open space, and other essential services and infrastructure make sense and are compatible. The Act provides a process for siting "Essential Public Facilities" including airports. Two principles of the Act are "consistency" and "concurrency." This means that not only consistent planning policies are required among various county and regional jurisdictions, but that the timing of such planning must occur in a manner that promotes the policies. The legislation currently does not address port authorities and their planning efforts but does require coordinated comprehensive plans for the jurisdictions surrounding Sea-Tac. The Port of Seattle has participated as an ex-officio member of the King County Growth Management Policy Council to facilitate coordination of land use and transportation planning.

A comprehensive plan by itself does little good and cannot control development or relieve noise impacts/incompatibilities without implementing a development plan, but there are other tools available, which are discussed subsequently.

Subdivision Regulations

The county and various communities have adopted subdivision regulations pursuant to the statutes outlined above, which govern the process of changing raw undeveloped land into subdivisions. This is an exercise of the police power by the local unit of government, as is the enactment of a zoning ordinance. To be most effective, subdivision regulations must be coordinated with the comprehensive plan and the zoning ordinance for proper implementation and goal achievement. Subdivision regulations can be used to ensure the granting of an avigation easement as part of the building permit process. In addition, the regulations can be utilized to control utility size and placement, street design, and the timing of the installation of these facilities when coupled with a capital improvements program. It appears that the subdividing of land must conform to the adopted comprehensive plan of a jurisdiction.

Subdivision regulations for the various jurisdictions within the Airport environs were examined. None of the jurisdictions requires notice of any kind on subdivision plats that the subdivision is within the vicinity of an airport and may experience aircraft noise. In addition, there is no requirement to grant an avigation easement to the jurisdiction for aircraft over flights in any of the subdivision regulations.

Easements

An easement is the right of the owner of land to make lawful and beneficial use of the land of another. It is a limited right, not an estate, or fee, in the land of another. Easements are probably the second most desirable, after the fee simple acquisition, as a means of land use control. Easements can be classified as one of two types, depending on what type of interest is involved. A *positive* easement is one in which the owner of the easement has the right to do something with the land, where a *negative* easement is one where the landowner relinquishes his right to do something. The right to construct an access road across someone's property is an example of a positive easement, compared to a landowner who gives up his right to build a tower, which is a negative easement. Many times both positive and negative easements are acquired in the same piece of property.

Easements may be acquired through grant, gift, devise, acquisition, or condemnation. The purchase of an easement in some cases can be as expensive as outright fee simple purchase. Easement acquisition by condemnation is usually restricted to certain types outlined in state enabling legislation and many times noise easements are not specifically mentioned in the legislation. Washington State case law specifically mentions that the acquisition of airspace by eminent domain is a proper use (*Port of Olympia v. Deschutes Animal Clinic, Inc.*, 1978, 19 Wash. App. 317).

Avigation easements are a prime and common example of the type of easement commonly required within the Airport environs. An avigation easement allows aircraft to fly over the property and make noise, and may limit the height of objects on the burdened property within approach areas.

Building Codes

Building codes are regulations that govern the construction practices in any given jurisdiction and which must be followed in order to obtain a building permit from the governing body. Adoption of a building code can provide suitable noise attenuation of new construction throughout the city or county, but sound attenuation for *site-specific* noise exposure areas is not easily accomplished through the building code. However, certain sound-attenuation measures can be included in the building code and referred to for specific areas through the zoning ordinance and subdivision regulations. The code is most easily enforced through the building permit procedure. As stated previously, the cities of SeaTac and Des Moines and King County have specific building code provisions addressing sound attenuation.

Capital Improvements Program

The implementation of capital improvements often encourages growth and development. To avoid incompatible land uses, capital improvements should be programmed to encourage compatible development and discourage incompatible development. Any programs which might discourage noise-sensitive uses should be undertaken in the identified noise zone. This can be particularly effective in directing industrial/commercial development to areas which would be incompatible for residential development.

Decision Matrix

Figure A11, entitled *LAND USE MANAGEMENT DECISION MATRIX*, shows the land use control techniques evaluated and the evaluation criteria used. The modes of comparison are shown as "positive," "negative," or "neutral" and are used to show the outcome of an activity (shown on the left) when compared with the evaluation criteria (across the top). A positive comparison denotes a favorable control technique, while a negative comparison denotes an unfavorable control technique. The matrix is intended to aid the city and county administrators in deciding which control techniques are viable.

State Legislation

The following are State of Washington statutes that may effect land use planning and compatibility with aircraft operations and airports.

State of Washington, Chapter 173-60 WAC

Maximum Permissible Environmental Noise Levels

Land use	Land Use of Receiving Property		
Noise Source	Residential	Commercial	Industrial
Residential	55 dBA	57 dBA	60 dBA
Commercial	57	60	65
Industrial	60	65	70

The maximum permissible levels are:

- ☐ Reduced by 10 decibels at night (10 pm to 7 am) when the receiving land use is residential.
- ☐ Increased by 15 dBA for up to 1.5 minutes, 10 dBA for up to 5 minutes and 5 dBA for up to 15 minutes.

Sounds created by aircraft in flight are exempt.

Sounds from engine testing and maintenance are exempt between the hours of 7:00 a.m. and 10:00 p.m., provided that aircraft testing and maintenance shall be conducted at remote sites whenever possible.

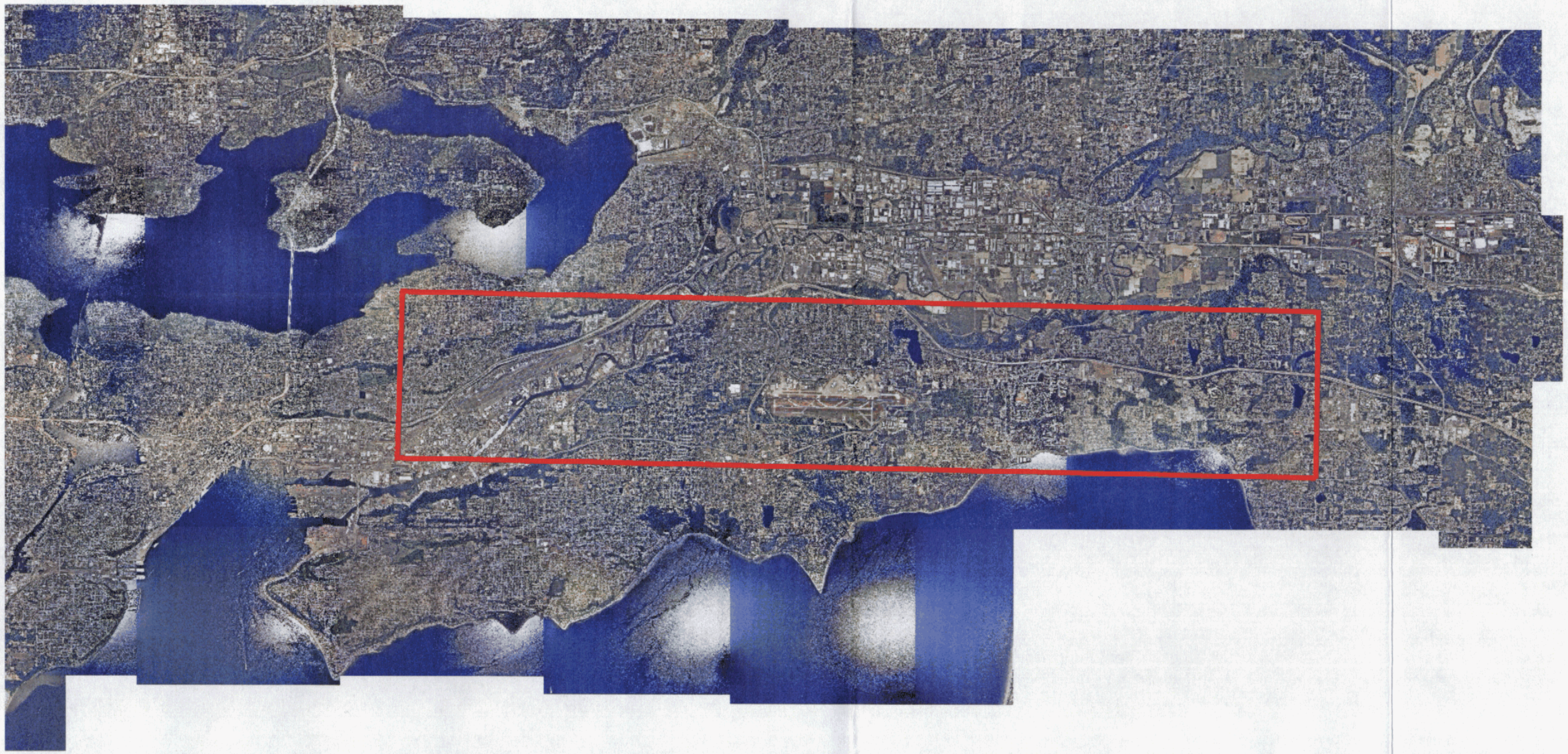
	Public Acceptance	Legal Authority	Litigation Potential	Cost to Airport	Ease of Implementation	Effectiveness	Administration	Political Acceptance	Implementation Time
Land Use Zoning	Positive	Positive	Neutral	Positive	Positive	Positive	Positive	Positive	Neutral
Aircraft Noise Contour Zoning	Negative	Neutral	Neutral	Positive	Neutral	Positive	Neutral	Neutral	Neutral
Subdivision Regulations	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive
Capital Improvements	Positive	Positive	Positive	Positive	Positive	Positive	Neutral	Positive	Positive
Avigation Easement/Dedication	Neutral	Neutral	Negative	Positive	Positive	Neutral	Positive	Positive	Positive
Avigation Easement/Purchase	Neutral	Positive	Neutral	Negative	Negative	Neutral	Negative	Neutral	Negative
Land Acquisition	Neutral	Positive	Neutral	Negative	Negative	Positive	Negative	Neutral	Negative
Comprehensive Plan	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Neutral
Building Code/Sound Attenuation	Positive	Positive	Positive	Positive	Positive	Neutral	Positive	Positive	Positive

Figure A11 **Land Use Management Decision Matrix**

- Positive
- Negative
- Neutral

State of Washington WAC 248-64-240 "Site Approval (Schools)"

This administrative code establishes noise level conditions for proposed new or expanded school sites. It is a Permanent Rule of the Board of Health. The Rule established an hourly LEQ limit of 55 dBA, and an hourly AL limit of 75 dBA during hours when school is in session, except that sites which exceed these sound levels are acceptable if a plan for sound reduction has been submitted and approved. Also, interior levels are not to exceed 45 dBA.



N Scale 1"=12,000' Approximately

Figure A12 **Study Area Map**

Detail Area

B Forecasts

Seattle-Tacoma International Airport

FAR Part 150 Study Update

Forecasts

Aviation Forecast

Background and Executive Summary

One of the key products of an FAR Part 150 Noise Compatibility Plan, are the Noise Exposure Maps (NEMs). The NEMs identify the existing and future noise exposure (five years into the future), and are prepared using the Federal Aviation Administration's Integrated Noise Model (INM). To prepare a noise exposure contour for a particular year, the INM requires information concerning the number of aircraft operations, the types of aircraft (fleet mix) and the time of day that the activity occurs. The forecasts prepared as part of the 1997 Supplemental Environmental Impact Statement for the Master Plan Update Improvements serve as the basis for future activity level projections that will be used in the Part 150 Noise Compatibility Study. The purpose of this working paper is to present the existing level of activity at Seattle-Tacoma International Airport (Sea-Tac) and summarize the future projections of activity.

While a Part 150 Noise Compatibility Study requires an airport to examine projected noise conditions for a period of only five years into the future, the longer-range forecast prepared for the Supplemental EIS is summarized in this paper for informational purposes. Therefore, existing activity (1997 unless so noted) and forecasts for 2000, 2005, and 2010 are presented.

In assessing aviation traffic and demand, the following terms are used:

<u>Enplaned Passengers</u> - passengers boarding aircraft that will be departing an airport. Enplanements are approximately half of total passengers.

<u>Origin-Destination Passenger</u> – passengers who begin or end their trip in the Seattle area.

<u>Total Passengers</u> - the sum of enplanements and deplanements.

<u>Operation or Aircraft Operation</u> - An aircraft arrival or departure from an airport.

Aviation demand forecasting is often incorrectly perceived of as a science, where all variables are predictable and known. However, as is shown by comparing any forecast to conditions that actually occur during the period that was forecast, forecasting is more an art than a science. As a result, precise forecasting for specific future years, particularly years more than 10 years into the future, is very difficult. Aviation demand has been particularly difficult to forecast, due to the volatility of the industry beginning with Deregulation in the late 1970s, through the airline consolidations of the 1980s and the airline financial difficulties of the early 1990s.

It is common for forecasts to show more or less airport activity for a particular year than actually occurs. When forecasts turn out to be different than the subsequent actual experience, it is sometimes the amount of future growth that does not match reality, but much more often it is the difficulty in forecasting the precise timeframe in which specified amounts of growth will occur. Although forecasts for near-term years may not match actual experience, typically those differences are relatively small. For more distant years, forecasting is much more uncertain. This uncertainty is inherent to the nature of forecasting and the nature of the air travel industry and cannot be cured by changing forecasting techniques. Multiple forecasts performed at the same time may reach different conclusions, but there is no reliable way of determining which is more likely to be correct than another. Several forecasts performed for different purposes have been compared and their conclusions are within a reasonable range.

Section 2 of this working paper provides a brief summary of historical and current activity levels. Section 3 summarizes the forecasts that will serve as the basis for the Part 150 Study and Section 4 provides a comparison of several forecasts for Sea-Tac.

Appendix Twenty provides a description of the regression models used in preparing the forecast.

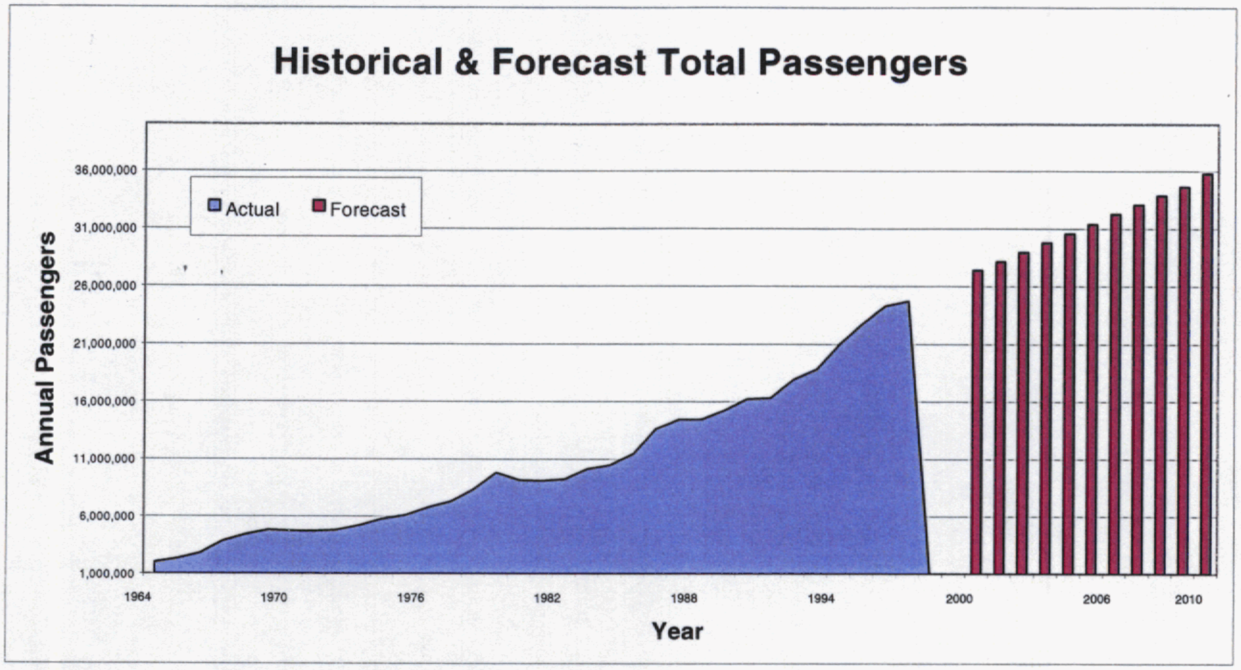
Existing Activity Levels

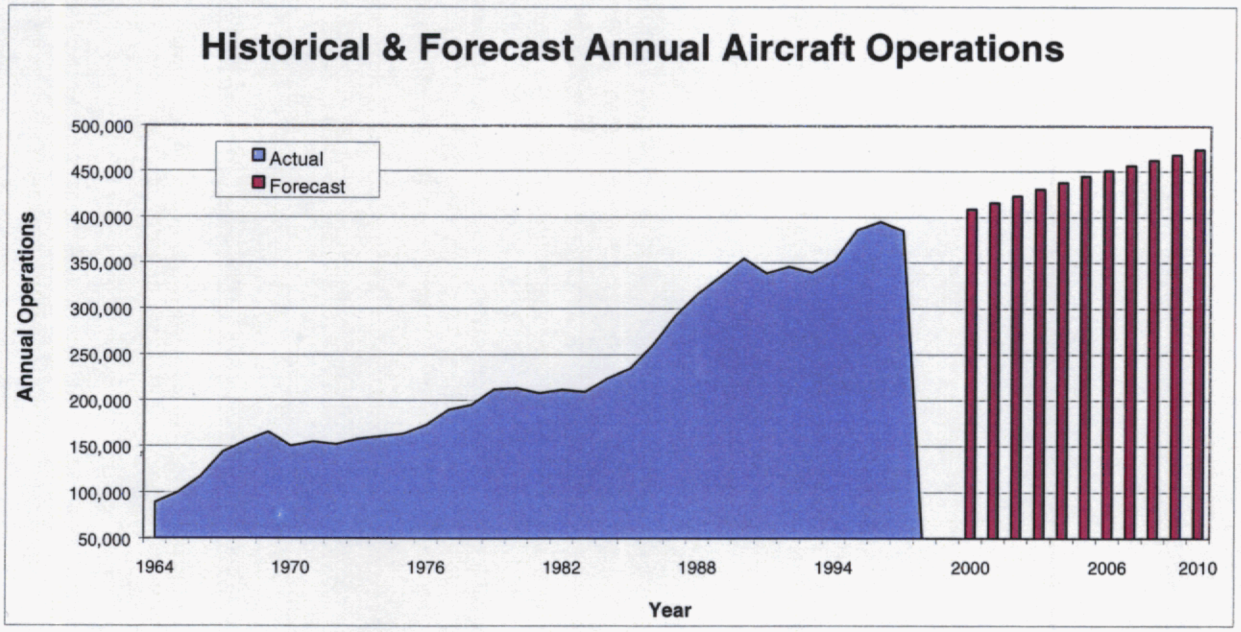
In 1997 Sea-Tac accommodated:

Annual Activity Level	Average Annual Daily Activity
24,738,476 total passengers	67,777 total passengers
12,345,573 enplaned passengers	33,823 enplaned passengers
385,298 aircraft operations	1,056 aircraft operations
393,786 metric tons of cargo	1,079 tons cargo

For each of the last 16 years, passenger activity has continued to grow at Sea-Tac. In 1980, about nine-million passengers were served, while in 1990, passenger activity had grown 77 percent to 16 million passengers. By 1997, passengers had increased to nearly 25 million (a 52 percent increase over 1990 levels). The following figure shows historical total passengers and aircraft operations.

Figure B1


Historical & Forecast Total Passengers
Actual
Forecast
Annual Passengers
36,000,000
31,000,000
26,000,000
21,000,000
16,000,000
11,000,000
6,000,000
1,000,000
1964
1970
1976
1982
1988
1994
2000
2006
2010
Year


Historical & Forecast Annual Aircraft Operations
Actual
Forecast
Annual Operations
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
1964
1970
1976
1982
1988
1994
2000
2006
2010
Year

Sea-Tac is the 24th busiest airport in the United States, as ranked by total aircraft operations and 19th busiest as ranked by total passengers in 1997. Non-stop service is provided to 67 cities in the United States and 15 foreign cities. About 92.5% of passengers using Sea-Tac were destined for domestic cities, while 7.5% were originating from or destined for international locations.

In 1997, on an average day, approximately 1,056 aircraft takeoff and land (referred to as daily operations). During the peak month, average daily operations increases to about 1,196. August continues to be the busiest month in terms of passengers and aircraft operations, with nearly 2.8 million passengers and 37,077 aircraft operations.

In 1993, Sea-Tac was served by 85 percent Stage 3 (quieter category of aircraft) and 15 percent Stage 2 (noisier) aircraft for jets weighing more than 75,000 pounds. By 1995 the percentage of Stage 3 aircraft had reached 92.5 and by 1997 94.3.

Future Activity Levels

Total annual passengers (enplanements and deplanements) are expected to grow as follows:

Year	Total Passengers	% Growth Over 1997
1997	24,738,476	N/A
2000	27,400,000	10.8%
2005	31,400,000	26.9%
2010	35,800,000	44.7%

Based on the annual total passengers, total annual aircraft operations were also projected:

Year	Total Operations	% Growth Over 1997	Average Annual Day Operations
1997	385,298	N/A	1,056
2000	409,000	6.2%	1,120
2005	445,000	15.5%	1,219
2010	474,000	23.0%	1,299

All jet aircraft over 75,000 pounds, are expected to meet Stage 3 aircraft levels by 2000 due to the Federal requirements to phase-out Stage 2 jets and phase-in Stage 3 jets.

Existing and Historical Activity Levels

The rate of air transportation passenger growth at Sea-Tac has outpaced the national rate over the last four decades. Much of this growth has been a function of tremendous population growth in the Puget Sound Region during the same period, shown in Figure B2. The annual rate of population and economic growth in the Region during the 1980s, 70s, 60s, and 50s was nearly double that of the nation.

Figure B2

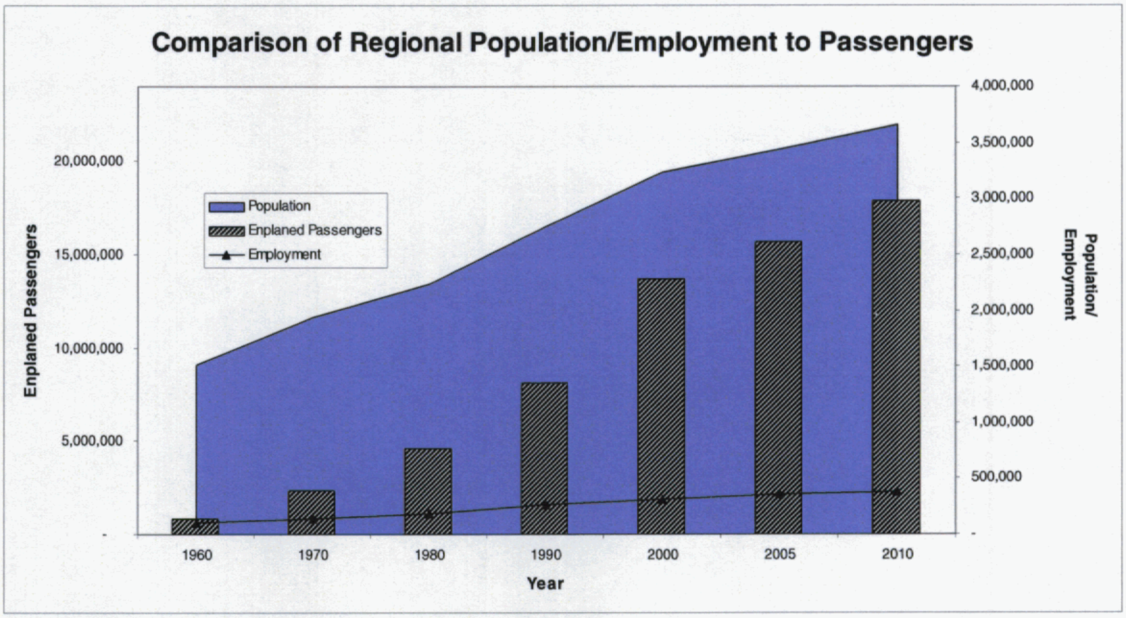


Figure B1showed annual enplaned passengers and total aircraft operations between 1964 and 1997 at Sea-Tac. As shown, the number of enplaned passengers nearly tripled between 1960 and 1970, and doubled between 1970 and 1980. Enplaned passenger levels increased by nearly 170 percent between 1980 and 1997. Enplaned passengers grew from nearly 2.4 million in 1970 to approximately 12.4 million in 1997 (with total passengers reaching 24.7 million).

While passenger demand grew 426 percent between 1970 and 1997, aircraft operations grew at a much slower rate – 156 percent over the same period. Commuter operations during this same period grew at the fastest rate, significantly increasing the percentage of smaller aircraft operating at Sea-Tac. Commuter operations peaked in 1990 and have declined slightly. In 1970, commuter operations represented 4 percent of total airport operations. By 1990, commuters represented 42 percent of total operations, declining to 37 percent in 1997. Because of the smaller aircraft used by these carriers, commuter passengers represented only 7 percent of total passengers in 1997.

Passenger growth rate at Sea-Tac during the early 1990s had slowed compared to previous years, yet grew at an average 4.6 percent increase annually. That annual growth rate, and the rate experienced throughout the 1990s, far surpasses the total growth experienced within the United States of less than 2 percent annually over the same period.

During the 1990s, national air-travel growth slowed radically. Aircraft operations have declined or stayed relatively constant in response to airline consolidation and worldwide economic conditions. During the first four years of the 1990s, the lethargy of both the U.S. and world economies presented the U.S. aviation industry with a series of challenges. Economic growth averaged less than 0.5 percent annually. As a result of a slowing world economy and increased airline competition, the airlines lost more than $10 billion (a figure greater than the total profit earned by the industry since the initiation of commercial passenger service). By 1994, as the airlines were emerging from financial difficulties, passenger demand grew substantially as airfares declined. Between 1993 and 1996, air passenger demand at Sea-Tac grew at an average annual growth rate of nearly 9 percent.

Total Passengers

The number of total passengers at Sea-Tac has grown from 4.6 million in 1970 to approximately 24.7 million in 1997, as shown in Table B1. Passenger growth at Sea-Tac has averaged 5.5 percent annually over the last 10 years and 6.6 percent a year over the last five years. In contrast, total U.S. passenger growth has averaged 3.9 percent annually over the last 10 years and 3.0 percent annually over the last five years. In 1970, Sea-Tac enplaned 1.4 percent of U.S. passengers, whereas in 1997 Sea-Tac enplaned slightly over 2.0 percent of the U.S. total.

Domestic enplanements have consistently accounted for approximately 90 to 93 percent of total enplanements at Sea-Tac. The international passenger percentage has declined from a high of 10.8 percent in 1990 to 7.2 percent in 1995, and has increased to 7.5 percent in 1997.

Air Cargo Tons

In 1997, nearly 394,000 tons of air cargo (freight and mail) were handled at Sea-Tac Airport. From 1970 to 1997, total air cargo shipped in and out of Sea-Tac has increased at an annual compounded rate of 4.2 percent. In 1997, 53 percent of cargo was domestic airfreight, 18 percent international airfreight, and 29 percent airmail. The greatest gains in recent years have been in international airfreight and mail. Table B2 lists the growth in air cargo at Sea-Tac since 1970.

Aircraft Operations

In 1997 there were 385,298 aircraft operations (takeoffs and landings) at Sea-Tac. Although the number of aircraft operations was relatively stable from 1989 to 1993, operations increased by 4 percent in 1994 and by 9.5 percent in 1995. In 1996, aircraft operations increased 2.2 percent, yet declined 2.5 percent between 1996 and 1997. Table B3 lists aircraft operations through 1997.

In 1997, air carrier aircraft accounted for approximately 61 percent of the Airport's total operations; commuter aircraft accounted for approximately 37 percent. The number of commuter operations in 1997 (143,500 operations) remains below the number of commuter operations in the peak year, which occurred in 1990 (150,376 operations).

Table B1

ENPLANED AND DEPLANED PASSENGERS, 1970 TO 1997

Seattle-Tacoma International Airport FAR Part 150 Study

Year	Enplaned Passengers	Deplaned Passengers	Total Passengers	Percent Change in Total Passengers	
				Annual	10-year Average
1970	2,351,812	2,301,631	4,653,443	-3.2	[b]
1971	2,370,360	2,327,245	4,697,605	0.9	[b]
1972	2,395,241	2,393,721	4,788,962	1.9	9.1
1973	2,588,959	2,616,134	5,205,093	8.7	11.3
1974	2,862,890	2,909,326	5,772,216	10.9	11.2
1975	3,038,999	3,073,424	6,112,423	5.9	10.1
1976	3,381,864	3,424,884	5,806,748	11.4	9.2
1977	3,625,965	3,706,478	7,332,443	7.7	6.6
1978	4,150,438	4,217,539	8,367,977	14.1	6.6
1979	4,879,285	4,941,134	9,820,419	17.4	7.4
1980	4,578,447	4,616,203	9,194,650	-6.4	7.0
1981	4,536,472	4,581,158	9,117,630	-0.8	6.9
1982	4,608,633	4,670,104	9,278,737	1.8	6.8
1983	5,008,874	5,132,863	10,141,737	9.3	6.9
1984	5,167,185	5,309,445	10,476,630	3.3	6.1
1985	5,683,437	5,783,318	11,466,755	9.5	6.5
1986	6,810,585	6,832,081	13,642,666	19.0	7.2
1987	7,248,535	7,196,947	14,445,482	5.9	7.0
1988	7,313,886	7,181,633	14,495,519	0.3	5.6
1989	7,509,012	7,732,246	15,241,258	5.1	4.5
1990	8,225,920	8,014,389	16,240,309	6.6	5.9
1991	8,294,093	8,019,196	16,313,289	0.4	6.0
1992	8,978,740	8,983,477	17,962,217	10.1	6.8
1993	9,384,565	9,415,959	18,800,524	5.3	6.4
1994	10,471,150	10,501,669	20,972,819	11.6	7.2
1995	11,390,521	11,383,465	22,773,986	8.6	7.1
1996	12,132,987	12,191,609	24,324,596	6.8	6.0
1997	12,445,575	12,392,903	24,738,476	1.7	5.5

Source: *Seattle-Tacoma International Airport, Traffic and Operations Report*, 1997
[b] Data not available.

Table B2

AIR CARGO, 1970 TO 1997, In tons

Seattle-Tacoma International Airport FAR Part 150 Study

Year	Domestic Freight (Unit of measure)	International Freight (Unit of measure)	Air Mail (Unit of measure)	Total (Unit of measure)
1970	74,031	1,047	55,093	130,171
1971	82,988	1,495	48,074	132,557
1972	92,555	1,977	42,738	137,270
1973	108,151	4,172	38,369	150,692
1974	127,077	3,792	37,141	168,010
1975	141,680	11,434	37,126	190,240
1976	148,359	14,184	37,699	200,242
1977	161,075	12,543	41,746	215,364
1978	153,797	15,266	43,477	212,540
1979	150,042	21,395	42,759	214,196
1980	141,461	19,949	49,767	211,177
1981	142,535	18,899	49,195	210,629
1982	129,873	18,077	50,697	198,647
1983	137,073	21,844	54,618	213,535
1984	139,685	28,019	59,859	227,563
1985	118,871	27,271	64,050	210,192
1986	121,193	35,834	65,975	223,002
1987	146,701	46,608	65,680	258,989
1988	161,630	49,602	65,845	277,077
1989	173,998	52,241	65,196	291,435
1990	186,113	59,022	68,324	313,459
1991	208,810	59,411	79,445	347,666
1992	225,736	58,505	77,366	361,607
1993	246,279	51,046	84,216	381,541
1994	264,784	55,243	90,109	410,136
1995	249,163	60,516	98,519	408,198
1996	222,017	63,960	102,241	388,218
1997	208,828	72,319	112,639	393,786

Source: *Seattle-Tacoma International Airport, Traffic and Operations Report*, 1997.

One metric ton equals 2,205 pounds.

Table B3
AIRCRAFT OPERATIONS, 1970 TO 1997
Seattle-Tacoma International Airport FAR Part 150 Study

Year	Air Carrier Aircraft [a]	Air Taxi Commuter Aircraft [a]	General Aviation Aircraft [b]	Military Aircraft [b]	Total Operations	Annual % Change in Total Operations
1970	104,414	6,202	38,893	1,167	150,676	-9.1
1971	114,372	5,215	33,874	1,683	155,144	3.0
1972	109,278	4,353	36,335	2,378	152,344	-1.8
1973	115,445	17,866	22,878	1,942	158,289	3.9
1974	106,466	31,654	21,492	1,304	161,077	1.8
1975	109,962	30,896	21,888	1,013	163,923	1.8
1976	114,998	31,818	25,865	844	173,699	6.0
1977	119,166	39,143	30,835	882	190,216	9.5
1978	119,850	41,747	32,787	607	195,186	2.6
1979	131,647	45,739	33,988	568	211,942	8.6
1980	143,646	40,681	27,876	541	212,744	0.4
1981	141,015	39,400	27,053	477	208,153	-2.2
1982	138,415	49,040	23,583	356	211,605	1.7
1983	137,920	48,757	22,247	329	209,462	-1.0
1984	142,717	59,824	20,878	409	224,052	7.0
1985	158,904	56,954	18,537	327	234,957	4.9
1986	187,870	54,977	16,606	286	260,199	10.7
1987	178,682	95,337	17,671	355	292,337	12.4
1988	176,732	124,245	14,520	447	316,260	8.2
1989	182,460	139,215	12,865	384	335,259	6.0
1990	193,482	150,376	10,844	305	355,007	5.9
1991	186,717	142,828	8,773	289	338,607	-4.6
1992	196,141	140,744	8,800	310	345,995	2.2
1993	200,040	131,046	8,097	276	339,459	-1.9
1994	212,016	132,160	8,505	371	353,052	4.0
1995	226,190	149,444	10,315	567	386,536	9.5
1996	239,063	149,882	6,077	197	395,216	2.2
1997	235,447	143,513	6,180	158	385,298	-2.5

Source: *Seattle-Tacoma International Airport, Traffic and Operations Report*, 1997.

[a] Horizon Airlines has flown both air carrier and air taxi/commuter aircraft from 1985 to 1997. Operations by each aircraft type are included in the appropriate column. [b] Includes training flights.

Future Activity Levels

Passenger Forecasts

An airport activity forecast was prepared as part of the 1997 Supplemental EIS for the Master Plan Update,. That forecast, prepared in the late fall of 1996, was an update to the Master Plan Update forecast prepared during 1994. Because that forecast was the most recent forecast for which all of the variables essential to evaluating noise are available, it is recommended for use in this Part 150 Noise Compatibility Study. Passenger and operations forecasts were prepared for various elements of activity for the years 2000, 2005, and 2010. Table B4 summarizes the forecasts.

In forecasting passenger activity, activity was categorized as either Domestic and International.

Domestic Enplanement Forecast

The domestic passenger enplanement forecast model was developed using multiple regression analysis in which mathematical relationships were developed between historic domestic enplaned passengers and various parameters known to influence air passenger travel. Appendix Twenty provides a discussion of the regression model used in preparing the forecasts. The model performed well in all statistical measures and explains 99 percent of the observed variation in domestic air passenger enplanements between 1970 and 1995. Based on projected population and regional economic conditions, domestic enplanements at Sea-Tac were expected to increase from 10.6 million in 1995 to 15.7 million in 2010. Domestic enplanements in 1997 reached 11,460,325.

International Enplanement Forecast

Similar to the domestic passenger forecast, a regression analysis was performed to evaluate past international passengers. That model explains 93 percent of the observed variation in international air passenger enplanements between 1970 and 1995. Using this model, international enplanements are expected to increase from approximately 820,000 in 1995 to 2.2 million in 2010. Actual international enplanements reached 918,558 in 1997.

Table B4
SUMMARY OF AVIATION FORECASTS, 1997 TO 2010
Seattle-Tacoma International Airport FAR Part 150 Study

Forecast Element	Actual 1997	Forecast 2000	2005	2010
Annual Passengers (Millions) and Annual Growth Rate				
Annual Enplaned Passengers	12.4	13.7	15.7	17.9
Annual Total Passengers	**24.7**	**27.4**	**31.4**	**35.8**
(Average Annual Growth Rate)		(3.7%)	(2.8%)	(2.7%)
Origin-Destination/Connecting Passengers				
Origin-Destination	17.5	18.9	21.6	24.5
Connecting	7.2	8.5	9.8	11.3
Total	**24.7**	**27.4**	**31.4**	**35.8**
Annual Air Carrier/Commuter Passengers				
Air Carrier	na	24.5	28.0	32.1
Air Taxi/Commuter	na	2.9	3.4	3.7
Total	**24.7**	**27.4**	**31.4**	**35.8**
Annual Aircraft Operations (Thousands) and Annual Growth Rates				
Total Annual Operations	**385.3**	**409.0**	**445.0**	**474.0**
(Average Annual Growth Rate)		(1.1%)	(1.7%)	(1.3%)
Annual Operations by Type				
Air Carrier	235.4	249.0	279.0	306.0
(Average Annual Growth Rate)		(1.9%)	(2.3%)	(4.2%)
Air Taxi/Commuter	143.5	149.0	155.0	157.0
(Average Annual Growth Rate)		(0%)	(0.8%)	(0.3%)
General Aviation	6.1	10.3	10.3	10.3
(Average Annual Growth Rate)		(0%)	(0%)	(0%)
Military	0.2	0.6	0.6	0.6
(Average Annual Growth Rate)		(0%)	(0%)	(0%)
Total	**385.3**	**409.0**	**445.0**	**474.0**
Peak-Hour Aircraft Operations				
Operations in Peak Hour of Average Day, Peak Month	**78**	**88**	**94**	**99**

Source: P&D Aviation and Seattle-Tacoma International Airport, Traffic and Operations Report, Port of Seattle, 1997.

Total Enplaned Passenger Forecast

The percentage of domestic passengers traveling on air carrier aircraft is projected to increase from 89.7 in 1995, to 91 in 2000, and to 92.5 in 2010. The air carrier percentage is estimated to increase with an increase in the total number of passengers, which is consistent with the experience at airports handling more passengers than Sea-Tac. This trend is also expected as a result of the shift of flights to some higher volume destinations (such as Spokane) from Horizon Airlines to operation by Alaska Airlines. The relationship between total enplanements and the percentage of air carrier enplanements is listed in Table B5.

Domestic air carrier enplanements are projected to increase to 14.5 million in 2010, and domestic air taxi/ commuter enplanements are projected to increase to 1.2 million in 2010. The international forecast anticipates 1.3 million international enplanements to Canada and 900,000 enplanements to other international destinations in 2010. The total number of enplaned passengers is projected to increase from 12.4 million in 1997 to 17.9 million in 2010.

Origin-Destination Passengers

The number of passengers in each of the four major categories (domestic air carrier, domestic air taxi/commuter, international to Canada, and international to other destinations) were allocated between origin-destination passengers and connecting passengers. Origin-destination (O&D) passengers begin or end their air trip at Sea-Tac. Connecting passengers transfer from one flight to another at Sea-Tac. Passengers who remain on the same aircraft at Sea-Tac (a continuation flight) are not counted as O&D passengers because they do not embark or disembark an aircraft at Sea-Tac.

Overall, 68 to 69 percent of Sea-Tac passengers are estimated to be O&D passengers.

Table B5

STATISTICS FOR AIRPORTS WITH 1995 ENPLANEMENTS SIMILAR TO FORECAST

Seattle-Tacoma International Airport FAR Part 150 Study

Airport	Enplanements (Millions)		Enplanements per Departure	
	Total	% Air Carrier (+ 60 seats)	Air Carrier	Air Taxi/ Commuter
Orlando, FL	11.0	95.3	102	10
Sea-Tac, WA – Actual 1995	11.4	88.6	89	17
St. Louis, MO	11.6	99.6	75	8
Minneapolis-St. Paul, MN	12.2	95.5	86	10
Boston, MA	12.2	90.7	87	11
Las Vegas, NV	13.1	96.9	106	7
Detroit, MI	13.7	95.3	79	13
Sea-Tac, WA – Projected 2000	13.7	89.4	98	20
Newark, NJ	13.9	92.8	84	17
J.F. Kennedy, NY	13.9	93.2	120	15
Miami, FL	14.6	92.7	84	13
Denver, CO	15.1	94.2	91	11
San Francisco, CA	16.4	95.3	106	14
Sea-Tac, WA - Projected 2010	17.9	90.8	106	24
Los Angeles International, CA	25.1	95.7	115	10
Atlanta, GA	27.2	96.1	97	13
Dallas-Ft. Worth, TX	27.2	92.4	79	19
Chicago O'Hare, IL	31.2	95.4	80	27

Sources: FAA, *Terminal Area Forecasts*, August 1996; and P& D Aviation.
Note: Departures include non-passenger flights, such as all-cargo flights.

Air Cargo Forecast

The air cargo forecast was also developed using a regression analysis model. Many model forms and variables relating to air cargo tonnage were evaluated, including: Washington State gross product; Puget Sound income; Puget Sound employment; Puget Sound population; and Puget Sound per capita income. With this model, 98 percent of the historical variation in air cargo tonnage can be explained.

According to the forecast, air cargo tonnage (including air mail) will increase from 408,000 tons in 1995 to 730,000 tons in 2010. Actual tonnage in 1997 had declined to 393,876 in 1997.

Aircraft Operations Forecast

Aircraft operations for each of the four categories of service (domestic air carrier, domestic air taxi/commuter, international operations to Canada, and operations to other international destinations) were derived by applying an average number of enplanements per departure to the number of enplanements. The average number of enplanements per passenger aircraft departure is derived by multiplying the average seats per departure by the boarding load factor.

Domestic Air Carrier Operations. For the forecast, the average number of seats per departure in domestic air carrier service was estimated to increase at the rate of one seat per year. This growth in aircraft size is approximately the average projected growth published by the Boeing Company[1/] and the FAA. The estimated boarding load factor for domestic air carrier operations increased from approximately 58 percent in 1993 to 64 percent in 1995. The FAA projects that the domestic air carrier boarding load factor for the nation will increase to 66 percent by 2010. The boarding load factor for domestic air carrier operations at Sea-Tac was assumed by the forecast to increase to 66 percent by 2010 from actual levels of 64 percent in 1995. Based on these assumptions, the domestic air carrier enplanements per departure will increase from approximately 98 in 1995 to 111 in 2010, and operations will increase from 194,000 in 1995 to 262,000 in 2010.

Domestic Air Taxi/Commuter Operations. It is estimated that the number of domestic air taxi/commuter average seats per departure at Sea-Tac has increased from approximately 25 in 1993 to 30 in 1995, due primarily to the Horizon Airlines use of larger commuter aircraft. The average seats per departure in domestic air taxi/commuter service is estimated to increase at the rate of approximately one seat per year to 2000 and one-half seat per year from 2000 to 2010, based partially on projections of fleet mix changes by Horizon Airlines.

It is estimated that the boarding load factor for domestic air taxi/commuter operations increased from 45 percent in 1993 to 53 percent in 1995. The boarding load factor for domestic commuter operations is projected to increase to 57 percent by 2010, which is proportional to the increase projected by the FAA for commuter service.

According to these assumptions, the number of enplanements per commuter departure will grow from approximately 16 in 1995 to 22 in 2010. This increase in enplanements per departure will result in a decrease in domestic air taxi/commuter aircraft operations from 138,000 in 1995 to 110,000 in 2010. Actual commuter operations decreased in 1997 over 1996 levels. This decline in commuter aircraft operations is due in part to the conversion of many Horizon Airlines aircraft from commuter aircraft to F28 aircraft, which have more than 60 seats and therefore fall into the air carrier category. This decline is also due partly to the planned increase in larger commuter aircraft, particularly the Dash 8-200 and Dash 8-300, which seat 38 to 56 passengers.

1/ *Current Market Outlook, World Market Demand and Airplane Supply Requirements*, The Boeing Corporation, March 1996.

International Operations to Canada. The projected number of average seats per departure in international service to Canada is estimated to increase approximately one seat per year. The boarding load factor for international operations to Canada is expected to increase from 50 percent in 1995 to 57 percent in 2010, which equals the projected load factor for domestic air taxi/commuter operations in 2010.

Based on these assumptions, the number of enplanements per departure will increase from 32.5 in 1995 to 46 in 2010, resulting in an increase in international operations to Canada from 24,000 in 1995 to 56,000 in 2010.

Operations to Other International Destinations. The forecast of operations to other international destinations is a projected growth from 4,000 operations in 1995 to 10,000 operations in 2010. Passenger aircraft operations in the four categories described above for the updated forecast are projected to increase from 360,000 in 1995 to 378,000 in 2000 and 438,000 in 2010. Overall, the average number of enplanements per departures for all sectors of passenger activity at Sea-Tac is projected to increase from 64 in 1995 to 83 in 2010.

Other Aircraft Operations. All-cargo operations are projected to increase from 16,000 in 1995 to 25,000 in 2010 in accordance with the growth in cargo tonnage. The number of general aviation and military operations is assumed to remain at the 1995 level through 2010, at approximately 11,000 annual operations.

Total Aircraft Operations

Total aircraft operations at Sea-Tac are projected to increase from 385,300 in 1997 to 409,000 in 2000, to 445,000 in 2005, and to 474,000 in 2010. Table B6 provides a linear interpolation of all interim years.

Table B6
PASSENGER AND OPERATIONS FORECAST BY YEAR, 1995 TO 2010
Seattle-Tacoma International Airport FAR Part 150 Study

Year	Forecast		
	Enplanements (Millions)	**Total Passengers (Millions)**	**Operations Forecast (Thousands)**
Actual			
1995	11.4	22.8	386.5
1996	12.1	24.3	395.2
1997	12.4	24.7	385.3
Forecast			
1998	12.8	25.6	400
1999	13.2	26.4	405
2000	13.7	27.2	409
2001	14.1	28.2	416
2002	14.5	29.0	423
2003	14.9	29.8	431
2004	15.3	30.6	438
2005	15.7	31.4	445
2006	16.1	32.2	451
2007	16.6	33.2	457
2008	17.0	34.0	462
2009	17.5	35.0	468
2010	17.9	35.8	474

[a] Source: P&D Aviation Analysis
[b] 2000 is the first year for which forecasts were developed.

Fleet Mix Forecast

An updated fleet mix forecast was developed by projecting the percentages of aircraft operations by type of aircraft, while maintaining consistency with the average seats per departure projections. As seen in Table B7, the mix of aircraft projected to be in service in later years generally contains larger aircraft than those in service today. The aircraft models shown in Table B7 are representative of the types in the forecast fleet. This information will be translated into specific aircraft types for use in the INM. Some aircraft in later years will be new aircraft but are projected to be of the same size as those shown in the table. Whereas the 121-to-170-seat category is projected to decrease from approximately 63 to 57 percent by 2010, the 171-to-240-seat category is projected to increase from approximately 14 to 18 percent by 2010.

Table B7

FORECAST OF AVERAGE DAILY OPERATIONS BY TYPE OF AIRCRAFT AT SEATTLE-TACOMA INTERNATIONAL AIRPORT, 1995 TO 2010

Aircraft Category [a[	Estimated 1995 [b]	Forecast		
		2000	2005	2010
Average Daily Operations by Air Taxi/Commuter Aircraft (60 Seats or Less)				
Under 10 Seats				
All Types	37.5	27.2	28.6	24.8
11-20 Seats				
J31, Metro	179.0	116.7	110.2	103.4
21-60 Seats				
S360, DHC-8-200, J41	199.9	186.7	167.4	140.7
ATR 42, DHC-8-300	0	58.4	102.0	144.8
Total Air Taxi/Commuter Aircraft	**416.4**	**389.0**	**408.2**	**413.7**
Average Daily Operations by Air Carrier Passenger Aircraft (Over 60 Seats)				
61-90 Seats				
F-28	34.2	32.3	28.8	31.5
ATR 72, RJ 70/85	0	6.5	14.4	15.7
91-120 Seats				
B737-100/200/500, F100	26.8	32.3	36.0	39.3
121-170 Seats				
B727	69.5	32.3	0	0
B737-300/400	140.8	187.5	237.8	259.5
MD80, MD90	135.1	155.2	158.5	157.3
A319, A320	14.2	19.4	28.8	31.5
171-240 Seats				
B757-200	71.8	84.1	100.9	110.1
B767-200	7.4	12.9	14.4	23.6
A310, A321	0	0	2.9	7.9
241-350 Seats				
A300	9.1	12.9	21.6	31.5
B767-300	9.1	29.1	36.0	49.5
L1011, DC10	44.5	25.9	14.4	0
A340-200	0	6.5	14.4	15.7
Over 350 Seats				
B747	3.7	3.2	3.6	3.9
MD-11	3.7	3.2	3.6	3.9
A340-400, A330	0	1.9	2.2	3.1
B777, MD-12	0	1.3	2.2	2.4
Total Air Carrier Passenger Aircraft	**569.9**	**646.6**	**720.5**	**786.3**

Table B7 (Continued)

FORECAST OF AVERAGE DAILY OPERATIONS BY TYPE OF AIRCRAFT AT SEATTLE-TACOMA INTERNATIONAL AIRPORT, 1995 TO 2010

Aircraft Category [a]	Estimated 1995 [b]	Forecast		
		2000	2005	2010
Average Daily Operations by All-Cargo Aircraft				
Under 60,000 Pounds	15.8	17.0	16.9	17.1
60,000-250,000 Pounds	17.5	23.6	27.1	32.2
Over 250,000 Pounds	10.5	14.2	16.3	19.2
Total	**43.8**	**54.8**	**60.3**	**68.5**
Average Daily Operations by Other Aircraft				
General Aviation	28.4	28.4	28.4	28.4
Military	1.7	1.7	1.7	1.7
Total Average Daily Aircraft Operations				
Airport Total	**1,060**	**1,120**	**1,219**	**1,299**

Source: P&D Aviation

[a] Aircraft models shown are representative of the types in the forecast fleet. Some aircraft in later years will be new aircraft models, but are projected to be of the same size as those listed.

[b] "Working Paper One, Unconstrained Aviation Forecast Update," P&D Aviation, January 2, 1997.

Day/Night Operations Forecast

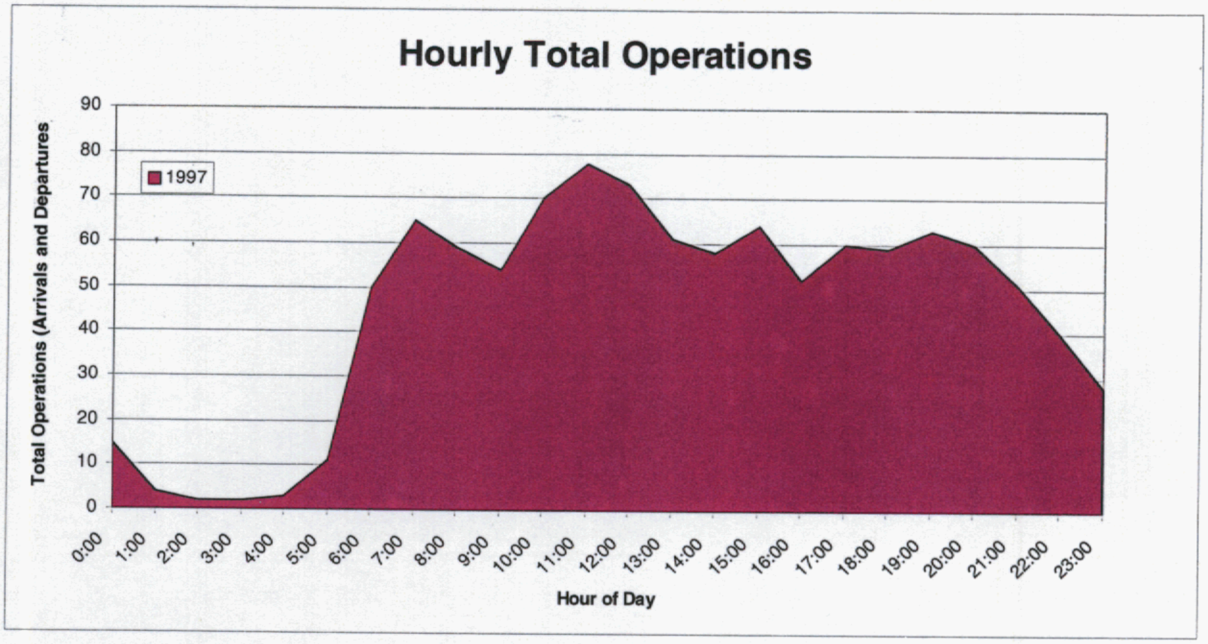
In Table B8 the day-night distribution of aircraft operations by type for 1997 is shown. Passenger aircraft operations data for this table are based on the published schedule from the Official Airline Guide for August 1997. These data will be considered in evaluating aircraft noise at the Airport. Aircraft noise generated from nighttime (10:00 p.m. to 6:59 a.m.) operations is weighted more heavily than from daytime operations when calculating some aircraft noise metrics.

Table B8
PERCENTAGE OF OPERATIONS BY TIME OF DAY
Seattle-Tacoma International Airport FAR Part 150 Study

Type of Operation	Total	Day (7:00 a.m. to 9:59 p.m.)	Night (10:00 p.m. to 6:59 a.m.)
Air Carrier Passenger Operations	100	85.6	14.4
Air Taxi/Commuter Passenger Operations	100	89.7	10.3
Air Cargo Operations			
Aircraft Under 60,000 Pounds Gross Weight	100	72.2	27.8
Aircraft of 60,000 Pounds Gross Weight and Over	100	53.1	46.9
Military Operations	100	100	0
General Aviation Operations	100	90.6	9.4

Source: P&D Aviation

Figure B3


Hourly Total Operations
90
80
70
60
50
40
30
20
10
0
1997
Total Operations (Arrivals and Departures
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Hour of Day

Comparison To Other Forecast

The passenger forecast described in the preceding section was compared with other forecasts prepared by various organizations for Sea-Tac. Table B9 shows that comparison. Other forecasts that have been prepared for Sea-Tac include the FAA's Terminal Area Forecast (TAF) and the Puget Sound Regional Council Flight Plan Study.

Federal Aviation Administration TAF

Purpose and Approach in the Development of the TAF. In comparing the TAF forecast prepared by the FAA with the master planning forecasts, it is important to consider the purposes for which the two sets of forecasts were developed, because the role of a forecast will influence the approach taken to develop it. The TAF forecast is prepared primarily to meet the planning and budgeting needs of the FAA and to provide airport-specific information that can be used by state and local aviation authorities, the aviation industry, and the public. Consistency with national FAA forecasts is important in the TAF development, and nationwide factors are primarily used to develop the forecast. In contrast, the master planning forecast is used to schedule specific facility improvements at an airport and uses primarily local factors in its development; it is prepared with a more rigorous approach and a greater level of detail.

TAF Domestic Air Carrier Enplanements. The TAF forecast was developed using a multiple regression analysis of data from 1984 to 1995 (12 years). The regression approach establishes a model (equation) based on the historic relationship between domestic air carrier enplanements and independent variables, then forecasts domestic air carrier enplanements based on projections of the independent variables. Independent variables used in the FAA analysis are U.S. yield in real dollars, U.S. domestic air carrier enplanements, and Seattle employment. Therefore, the forecast approach has some characteristics of a top-down approach (because it is tied to the FAA U.S. domestic enplanement forecast) yet it considers the local economy (Seattle employment).

The coefficient of determination (R^2) of the TAF regression equation is 0.91, which indicates that 91 percent of the variation in the historical number of domestic air carrier enplanements is explained by the model. In contrast the forecast to be used in this FAR Part 150 yielded a higher coefficient of determination of 99.6 percent.

TAF International Air Carrier Enplanements. International air carrier enplanements in the TAF were projected using an average annual growth rate of 6.0 percent, from a base of approximately 514,000 international air carrier enplanements in 1995. The 6-percent growth rate was based on the existing trend. The master planning forecast of international enplanements is a 4.7-percent annual rate of growth, with a base of approximately 800,000 total international enplanements in 1995.

TAF Commuter Enplanements. Commuter enplanements were forecast in the TAF by assuming the middle ground between a straight-line trend projection and growth rate projections by Horizon Airlines. The FAA first attempted to forecast commuter enplanements by regression analysis as a function of U.S commuter enplanements. The coefficient of determination (R^2) for the resulting model was weak, and the projected growth in commuter enplaned passengers was relatively modest. This approach was rejected by the FAA forecasters.

Next, the FAA estimated commuter enplanements by a straight-line trend of commuter enplanement data from 1984 to 1995. This approach produced a forecast with a higher short-term growth rate than that projected by Horizon Airlines. Consequently, the FAA chose to base the commuter forecast on a series of growth rates which represented a middle ground between the trend forecast and the Horizon growth projection.

Comparison with Flight Plan

The flight plan forecast, prepared in 1990 for 2010 is slightly less than the forecast, as shown in Table B9.

Table B9
COMPARISON OF FORECASTS FOR
SEATTLE-TACOMA INTERNATIONAL AIRPORT

Year	Actual Enplane ments	Port Forecast (1996)	PSRC Flight Plan (1990)	1993 FAA TAF	1996 FAA TAF [a]	1997 FAA TAF [b]
Enplaned Passengers						
1991	8,294,093					
1992	8,978,740					
1993	9,400,262					
1994	10,486,410					
1995	11,395,460		10,500,000	8,400,000		
1996	12,132,987					
1997	12,345,573					
2000		13,700,000	12,700,000	11,360,000	12,916,969	13,916,641
2005		15,700,000		13,920,000	15,786,027	16,290,082
2010		17,900,000	17,000,000		19,281,922	18,946,865
2020			22,500,000			
Operations						
1991	338,607					
1992	345,995					
1993	339,459					
1994	353,052					
1995	386,536		407,000	370,000		
1996	395,216					
1997	385,298					
2000		409,000	410,000	417,000	406,939	433,474
2005		445,000		435,000	452,029	478,053
2010		474,000	450,000		498,683	528,205
2020			526,000			
Estimated Enplanements per Passenger Departure [c]						
1991	54					
1992	57					
1993	60					
1994	64					
1995	64					
2000		72	62	59	69	69
2005		76		69	75	73
2010		83	76		83	77
2020			86			

Source: Seattle-Tacoma International Airport

[a] Source: FAA, *Terminal Area Forecasts*, 1993 and 1996.
[b] Source: FAA, December 1996.
[c] Adjusted to exclude all-cargo, general aviation, and military departures.

Conclusion

As the preceding section showed, several aviation forecasts have been prepared for Sea-Tac all indicting healthy growth in demand for air travel through the planning horizon. The Master Plan Update forecasts are the most recent forecasts prepared for Sea-Tac developed at sufficient detail (at an aircraft fleet mix level) to enable the preparation of a noise evaluation, and were therefore used during the Part 150 Study.

The forecasts of total annual passengers (enplanements and deplanements) are expected to grow as follows:

Year	Total Passengers	% Growth Over 1997
1997	24,738,476	N/A
2000	27,400,000	10.8%
2005	31,400,000	26.9%
2010	35,800,000	44.7%

Based on the annual total passengers, total annual aircraft operations were also projected:

Year	Total Operations	% Growth Over 1997	Average Annual Day Operations
1997	385,298	N/A	1,056
2000	409,000	6.2%	1,120
2005	445,000	15.5%	1,219
2010	474,000	23.0%	1,299

Forecast Revisions

Subsequent to the publication of the Forecast Working Paper and prior to the completion of the aircraft noise evaluation, additional noise monitoring and public involvement opportuniteis occurred. As a result, the existing baseline noise contour was completed in 1999. This contour was based on activity occurring during the last full calendar year, which was 1998. This corresponded to the actual full year of noise monitoring that was conducted, which is mentioned above and outlined in the next chapter. In addition, the five-year Base Case contour was determined to be the year 2004, which was anticipated to be five years from the date of submittal (1999). The actual 1998 operations by aircraft type are presented in the following table.

Table B.10

SUMMARY OF OPERATIONS BY CATEGORY, AVERAGE DAILY OPERATIONS, EXISTING 1998

Seattle-Tacoma International Airport FAR Part 150 Study

Category	Average Daily Operations
Wide Body Jets	69.6
Narrow Body Jets	577.3
Regional Jets	79.6
Commuter and Twin Propeller	310.2
General Aviation and Military Jets	5.9
General Aviation and Military Single Props and Other	74.2
TOTAL	1,116.6

C Noise Analysis Methodology





Seattle-Tacoma International Airport

FAR Part 150 Study Update

Noise Analysis Methodology

Noise Analysis

This section presents background information on the characteristics of aircraft noise as it relates to Seattle-Tacoma International Airport (Sea-Tac). The section also summarizes the methodologies used to study the aircraft noise environment. This section is intended to give the reader a greater understanding of the noise metrics and methodologies that are being used to assess noise impacts. References in paranthacies are found in Appendix 23.

Introduction

This section is divided into the following sub-sections:

- ✓ Characteristics of Sound - Presents properties of sound that are important for technically describing noise in an airport setting.
- ✓ Factors Influencing Human Response to Sound -Presents acoustic factors in human subjective response to a sound that affects its perception.
- ✓ Health Effects of Noise - Sumarizes the potential human disturbances and health effects to noise.
- ✓ Sound Rating Scales - Presents various sound rating scales and how they may be applied to addressing aircraft operations
- ✓ Noise Assessment Guidelines - Presents a summary of current noise assessment criteria used to assess aircraft noise impacts.
- ✓ Methodology in Determining the Noise Environment - Presents the methodology used to measure and model the noise environment around Sea-Tac.

Characteristics of Sound

Amplitude and Frequency. Sound can be technically described in terms of its sound pressure (amplitude) and frequency (similar to pitch).

Amplitude is a direct measure of the magnitude of a sound without consideration for other factors that may influence its perception. The range of sound pressures that occurs in the environment is so large that it is convenient to express these pressures as sound pressure levels on a logarithmic scale. The standard unit of measurement of sound is the decibel (dB). The sound pressure level in decibels describes the pressure of a sound relative to a reference pressure. The logarithmic scale compresses the wide range in sound pressures to a more usable range of numbers.

For example, a sound level of 70 dB has 10 times as much acoustic energy as a level of 60 dB, while a sound level of 80 dB has 100 times as much acoustic energy as a levek of 60 dB. In terms of human response to noise, the perception is very different. A sound 10 dB higher than another is usually judged to be twice as loud; 20 dB higher four times as loud; and so forth.

The frequency of a sound is expressed as Hertz (Hz) or cycles per second. The normal audible frequency range for young adults is 20 Hz to 20,000 Hz. The prominent frequency range for community noise, including aircraft and motor vehicles, is between 50 Hz and 5,000 Hz. The human ear is not equally sensitive to all frequencies, with some frequencies judged to be louder for a given signal than others. As a result, research studies have analyzed how individuals make relative judgements as to the "loudness" or "annoyance" to a sound. The most prominent of these scales include Loudness Level, Frequency-Weighted Contours (such as the A-weighted scale), and Perceived Noise Level. Noise metrics used in aircraft noise assessments are based upon these frequency weighting scales, whichare discussed in the following paragraphs.

Loudness Level. This scale has been devised to approximate the human subjective assessment to the "loudness" of a sound. Loudness is the subjective judgment of an individual as to how loud or quiet a particular sound is perceived. The human ear is not equally sensitive to all frequencies, with some frequencies judged to be louder for a given signal than others. This sensitivity difference also varies for different sound pressure levels.

These data are obtained through group laboratory studies of human response to noise. Generally a pure tone signal of 1,000 hertz is played, and following an elapsed interval, a second tone of a different frequency is played. The listener then adjusts the signal until the two tones are judged to be the same.

Frequency-Weighted Contours (dBA, dBB, and dBC). In order to simplify the measurement and computation of sound loudness levels, frequency-weighted networks have obtained wide acceptance. The equal loudness level contours for 40 dB, 70 dB, and 100 dB have been selected to represent human frequency response to low, medium, and loud sound levels. By inverting these equal loudness level contours, the A-weighted, B-weighted and C-weighted frequency weightings were developed. These frequency-weighted contours are presented in Figure C1.

The most common weighting is the A-weighted noise curve. The A-weighted decibel scale (dBA) performs this compensation by discriminating against frequencies in a manner approximating the sensitivity of the human ear. In the A-weighted decibel, everyday sounds normally range from 30 dBA (very quiet) to 100 dBA (very loud). Most community noise analyses are based upon the A-weighted decibel scale. Examples of various sound environments, expressed in dBA, are presented in Figure C2.

Some interest has developed in utilizing a noise curve other than A-weighting for lower frequency noise sources. For example, the C-weighted curve is used for the analysis of the noise impacts from artillery noise.

Perceived Noise Level. Perceived noisiness is another method of rating sound. It was originally developed for the assessment of aircraft noise. Perceived noisiness is defined as "the subjective impression of the unwantedness of a not unexpected, nonpain or fear-provoking sound as part of one's environment," (Kryter, 1970) "Noisiness" curves differ from "loudness curves" in that they have been developed to rate the noisiness or annoyance of a sound as opposed to the loudness of a sound.

As with loudness curves, noisiness curves have been developed from laboratory psychoacoustic surveys of individuals. However, in noisiness surveys, individuals are asked to judge in a laboratory setting when two sounds are equally noisy or disturbing if heard regularly in their own environment. These surveys are more complex and are therefore subject to greater variability. Aircraft certification data is based upon these types of noisiness scales.

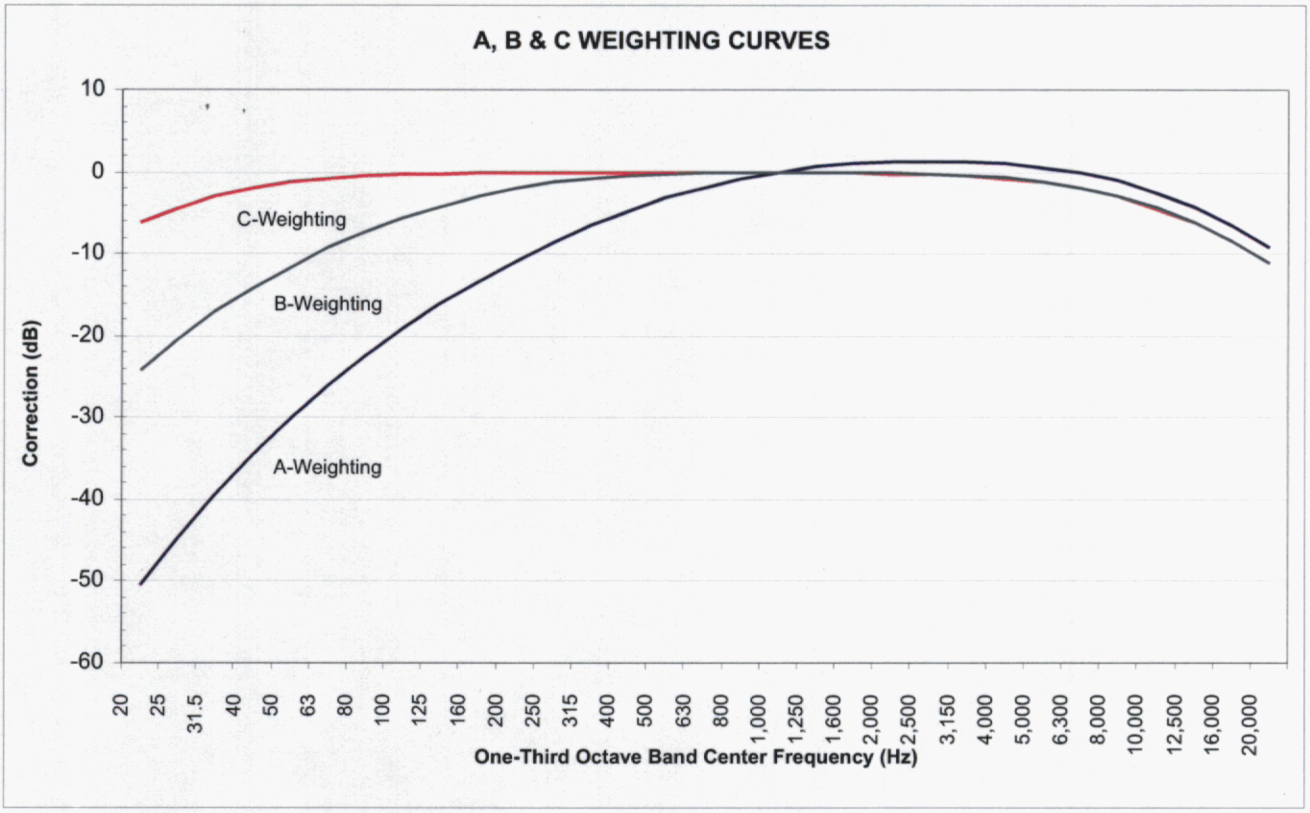


Figure C1 **Frequency Weighting Curves**

dB(A)	OVER-ALL LEVEL Sound Pressure Level Approx. 0.0002 Microbar	COMMUNITY (Outdoor)	HOME or INDUSTRY	LOUDNESS Human Judgement of Different Sound Levels
130	UNCOMFORTABLY	Military Jet Aircraft Take-Off with Afterburner from Aircraft Carrier @ 50 ft. (130)	Oxygen Torch (121)	120 dB(A) 32 Times as Loud
120 110	LOUD	Turbo-Fan Aircraft @ Take-Off Power @ 200 ft. (90)	Riveting Machine (110) Rock and Roll Band (108-114)	110 dB(A) 16 Times as Loud
100	VERY	Boeing 707 @ 1000 ft. (103) DC-8 @ 6080 ft. (106) Bell J2A Helicopter @ 100 ft. (100)		100 dB(A) 8 Times as Loud
90	LOUD	Power Mower (96) Boeing 737. DC-9 @ 6080 ft. (97) Motorcycle @ 25 ft. (90)	Newspaper Press (97)	90 dB(A) 4 Times as Loud
80		Car Wash @ 20 ft. (89) Prop. Airplane Flyover @ 1000 ft. (88) Diesel Truck, 40 mph @ 50 ft. (84)	Food Blender (88) Milling Machine (85) Garbage Disposal (80)	80 dB(A) 2 Times as Loud
70	MODERATELY LOUD	High Urban Ambient Sound (80) Passenger Car, 65 mph @ 25 ft. (77) Freeway @ 50 ft., 10:00am (76)	Living Room Music (76) TV-Audio, Vacumn Cleaner	70 dB(A)
60		Air Conditioning Unit @ 100 ft. (60)	Cash Register @ 10 ft. (65-70) Electric Typewriter @ 10 ft. (64) Conversation (60)	60 dB(A) 1/2 Times as Loud
50	QUIET	Large Transformers @ 100 ft. (50)		50 dB(A) 1/4 Times as Loud
40		Bird Calls (44) Low Urban Ambient Sound (40)		40 dB(A) 1/8 Times as Loud
	JUST AUDIBLE	(dB(A) Scale Interrupted)		
10	THRESHOLD OF HEARING			

SOURCE: Reproduced from Melville C. Branch and R. Dale Beland, "Outdoor Noise in the Metropolitan Environment". Published by the City of Los Angeles. 1970. p2

Figure C2 **Examples of Various Sound Environments**

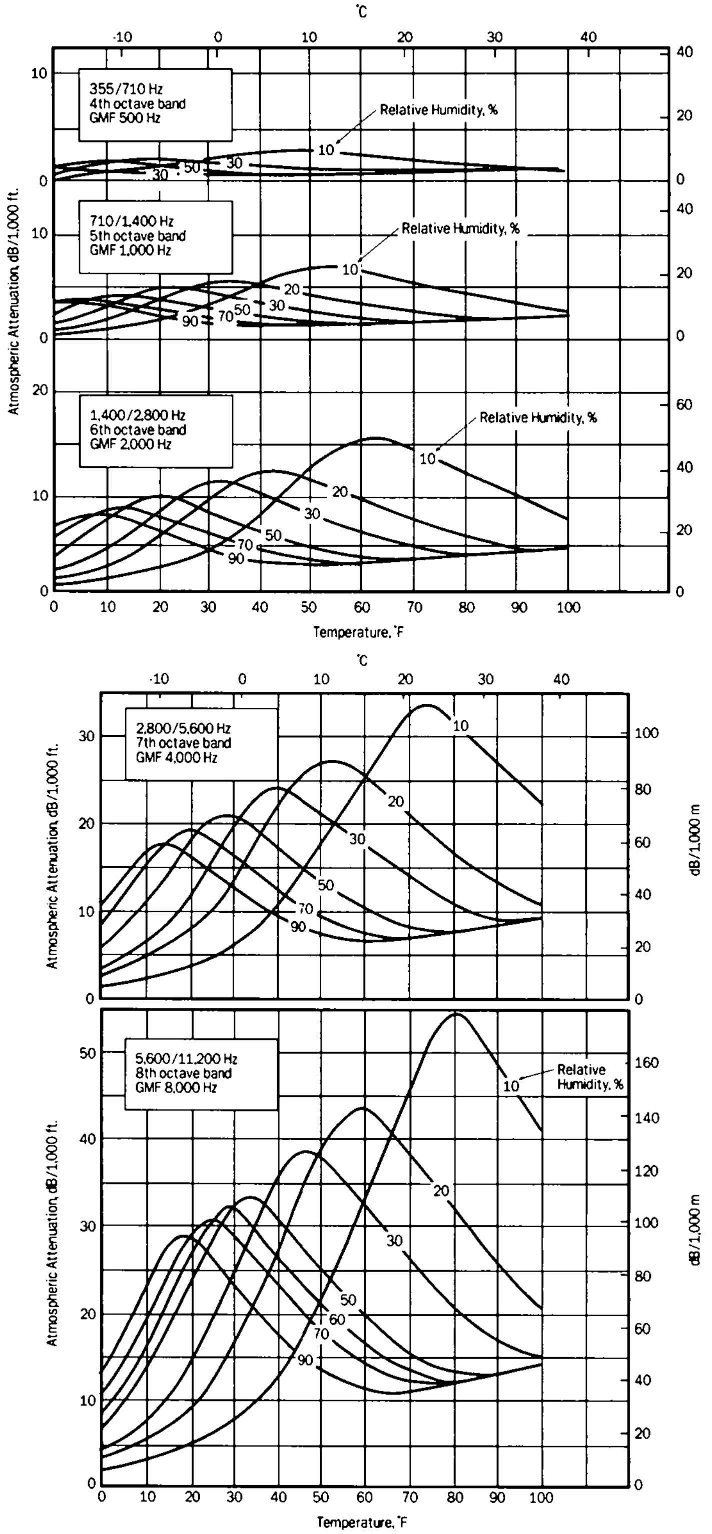
Propagation of Noise. Outdoor sound levels decrease as a function of distance from the source, and as a result of wave divergence, atmospheric absorption, and ground attenuation. If sound is radiated from a source in an homogeneous and undisturbed manner, the sound travels as spherical waves. As the sound wave travels away from the source, the sound energy is distributed over a greater area, dispersing the sound power of the wave. Spherical spreading of the sound wave reduces the noise level at a rate of 6 dB per doubling of the distance.

Atmospheric absorption also influences the levels that are received by the observer. The greater the distance traveled, the greater the influence of the atmosphere and the resultant fluctuations. Atmospheric absorption becomes important at distances of greater than 1,000 feet. The degree of absorption is a function of the frequency of the sound as well as the humidity and temperature of the air. For example, atmospheric absorption is lowest at high humidity and higher temperatures. Sample atmospheric attenuation graphs are presented in Figure C3. Turbulence and gradients of wind, temperature, and humidity also play a significant role in determining the degree of attenuation. Certain conditions, such as inversions, can also result in higher noise levels than would result from spherical spreading as a result of channeling or focusing the sound waves.

Absorption effects in the atmosphere vary with frequency. The higher frequencies are more readily absorbed than the lower frequencies. Over large distances, the lower frequencies become the dominant sound as the higher frequencies are attenuated.

The effects of ground attenuation on noise propagation is a function of the height of the source and/or receiver and the characteristics of the terrain. The closer the source of noise is to the ground, the greater the ground absorption. Terrain consisting of soft surfaces such as vegetation provide for more ground absorption than hard surfaces such as a lake surface. Ground attenuation is important for the study of noise from airfield operations (such as, thrust reversals) and in the design of noise berms or engine run-up facilities.

These factors are an important consideration for assessing in-flight and ground noise in the Puget Sound area. Atmospheric conditions will play a significant role in affecting the sound levels on a daily basis and how these sounds are perceived by the population.



SOURCE: Beranek, 1981

Figure C3 **Atmospheric Attenuation Graphs**

Duration of Sound. The annoyance from a noise event increases with increased duration of the noise event, i.e., the longer the noise event lasts the more annoying it is perceived to be. The "effective duration" of a sound is the time between when a sound rises above the background sound level until it drops back below the background level. Psychoacoustic studies have determined a relationship between duration and annoyance. These studies determined the amount a sound must be reduced to be judged equally annoying for increased duration. Duration is an important factor in describing sound in a community setting.

The relationship between duration and noise level is the basis of the equivalent energy principal of sound exposure. Reducing the acoustic energy of a sound by one half results in a 3 dB reduction. Doubling the duration of the sound increases the total energy of the event by 3 dB. This equivalent energy principal is based upon the premise that the potential for a noise to impact a person is dependent on the total acoustical energy content of the noise. The noise measurements CNEL, DNL, LEQ and SENEL are all based upon the equal energy principle and defined in subsequent sections of this study.

Change in Noise. The concept of change in ambient sound levels can be understood with an explanation of the hearing mechanism's reaction to sound. The human ear is a far better detector of relative differences in sound levels than absolute values of levels. Under controlled laboratory conditions, listening to a steady unwavering pure tone sound that can be changed to slightly different sound levels, a person can just barely detect a sound-level change of approximately 1 dB for sounds in the mid-frequency region. When ordinary noises are heard, a young healthy ear can detect changes of 2 to 3 dB. A 5-dB change is readily noticeable, while a 10-dB change is judged by most people as a doubling or a halving of the loudness of the sound.

Recruitment of Loudness. Recruitment describes the perception of loudness in situations where masking elevates the threshold of hearing of a sound from a background sound. A listener's judgment of the loudness of a sound will vary with different levels of background noise. In low level background situations that are near the threshold of hearing, the loudness level of a sound increases gradually. In these situations, a desired sound, such as music that is a level of 40 to 60 dB above the background, would be judged as comfortable. In loud background settings, a sound that is approximately 20 dB above the masking threshold will be perceived as having the same loudness as the sound would have had if no masking sound were present.

Masking Effect. Another characteristic of sound is its ability to interfere with the ability of a listener to hear another sound. This interference is defined as the masking effect. The presence of one sound effectively raises the threshold of audibility for the hearing of a second sound. For a signal to be heard, it must exceed the threshold of hearing for that particular individual and exceed the masking threshold for the background noise.

The masking characteristics of sound depend upon many factors, including the spectral (frequency) characteristics of the two sounds, the sound pressure levels, and the relative start time of the sounds. The masking effect is greatest when the masking frequency is closest to the frequency of the signal. Low frequency sounds can mask higher frequency sounds, however, the reverse is not true.

Factors Influencing Human Response to Sound

Many factors influence how a sound is perceived and whether or not it is considered annoying to the listener. These factors include not only physical characteristics of the sound but also secondary influences, such as sociological and external factors. Molino, in the *Handbook of Noise Control*, describes human response to sound in terms of both acoustic and non-acoustic factors. These factors are summarized in Table C1.

Table C1
FACTORS THAT AFFECT INDIVIDUAL ANNOYANCE TO NOISE
Seattle-Tacoma International Airport FAR Part 150 Study

Primary Acoustic Factors
- Sound Level
- Frequency
- Duration

Secondary Acoustic Factors
- Spectral Complexity
- Fluctuations in Sound Level
- Fluctuations in Frequency
- Rise-time of the Noise

Non-Acoustic Factors
- Physiology
- Adaptation and Past Experience
- How the Listener's Activity Affects Annoyance
- Predictability of When a Noise will Occur
- Is the Noise Necessary?
- Individual Differences and Personality

Source: C. Harris, 1979

Sound rating scales are developed to account for the factors that affect human response to sound. Nearly all of these factors are relevant in describing how sounds are perceived in the community. Many of the non-acoustic parameters play a prominent role in affecting individual response to noise. Background sound, an additional acoustic factor not specifically listed, is also important in describing sound in rural settings. In his analysis of the effects of personal and situation-dependent variables on noise annoyance, Fields has identified a clear association of reported annoyance and fear of an accident. In particular, Fields has stated that there is solid evidence that noise annoyance is associated with: (1) the fear of an aircraft crashing or of danger from nearby surface transportation; (2) the belief that aircraft noise could be prevented or reduced by designers, pilots, or authorities related to airlines; and (3) an expressed sensitivity to noise generally. Thus, it is important to recognize that non-acoustic factors such as the ones described above, as well as acoustic factors, contribute to human response to noise.

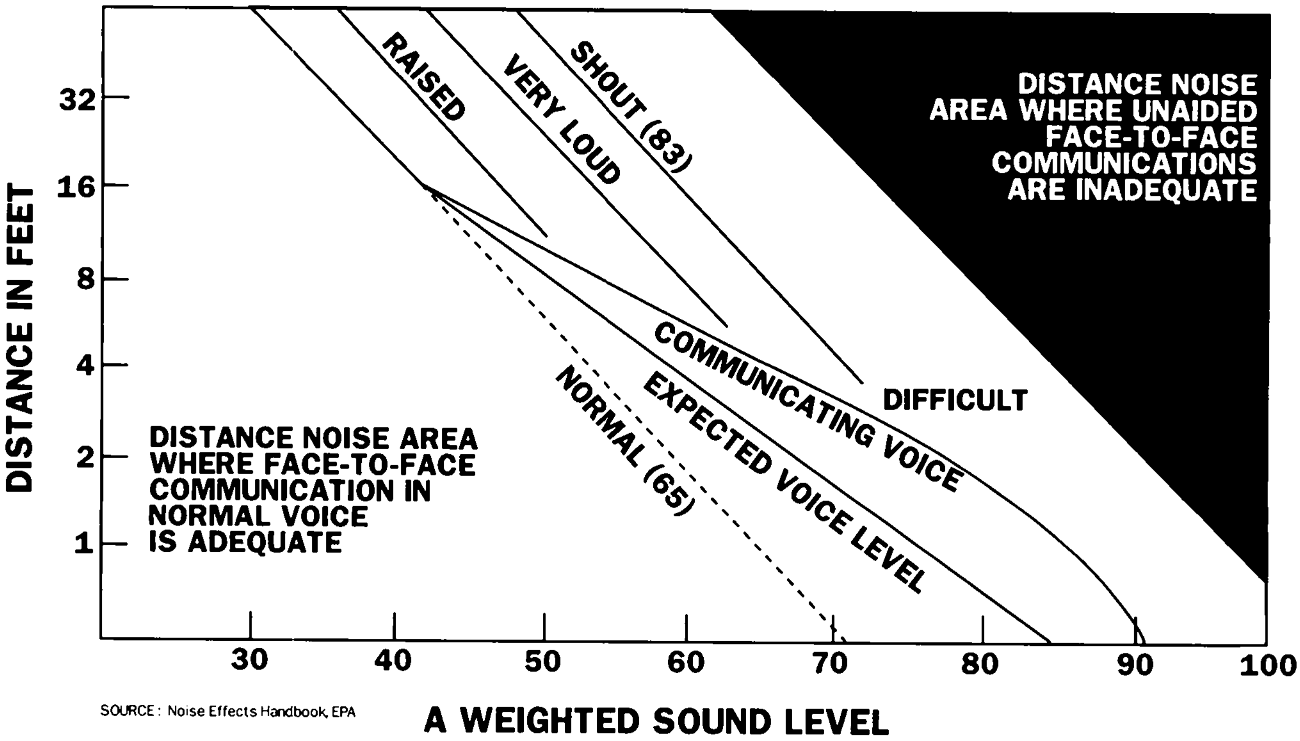
Health Effects of Noise

Noise, often described as unwanted sound, is known to have several adverse effects on people. From these known adverse effects of noise, criteria have been established to help protect the public health and safety and prevent disruption of certain human activities. These criteria are based on the effects of noise on people, such as hearing loss (not a factor with typical community noise), communication interference, sleep interference, physiological responses, and annoyance. Each of these potential noise impacts on people is briefly discussed in the following narrative:

- *Hearing Loss* is generally not a concern in community noise problems, even very near a major airport or a major freeway. The potential for noise-induced hearing loss is more commonly associated with occupational noise exposures in heavy industry, very noisy work environments with long-term exposure, or certain very loud recreational activities such as target shooting and motorcycle or car racing. The Occupational Safety and Health Administration (OSHA) identifies a noise exposure limit of 90 dBA for 8 hours per day to protect from hearing loss (higher limits are allowed for shorter duration exposures). Noise levels in neighborhoods, even in very noisy neighborhoods, are not sufficiently loud to cause hearing loss.

- *Communication Interference* is one of the primary concerns in environmental noise problems. Intrusive and background noises can mask speech, degrading intelligibility and disrupting communication. Frequent speech interference typically triggers annoyance and in a small percent of cases complaints. Activities where speech intelligibility is critical include classroom instruction, outdoor concerts, and other leisure listening endeavors (person to person conversation, TV listening, and phone conversation). In addition, annoyance response is often triggered by speech interference. Factors influencing communication interference include: location (indoor or outdoor), transmission loss (acoustical isolation) of structure, vocal effort, vocal frequency content (male or female), listening skill, hearing acuity, noise frequency spectrum content, and noise temporal characteristics.

  Normal conversational speech is in the range of 60 to 65 dBA and any noise in this range or louder may interfere with speech. There are specific methods of describing speech interference as a function of distance between speaker and listener and voice level. Figure C4 shows the relation of quality of speech communication with respect to various noise levels.



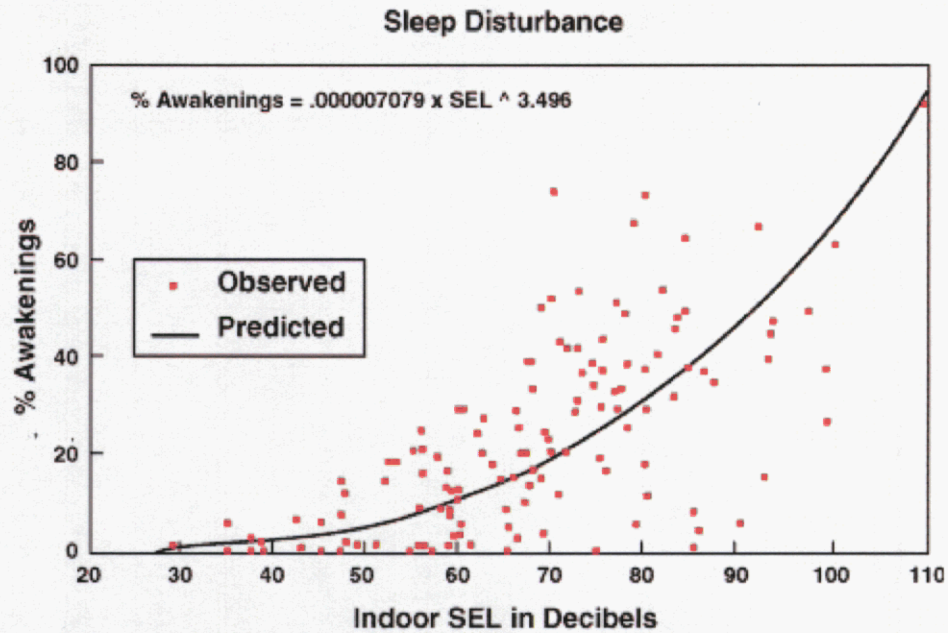
SOURCE: Noise Effects Handbook, EPA

Figure C4 **Quality of Speech Communication in Relation to Distance Between the Talker and the Listener**

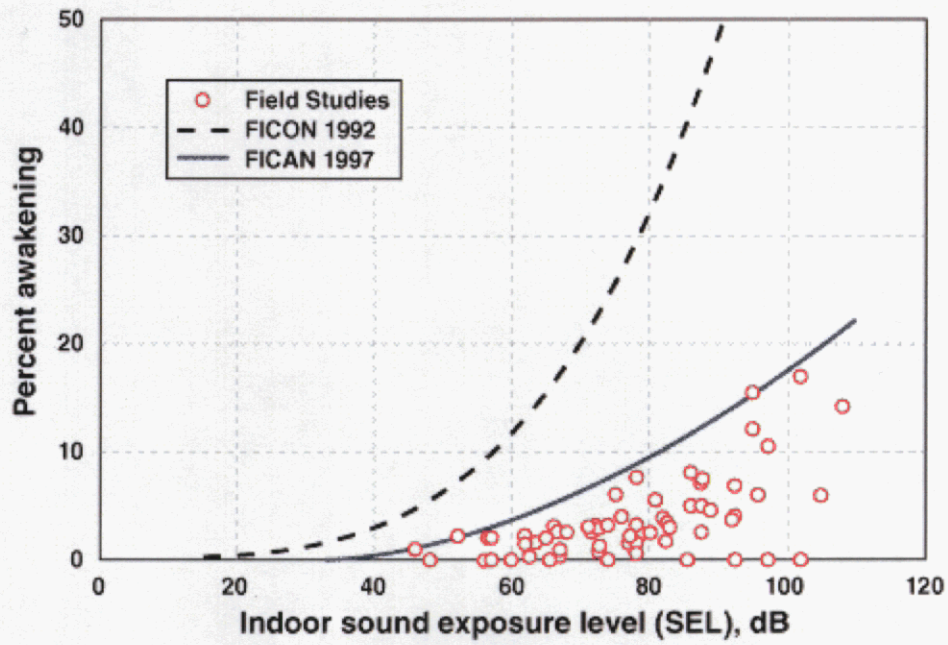
- *Sleep Interference* is a major noise concern in noise assessment and, of course, is most critical during nighttime hours. Sleep disturbance is one of the major causes of annoyance due to community noise. Noise can make it difficult to fall asleep, create momentary disturbances of natural sleep patterns by causing shifts from deep to lighter stages and cause awakening. Noise may even cause awakening, which a person may or may not be able to recall.

  Extensive research has been conducted on the effect of noise on sleep disturbance. Recommended values for desired sound levels in residential bedroom space range from 25 to 45 dBA, with 35 to 40 dBA being the norm. The National Association of Noise Control Officials has published data on the probability of sleep disturbance with various single-event noise levels. Based on experimental sleep data (laboratory) as related to noise exposure, a 75 dBA interior noise level event will cause noise-induced awakening in 30 percent of the cases. A summary of these data is presented in the top portion of Figure C5.

  It is important to note that recent research from England [4] and the U.S. Air Force (USAF) has shown that the probability for sleep disturbance is less than what had been reported in earlier research. This research showed that once a person was asleep, it is much more unlikely that they will be awakened by a noise. The significant difference in the recent studies is the use of actual in-home sleep disturbance patterns as opposed to laboratory data that had been the historic basis for predicting sleep disturbance. The results of that research are summarized in the bottom portion of Figure C5. It is therefore likely that the data shown in the top of Figure C5 overestimates the sleep disturbance at a given noise level and is more reflected by the field data presented in the bottom portion of the figure. The USAF study concluded that the prevelance of awakening associated with noise events of an indoor SEL on the order of 70 dBA is 1.6 percent. An increase in prevelance of awakening of 1.6 percent is predicted for each 10-dB increase in the SEL.



Interim Sleep Disturbance Dose-Response Relationship based upon Laboratory Research (FICON, 1992)



FICON Recommended Sleep Disturbance Dose-Response Relationship based upon Field Studies (FICAN, 1997)

SOURCE: NANCO "Noise Effects Handbook", 1981

Figure C5 **Sample Sleep Interference**

- *Physiological Responses* are those measurable effects of noise on people, which are realized as changes in pulse rate, blood pressure, etc. While such effects can be induced and observed, the extent is not known to which these physiological responses cause harm or are a sign of harm. Health effects of noise have been studied for nearly 30 years, here in the United States and abroad. A wide range of effects has been studied, from cardiovascular response to fetal weight, to mortality. While noise is acknowledged to be a biological "stressor," capable of stimulating certain short-term physiological responses, 30 years of research have not produced a single, repeatable experiment which provides a clear dose/response relationship linking environmental noise with long-term effects other than annoyance. The summary reports published in the 1990s echo the same "call for more and better research" stated in the summary reports of the 1970s. Physiological /health response is very difficult to measure in a controlled fashion. In addition, much of the research has fallen far short of controlling and defining critically important variables necessary to emerge with a credible conclusion. Physiological effects are an area of continued research and debate with respect to aircraft noise.

- Annoyance is the most difficult of all noise responses to describe. Annoyance is a very individual characteristic and can vary widely from person to person. What one person considers tolerable can be quite unbearable to another of equal hearing capability. The level of annoyance, of course, depends on the characteristics of the noise (i.e.; loudness, frequency, time, and duration), and how much activity interference (such as speech interference and sleep interference) results from the noise. However, the level of annoyance is also a function of the attitude of the receiver. Personal sensitivity to noise varies widely. It has been estimated that 2 to 10 percent of the population is highly susceptible to annoyance from noise not of their own making, while approximately 20 percent are not affected by noise. Attitudes are affected by the relationship between the person and the noise source. (For example, is it our dog barking or the neighbor's dog?) Whether we believe that someone is trying to abate the noise will also affect our level of annoyance.

Sound Rating Scales

The description, analysis, and reporting of community sound levels is made difficult by the complexity of human response to sound and the myriad of sound-rating scales and metrics that have been developed for describing acoustic effects. Various rating scales have been devised to approximate the human subjective assessment to the "loudness" or "noisiness" of a sound. Noise metrics have been developed to account for additional parameters such as duration and cumulative effect of multiple events.

Noise metrics can be categorized as single-event metrics and cumulative metrics. Single-event metrics describe the noise from individual events, such as an aircraft flyover. Cumulative metrics describe the noise in terms of the total noise exposure throughout the day. Noise metrics used in this study are summarized below:

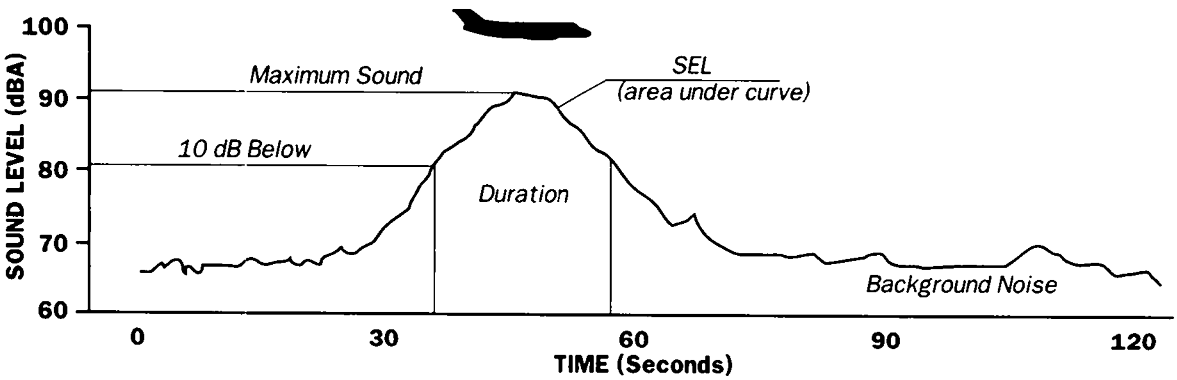
Single-Event Metrics

- *Frequency-Weighted Metrics (dBA)*. In order to simplify the measurement and computation of sound loudness levels, frequency-weighted networks have obtained wide acceptance. The A-weighting (dBA) scale has become the most prominent of these scales and is widely used in community noise analysis. Its advantages are that it has shown good correlation with community response and is easily measured. The metrics used in this study are all based upon the dBA scale unless otherwise noted.

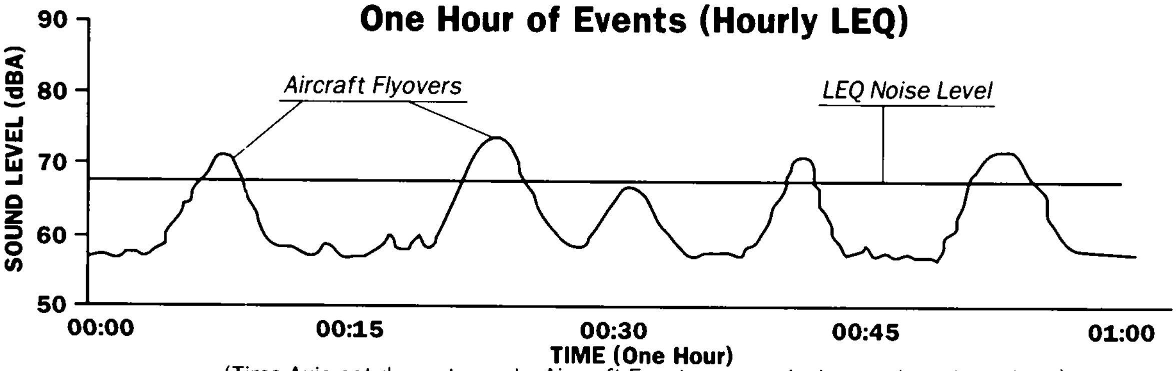
- *Maximum Noise Level*. The highest noise level reached during a noise event is, not surprisingly, called the "Maximum Noise Level," or Lmax. For example, as an aircraft approaches, the sound of the aircraft begins to rise above ambient noise levels. The closer the aircraft gets the louder it is until the aircraft is at its closest point directly overhead. Then as the aircraft passes, the noise level decreases until the sound level again settles to ambient levels. Such a history of a flyover is plotted at the top of Figure C6. It is this metric to which people generally instantaneously respond when an aircraft flyover occurs.

- *Sound Exposure Level (SEL)*. Another metric that is reported for aircraft flyovers is the Sound Exposure Level (SEL) metric. It is computed from dBA sound levels. Referring again to the top of Figure C6, the shaded area, or the area within 10 dB of the maximum noise level, is the area from which the SEL is computed. The SEL value is the integration of all the acoustic energy contained within the event. Speech and sleep interference research can be assessed relative to Single-Event Noise Exposure Level data.

Single Event Sound Exposure Level (SEL)



One Hour of Events (Hourly LEQ)



(Time Axis not drawn to scale. Aircraft Events are much shorter than shown here)

Twenty-Four Hours of Events (Hourly LEQ)

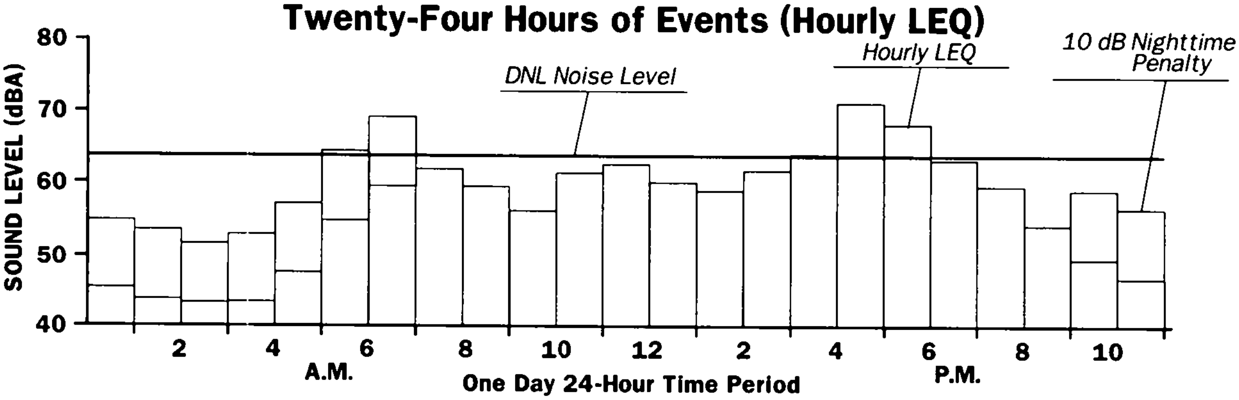


Figure C6 **SEL, LEQ and DNL Illustrations**

This metric takes into account the maximum noise level of the event and the duration of the event. For aircraft flyovers, the SEL value is typically about 10 dBA higher than the maximum noise level. Single event metrics are a convenient method for describing noise from individual aircraft events. This metric is useful in that airport noise models contain aircraft noise curve data based upon the SEL metric. In addition, cumulative noise metrics such as LEQ, CNEL, and DNL can be computed from SEL data.

Cumulative Metrics

- *Equivalent Noise Level (LEQ).* LEQ is the sound level corresponding to a steady-state A-weighted sound level containing the same total energy as a time-varying signal over a given sample period. LEQ is the "energy" average noise level during the time period of the sample. It is based on the observation that the potential for a noise to impact people is dependent on the total acoustical energy content of the noise. It is the energy sum of all the sound that occurs during that time period. This is graphically illustrated in the middle graph of Figure C6. LEQ can be measured for any time period, but is typically measured for 15 minutes, 1 hour, or 24 hours. LEQ for one hour is called Hourly Noise Level (HNL) in the California Airport Noise Regulations [6] and is used to develop the Day-Night Noise Level (DNL) values for aircraft operations.

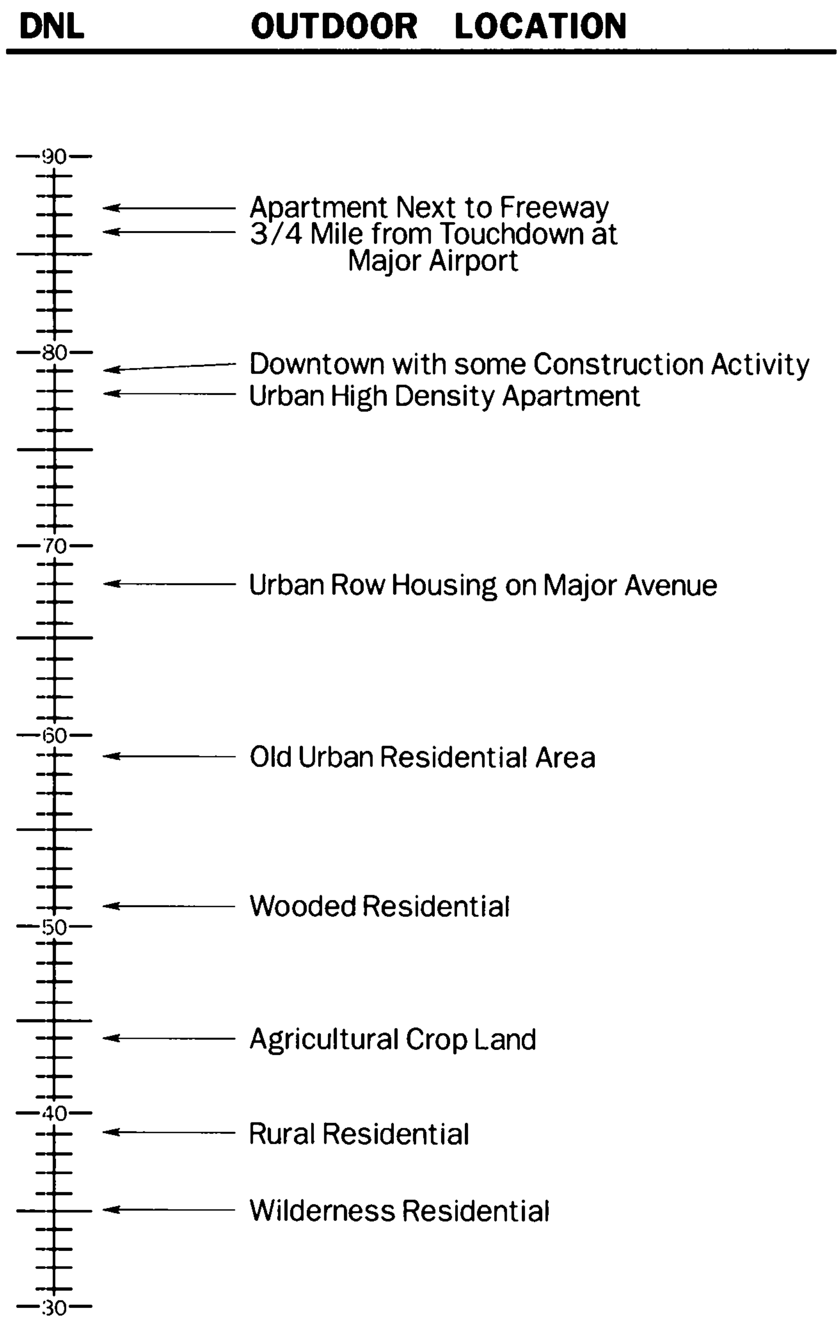
- Cumulative noise metrics have been developed to assess community response to noise. They are useful because these scales attempt to include the loudness of the noise, the duration of the noise, the total number of noise events and the time of day these events occur into one single number rating scale. They are designed to account for the known health effects of noise on people described earlier.

  Day-Night Noise Level (DNL). The DNL index is a 24-hour, time-weighted energy average noise level based on the A-weighted decibel. It is a measure of the overall noise experienced during an entire day. The time-weighted refers to the fact that noise that occurs during certain sensitive time periods is penalized for occurring at these times. In the DNL scale, noise occurring between the hours of 10 p.m. to 7 a.m. is penalized by 10 dB. This penalty was selected to attempt to account for the higher sensitivity to noise in the nighttime and the expected further decrease in background noise levels that typically occur in the nighttime. The FAA specifies DNL for airport noise assessement, and the Environmental Protection Agency (EPA) specifies DNL for community noise and airport noise assessment. DNL, also referred to as LDN, is graphically illustrated in the bottom of Figure C6. Examples of various noise environments in terms of DNL are presented in Figure C7.

Supplemental Metrics

- *Time Above (TA).* The FAA has developed the Time Above metric as a second metric for assessing impacts of aircraft noise around airports. The TA index refers to the total time in seconds or minutes that aircraft noise exceeds certain dBA noise levels in a 24-hour period. It is typically expressed as Time Above 75 and 85 dBA sound levels. While this index is not widely used, it may be used by the FAA in environmental assessments of airport projects that show a significant increase in noise levels. There are no noise/land use standards in terms of the TA index.

- *Percent Noise Level (Ln).* To account for intermittent or fluctuating noise, another method to characterize noise is the Percent Noise Level (Ln). The Percent Noise Level is the level exceeded n% of the time during the measurement period. It is usually measured in the A-weighted decibel, but can be an expression of any noise rating scale. Percent Noise Levels are another method of characterizing ambient noise where, for example, L90 is the noise level exceeded 90 percent of the time, L50 is the level exceeded 50 percent, and L10 is the level exceeded 10 percent of the time. L90 represents the background or minimum noise level, L50 represents the median noise level, and L10 represents the peak or intrusive noise levels. Percent noise level is commonly used in community noise ordinances which regulate noise from mechanical equipment, entertainment noise sources, and the like. It is not normally used for transportation noise regulation.



SOURCE: EPA Levels Document, 1974

Figure C7 **Typical Outdoor Noise Environments**

Noise/Land Use Compatibility Standards and Guidelines

The use of noise metrics is an attempt to quantify community response to various noise exposure levels. The public reaction to different noise levels has been estimated based upon extensive research on human responses to exposure of different levels of aircraft noise. Figure C8 relates DNL noise levels to community response from one of these surveys. Community noise standards are derived from tradeoffs between community response surveys, such as this, and economic considerations for achieving these levels. These standards generally are in terms of the DNL 24-hour averaging scale that is based upon the A-weighted decibel. Utilizing these metrics and surveys, agencies have developed standards for assessing the compatibility of various land uses within the noise environment.

This section presents information regarding noise and land use criteria that may be useful in the evaluation of noise impacts. With respect to airports, the FAA has a long history of publishing noise/land use assessment criteria. These laws and regulations provide the basis for local development of airport plans, analyses of airport impacts, and the enactment of compatibility policies. Other agencies, including the EPA and the Department of Defense, have developed noise/land use criteria. The most common noise/land use compatibility standard or criteria used is 65 dB DNL (CNEL in California) for residential land use with outdoor activity areas. At 65 dB DNL the Schultz curve predicts approximately 14% of the exposed population to be highly annoyed. At 60 dB DNL this decreases to approximately 8% of the population highly annoyed. It should be further pointed out that the data upon which the Schultz curve and the more recent updates are based include a very wide range of scatter among the data with communities near some airports reporting a much higher percentage of the population highly annoyed at these noise exposure levels. A summary of some of the more pertinent regulations and guidelines is presented in the following paragraphs.

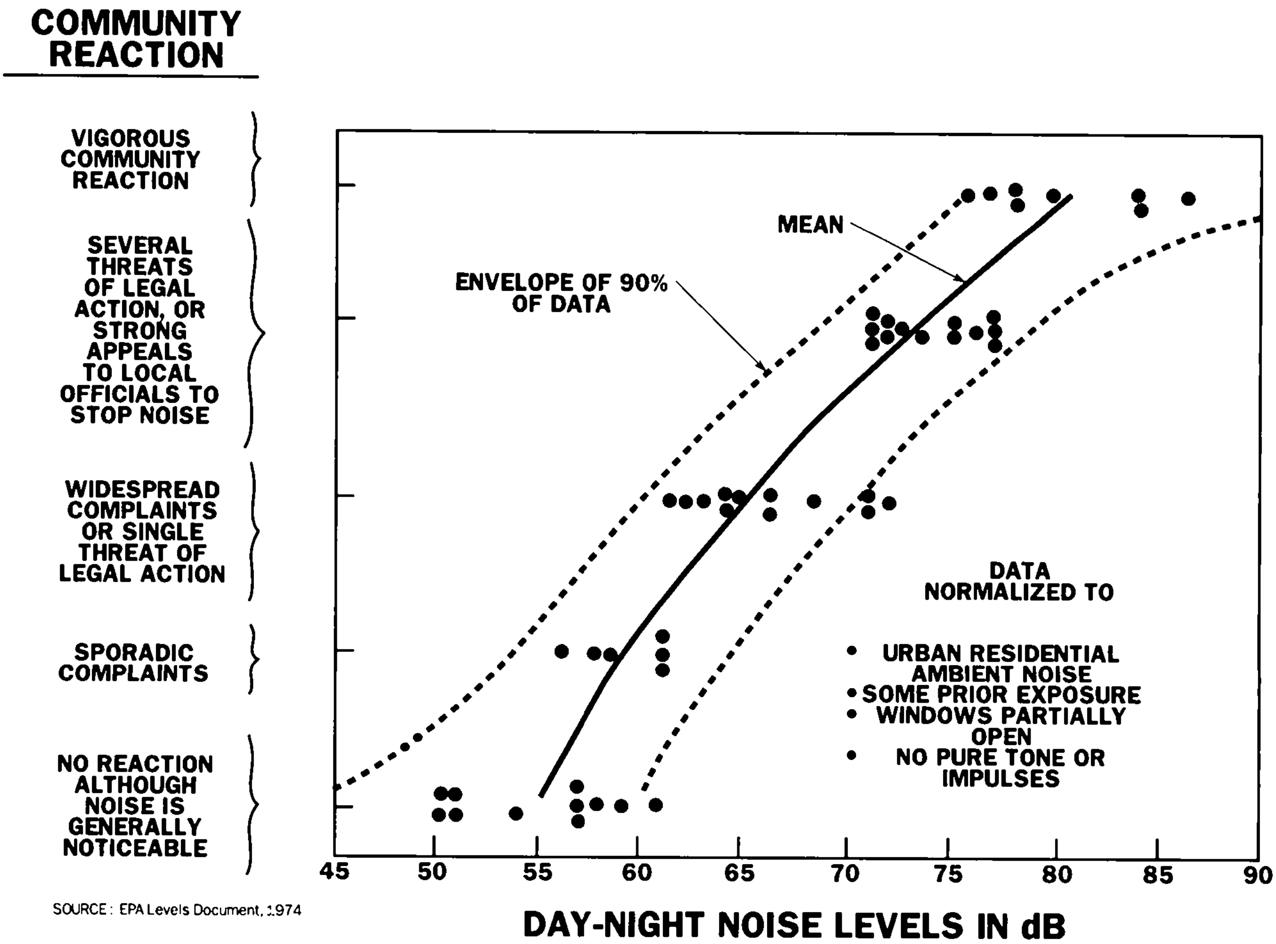


Figure C8 **Community Reaction to Noise**

Federal Aviation Administration

Federal Aviation Regulations, Part 36, "Noise Standards: Aircraft Type and Airworthiness Certification".

Originally adopted in 1960, FAR Part 36 prescribes noise standards for issuance of new aircraft type certificates. Part 36 prescribes limiting noise levels for certification of new types of propeller-driven, small airplanes as well as for transport category, large airplanes. Subsequent amendments extended the standards to certain newly produced aircraft of older type designs. Other amendments have at various times extended the required compliance dates. Aircraft may be certified as Stage 1, Stage 2, or Stage 3 aircraft based on their noise level, weight, number of engines, and in some cases, number of passengers. Stage 1 aircraft are no longer permitted to operate in the United States. Stage 2 aircraft are being phased out of the U.S. fleet as discussed in a later paragraph on the Airport Noise and Capacity Act of 1990. Although aircraft meeting Part 36 standards are noticeably quieter than many of the older aircraft, the regulations make no determination that such aircraft are acceptably quiet for operation at any given airport.

U.S. Department of Transportation Aviation Noise Abatement Policy.

This policy, adopted in 1976, sets forth the noise abatement authorities and responsibilities of the Federal government, airport proprietors, State and local governments, the air carriers, air travelers and shippers, and airport area residents and prospective residents. The basic thrust of the policy is that the FAA's role is primarily one of regulating noise at its source (the aircraft) plus supporting local efforts to develop airport noise abatement plans. The FAA will give high priority in the allocation of Airport Improvement Program (AIP) funds to projects designed to ensure compatible use of land near airports, but it is the role of State and local governments and airport proprietors to undertake the land use and operational actions necessary to promote compatibility.

Aviation Safety and Noise Abatement Act of 1979

Further weight was given to the FAA's supporting role in noise compatibility planning by congressional adoption of this legislation. Among the stated purposes of this act is "To provide assistance to airport operators to prepare and carry out noise compatibility programs." The law establishes funding for noise compatibility planning and sets the requirements by which airport operators can apply for funding. The law does not require any airport to develop a noise compatibility program.

Federal Aviation Regulations, Part 150, "Airport Noise Compatibility Planning"

As a means of implementing the Aviation Safety and Noise Abatement Act, the FAA adopted Regulations on Airport Noise Compatibility Planning Programs. These regulations are spelled out in FAR Part 150. As part of the FAR Part 150 Noise Control program, the FAA published noise and land use compatibility charts to be used for land use planning with respect to aircraft noise. An expanded version of this chart appears in Aviation Circular 150/5020-1 (dated August 5, 1983) and is reproduced in Figure C9. These guidelines represent recommendations to local authorities for determining acceptability and permissibility of land uses. The guidelines specify a maximum amount of noise exposure (in terms of the cumulative noise metric DNL) that will be considered acceptable to or compatible with people in living and working areas.

These noise levels are derived from case histories involving aircraft noise problems at civilian and military airports and the resultant community response. Note that residential land use is deemed acceptable for noise exposures up to 65 dB DNL. Recreational areas are also considered acceptable for noise levels above 65 dB DNL (with certain exceptions for amphitheaters that are recommended not to exceed 65 dB DNL). Several important notes appear for the FAA guidelines including one which indicates that ultimately "the responsibility for determining the acceptability and permissible land uses remains with the local authorities."

Federal Aviation Order 5050.4 and Directive 1050.1 for Environmental Analysis of Aircraft Noise Around Airports

The FAA has developed guidelines (Order 5050.4D) for the environmental analysis of airports. Federal requirements now dictate that increases in noise levels in noise-sensitive land uses of over 1.5 dB DNL within the 65 dB DNL contour are considered significant (1050.1A, 12.21.83). The FAA considers only those noise impacts that occur at the 65 dB DNL or greater. No analysis is required by the FAA beyond the 65 dB DNL.

Land Use	Yearly Day-Night Noise Level (DNL) in decibels					
	Below 65	65-70	70-75	75-80	80-85	Over 85
Residential						
Residential, other than mobile homes and transient lodgings	Y	N(1)	N(1)	N	N	N
Mobile home parks	Y	N	N	N	N	N
Transient lodgings	Y	N(1)	N(1)	N(1)	N	N
Public Use						
Schools	Y	N(1)1	N(1)	N	N	N
Hospitals and nursing homes	Y	25	30	N	N	N
Churches, auditoriums and concert halls	Y	25	30	N	N	N
Governmental services	Y	Y	25	30	N	N
Transportation	Y	Y	Y(2)	Y(3)	Y(4)	Y(4)
Parking	Y	Y	Y(2)	Y(3)	Y(4)	N
Commercial Use						
Offices, business and professional	Y	Y	25	30	N	N
Wholesale and retail-building materials, hardware and farm equipment	Y	Y	Y(2)	Y(3)	Y(4)	N
Retail trade-general	Y	Y	25	30	N	N
Utilities	Y	Y	Y(2)	Y(3)	Y(4)	N
Communication	Y	Y	25	30	N	N
Manufacturing and Production						
Manufacturing, general	Y	Y	Y(2)	Y(3)	Y(4)	N
Photographic and optical	Y	Y	25	30	N	N
Agriculture (except livestock) and forestry	Y	Y(6)	Y(7)	Y(8)	Y(8)	Y(8)
Livestock farming and breeding	Y	Y(6)	Y(7)	N	N	N
Mining and fishing resource production and extraction	Y	Y	Y	Y	Y	Y
Recreational						
Outdoor sports arenas and spectator sports	Y	Y(5)	Y(5)	N	N	N
Outdoor music shells, amphitheaters	Y	N	N	N	N	N
Nature exhibits and zoos	Y	Y	N	N	N	N
Amusements, parks, resorts and camps	Y	Y	Y	N	N	N
Golf courses, riding stables and water recreation	Y	Y	25	30	N	N

Numbers in parentheses refer to notes.

• The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable or unacceptable under Federal, State or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

Key to Table 1

SLUCM	Standard Land Use Coding Manual.
Y(Yes)	Land Use and related structures compatible without restrictions.
N(No)	Land Use and related structures are not compatible and should be prohibited.
NLR	Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.
25, 30 or 35	Land Use and related structures generally compatible; measures to achieve NLR of 25, 30 or 35 dB must be incorporated into design and construction of structure.

Notes

(1) Where the community determines that residential or school uses must be allowed, measures to achieve outdoor to indoor Noise Level Reduction (NLR) of at least 25 dB to 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide a NLR of 20 dB, thus, the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year round. However, the use of NLR criteria will not eliminate outdoor noise problems.

(2) Measures to achieve NLR of 25 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.

(3) Measures to achieve NLR of 30 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.

(4) Measures to achieve NLR of 35 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.

(5) Land use compatible provided that special sound reinforcement systems are installed.

(6) Residential buildings require an NLR of 25.

(7) Residential buildings require an NLR of 30.

(8) Residential buildings not permitted.

SOURCE: FAR Part 150

Figure C9 **FAR Part 150 Guidelines**

Airport Noise and Capacity Act of 1990

The Airport Noise and Capacity Act of 1990 (PL 101-508, 104 Stat. 1388), also known as ANCA or the Noise Act, established two broad directives to the FAA: (1) establish a method to review aircraft noise, and airport use or access restrictions, imposed by airport proprietors, and (2) institute a program to phase-out Stage 2 aircraft over 75,000 pounds by December 31, 1999. Stage 2 aircraft are older, noisier aircraft (B-737-200, B-727 and DC-9); Stage 3 aircraft are newer, quieter aircraft (B-737-300, B-757, MD-80/90). To implement ANCA, FAA amended Part 91 and issued a new Part 161 of the Federal Aviation Regulations. Part 91 addresses the phase-out of large Stage 2 aircraft and the phase-in of Stage 3 aircraft. Part 161 establishes a stringent review and approval process for implementing use or access restrictions by airport proprietors.

Part 91 generally states that all Stage 2 aircraft, over 75,000 pounds, will be out of the domestic fleet by December 31, 1999. There are a few exceptions, but for the most part, only Stage 3 aircraft greater than 75,000 pounds will be in the domestic fleet after that date. The airlines have all achieved complience with the regulation and all aircraft in the civilan fleet over 75,000 pounds are now Stage 3.

Part 161 sets out the requirements and procedures for implementing new airport use and access restrictions by airport proprietors. Proprietors must use the DNL metric to measure noise effects, and the Part 150 land use guideline table, including 65 dB DNL as the threshold contour, must be used to determine compatibility, unless there is a locally adopted, more stringent standard..

The regulation identifies three types of use restrictions and treats each one differently: negotiated restrictions, Stage 2 aircraft restrictions, and Stage 3 aircraft restrictions. Generally speaking, any use restriction which affects the number or times of aircraft operations will be considered an access restriction. Even though the Part 91 phase-out does not apply to aircraft under 75,000 pounds, FAA has determined that Part 161 limitations on proprietors' authority applies as well to the smaller aircraft.

Negotiated restrictions are more favorable from the FAA's standpoint, but still require unwieldy procedures for approval and implementation. The restrictions must be agreed upon by all airlines, and public notice must be given.

Stage 2 restrictions are more difficult, as one of the major reasons for ANCA was to discourage local restrictions more stringent that the ANCA's 1999 phase-out. To comply with the regulation and institute a new Stage 2 restriction, the airport proprietor must generally do two things. It must prepare a cost/benefit analysis of the proposed restriction and give proper notice. The cost/benefit analysis is extensive and entails considerable evaluation. Stage 2 restrictions do not require approval by the FAA.

Stage 3 restrictions are especially difficult to implement. A Stage 3 restriction involves considerable additional analysis, justification, evaluation, and financial discussion. In addition, a Stage 3 restriction must result in a decrease in noise exposure of the 65 dB DNL to noise-sensitive land uses (residences, schools, churches, parks). The regulation requires both public notice and FAA approval.

ANCA applies to all local noise restrictions that are proposed after October 1990. It also applies to amendments to existing restrictions proposed after October 1990. There have not been any Part 161 evaluations approved by the FAA to date.

Environmental Protection Agency Noise Assessment Guidelines

Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety"

In March 1974, the EPA published a very important document [1] entitled "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety" (EPA 550/9-74-004). In this document, 55 dB DNL is described as the requisite level with an adequate margin of safety for areas with outdoor uses, including residences and recreational areas. This document does not constitute EPA regulations or standards. Rather, it is intended to "provide State and local governments as well as the Federal government and the private sector with an informational point of departure for the purpose of decision-making." Note that these levels were developed for suburban type uses. In some urban settings, the noise levels will be significantly above this level, while in some wilderness settings, the noise levels will be well below this level. The EPA "levels document" does not constitute a standard, specification, or regulation, but identifies safe levels of environmental noise exposure without consideration for economic cost for achieving these levels.

Federal Interagency Committee on Noise

Federal Interagency Committee on Noise (FICON) Report of 1992 [13]

The use of the DNL metric and the 65 dB DNL criteria has been subject to criticism from various interest groups concerning its usefulness in assessing aircraft noise impacts. As a result, at the direction of the EPA and the FAA, the Federal Interagency Committee On Noise (FICON) was formed to review specific elements of the assessment of airport noise impacts and to make recommendations regarding potential improvements. FICON is composed of representatives from the Departments of Transportation, Defense, Justice, Veterans Affairs, Housing and Urban Development, the Environmental Protection Agency, and the Council on Environmental Quality.

FICON was formed to review Federal policies that are used in the assessment of airport noise impacts. The FICON review focused primarily on the manner in which noise impacts are determined, including whether aircraft noise impacts are fundamentally different from other transportation noise impacts; the manner in which noise impacts are described; and the extent of impacts outside of Day-Night Average A-Weighted Sound Level (DNL) 65 decibels (dB) that should be reviewed in a National Environmental Policy Act (NEPA) document.

The committee determined that there are no new descriptors or metrics of sufficient scientific standing to substitute for the present DNL cumulative noise exposure metric. The methodology employing DNL as the noise exposure metric and appropriate dose-response relationships to determine noise impact is considered the proper one for civil and military aviation scenarios in the general vicinity of airports. The report does support agency discretion in the use of supplemental noise analysis. The report does recommend improvement in public understanding of the DNL, supplemental methodologies, and aircraft noise impacts.

The report states that if the screening analysis shows that noise-sensitive areas that are exposed to noise levels at or above DNL 65 dB and have an increase of DNL 1.5 dB or more, then further analysis should be conducted. For noise-sensitive areas between DNL 60-65 dB and an increase of DNL 3 dB or more due to the proposed airport noise exposure, then further analysis should also be conducted.

Federal Interagency Committee on Aviation Noise (FICAN)

The Federal Interagency Committee on Aviation Noise (FICAN) was formed in 1993 to provide forums for debate over needs for future aviation noise research and to encourage new development efforts in this area. All federal agencies concerned with aviation noise are represented on the Committee.

Agency members of FICAN include:

- ✓ Department of Defense
- ✓ Air Force
- ✓ Army
- ✓ Navy
- ✓ Department of Interior
- ✓ National Park Service
- ✓ Department of Transportation
- ✓ Office of the Secretary
- ✓ Federal Aviation Administration
- ✓ Environmental Protection Agency
- ✓ National Aeronautics and Space Administration
- ✓ Department of Housing and Urban Development

FICAN holds regular membership meetings and annual public forums in different locations. Public forums were held in Seattle in 1996, Minneapolis St. Paul in 1997, and Washington, DC in 1998. Information about FICAN can also be found on their web page at http://www.fican.org.

Recent meetings have included reports on acoustic research on sleep interference and the effect of noise on learning.

Sleep Interference: Two studies on the effects of aircraft noise on sleep were summarized. Results of the studies conducted in private homes in the United Kingdom and in Denver, CO were consistent. They both demonstrated that the sleep disturbance from aircraft noise is less prevalent than had been previously indicated by laboratory studies. "Generally, laboratory studies have shown considerably more disturbance than field studies."

Although the study found that "at outdoor event levels below 90 dBA SEL (80 dBA Lmax), average sleep disturbance rates are unlikely to be affected by aircraft noise," FICAN did not recommend any change in the 10dB penalty assigned to nighttime noise events when calculating average annual DNL. The committee concluded that, due to the lower ambient noise at night and the presence of more people in the house, the opportunity for disturbance is higher than during the daytime.

Effects of Aircraft Noise on School-Aged Children: Research in Los Angeles, New York City and Munich, Germany indicated that exposure to high noise levels has some effect on reading and puzzle-solving ability. Researcher Dr. Gary Evans, pointed out that there is a significant lack of research in the dose-response relationship; that is, the relationship between amount of noise exposure and the response seen in children. He requested FICAN members to encourage more research in this area.

Existing Noise Environment

The purpose of this section of the report is to present the existing conditions noise levels. This includes the results of the noise measurement survey completed for the last three quarters of 1998 and the first quarter of 1999. Based upon this measurement data, and actual 1998 annual operational conditions, an existing noise contour has been developed. The measurement survey was based upon a four-season measurement program, and this report summarizes the results from all four of the measurement seasons.

Introduction

This Section is divided into the following parts:

- ✓ **Noise Measurement Sites**. Summarizes the locations of the noise measurement survey.
- ✓ **Noise Measurement Results**. Presents the results of the noise measurement survey based upon the four seasons of noise monitoring.
- ✓ **Existing Noise Contour**. Presents an existing noise contour.

Noise Measurement Sites

The noise measurement survey consisted of monitoring at 45 different locations around Seattle-Tacoma International Airport. The sites were grouped into four categories that differ in terms of the duration of the monitoring and the type of data that was collected. These categories include:

Permanent Noise Monitoring System Sites (11 Sites). Noise data from the Airport's permanent noise monitoring system was used in the study. The Port of Seattle (POS) has been operating the noise monitoring system from these eleven locations since the early eighties.. From this data a number of noise descriptors were determined, including DNL, hourly LEQ, single event (SEL, Lmax and duration), and ambient descriptors (L1, L10, L50, L90, L99).

Semi-Permanent Measurement Sites (10 Sites). Measurements at these 10 locations consisted of placing a noise monitor for a one-week to ten-day period during each of the four seasons. These A-weighted measurements utilized continuous noise monitoring of all noise during the measurement period. From this data, a number of noise descriptors were determined, including DNL, hourly LEQ, Time Above (TA) noise levels (TA85, TA75 and TA65), single event (SEL, Lmax and duration), and ambient descriptors (L1, L10, L50, L90, L99).

***Close in or Ground Noise Measurement Sites** (Four Sites).* Four sites were used for the measurement of ground noise sources around the Airport. These A-weighted measurements utilized continuous noise monitoring of all noise during the measurement period. From this data a number of noise descriptors were determined, including DNL, hourly LEQ, Time Above noise levels (TA85, TA75 and TA65), single event (SEL, Lmax and duration), and ambient descriptors (L1, L10, L50, L90, L99).

***Temporary Short-term Measurement Sites** (20 Sites).* These 20 sites were used for the measurement of short-term (aircraft and non-aircraft) noise levels. The purpose of these sites was to provide short-term measurement results at representative locations around the Airport. Each site was measured for a period of one to four days in duration.

Noise Measurement Locations. Noise measurement surveys were conducted at selected locations around the Airport. The measurement locations were selected on the basis of: (1) proximity to aircraft flight tracks, (2) proximity to noise sensitive land use areas, and (3) ambient noise levels.

The Airport's permanent locations are designated RMS1--RMS11. The semi-permanent sites on the north side of the Airport were designated Sites PN1 – PN5 while the sites on the south side of the Airport were designated Sites PS1 – PS5. The close-in sites were designated as Sites C1 – C4. The temporary noise-monitoring sites were located half on the north end of the Airport and half on the south end of the Airport. The temporary sites were designated Sites T1 – T20. The locations of all the sites are presented in Table C2.

The measurement locations are presented in Figure C.10. More detailed maps showing each of the noise monitoring locations are presented in Figures C.11 and C.12 for the sites located north and south of the Airport, respectively. All noise monitoring was done in accordance with Part 150 guidelines.

Table C2
PART 150 NOISE MEASUREMENT LOCATIONS
Seattle-Tacoma International Airport FAR Part 150 Study

Sites	Address	Neighborhood
Permanent Sites		
R 1	Parkside Elem. (S 247th St)	Des Moines
R 2	12 Ave S and S 226th St.	Des Moines
R 3	24th Ave S and S 223rd St	Midway Elementary
R 4	200th St and 20th Ave S	Tyee Golf Course
R 5	S 171 and 12 Ave S	Five Corners
R 6	S 146 St Between Runways	North of Airport
R 7	13th Ave S and S 120th St	Boulevard Park
R 8	S 104th St and 13th Ave S	Glendale School
R 9	23rd Ave S and S 126th St	Riverton
R 10	Highway 509 at S 192nd	Normandy Park
R 11	26th Ave S and S 151st	Riverton Heights
Semi-Permanent Sites		
PN1	1203 Sullivan St.	South Park
PN2	3717 Brandon St.	Rainier Valley
PN3	2503 37th Ave. W	Magnolia
PN4	223 31st Ave.	Leschi
PN5	8443 6th Ave. NE	Medina
PS1	20624 9th Ave. S	Des Moines
PS2	1805 S. 268th St.	Woodmont
PS3	29827 23 Ave.	Steel Lake
PS4	29310 45th Pl. S	Auburn
PS5	1608 SW 327th	Federal Way

Table C2 continued
PART 150 NOISE MEASUREMENT LOCATIONS
Seattle-Tacoma International Airport FAR Part 150 Study

Sites	Address	Neighborhood
Close-in Sites		
C1	16056 9th Ave. SW	Burien
C2	3223 S. 164th St.	McMicken Heights
C3	331 S 185th St.	Burien
C4	18320 38th Ave. S	East SeaTac
Temporary Sites		
T1	31602 45th Place SW	Dash Point
T2	19407 Military Rd. S	Angle Lake West
T3	16856 Des Moines Memorial Dr.	Burien
T4	S 360th St. and 32nd Ave. S	Lakeland School
T5	33rd Ave. and S 194th St.	Angle Lake Park
T6	S 156th St. and 4th Ave. S	Mosher Park
T7	Alki Beach Park	Alki Point
T8	Calif. Ave. SW and Palm Ave. SW	Alki Point
T9	NE 70th St. and 15th Ave. NE	University District
T10	17th Ave. S and S Ferdinand St.	Beacon Hill
T11	84th Ave. SE (Luther Burbank Park)	Mercer Island
T12	11th Ave. and E Howell St.	Capital Hill
T13	24th Ave. S and F St. SE	Auburn
T14	Ambaum Blvd. SW 128th St.	Mt. View
T15	26020 10th Pl. S	Des Moines
T16	1st Pl. SW and SW 200th St.	Normandy Park
T17	3303 S 132nd St.	Tukwila
T18	3735 S 175th St.	East SeaTac
T19	730 16th Ave. E	Capital Hill
T20	2102 S 279th Pl.	Federal Way

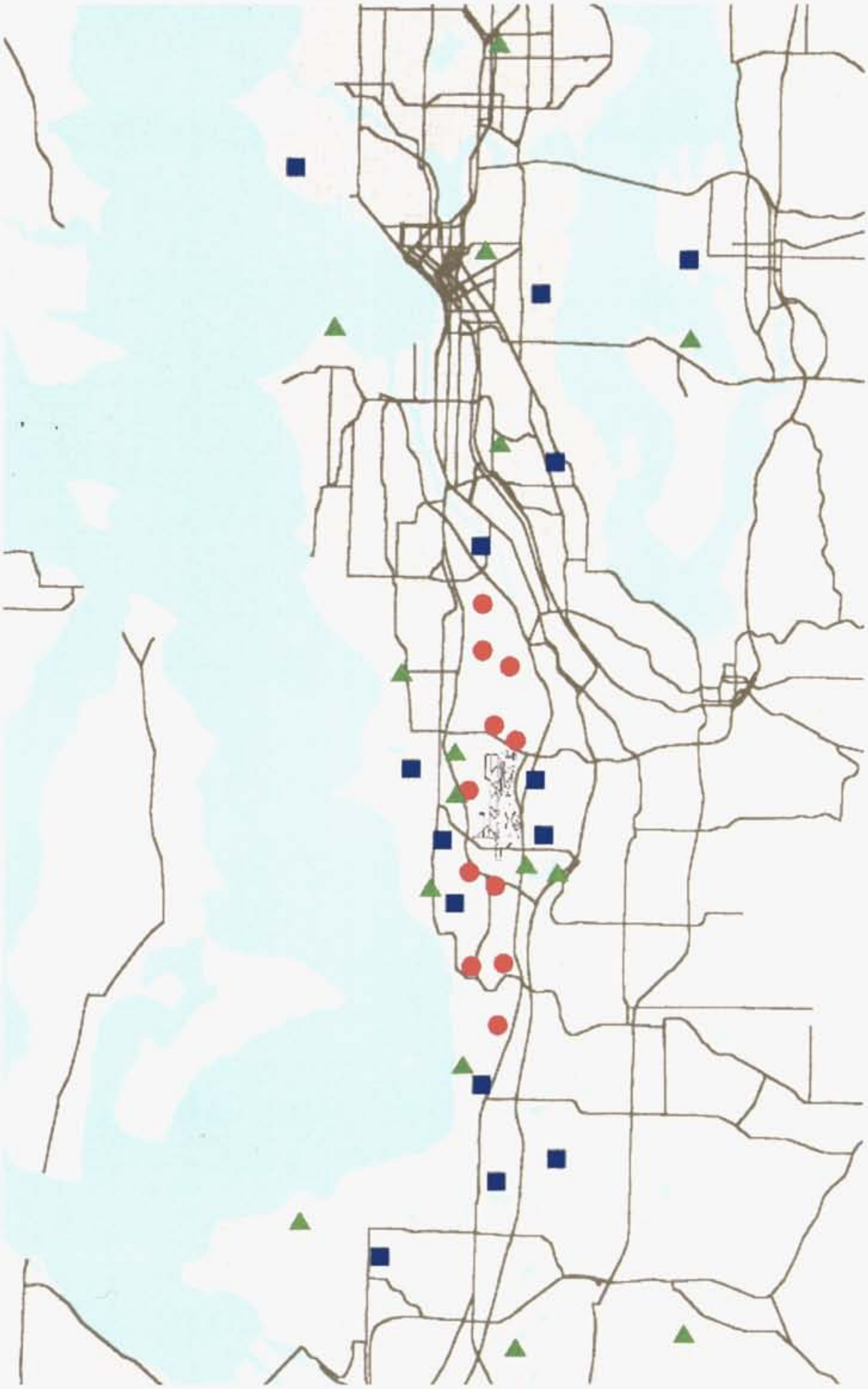
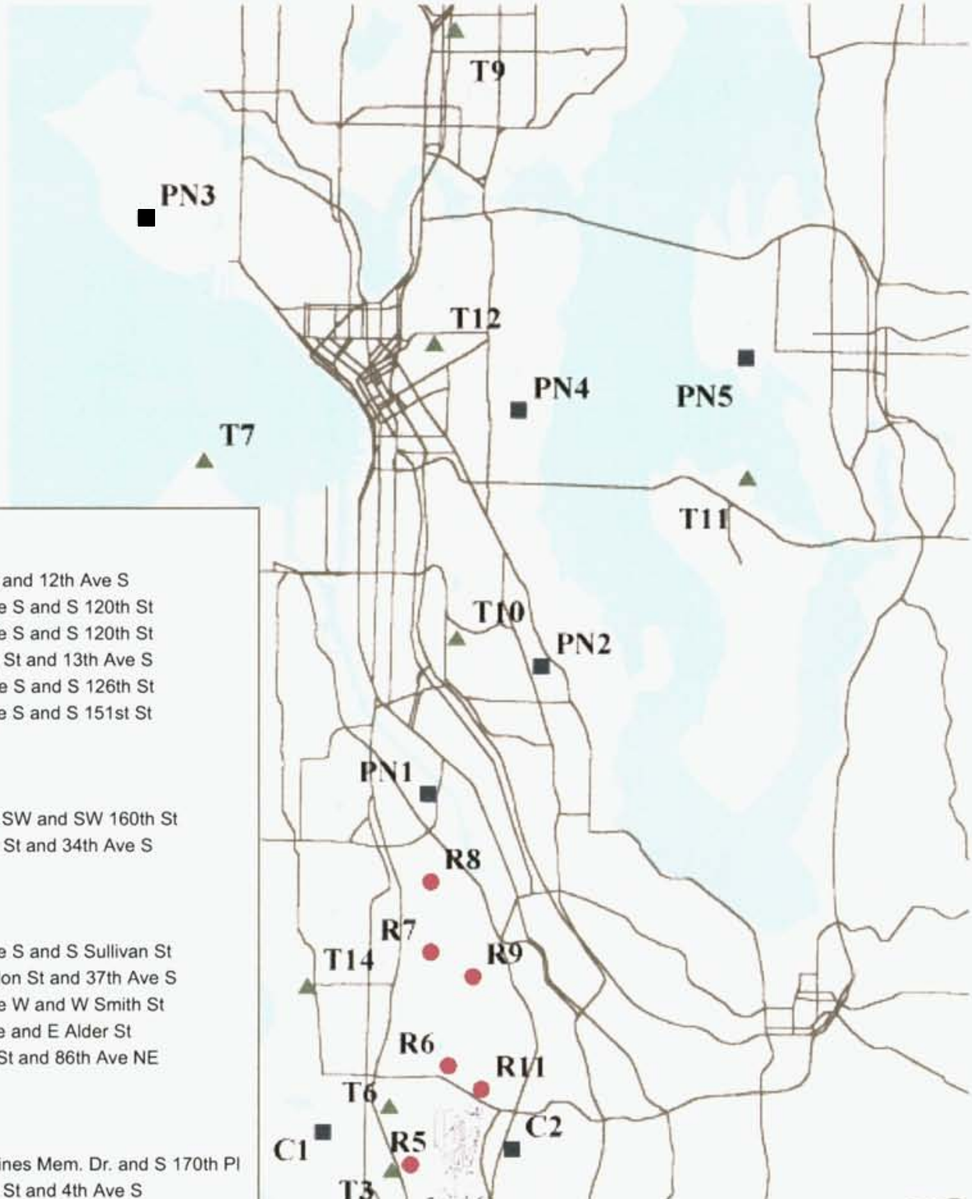


Figure C10 **FAR Part 150 Noise Monitoring Locations**

- Permanent
- Semi-Permanent
- Temporary



Permanent Sites

R5	Five Corners	S 171st and 12th Ave S
R6	North Airport	75th Ave S and S 120th St
R7	Boulevard Park	13th Ave S and S 120th St
R8	Glendale Jr High	S 104th St and 13th Ave S
R9	Riverton	23rd Ave S and S 126th St
R11	Riverton Heights	26th Ave S and S 151st St

Close-in Ground Noise Sites

C1	Highline Hospital	9th Ave SW and SW 160th St
C2	McMicken Heights	S 164th St and 34th Ave S

Semi-permanent Sites

PN1	South Park	12th Ave S and S Sullivan St
PN2	Rainier Valley	S Brandon St and 37th Ave S
PN3	Magnolia	37th Ave W and W Smith St
PN4	Leschi	31st Ave and E Alder St
PN5	Medina	NE 6th St and 86th Ave NE

Temporary Sites

T3	Burien	Des Moines Mem. Dr. and S 170th Pl
T6	Mosier Park	S 156th St and 4th Ave S
T7	Alki Point	Calif. Ave SW and Palm Ave SW
T9	University District	NE 70th St and 15 Ave NE
T10	Beacon Hill	17th Ave S and S Ferdinand St
T11	Mercer Island	84th Ave SE (Luther Burbank Park)
T12	Capital Hill	11th Ave and E Howell St
T14	Mt ViewSW	128th St and 14th Ave SW

N —— **Not to Scale**

Figure C11 **FAR Part 150 Noise Monitoring Locations:**
Close-In and North

- Permanent
- Semi-Permanent
- Temporary

Permanent Sites

R1	Des Moines	Parkside Elem. (S 247th St)
R2	Des Moines	12 Ave S and S 226th St
R3	Midway Elem.	24th Ave S and S 223rd St
R4	Tyee Golf Course	200th St and 20th Ave S
R5	Five Corners	South 171 and 12 Ave S
R6	North Airport	75th Ave S and S 120th St
R10	Normandy Park	Highway 509 at S 192nd
R11	Riverton Heights	26 Ave S and S 151 St

Close-in Ground Noise Sites

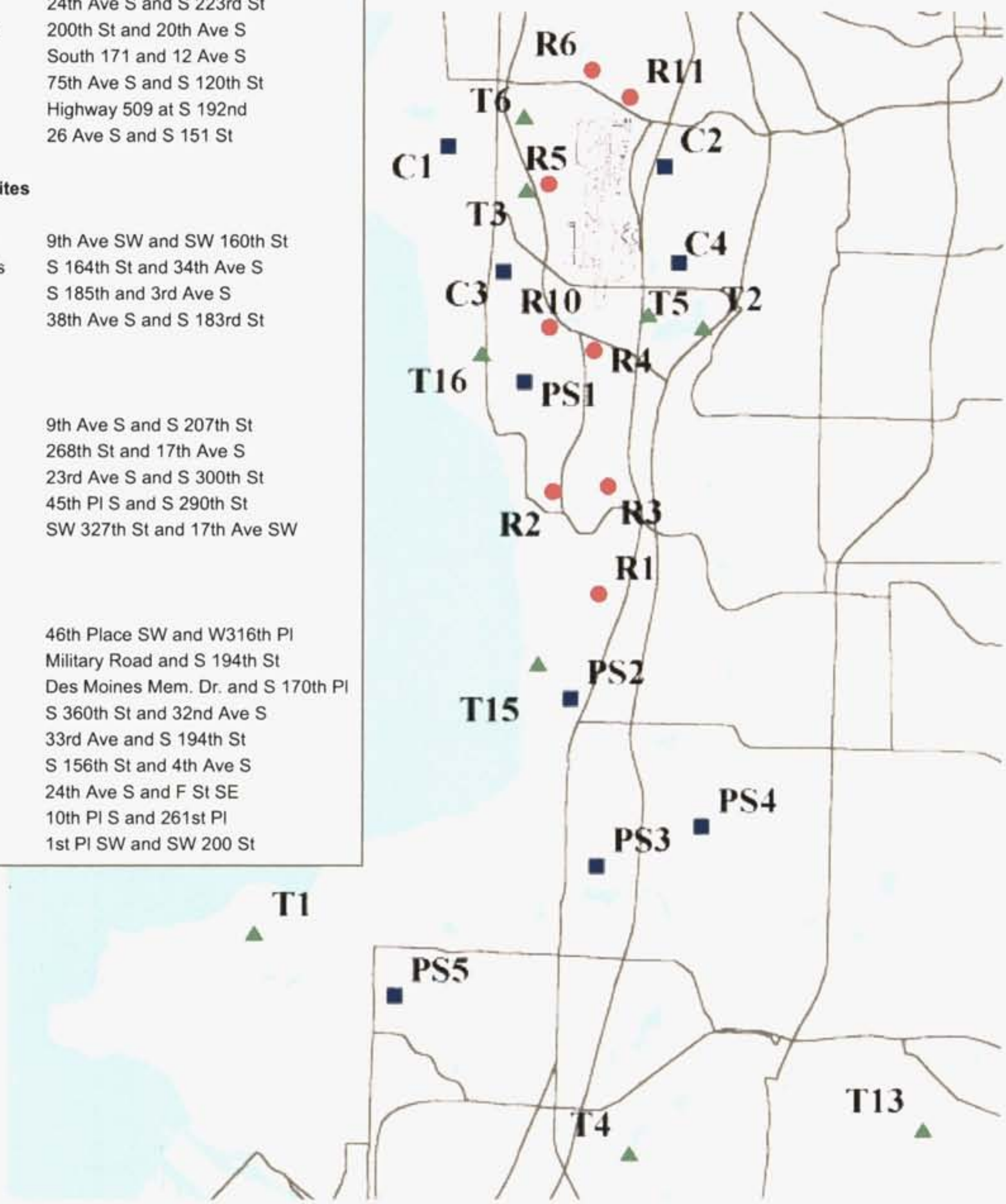
C1	Highline Hospital	9th Ave SW and SW 160th St
C2	McMicken Heights	S 164th St and 34th Ave S
C3	Normandy Park	S 185th and 3rd Ave S
C4	SeaTac (East)	38th Ave S and S 183rd St

Semi-permanent Sites

PS1	Des Moines	9th Ave S and S 207th St
PS2	Woodmont	268th St and 17th Ave S
PS3	Steel Lake	23rd Ave S and S 300th St
PS4	Auburn	45th Pl S and S 290th St
PS5	Federal Way	SW 327th St and 17th Ave SW

Temporary Sites

T1	Dash Point	46th Place SW and W316th Pl
T2	East Angle Lake	Military Road and S 194th St
T3	Burien	Des Moines Mem. Dr. and S 170th Pl
T4	Lakeland School	S 360th St and 32nd Ave S
T5	Angle Lake Park	33rd Ave and S 194th St
T6	Mosier Park	S 156th St and 4th Ave S
T13	Auburn	24th Ave S and F St SE
T15	Des Moines	10th Pl S and 261st Pl
T16	Normandy Park	1st Pl SW and SW 200 St



N —— **Not to Scale**

Figure C12 **FAR Part 150 Noise Monitoring Locations:** ***Close-In and South***

- Permanent
- Semi-Permanent
- Temporary

Seattle-Tacoma International Airport
FAR Part 150 Study Update

Noise Measurement Results

The final results from the noise measurement survey are summarized in the following tables and figures. They include results from measurements taken during the Spring, Summer, and Fall of 1998, and during the Winter of 1999. The Spring noise measurements were completed during the late April to early May 1998 time period. The Summer measurements were completed during the month of August, 1998, which is considered the peak month for operations. The Fall noise measurements were taken during November 1998, and the Winter measurements were taken during January and February of 1999. The types of noise measurement data that were determined from the noise measurement program are listed below.

DNL Noise Measurements
- Permanent Sites
- Semi-permanent Sites
- Close-in Sites

LEQ Noise Measurement Results
- Hourly LEQ
- Nighttime LEQ
- School Hour LEQ

TA Measurement Results
- TA 85
- TA 75
- TA 65

Single Event Noise Analysis
- Histogram of Noise Events
- Peak Noise Events
- Single Event Levels by Aircraft Type

Ambient Measurements
- Percentile Noise Levels

DNL Noise Measurement Results. The measured DNL noise level from the Airport's permanent noise monitoring system is based upon continuous noise monitoring. For the semi-permanent and close-in sites, the data is based upon the measurements of four one-week to ten-day periods that were completed during the four season measurement program.

The DNL noise levels from the 11 permanent noise-monitoring sites are presented in Table C.3. This table presents the annual average aircraft DNL noise level at each of the sites measured since 1990. Note that the data for 1998 was from April 3, 1998. The Airport's permanent noise monitoring system failed in late 1997, and was replaced by an interim system in April 1998. These are different noise monitoring systems that can result in slight differences in the measured results.

The range in the measured DNL noise levels is presented graphically in the top portion of Figure C.13 for the 1998 measurement period. These data present the measured minimum and maximum DNL noise level along with measured energy average level. The bottom portion of Figure C.13 presents the measured aircraft, other and total DNL noise levels at these locations.

The measured aircraft DNL for the 10 semi-permanent sites for all four quarters are summarized in Table C.4. This table presents the measured aircraft DNL noise level at these locations. These same data are also presented in Table C.5 for the four close-in locations adjusted for annual flow conditions. The close-in locations present the total DNL noise level, which includes the aircraft, event noise and other noise sources in the area. At sites very close to the Airport, ground activities were difficult to separate from other sources of noise. As a result, this report presents the total DNL noise level for these locations.

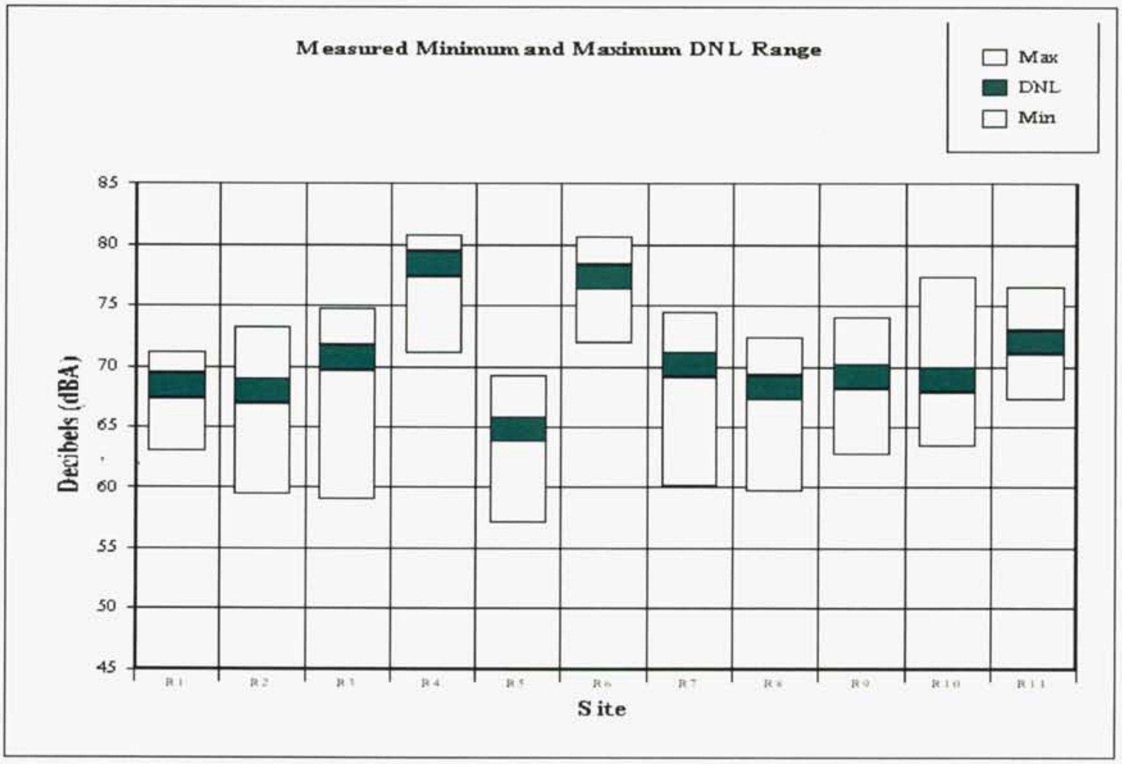
Figure C.14 lists the noise level due to the aircraft events, the noise due to other sources than aircraft, and the total DNL for each day of measurement during the Fall 1998 season at Site PS3. This figure also includes a histogram of the noise levels of all of the events measured at the site during that time period. This helps illustrate the range in the single event noise levels measured at the site and the relative number of events. Additional figures presenting this information for the other sites and for the other seasons are presented in Appendix 23.

Table C.3
ANNUAL AIRCRAFT DNL NOISE LEVEL (Permanent Sites)
Seattle-Tacoma International Airport FAR Part 150 Study

Measurement Location	Community	Annual Aircraft DNL Noise Level (dB)								
		1990	1991	1992	1993	1994	1995	1996	1997	1998
RMS 1	Des Moines	71.5	71.3	69.8	69.2	68.9	68.6	69.0	68.7	68.5
RMS 2	Des Moines	71.4	72.0	70.7	69.3	68.9	68.3	68.4	68.4	68.0
RMS 3	Midway Elementary	74.2	73.9	72.6	71.8	71.2	70.6	70.7	70.8	70.8
RMS 4	Tyee Golf Course	83.2	82.3	81.4	80.0	79.6	79.0	79.0	78.3	78.4
RMS 5	Five Corners	70.3	69.8	69.5	68.1	66.9	67.2	67.1	66.9	64.8
RMS 6	North of Airport	81.3	81.1	80.8	78.7	77.6	78.7	78.4	78.3	77.2
RMS 7	Boulevard Park	74.3	74.1	74.4	71.4	70.0	69.8	69.9	69.0	69.9
RMS 8	Glendale School	70.9	70.9	*	69.3	68.1	68.2	67.9	66.9	68.1
RMS 9	Riverton	70.7	70.4	70.1	68.3	67.6	67.7	67.8	67.1	69.0
RMS 10	Normandy Park	72.8	71.6	71.3	69.5	69.2	68.8	68.6	68.2	68.6
RMS 11	Riverton Heights	76.3	75.6	74.4	73.8	73.9	72.9	72.8	72.6	72.1
11 RMS Sites Airport Average		74.3	73.9	73.2	71.8	71.1	70.9	70.9	70.5	70.5

The noise monitoring system was replaced in 1998 with a new interim system.
* *RMS 8 was not operational in 1992.*
1998 data is from April 3, 1998.

Source: Port of Seattle



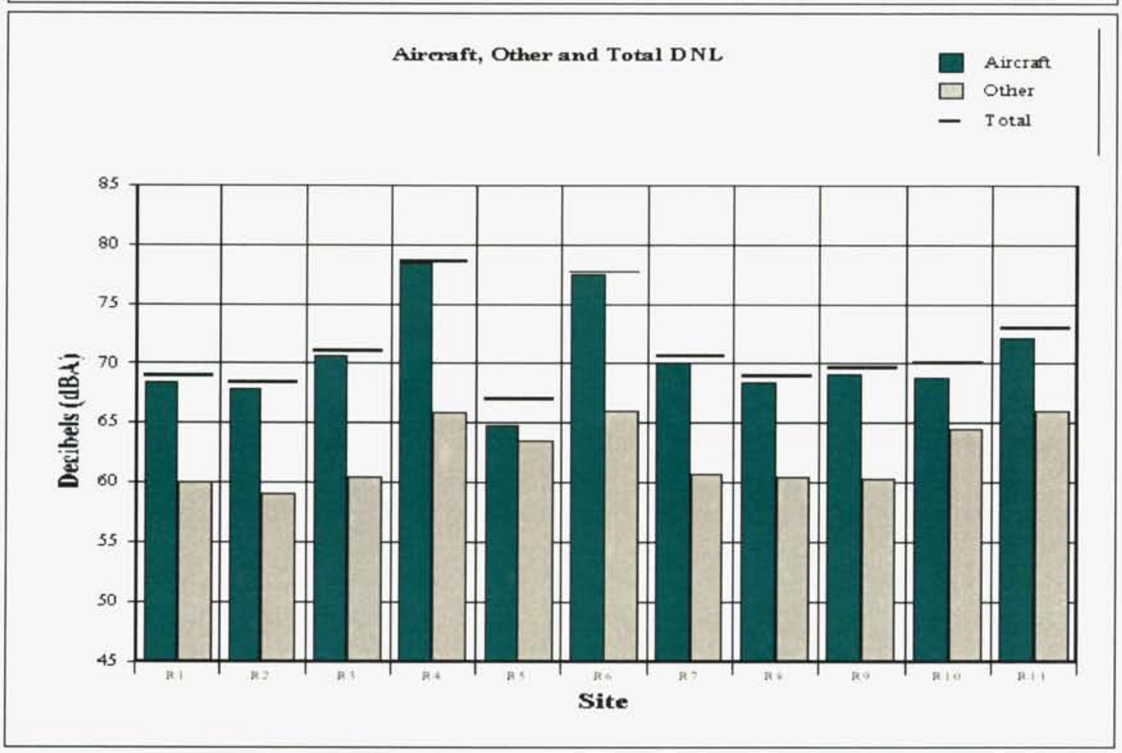


Figure C13 **Measured DNL Noise Levels**
Permanent Sites
Period: April 1, 1998 to October 18, 1998

Table C.4
MEASURED AIRCRAFT DNL NOISE LEVEL (Semi-Permanent Monitoring Sites)
Seattle-Tacoma International Airport FAR Part 150 Study

RMS Site Location	Community	Aircraft DNL (dB)
PN1	South Park	66
PN2	Rainier Valley	57
PN3	Magnolia	52
PN4	Leschi	55
PN5	Medina	53
PS1	Des Moines	66
PS2	Woodmont	66
PS3	Steel Lake	64
PS4	Auburn	57
PS5	Federal Way	56

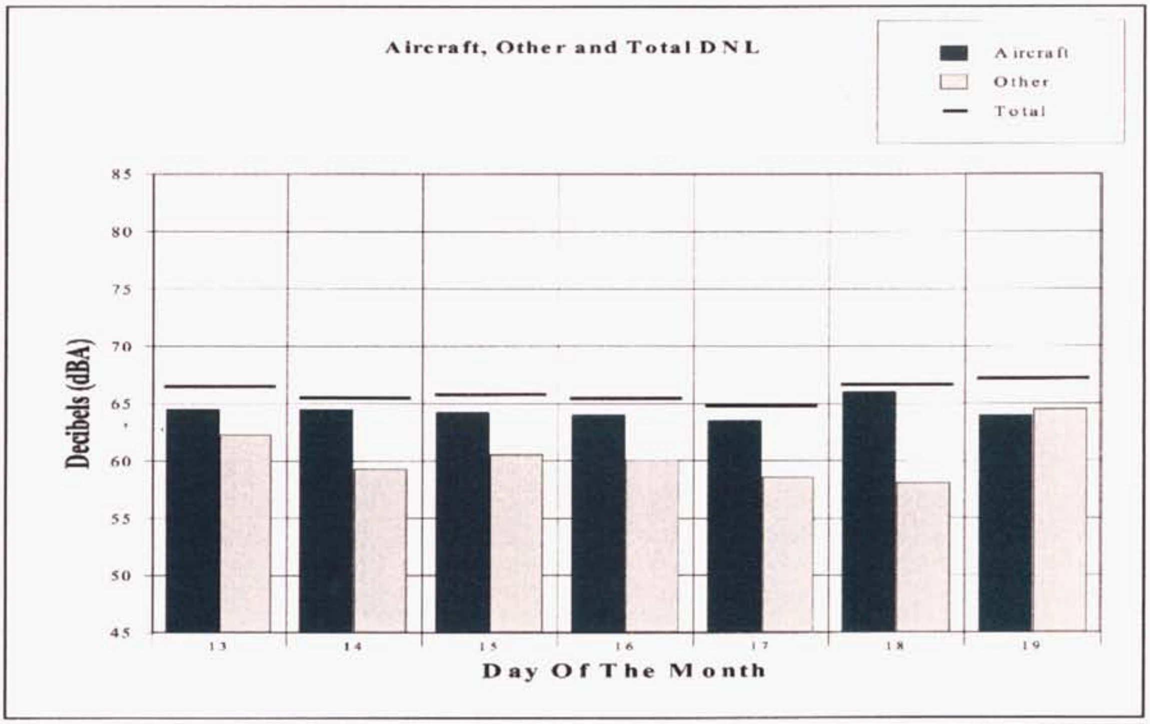
Source: BridgeNet, Inc.

Table C.5
MEASURED TOTAL DNL NOISE LEVEL (Close-In Monitoring Sites)
Seattle-Tacoma International Airport FAR Part 150 Study

RMS Site Location	Community	Total DNL (dB)
C1	Highline Hospital	59
C2	McMicken Heights	63
C3	Normandy Park	60
C4	SeaTac (East)	63

Note: For close-in sites the Total DNL for all sources of Noise is presented in this table.

Source: BridgeNet, Inc.



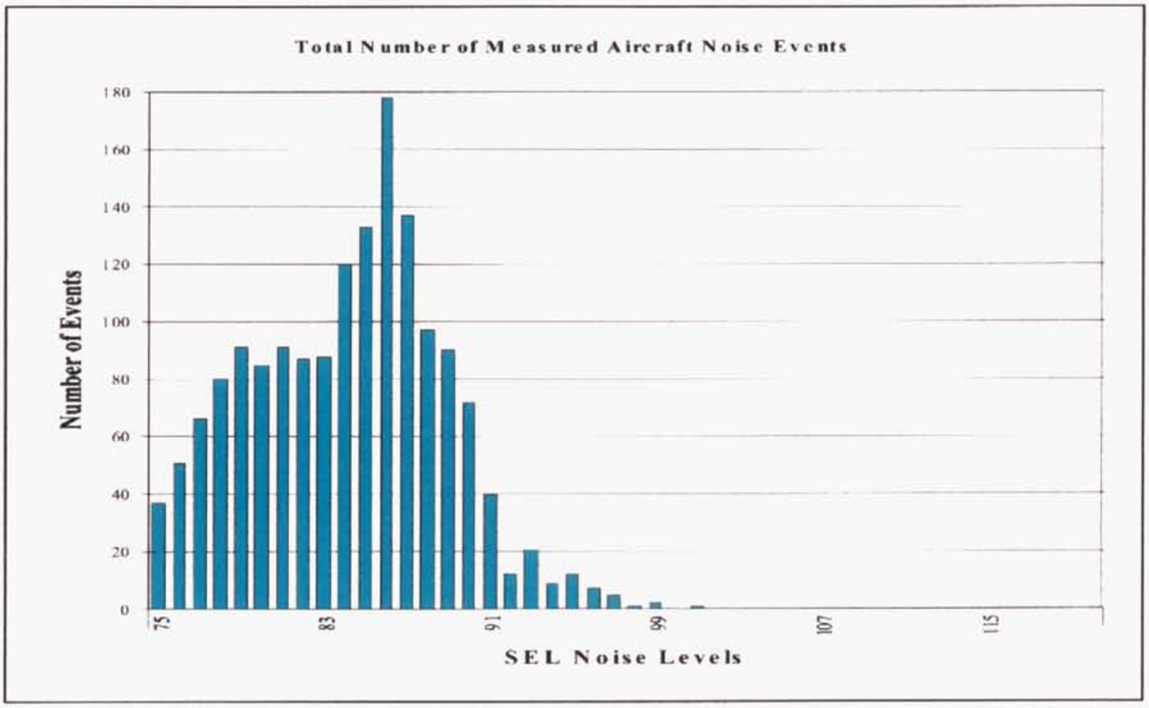


Figure C14 **Sample Measured DNL Noise Levels**
Period: Fall 1998 (November 13 to November 19)
Site: PS3 - Steel Lake - 23rd Avenue S and S 300th Street

LEQ Noise Measurement Results. For each of the permanent, semi-permanent and close-in locations, the measured hourly LEQ noise levels were determined. Based upon these data, the measured LEQ noise levels for each hour or during selected hours of the day were calculated. This information was used to identify the hours of the day for which the noise levels are the highest, or to determine the average noise levels for specific time periods of interest.

Table C.6 presents the energy average hourly LEQ noise level for each hour of the day for the permanent, semi-permanent and close-in measurement locations. The results of the analysis show that while the noise levels fluctuate throughout the day, there was no one hour that was dramatically higher in average hourly LEQ noise level than the others. Generally, the peak hour noise level occurred during the 7:00 a.m. hour or the mid-day hour of 12:00 noon..

Two examples of special time periods are the nighttime hours (10 p.m. to 7 a.m.) and the sample school hours (8 a.m. to 5 p.m.). These data are summarized in Table C.7 which presents the measured LEQ noise levels during these times for the selected periods. The results show that nighttime noise is a larger component at the sites close-in to the Airport.

Table C.6
Measured Hourly Aircraft LEQ Noise Levels
Sea-Tac International Airport Part 150 Noise Study

Port of Seattle
Seattle-Tacoma International Airport

RMS #	Community	Hour Of The Day																							
		00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
R1	Des Moines	61	57	56	58	61	60	66	67	67	65	67	68	66	74	67	68	64	64	65	65	65	65	62	61
R2	Des Moines	61	57	55	57	61	59	66	67	67	65	67	67	66	68	74	67	64	64	65	65	65	65	62	61
R3	Midway Elementary	63	59	58	60	63	62	69	70	69	68	70	70	69	71	73	70	66	67	68	68	68	68	65	63
R4	Tyee Golf Course	70	67	67	69	71	71	75	76	77	74	77	77	75	78	77	77	73	73	75	74	74	75	72	70
R5	Five Corners	59	55	54	55	57	58	63	65	64	63	64	64	62	63	62	61	60	61	62	62	63	63	60	59
R6	North Airport	69	66	66	65	70	70	73	75	75	75	76	76	75	76	76	77	74	89	75	75	75	75	72	70
R7	Boulevard Park	80	80	80	80	80	80	80	80	80	80	80	81	80	80	82	80	80	80	80	80	80	80	80	80
R8	Glendale School	60	56	56	56	59	59	64	65	66	65	66	66	65	67	66	68	78	64	66	65	66	65	63	61
R9	Riverton	60	57	57	57	61	60	64	64	65	64	66	66	65	66	66	75	64	65	65	66	66	66	63	61
R10	Normandy Park	73	70	66	70	70	69	77	78	78	76	77	78	77	78	77	76	74	75	76	76	77	77	74	73
R11	Riverton Heights	66	63	62	62	64	63	70	71	71	70	71	71	70	71	71	76	68	69	70	70	70	70	67	65
PN1	South Park	57	54	53	54	57	55	61	62	60	61	63	63	62	64	64	65	61	62	63	63	63	62	60	57
PN2	Rainier Valley	47	44	41	43	46	43	50	50	50	51	52	51	51	52	54	58	53	51	56	53	53	52	49	46
PN3	Magnolia	46	43	41	47	49	48	47	48	46	49	58	48	55	52	50	49	49	50	49	50	48	49	48	46
PN4	Leschi	43	42	39	39	43	47	54	54	54	54	56	55	54	55	56	58	53	54	56	56	56	52	48	45
PN5	Medina	34	23	27	24	25	36	49	50	50	49	58	50	51	53	54	53	60	50	50	50	51	48	37	31
PS1	Des Moines	62	58	55	59	59	59	67	67	67	65	67	67	67	68	67	66	64	64	66	65	65	66	63	62
PS2	Woodmont	58	56	53	57	58	57	64	64	64	63	65	66	64	66	65	66	62	62	64	63	63	63	61	58
PS3	Steel Lake	56	53	51	55	56	53	61	62	62	60	64	64	61	64	63	64	60	61	61	61	60	61	58	56
PS4	Auburn	51	46	42	48	53	49	54	54	54	54	56	57	57	60	60	57	56	55	56	54	54	53	50	50
PS5	Federal Way	47	48	45	50	48	44	53	53	53	50	52	50	54	54	53	51	50	53	48	51	49	55	52	49
C1	Highline Hospital	51	49	48	49	51	52	58	58	56	55	57	56	55	55	55	55	56	54	55	55	55	55	53	52
C2	McMicken Heights	57	54	52	53	55	56	61	61	60	60	61	61	60	61	61	61	60	60	62	62	61	61	59	58
C3	Normandy Park	54	51	49	50	50	51	59	60	58	57	58	58	57	58	56	59	56	58	58	58	57	57	55	55
C4	E Seatac	56	53	51	53	54	56	61	63	62	61	62	61	61	63	61	62	59	60	61	61	61	61	58	57

Note for the Close in sites (C1 - C4) the Total DNL for all sources of noise is presented in this table

Table C.7

MEASURED LEQ NOISE LEVELS (Nighttime and School Hours)

Seattle-Tacoma International Airport FAR Part 150 Study

RMS Site	Community	Nighttime LEQ (dB) *10 pm to 7 am*	School Hours LEQ (dB) *8 am to 5 pm*
RMS 1	Des Moines	61	67
RMS 2	Des Moines	60	66
RMS 3	Midway Elementary	63	69
RMS 4	Tyee Golf Course	71	76
RMS 5	Five Corners	57	61
RMS 6	North of Airport	70	76
RMS 7	Boulevard Park	62	69
RMS 8	Glendale School	60	67
RMS 9	Riverton	61	67
RMS 10	Normandy Park	66	68
RMS 11	Riverton Heights	64	70
PN1	South Park	57	65
PN2	Rainier Valley	48	54
PN3	Magnolia	47	53
PN4	Leschi	47	55
PN5	Medina	42	53
PS1	Des Moines	61	66
PS2	Woodmont	59	65
PS3	Steel Lake	57	63
PS4	Auburn	49	59
PS5	Federal Way	48	54
C1	Highline Hospital	52	55
C2	McMicken Heights	56	59
C3	Normandy Park	53	56
C4	SeaTac (East)	55	60

Note- C1, C2, C3 and C4 are based on Total LEQ

Source: BridgeNet, Inc.

Time Above (TA) Noise Measurement Results. For each of the permanent, semi-permanent and close-in locations, the daily TA noise levels were determined. This measurement included aircraft noise as well as all other sources of noise. The TA noise level data were used to identify changes that may have occurred in terms of speech and activity interference.

These data are summarized in Table C.8. This table presents the measured TA noise levels in terms of minutes per day that each of the TA noise levels were exceeded, including the TA 85 dBA, 75 dBA and 65 dBA. The results indicate that the TA levels decrease at distances farther away from the Airport. In addition, the TA 85 dBA level generally occurred only at sites close to the Airport under the primary departure pattern.

Table C.8
MEASURED TIME ABOVE NOISE LEVELS (Average Minutes per Day)
Seattle-Tacoma International Airport FAR Part 150 Study

RMS Site	Community	T A 85 dBA	T A 75 dBA	T A 65 dBA
RMS 1	Des Moines	1.4	29	150
RMS 2	Des Moines	1.1	29	148
RMS 3	Midway Elementary	3.7	40	155
RMS 4	Tyee Golf Course	21.6	80	215
RMS 5	Five Corners	0.3	11	116
RMS 6	North of Airport	23.3	80	215
RMS 7	Boulevard Park	5.5	39	160
RMS 8	Glendale School	2.3	28	140
RMS 9	Riverton	2.8	42	151
RMS 10	Normandy Park	8.6	66	249
RMS 11	Riverton Heights	5.9	65	254
PN1	South Park	0.7	18	106
PN2	Rainier Valley	0.4	2	20
PN3	Magnolia	0.1	1	9
PN4	Leschi	0.3	2	31
PN5	Medina	0.2	2	17
PS1	Des Moines	0.2	27	124
PS2	Woodmont	0.6	20	113
PS3	Steel Lake	0.3	10	80
PS4	Auburn	0.0	4	38
PS5	Federal Way	0.0	1	13
C1	Highline Hospital	0.0	0	10
C2	McMicken Heights	0.0	1	64
C3	Normandy Park	0.0	1	29
C4	SeaTac (East)	0.0	2	64

Data represents year to date average for 1998 measurement data.

Source: BridgeNet, Inc.

Single-Event Noise Measurement Results. Aircraft single event noise levels were determined at each of the aircraft measurement sites. The single event data that were determined from the measurement survey included both acoustic and aircraft data. The acoustic data included the maximum noise level (Lmax), Sound Exposure Level (SEL), and the duration of the aircraft events. The aircraft data included the aircraft type, aircraft flight track, and any special operational procedure. The purpose of aircraft single event data measurements was to provide single event noise data specific to Sea-Tac that could be used in the correlation of the Integrated Noise Model (INM) and to identify the loudest operations at the Airport.

The single-event noise levels data measured in the field were processed and coded into a microcomputer-based data management program. This program included a list of all of the aircraft events that could be analyzed in order to present various types of aircraft noise event information.

The single event data were analyzed in terms of noise level per aircraft type and in terms of the total range in noise events. An example of the range in noise data is presented for two sites in Figure C.15. This figure presents a histogram of all the aircraft events that were measured at Sites PN1 and at PS1 during all four measurement seasons.

These results show the wide range in aircraft events that occur at each site as well as the number of noise events. The longer bar graph illustrates those aircraft with the loudest events. The louder events were generally Stage 2 jet aircraft departures. These data illustrate the difference in noise events generated by departures versus arrivals. PS1 measures more departure noise while PN2 measures more arrival noise.

To better illustrate which aircraft generate the highest noise events, the 25 loudest single event noise levels at each measurement site were identified. These events were correlated with an aircraft type and plotted. The results are shown in Figures C.16 and C.17 for sites PN1 and PS1, respectively. The figure includes the date and time of the event, the aircraft type, the noise stage of the aircraft, the operation, and the associated noise levels. For most of the measurement locations, the loudest identified aircraft were typically Stage 2 B727 or DC8S aircraft. Data for other sites are presented in the Appendix 23.

The level of noise generated by each type of aircraft also varied. To illustrate this difference, the energy average single-event noise level per type of aircraft was also determined. Figures C.18 and C.19 present these data for Sites PS1 and PN1, respectively. For Site PS1, these data are presented for departures. For PN1, these data are presented for arrivals. These data show that the new generation Stage 3 aircraft were significantly quieter in terms of departure noise, while that difference is not as great for arrival noise. Data for other sites are presented in Appendix 20.

The noise model used actual noise and flight track data results from the Airport's noise and flight track monitoring system in the development of the INM noise contours. The measurement results were used to validate the assumptions used in the noise model and to demonstrate to the community that the modeled noise environment was based upon reasonable modeling assumptions that were consisted with real world noise and operations data. Table 8A presents the measured vs. modeled DNL noise levels for the existing 1998 conditions.

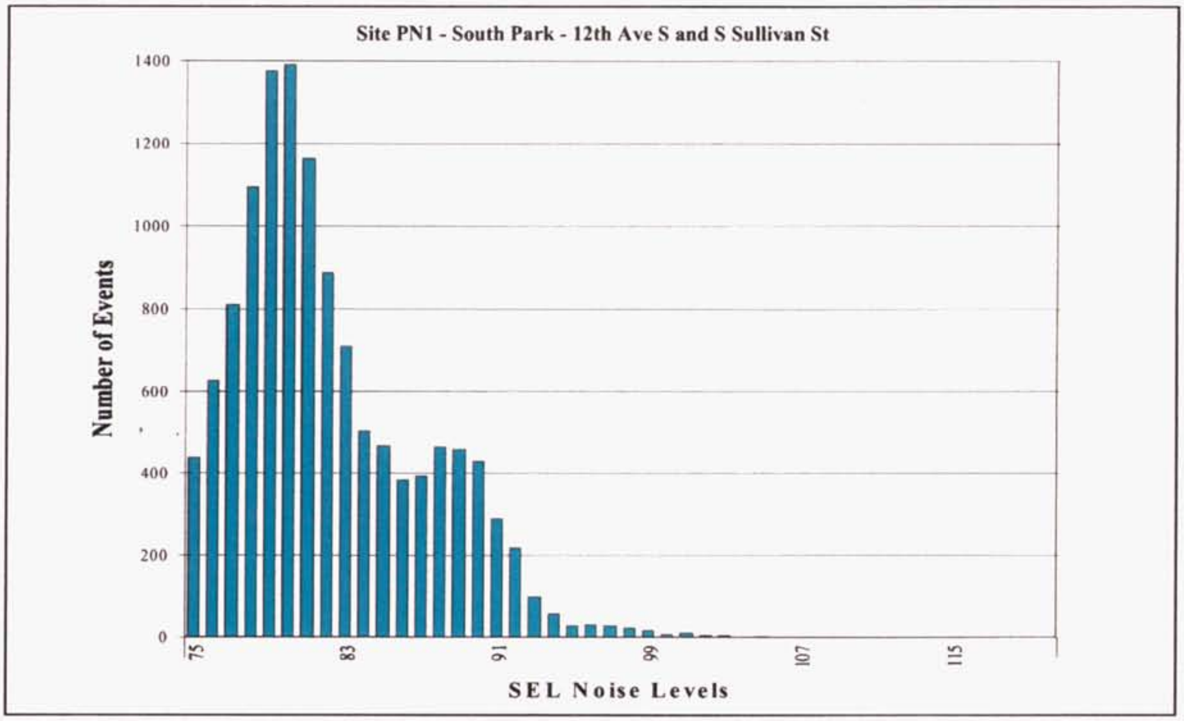
The results of the noise measurement survey showed that the noise levels for many narrowbody Stage 3 aircraft were higher than initially predicted by the INM noise model. This was especially true at locations more distant from the Airport. In reviewing the climb profile for these aircraft, it was found that the actual climb profiles were lower to the ground than is predicted by the INM, when the climb profile is based upon flight distance. This resulted in the model underestimating the aircraft noise because the model assumed that the aircraft were higher above the ground then they actually were. To account for this difference, the climb profiles were assigned based upon actual radar data climb profiles. Therefore, the climb profiles for Stage 3 aircraft, used in the INM noise model, were the ones that more closely match the actual climb profiles being flown. With this adjustment, the predicted INM noise levels for Stage 3 aircraft more closely matched the measured noise levels.

The actual dispersion of the radar flight paths was used to model the INM dispersion paths. There were no changes to the noise curves or climb profiles algorithms that are contained tin the IMM database.

Table C8A
Measured vs. Modeled Noise Levels
Seattle-Tacoma International Airport
1998 Annual Noise Levels

NMS		Measured Aircraft DNL	Modeled Aircraft DNL		Difference
R1	Des Moines	68.6	68.5		-0.1
R10	Normandy Park	68.5	69.0		0.5
R11	Riverton Heights	72.7	73.3		0.6
R2	Des Moines	68.3	68.4		0.1
R3	Midway Elementary	71.1	70.7		-0.4
R4	Tyee Golf Course	78.4	78.6		0.2
R5	Five Corners	65.8	63.8		-2.0
R6	North Airport	77.4	77.8		0.4
R7	Boulevard Park	69.8	69.4		-0.4
R8	Glendale School	68.1	67.8		-0.3
R9	Riverton	68.7	68.8		0.1
PS1	Des Moines	68.9	65.3		-3.6
PS2	Woodmont	66.6	66.4		-0.2
PS3	Steel Lake	64.3	63.4		-0.9
PS4	Auburn	58.2	54.6		-3.6
PS5	Federal Way	55.9	56.4		0.5
PN1	South Park	65.3	65.2		-0.1
PN2	Rainier Valley	55.0	52.5		-2.5
PN3	Magnolia	54.5	47.4	*	-7.1
PN4	Leschi	56.3	54.6		-1.7
PN5	Medina	52.8	50.4		-2.4
C1	Highline Hospital	55.9	51.8		-4.1
C2	McMicken Heights	61.1	61.3		0.2
C3	Normandy Park	59.9	61.0		1.1
C4	E Seatac	61.9	61.1		-0.8

Measurement Period: February 1998 to January 1999
* Note: Includes Aircraft Noise from BFI



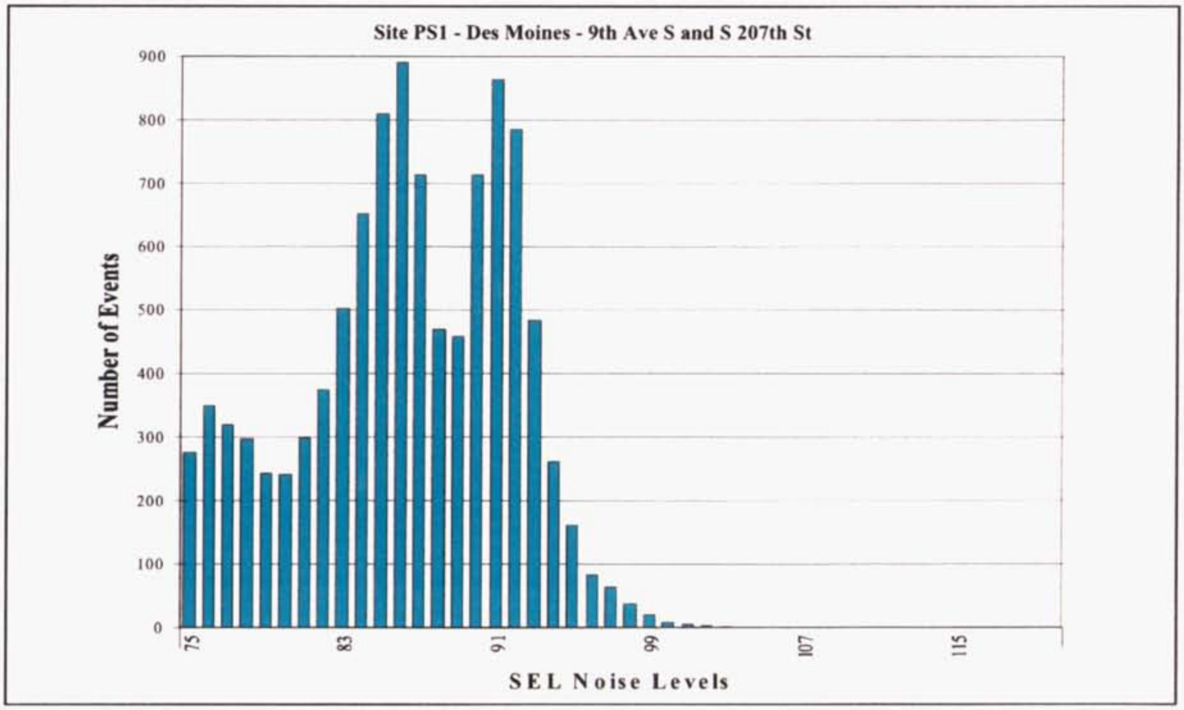


Figure C15 **Example Single Event Histogram of Measured Aircraft Events**
Period: All Periods

Aircraft	Event Time	Aircraft	Stage	Airline	Ops	Rwy	Lmax	SEL	Graph Of SEL
	Aug 11, 15:13	B727	2	COA	D	34R	91.8	105.4	
	Aug 07, 15:05	B727	2	COA	D	34R	94.5	104.5	
	Aug 07, 19:23	B727	2	SCX	D	34R	92.5	102.7	
	Aug 08, 10:44	B727	2	DAL	D	34L	93.5	102.6	
	Aug 06, 15:52	B727	2	DAL	D	34R	91.8	101.9	
	Jan 24, 11:01	B722	2	DAL	D	34R	90.0	101.8	
	May 03, 14:58	B727	2	DAL	D	34R	89.3	101.7	
	Aug 09, 20:23	B727	2	UAL	D	34L	89.7	101.5	
	Aug 08, 07:23	B727	2	UAL	D	34R	90.0	101.2	
	Aug 03, 17:54	B727	2	SCX	D	34R	89.8	101.2	
	May 03, 13:52	B727	2	DAL	D	34R	89.0	100.7	
	Aug 04, 15:23	B727	2	COA	D	34R	89.2	100.3	
	Aug 08, 15:11	B727	2	COA	D	34R	89.5	100.3	
	Aug 10, 20:02	B727	2	UAL	D	34R	89.4	100.2	
	Aug 09, 15:08	B727	2	COA	D	34R	90.9	100.0	
	Aug 09, 07:19	B727	2	UAL	D	34R	88.0	99.9	
	Aug 03, 20:01	B727	2	UAL	D	34L	89.8	99.6	
	May 02, 18:11	B727	2	UAL	D	34R	88.4	99.5	
	Aug 06, 14:57	B727	2	COA	D	34R	88.4	99.5	
	Jan 22, 13:34	B742	3	NWA	D	34R	88.4	99.2	
	Aug 07, 11:00	B727	2	DAL	D	34L	90.4	99.2	
	Nov 10, 11:28	B722	2	DAL	D	34R	88.1	99.1	
	Jan 23, 15:21	B722	2	DAL	D	34R	86.5	99.1	
	Aug 11, 19:56	B727	2	UAL	D	34R	86.9	99.0	
	Aug 11, 10:53	B727	2	DAL	D	34R	87.0	98.9	

Figure C16 **Loudest Aircraft Noise Events (PN1)**
Site: PN1 - South Park - 12th Ave S and S Sullivan Street

Aircraft	Event Time	Aircraft	Stage	Airline	Ops	Rwy	Lmax	SEL	Graph Of SEL
	Jan 18, 11:05	B722	2	DAL	D	16L	91.8	103.1	
	Feb 02, 13:13	B722	2	DAL	D	16L	92.4	102.3	
	Jan 16, 10:59	B722	2	DAL	D	16L	90.5	102.0	
	Feb 02, 14:54	B722	2	DAL	D	16L	90.2	101.5	
	Nov 13, 14:51	B722	2	DAL	D	16L	92.9	101.3	
	Nov 19, 22:57	B721	2	CTT	D	16L	92.4	101.1	
	Jan 14, 13:18	B72Q	3	DAL	D	16L	91.7	101.0	
	Jan 17, 15:03	B722	2	DAL	D	16L	90.7	100.9	
	Jan 18, 14:59	B722	2	DAL	D	16L	91.9	100.5	
	Jan 17, 13:35	B72Q	3	DAL	D	16L	90.5	100.3	
	Jan 15, 16:17	B722	2	DAL	D	16L	90.3	100.1	
	Apr 16, 21:28	DC8	2	CKS	D	16L	88.3	100.0	
	Feb 02, 10:45	B722	2	DAL	D	16L	88.1	99.9	
	Jan 19, 12:29	DC8	2	CKS	D	16L	90.0	99.9	
	Apr 17, 21:39	DC8	2	CKS	D	16L	88.0	99.9	
	Apr 17, 10:40	DC8	2	CKS	D	16L	89.2	99.7	
	Jan 18, 09:41	B722	2	DAL	A	16R	87.3	99.6	
	Jan 17, 11:23	B722	2	DAL	D	16L	89.7	99.5	
	Nov 14, 13:15	B722	2	DAL	D	16L	88.6	99.5	
	Jan 14, 21:40	DC8	2	CKS	D	16L	87.7	99.4	
	Nov 20, 04:37	B722	2	KHA	D	16L	91.4	99.3	
	Apr 18, 21:16	DC8	2	CKS	D	16L	87.6	99.3	
	Nov 18, 13:03	B742	3	NWA	D	16L	85.9	99.2	
	Jan 14, 19:56	DC8	2	CKS	D	16L	88.4	99.2	
	Nov 19, 19:52	DC85	2	CKS	D	16L	87.0	99.2	

Figure C17 **Loudest Aircraft Noise Events (PS1)**
Site: PS1 - Des Moines - 9th Avenue S and S 207th Street

Aircraft	FAR 36 Stage	Event Count	Energy Average SEL
B727	2/3	289	83.5
B73A	2/3	96	78.7
B73B	3	1989	80.0
B747	3	157	85.7
B757	3	489	79.1
B767	3	89	81.4
DC10	3	262	84.1
DC8	2/3	66	84.3
DC9	2/3	81	82.6
EA32	3	219	79.7
F28	2	543	79.5
MD11	3	83	84.2
MD80	3	1418	80.4
Other Aircraft		1185	79.2

Graph of Energy Average SEL

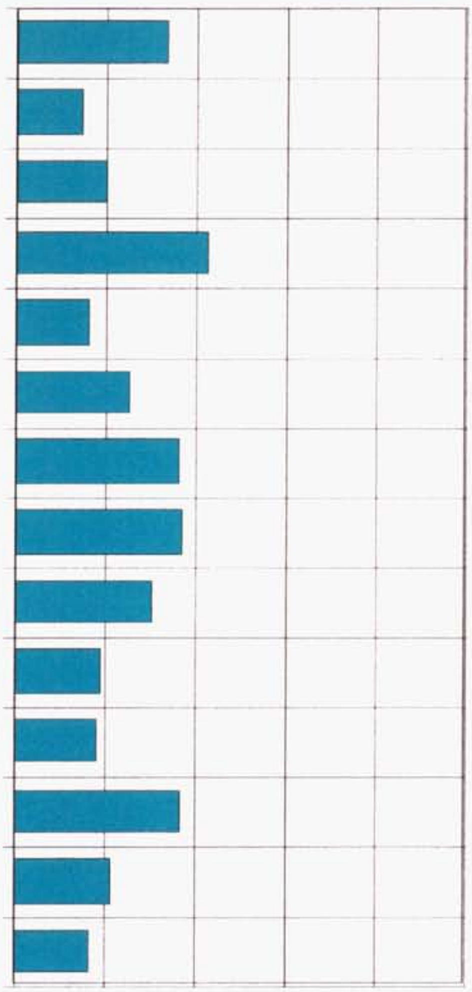


Figure C18 **Single Event Noise Level by Aircraft (PN1)**
Period: All Seasons
Site: PN1 - South Park - 12th Ave S and S Sullivan Street
Operations: A Runways: 16L;16R Tracks: ALL

Aircraft	FAR 36 Stage	Event Count	Energy Average SEL
B727	2/3	305	95.2
B73A	2/3	150	93.0
B73B	3	2465	86.0
B747	3	149	92.3
B757	3	678	83.3
B767	3	107	87.7
DC10	3	300	89.7
DC8	2/3	61	96.8
DC9	2/3	93	92.2
EA32	3	328	83.2
F28	2	876	91.4
MD11	3	89	91.0
MD80	3	1836	91.5
Other Aircraft		1552	85.0

Graph of Energy Average SEL

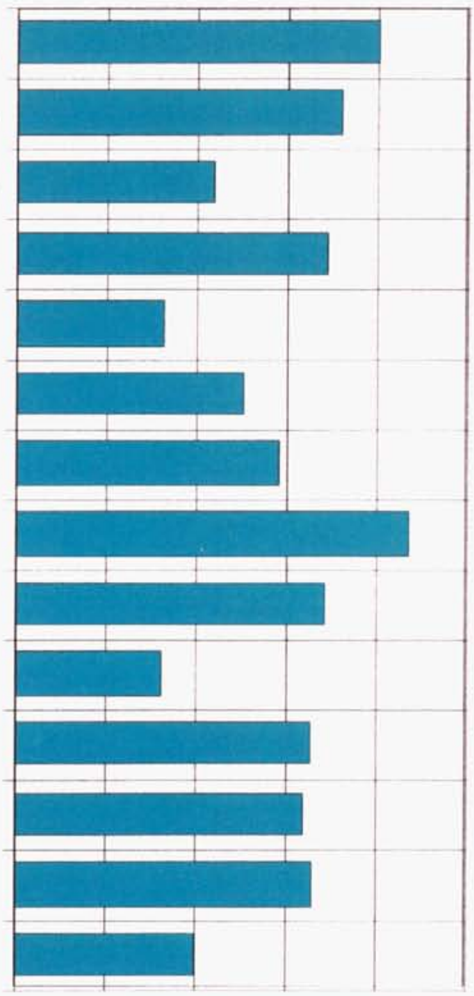
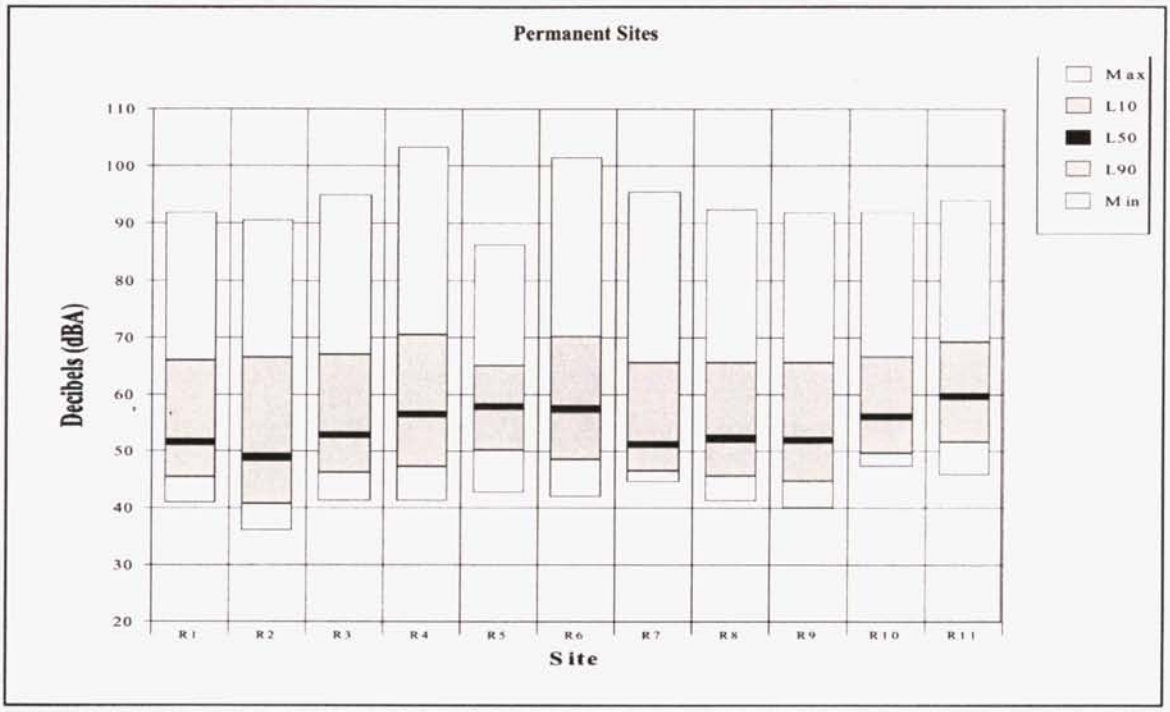


Figure C19 **Single Event Noise Level by Aircraft (PS1)**
Period: All Seasons
Site: PS1 - Des Moines - 9th Avenue S and S 207th Street
Operations: D Runways: 16L;16R Tracks: ALL

Ambient Noise Measurement Results. The ambient and background noise environment was also determined from the noise measurement survey. The ambient and background noise levels were determined at each of the measurement sites. The ambient noise environment is presented in terms of the statistical noise levels. The statistical noise levels (Lmax, L10, L50, L90, Lmin) present the ranges in noise that occur at a site, with the Lmin being the lowest level and the Lmax the highest. The L50 is the median noise level. Since it is not possible to completely remove aircraft noise from all other noise sources, the statistical noise levels include aircraft as well as other noise sources. The aircraft noise is usually the cause of the Lmax or maximum level. The L50, L90 and LMin are primarily determined by noise sources other than aircraft. The results indicate that there can be a number of significant non-aircraft noise sources within the Airport environs, however, at locations away from these sources, the ambient noise levels are low and were indicative of a rural residential environment.

The L90 dBA noise descriptor can be used to illustrate the background sound environment. L90 is the noise level that is exceeded ninety percent (90%) of the time and is commonly used to describe the typical background noise environment that is present when events are not occurring. Figure C.20 presents the statistical noise levels (Lmax, L10, L50, L90 and Lmin) including the L90 from the permanent, semi-permanent, and close-in measurement locations. These data represent the average statistical noise levels during the four seasons of measurements.

The ambient noise levels can vary on a day-to-day basis. To illustrate the daily changes in the ambient noise levels, Figure C.21 presents the daily statistical noise levels (Lmax, L10, L50, L90 and Lmin) for two sample measurement sites during the Summer measurement season (PS5 and PN5). The results indicate that the ambient noise levels drop below 40 dBA.



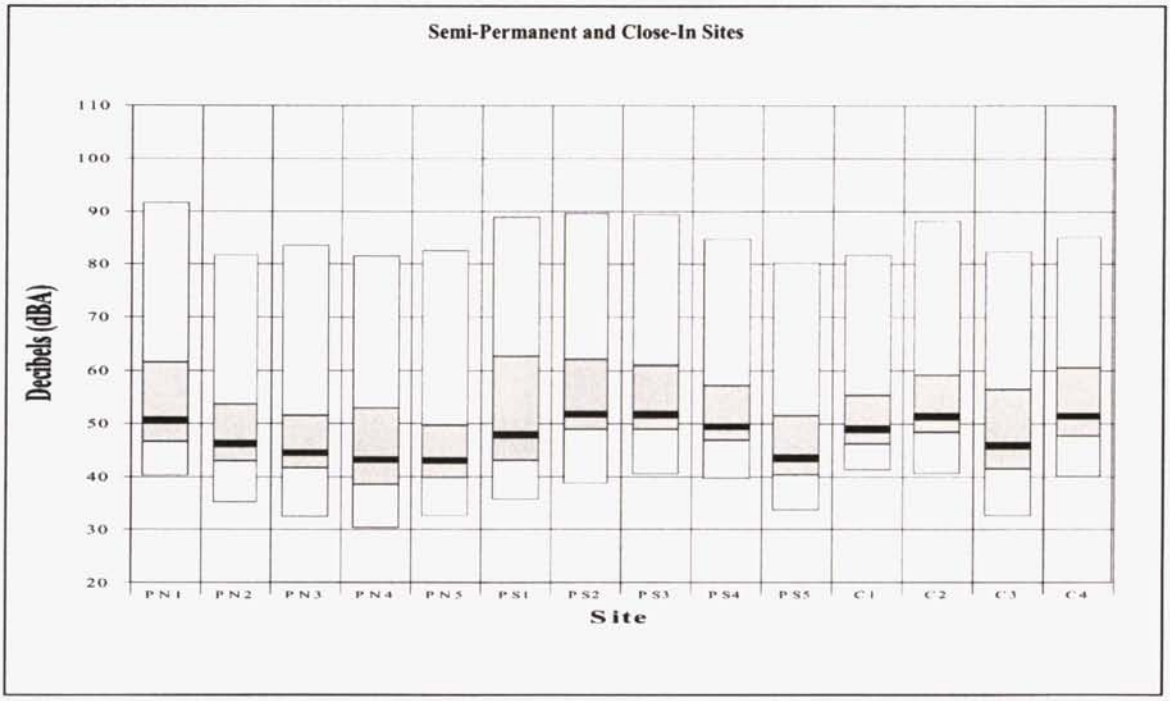
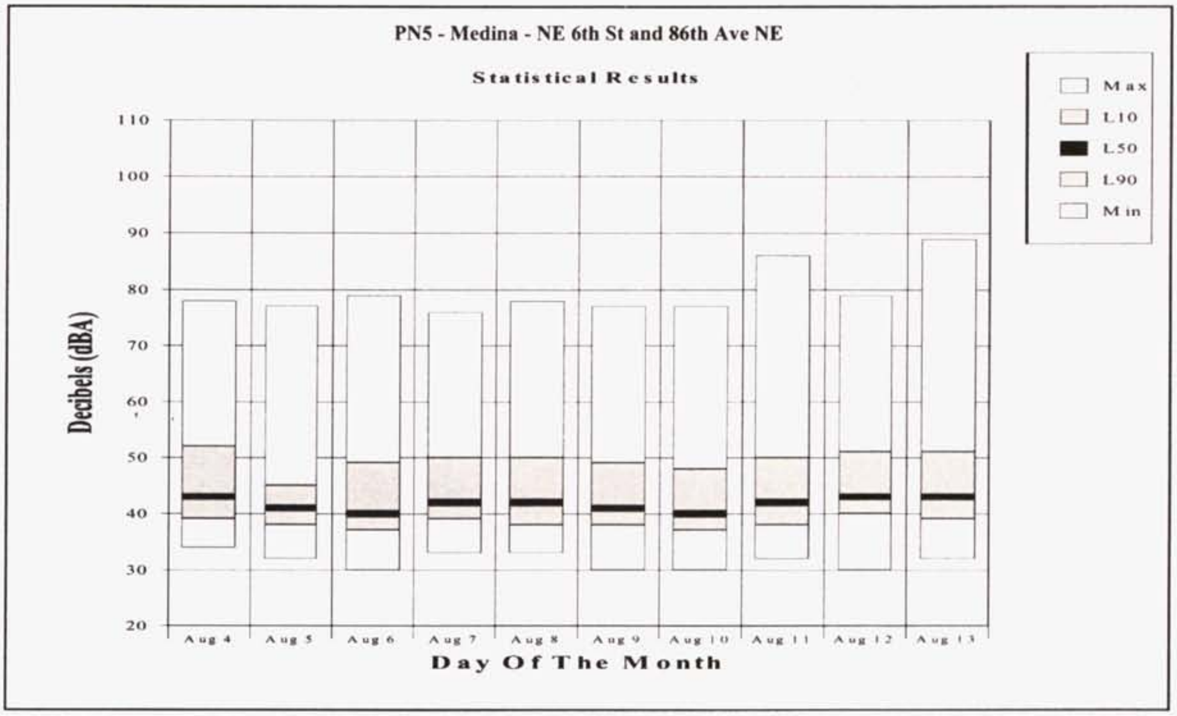


Figure C20 **Ambient Noise Measurement Results**
Period: All Seasons



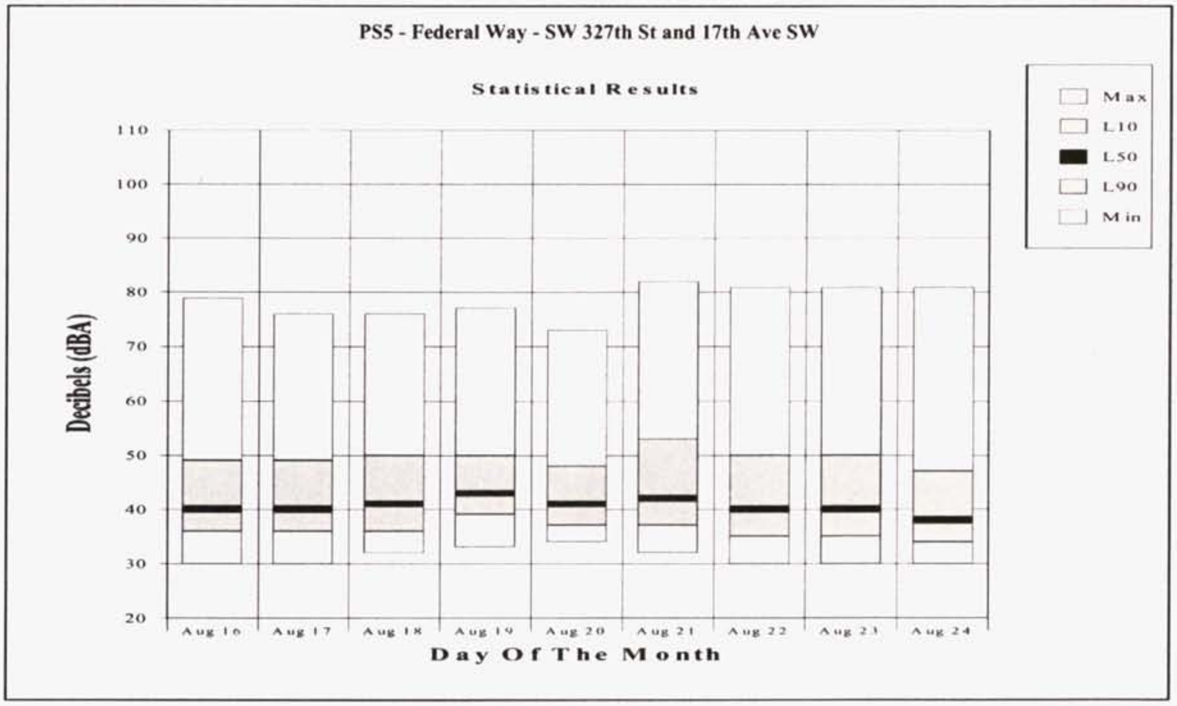


Figure C21 **Daily Ambient Noise Measurement Results**
Period: Summer Seasons (August)

Existing Noise Exposure Contours

The existing noise environment at Sea-Tac was determined through a comprehensive computer modeling assessment correlation using noise data from the Airport's on-going noise-monitoring program. The noise environment is commonly depicted in terms of lines of equal noise exposure levels, or noise contours. The following section details the methodology that was used in the computer modeling of these noise contours. The operational assumptions used in the analysis are also presented.

Computer Modeling

The FAA's Integrated Noise Model (INM) Version 5.2a was used to model the flight operations noise contours at Sea-Tac. The INM is a large computer program developed to plot noise contours for airports. The INM program is described in complete detail in a previous section.

Existing Aircraft Operational Assumptions. The existing noise environment for Sea-Tac was analyzed based upon 1998 operational conditions. These data were derived from various sources, including aircraft tower counts, landing reports, ARTS radar data, Official Airline Guide (OAG) flight schedules, Noise Budget reports, and discussions with Air Traffic Control Tower (ATCT) and Sea-Tac noise abatement office personnel. A variety of operational data are necessary in order to determine the noise environment around the airport. These data include the following summary information and are discussed in detail in the following paragraphs:

- Aircraft Activity Levels
- Fleet Mix
- Time of Day
- Stage Length
- Runway Use
- Flight Path Utilization

Aircraft Activity Levels. The total aircraft operational levels were derived directly from the Sea-Tac ATCT counts. From these data, the actual annual count resulted in 407,577 operations during the base year 1998, or an average of 1,117 daily operations (an operation is defined as either one takeoff or one landing). The 1998 aircraft operations for each category of operation are summarized in Table C.9. These operations consist of air carrier, commuter, military and general aviation aircraft. These data were determined from the 1998 annual ATCT counts as well as the other sources noted above.

Table C.9
SUMMARY OF OPERATIONS BY CATEGORY, AVERAGE DAILY OPERATIONS, EXISTING 1998
Seattle-Tacoma International Airport FAR Part 150 Study

Category	Average Daily Operations
Wide Body Jets	69.6
Narrow Body Jets	577.3
Regional Jets	79.6
Commuter and Twin Propeller	310.2
General Aviation and Military Jets	5.9
General Aviation and Military Single Props and Other	74.2
TOTAL	**1,116.6**

Fleet Mix. The fleet mix of aircraft that operate at the Airport is one of the most important factors in terms of the airport noise environment. Fleet mix data were determined from a review of the Airport landing reports for 1998, the Airport noise budget reports, and the ARTS radar data information. The fleet mix assumptions are presented in Table C.10. This table presents the average daily operations for each type of aircraft used in the INM noise model as well as a description of these aircraft. The INM aircraft type assigned for each of the aircraft operating at Sea-Tac were based upon the INM type that was most closely matched the type of aircraft that each airline operated at Sea-Tac. Some aircraft with smaller numbers of operations were grouped into the aircraft type that was most representative of those aircraft. The percentage of operations for each of the aircraft types is also presented. The Stage 3 generation of the B737 series aircraft and the MD80 were the dominant aircraft operating at Sea-Tac during the study period..

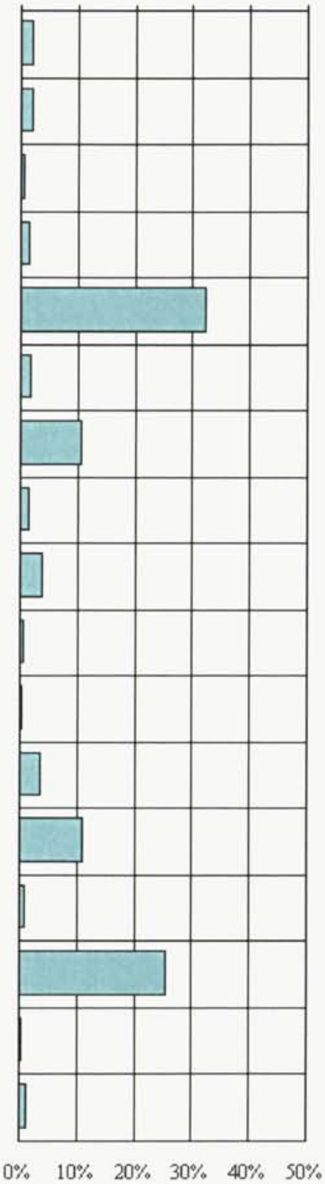
The mix of jet aircraft is illustrated in Figures C.22 and C.23. Figure C22 presents the average daily operations of jet aircraft, including the number of operations by FAR Part 36 Stage level. Figure C.23 shows the number of jet aircraft operations by each airline and the correlating Stage 3 percentages.

Table C.10
AIRCRAFT FLEET MIX ASSUMPTIONS FOR EXISTING CONDITIONS
Seattle-Tacoma International Airport FAR Part 150 Study

INM Type	Far Stg	Daily Arrivals Day	Daily Arrivals Night	Daily Departures Day	Daily Departures Night	Daily Operations Arrivals	Daily Operations Departures	Daily Operations Total	Annual Operations
727EM1	3	1.89	2.22	3.85	0.25	4.11	4.10	8.21	2,996
727EM2	3	2.90	1.03	2.83	0.81	3.93	3.64	7.57	2,764
727Q15	2	6.08		6.37		6.08	6.37	12.44	4,542
727Q7	2	0.96		0.97		0.96	0.97	1.93	705
7373B2	3	44.49	6.82	44.20	7.10	51.31	51.30	102.60	37,450
737400	3	44.81	11.34	48.10	8.05	56.16	56.15	112.31	40,992
737500	3	8.36	1.67	8.48	1.56	10.03	10.04	20.07	7,325
737D17	2	1.83	0.22	1.86	0.17	2.05	2.04	4.08	1,489
74720B	3	2.84	0.87	3.06	0.65	3.70	3.72	7.42	2,708
747400	3	2.09	0.89	1.88	1.11	2.98	2.98	5.97	2,179
757PW	3	26.03	8.21	26.76	7.48	34.24	34.24	68.48	24,997
757RR	3	3.48	0.50	3.25	0.74	3.99	3.99	7.97	2,910
767300	3	1.28	0.04	1.29	0.03	1.33	1.33	2.65	968
767CF6	3	3.16	1.07	2.52	1.70	4.23	4.22	8.44	3,082
A300	3	1.14	0.09	1.22	0.01	1.23	1.23	2.46	899
A320	3	10.95	2.22	10.21	2.95	13.17	13.16	26.33	9,611
BAE146	3	0.19		0.19		0.19	0.19	0.38	137
DC1030	3	10.97	2.76	13.16	0.56	13.72	13.72	27.45	10,019
DC870	3	0.56	0.13	0.61	0.08	0.69	0.69	1.38	503
DC8QN	2	2.47		2.20		2.47	2.20	4.67	1,704
DC9Q9	2	1.27		1.37		1.27	1.37	2.64	963
DHC6		26.19	3.14	27.73	1.61	29.33	29.34	58.66	21,412
DHC830		114.04	11.71	113.16	12.59	125.75	125.75	251.50	91,797
F28MK2	2	37.76	2.04	37.22	2.56	39.79	39.77	79.57	29,042
GASEPV		33.44	3.64	31.91	5.18	37.08	37.08	74.16	27,069
GIIB		2.67	0.26	2.61	0.32	2.93	2.93	5.87	2,141
MD11GE		2.04	1.64	2.40	1.28	3.68	3.68	7.37	2,689
MD83	3	73.13	19.70	76.03	16.80	92.83	92.83	185.67	67,768
MD83	3	0.54		0.54		0.54	0.54	1.09	396
737D17	Sub 3	2.16	2.84	2.89	2.11	5.00	5.00	10.00	3,649
DC95HW	3	1.07	1.75	0.98	1.76	2.82	2.74	5.56	2,028
DC8QN	Sub 3	0.45	0.30	0.46	0.55	0.75	1.01	1.76	642
Total		**471.23**	**87.11**	**480.30**	**78.01**	**558.34**	**558.31**	**1116.65**	**407,577**

Jet Aircraft	FAR 36 Stage	Operations Average Per Day	Percent of Total
B727 Stage 2	2	14.4	**2.0%**
B727 Stage 3	3	15.8	**2.2%**
B737-200 Stage 2	2	4.1	**0.6%**
B737-200 Stage 3	3	10.0	**1.4%**
B737-300/800	3	235.0	**32.3%**
B747 All Series	3	13.4	**1.8%**
B757 All Series	3	76.5	**10.5%**
B767 All Series	3	11.1	**1.5%**
DC10 All Series	3	27.5	**3.8%**
DC8S Stage 2	2	4.7	**0.6%**
DC8S RE/HK	3	3.1	**0.4%**
A320	3	26.3	**3.6%**
F28	2	79.6	**11.0%**
MD11 All Series	3	7.4	**1.0%**
MD80 All Series	3	185.7	**25.6%**
Other Aircraft (Stage 2)	2	2.6	**0.4%**
Other Aircraft (Stage 3)	3	9.5	**1.3%**

Percentage Of Total



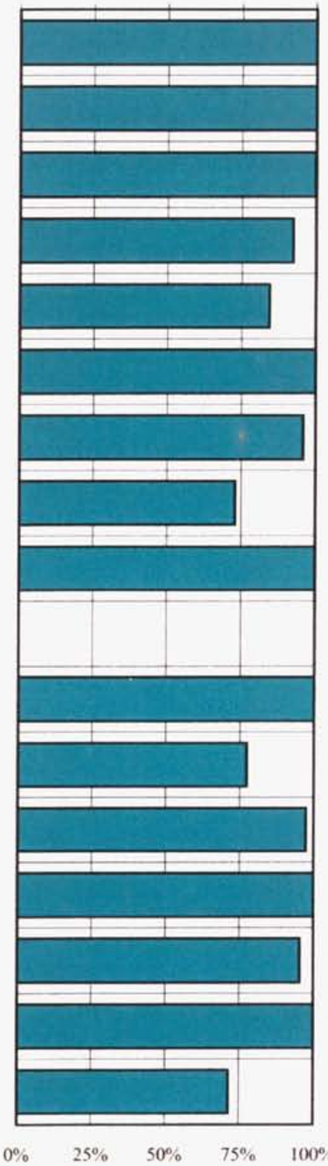
Numbers are rounded to nearest 0.0 value

Source: BridgeNet International

Figure C22 **Aircraft Jet Fleet Mix Summary (1998)**

Airline		Daily Jet Operations Stage 2	Stage 3	Total	Percent Stage 3
American	AAL	0.0	32.2	32.2	100%
Alaska Airlines	ASA	0.0	242.7	242.7	100%
America West Airlines	AWE	0.0	13.1	13.2	100%
Continental	COA	1.2	14.7	15.9	92%
Delta Air Lines	DAL	6.2	33.5	39.8	84%
EVA AIR	EVA	0.0	3.7	3.7	100%
Federal Express	FDX	0.3	7.5	7.9	96%
Frontier	FFT	1.3	3.5	4.8	73%
Northwest	NWA	0.0	37.9	37.9	100%
Horizon Air	QXE	76.9	0.0	76.9	0%
RenoAir	ROA	0.0	17.0	17.0	100%
United States Postal Service	RYN	1.2	4.1	5.3	77%
Southwest Airlines	SWA	1.7	62.4	64.1	97%
TWA	TWA	0.0	14.5	14.5	100%
United	UAL	4.4	91.1	95.5	95%
USAir	USA	0.0	11.7	11.7	100%
Other Airlines		11.3	28.1	39.5	71%
Airport Commercial Jet Stage 3 Percent					**86%**

Airline Stage 3 Percent



Numbers are rounded to nearest 0.0 value

Source: BridgeNet International

Figure C23 **Commercial Airline Jet FAR 36 Fleet Mix Summary (1998)**

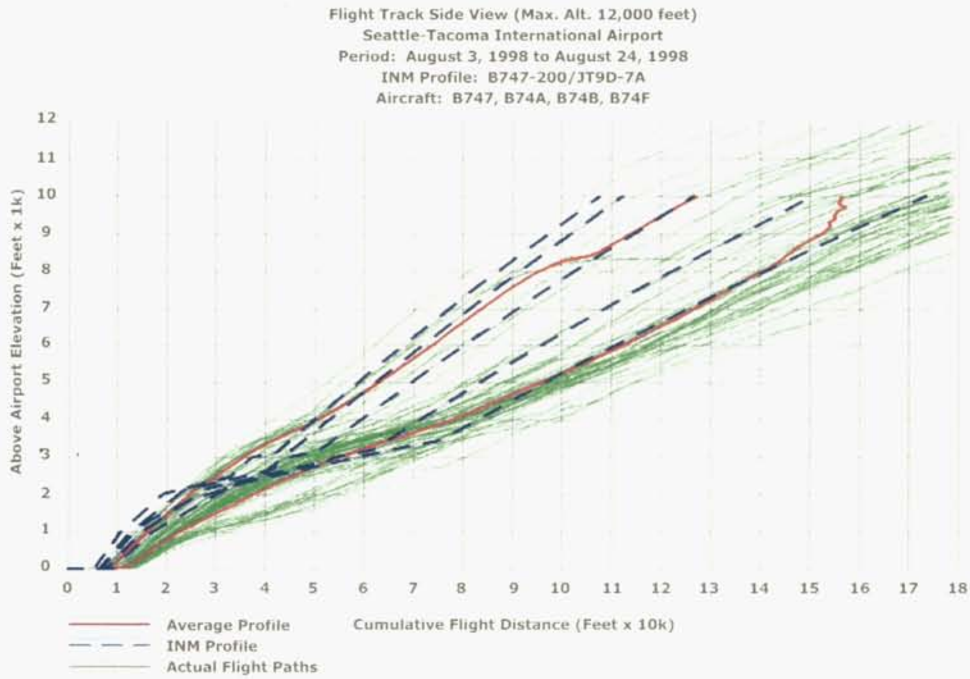
Time of Day. In the DNL metric, any operations that occur after 10 p.m. and before 7 a.m. are considered more intrusive and their noise levels are penalized by adding 10 dBA. Therefore, the number of nighttime operations is significant in determining the DNL noise environment. The nighttime operations assumptions were determined from the Airport's flight-track monitoring system. The results are based upon all operations between January 1, 1998 and December 31, 1998. The overall percentage of nighttime operations at Sea-Tac was determined to be 17.4 percent. The overall percentages of nighttime operations are summarized in Table C.11 for each category of aircraft. The time of day assumptions used in the model where specific to each aircraft type. Table C.10 presented the actual number of operations in each of the time period by INM aircraft type.

Table C.11
SUMMARY HOURS OF OPERATION BY CATEGORY, EXISTING 1998
Seattle-Tacoma International Airport FAR Part 150 Study

Category	***Percentage Nighttime Operations***	
	Departures	*Arrivals*
Air Carrier (Wide Body Jet)	15.0%	21.4%
Air Carrier (Narrow Body Jet)	17.5%	20.4%
Regional Jet	6.4%	5.1%
Commuter (Propeller)	10.1%	9.6%
General Aviation & Other	11.1%	8.9%

Stage Length. The aircraft departure stage length is the distance the aircraft flies from the Airport to its first destination. The stage length of a flight can be used as a rough surrogate for the aircraft departure weight. Generally, heavier aircraft climb at a slower rate, and thus the noise levels under the flight path are likely to be louder. The aircraft departure stage lengths were determined based upon the actual climb gradient for aircraft operating at Sea-Tac, as determined from the ARTS radar data.

An example of the departure climb gradients for the B747 and the MD80 aircraft are presented in Figure C.24. Based upon these data, the stage lengths that were used in the model where those that were actually flown based upon the radar data. For example, the MD80 aircraft were all modeled at the higher stage length which more closely matched the measured departure climb gradients. Climb profiles for other aircraft are presented in the Appendix. This information, along with other detailed noise information, was developed and presented in an effort to help the Committee members understand the various components associated with aircraft operations and resultant noise levels.



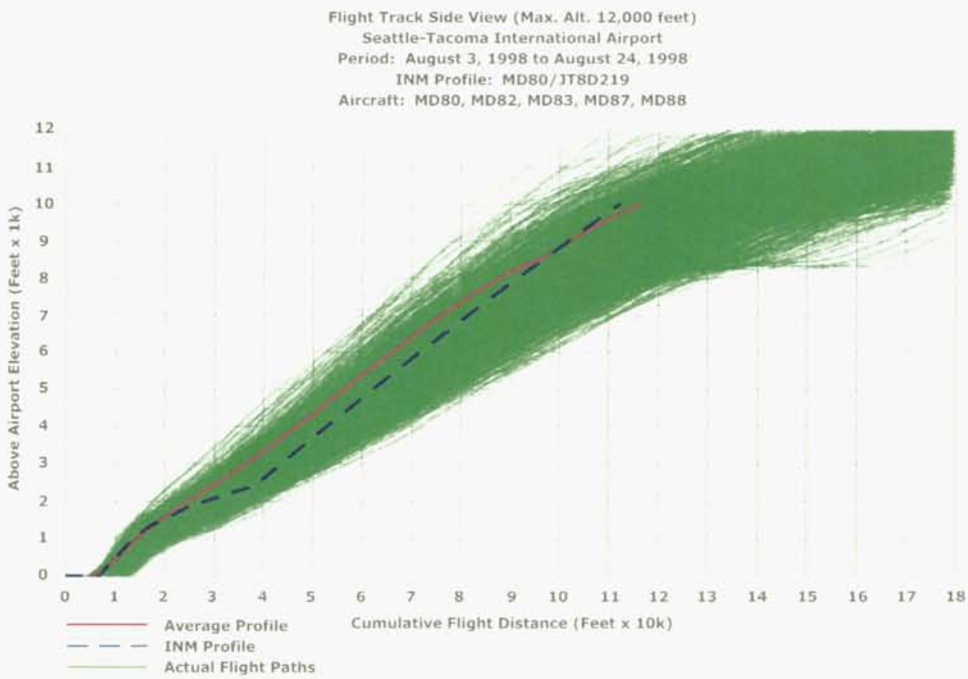


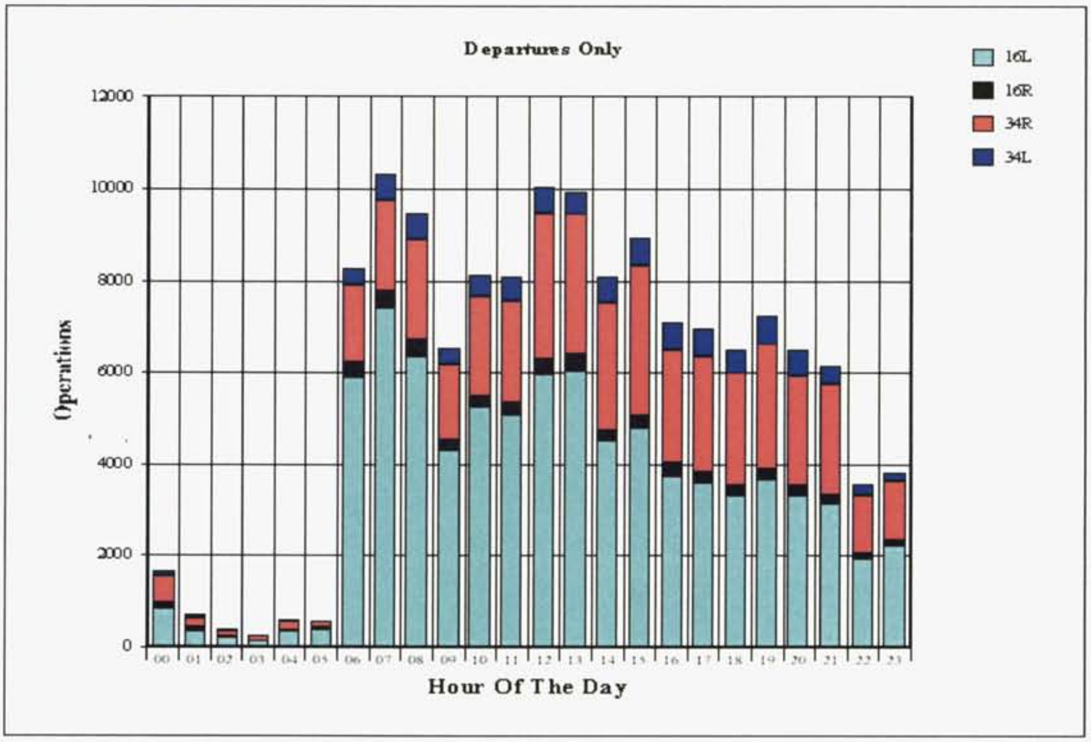
Figure C24 **Departure Profiles for B747 and MD80**
Period: August 3, 1998 to August 24, 1998

Runway Use. An additional important consideration in developing the noise exposure contours is the percentage of time each runway is utilized. The speed and direction of the wind dictate the runway direction that is utilized by an aircraft. From a safety and stability standpoint, it is desirable, and usually necessary, to arrive and depart an aircraft into the wind. When the wind direction changes, the operations are shifted to the runway end that favors the new wind direction.

The existing conditions runway use is presented in Table C.12. The results are based upon data from the Airport's noise and flight track monitoring system for the time period between January 1, 1998 and December 31, 1998. This table presents the percentage utilization of each runway for departures and arrivals separately, and during the daytime and nighttime hours. These same data are presented graphically in Figure C.25. The top portion of this figure shows the total number of departure operations per hour of the day for each runway. The same data are presented in the bottom portion of the graph for arrivals.

Table C.12
PERCENTAGE RUNWAY UTILIZATION BY TIME OF DAY
Seattle-Tacoma International Airport FAR Part 150 Study

Runway	**Arrivals**		**Departures**	
	All Hours	*Nighttime*	*All Hours*	*Nighttime*
16L	18.3%	27.9%	72.0%	73.3%
16R	50.1%	41.2%	3.4%	3.8%
34R	16.2%	23.4%	21.2%	19.9%
34L	15.4%	7.5%	3.4%	3.0%
Total	100%	100%	100%	100%



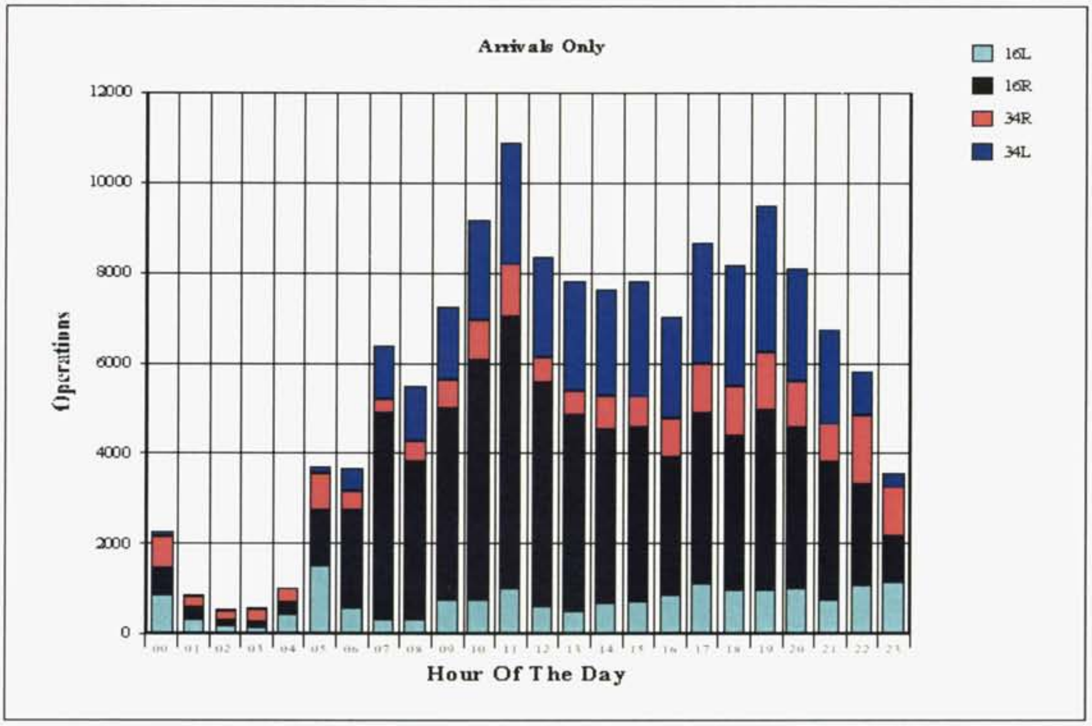


Figure C25 **Hourly Runway Use Report**
Period: January 1, 1998 to September 30, 1998

Flight Paths and Flight Path Utilization. The Airport and ATCT have established paths for aircraft arriving and departing from Sea-Tac. These paths are not precisely defined ground tracks, but represent an area over which the aircraft will generally fly. The location and utilization of the flight tracks are based upon a review of ARTS radar data, field observations, and discussions with noise-abatement personnel.

The modeling analysis for existing conditions included a total of 28 primary departure flight tracks and 13 primary arrival flight tracks to model the aircraft flight paths at the Airport. Flight tracks were modeled using the dispersion element of the INM program, which spreads the actual tracks over a wider area. The dispersions used in the model were derived from a review of actual radar plots of the flight paths at Sea-Tac. The flight tracks modeled in the study were only those tracks generally within the 55 DNL study area or to distances where potential flight track changes may be studied.

The existing flight tracks used in the modeling analysis are presented in Figures C.26 and C.27. Figure C.26 presents the dispersed departure flight tracks. Figure C.27 presents the dispersed arrival flight tracks. These Figures present tracks for both jet and propeller aircraft. Note that these Figures also illustrate which tracks are used for propeller aircraft only.

Actual radar data from aircraft operations were used in the development of the flight tracks and the dispersion of these tracks. Examples of two days of data are presented in this report. Figure C.28 presents flight track data for South flow operations. Figure C.29 presents flight track data for North flow operations. Both of these maps represent jet departure operations only. Figures C.30 and C.31 present the typical flight tracks for propeller aircraft. Figure C.30 presents south flow tracks while Figure C.31 presents north flow tracks.

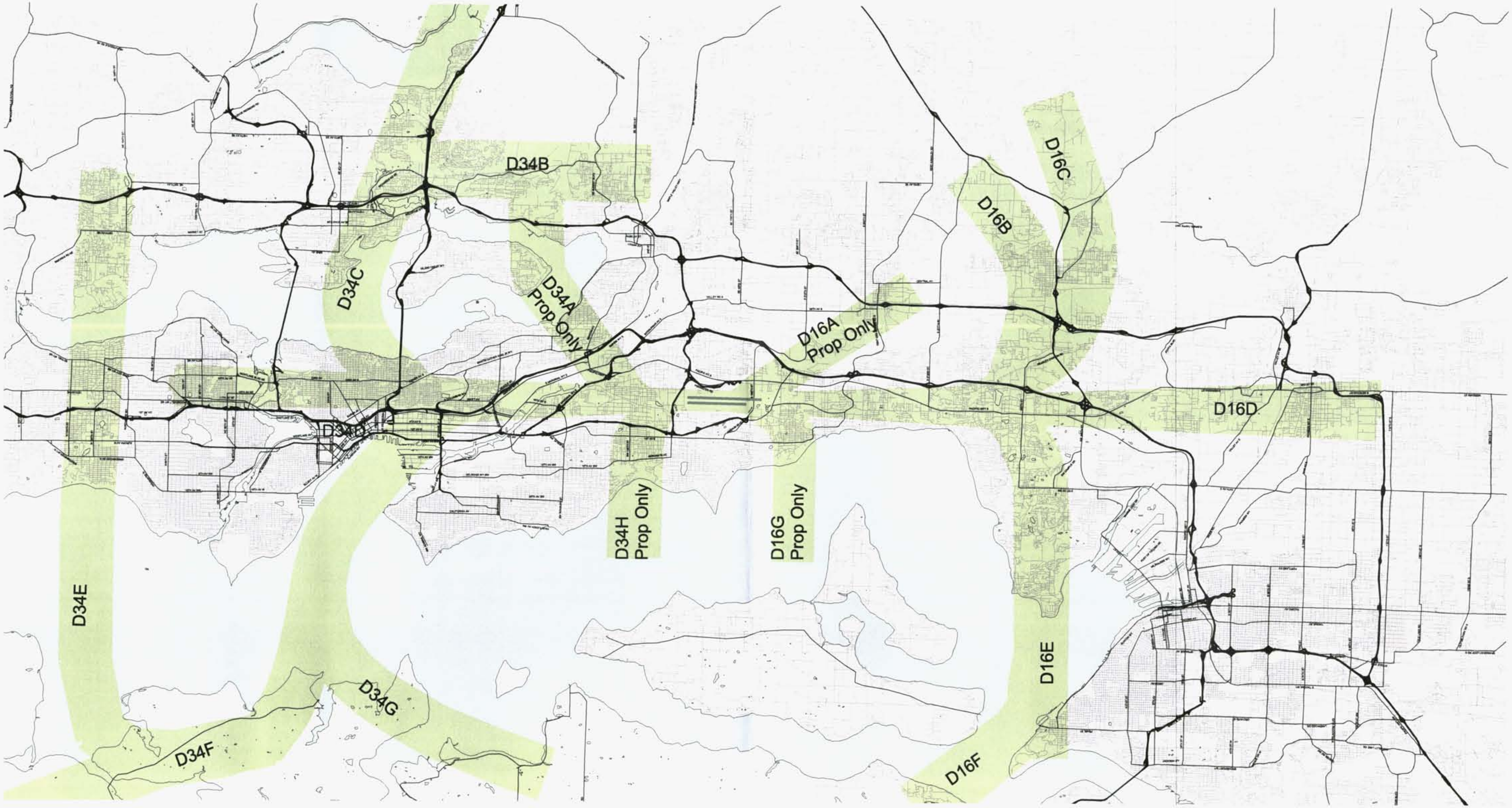
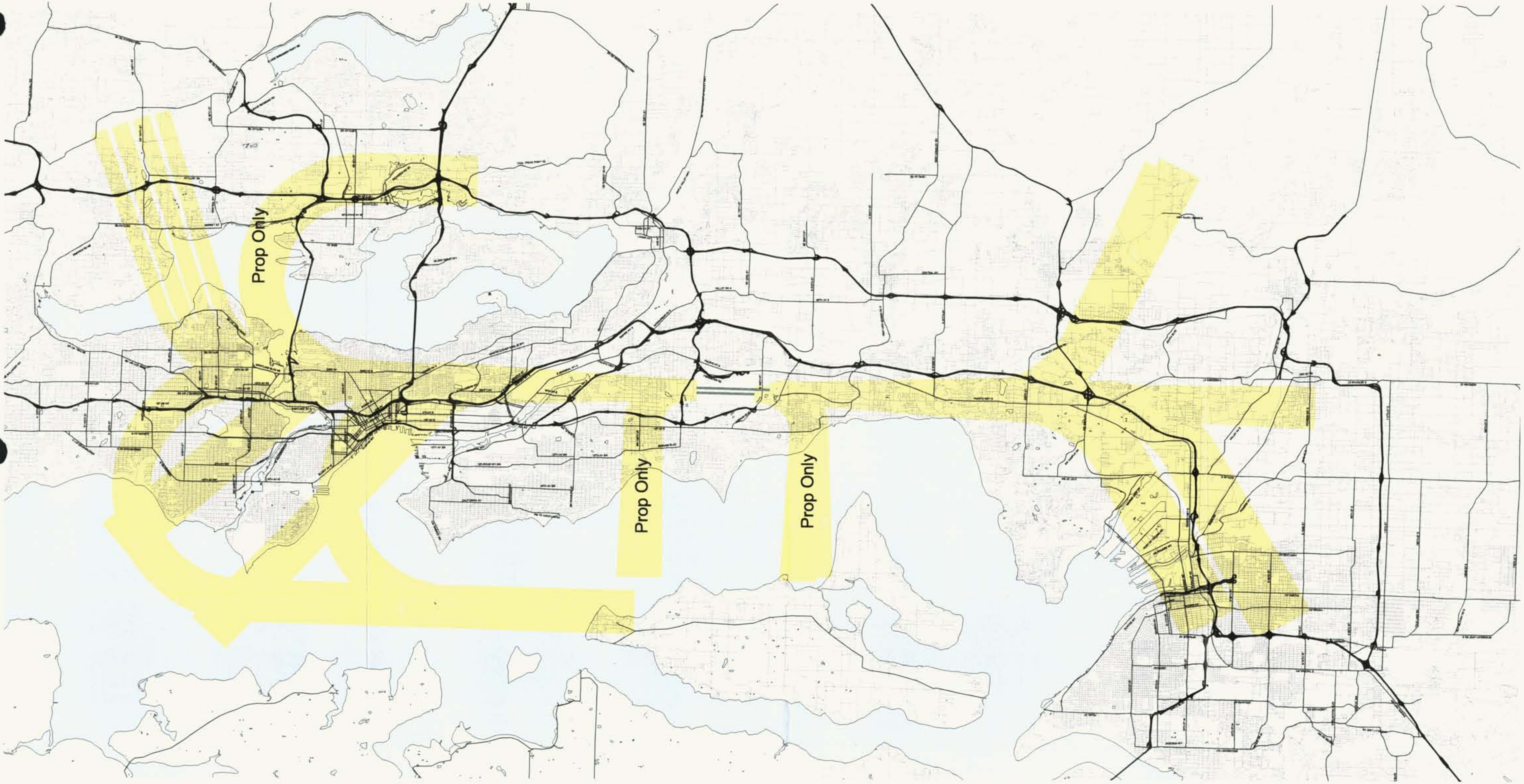
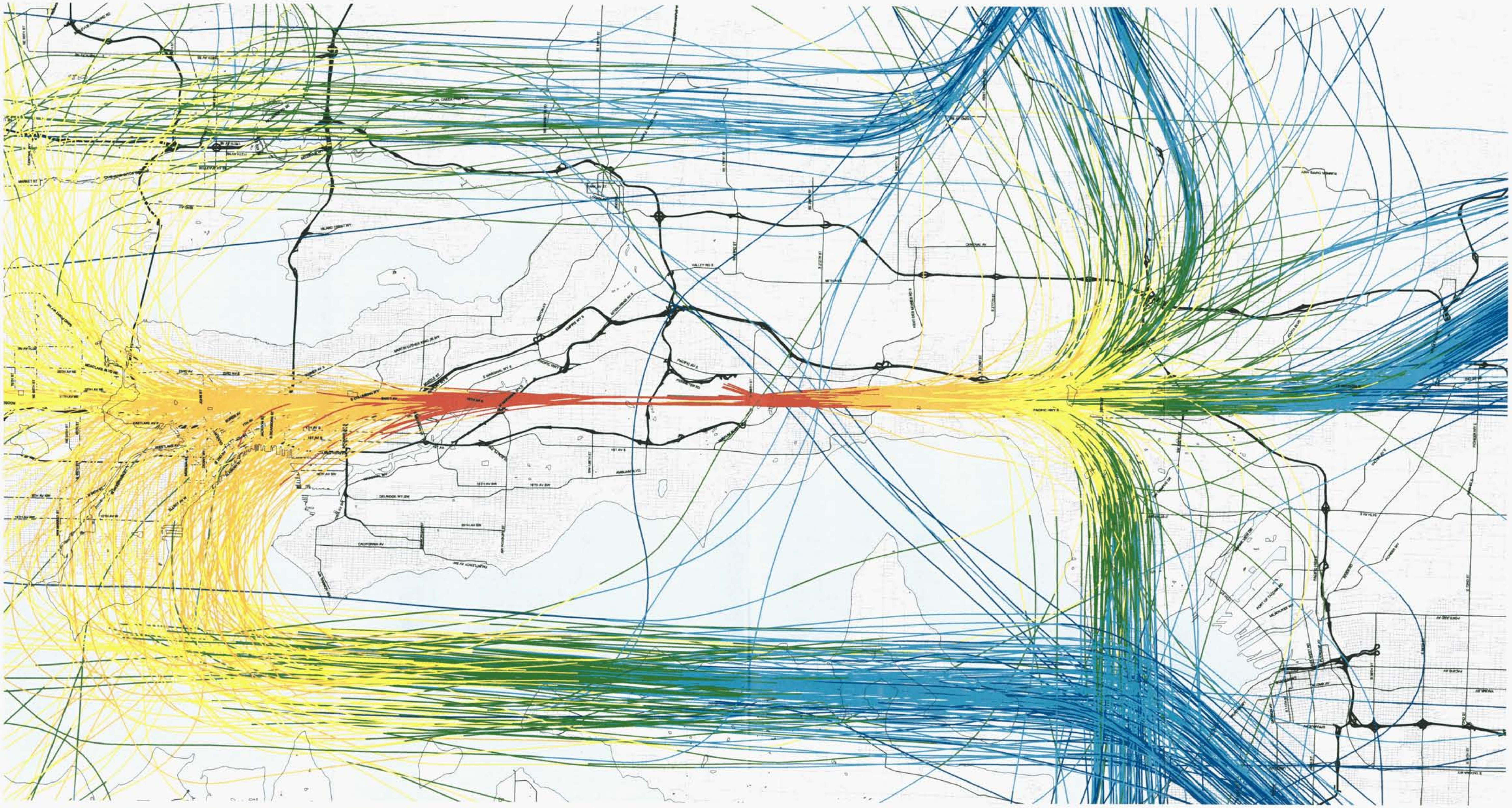


Figure C26 **INM Departure Flight Tracks**



N Scale 1"=16,000' Approximately

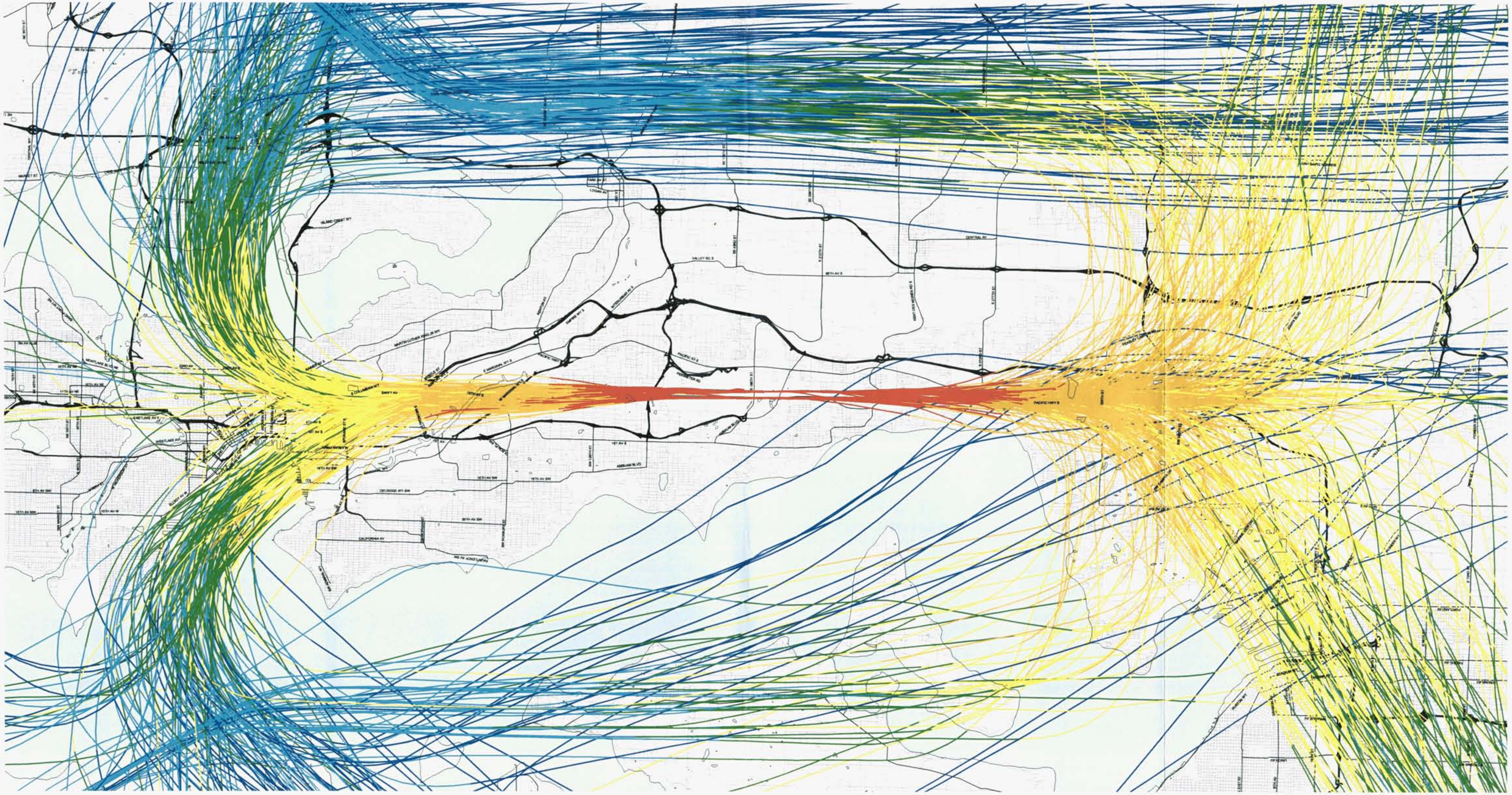
Figure C27 **INM Approach Flight Tracks**



N Scale 1"=12,000' Approximately

Figure C28 **Flight Track Map**
Sample South Flow by Altitude

- 0 - 2000 AGL
- 2000 - 4000 AGL
- 4000 - 6000 AGL
- 6000 - 8000 AGL
- 8000 - 10000 AGL
- >10,000 AGL



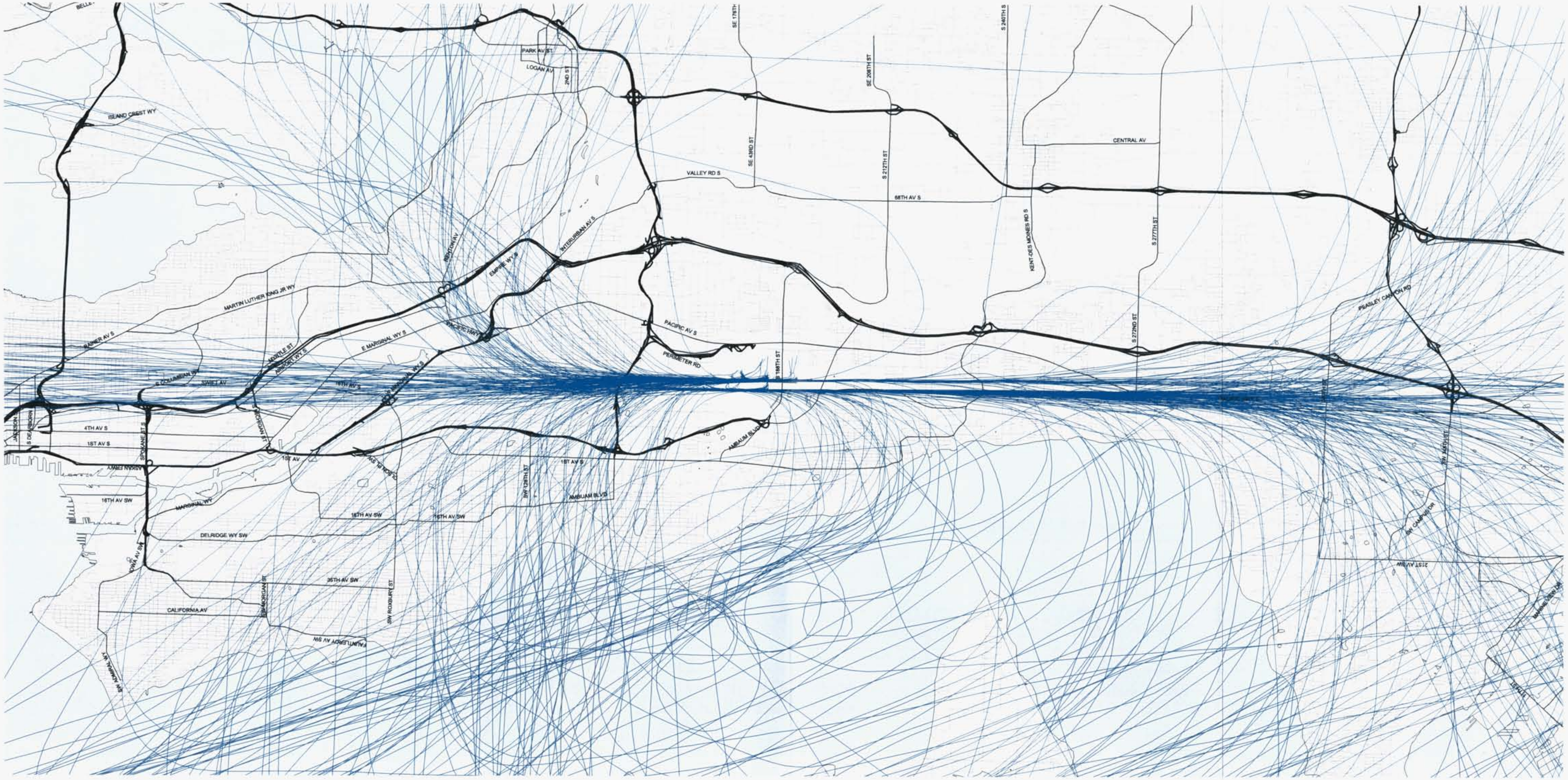
N Scale 1"=12,000' Approximately

Figure C29 **Flight Track Map**
Sample North Flow by Altitude

- 0 - 2000 AGL
- 2000 - 4000 AGL
- 4000 - 6000 AGL
- 6000 - 8000 AGL
- 8000 - 10000 AGL
- >10,000 AGL

N Scale 1"=8,000' Approximately

Figure C30 **Example South Flow Propeller Flight Track Plots**



N Scale 1"=8,000' Approximately

Figure C31 **Example North Flow Propeller Flight Track Plots**

Noise Contour Modeling Results

Noise exposure contours were developed for both cumulative noise levels and single-event noise levels. The cumulative noise levels were quantified in terms of DNL. As required by the FAA, the primary noise criterion to describe the existing noise environment is DNL. The single-event analysis was quantified in terms of SEL. The SEL data were used to supplement the DNL analysis.

DNL Noise Contours. While single-event noise levels can be useful to help anticipate a community's response to noise, community noise standards are expressed in terms of cumulative noise exposure metrics such as the DNL. The existing annual 1998 DNL noise exposure contours for Sea-Tac are presented in Figure C.32. This figure presents the 55, 60, 65, 70 and 75 DNL noise exposure contours. Note that the 55 and 60 DNL contours are presented in dashed lines. A more detailed view around the 65 DNL noise contour area is presented in Figure C.33.

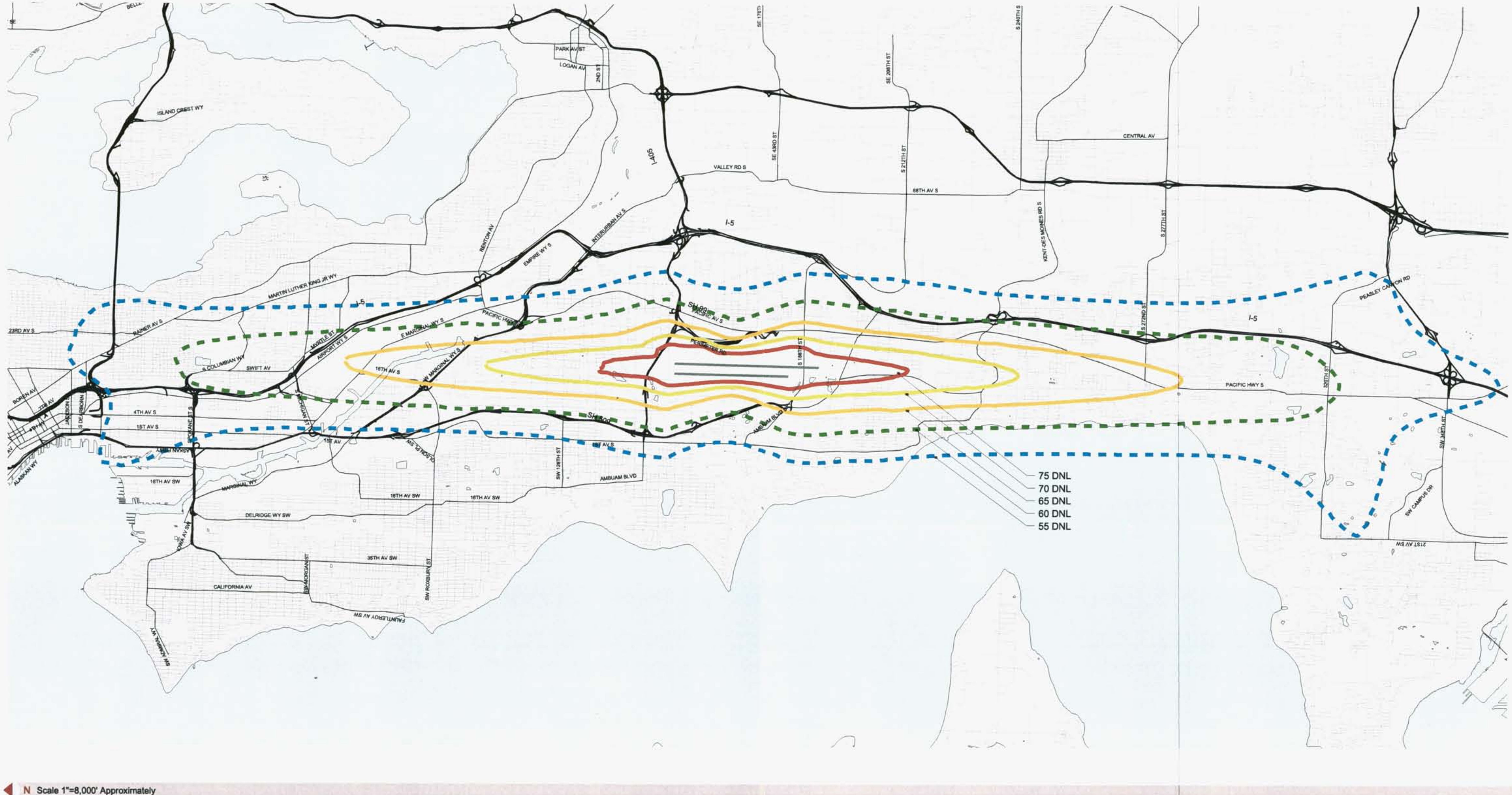


Figure C32 **Existing DNL Noise Contour**

CONTOUR-75
CONTOUR-70
CONTOUR-65
CONTOUR-60
CONTOUR-55

GRAPHIC SCALE IN FEET
0 2,000 4,000 6,000 8,000 10,000

N —— Approximate Scale 1" = 6,000'

Figure C33 **Existing (1998) DNL Noise Contour (Close in View)**

*Source: Basemap compiled from Tiger Line Data, 1994.
Generalized Existing Land Use, Gambrell Urban, Inc., EIS Master Plan, 1997. Noise Contours—BCS International*

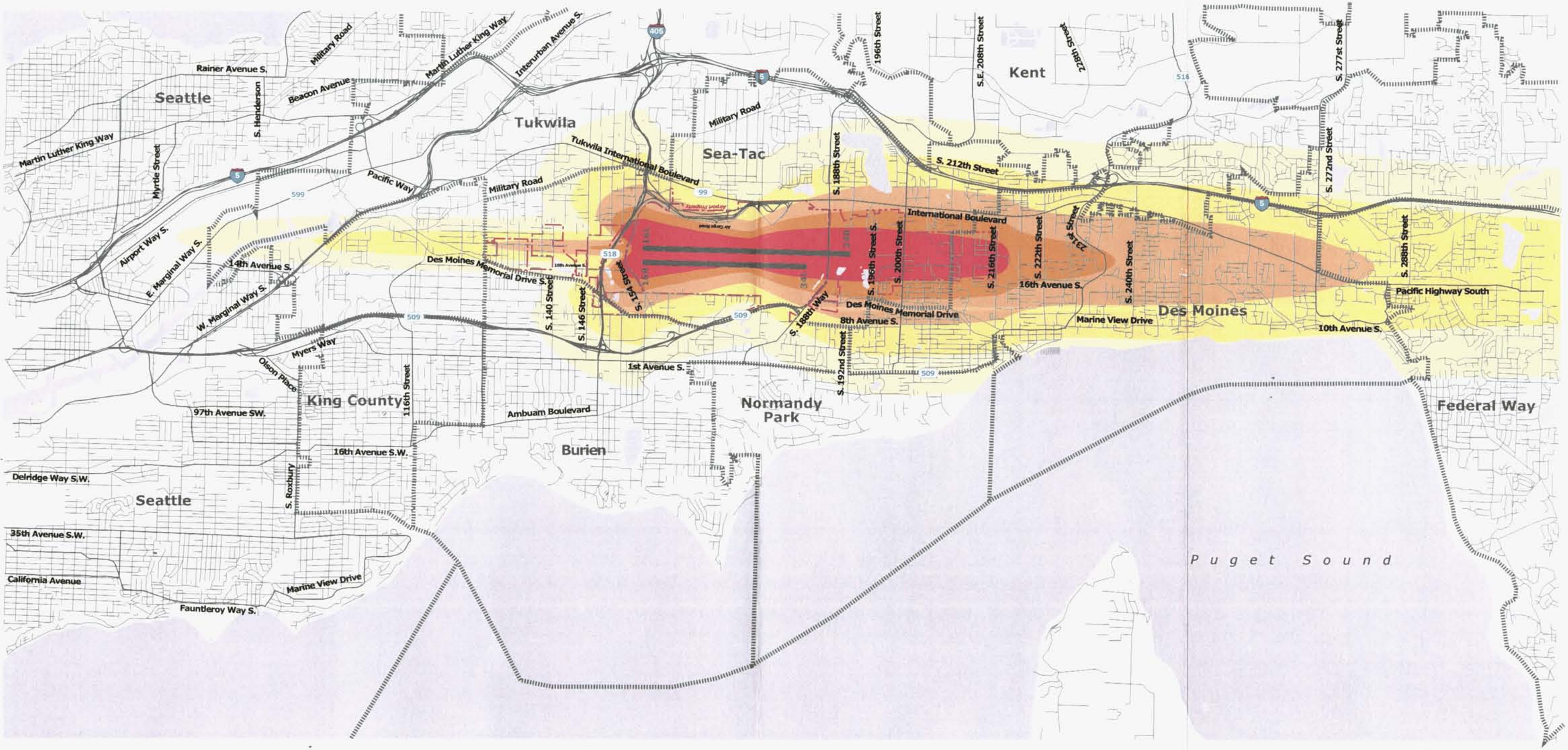
Single-Event Noise Contours. Single-event noise exposure contours for sample aircraft were also developed. These contours represent the single-event noise levels for one departure and one arrival operation. These contours are presented in terms of the SEL noise metric. Sample single-event noise exposure contours are presented in Figures C.34 through C.37 for the B727, F-28, B737-400 and MD80 aircraft respectively. These noise exposure contours illustrate a north flow operation on Runway 34R for both a departure on the east turn and a straight in arrival. The noise contours present the 85, 90, 95, 100 and 105 SEL noise level.

Value of Additional Noise Metrics

This FAR Part 150 Study extended the standard noise analysis in two significant ways: conducting sample noise monitoring in locations around the airport during four seasons and supplement DNL contours with SEL and Time Above (TA) noise metrics. Both of these tasks were initiated in response to community doubts about the quality and accuracy of strictly modeled, one season, and/or average noise data. Additionally there was a very strong desire for noise information to be related to daily living activities, particularly speech and sleep.

Field noise measurement for every season allowed small adjustment to be made to the INM model to more accurately reflected actual fleet and meteorological conditions in Seattle. The resulting DNL contour, when produced, were more credible and, therefore, more readily accepted by area citizens a accurate.

Similarly providing SEL contours to describe the probable impact of several alternatives on sleep interference and TA data to predict the frequency of speech interference can produce a level of comfort with the study findings. As a result, discussion can move beyond the accuracy of the data and on to the substance of the findings. Using additional measuring and metrics does not reduce differences of opinion on the value of various alternatives, but it does change the nature of the debate. Rather than dismissing noise data as skewed, inaccurate and/or unfair, the relative impact of alternative proposals becomes the primary topic.



GRAPHIC SCALE IN FEET

0 2,000 4,000 6,000 8,000 10,000

N —— Approximate Scale 1" = 6,000'

Figure C34 **Example Single Event Noise Contours (B727Q15)**

- 85 Single Event Level Contour (SEL)
- 90 Single Event Level Contour (SEL)
- 95 Single Event Level Contour (SEL)
- 100 Single Event Level Contour (SEL)
- 105 Single Event Level Contour (SEL)

Source: Basemap compiled from Tiger Line Data, 1994.
Single Event Level (SEL) Noise Contours—BCS International

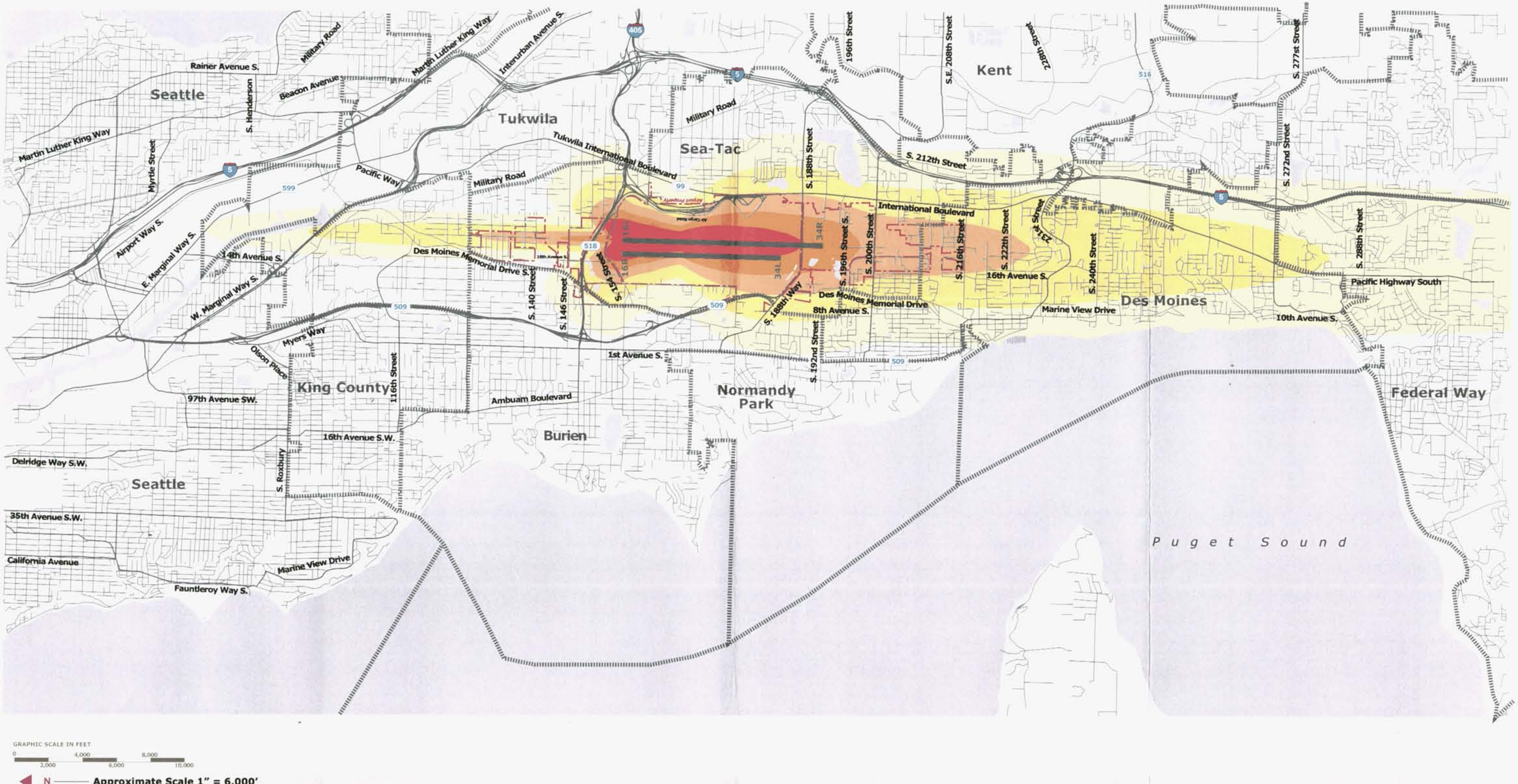


Figure C35 **Example Single Event Noise Contours (FOKKER28)**

- 85 Single Event Level Contour (SEL)
- 90 Single Event Level Contour (SEL)
- 95 Single Event Level Contour (SEL)
- 100 Single Event Level Contour (SEL)
- 105 Single Event Level Contour (SEL)

Source: Basemap compiled from Tiger Line Data, 1994.
Single Event Level (SEL) Noise Contours—BCS International

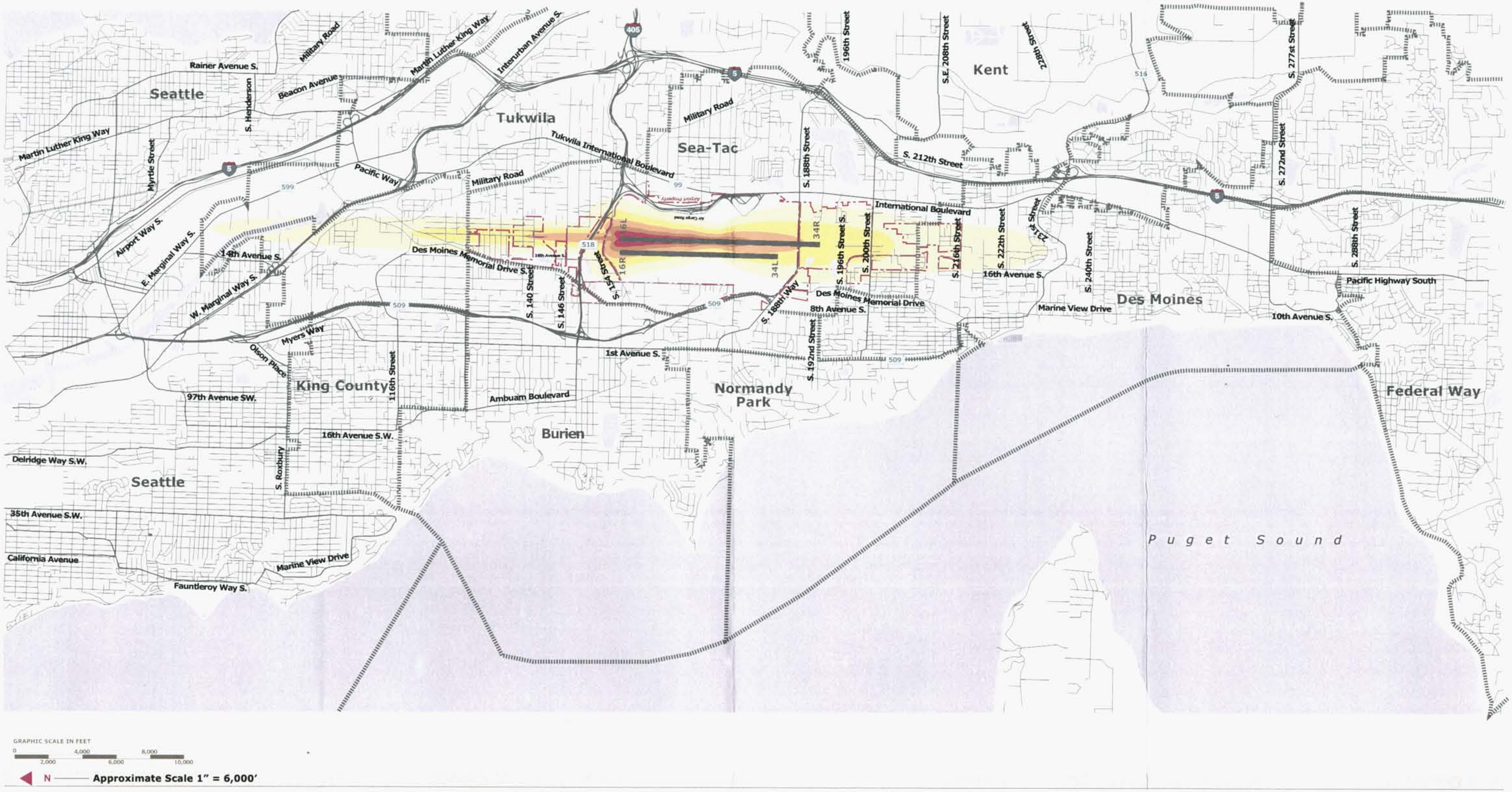


Figure C36 **Example Single Event Noise Contours (B737400)**

- 85 Single Event Level Contour (SEL)
- 90 Single Event Level Contour (SEL)
- 95 Single Event Level Contour (SEL)
- 100 Single Event Level Contour (SEL)
- 105 Single Event Level Contour (SEL)

Source: Basemap compiled from Tiger Line Data, 1994.
Single Event Level (SEL) Noise Contours—BCS International

N —— Approximate Scale 1" = 6,000'

Figure C37 **Example Single Event Noise Contours (MD80)**

- 85 Single Event Level Contour (SEL)
- 90 Single Event Level Contour (SEL)
- 95 Single Event Level Contour (SEL)
- 100 Single Event Level Contour (SEL)
- 105 Single Event Level Contour (SEL)

Source: Basemap compiled from Tiger Line Data, 1994.
Single Event Level (SEL) Noise Contours—BCS International

Future Noise Environment

The purpose of this section of the FAR Part 150 Study is to present the anticipated future noise conditions at Sea-Tac based upon the projected operational assumptions. Future operational figures and aircraft use percentages were developed for two future cases: the year 2004 and the year 2010.

Future (2004) Aircraft Operations

The future noise environment for Sea-Tac was analyzed based upon 2004 forecast operational conditions. The forecasts of aviation activity are presented in Chapter Two of this Study.

Aircraft Activity Levels. The forecast estimates that there will be 450,162 operations during the 2004 time period, or an average of 1,233 daily operations (an operation is defined as one takeoff or one landing). The 2004 aircraft operations for each category of operation are summarized in Table C13.

Table C13
SUMMARY OF FUTURE (2004) OPERATIONS
Seattle-Tacoma International Airport FAR Part 150 Study

Category	Average Daily Operations
Wide-Body Jets	69.8
Narrow-Body Jets	583.1
Regional Jets	161.2
Commuter Twin Propeller	336.7
General Aviation and Military Jets	6.4
General Aviation and Military Props and Other	76.1
TOTAL	**1,233.3**

All remaining assumptions are the same as with the existing conditions except for the mix of aircraft for the future year. The most significant change between the existing (1998) fleet mix and the future (2004) fleet mix will be the elimination of Stage 2 aircraft from the fleet. The older Stage 2 aircraft will either be retrofitted with hush-kits, in order to reduce their noise level to Stage 3 levels, or the Stage 3 aircraft will be replaced altogether. The remaining jet fleet mix and nighttime percentages are assumed to remain the same. A more detailed breakdown of the data is presented in Appendix 23 and Table C13A.

Future Base Case (2004) DNL Contours

The 2004 DNL noise contours for Sea-Tac were also prepared using INM Version 5.2a. Noise contours for calendar year 2004 that depict the noise exposure in terms of DNL are shown in Figure C38. The contours shown are the 55, 60, 65, 70, and 75 DNL. The results of the analysis show that these future noise exposure contours are slightly smaller than the existing condition contours. This anticipated reduction is a result of the increase in Stage 3 operations that are projected to occur and the replacement of the F28 aircraft.

The Future (2004) operations are the base-case conditions against which future noise abatement alternatives at the Airport can be measured. No noise abatement actions were accounted for in these noise exposure contours.

Table C.13A
AIRCRAFT FLEET MIX ASSUMPTIONS FOR FUTURE (2004) CONDITIONS
Seattle-Tacoma International Airport FAR Part 150 Study

INM	Daily Arrivals		Daily Departures		Daily Operations			Annual
Type	Day	Night	Day	Night	Arrivals	Departures	Total	Operations
727EM1	4.62	3.22	6.38	0.40	7.84	6.78	14.62	5,336
727EM2	5.56	0.32	5.28	0.44	5.88	5.72	11.60	4,234
727Q15								
727Q7								
7373B2	48.56	7.44	48.58	7.80	56.00	56.38	112.38	41,019
737400	57.59	14.58	61.93	10.36	72.17	72.29	144.46	52,728
737500	8.82	1.77	9.33	1.71	10.59	11.04	21.63	7,895
737D17								
74720B	3.12	0.95	3.35	0.71	4.07	4.06	8.13	2,967
747400	2.21	0.94	2.06	1.22	3.15	3.28	6.43	2,347
757PW	27.99	8.83	29.41	8.22	36.82	37.63	74.45	27,174
757RR	3.80	0.55	3.57	0.81	4.35	4.38	8.73	3,186
767300	1.41	0.05	1.40	0.03	1.46	1.43	2.89	1,055
767CF6	3.30	1.11	2.76	1.87	4.41	4.63	9.04	3,300
A300	1.25	0.10	1.25	0.01	1.35	1.26	2.61	953
A320	11.94	2.42	11.22	3.25	14.36	14.47	28.83	10,523
BAE146	0.21		0.21		0.21	0.21	0.42	153
DC1030	12.05	3.03	14.46	0.62	15.08	15.08	30.16	11,008
DC870	0.62	0.14	0.61	0.08	0.76	0.69	1.45	529
DC8QN								
DC9Q9								
DHC6	28.78	3.45	27.54	1.59	32.23	29.13	61.36	22,396
DHC830	125.33	12.87	123.38	13.73	138.20	137.11	275.31	100,488
EMB145	21.23	1.14	21.04	1.45	22.37	22.49	44.86	16,374
GASEPV	36.75	4.00	30.41	4.93	40.75	35.34	76.09	27,773
GIIB	2.94	0.29	2.86	0.36	3.23	3.22	6.45	2,354
MD11GE	2.21	1.78	2.64	1.41	3.99	4.05	8.04	2,935
MD83	59.58	15.08	64.07	10.72	74.66	74.79	149.45	54,549
MD83	0.60		0.60		0.60	0.60	1.20	438
737D17	1.84	2.42	2.39	1.75	4.26	4.14	8.40	3,066
DC95HW	1.34	1.90	1.41	2.31	3.24	3.72	6.96	2,540
DC8QN	0.43	0.17	0.33	0.12	0.60	0.45	1.05	383
EMB145	55.05	2.97	54.56	3.75	58.02	58.31	116.33	42,460
Total	**529.13**	**91.52**	**533.03**	**79.65**	**620.65**	**612.68**	**1233.33**	**450,165**

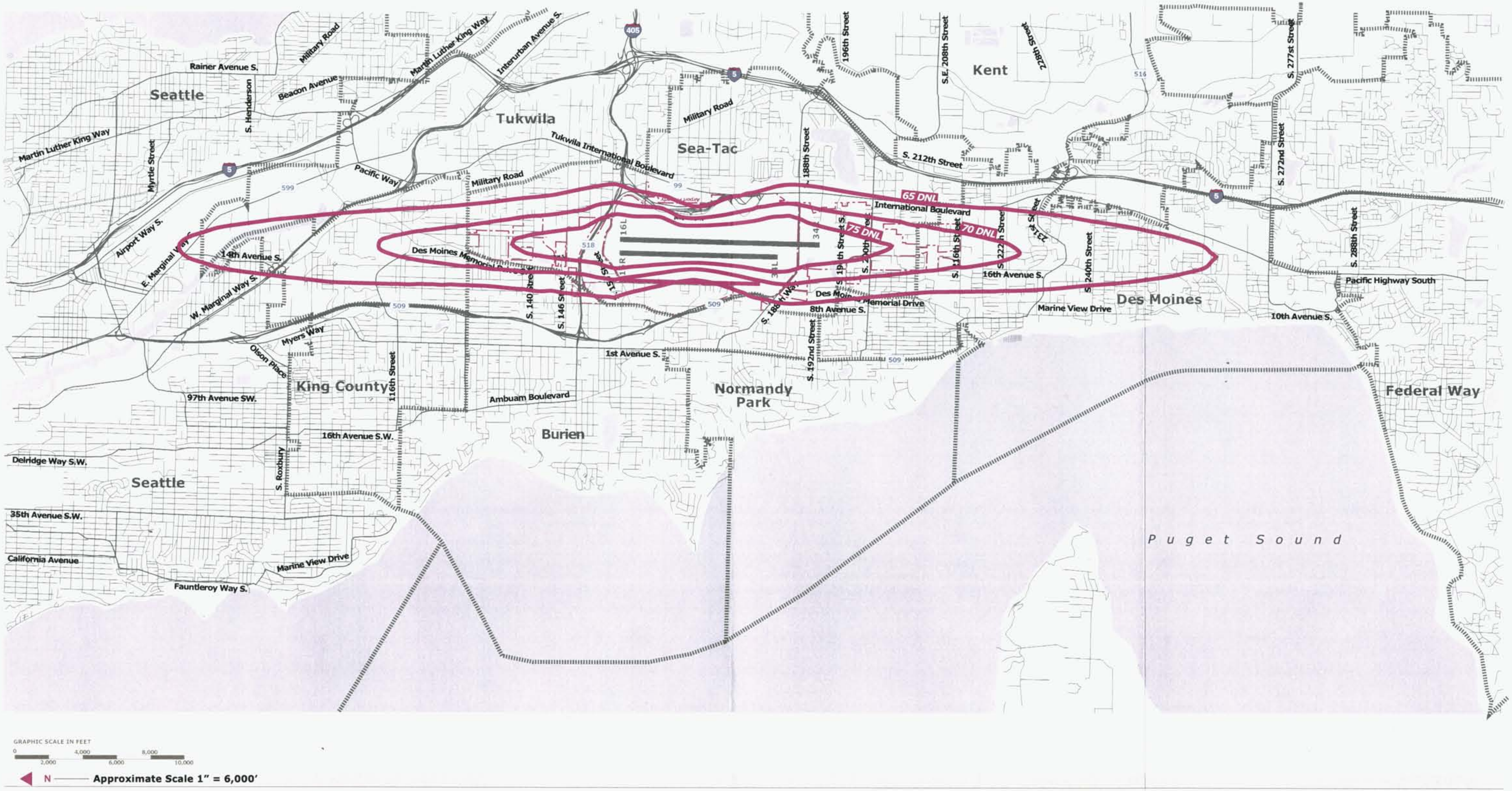


Figure C38 **Future Base Case (2004) DNL Noise Contours**

Source: Basemap compiled from Tiger Line Data, 1994.
Noise Contours—BCS International

Future (2010) Aircraft Operations

The future noise environment for Sea-Tac was analyzed based upon 2010 forecast operational conditions. The forecasts were presented in Chapter Two of this Study. The 2010 noise contours were generated in an effort to provide a reasonable representation of the aircraft noise levels associated with the operation of the third runway, as it will not be operational until after the time-frame of this Part 150 Study. The 2010 contours indicate that even though aircraft operations are increasing, overall size of the contours will decrease when compared to the existing condition.

Aircraft Activity Levels. The forecasts estimates that there will be 473,750 operations during that 2010 time period, or an average of 1,298 daily operations (an operation is defined as one takeoff or one landing). The 2010 aircraft operations for each category of operation are summarized in Table C14.

Table C14
SUMMARY OF FUTURE (2010) OPERATIONS
Seattle-Tacoma International Airport FAR Part 150 Study

Category	Average Daily Operations
Wide- Body Jets	170.7
Narrow-Body Jets	580.6
Regional Jets	186.5
Commuter Twin Propeller	306.0
General Aviation and Military Jets	30.1
General Aviation and Military Props and Other	24.0
TOTAL	**1,297.9**

The aircraft type assumptions for the Future 2010 case assume a quieter fleet than the Future 2004 case. A more detailed breakdown of this data is presented in Appendix 23. The most significant change between the two future cases is the inclusion of the Airport's third runway for the Future 2010 case. The third runway is expected to be operational in 2006 and will be located west of, and parallel to, the existing two runways.

Future Base Case (2010) DNL Contours

The 2010 DNL contours for Sea-Tac were prepared using INM Version 5.2a. Noise contours for calendar year 2010 that depict the noise exposure in terms of DNL are shown in Figure C39. The contours shown are the 55, 60, 65, 70 and 75 dBA DNL. The results of the analysis show that these future contours are wider than the contours for the Future 2004 case, however the 2010 noise contours are also shorter than the 2004 noise contours. The increase in width is anticipated to be a result of the operations being distributed to three parallel runways instead of the current two. The anticipated decrease in length of the noise contour is due to the increase in operations of quieter aircraft forecasted to occur. No noise abatement alternatives were accounted for in these contours.

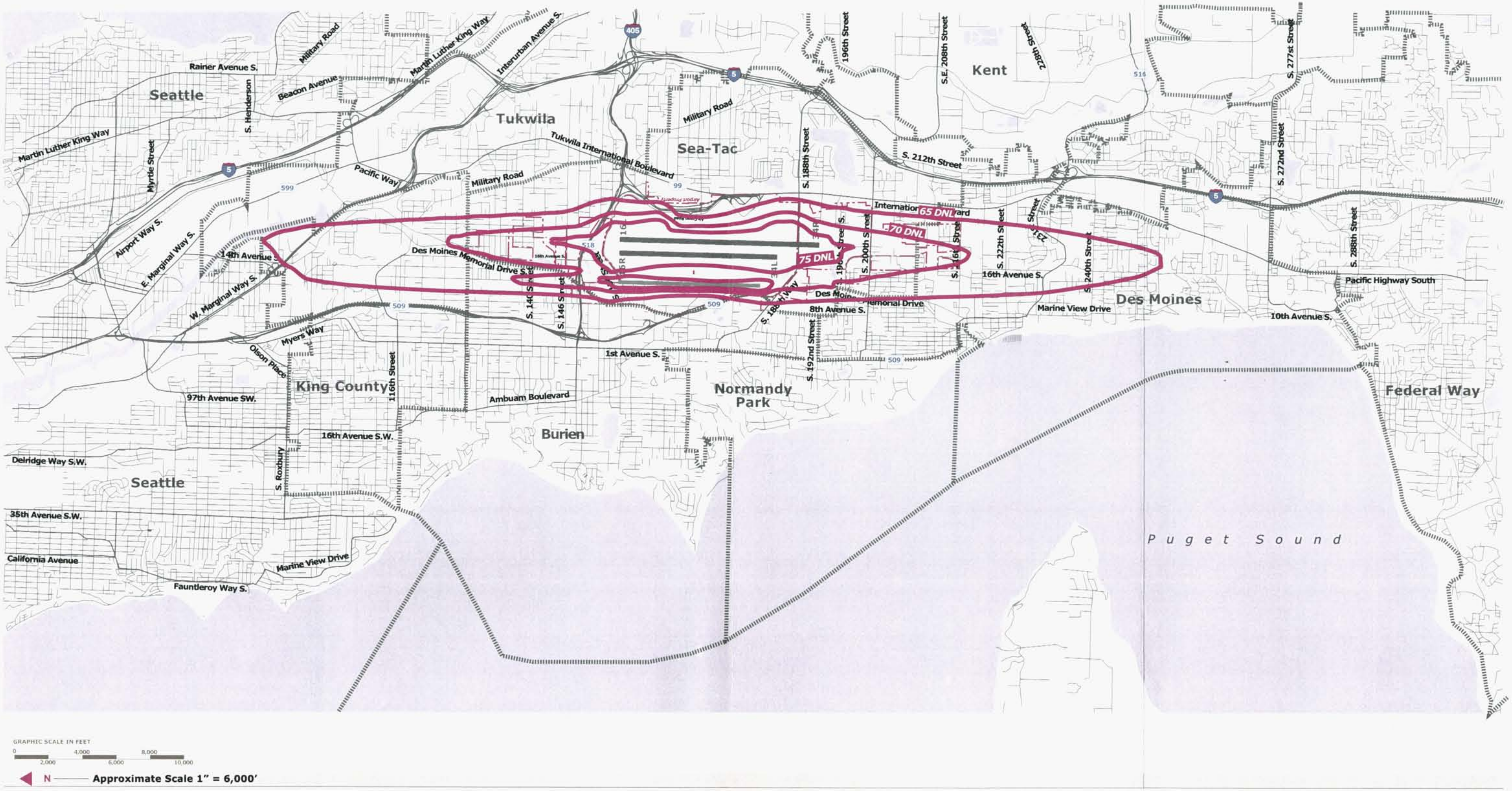
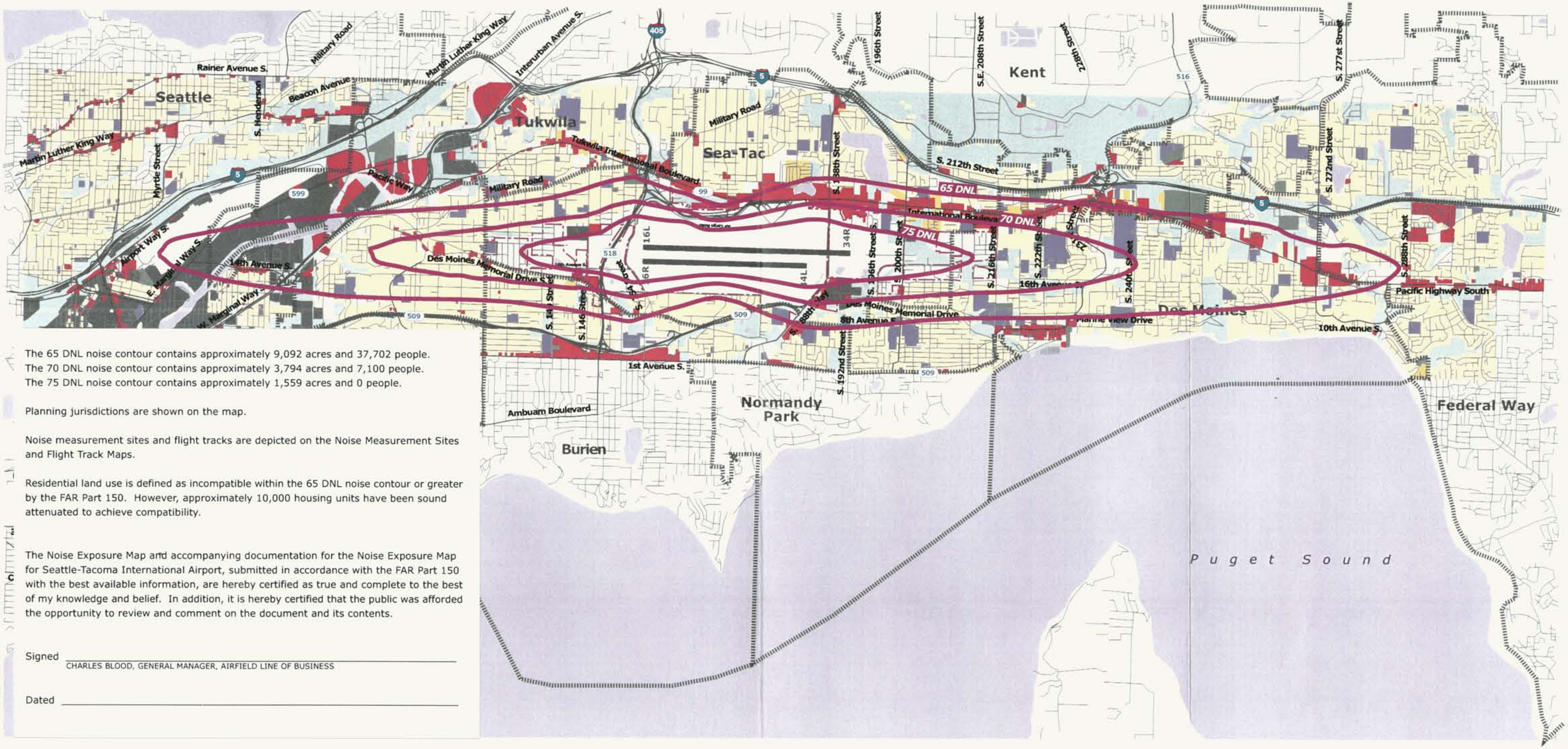


Figure C39 **Future (2010) DNL Noise Contours**

Source: Basemap compiled from Tiger Line Data, 1994.
Noise Contours—BCS International



The 65 DNL noise contour contains approximately 9,092 acres and 37,702 people.
The 70 DNL noise contour contains approximately 3,794 acres and 7,100 people.
The 75 DNL noise contour contains approximately 1,559 acres and 0 people.

Planning jurisdictions are shown on the map.

Noise measurement sites and flight tracks are depicted on the Noise Measurement Sites and Flight Track Maps.

Residential land use is defined as incompatible within the 65 DNL noise contour or greater by the FAR Part 150. However, approximately 10,000 housing units have been sound attenuated to achieve compatibility.

The Noise Exposure Map and accompanying documentation for the Noise Exposure Map for Seattle-Tacoma International Airport, submitted in accordance with the FAR Part 150 with the best available information, are hereby certified as true and complete to the best of my knowledge and belief. In addition, it is hereby certified that the public was afforded the opportunity to review and comment on the document and its contents.

Signed ______________________________
CHARLES BLOOD, GENERAL MANAGER, AIRFIELD LINE OF BUSINESS

Dated ______________________________

GRAPHIC SCALE IN FEET
0 2,000 4,000 6,000 8,000 10,000

N — Approximate Scale 1" = 6,000'

Figure C40 **Existing Noise Exposure Map (1998) DNL Noise Contours with Existing Land Use**

- Single-Family Residential
- Multi-Family residential
- Mobile Home Park
- Commercial
- Public Facilities
- Governmental Services
- Water Resources and Recreation
- Airport
- Industrial
- Open Space, Parks, Cemeteries Agricultural Land and Freeways

Source: Basemap compiled from Tiger Line Data, 1994.
Generalized Existing Land Use, Gambrell Urban, Inc., EIS Master Plan, 1997. Noise Contours—BCS International.

D Land Use Analysis

Seattle-Tacoma International Airport

FAR Part 150 Study Update

Land Use Analysis

Land Use Analysis

Introduction

This section of the FAR Part 150 Noise Exposure and Land Use Compatibility Study for Seattle-Tacoma International Airport deals with the evaluation of land uses within both the existing (1998) and future noise contours (2004 and 2010).

The development of realistic and effective alternatives is the focus of the FAR Part 150 noise compatibility planning process, with the overall objective being to explore a wide range of feasible alternatives of land use patterns, noise control actions and noise impact patterns. Solutions are explored which may accommodate both airport users and inhabitants, as well as environmental parameters. As a prelude to analyzing future noise exposure impacts resulting from changes in noise contours, an examination of existing conditions in terms of areas and persons affected by the existing noise contours is presented here. The following section deals with the types of land uses affected by the existing noise contours and the approximate number of persons within the designated noise contours. A subsequent section deals with these same items, but as they are affected by the future noise contours.

Existing Land Use Analysis/Existing Noise Contours, 1998

This section discusses the land use types found within the existing noise contours generated by aircraft utilizing Seattle Tacoma International Airport. The existing situation is represented by five contours, the DNL 55, 60, 65, 70 and 75 contours. An FAR Part 150 Study utilizes the DNL 65 contour as the threshold contour for land use analysis. However, this Study will present very generalized housing units and population information for the 55 and 60 also. It must be remembered that the total figures given below are cumulative. The figures for the larger contours contain the area within all smaller contours; i.e., the DNL 65 contour area includes the area representing the 70 and 75 contours.

The DNL 55 contour is the largest and contains approximately 40,720 acres. There are approximately 80,709 housing units representing approximately 194,997 persons within the contour.

The DNL 60 contour is the next largest and contains approximately18,197 acres. There are approximately 43,213 housing units representing approximately 99,980 persons within the contour.

The DNL 65 contour is the next largest and contains approximately 9,092 acres. There are approximately 16,272 housing units representing approximately 37,702 persons within the contour. This represents approximately 3,605 acres of residential development. There are approximately 418 acres of manufacturing development, approximately 620 acres of commercial development within the contour. In addition, there are approximately 463 acres of public/government land use and approximately 1,421 acres of open space within the contour. The remaining property consists of approximately 123 acres of water and approximately 2,442 acres are on airport property. There are approximately 24 churches, 27 schools, two libraries and five health care facilities in the contour. There is one historical site listed on the National Register (14^{th} Ave. S. Bridge) within the 65 DNL noise contour.

The DNL 70 is the next largest noise contour and contains approximately 3,794) acres. There are approximately 3,092 housing units representing approximately 7,100 persons within the contour, occurring on approximately 802 acres of residential land use. There are approximately 85 acres of manufacturing land use, approximately 112 acres of commercial land use and 138 acres of public/government land use. In addition, there are approximately 472 acres of open space within the contour and the remaining 2,185 acres remain on airport property. There are approximately twelve churches, twelve schools and one library within the contour. There are no historical sites listed on the National Register within the contour.

The DNL 75 is the smallest contour. It contains approximately 1,559 acres. There is no residential development within the contour. There are approximately twenty-seven acres of manufacturing land use, approximately five acres of commercial development, 155 acres of open space and one acre of public/government land use. The remaining 1,371 acres are entirely on airport property.

The existing table, entitled *EXISTING LAND USE WITHIN EXISTING NOISE CONTOURS, 1998* summarizes the above land use information.

Table D1
EXISTING LAND USE WITHIN EXISTING NOISE CONTOURS, 1998
Sea-Tac International Airport FAR Part 150 Study

Land Use	DNL 55 Contour		DNL 60 Contour		DNL 65 Contour		DNL 70 Contour		DNL 75 Contour	
Residential	NA	Ac	NA	Ac	3,605	Ac	802	Ac	0	Ac
People	194,997		99,980		37,702		7,100		0	
House. Units	80,709		43,213		16,272		3,092		0	
Churches	NA		NA		22		12		0	
Schools	NA		NA		25		10		0	
Libraries	NA		NA		2		1		0	
Health Care	NA		NA		3		1		0	
Com/Retail	NA	Ac	NA	Ac	620	Ac	112	Ac	5	Ac
Open Space	NA	Ac	NA	Ac	1,421	Ac	472	Ac	155	Ac
Govt./Public	NA	Ac	NA	Ac	463	Ac	138	Ac	1	Ac
Airport	NA	Ac	NA	Ac	2,442	Ac	2,185	Ac	1,371	Ac
Water	NA	Ac	NA	Ac	123	Ac	0	Ac	0	Ac
Manufacture	NA	Ac	NA	Ac	418	Ac	85	Ac	27	Ac
Total	**40,720**	**Ac**	**18,197**	**Ac**	**9,092**	**Ac**	**3,794**	**Ac**	**1,559**	**Ac**

The total figures for each contour are cumulative. The figures for the larger contours contain the area -within all smaller contours. Contour totals do not include rights-of-way.

SOURCE: Master Plan EIS, Seattle-Tacoma International Airport, BDC Analysis

Existing Land Use Inconsistencies

Land use incompatibility is an area of determination and regulation that is to be resolved solely at the discretion of the local community or by the state. To determine what constitutes land use incompatibility, the individual land use types within particular noise contours need to be defined. The Federal Aviation Administration, through the FAR Part 150 Study, has developed generalized guidelines for land use compatibility for land use planning purposes, as presented earlier. However, these are guidelines and do not automatically define incompatible land uses. Based on these guidelines, the residential land uses, schools, churches, libraries and health care facilities within the 65 or greater DNL noise contours, that are not sound attenuated are inconsistent with these guidelines. The Port has sound attenuated approximately 10,000 residences, two churches, two schools one condominium and one convalescent home. In addition, any single-family homes constructed after 1987 are considered compatible due to building code requirements.

Existing Land Use Analysis/ Future (Base Case, 2004) Noise Contours

This section discusses the land use types found within the base case future (2004) noise contours generated by aircraft utilizing Seattle-Tacoma International Airport, assuming that all land uses will remain the same. This is the "base case" which assumes that no operational or facility modifications will occur at the airport, and is reflective of the forecast operations and aircraft types explained previously. This is the situation with which future alternative scenarios will be measured to quantify impacts as compared with the impacts that would occur if not mitigation measures were implemented.

The future base case situation is represented by five contours, the DNL 55, 60, 65, 70 and 75 contours. The DNL 55 contour is the largest and contains approximately 31,075 acres. There are approximately 63,583 housing units representing approximately 149,643 persons within the contour.

The DNL 60 contour is the next largest and contains approximately 15,642 acres. There are approximately 32,045 housing units representing approximately 74,391 persons within the contour.

The DNL 65 contour is the next largest and contains approximately 6,765 acres. There are approximately 8,939 housing units representing approximately 21,683 persons within the contour, representing approximately 2,482 acres of residential land use. There are approximately 330 acres of manufacturing development, 231 acres of commercial development and approximately 1,006 acres of open space within the contour. In addition, there are approximately 287 acres of public/government land use within the contour. Water accounts for approximately 85 acres and the remaining 2,313 acres are on airport property. There are approximately nineteen churches, twenty-three schools, one health care facility and two libraries within the contour. There is one historical site listed on the National Register (14^{th} Ave. S. Bridge) within the 65 DNL noise contour.

The DNL 70 is the next largest noise contour and contains approximately 2,807 acres. There are approximately 1,116 housing units representing approximately 2,540 people within the contour, occurring on approximately 341 acres of residential development. There are approximately 80 acres of manufacturing land use, approximately 60 acres of commercial land use and approximately 351 acres of open space within the contour. In addition, there are approximately 47 acres of public/government land use. The remaining 1,927 acres are airport property. There are approximately nine churches, five schools and one library within the contour. There are no historical sites listed on the National Register within the contour.

The DNL 75 is the smallest contour. It contains approximately 1,178 acres with no residential land use. There are approximately thirteen acres of manufacturing land use, four acres of commercial land use and 60 acres of open space. The remaining 1,100 acres are on airport property.

The following table, entitled *EXISTING LAND USE WITHIN FUTURE NOISE CONTOURS, 2004* summarizes the above land use information.

Table D2
EXISTING LAND USE WITHIN FUTURE NOISE CONTOURS, 2004
Sea-Tac International Airport FAR Part 150 Study

Land Use	DNL 55 Contour		DNL 60 Contour		DNL 65 Contour		DNL 70 Contour		DNL 75 Contour	
Residential	NA	Ac	NA	Ac	2,482	Ac	341	Ac	0	Ac
People	149,643		74,391		2,1683		2,540		0	
House. Units	63,583		32,045		8,939		1,116		0	
Churches	NA		NA		18		9		0	
Schools	NA		NA		23		5		0	
Libraries	NA		NA		2		1		0	
Health Care	NA		NA		1		0		0	
Com/Retail	NA	Ac	NA	Ac	231	Ac	60	Ac	4	Ac
Open Space	NA	Ac	NA	Ac	1,006	Ac	351	Ac	60	Ac
Govt./Public	NA	Ac	NA	Ac	287	Ac	47	Ac	0	Ac
Airport	NA	Ac	NA	Ac	2,313	Ac	1,927	Ac	1,100	Ac
Water	NA	Ac	NA	Ac	85	Ac	0	Ac	0	Ac
Manufacture	NA	Ac	NA	Ac	330	Ac	80	Ac	13	Ac
Total	**31,075**	**Ac**	**15,642**	**Ac**	**6,765**	**Ac**	**2,807**	**Ac**	**1,178**	**Ac**

The total figures for each contour are cumulative. The figures for the larger contours contain the area -within all smaller contours. Contour totals do not include rights-of-way.

SOURCE: Master Plan EIS, Seattle-Tacoma International Airport, BDC Analysis

Future Base Case (2004) Land Use Inconsistencies

Based on the Federal guidelines, the residential land uses, schools, churches, libraries and health care facilities within the 65 or greater DNL noise contours, that are not sound attenuated, are inconsistent with these guidelines. As with the existing noise contour analysis, there are several such uses that have been attenuated.

Existing Land Use Analysis/ Future (Base Case, 2010) Noise Contours

This section discusses the land use types found within the future noise contours (2010) generated by aircraft utilizing Seattle-Tacoma International Airport, assuming that all land uses will remain the same and the third runway is operational. This is reflective of the forecast operations and aircraft types explained previously.

The future 2010 situation is represented by five contours, the DNL 55, 60, 65, 70 and 75 contours. The DNL 55 contour is the largest and contains approximately 24,818 acres. There are approximately 51,901 housing units representing approximately 121,356 persons within the contour.

The DNL 60 contour is the next largest and contains approximately12,166 acres. There are approximately 22,853 housing units representing approximately 53,695 persons within the contour.

The DNL 65 contour is the next largest and contains approximately 5,412 acres. There are approximately 6,212 housing units representing approximately 15,320 persons within the contour, representing approximately 1,833 acres of residential land use. There are approximately 141 acres of manufacturing development, approximately 135 acres of commercial development and approximately 818 acres of open space within the contour. In addition, there are approximately 200 acres of government/public land use. There are approximately14 acres of water with the remaining 2,265 acres are on airport property. There are approximately seventeen schools, fourteen churches, two libraries and two health care facilities within the contour. There are no historical sites listed on the National Register within the contour.

The DNL 70 is the next largest noise contour and contains approximately 2,259 acres. There are approximately 164 housing units representing approximately 356 persons within the contour, representing approximately 94 acres of residential land use. There are approximately 62 acres of manufacturing land use, approximately 20 acres of commercial land use and approximately 252 acres of open space. The remaining 1,788 acres remain on airport property. There are no historical sites listed on the National Register within the contour.

The DNL 75 is the smallest contour. It contains approximately 951 acres, including approximately 5 acres of manufacturing land use and 7 acres of open space. The remaining 939 acres are entirely on airport property.

The following table, entitled *EXISTING LAND USE WITHIN FUTURE NOISE CONTOURS, 2010* summarizes the above land use information.

Table D3
EXISTING LAND USE WITHIN FUTURE NOISE CONTOURS, 2010
Sea-Tac International Airport FAR Part 150 Study

Land Use	DNL 55 Contour		DNL 60 Contour		DNL 65 Contour		DNL 70 Contour		DNL 75 Contour	
Residential	NA	Ac	NA	Ac	1,833	Ac	94	Ac	0	Ac
People	121,356		53,695		15,320		356		0	
House. Units	51,901		22,853		6,212		164		0	
Churches	NA		NA		14		2		0	
Schools	NA		NA		17		3		0	
Libraries	NA		NA		2		0		0	
Health Care	NA		NA		2		0		0	
Com/Retail	NA	Ac	NA	Ac	135	Ac	20	Ac	0	Ac
Open Space	NA	Ac	NA	Ac	818	Ac	252	Ac	7	Ac
Govt./Public	NA	Ac	NA	Ac	200	Ac	13	Ac	0	Ac
Airport	NA	Ac	NA	Ac	2,265	Ac	1,788	Ac	939	Ac
Water	NA	Ac	NA	Ac	14	Ac	0	Ac	0	Ac
Manufacture	NA	Ac	NA	Ac	141	Ac	62	Ac	5	Ac
Total	**24,818**	**Ac**	**12,166**	**Ac**	**5,412**	**Ac**	**2,259**	**Ac**	**951**	**Ac**

The total figures for each contour are cumulative. The figures for the larger contours contain the area -within all smaller contours. Contour totals do not include rights-of-way.

SOURCE: Master Plan EIS, Seattle-Tacoma International Airport, BDC Analysis

Future Base Case (2010) Land Use Inconsistencies

Based on the Federal guidelines, the residential land uses, schools, churches, libraries and health care facilities within the 65 or greater DNL noise contours, that are not sound attenuated, are inconsistent with these guidelines.

F Noise Abatement Alternatives

Seattle-Tacoma International Airport

FAR Part 150 Study Update

Land Use Compatibility Alternatives

Introduction

The following land use-related issues were identified for consideration during the FAR Part 150 Study:

- Actions required by FAR Part 150 for review during a Part 150 Study
- Actions required for consideration by the Puget Sound Regional Council Resolution A-96-02 and Port Commission Resolution 3212
- Actions suggested by the public

While various actions were identified, the Land Use Subcommittee and the general public were asked to assist in identifying specific areas of concern that could be addressed in this Study. In general these areas of concern can be categorized as:

- Schools (being addressed in a separate process)
- Mobile Homes
- Approach Transition
- Multi-family Structures
- Public Buildings (including assisted living)

The following types of land use actions are suggested for consideration:

✓ **LAND USE CHANGES (Corrective Changes)** - Alternatives within this category are those options that involve potential changes to existing land use.

II.1 Acquisition of Property/Residences
II.2 Changes within Approach Transition Zone
II.3 Relocation of Mobile Home Parks

- ✓ **NOISE REMEDY CHANGES (Corrective Changes)** - Alternatives within this category are those options that involve changes to the noise remedy program.

  II.4 Change of Noise Remedy Boundary for Single-family Structures
  II.5 Sound Insulation of Multi-family Structures
  II.6 Sound Insulation of Public-Use Facilities

- ✓ **PLANNING/REGULATORY CHANGES (Preventive Changes)** - Alternatives within this category are those options that involve changes to the comprehensive plans, zoning ordinances, building codes, or other regulatory documents.

  II.7 Changes to Comprehensive Plans
  II.8 Changes to Zoning Ordinances
  II.9 Building Code Recommendations for uniformity
  II.10 Airport Overlay Zone—Not applicable when many jurisdictions are involved

Table E1 identifies the operational actions identified for review and shows which types of noise these actions will likely address. The actions are numbered in sequence for ease of reference and comparison.

As was discussed in preceding chapters, noise exposure contours were developed to examine the existing and anticipated future noise exposure conditions. In developing recommendations for land use compatibility, it is important to select a noise contour to enable identification of the land uses that might be subject to the actions noted above. The contours developed for this Study were for the years 1998 (existing) and 2004 (future).

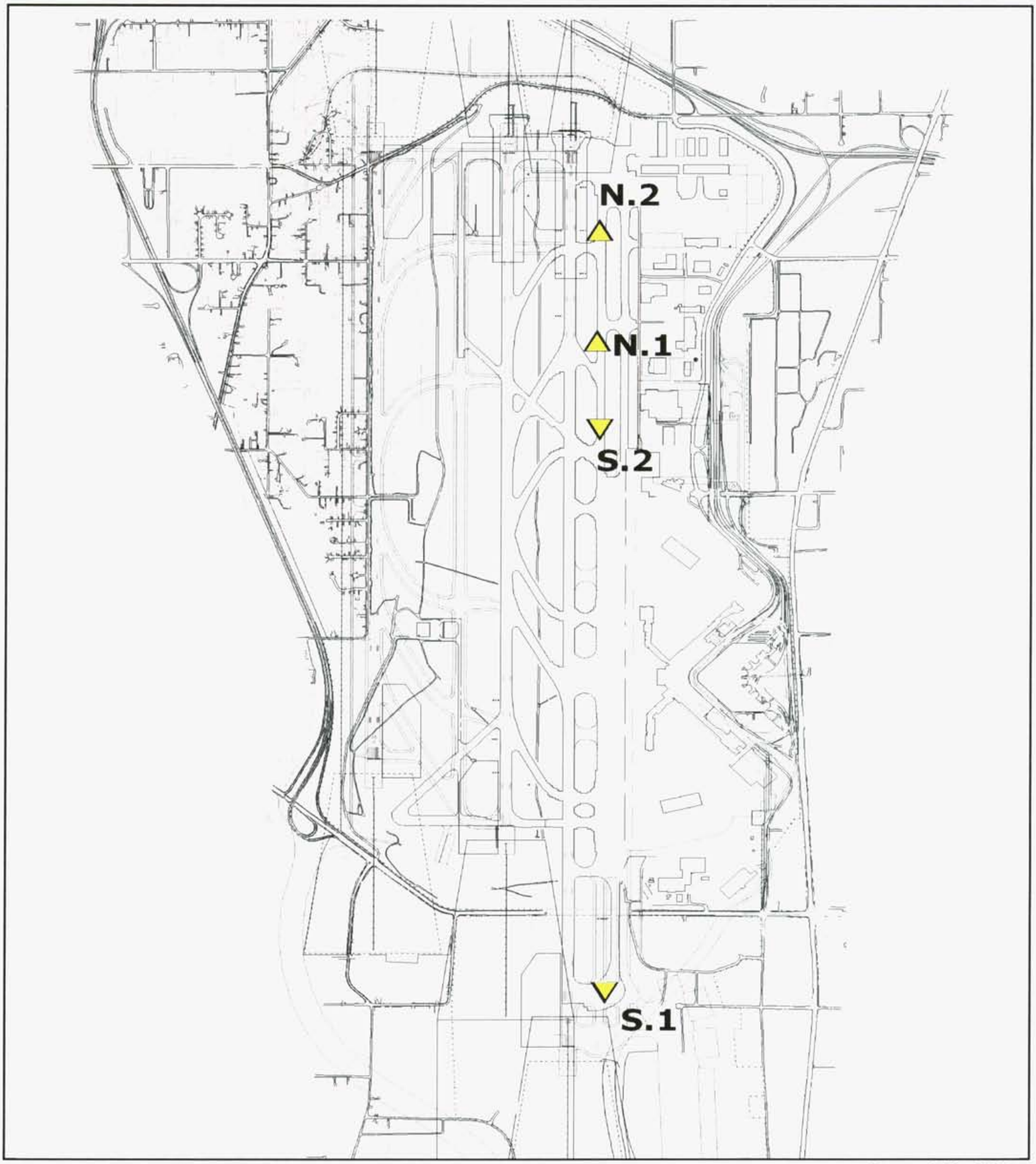
Evaluated Actions

1.1 Acquisition of Property/Residences

Areas defined by the Noise Remedy Boundary or the Approach Transition Zone (ATZ) may be eligible for acquisition of certain properties that are not compatible with either aircraft noise contours or airport development. Other properties may be eligible for acquisition within the Approach Transition Area or Zones north and south of the new runway as defined by the 1997 Final Supplemental EIS and as further defined in Action 1.2.

Figure E.2
Seattle-Tacoma International Airport Part 150 Noise Study
Existing Aircraft Maintenance Run-up Positions

Port of Seattle
Seattle-Tacoma International Airport



Prepared Mar-2000

In 1985, the Port completed an FAR Part 150 Study that defined the existing Noise Remedy Program boundaries. That program determined that the single-family residential areas closest to the Airport, guided by the 75 DNL noise exposure contour, should be acquired and the residents relocated. The land acquisition portion of that program has been completed and no additional structures are programmed for acquisition within the boundaries established for mitigation of single-family homes.

In 1997, the Federal Aviation Administration (FAA) approved an Environmental Impact Statement (EIS) for the Master Plan Update at Sea-Tac that included the construction of a new runway. The EIS and Supplemental EIS (SEIS) identified an area for potential mitigation off the ends of the new runway that would likely experience low flying aircraft. This mitigation identified residential properties that could be acquired in an area referred to as the Approach Transition Zone (ATZ). This mitigation alternative was forwarded to this Part 150 Study Update for further evaluation. This action is being evaluated as a separate Action (Action 1.2).

Table E1
Land Use Actions

Consider these Actions		Actions suggested by Public and PSRC	Noise Issue Addressed by Action						
			Ground noise	Departure flight	Approach Flight	Landing Roll	Training Flights	Maint. Activity	Ground Equip.
Corrective Land Use	Acquisition	Acquire single-family residences Acquire vacant residential land Acquire multi-family residential	◆	◆	◆	◆	◆	◆	
	Sound Insulation	Insulate single-family residential Insulate multi-family residential Insulate public buildings Insulate schools	◆	◆	◆	◆	◆	◆	
	Mobile Homes	Relocate mobile homes to another location	◆	◆	◆	◆	◆	◆	
	Approach Transition Area	None		◆	◆	◆	◆		
	Noise Remedy Program Boundaries	Expand the boundaries	◆	◆	◆	◆	◆	◆	◆
Preventive Land Use	Zoning	None	◆	◆	◆	◆	◆	◆	◆
	Building Code Modifications	None	◆	◆	◆	◆	◆	◆	◆
	Comprehensive Plans	None	◆	◆	◆	◆	◆		
	Noise Overlay Zone	None	◆	◆	◆	◆	◆	◆	◆

1.2 Changes in Approach Transition Zone (ATZ)

Areas north and south of the new 3rd Runway, which are eligible to be classified as ATZ, were evaluated for conversion to land uses compatible with airport operations. A recommendation will be made whether to proceed toward a property acquisition program and development of agreements between local jurisdictions, primarily the Cities of Burien and SeaTac, and the FAA regarding the future use(s) of properties if acquired.

The 1997 Final SEIS identified the Approach Transition Zones associated with the new runway as areas for possible acquisition as a mitigation measure. Specifically, the SEIS indicated:

> In recognition of the fact that the standard Runway Protection Zone (RPZ) dimensions do not always provide sufficient buffer to the satisfaction of nearby residents, the FAA has indicated that funding could be available to airport operators acquiring "up to 1,250 feet laterally from the runway centerline, and extending 5,000 feet beyond each end of the primary surface.[1/] Based on the configuration of current airport land, local streets, and residential development patterns, the approach and transitional area selected for use as a mitigation area includes the standard Runway Protection Zone and a rectangular extension of the RPZ outward another 2,500 feet.
>
> The acquisition of properties within the approach transitional areas north and south of the proposed runway may serve as a feasible and appropriate mitigation measure. This measure could involve the acquisition of all residential uses, and any vacant, residentially zoned properties, which cannot be compatibly zoned, within selected areas both to the north and the south of the new runway ends. Commercial land uses, which make up most of the eligible area to the south, need not be acquired and may remain in place on both runway ends.
>
> In the northern approach transitional area, 82 single-family residential parcels, 2 apartment buildings (with 28 units), and 2 mobile home parks, with 96 units, could be acquired. To the south, 71 single-family residential parcels and 6 apartment buildings (with 32 units) could be acquired.

This FAR Part 150 Study was tasked with addressing whether or not the residential uses within these areas should be purchased, and if so, on what criteria

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1/ FAA Memorandum, Action: Land Acquisition - eligible Runway Protection, Object Free Area and Approach and Transitional Zones, dated April 30, 1991.

should the purchase decision be based. Additional analysis may be needed before a final acquisition decision is made. Issues to be evaluated may include:

- Interests of residents living in this area;
- Tax base implications for local jurisdictions and utility districts;
- FAA funding;
- Land use and resale requirements:
- Comprehensive plan designation and land use compatibility;
- Safety considerations for aircraft and people on the ground; and
- Other issues that may be identified.

Other provisions of the Part 150 Study recommendations and the Airport's Noise Remedy Program may apply to residential and other noise-sensitive uses within these zones. Land use issues beyond noise compatibility must be addressed as part of any decision to acquire property in the ATZs.

Options considered for the ATZs include:

1. No acquisition in this area. Other Noise Remedy Program measures are applied as eligible and appropriate.

2. Acquisition of property developed with residential uses, subject to the following criteria:

    - Residents must experience low flying aircraft and a noise level in excess of an established criterion.
    - The municipalities in which the residences are located agree to work with the Port to achieve compatible use(s) for the acquired properties.
    - Only eligible properties whose owners desire to sell will be purchased.
    - Other Noise Remedy Program measures are applied as eligible and appropriate.

3. Acquisition of property developed with residential uses, subject to the following criteria:

    - Residents must experience low flying aircraft and a noise level in excess of an established criterion.

- The municipalities in which the residences are located agree to work with the Port to achieve compatible use(s) for the acquired properties.
- All eligible properties will be purchased, including the use of condemnation if necessary.
- Other Noise Remedy Program measures are applied as eligible and appropriate.

4. Acquisition of property developed with residential uses and the acquisition or rezoning of undeveloped property currently zoned for residential use.

   - Residents must experience low flying aircraft and a noise level in excess of an established criterion.
   - The municipalities in which the residences are located agree to work with the Port to achieve compatible use(s) for the acquired properties.
   - All eligible properties will be purchased, including the use of condemnation if necessary.
   - Other Noise Remedy Program measures are applied as eligible and appropriate.

1.3 Relocation of Mobile Homes/Parks

There are several mobile home parks, primarily south of the Airport, that are within the 1998 65 DNL or greater noise contour. Due to the nature of their construction, mobile homes (also referred to as manufactured homes) cannot be sound attenuated like other residential structures. Thus, the only method of ensuring land use compatibility is to remove such homes from within the noise contours. There are two different mobile home situations: mobile homes on single lots owned by the mobile homeowner and units on leased space that is part of a large mobile home park.

The homes on privately owned lots are currently being addressed through the purchase of an avigation easement from the owner, as part of the existing Noise Remedy Program. If these structures are within high enough noise levels (currently 75 DNL and above) they were purchased and the residents relocated. It is important to note that these situations are treated differently because the resident owns the property on which the mobile home resides. The FAA will only allow monies to be given to owners of the property. Homes that lease space from a large park, which is owned by a second party, must be addressed in a different manor and are more difficult to address. In this case, the residents own the individual units but do not own the land the mobile resides on.

Based on current information there are 17 parks within the 1998 noise contours (65 DNL and greater) representing about 1,057 spaces:

1. Sound Vista, 157 spaces,
2. Des Moines Estates, 51 spaces,
3. Firs Mobile Home Park, 71 spaces,
4. Pine Terrace Trailer Village, 101 spaces,
5. Puget View Mobile Home Estates, 51 spaces,
6. Town & Country Villa, 112 spaces,
7. Tyee Valley Mobile Manor, 44 spaces,
8. Secoma, 32 spaces,
9. Burien Gardens, 79 spaces,
10. Locust Trailer Court, 79 spaces,
11. Marine View Manor, 49 spaces,
12. Town and Country Lane, 32 spaces,
13. Angle Lake Mobile Home Park, 63 spaces,
14. New Alaska, 24 spaces,
15. Westhill, 63 spaces,
16. Unnamed, 21 spaces, and
17. Flora Vista, 28 spaces.

There are no known existing mobile home parks within the vicinity that can accommodate additional homes beyond normal attrition and there are no known plans to build any new parks. Surrounding jurisdictions have not made provisions for such parks in their comprehensive plans.

Questions to be answered in the formation of a program for mobile homes in a larger park include:

- ✓ Where and how can residents of existing parks be relocated?
- ✓ Will new parks have to be developed?
- ✓ Who will the developer be and what will become of the existing parks?
- ✓ Are existing homes to be relocated or new ones provided?
- ✓ What are the State regulations involved in relocating mobile homes or parks?
- ✓ What organization or entity will provide this assistance?
- ✓ What funding is available to assist in the relocation?

Other options for safe, sanitary, and comparable housing located outside the noise exposure contours must be considered. It appears that there are eight mobile home parks within the 1998 Baseline 70 DNL noise contour with approximately 427 mobile homes (this includes the two mobile home parks in the north ATZ). The parks are Town and Country Villa, Tyee Valley, Town and Country Lane, Des Moines Estates, Locust Trailer Court, Marine View Manor, Burien Gardens and Flora Vista. All but Des Moines Estates, Burien Gardens and Flora Vista are within the City of SeaTac. There are nine mobile home parks between the 1998 Baseline 65 and 70 DNL noise contours, containing approximately 683 mobile homes.

Options considered were:

1. No action
2. Acquisition of mobile home parks inside 70 DNL
3. Acquisition of mobile home parks inside 65 DNL

Based on the data collected, options 2 and 3 noted above were evaluated:

Option 2 – Acquisition of mobile home parks inside 70 DNL, which include:

1. Locust Trailer Court, 79 spaces in SeaTac
2. Marine View Manor, 49 spaces in SeaTac
3. Town and Country Lane, 32 spaces in SeaTac
4. Town & Country Villa, 112 spaces in SeaTac
5. Tyee Valley Mobile Manor, 44 spaces
6. Flora Vista, 28 spaces in Des Moines
7. Des Moines Estates, 51 spaces
8. Burien Gardens, 79 spaces in Burien

During the course of this Study, the owner of Marine View Manor closed the park. Since residents do not reside there now, this park will no longer be considered for any recommended programs. A total of 425 spaces would be affected. The cost to purchase and relocate the units is estimated at $8,600,000. The cost to purchase the parks is estimated to be approximately $30 to 35 million.

Option 3 – Acquisition of mobile homes inside 65 DNL, include those noted above in option 2 and:

1. Sound Vista, 157 spaces
2. Firs Mobile Home Park, 71 spaces
3. Pine Terrace Trailer Village, 101 spaces
4. Angle Lake Mobile Home Park, 63 spaces
5. Puget View Mobile Home Estates, 51 spaces
6. New Alaska, 24 spaces
7. Westhill, 63 spaces
8. Unnamed, 21 spaces, and
9. Secoma, 32 spaces

A total of 17 parks would be affected by the 65 DNL, with 1,057 spaces. The acquisition of all mobile home parks inside 65 DNL (including the eight parks called out in Option 2) is estimated at $64 to 74 million, while the cost to purchase and relocate the units is estimated at $20 million.

1.4 Change of Noise Remedy Boundary

The Port's existing Noise Remedy Program boundaries established the single-family homes that are eligible to receive funding for sound insulation purposes. The insulation boundaries were established based on the 65 and greater noise contour forecasts prepared in 1985 of conditions that were anticipated to exist in 2000. The goal of the sound insulation program is to significantly reduce noise levels within homes around the Airport, thereby reducing noise impacts to area residents and supporting the residential nature of the neighborhoods.

The current Noise Remedy Program boundary has been utilized for single-family dwelling programs since inception. Once the contours are completed for this Part 150 Study, a determination will be made as to whether or not the boundaries for single-family home sound insulation should be expanded. It appears that there are approximately 1,800 residences (single-family, multi-family, rental, and owner occupied) outside the existing Noise Remedy Boundary but within the 1998 Baseline 65 DNL and greater noise exposure contour. In addition, it appears that there will be only 100 residences (approximately) outside the current Noise Remedy Boundary and within the 65 DNL noise exposure contour based on the year 2004 noise exposure conditions.

The options considered were to expand the boundaries to include additional houses and apply existing guidelines, or leave as is.

Sound-insulation of the estimated 1,800 residential properties currently outside the Noise Remedy Program Boundaries that are affected by 65 DNL and greater sound levels is estimated to cost $54 million based on an estimated average cost of $30,000 per structure.

1.5 Insulation of Multi-Family Structures

Multi-family structures, defined as having more than four (4) dwelling units, are currently not eligible for sound attenuation under the existing Noise Remedy Program. One goal of this Part 150 Study was to examine the potential development of a program for sound attenuation treatment for these structures. A pilot program was undertaken a few years ago subsequent to the last FAR Part 150 Update to determine the feasibility of sound attenuating such structures.

There are several issues considered as part of the subcommittee discussions relating to multi-family structures. These issues include such things as owner-occupied versus renter-occupied structures, age of the structures and the priorities for addressing these properties. There are approximately 1,400 apartment units within the 70 DNL noise exposure contour and 1,600 within the 65 DNL contour.

It appears that there are approximately eight (8) owner-occupied complexes consisting of approximately 300 units within the 1998 Baseline 70 DNL contour. It appears that all of these may be within the 70 DNL noise exposure contour (approximately 300 units) with an additional three complexes (approximately 300 units) within the 65 DNL contour. The pilot project indicated an approximate cost of $22,000 per unit for the Sound Ridge complex, located south of the Airport.

1.6 Sound-Insulation of Public Buildings

This Action is the same as the previous Action except for public buildings. One of the first decisions to be made would be to develop a definition of public buildings and which ones would be eligible. The FAA normally identifies these as schools, churches, hospitals, and other publicly owned buildings specifically identified in the Noise Compatibility Program.

Following the last update to the Part 150 Study in 1993, the Port undertook several pilot projects for public use buildings to determine the feasibility of insulating these types of structures. These pilot programs included the sound-insulation of: the Highline Community College, Seatoma Convalescent Home, St. Philomena Church and School, and Boulevard Park Church. Insulation of Highline Community College is currently underway. The remaining pilot projects have been completed. Insulation of Seatoma Convalescent Home cost approximately $1.6 million, St. Philomena Church and School cost approximately $650,000 to attenuate, and Boulevard Park Church cost approximately $500,000 to attenuate.

Analysis of the 1998 noise exposure contours identified two additional health-care facilities (Monarch Care Center and Harmony Gardens) located within the 65 DNL contour, with portions of the Wesley Home Health Care Center located in the 65 DNL. In addition, there is one library and two fire stations (one in Des Moines and one in SeaTac) within the 65 DNL noise contour with the fire station in Des Moines being located within the 70 DNL contour. There are a total of 19 churches within the 65 or greater DNL noise contour (10 between the 65 and 70 DNL contours and nine within the 70 DNL contour, including the two that have been sound-insulated).

1.7 Changes to Comprehensive Plans

Community comprehensive plans are policy guides for future development of a particular jurisdiction. The plans provide guidance for future land use development and land use changes. These plans are particularly important in the area around the Airport that may experience noise levels that could impact certain types of residential structures or public buildings. It is desirable that each community develop its plans and policies to be compatible with aircraft noise levels. This approach will help ensure that compatible development occurs in the future, as it is much easier to avoid creation of land use incompatibilities than it is to remedy incompatibilities in the future.

All of the jurisdictions surrounding Sea-Tac have developed long-range comprehensive plans that reflect the requirements of the Growth Management Act. Each of these plans has been reviewed as to consistency and compatibility with the new noise exposure contours.

Future land use development should be compatible with noise exposure contours, and future land use recommendations should not only be compatible with aircraft operations but must also address community concerns and be compatible with non-airport related land use development. This Action is also related to the ATZ Action and the recommendations addressing that Action.

Generally, all comprehensive plans must conform to the Growth Management Act requirements addressing compatibility. In addition, this Action must be considered in conjunction with the ATZ recommendations.

1.8 Changes to Zoning Ordinances/Maps

A zoning ordinance has more regulatory authority than a comprehensive plan. All development within a zoning ordinance must be consistent with the zoning designation assigned for any specific property. In other words, residential development normally can take place only in a district zoned for residential uses. Thus, the zoning ordinance and map are just as important, if not more so, than a comprehensive plan. The zoning code also prescribes development standards that new development must meet.

The analysis for zoning ordinances is similar to the previous Action, changes to comprehensive plans.

Zoning maps should be amended and/or adopted, as necessary, in the future to reflect the recommendations of the community comprehensive plans and policies concerning development. This is most appropriate in the ATZs if a recommendation for land use conversion is approved that is not consistent with existing Noise Exposure Maps.

1.8 Building Code Uniformity

The purpose of the Action is to have uniform sound-attenuation requirements for all of the jurisdictions that are affected by the noise contours. This Action would ensure that all sound-attenuation will use similar construction and would provide for consistent requirements for building contractors. This Action would simplify supplier and contractor requirements throughout the area and make the entire process easier, quicker, and more consistent. The disadvantage of such uniformity is that it reduces the flexibility of contractors in complying with sound-attenuation standards.

Presently, King County, Des Moines, SeaTac, and Burien have sound-attenuation requirements included in their respective codes. However, they are not entirely consistent concerning construction requirements. In addition, they refer only to all buildings or structures placed in use for human occupancy. Sound-attenuation requirements should also apply to other noise-sensitive buildings or structures; such as rest homes, hospitals, libraries, churches, schools, and other public buildings.

Code requirements reduce inside noise levels as specified, but only for buildings placed in use for human occupancy. However, for ease of implementation, code requirements could be uniform and should be applied to all noise-sensitive uses. In the communities surrounding Sea-Tac, the sound-attenuation requirements of the building code are similar but not identical. Manufacturers of sound-insulation materials must make different versions to meet code requirements. Contractors have different installation requirements based on jurisdictions, which increases the cost of sound insulation.

It would be acceptable if the communities surrounding Sea-Tac, would amend the sound-attenuation requirements of the building code to provide for consistency of materials and their installation; provided that these amendments recognize that buildings close to Sea-Tac will require a greater degree of sound attenuation than those farther away.

The existing policy of the Port for sound-attenuation eligibility states that residences constructed after 1987 are not eligible for sound attenuation because that is the date the Noise Exposure Maps for the existing Noise Remedy Program were published. Following the publishing of these maps, building code requirements for sound attenuation were or should have been adopted.

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Aircraft and Airport Operations Noise-Abatement Alternatives

Introduction

The purpose of this chapter of the report is to document the review of various aircraft and airport operational noise-abatement actions feasible for Seattle-Tacoma International Airport (Sea-Tac). The study examined the full range of alternatives, based on the requirements of Federal Aviation Requirement (FAR) Part 150, as well as thorough input from the Puget Sound Regional Council, the Citizen Advisory Committee (CAC), Technical Advisory Committee (TAC), and the general public. At the first meeting of the Operations Sub-committee on October 21, 1998, the following airport and aircraft operational issues were identified for consideration during the FAR Part 150 Study:

- Actions required by FAR Part 150 for review during a Part 150 Study
- Actions required for consideration by the Puget Sound Regional Council (PSRC) Resolution A-96-02 and Port Commission Resolution 3212
- Actions suggested by the study committee and the public

Table E2 lists the actions suggested for study, which were grouped in the following categories:

1. Airport Plan Actions
2. Airport and Airspace Use Actions
3. Aircraft Operation Actions
4. Noise Program Management Actions

Each of these categories is discussed in the following sections. The Actions within each category are numbered for easy reference in regards to each other.

Airport Plan Actions

The following types of airport plan actions are suggested for consideration:

✓ **AIRPORT FACILITY CHANGES** - Alternatives within this category are those options that involve potential changes to the Airport facilities.

- Changes in runway location, length, or strength
- Displaced thresholds
- High-speed exit taxiways
- Reconfigured taxiway exits to reduce reverse thrust
- Relocated terminals

✓ **AIRCRAFT MAINTENANCE RUN-UPS** - Alternatives within this category are those options that involve mitigation measures related to aircraft engine maintenance run-ups.

- Establishing locations on Airport for run-ups and aircraft orientation
- Hush-house / ground run-up enclosure (GRE)
- Use of test stand noise suppressors and barriers

2.1 Changes in Runway Location, Length,, or Strength

Changes in the location of runways can affect the path of aircraft on arrival to and from an airport. Changes in runway location, length and strength can affect the frequency with which specific types of aircraft takeoff or land on a given runway. This type of action is typically considered only at airport sites where available lands could alter the runway layout in a manner that facilitates reduction in noise exposure.

Sea-Tac currently has two parallel runways as shown in Figure E1. Runway 16L/34R is the longer runway at 11,900 feet, while Runway 16R/34L is 9,425 feet long. Runway 16R/34L is located 800 feet west of Runway 16L/34R. The Master Plan Update calls for the development of a third parallel runway (16X/34X) to be located 2,500 feet west of Runway 16L/34R. Runway end 34R (the south end of the longer runway) will be extended 600 feet to 12,500 feet after 2010.

Due to area constraints, changes in runway location, length, or strength beyond that recommended by the Master Plan could have substantial effect on the surrounding area. Noise exposure changes could be significant, depending upon the change. Because of the developed, urban nature of the area surrounding Sea-Tac, no noise reduction alternatives are readily available in terms of runway location, length, and strength.

This alternative would not have material effects on aircraft noise, and, at this time, was not considered further in the Part 150 Study.

Table E2-- Evaluated Airport and Aircraft Actions

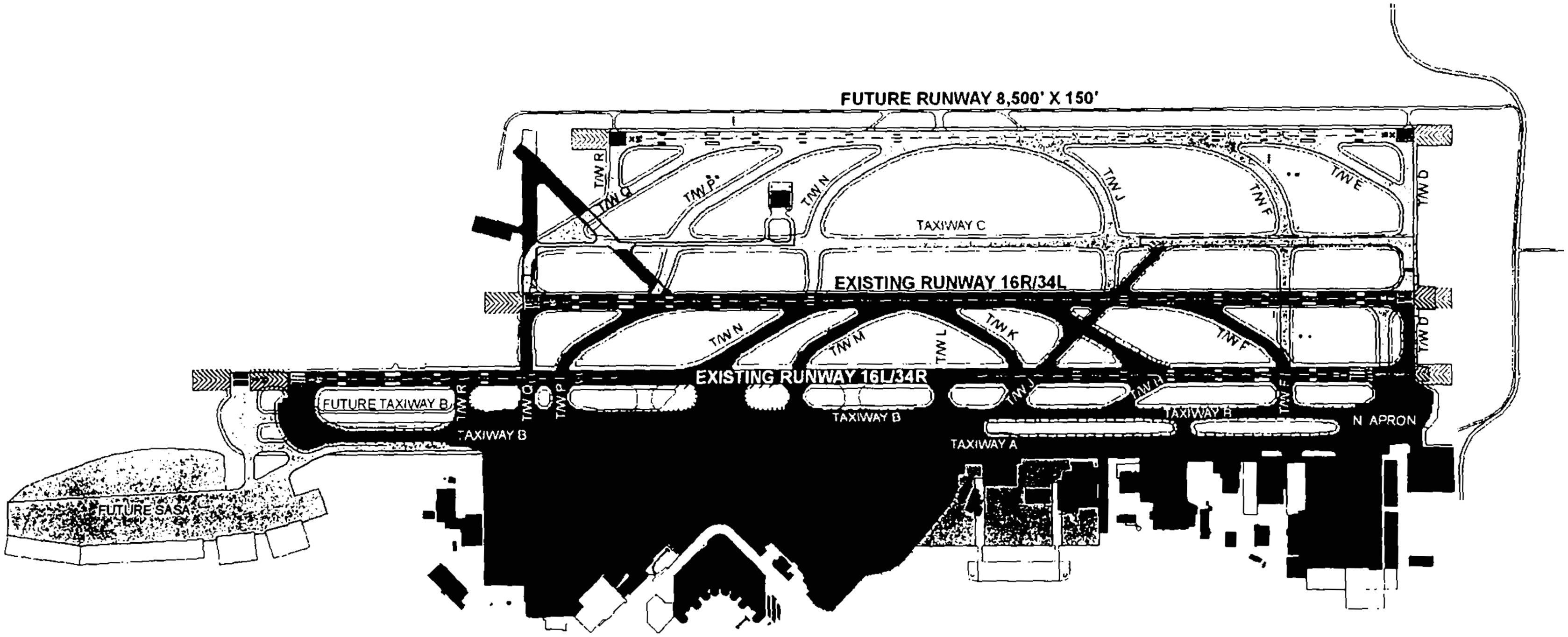
	Consider these Actions	Actions suggested by Public and PSRC	Noise Issue Addressed by Action						
			Ground noise	Departure flight	Approach Flight	Landing Roll	Training Flights	Maint. Activity	Ground Equip.
Airport Plan	Changes in Runway location, length or strength		◆	◆	◆	◆	◆		
	Displaced Thresholds		◆		◆		◆		
	High Speed Exit Taxiways	Examine locations of taxiway exits to reduce use of reverse thrust	◆			◆			
	Relocated Terminals		◆					◆	◆
	Isolating Maintenance Run-ups Use of Test Stand Noise Suppressors and Barriers	Barriers, Hush House/Ground Run-up Enclosure	◆					◆	◆
Airport and Airspace Use	Preferential or Rotational Runway Use	Increased north flow Increased south flow Balanced flow	◆	◆	◆	◆	◆		
	Preferential Flight Tracks Use of Modification to Approach and Departure Procedures	Monitor compliance with existing corridors; *Greater compliance with north flow departure* procedures; Develop "minimum" population flight tracks; Fly quiet		◆	◆		◆		
	Restrictions on Ground Movement of Aircraft		◆						
	Restrictions on Engine Run-ups or Use of Ground Equipment	Minimize the number of daytime run-ups	◆					◆	◆
	Limits on Number or Types of Operations or Types of Aircraft	Conduct a Part 161 Study; Minimize number of late night flights (1:30-5:30); Limit number of nighttime Stage 2 operations to aircraft <75,000 pounds	◆	◆	◆	◆	◆	◆	◆
	Use Restrictions		◆	◆	◆	◆	◆	◆	◆
	Raise Glide Slope Angle or Intercept				◆	◆			

TABLE E2 (continued)
Evaluated Airport and Aircraft Actions

	Consider these Actions	Actions suggested by Public and PSRC	Noise Issue Addressed by Action						
			Ground noise	Departure flight	Approach Flight	Landing Roll	Training Flights	Maint. Activity	Ground Equip.
Aircraft Operation	Power and Flap Management	Identify appropriate departure climb profile to reduce noise; Fly quiet		◆	◆		◆		
	Limited use of Reverse Thrust	Implement reverse thrust reduction procedures; Fly quiet				◆			
Noise Program Management	Noise-related Landing Fees			◆	◆	◆	◆		
	Noise Monitoring	New Noise Monitoring Stations		◆	◆		◆	◆	
	Establish Citizen Complaint Mechanism		◆	◆	◆	◆	◆	◆	◆
	Establish Community Participation Program		◆	◆	◆	◆	◆	◆	◆

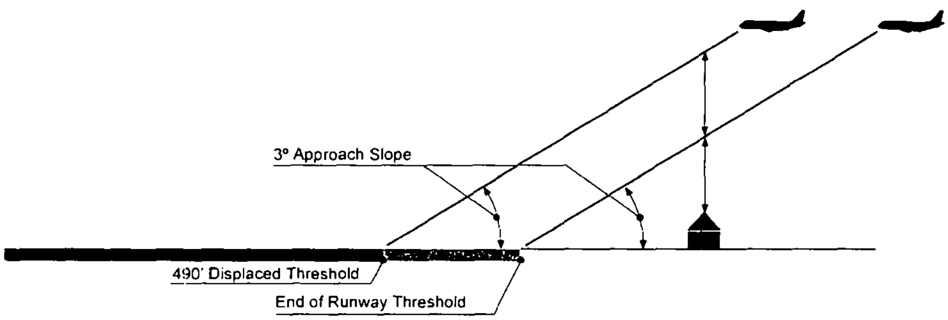
Figure E1 – Layout of Airport Facilities – Seattle-Tacoma International Airport

North ▶



2.2 Displaced Thresholds

A displaced threshold is a runway marking that identifies the runway end for landing aircraft, at a location that is not at the physical end of the runway. Because the landing threshold is farther down the runway than the actual runway end, aircraft on approach must maintain a higher altitude to reach the extended touchdown point than would otherwise be necessary.



The landing threshold of Runway 16L was displaced 490 feet. Thus, aircraft were not permitted to land on this runway at the physical end, but instead were required to land at least 490 feet south of the physical end. The Master Plan Update called for the removal of this displaced threshold on Runway 16L, which has since been put into practice.

Displacing a landing threshold would slightly increase the altitude that the landing aircraft is flying over residential areas immediately off the ends of the runway:

- ✓ For every 1,000 feet that the threshold is displaced, the aircraft would be 50 feet higher on approach;
- ✓ A 50-foot increase in altitude on approach reduces noise from each aircraft by 1 dBA;
- ✓ To achieve a sound-level reduction that is perceptible to the human ear, a sound-level reduction of 3 dBA or more would be required.

To achieve a perceptible sound-level reduction with a displaced threshold at Sea-Tac, a displacement of 3,000 feet or more would be required. Thus, Runway 16L/34R would effectively be shortened to 8,900 feet or less and Runway 16R/34L would effectively be shortened to 6,425 feet or less; and

A reduction in runway length of this magnitude would adversely affect the operating efficiency of the runways at Sea-Tac, and a less extensive displacement would provide no appreciable noise reduction benefit.

There was no further consideration of the displaced threshold alternative due to the high operational efficiency costs and low noise reduction potential.

2.3 High-Speed Exit Taxiways

High-speed exit taxiways connect a runway to an adjoining taxiway at an angle of about 30 degrees, enabling aircraft to exit the runway at higher than normal speeds, and therefore, spend less time in the landing roll. Other taxiways are at a 90-degree angle to the runway. High-speed exit taxiway use can reduce the amount of reverse thrust needed by landing aircraft and increase the capacity of the runway by reducing runway occupancy time. The ability to use high-speed taxiway exits depends on the runway length required by the landing aircraft. In general, larger/heavier aircraft require longer landing distances.

Figure E1 shows the locations of the runways, parallel taxiways, and runway exits at Sea-Tac. The following paragraphs describe the high-speed taxiways that are available for use at Sea-Tac:

- ✓ When landing to the south on Runway 16R, aircraft have access to three high-speed taxiway exits, while aircraft landing on Runway 16L have access to no high-speed taxiway exits due to the close proximity of the terminal area to this runway.
- ✓ During north flow, Runway 34L landings have access to three high-speed taxiway exits, while aircraft landing on Runway 34R do not have access to high-speed taxiway exits due to the close proximity of the terminal area to this runway.
- ✓ The most common high-speed taxiway exit used is Taxiway N as shown on Figure E1.

Based on a review of existing taxiway exits, no additional locations were identified that would materially reduce aircraft noise exposure at Sea-Tac.

2.4 Examine Placement of Taxiway Exits to Reduce Reverse Thrust

This action was suggested for consideration during the study. After review of its objective, to reduce the use of reverse thrust, it was found to be the same as the preceding action "High Speed Taxiway Exits," and was not considered further in the analysis.

2.5 Relocate Terminals

Neighborhoods located at a sideline to the runway system, often experience noise from aircraft movement in the vicinity of the passenger terminal as well as noise from vehicles servicing aircraft. Although no case exists of relocating an existing terminal due to noise, this action is often used when considering relocation of terminal facilities or the development of new terminal facilities.

As is shown in Figure E1, the passenger terminal and cargo facilities are located to the east of the runway system. Development of a terminal complex in the middle of the runway system is not feasible, because sufficient land does not exist. To provide the required land area, substantial acquisition and disruption would be required, making this action infeasible.

Noise associated with terminals is primarily a result of aircraft taxiing to and from the runways, engine start, auxiliary power units, and ground power equipment.

No alternatives were identified that would reasonably reduce aircraft noise exposure and thus, this action was not considered further in the Study. Abatement of noise from aircraft at the terminal and during taxiing is addressed in other methods of mitigation considered in this Study.

2.6 Maintenance Run-Ups and Establishing Locations for Run-Ups

Airlines must regularly conduct maintenance or repairs on aircraft systems and engines. For certain types of maintenance, aircraft must conduct an engine run-up in order to demonstrate that the aircraft's in-flight systems are working properly. A substantial amount of noise can be created when run-up testing occurs. As a result, airports often establish locations on the airfield for run-ups to minimize the noise impacts to nearby residences.

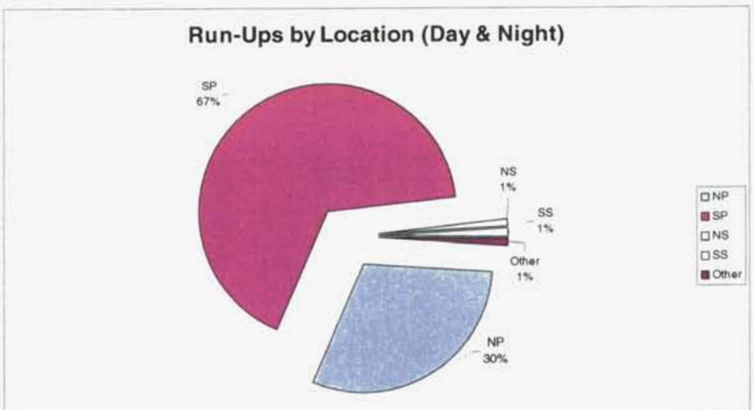
The current run-up regulations at Sea-Tac include:

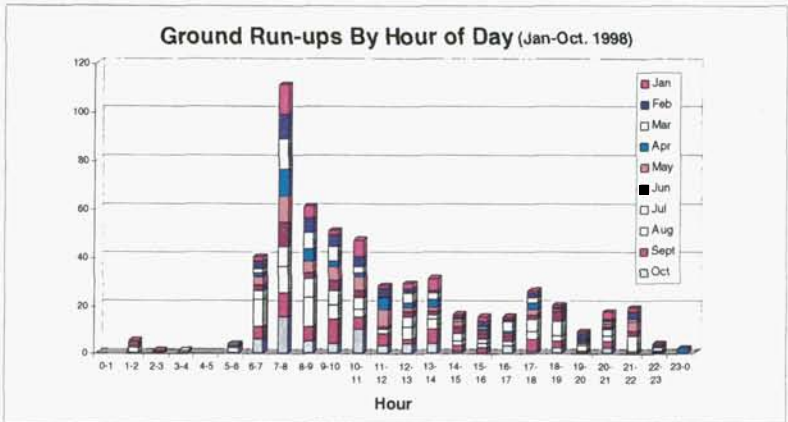
- ✓ Strict regulations concerning location of all aircraft run-ups and time limitations for those that occur during the nighttime hours.
- ✓ Four locations are used for engine run-ups (see Figure E2).
- ✓ Locations are based on wind conditions and airfield flow:
  - Winds from north (north flow): The North Sites (North Primary or Secondary) are utilized with the aircraft nose pointed to the north, so the noise from the rear of the engines is directed toward the airfield.
  - Winds from south (south flow): The South Sites (South Primary or Secondary) are utilized with the aircraft nose pointed to the south, so the noise from the rear of the engines is directed toward the airfield.

- ✓ There are two primary locations for run-ups, and two secondary locations. Secondary locations are used when another aircraft is utilizing the primary location (see Figure E2).
- ✓ The Port of Seattle has established time limits on aircraft engine run-ups that occur between the hours of 10 p.m. and 7 a.m.

PORT OF SEATTLE RULES AND REGULATIONS: NUMBER 4 SECTION 7 -- No aircraft engine run-ups shall be conducted between the hours of 2200 and 0700 except as follows: 1) Between 2200 and 0700 aircraft run-ups can be conducted above idle power for up to two minutes at the designated locations and with the prior approval of the Port of Seattle. 2) Aircraft that are regularly scheduled to depart between the hours of 0700 and 0830 shall be allowed to run-up as necessary between 0600 and 0700 if prior approval of the POS Airport Supervisor is obtained. No aircraft shall conduct engine run-ups for maintenance purposes except at locations specified by the Director.

The Port is responsible for enforcement of these regulations. Violations of these regulations can result in a fine. With the first violation, a letter is sent to the carrier notifying them of the offense and reminding the carrier of the rules and regulations surrounding engine run-ups. The fine for a second violation is $100, with fines doubling for each infraction thereafter.





Summary of Engine Run-up Activity. The Port of Seattle requires that airlines receive permission from the Port prior to conducting an engine run-up. Ground run-up activities between January and October 1998 were evaluated and are shown graphically above. This evaluation showed:

- ✓ 566 day and night (total) run-ups occurred during the 10 months: about 1.9 per day or 56.6 per month.
- ✓ No specific day of the week receives substantially more run-ups.
- ✓ Nearly 50 percent of total run-ups occur between 7 a.m.. and 11a.m.
- ✓ About 63 percent of total run-ups are conducted by Alaska and Horizon airlines.
- ✓ About 34 percent of total run-ups are conducted by MD80 aircraft, 18 percent by Dash-8, and 10 percent by 737-300.
- ✓ About 30 percent of total run-ups occur at the North Primary, while 67 percent occur at the South Primary reflecting the proportion of north flow and south flow runway use.
- ✓ 56 run-ups occurred at night (10 p.m. to 7 a.m.) – about 1 every 5th night or 5.6 per month.
- ✓ About 70 percent of nighttime run-ups occur between 6 a.m. and 7 a.m.
- ✓ About 37 percent of nighttime run-ups are conducted by Alaska, 25 percent by United, and 10 percent by Horizon airlines.
- ✓ About 27 percent occur at night at the North Primary and 67 percent at the South Primary.
- ✓ During the study period, five violations of the run-up procedures occurred: four of these violations occurred at night.

Noise Complaints. One of the noise-complaint categories recorded by the Port includes noise perceived to be from an aircraft engine run-up. Complaints from run-up noise averages 12 calls per month (representing 5 percent of the total noise complaints).

Noise Characteristics. Noise from aircraft engine run-ups has varying characteristics depending upon the type of run-up procedure, the power level, the engine type, and the orientation of the aircraft. Full-power run-ups present the greatest potential for noise impacts. The characteristics of engine run-up noise are summarized below:

- ✓ Varying duration noise events that can last many minutes.
- ✓ Quick onset and drop-off of the noise.
- ✓ Dominant low-frequency characteristics that attenuate slowly.
- ✓ Magnitude of the noise is similar to departure ground roll.
- ✓ Some engine run-ups include a number of cycles at full power.
- ✓ Greatest potential for impact is sideline to the Airport.

Run-up Noise Exposure Contours. Run-up noise exposure contours were generated for the B737-200 (hush-kitted) aircraft. Figure E3 presents the Lmax 65 dBA contour for a B737-200 engine run-up at full power. This engine run-up is at the North Primary run-up location, with the aircraft facing north and also at the South Primary run-up location, with the aircraft facing south. The results of the analysis show that the noise levels from a full power run-up cover a rather large area.

The existing regulation limits the duration for nighttime run-ups to two minutes between the hours of 10 PM and 7 AM. Aircraft can conduct run-ups at idle power at any time with no time limit restrictions. However, aircraft scheduled to depart prior to 8:30 AM may run-up for as long as is necessary after 6 AM, as long as the Airport Supervisor has approved the run-up.

Violations of this rule; that is run-ups lasting longer than two minutes during the restricted period, run-ups taking place in locations other than those approved in the rules and regulations of the Airport, or conducted between 6 and 7 AM without supervisory approval are subject to letters of reprimand and fines – a letter for the first violation and $100.00 fine for the second. Fines double for every violation after the second.

During the course of the Study, discussion centered on the hours of the restriction and the amount of the fines. Although citizens wished to have the restricted period extended later in the morning, a review of operations indicated that an extension of the timeframe for run-ups limited to two minutes could inhibit morning departures. The majority of the run-ups at the Airport occur between the hours of 6 AM and 9 AM for morning departures. On weekend mornings, however, analysis showed that scheduled maintenance run-ups were occurring in the early morning hours immediately following the 7 AM curfew.

Citizens expressed a desire to have these discretionary run-ups occur later in the day, as they tend to be at high power settings and for long periods of time. The citizens felt that since these were scheduled run-ups, typically associated with heavy maintenance and not a scheduled departure, airlines could adjust their maintenance schedule.

The size of the fines was deemed to be too low, by the citizens, to have any significant effect on airline behavior. Citizens expressed a strong desire to increase the fine for violations to an amount that was large enough to serve as a deterrent to violation of the rules. Furthermore, no increased fine for violations of the two-minute run-up rule were contemplated until the new noise monitoring system is fully tested and can be relied upon to determine whether a violation has occurred.

As a result of this analysis and discussion, the Citizens and Technical Advisory Committee (CAC/TAC) approved the following recommendation with regard to run-ups.

- Extend the two minute run-up restriction by one hour from 7 AM to 8 AM on weekends
- Increase fines for run-up violations at night from $100 to $1,000 for the first violation, to $2,000 for the second violation and $4,000 for the third violation. For violations thereafter, there would be a doubling for every additional violation during a twelve month period.
- This fine would be implemented once the new noise monitoring system has been fully installed and tested for reliability.
- Prohibit discretionary run-ups before 9 AM on weekends with the term "discretionary" to be defined by a public committee.

After a review and discussion of the CAC/TAC run-up recommendation, Port staff agreed with the overall approach of the CAC/TAC recommendation except fro the portion of the recommendation that a public committee would define "discretionary" run-ups. Staff did not believe that a public committee would have the technical expertise to determine which run-ups were necessary and which ones were discretionary. Staff then proceeded to discuss the other provisions in more detail with the airlines most likely to be affected by this regulation change if adopted.

During the fall of 2000, Airport staff met with representatives of both Alaska Airlines (also representing Horizon Airlines) and Northwest Airlines. Together these airlines conduct over 70% of run-ups (both scheduled and non-scheduled) at Sea-Tac. At this meeting the airlines expressed some concern over the current 2-minute restriction and suggested an alternative regulation based on an existing rule at Minneapolis-St. Paul International Airport (MSP), where Northwest Airlines operaties a major maintenance base. This rule fully prohibits nighttime run-ups between the hours of midnight and 5 AM but allows more flexibility in the shoulder hours for run-ups if needed for a departure. Run-ups between 10:30 PM and midnight and 5 AM and 6 AM are only permitted if a scheduled departure time cannot be met without the run-up.

During these meetings, the airlines indicated a preference for this type of regulation over both the existing Sea-Tac rule and the rule proposed by the CAC/TAC as there would be no time limits on run-ups if needed for a departure within a certain time window. The MSP rule, although more restrictive in the late night hours, offers more flexibility during the shoulder periods (which are more crucial to the airlines to meet scheduled operations). The airline representatives felt that they could avoid run-ups during the middle of the night altogether if they could conduct the maintenance run-ups necessary for scheduled departures in the shoulder hours.

Airport staff, upon consideration of the airlines' position, agreed that the MSP model might be preferable in that it offered a complete prohibition on run-ups during the late night hours – something the community representatives favored, while providing the airlines with the ability to insure that their departure schedules could be met.

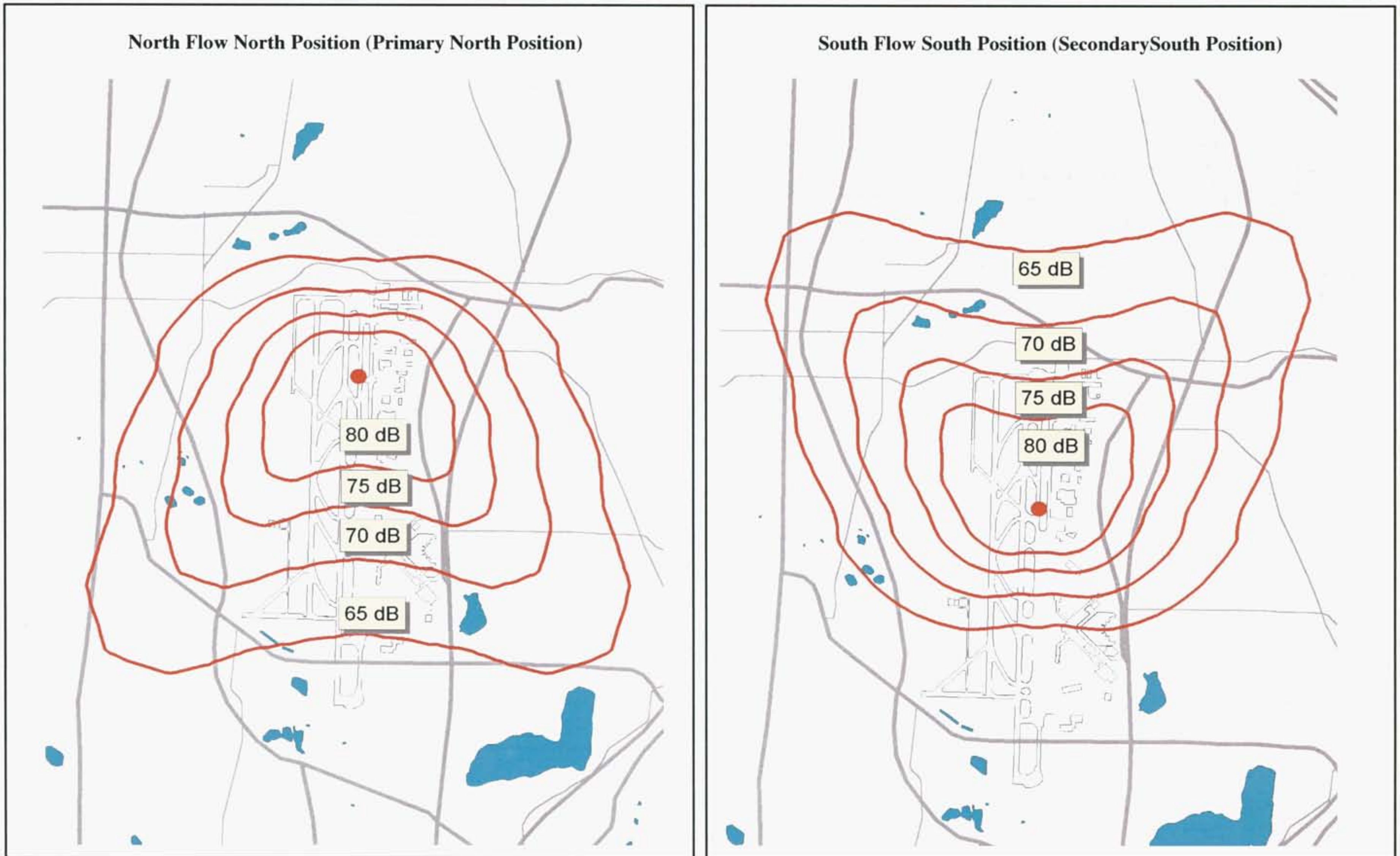
Figure E.3

Seattle Tacoma International Airport Part 150 Noise Study

Example of Noise Levels for Aircraft Maintenance Run-ups

A-weighted -- Full Power Run-up of B747-400

Port of Seattle
Seattle-Tacoma International Airport



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As is shown on Figure E3, the sizes of the contours for the lower power level engine run-up are significantly smaller than for those at full power. Similarly, the run-up noise levels for new generation Stage 3 aircraft are also much smaller.

Alternatives: The following noise-reduction alternatives were examined with regard to engine run-ups:

1. Identify alternative locations for engine run-ups:

   The existing engine run-up positions are the most effective locations for minimizing the noise levels in the communities surrounding the Airport. However, use of the secondary location for wide-body aircraft for the south position was identified as a possible alternative. For aircraft with large, high bypass ratio-engines (such as the B-747-400), there is a higher noise component from the front of the engine compared to aircraft with the smaller, low bypass ratio-engines. Because this secondary location is more toward the center of the Airport, using it for these larger aircraft in the south location would reduce noise impacts to the community. For narrow-body aircraft, the current primary location is preferred, because greater impacts are produced from the rear of the engine. Figure E4 presents the engine run-up noise levels for a B-747-400 aircraft at the south run-up position (secondary position) and for the north run-up (primary position).

2. Identify alternative positions/orientations of the aircraft at the engine run-up locations:

   Existing orientations provide the most effective noise reduction. In addition to the secondary locations noted above, consideration was given to alternative aircraft orientations to minimize noise exposure. However, because the current orientations provide for the fewest impacts to the community, no changes are examined further in this analysis.

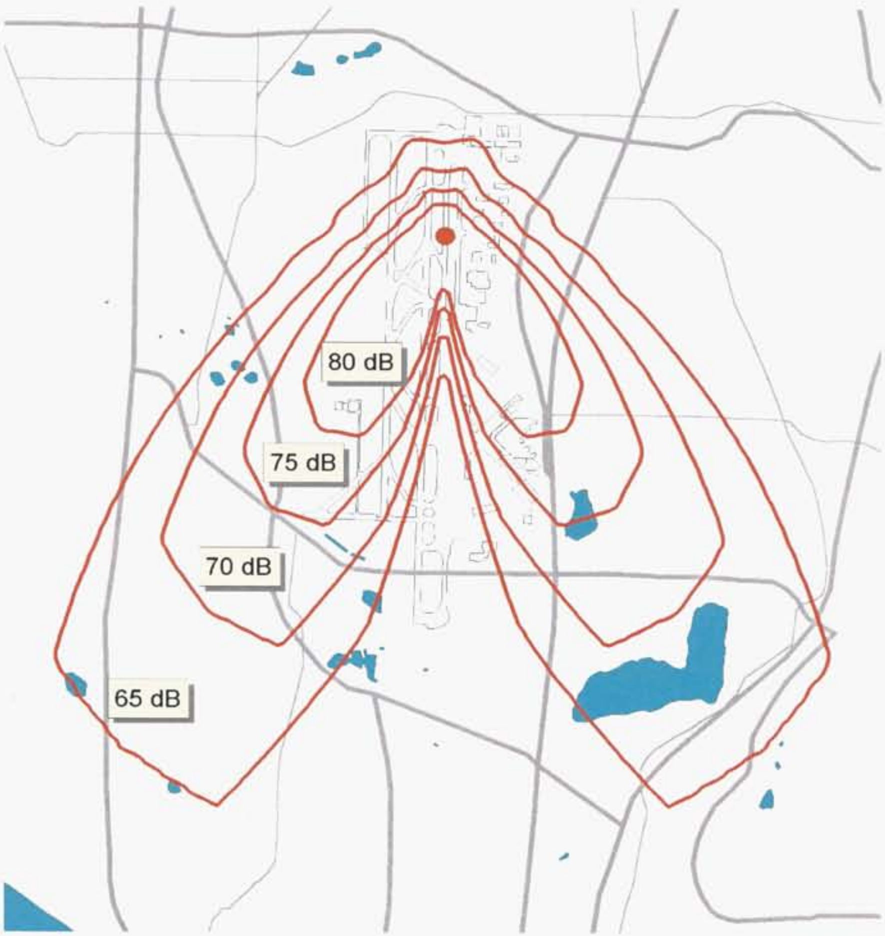
3. Enhanced compliance monitoring to evaluate engine run-up duration:

   The existing nighttime procedures allow for idle power engine run-ups to occur for a duration up to two minutes between 10 p.m. and 7 a.m. The new noise-monitoring system being installed in 2000 will enable the Port to monitor engine run-up noise more effectively. After a one-year test to ensure that the noise-monitoring system is functioning properly, the Port could institute fines for operators by strictly enforcing the current rules and regulations limiting engine tests to no longer than two minutes between 10 p.m. and 7:00 a.m.

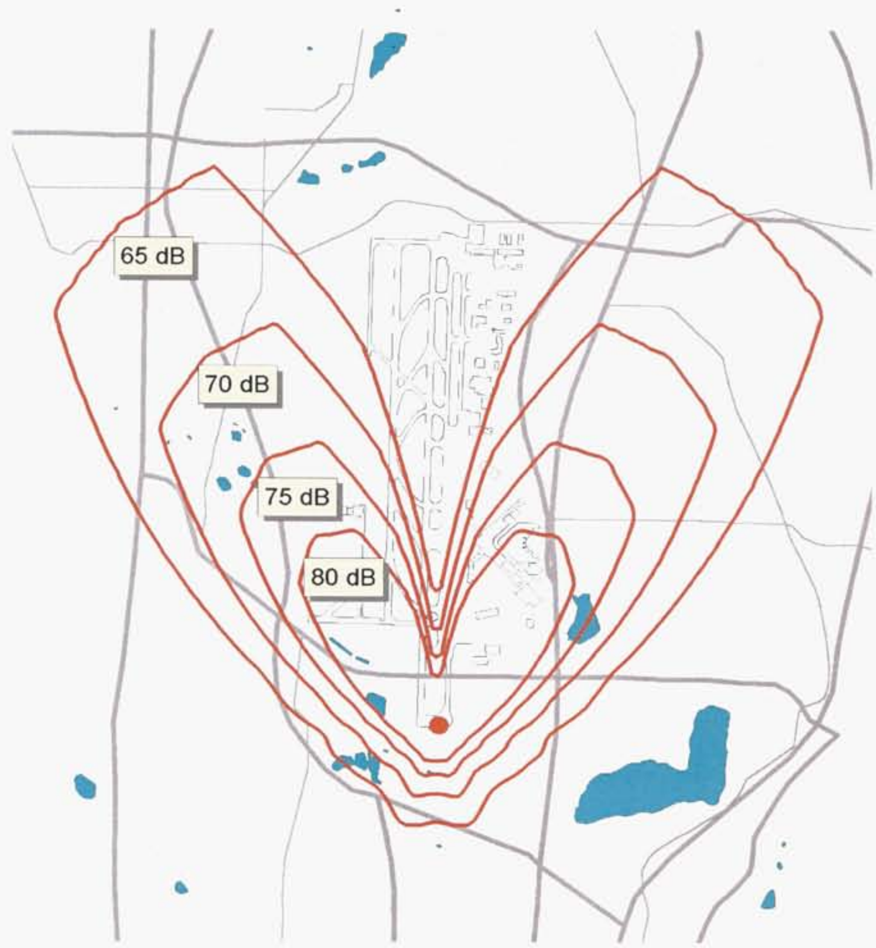
Figure E.4
Seattle Tacoma International Airport Part 150 Noise Study
Example of Noise Levels for Aircraft Maintenance Run-ups
A-weighted -- Full Power Run-up of B737-200

Port of Seattle
Seattle-Tacoma International Airport

North Flow North Position (Primary)



South Flow South Position (Primary)



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4. Modify run-up regulations to reflect revised locations/orientations for engine run-ups and revise fine system:

   Based on Items 1 and 2 above, the Port could revise the Airport policies and procedures reflecting the engine run-up program. This revision would involve formal notification to the Airport tenants and inclusion of the revised procedures in the official rules and regulations documentation of the Airport. In addition to the locations and aircraft orientations, the rules could be revised to include a revised fine schedule for violations. The proposed fine schedule would be increased from $100 to $1,000 per violation. After three occurrences per calendar year, the fine would be increased to $5,000. Upon acceptance of the enhanced monitoring system, a fine for violation of the two-minute engine run-up duration could also be implemented. A one-year test period would be recommended to ensure that the monitoring system can discern the duration at all locations, and that administrative procedures are in effect to levy such a fine. A fine of $500 per violation is a suggestion.

5. Expand restricted hours for weekend run-ups:

   This alternative proposes that the restricted hours for run-ups be extended by an hour, from 7 a.m. to 8 a.m. on Saturdays and Sundays. All other aspects of the regulation would remain the same.

6. Construct a Ground Run-up Enclosure (GRE), also called a Hush House – (see Action 2.7 below).

2.7 Construction of a Ground Run-Up Enclosure (GRE) – Hush-House

For certain types of maintenance, the aircraft must conduct an engine run-up in order to demonstrate that the aircraft's in-flight systems are working properly. A Ground Run-up Enclosure (GRE), or hush-house is an enclosed structure in which run-ups may be conducted. The structure is designed to deflect engine blast upward and absorb sound. Chicago O'Hare International Airport is the only airport in the United States that has developed a GRE. Their GRE cost $3 million and was built to accommodate the large B-747-400.

Structures on an airport, such as a hush-house, must conform to FAR Part 77 requirements. FAR Part 77 identifies imaginary surfaces on and around an airport that, if penetrated, can be a hazard or obstruction to the safe operation of aircraft both in the air and on the ground. A Part 77 analysis at Sea-Tac indicates that there is little available space on the existing airfield that would meet safety standards and accommodate a hush house.

Other issues to be considered include:

- A GRE is a three-sided enclosure, with no roof, to which aircraft taxi for the purpose of conducting an engine run-up. The size of the facility is dependent upon the type of aircraft that would use the facility. An example of the relationship of cost and size of a GRE facility is presented below.

Aircraft	Percent of Run-ups That Could Use Facility of This S	Cost ($ million)	Land Site (sq. ft.)
B-747	100%	3	100,000
B-757	90%	2.1	60,000
B-737/MD80	85%	2.0	50,000

- The SEL footprint for a B737-200 aircraft (hush-kitted) engine run-up without a GRE is shown in Figure E5 along with the footprint of the same aircraft inside a GRE. The GRE could potentially reduce noise levels by 15 dBA.
- No locations exist at Sea-Tac that would eliminate all engine run-up noise from every area adjacent the Airport. However, several locations could be used to minimize effects.
- A GRE cannot be used in all wind conditions. Assuming a south orientation of the GRE, the facility could potentially be used about 85 percent of the time.
- Given the meteorological conditions that exist at Sea-Tac, there are times that a GRE is less effective. This is typically during inversions, which at night occurs about 5 percent of the time. Under these conditions, the benefits of a GRE are significantly reduced.

At Sea-Tac, consideration was given to the following locations for a GRE:

✓ Construction of a GRE on the South Side of the Airport in the South Aviation Support Area (SASA).

✓ Construction of a GRE on the North Side of the Airport in the cargo area.

✓ Construction of a GRE west of the new parallel runway.

Based on the limited availability of land to construct a GRE, more analysis will be required to determine a suitable location and to determine the effects of the weather conditions in the Pacific Northwest on the potential noise reduction benefits.

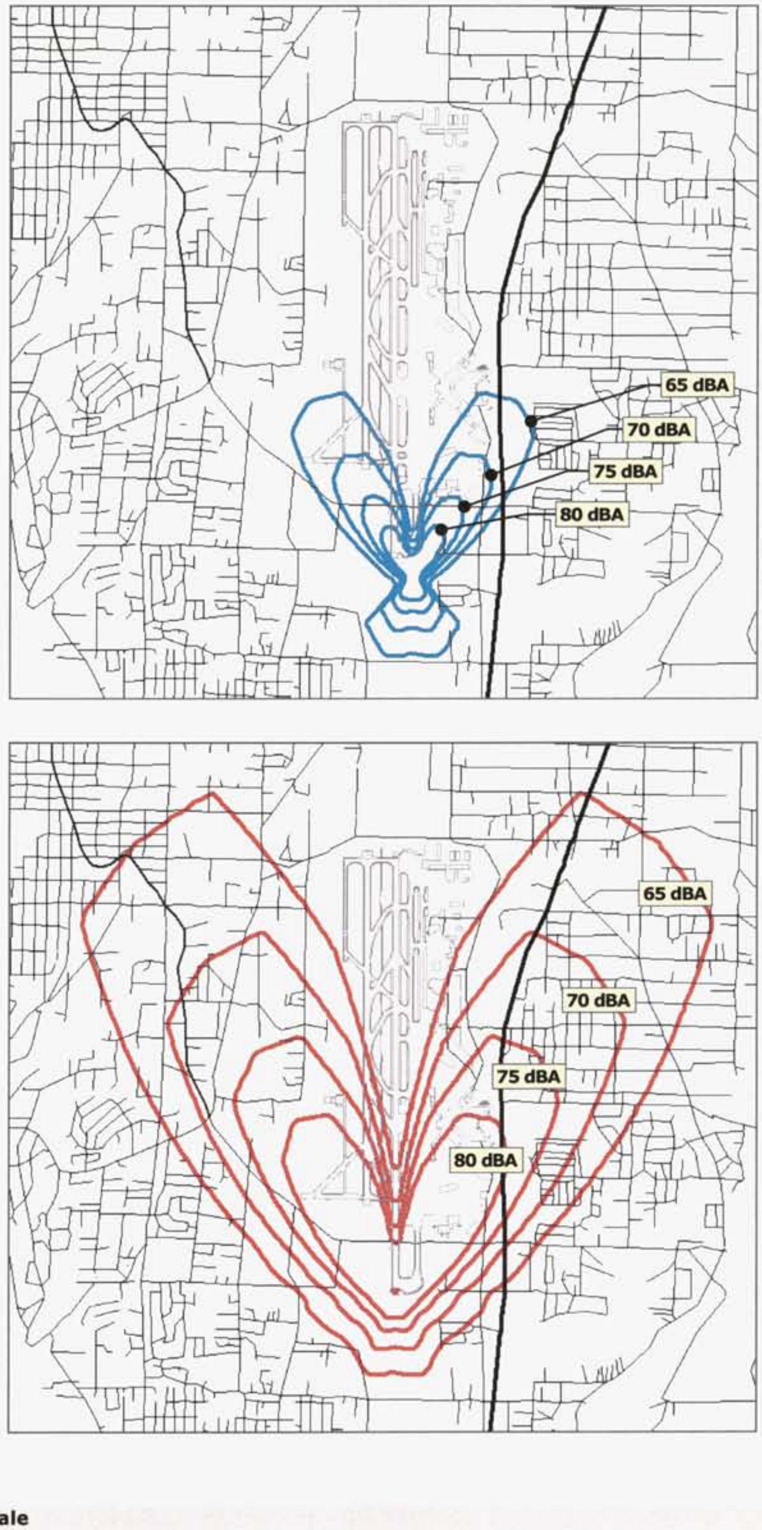


Figure E5 **Combined 737-200 Run-up Noise Contours With (blue) and Without (red) GRE**

2.8 Use of Noise Barriers

A noise barrier is an obstruction to the path of the sound transmission. Barriers include: walls (as are often used along highways), earth mounds (or berms), or placement of buildings and landscaping. In the case of barriers, neighbors are shielded from the noise source as long as the barrier is solid and sufficiently breaks the line-of-sight from the noise source to the listener. Barriers can potentially provide noise reduction benefits for communities near an airport from aircraft ground operations. Once an aircraft becomes airborne, barriers have no further effect.

Noise barriers around airports are not frequently constructed, because they have marginal benefit in reducing noise from flight operations. In addition, because of terrain changes, space limitations, and FAA safety restrictions, walls and barriers have not been constructed at Sea-Tac for noise mitigation. Existing buildings on the Airport and adjacent land provide some limited shielding from noise of aircraft operating on the airfield

Noise sources addressed in this alternative are generally stationary and ground based, meaning they occur when the aircraft is at or near its parking location. These noise sources include stationary ground noise sources both auxiliary and ground power, taxi, and idle noise (engine start-up and initial taxiing to and from its parking location).

Stationary Ground Noise Sources

Background: In flight and during taxiing, the aircraft's engines power the aircraft's electrical demands and HVAC (heating, ventilation and air conditioning) needs. The aircraft's internal battery system is designed to be used for emergency needs or limited use when on the ground. Therefore, when an aircraft is parked at a gate with the engines off, alternative sources of power are necessary for one or more of the following functions:

- Electrical power (115/200v AC at 400 Hz and 28v DC)
- Pre-conditioned air for aircraft ventilation
- Air compression for engine starts

Various methods for providing necessary alternative power range from auxiliary power units located on the aircraft to fixed power sources located at the gates:

- Auxiliary Power Units (APU) -- A small jet engine located on the aircraft that provides electrical power, air compression to operate the aircraft HVAC system, and air compression for engine starts. Nearly all modern commercial jet aircraft have APUs. These auxiliary power jet engines are located in the tail of the aircraft, or in the case of the 727/MD80, behind the right wing.

- Ground Power Units (GPU) -- GPUs are portable carts that provide electrical power, compressed air, or both. Electrical carts are portable diesel generators that provide electrical power. Engine start carts are mini jet engines that provide compressed air for engine starts. Other systems are a combination of air starting units and electric power. GPUs are most commonly used by older aircraft, aircraft requiring power for an extended period of time, and cargo operators.
- Fixed Power System -- Fixed power systems are attached to the jetway. Most fixed power systems supply only electrical power, but new systems now supply preconditioned air and compressed air as well.

Passenger jet aircraft generally utilize auxiliary electrical power when preparing for departure, loading and unloading passengers, or when servicing the aircraft for cleaning and maintenance. Cargo aircraft occasionally utilize auxiliary power when loading and unloading cargo and when performing aircraft maintenance. In addition, passenger jet aircraft may at times require the operation of the aircraft HVAC system or preconditioned air to maintain a comfortable cabin environment when loading and unloading passengers at the gate.

Gates and aircraft parking areas at Sea-Tac have a variety of auxiliary power facilities depending upon the airline and the type of aircraft operation. The current facilities at Sea-Tac are described below:

- Major Airlines Gates. Aircraft parked at these gates generally operate on APUs for engine starts or during short turnarounds. Some do not have preconditioned air, so APUs are needed when aircraft air conditioning is necessary. Future gates are likely to be electrified and have preconditioned air.
- International Gates (S gates 12 and 13). International gates are used by multiple carriers, unlike most domestic-service gates. As there is no fixed power available at these gates, aircraft operate APUs for electricity, ventilation, and engine starts.
- Cargo Aircraft Parking Locations. Cargo carriers do not have any fixed power at their parking locations. Electrical power is supplied by either APU or GPU and is generally required only during cargo loading and unloading.
- Commuter Aircraft Parking Locations. Commuter airlines do not have fixed power, because they do not park at a gate, but are located in a confined area, where fixed power is not practical. The aircraft's internal battery, external battery carts, or GPU supplies electrical power. These aircraft do not have APUs.

Noise Characteristics: An APU is a small jet engine, so the noise it generates has similar characteristics to a jet aircraft under idle power. APU noise characteristics are summarized below:

- Magnitude significantly less than that from other aircraft operations.
- Steady-state or constant noise level.
- There is a cumulative effect of multiple APU units.
- Noise levels are directed toward the back of the aircraft.
- Frequency characteristics similar to jet engine idle combustor noise.
- Noise is potentially more noticeable during nighttime hours when other aircraft and non-aircraft noise levels are lowest.

Noise Data: Analysis of the noise data from APUs identified important characteristics for evaluating its contribution to overall ground noise around Sea-Tac. The results of the analysis are summarized in the following paragraphs.

Noise levels generated by APUs were determined from measurements of a variety of aircraft parked at gates at Sea-Tac. Measurement results show a range in noise levels generated by each type of aircraft APU, and also in the direction of the noise. At a reference distance of 100 feet, noise levels from the APU range from 81 to 90 dBA.

Because APU air intakes have a long inlet manifold, there is very little noise emitted toward the front of the aircraft. All of the noise comes from the jet exhaust that is directed toward the rear of the aircraft. For tail-mounted APUs (B737, B747, B757, B767, Airbus), the noise levels are greatest at an angle of approximately 135/225 degrees back from the nose of the plane. The noise levels directly behind these aircraft are slightly quieter. Some aircraft have the APU mounted on the right rear side of the fuselage (B727/MD80). For these aircraft, noise levels are greatest toward the rear on the right side of the aircraft, as the fuselage shields noise on the left side.

Table E3 presents APU noise from the direction that generates the highest noise level at a distance of 100 feet from the APU exhaust. (At a distance of 250 feet these noise levels would be approximately 8 dBA less.)

TABLE E3
APU Noise Referenced to 100 Feet

Aircraft Type	Maximum Noise Level (dBA)
B727-200	90 dBA
B737-200	90 dBA
B737-400	85 dBA
B747-400	88 dBA
B757-200	87 dBA
DC-9	90 dBA
MD83	88 dBA
A320	81 dBA
L1011	81 dBA

Noise measurements associated with a number of GPUs were also conducted. All systems were diesel generators operating at commuter, air carrier, and cargo aircraft parking locations. These measurements show that GPUs generate less noise than APUs; however, their noise levels are substantial enough to be important if several units are in operation at the same time. GPU noise levels ranged from 76 to 82 dBA at a distance of 100 feet.

Combined Effects of Multiple APU Operations: Figure E6 presents the noise contour from multiple APU operating at the north cargo area. The exhibit presents the Lmax 65 and 75 dBC noise contour from a mix of three (3) B727, one (1) DC8, and one (1) DC9 aircraft. Although noise from one APU is not considered significant, the operation of many APUs can increase the potential for noise impacts. These aircraft are commonly operating APUs in the late evening hours.

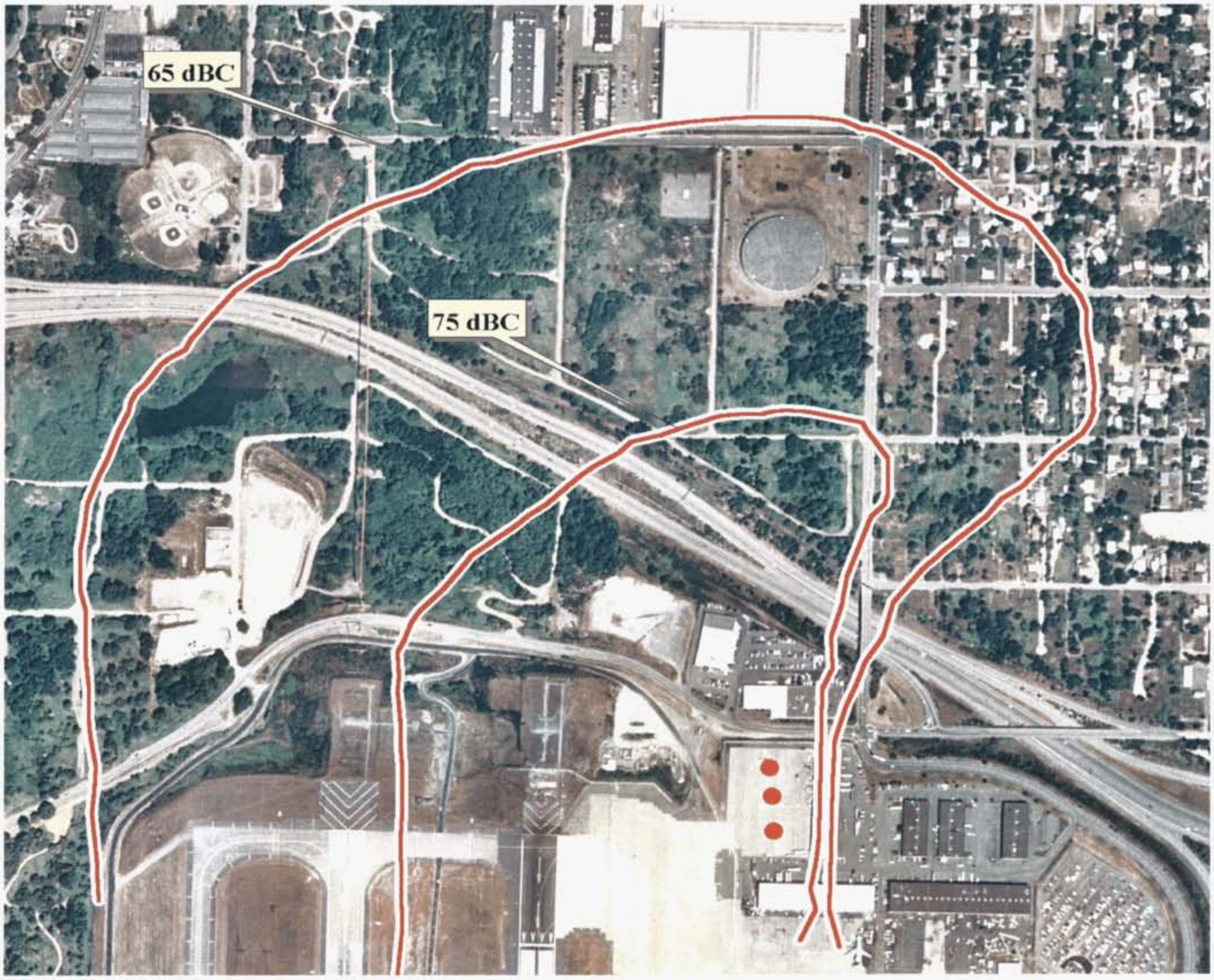
APU noise from different types of aircraft operating at Sea-Tac was determined from actual noise measurements completed during the Sea-Tac Ground Noise Study completed in 1995. Those measurements determined that noise level, directional and frequency characteristics of APUs. A noise model based on standard point source propagation algorithms was then used to predict the noise levels at different locations for multiple APU operations. This model could then generate noise contours from the different APU operations. The results were presented in terms of C-weighted noise levels because of the low frequency nature of ground noise. C-weighting is similar to A-weighting except that it places a greater weighting on low frequency noise.

Night Operations of APUs: APU noise was not found to be significant during the day when other aircraft and non-aircraft noise is dominant. However, during the nighttime hours, when other sources of noise are reduced, the potential for impacts from APU operations is greater.

The survey found very little use of APUs during the late night hours (midnight to 5 a.m.), because most aircraft were parked for the night. The cargo area, where late night activities occur, is an exception. After 5 a.m., APU use increases as airline employees prepare aircraft for morning departures. APU use was also more common during the late evening hours (8 p.m. to midnight).

Figure E.6
Seattle-Tacoma International Airport Part 150 Noise Study
C-Weighted APU/GPU Noise Contours for Multiple Aircraft
Location: North Cargo Area (3 Aircraft)

Port of Seattle
Seattle-Tacoma International Airport



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Summary of Stationary Ground Noise Sources: The following summary presents the findings concerning the noise impacts from auxiliary power noise generated by jet aircraft operating at Sea-Tac.

- The noise from APUs is a constant steady-state noise with broadband frequency characteristics similar to the noise levels at the rear portion of a jet aircraft engine at idle power. The noise from APUs is directed toward the tail of the aircraft.
- Noise levels from an individual APU are not significant in comparison to other aircraft noise sources. APU noise levels vary depending on aircraft type, ranging from 81 to 90 dBA at a reference distance of 100 feet.
- In the daytime, noise from other aircraft and non-aircraft activities dominate any noise that is generated by the APUs. However, during the nighttime hours, the background noise levels are lower and the potential for impacts from APU use is greater. APU noise can become noticeable if several APUs are operating at once.

During the late-night hours, few aircraft operate on APUs with the exception of some international passenger flights and cargo aircraft loading and unloading. APUs are likely to be used more extensively during the early night (up until around midnight) and again in the early morning (after 5 a.m.).

Taxi and Idle Noise

Background: Aircraft engine idling and taxiing to and from the runways are additional sources of ground noise at Sea-Tac. Prior to departure, noise generated from taxiing and idling includes all ground operations from engine startup, to start of taxiing, to the runway end. After arrival, taxi and idle noise refers to taxiing from the runway to the point at which the pilot shuts the engines down at the gate.

Taxi/Idle Noise Characteristics: Taxi and idle noise each have unique characteristics. Though lower in magnitude than takeoff and landing noise, the duration can be significantly greater. High-frequency fan noise at the front of the aircraft is the most significant source of noise from taxi/idle operations. These noise characteristics are summarized below:

- Magnitude less than takeoff and landings.
- Multiple aircraft can cause cumulative effects.
- High-frequency noise from the front of the aircraft is most significant.
- Fluctuates in magnitude as power is increased or decreased for aircraft positioning.
- Noise is more noticeable during nighttime hours when other aircraft and ambient noise sources are less noticeable.

Taxi/Idle Noise Data: Noise measurement data from taxi/idle noise identified important characteristics to evaluate its contribution to overall ground noise.

Taxi/idle noise is not equally distributed in all directions. Although A-weighted noise levels are similar in all directions with a slightly higher level toward the front, frequency analysis shows a significant difference between the front and the back of the aircraft. Noise from the front of the aircraft is dominated by high-frequency fan and compressor noise. Noise from the rear of the aircraft is dominated by low-frequency combustor noise and turbulent air mixing. The characteristics of high-frequency noise are that it has the greatest impact close to the Airport, but dissipates rapidly with distance. Low-frequency taxi/idle noise directed toward the rear of the aircraft is of a significantly lower magnitude compared to full power. Therefore, taxi/idle noise impacts at the rear of the aircraft are not significant.

Table E4 presents Lmax noise levels associated with aircraft taxiing at a reference distance of 250 feet from the closest point to the microphone location. This closest point is when the aircraft has reached an angle of 90 degrees from the measurement site. The highest noise level is reached just prior to the aircraft's closest point of approach, because noise from taxi/idle is largely a function of fan noise, which comes from the forward portion of the engine. These aircraft were operating at a steady idle power setting. The results show the range in noise levels for various aircraft types. Measurements of multiple aircraft of the same type generally showed a range of plus or minus 5 dBA. Note that the newer generation Stage 3 aircraft generally generate lower taxi and idle noise compared to the equivalent size aircraft that they are replacing. For example, the B737-300 aircraft is about 5 dBA quieter than the B727 aircraft.

Table E4
Example Taxi Noise Referenced to 250 Feet

Aircraft Type	Maximum Noise Level (dBA)
B747-400	87
B727-200	90
MD83	82
B737-300	85
A320	81
B737-200	87

Summary of Taxi and Idle Noise: The following summary presents noise impacts from jet aircraft taxi/idle noise at Sea-Tac.

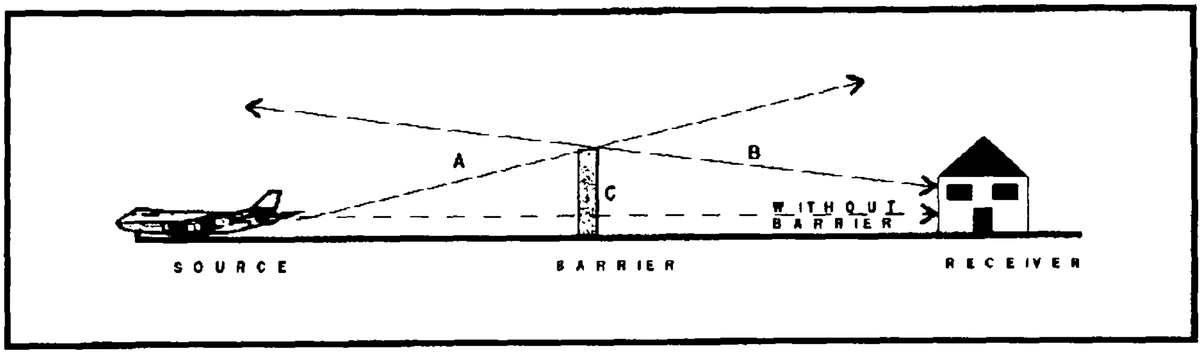
- Impacts from taxi/idle noise are potentially more of a problem toward the front of the aircraft because of the higher-frequency fan noise. This noise is only a problem relatively close to the Airport because high-frequency noise attenuates more rapidly compared to low-frequency noise at greater distances from the aircraft.

- The contribution of taxi/idle noise to the overall noise levels at the Airport is most noticeable during the late-night hours when other sources of aircraft and non-aircraft noise are quieter.
- The newer generation Stage 3 jet aircraft generally produce lower levels of taxi/idle noise compared to the older Stage 2 aircraft, though this difference is not as great as with departure roll noise.

Noise Barrier Design Overview: Noise barriers are structures designed to block the propagation of noise at the source. An overview of the acoustic principles behind noise-barrier design is summarized below. An understanding of these acoustical principles is essential in the design of effective noise barriers.

When no obstacles are present between the source and adjoining areas, sound travels by a direct path of "source" to "receiver," as shown in Figure E7. This straight line is referred to as the "line-of-sight."

Figure E7
Noise-Barrier Design



Introducing a barrier between the source and the receiver, which interrupts the line of sight, redistributes the sound energy into several paths: a diffracted path over the top of the barrier, a transmitted path through the barrier, and a reflected path directed away from the receiver. When masonry walls, berms, or specially designed prefabricated materials are used, the noise passing through the wall is negligible. The transmitted path may become important if the barrier contains gaps or holes, or it is made from a lighter material such as wood.

The noise reflected off the sound barrier is usually directed away from the receiver, and can be ignored unless large buildings or other reflecting surfaces are present. Absorptive barriers are often used if there are receivers located on the other side of the noise source as well. The noise path of primary concern is the diffracted path.

In most situations, the only way that sound can reach the receiver is by "bending" over the top of the barrier as shown in Figure E7. The bending of sound waves over an obstacle in this manner is known as diffraction. The area in which diffraction occurs behind the barrier is known as the "shadow zone." The straight path from the source over the top of the barrier forms the boundary of this zone.

All receivers located in the shadow zone will experience some sound attenuation; the amount of that attenuation is directly related to the amount that the sound must bend or diffract. That is, the barrier attenuation is a function of the geometrical relationship between the source, receiver, and barrier. (The closer the receiver is to the barrier, the more attenuation it will receive.) These parameters can be related to the barrier attenuation by defining the path length difference, or the difference in distance the sound must travel in diffracting over the top of the barrier rather than passing directly through it.

The frequency of the noise also affects the ability of the sound wave to diffract. Low-frequency sounds, which possess a longer wavelength, will bend over a barrier more readily than high-frequency sounds that possess a shorter wavelength. The frequency characteristics of engine run-up noise, one of the noise sources to attenuate, indicate that the major frequency components are located between 63-hertz and 1000-hertz octave bands with the 125- to 250-hertz being the most critical. In order to predict the effect of a noise barrier, it is necessary to compute the barrier noise reduction at each frequency.

Noise Barrier Materials: Noise barriers may be constructed from a variety of materials. Generally for airports, these materials include block masonry walls or special sound-absorptive panels. The material must be of sufficient density so that the noise does not pass through the barrier. When reflection is of concern, then material with absorptive properties is also used, although the cost of absorptive barriers is usually much higher. Barriers may also be constructed with vented walls that allow for better air circulation and improved noise-reduction capabilities.

Noise-Barrier Mitigation: This mitigation option addresses the potential noise reduction benefits to building a sound barrier near the north cargo area and the south hangar area. This barrier is designed to shield nearby communities from ground noise sources including APUs, GPUs, engine starts, engine idle, and taxiing in these locations. The proposed location of the barrier is shown in Figure E8.

The barrier is assumed to be 20-feet high and constructed of absorptive material. Given the differences in terrain and varying distances from the receiver, the noise reduction of the barrier is in the range of 3 to 5 dBC, with most areas achieving 5 dBC of noise reduction. The noise exposure contours for the with-barrier option are presented in Figure E9. This figure shows the 65 and 75 dBC noise exposure contour for the multiple APU activities in the north hangar area that was presented earlier in Figure E6.

Airport and Airspace Actions

The following airport and airspace use actions were considered for analysis in this Study:

✓ PREFERENTIAL OR ROTATIONAL RUNWAY USE
- Preferential or rotational runway use (north flow versus south flow)
- Preferential or rotational runway use under north flow conditions
- Preferential or rotational runway use under south flow conditions

✓ PREFERENTIAL FLIGHT TRACKS
- Compliance with existing aircraft approach and departure corridors
- Greater compliance with north flow departure procedures
- Develop new preferential flight tracks
- Develop "minimum" population flight tracks
- Flight tracks - fly quiet

✓ RESTRICTIONS ON GROUND NOISE FROM AIRCRAFT
- Restrictions in ground movement of aircraft
- Restrictions on use of ground equipment
- Restrictions on engine run-ups

Figure E.8

Seattle-Tacoma International Airport Part 150 Noise Study

Proposed Noise Barrier Location

Location: North Cargo Area

Port of Seattle
Seattle-Tacoma International Airport

Prepared Mar-2000

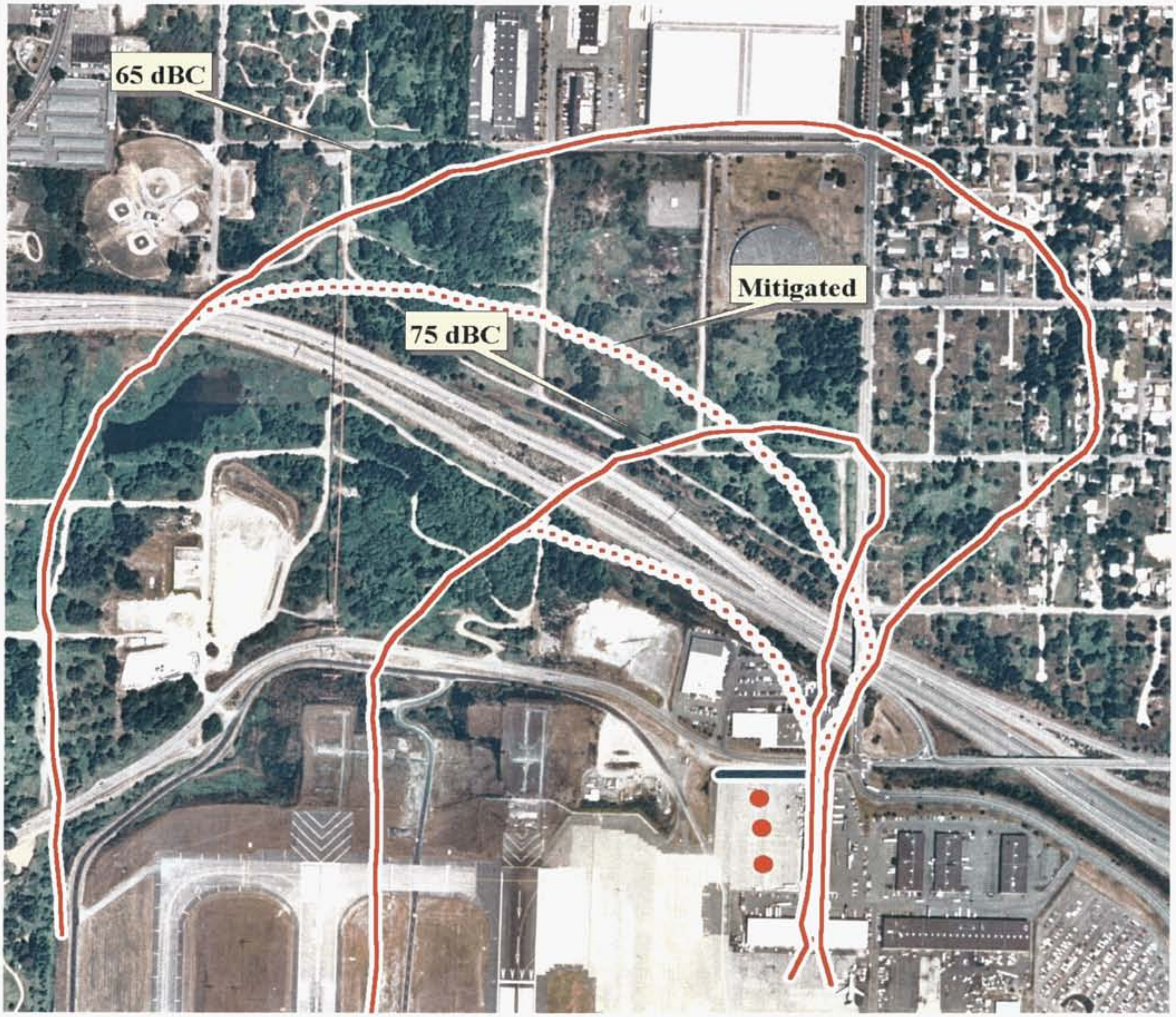
Figure E.9

Seattle-Tacoma International Airport Part 150 Noise Study

C-Weighted APU/GPU Noise Contours for Multiple Aircraft

Location: North Cargo Area (3 Aircraft) - MITIGATED

Port of Seattle
Seattle-Tacoma
International Airport



Prepared Mar-2000

✓ AIRPORT ACCESS RESTRICTIONS
  - Limits on numbers or types of operations or types of aircraft
  - Conduct an FAR Part 161 study
  - Minimize the number of late-night flights (1:30 a.m. to 5:30 a.m.)
  - Limit number of nighttime Stage 2 operations by aircraft weighing more than 75,000 pounds
  - Use restrictions

✓ AIRPORT FACILITY CHANGES
  - Raise Glide Slope angle or intercept

3.1 Preferential or Rotational Runway Use (North Versus South Flow)

A Preferential Runway System, as the name implies, refers to the preferred allocation of arriving and departing aircraft to specific runway ends. Because aircraft normally takeoff and arrive into the prevailing wind, preferential runway assignments can be made only during discretionary weather conditions; that is, when wind direction and speed do not dictate runway use.

Historically, Sea-Tac operates in south flow about two thirds of the time (65 percent). This has been the case for many years, with the year-to-year variation being less than 5 percent. In general, under calm wind conditions, south flow will be utilized more than north flow for of the following reasons:

- The predominant wind direction is from the south, and aircraft normally takeoff and arrive into the prevailing wind. Winds are from the south about two thirds of the time. However, for about one quarter of that time, wind speeds are light.

- The Airport has a slight slope to the south (about 40 feet). Heavy aircraft such as B747s prefer to takeoff to the south, because the effective runway length is greater.

- The Airport operates more efficiently in south flow than north flow, because of a number of factors including reduced conflict with operations from King County International Airport (KCIA). Therefore, Sea-Tac ATC prefers south flow.

The purpose of this alternative action is to evaluate the potential noise affects of balancing north flow with south flow. Thus, this alternative would involve increasing the percentage of time north flow is utilized. To accomplish this alternative might require forcing the natural flow of the Airport in the other direction by asking aircraft to takeoff with a tail wind of up to eight knots.

Based upon 1998 actual wind speed/direction data, it might be theoretically possible to direct up to 60 percent of the operations annually into north flow. This assumes that whenever the tail winds are less than eight knots, every aircraft would depart to the north. Although this amount of tail wind is allowable, it is not possible for all operations for the following reasons:

- Shifting the flow between south flow and north flow, especially during peak activity periods, is a complex and time-consuming process. For this reason, ATC makes runway changes as infrequently as possible. In general, the flow is changed once the predominant wind direction has shifted and is expected to remain that way for some period of time. Flow shifts generally occur once per day to every few days, not every few flights, or even every few hours.
- Because of the interactions between other airports in the region, especially Boeing Field, the flows between the different airports must be coordinated. When Sea-Tac shifts, Boeing Field generally does so as well.
- Although it is possible to land and takeoff with a tail wind component, it is still desirable to land and takeoff into the wind. Pilots will opt for that condition whenever possible.

A realistic assumption is that it may be possible to shift the flow from the current 65-percent south flow to 55-percent south flow (45-percent north flow).

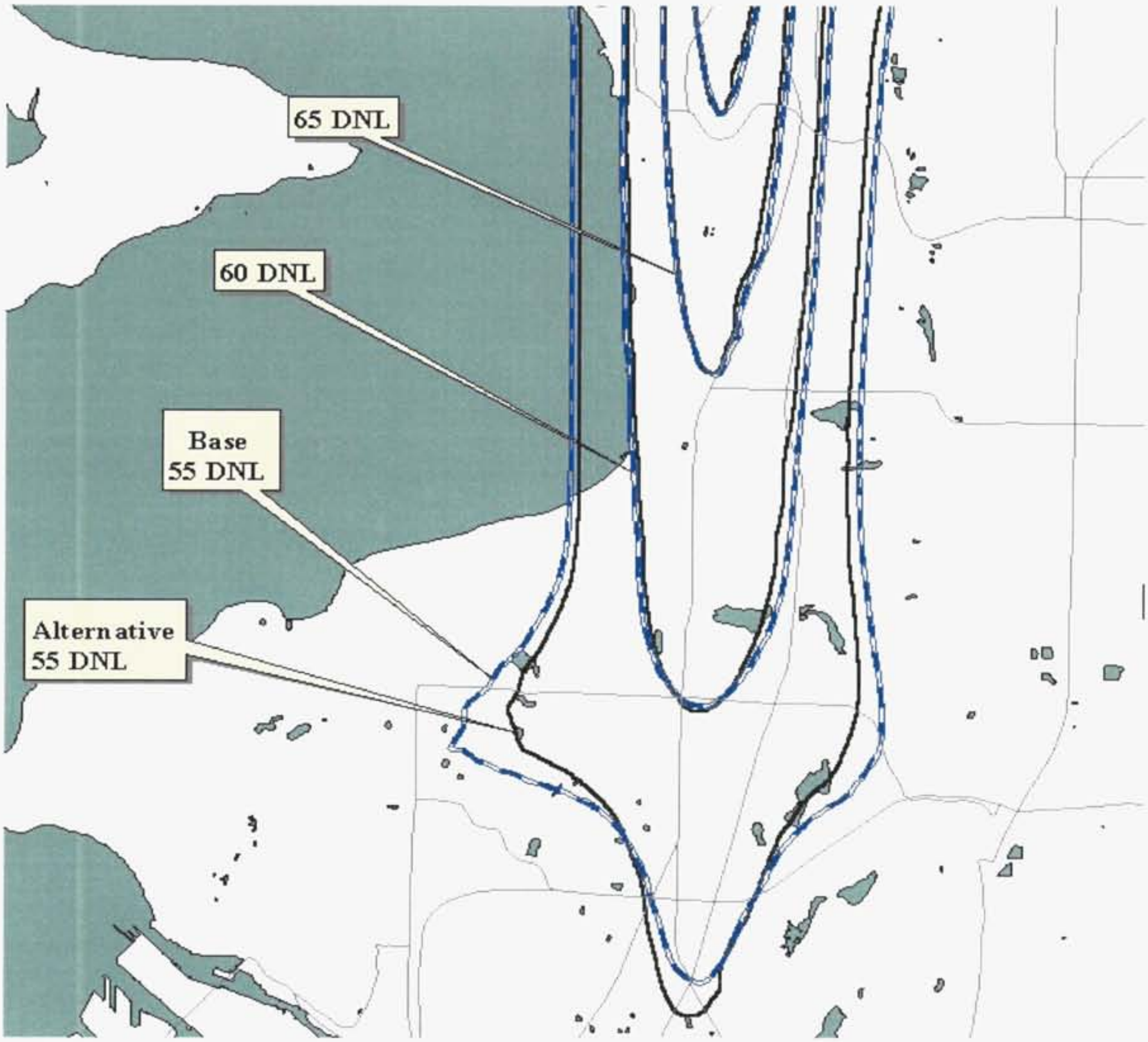
The potential impacts from this alternative were evaluated with respect to the 2004 future base-case noise exposure contours. The results of the analysis are presented in Figures E10 and E11. These figures show the base-case 2004 annual DNL noise contour and the change that would occur with the preferential runway shift for south of the Airport and north of the Airport, respectively.

The changes to the DNL noise levels in the Part 150 study area are roughly a reduction of less than 0.3 dBA to the south and an increase of less than 0.5 dBA to the north. At locations more distant from the arrival paths, the changes are greater. At locations not exposed to arrival noise, the decreases to both the south and north are less than 1 dBA.

These changes are smaller than what might be expected by a preferential runway use program, because by 2004 the fleet is expected to be quieter than it is today. And, newer aircraft make less noise in departure, so that the difference between departures and arrivals will be less than in older aircraft.

Figure E10
Seattle-Tacoma International Airport
Change in DNL Noise Levels (South of Airport)
2004 Annual DNL Noise Contours

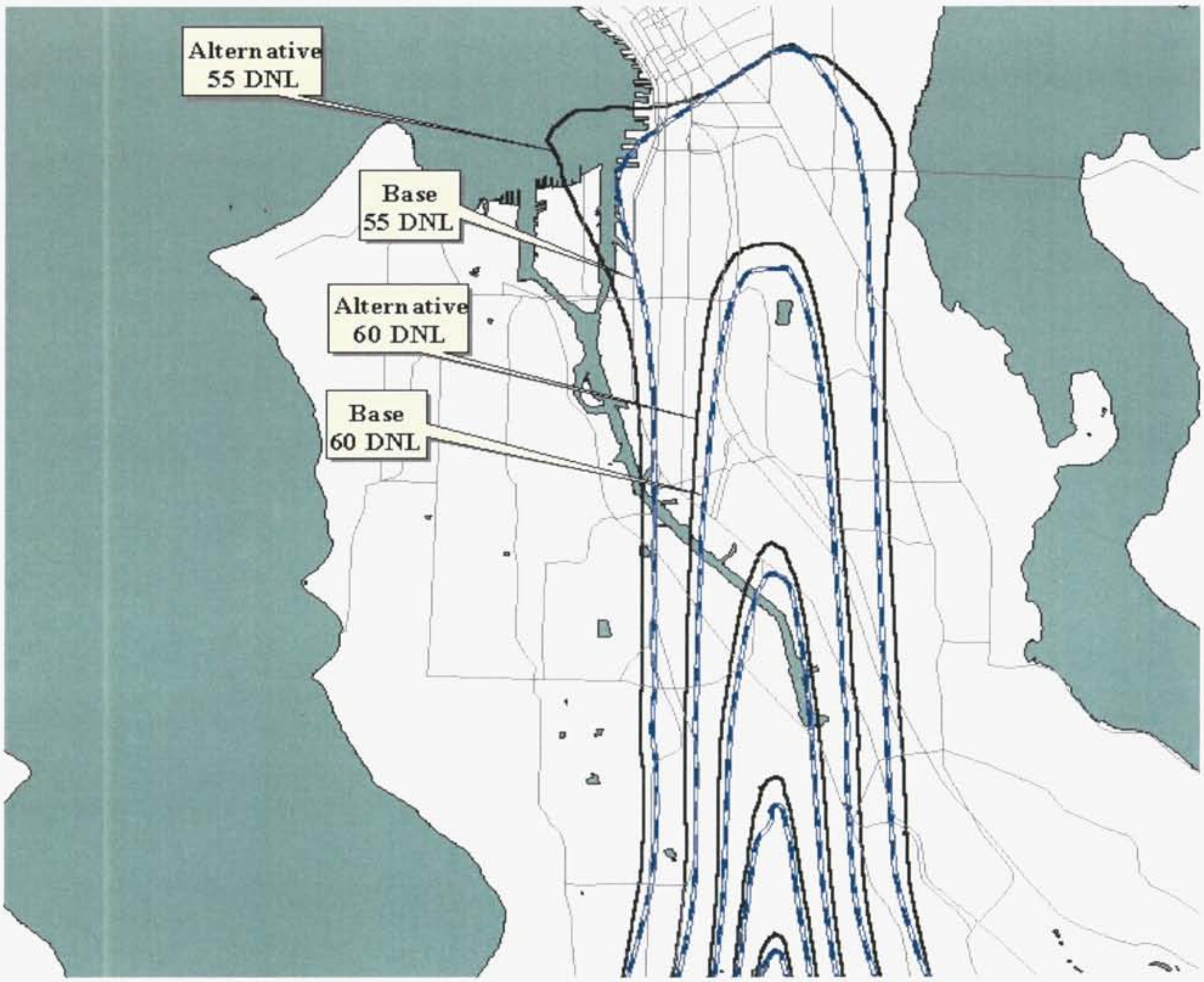
Port of Seattle
Seattle-Tacoma International Airport



Prepared May 2000

Figure E11
Seattle-Tacoma International Airport
Change in DNL Noise Levels (North of Airport)
2004 Annual DNL Noise Contours

Port of Seattle
Seattle-Tacoma International Airport



Prepared May 2000

3.2 Preferential or Rotational Runway Use - North Flow

This action would utilize a specific runway for arrivals and a specific runway for departures during north flow.

Sea-Tac currently operates with arrivals on the west runway (Runway 16R/34L) and departures on the east runway (Runway 16R/34L), based on airfield operational and efficiency considerations. This preferential use is true for both instrument conditions and visual conditions.

Action 3.1 discusses the consequence of a north-flow emphasis.

3.3 Preferential or Rotational Runway Use - South Flow

This action would use a specific runway for arrivals and a specific runway for departures during south flow.

The Airport currently operates with arrivals on the west runway (Runway 16R/34L) and departures on the east runway (Runway 16L/34R), based on airfield operational and efficiency considerations. This preferential use is true for both instrument conditions and visual conditions.

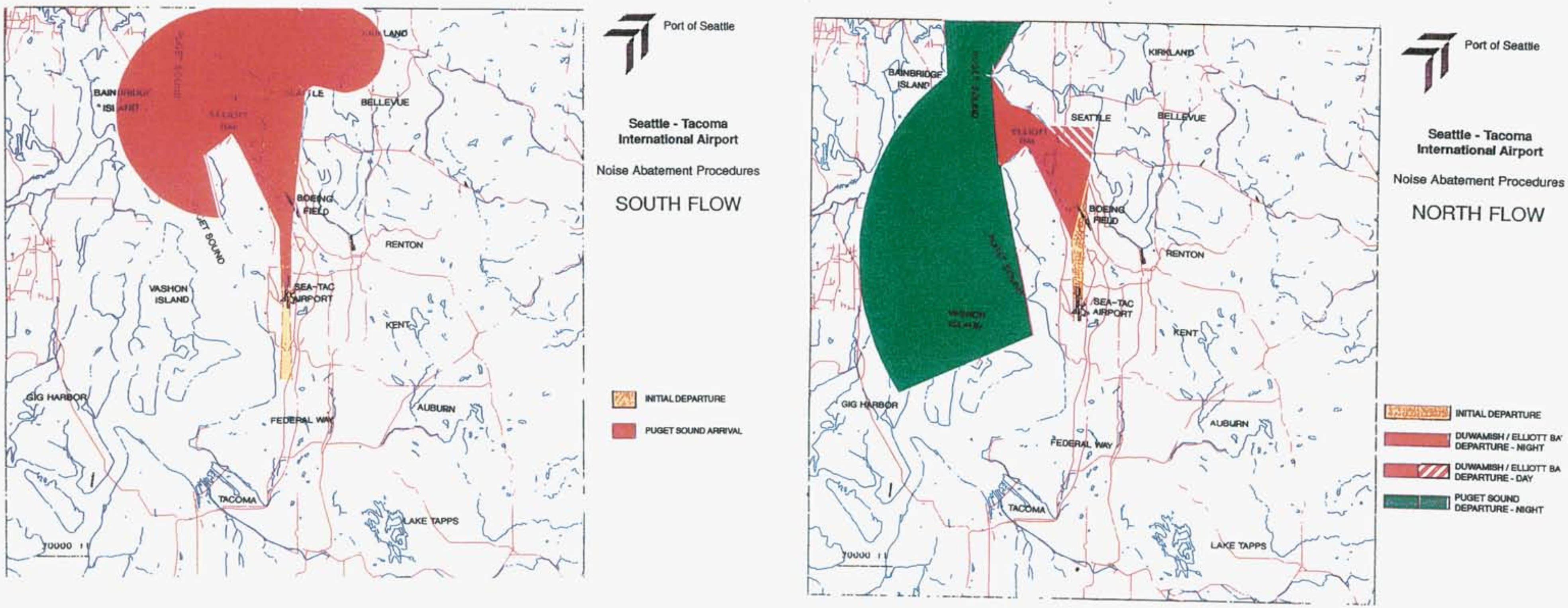
Action 3.1 discusses an emphasized south-flow operation.

3.4 Compliance with Noise-Abatement Flight Corridors

Flight corridors at Sea-Tac have been designed to minimize the noise impacts to people living near the Airport. With the introduction of new technology, existing and future tracks may be flown more precisely (concentrated along the corridors), and adherence can be evaluated through the use of radar flight tracks.

Working with the Port of Seattle, the FAA has developed a number of noise-abatement flight corridors. These existing flight corridors are presented in Figure E12 and described below:

Figure E.12
Existing Flight Corridors



Existing Noise-Abatement Departure Flight Corridors:

- ✓ *Initial heading for south- flow departures* –Departing aircraft head south remaining in the designated corridor until reaching 5 DME (about 5 miles) and an altitude of 3000 feet Mean Sea Level (MSL).
- ✓ *Initial heading for north-flow departures* – Departing aircraft head north into the designated corridor until reaching 8 DME and 4,000 feet MSL before turning.
- ✓ *North-flow nighttime departure corridor* – When traffic conditions permit, all aircraft proceed west over the Duwamish/Elliott Bay Corridor where they proceed to 20 nautical miles or an altitude of 10,000 feet MSL before turning toward their destination.

A deviation from the flight track (non-compliance) is a track that extends beyond the limits of the defined corridors. Compliance with the existing procedures ranges from about 70 percent for the more complex procedure (north-flow nighttime corridor) to over 95 percent for initial departure corridors.

Flight-Track Compliance. To monitor compliance, the Port has utilized flight-tracking software (ANOMS) that utilizes data from the FAA's radar.

The Port of Seattle is currently in the process of acquiring a new flight-tracking software program that should allow for more sophisticated analysis of the level and accuracy of compliance with the Airport's noise-abatement flight corridors.

Goals for the enhanced flight-track compliance program could include:

- ✓ Identify those operations that do not achieve compliance.
- ✓ Investigate those operations that are out of compliance, to identify trends.
- ✓ Determine level of compliance per airline and aircraft type.
- ✓ Determine accuracy of compliance per airline and aircraft type.

Figure E13 is an example of the analysis reports that could be used to identify compliance.

Figure E.13
Example Flight Track Analysis Reports

Airline Report

Corridor Performance Report by Airline
Sea-Tac International Airport
Period: August 3, 1998 to August 24, 1998

Port of Seattle
Seattle-Tacoma International Airport

Airline		Total Flights	Inside of Corridor	Outside of Corridor	Percent Successful
American	AAL	44	34	10	77.3%
Alaska Airlines	ASA	726	572	154	78.8%
America West Airlines	AWE	20	14	6	70.0%
British Airways	BAW	1	--	1	0.0%
Continental	COA	48	36	12	75.0%
Delta Air Lines	DAL	65	45	20	69.2%

Aircraft Report

Corridor Compliance Report by Aircraft
Sea-Tac International Airport
Period: August 3, 1998 to August 24, 1998

Port of Seattle
Seattle-Tacoma International Airport

Aircraft	Total Flights	Inside of Corridor	Outside of Corridor	Percent Successful
B727	26	19	7	73.1%
B73A	51	43	8	84.3%
B73B	733	534	199	72.9%
B747	30	16	14	53.3%

Flight Management System (FMS)/Global Positioning System (GPS). This technology could greatly improve the ability of aircraft to fly within predefined corridors.

- ✓ In order for FMS/GPS to be used, an aircraft must have the equipment and Air Traffic Control (ATC) must have the procedures in place. The FAA has established some FMS/GPS approach and departure procedures for Sea-Tac.
- ✓ Generally only the newest of aircraft have this technology.

Many citizens have expressed a concern with the effect that FMS has of concentrating aircraft overflights over a specific area, especially residential areas.

A survey of airlines was conducted to determine which aircraft in their fleet have this technology and how it is utilized at Sea-Tac.

- ✓ The effect of FMS on the ability of aircraft to accurately fly complex noise-abatement corridors is illustrated in Figure E14 for both aircraft known to have FMS/GPS and those without the technology.
- ✓ These figures show the Elliott Bay/Duwamish Corridor noise-abatement procedure for aircraft operating to Alaska destinations and clearly demonstrate the precision tracking capability of new technology.

Figure E.14
Flight Tracks with and without FMS

Without FMS

With FMS

3.5 Preferential Flight Tracks – Greater Compliance with North-Flow Departure Procedures

The north-flow departures generally consist of two major tracks:

- ✓ A nighttime departure track over the Duwamish/Elliot Bay corridor where aircraft proceed to twenty nautical miles or an altitude of 10,000 feet MSL before turning toward their destination; and
- ✓ a daytime departure track with departing aircraft heading north into the designated corridor until reaching eight DME (approximately eight miles) and 4,000 feet MSL before turning. The right turn off of this track has historically caused concern for citizens living in several areas including Leschi, Beacon Hill, the Central District, Mercer Island, Bellevue, and Medina.

The Port has used flight- tracking software which that utilized data from the FAA's radar. The Port of Seattle is currently in the process of updating that system which should allow for a more sophisticated analysis of the accuracy of compliance with the flight tracks.

In addition to the new flight-tracking software mentioned previously, the use of Flight Management System (FMS) and Global Positioning System (GPS) will greatly improve the ability of aircraft to fly on more precise tracks. For this technology to be effective, however, a particular aircraft must have the equipment and there must be such procedures in place. The newer aircraft entering the fleet generally are the ones with this technology. The FAA has established such routes for arrivals and departures at Sea-Tac.

3.6 Develop New Preferential Flight Corridors or Tracks

Flight corridors are two-dimensional paths along the ground that define areas of aircraft operation. Each runway at Sea-Tac has flight tracks associated with operations (departures and arrivals) on that particular runway. All flight tracks are under the control of the FAA. Noise-abatement flight tracks are designed to minimize noise exposure within the departure and arrival corridors. Flight tracks may be effective in reducing single-event noise levels at noise-sensitive locations in the vicinity of the Airport.

Noise-abatement flight tracks are specifically developed to route aircraft away from noise-sensitive land uses. Typically they are designed to avoid residential areas to the extent possible and follow industrial areas, highways, and water where it is available. These relocated tracks result in decreased noise exposure in the vicinity of noise-sensitive land uses and increased noise exposure at the location of the relocated track.

The primary aircraft noise concern at Sea-Tac relative to this alternative is cumulative and single-event noise exposure associated with commercial aircraft operations. These operations are normally conducted under instrument flight rules (IFR). IFR operations, which are associated with poor weather flying, are carefully preplanned. IFR aircraft departing Sea-Tac initially follow a standard instrument departure (SID), and arriving aircraft follow standard instrument or visual approach procedures.

SIDs are constructed by the FAA to relieve air traffic controllers from repeating the same departure instructions to each aircraft. SIDs may also be used to standardize the flight tracks of departing aircraft, and they may be designed to minimize noise.

Instrument approach procedures are standard paths that aircraft follow in preparation for landing. Safety is a critical concern during this phase of flight. For this reason, instrument approach procedures typically have a final straight segment of at least 10 nautical miles (nm) prior to landing. Turns are minimized during the final phase of flight allowing the pilot to focus on aircraft altitude and location with regard to the runway. However, technology is becoming available which may allow safe turns to be made by the aircraft during the final phases of flight. This technology may allow the future development of noise-abatement arrival flight tracks.

Sea-Tac has a number of flight procedures and existing noise-abatement procedures (see description in Noise Abatement Flight Corridors Action 3.4). Because Sea-Tac has existing noise-abatement flight tracks, opportunities for further improvements may not be easy to achieve. Changing flight tracks may only shift noise from one community to another, therefore not achieving real reduction in noise impacts.

3.7 Preferential Flight Tracks – Develop Minimum Population Flight Tracks

Flight corridors are typically established to reduce the total population affected by arrivals or departures from an airport. Therefore, these procedures are often referred to as tracks or corridors that have the minimum population impact associated with them.

This action is the same as Action 3.6.

3.8 Fly Quiet

Fly Quiet is a family of programs encouraging airlines and pilots to operate aircraft as quietly as possible for people living around an airport. As a voluntary program, Fly Quiet has the advantage of reinforcing desirable flight procedures without going through the onerous regulatory requirements of an FAR Part 161 filing or similar federal approval process. A Fly Quiet program could be built upon the considerable technical improvements to be provided by the new Noise Monitoring System (NMS) currently being installed by the Port of Seattle. Using data produced by the NMS, the airlines, pilots, and the public can be informed about how each type of operation, aircraft type, and airline compares to others in adherence to new programs that may be developed. This information, combined with incentives, should result in continued improvements to the noise environment around Sea-Tac.

In 1990, Sea-Tac established a large program for the reduction of overall noise in the Seattle area. This program, known as the Mediation Agreement, focused on reducing noise at the source. These programs became the benchmark for the industry and most major airports are still in the process of trying to adopt programs similar to the ones Sea-Tac has had in place for a decade. The Mediation Agreement consisted of several elements including:

- Noise Budget,
- Nighttime limitation on Stage 2 aircraft,
- Doubling the sound insulation program,
- Implementation of a state-of-the-art flight track monitoring system,
- Improvement of flight procedures through the Elliott Bay corridor,
- Other administrative actions.

The Noise Budget and nighttime limitations have been fully implemented, achieving the goal of reducing aircraft noise by at least 50 percent by 2001, and the sound insulation program will be completed this year. These programs, which, for the most part, address noise at the source, have all been implemented on a voluntary basis.

A Fly Quiet program would be a logical next step in the continuation of noise reduction efforts for Sea-Tac. Such a program should also be voluntary in nature so as to comply with FAR Part 161. The Port is in the process of final implementation of a new Noise Monitoring System that is capable of providing a variety of data that can be incorporated into a Fly Quiet Program.

A Fly Quiet program has the potential of reducing single-event noise levels and encouraging greater compliance with preferential flight corridors and procedures. The program could potentially result in overall reductions in cumulative noise levels in some focused areas around the Airport as well. Identification of how individual aircraft operate at specific locations compared to the way the majority of aircraft operate, can help encourage the noisier operations to lower noise levels and/or adhere to established flight tracks.

Potential elements of a Fly Quiet program could include:

- Noise-abatement flight path compliance
- Tracking adherence to noise-abatement departure climb profiles
- Maintaining arrival glide slope use during VFR conditions
- Maintaining desirable minimal altitudes
- Late-night departure procedures
- Analysis of noisiest single-event flights
- Monitoring adherence with nighttime run-up rules
- Special studies

An example of how a Fly Quiet program might work includes the following analytical steps:

1. Examples of some of the data that may be used in the analysis or development of the Fly Quiet program.

    - Noise complaint information
    - Measured single-event noise levels
    - Measured cumulative noise levels
    - Single flight track information
    - Large volume of flight track data
    - Aircraft departure and arrival profiles
    - Meteorological information

2. Categorize the data according to a variety of factors including:

    - Measured noise levels from the noise monitoring system, identifying operations producing the highest, lowest, mean, and average levels.
    - Measured distance from ideal flight path, identifying operations in or out of compliance with a procedure and rating the quality of the flight in meeting that procedure.
    - Measure flight profile identifying operations that produce the highest, lowest, mean, and average altitudes at different points along a flight path.

    Data would be sorted according to noise level or flight path/profile compliance, so that it would be clear which operators were the quietest/best and which were the noisiest/worst for a given operation type. It will be important to structure the data analysis so that similar operations are compared; such as similar operations in similar conditions by similar aircraft types. It will be very important to draw conclusions from an ample number of data points, so that reports reflect accurate patterns rather than single, odd events. Examples of methods of categorizing the data are listed below.

- Airline or group of airlines
- Aircraft type
- Deviation from mean
- Available navigational equipment on aircraft
- Time of day or night
- Flight stage length (distance)
- Weather

3. Define patterns such as:

- Quietest/best airline/aircraft type on a given procedure
- Noisiest/worst airline/aircraft type on a given procedure
- Closest adherence to noise-abatement departure procedure by airline/aircraft type
- Conditions which produce noisier or quieter operations

4. Prepare Findings:

- How closely individual flights followed the centerline of the ideal path
- Specific airline performance
- Specific aircraft type performance
- Whether or not the aircraft was equipped with FMS
- Destination of the flight
- Other factors, such as weather, other aircraft in the area, ATC, and time of day, which might impact compliance.

Potential Fly Quiet elements that are specific to Sea-Tac are listed below.

- Daytime Elliott Bay flight path compliance
- Nighttime Elliott Bay flight path compliance
- Nighttime southbound procedures
- Hours of operation for east turn curfew
- Altitude on arrival
- Departure climb rate
- Low-level over flights west of Sea-Tac
- Fleet quality measurement

The Operations Sub-committee of the Part 150 Study discussed in some detail the most important components to include in a Fly Quiet program. The Sub-committee made a number of suggestions with key points summarized below:

- To the extent possible, the aircraft noise should be related to its effects on people, including such factors as: annoyance, speech interference, and sleep disturbance.

- Comparative fleet quality between airlines should also be included in the program.
- The program should utilize measured data from the Airport's noise monitoring system.
- Some method of normalizing data to account for airlines that most efficiently serve the region's air transportation needs should be developed. This normalization could account for number of passengers or tons of cargo per number of operations or flight distance.
- The program should include incentives/disincentives of sufficient importance that airlines will take notice of the results.
- Pilots and air traffic controllers should also be included in the incentive program.
- A continuing committee should be developed to finalize the details of the program and monitor its operation.

Based upon these discussions, the following four elements are proposed to comprise a Fly Quiet program. Committee members would weight these four elements according to their collective priorities. Airlines would be ranked every quarter, and the airline with the best rating each year would be named the quietest airline at Sea-Tac for that period.

- <u>Adherence to Procedures</u> – This measure accounts for how each airline meets each of the noise-abatement procedures that have been established at the Airport. Measures of adherence could include not only if a procedure is followed, but also how well. The airline that performs the best per 1,000 operations would be rated the highest. A follow-on committee could be involved in developing the precise measure of each procedure and "rating the importance" of each measure. These procedures may include the following:

    - Daytime Elliott Bay flight path compliance
    - Nighttime Elliott Bay flight path compliance
    - Nighttime southbound procedures
    - Hours of operation for east turn curfew
    - Altitude on arrival
    - Departure climb rate
    - Low-level over-flights west of Sea-Tac
    - Any new procedures

- <u>Contribution to overall DNL</u> – This measure accounts for the total contribution of any single airline to the overall DNL noise level around Sea-Tac, because DNL can be directly related to potential annoyance effects on the population. Contribution to total DNL can be normalized for the number of passengers served (with an equivalent number of pounds for cargo operators). As an example, at an aggregate number of noise-monitoring locations, the DNL contribution would be determined per airline, per million passengers over a quarter period. An airline with a lower aggregate contribution to the DNL per million passengers would be rated higher than an airline with a larger contribution.

- Loudest Noise Events –Operations generating the highest noise levels are always a concern to the community. This measure proposes to track the highest noise level operations for the period. An airline with few or no "loudest noise events" would be rated high in the Fly Quiet program.

- Awakening Potential – This measure would account for operations that could potentially result in sleep disturbance between 10 p.m. and 7 a.m. based on existing sleep research and the measured noise levels at the noise-monitoring locations. The population represented by each monitor would be determined, and adjustments for differences in flight tracks could be included to counter any concern over aircraft trying to avoid noise monitors. The airline with the lowest number of potential awakenings per million passengers served would be rated the best.

Based upon this program, each airline operating at Sea-Tac would be rated in terms of their contribution to the overall noise. The rating would include compliance with the noise-abatement procedures, effects on people living around the Airport, and the number of higher than normal noise events.

The following are suggested methods of using this data.

- Publishing the Results – The Fly Quiet airline ranking would be published quarterly or annually to allow the general public access to the results. The publishing of the information should involve a major effort including local newspapers so that the results are important to the airlines.
- Pilot Incentives – Because pilots are an important factor in any Fly Quiet program, incentives for pilots should also be considered. These incentives may take the form of simple programs such as coffee or other perks for pilots of the airline that performs the best.
- Awards – Annual awards such as "Environmental Airline of the Year" may be another method of raising the public awareness of the Fly Quiet program.
- Track Changes Over Time – The results of the fly quiet program can be tracked over time to identify trends and areas for improvement. With this information, the Port staff can work with the airlines, ATC, and pilot organizations to improve compliance with the programs, and develop new programs as necessary.

3.9 Restrictions on Ground Movement of Aircraft

Restricting by time or place the movement of aircraft on the airfield could reduce ground-generated noise. This action is typically used at airports where numerous taxi patterns are available or where the taxiway system is configured with certain taxiways closer to residential areas than others. Alternative taxi patterns could be used to minimize noise to nearby residential areas.

Because of the location of terminal and cargo facilities on the east side of the runway system at Sea-Tac, aircraft are typically taxied directly between gate/parking positions and the runway system in the most efficient fashion. Because of the parallel runway and taxiway system, and east side terminal/cargo complex, no alternative taxiways are available to minimize the impacts of ground movement noise to adjacent residential areas.

No further consideration is recommended for this alternative, because no alternative taxiway patterns or taxiway locations are available that would improve ground taxi noise impacts.

3.10 Restrictions on Engine Run-Ups or Use of Ground Equipment

The purpose of this action would be to restrict engine run-ups to certain time periods, length, and/or location to reduce ground noise effects. Some ground equipment, such as tugs and ancillary power units, can create ground noise for certain periods of time.

This action is the same as Action 2.6.

3.11 Restrictions on Engine Run-Ups or Use of Ground Equipment – Minimize the Number of Nighttime Run-Ups

This action is the same as Action 2.6.

3.12 Limits on Numbers or Types of Operations or Types of Aircraft

This action would set limits on the number of aircraft operations, aircraft types, total cumulative noise level, or other similar measures intended to reduce overall noise at the Airport. For example, maximum cumulative impact could be defined as the total area within the existing DNL 65, 70, or 75 noise contour, which would be established as the baseline. The Airport's operations would be adjusted or limited so as not to exceed that maximum noise level in the future. This concept can also be formulated to set a threshold noise level, which cannot be exceeded by individual aircraft, or different thresholds could be established for day and night. An aircraft's compliance with this limit would be determined from the published FAA certification data.

An operations-limit noise rule would be subject to an FAR Part 161 Study, which includes a rigorous cost/benefit and noise/land use study. The ability of an airport operator to implement such restrictions is limited. In addition, such restrictions are subject to vigorous constitutional analysis to ensure compliance with interstate commerce interests and discrimination concerns.

Sea-Tac currently has an airport limit in place, known as the "Noise Budget," which will be fully achieved in 2001. Any adjustment or amendment to the existing Noise Mediation Agreement conditions could trigger an FAR Part 161 requirement.

The "Noise Budget" represents an allocation of noise for the Airport to the airlines that will decrease over time. The budget limits and controls aircraft noise and accelerates the use of the new Stage 3 aircraft. This program guarantees that Sea-Tac will move steadily and predictably toward an all Stage 3 jet fleet, reducing noise each year over a 10-year period. The budget allocates the maximum amount of noise that airlines are allowed to make each year at Sea-Tac and this allocation is reduced annually.

The existing Noise Budget has achieved significant overall noise reductions and will continue to enforce that reduction. An attempt to amend that program may put these restrictions at risk as the required FAR Part 161 process may result in the loss of what has been achieved.

3.13 Limits on Numbers or Types of Operations or Types of Aircraft - Conduct a Part 161 Study

An FAR Part 161 study is a specific study required by the FAA to allow an airport to reduce overall or single-event noise levels through restricting operations by a limitation on the number or type of aircraft. Such a study could address Stage 2, Stage 3 aircraft, or both Stage 2 and 3.

There has not been an FAR Part 161 study undertaken successfully for any airport in the country since the passage of the Airport Noise and Capacity Act (ANCA) in 1990. Several have been attempted, but none has been implemented.

Prior to ANCA, the Port of Seattle adopted a voluntary agreement that limits the cumulative noise at the Airport.

For actions affecting Stage 3 aircraft, approval of the restriction by the FAA is required. Elements of a Part 161 Study would be expected to include:

- ✓ Detailed cost-benefit analysis using an FAA-agreed methodology;
- ✓ Demonstration that all other avenues of noise reduction have been undertaken or considered;
- ✓ An evaluation that shows:
  - Action is reasonable, does not discriminate, and is not arbitrary;
  - Action does not cause unreasonable interstate commerce impacts;
  - Action does not adversely affect safe and efficient use of airspace;
  - Action does not conflict with statutes and regulations;
  - Action does not cause adverse impacts to the national airspace system.
- ✓ The documentation must show that the opportunity for public and airport user input has been allowed; and that certain regulatory time periods have been followed.

A Part 161 program, if approved and accepted, could reduce noise levels, but none has ever been approved by the FAA. For a restriction on Stage 3 aircraft, which would be the only kind applicable after the year 2000, the FAA must approve not only the cost benefit methodology, but also the proposed restriction. These studies are very costly and time consuming, and are without either guarantee or even likelihood of ultimate approval.

3.14 Limits on Numbers or Types of Operations or Types of Aircraft - Minimize the Number of Late-Night Flights

The purpose of this action would be to reduce aircraft noise levels associated with aircraft operations during the late nighttime hours.

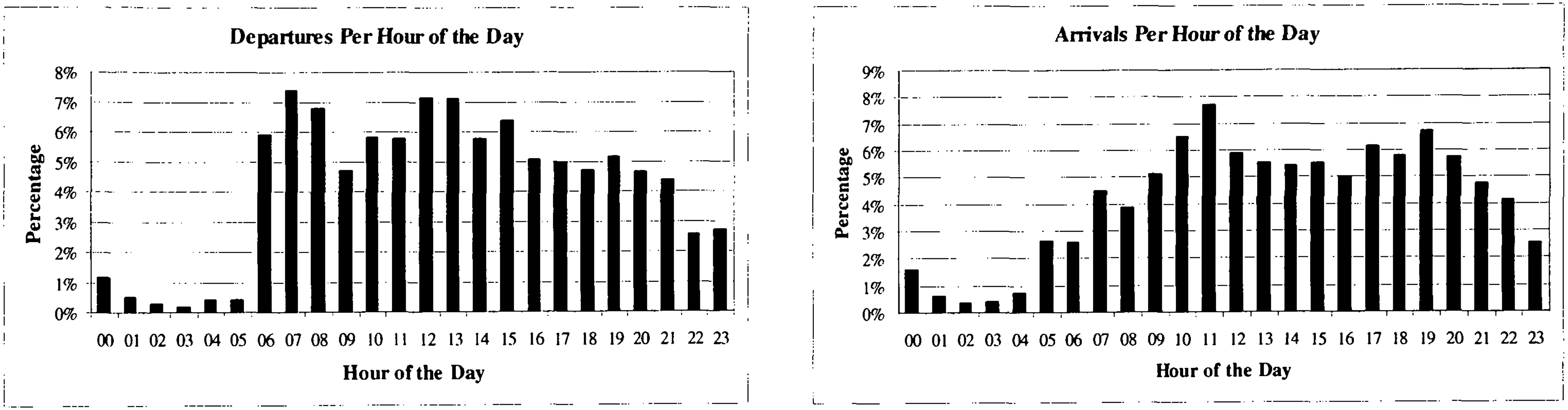
There is currently no program at Sea-Tac to discourage the use of Stage 3 aircraft during late nighttime hours. Flights during this time period may increase over time with overall increased operations. Figure E15 shows the number of operations per hour of the day for arrivals and departures.

Late-night flights, even by quieter Stage 3 aircraft, can be disruptive. If these flights can be reduced or eliminated, nighttime disruptions can be minimized. A nighttime restriction may have little if any effect on the cumulative noise levels, but may be important during specific time periods. A mandatory restriction on nighttime operations would be considered an access restriction, and compliance with FAR Part 161 would be required (see Actions 3.12 and 3.13).

A voluntary program, possibly part of a Fly Quiet program, could be established to discourage aircraft flights, to the extent possible, during late nighttime hours. Both incentives and deterrents could be evaluated.

(See Action 3.8 concerning Fly Quiet.)

Figure E.15
Operations per Hour of the Day



3.15 Limits on Numbers or Types of Operations or Types of Aircraft - Limit Number of Nighttime Stage 2 Operations by Aircraft Weighing Less Than 75,000 Pounds

Aircraft weighing less than 75,000 pounds were not included in the federally required phase-out of Stage 2 aircraft by the year 2000; these smaller Stage 2 aircraft continue to legally operate after the deadline for larger aircraft has passed. Aircraft in this category are generally business jets and small commuter or regional jets, such as the F-28 aircraft flown by Horizon Airlines. Restricting or limiting these aircraft would require an FAR Part 161 Study. This action would consider a limit on the use of Stage 2 aircraft under 75,000 pounds during the nighttime hours.

There is no limit on the numbers or types of operations or types of aircraft under 75,000 pounds during the nighttime at the Airport. Such a limit could reduce existing and potential future noise impacts during the nighttime hours. An evaluation of both existing and future operations by such aircraft would be required to determine the effectiveness of such a limit.

Under FAR Part 161, actions affecting Stage 2 aircraft would require FAA approval of the cost/benefit analysis. The FAA is not required to approve the ultimate restriction as it does for a Stage 3 restriction. However, all of the elements required for a Stage 3 restriction (see Action 3.13) need to be completed for a Stage 2 restriction, and the same constitutional issues must be addressed.

3.16 Use Restrictions

See discussion under Limits on Numbers or Types of Operations of Aircraft, Actions 3.12 and 3.13

3.17 Raise Glide Slope Angle or Intercept

When aircraft are on arrival to the Airport under instrument conditions, they are utilizing the glide slope and the angle of the glide slope to line up on the runway and descend at the proper rate of speed and angle to touch down on the runway at the proper location. This arrival procedure is usually conducted under IFR conditions, but almost all –commercial-service and cargo aircraft fly the glide slope, even during clear weather conditions (VFR).

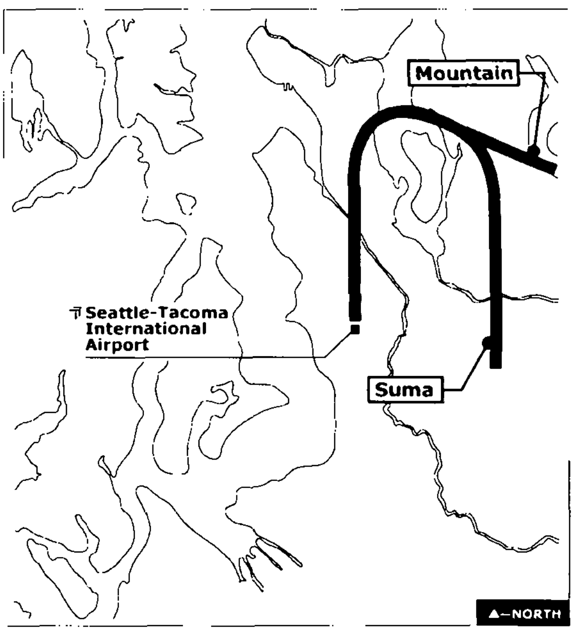
All glide slope angles at Sea-Tac are at three degrees. This glide slope is consistent with almost every other airport in the country. Aircraft are designed to operate at an approximate three-degree glide slope for safety, performance of the aircraft, and comfort to the passengers.

Depending on flap and power settings, aircraft may be quieter with adjustments to the glide slope angle or with a different intercept position. A different intercept position may determine how long an aircraft is on the glide slope. This can vary with weather conditions.

3.18 North-Flow, East-Turn Departure Procedures and Paths

The purpose of this alternative is to evaluate the departure procedures and paths for jet aircraft departing eastward during north-flow conditions. These procedures, known as the "East Turn," currently consist of two paths:

- MOUNTAIN procedure for aircraft departing to the east, and
- SUMMA procedure for aircraft departing to central states and Southern California.



The MOUNTAIN procedure currently includes FMS track instructions.

The current procedure for Sea-Tac north-flow jet departures on the East Turn is for departing aircraft to head north until reaching 8 DME and 4,000 feet MSL before turning. Aircraft then turn eastbound with the majority of the traffic turning at a location between the I-90 and Highway 520 bridges. The center of the track is roughly between the north end of Mercer Island and the south end of Medina.

Aircraft on the MOUNTAIN procedure turn eastbound to an eventual heading that is generally parallel to the I-90 corridor. For those aircraft that are not equipped with FMS technology, the flight path has a wide dispersion of aircraft tracks over eastside communities. For those aircraft that are equipped with FMS technology, the path is more precise. Examples of the MOUNTAIN procedure both with and without FMS technology are shown in Figure E16. Note that the FMS track at the point of the turn over Lake Washington is currently not as precise as other portions of the track.

Aircraft on the SUMMA procedure proceed east to a location approximately west of the I-405 corridor, then turn south over a wide area, as shown above. This SUMMA procedure does not currently provide for FMS.

Both the SUMMA and MOUNTAIN procedures are used during heavy traffic hours from roughly 6 a.m. to 10 p.m. During nighttime hours, when operating demand allows, traffic that would normally use these procedures is directed west through Elliott Bay.

Based on data collected during this study of jet departures in a north flow, about 55-65 percent of departures (about 227 jets daily) use the East Turn. Of the East Turn jet departures, about 55 percent follow SUMMA and 45 percent follow MOUNTAIN.

Some current air traffic procedures are designed for navigation equipment that is less precise than newer technology makes possible. As a result, there is a natural dispersion of aircraft turning in somewhat different places, causing noise to spread over a larger area on the ground. An FMS procedure would allow newer aircraft, equipped with this technology, to follow a more precise and narrow path. Over time, a greater percentage of aircraft will be able to use this procedure, as older aircraft are replaced by newer models equipped with FMS. In general, the FMS-equipped aircraft are also quieter than those they replace.

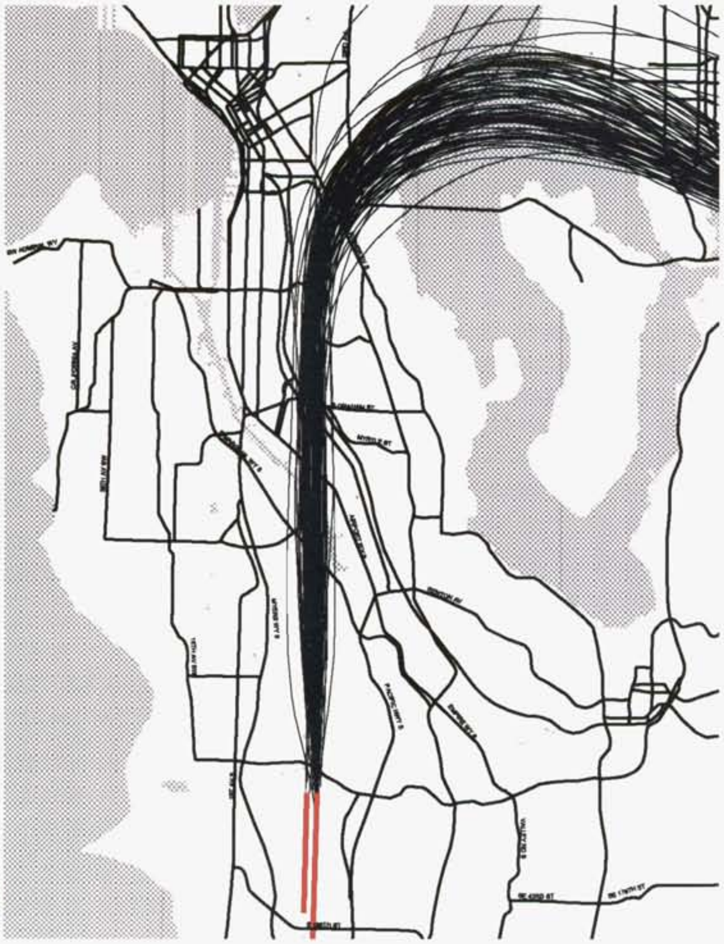
Before a new flight track could be implemented, the FAA would be required to review the impact. It is likely that a NEPA document would be required, which would take 12-18 months to complete. Following completion of the EIS, the FAA would be required to test and implement the track, which could require an additional year.

EAST TURN ALTERNATIVES: Based on a series of meetings of the Operations Subcommittee and Data Subcommittee, two specific track alternatives were considered and addressed separately:

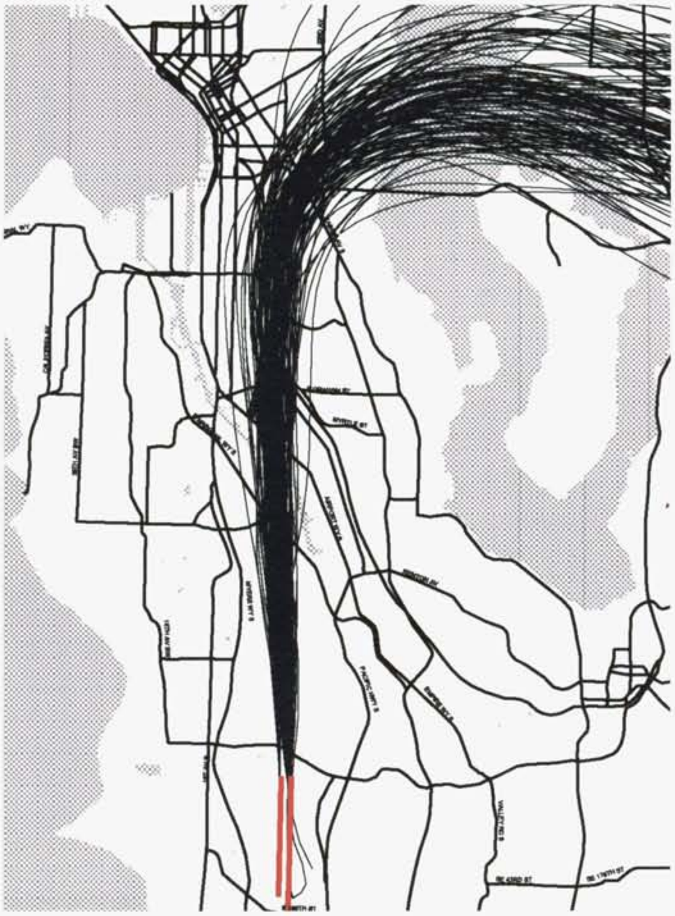
III-18A Split flights on the East Turn into two paths

III-18B Concentrate flights along a path/FMS for all East Turn

The following sections discuss the analysis of both of these flight track options:



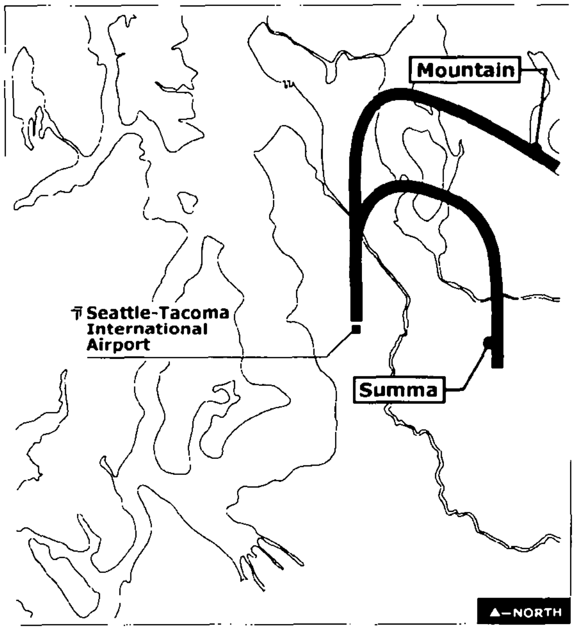
Existing Mountain
Procedure With FMS



Existing Mountain
Procedure Without FMS

E.16 **Existing Mountain Procedure With and Without FMS**

III-18A. Split Flights on East Turn



Operations Sub-committee members suggested that East Turn departures be dispersed to minimize and equalize noise impacts to people. Conceptually, this alternative would mean fanning traffic on multiple departure headings.

Definition: Presented with the idea to disperse or fan north-flow East Turn traffic, FAA ATC determined that such a procedure would not be possible for safety reasons. Safety issues would arise because ATC would be required to separate the departures of fast and slower moving aircraft. Fanning might place a MOUNTAIN departure turning before a SUMMA departure, and the Controller would then be required to cross these flights back again toward the direction of the destination city. This increase in controller workload was considered unsafe.

Based on this FAA assessment of the Operations Sub-committee proposal, Port staff and consultants then met with the FAA to identify procedures that could be implemented that might achieve the objectives identified by the Sub-committee. The procedure that was identified was a split procedure with two corridors: the first for the SUMMA departures, and the second for the MOUNTAIN departures. Figure E17 shows the East Turn corridors.

The SUMMA corridor would turn east at the earliest point possible, just north of Boeing Field, or about 5 DME (Distance Measurement Equipment – the distance from the Sea-Tac VOR, which is located at Sea-Tac). ATC procedures require a minimum separation of three miles both in-trail and lateral, and a greater distance is desirable to maintain adequate separation between flights. Therefore, the MOUNTAIN corridor would be required to turn no sooner than three miles past the SUMMA turn. Based on these FAA criteria, turns at 5 and 9 DME were selected for analysis. Both the MOUNTAIN and SUMMA turns were then assumed to follow their existing turn radius, and MOUNTAIN traffic would proceed east, whereas the SUMMA traffic would proceed southeast. The turn must occur before about 12 DME to avoid regional east-west traffic.

As was defined by Operations Sub-committee, the evaluation of the flight-track options considered:

- Probable number of overflights by geographic area
- Number of people likely to be annoyed by aircraft noise
- Number of people potentially awakened from aircraft noise

North

10000 0 10000 20000 Feet

.17 **Flight Tracks Showing Dispersion**

Departure Tracks

- Number of people experiencing potential speech interference

The following discussions summarize the impacts of the Split East Turn.

Overall Noise Conditions

To evaluate the overall effectiveness in reducing noise exposure, annual DNL noise exposure contours were prepared, as well as a DNL contour reflecting an average day in north flow:

Split East Turn, North Flow
Population Affected (using 1998 Housing Data)

	DNL Noise Exposure			
	Annual Noise Exposure		North-Flow Day	
Contour	Existing	Track III-18A Split Turn	Existing	Track III-18A Split Turn
55 DNL	217,510	217,650	212,710	230,430
60 DNL	111,850	110,670	98,720	96,330
65 DNL	41,960	41,960	31,920	31,920
70 DNL	7,500	7,500	9,860	9,860
75 DNL	0	0	0	0

As the table above shows, the north-flow split turn would result in more people being affected by noise levels above 55 DNL. On an annual basis, a reduction of 1 percent would occur within the 60 DNL noise exposure contour. No other noise exposure contours would be affected. When examining noise exposure conditions on a north-flow day (using a sound-level metric such as the DNL), impacts would increase by 8 percent within the 55 DNL and greater noise contour and decrease by 2.4 percent within the 60 DNL noise contour. As a result, noise exposure within southern Capital Hill would decrease, while impacts to northern Capital Hill and Madrona would increase.

Probable Number of Overflights

Table E5 presents the number of aircraft overflights during north-flow conditions at each of the locations shown in Figure E18. This evaluation was prepared to consider frequency of overflights in each alternative. Table E5 shows that the locations in Leschi, southern Medina, and northern Mercer Island would experience a reduction in overflights while locations in Madrona, northern Medina, Seward Park, and southern Mercer Island would experience an increase in overflights.

Table E5 Number of Overflights

		Number of Flights Exceeding the SEL							
	Pop-	Existing Procedures				Track III.18A (Split East Turn)			
Location	ulation	90 SEL	85 SEL	80 SEL	75 SEL	90 SEL	85 SEL	80 SEL	75 SEL
1	6,034	52	100	193	277	53	88	168	240
2	8,818	0	2	16	51	12	29	61	100
3	7,291	0	4	18	71	7	42	64	117
4	9,878	17	77	129	231	10	34	77	147
5	5,865	2	12	56	127	2	11	43	105
6	6,938	9	49	88	156	2	10	29	70
7	11,787	12	66	97	170	7	24	44	77
8	8,712	11	63	88	156	3	13	31	58
9	10,082	9	63	84	149	3	16	30	55
10	8,903	3	27	69	119	3	18	33	54
11	6,034	0	1	11	50	0	4	16	37
12	2,009	0	4	22	23	1	5	45	60
13	3,153	0	-	1	13	3	29	45	75
14	3,996	0	4	33	42	0	3	31	55
15	4,545	1	7	46	83	-	1	9	38
16	5,140	0	10	60	76	-	1	11	37
17	4,969	2	14	75	93	0	3	17	34
18	1,286	3	15	77	103	1	6	20	36
19	2,389	2	12	72	98	1	9	27	37
20	5,949	0	2	15	65	-	5	19	32
21	2,193	0	1	13	52	0	5	18	32
22	7,639	1	4	23	38	2	9	58	104
23	414	0	-	-	4	-	-	-	4

Figure E.18
North Points

People Highly Annoyed

Based on the updated Schultz Curve, the accepted research on annoyance caused by aircraft noise, the population expected to be highly annoyed was calculated for each flight-track alternative. As one would expect, the percentage of people annoyed increases with the noise level. Because the percentage of annoyed people is proportional to the noise level, this methodology normalizes populations within each noise contour band according to their probable annoyance level. Using this methodology ensures that population predicted to be highly annoyed by any flight-track change is proportional to the noise level they would experience. This normalized or weighted population number is known as Level Weighted Population (LWP) and is based on the following equation:

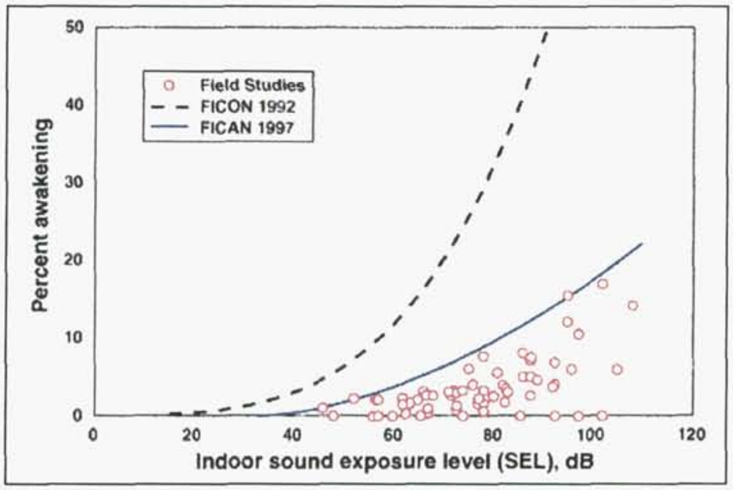
Level Weighted Population = $\Sigma W_i P_i$
P_i = Number of People in each Noise Level Range
W_i = Weighting Factor in that range based upon annoyance curves

Table E6 indicates that the split turn will increase the number of people highly annoyed at the following locations; grid points 2, 3, 10, 11, 12, 13, 20 and 21. The remaining locations will be reduced in the number of people highly annoyed with the implementation of the split east turn.

Table E6 Population Highly Annoyed

	Existing Actual Conditions			Track III.18A Split East Turn		
Location	Sound Level (DNL)	Population at Location	Population Highly Annoyed	Sound Level (DNL)	Population at Location	Population Highly Annoyed
1	62.8	6,034	562	62.7	6,034	555
2	46.6	8,818	91	52.3	8,818	201
3	48.4	7,291	97	52.2	7,291	164
4	59.9	9,878	631	59.3	9,878	583
5	52.8	5,865	144	51.5	5,865	120
6	55.3	6,938	239	52.7	6,938	168
7	56.8	11,787	498	56.7	11,787	491
8	54.9	8,712	284	52.9	8,712	216
9	53.1	10,082	257	52.2	10,082	227
10	50.6	8,903	161	51.6	8,903	185
11	46.8	6,034	64	48.0	6,034	76
12	43.7	2,009	14	46.9	2,009	22
13	39.1	3,153	11	49.3	3,153	48
14	44.6	3,996	31	44.0	3,996	29
15	48.6	4,545	62	43.4	4,545	30
16	48.4	5,140	68	43.7	5,140	36
17	50.4	4,969	87	46.1	4,969	48
18	51.2	1,286	25	47.8	1,286	16
19	49.5	2,389	37	49.3	2,389	36
20	44.8	5,949	48	46.1	5,949	57
21	43.6	2,193	15	46.3	2,193	22

People Potentially Awakened



The probable noise impact from sleep disturbance was evaluated based upon established research from field studies completed in the past 10 years. The applicable metric in this case is the SEL at individual points on the ground, because sleep disturbance is based on the noise level of one or more single flights. Approximately 60 dBA or above interior noise SEL is the level where the research has found sleep disturbance may occur. The sleep disturbance curve produced by the Federal Interagency Committee on Aircraft Noise (FICAN 1997) is reproduced here. This curve, showing indoor SEL, represents the upper limit of the observed field data, and should be interpreted as predicting the maximum percentage of people likely to be awakened for a given residential population. Using these data, the typical worst-case nighttime noise event was used to predict the likely degree of sleep disturbance each flight-track alternative would cause in the Seattle area.

Table E7 Sleep Disturbance

SEL Noise Contour	Percent Population Potentially Awakened (Windows Open/Closed)	Existing Actual Conditions		Track III.18A (Split East Turn)	
		Open Windows # People Possibly Awakened	Closed Windows # of People Possibly Awakened	Open Windows # People Possibly Awakened	Closed Windows # of People Possibly Awakened
	Open/Closed				
105	12%/10%	600	500	600	500
100	11%/9%	900	700	900	700
95	10%/8%	1,900	1,500	1,900	1,500
90	9%/7%	4,400	3,400	6,500	5,000
85	8%/6%	4,700	3,600	6,400	4,800

People Potentially Experiencing Speech Interference

Speech interference is one of the issues most commonly mentioned by the public as a source of annoyance. The term applies not only to conversations, but also to listening to radio and television and talking on the phone. For evaluation of speech interference, the Time Above (TA) is the selected metric, because it measures the number of minutes a day when the noise level exceeds 65 dBA, the noise level where speech interference begins to occur. The ability to communicate decreases as sound levels increase, unless individuals move closer to one another or raise their voices.

People Exposed to Sound Above 65 dBA

	Existing North Flow	III-18A (Split East Turn)
Greater than 150 minutes per day	1,058	1,058
Greater than 120 minutes per day	9,379	9,379
Greater than 90 minutes per day	18,284	18,137
Greater than 60 minutes per day	41,131	35,775
Greater than 30 minutes per day	94,494	86,272
Greater than 10 minutes per day	211,114	258,722

The residences affected by 65 dBA would experience a reduction in time exposed at higher duration locations and an increase at lower duration locations. In comparison to existing conditions, the North Flow Split East Turn Alternative (III-20A) would reduce the number of residences experiencing 60 minutes of noise above 65 dBA by about 13 percent. Residences affected by fewer than 10 minutes above 65 dBA would be increased by 23 percent.

Table E8 Speech Interference

Time Above 65 dBA (percentage)				
	Existing Actual Conditions		III-18A (Split East Turn)	
Location	North-Flow Day	Annual	North-Flow Day	Annual
1	80.4	54.9	76.0	53.5
2	4.3	1.4	20.3	6.4
3	9.5	3.1	22.2	7.1
4	61.3	37.8	43.1	32.0
5	29.7	9.5	21.0	6.8
6	41.5	13.3	23.6	7.7
7	35.9	17.8	28.8	15.6
8	38.7	12.4	23.9	7.8
9	32.3	10.3	23.0	7.4
10	20.1	6.5	21.0	6.8
11	2.2	0.7	7.3	2.4
12	4.7	1.5	11.9	3.8
13	0.0	0.0	14.2	4.5
14	7.1	2.3	5.6	1.8
15	16.7	5.4	2.7	0.9
16	20.3	6.5	3.9	1.3
17	27.6	8.9	9.2	3.0
18	30.2	9.7	14.1	4.6
19	21.4	6.9	17.9	5.8
20	3.7	1.2	9.9	3.2
21	2.4	0.8	9.6	3.1

The above table shows that locations 2, 3, 10, 11, 12, 13, 20 and 21 will increase in the number of minutes they experience above 65 dBA, on both an annual and north-flow basis. Location 13 shows the greatest increase in time-above 65 dBA.

III-18B. FMS for All East Turns

Definition: This flight-track alternative would result in the definition of an FMS track for the SUMMA corridor, as it is the only East Turn track for which an FMS procedure does not exist. The track would follow the existing track, but because the track would use FMS technology, aircraft using this procedure would more closely follow the over-water departure track.

Impact: As was defined previously, the evaluation of the flight-track options considered:

- Probable number of overflights by geographic area
- Number of people likely to be annoyed by aircraft noise
- Number of people potentially awakened from aircraft noise
- Number of people experiencing potential speech interference

The following discussions summarize the impacts of the FMS East Turn.

Overall Noise Conditions

To evaluate the overall effectiveness in reducing noise exposure, annual DNL noise exposure contours were prepared, as well as a DNL contour reflecting an average day in north flow:

FMS East Turn, North Flow
Population Affected (1998 Housing Data)

	DNL Noise Exposure			
	Annual Noise Exposure		North Flow Day	
Contour	Existing	Track III-18B FMS Turn	Existing	Track III-18B FMS Turn
55 DNL	217,510	217,510	212,710	209,230
60 DNL	111,850	111,850	98,720	98,720
65 DNL	41,960	41,960	31,920	31,920
70 DNL	7,500	7,500	9,860	9,860
75 DNL	0	0	0	0

As the table above shows, the north-flow split turn would result in slightly fewer people being affected by noise levels above 55 DNL. On an annual basis, there would be no change. When examining noise exposure conditions on a north-flow day (using a sound-level metric such as the DNL), impacts would reduce by 2 percent within the 55 DNL and greater noise exposure contour.

Probable Number of Overflights

Table E9 presents the number of aircraft overflights on a north-flow day at each of the locations shown in Figure E18. This evaluation was prepared to consider frequency of overflights in each alternative. Table E9 shows that the locations in Leschi and central Median would experience a reduction in overflights while locations in Madrona, the south tip of Medina, and northern Mercer Island would experience an increase in overflights.

Table E9 Number of Overflights

		Number of Flights Exceeding the SEL							
	Pop-	Existing Procedures				Track III.18B (FMS East Turn)			
Location	ulation	90 SEL	85 SEL	80 SEL	75 SEL	90 SEL	85 SEL	80 SEL	75 SEL
1	6,034	277	193	100	52	277	193	100	52
2	8,818	51	16	2	-	51	16	2	-
3	7,291	71	18	4	-	71	18	4	-
4	9,878	231	129	77	17	231	132	77	17
5	5,865	127	56	12	2	127	56	12	2
6	6,938	156	88	49	9	158	89	60	10
7	11,787	170	97	66	12	170	97	59	12
8	8,712	156	88	63	11	157	88	71	11
9	10,082	149	84	63	9	151	85	65	11
10	8,903	119	69	27	3	109	76	14	2
11	6,034	50	11	1	-	37	13	0	-
12	2,009	23	22	4	-	17	16	4	-
13	3,153	13	1	-	-	6	-	-	-
14	3,996	42	33	4	-	43	35	4	-
15	4,545	83	46	7	1	87	70	10	-
16	5,140	76	60	10	0	86	72	11	0
17	4,969	93	75	14	2	100	77	15	3
18	1,286	103	77	15	3	108	79	17	4
19	2,389	98	72	12	2	96	66	12	-
20	5,949	65	15	2	-	70	11	-	-
21	2,193	52	13	1	-	47	11	-	-

People Highly Annoyed

Based on the Schultz Curve, the accepted research on annoyance caused by aircraft noise, the population expected to be highly annoyed was calculated for each flight-track alternative. As one would expect, the percentage of people annoyed increases with the noise level. Because the percentage of annoyed people is proportional to the noise level, this methodology normalizes populations within each noise contour band according to their probable annoyance level. Using this methodology ensures that population predicted to be highly annoyed by any flight-track change is proportional to the noise level they would experience. This normalized or weighted population number is known as Level Weighted Population (LWP) and is based on the following equation:

Level Weighted Population = $\Sigma W_i P_i$
P_i = Number of People in each Noise Level Range
W_i = Weighting Factor in that range based upon annoyance curves

As can be seen in Table E10 on the following page, grid point locations 3, 4, 5, 6, 8, 14, 15, 16, 17 and 18 show increases in the number of people highly annoyed with the implementation of the FMS east turn procedure.

Table E10 Population Highly Annoyed

Location	Existing Actual Conditions			Track III.18B FMS East Turn		
	Sound Level (DNL)	Population at Location	Population Highly Annoyed	Sound Level (DNL)	Population at Location	Population Highly Annoyed
1	62.8	6,034	562	62.7	6,034	562
2	46.6	8,818	91	52.3	8,818	91
3	48.4	7,291	97	52.2	7,291	98
4	59.9	9,878	631	59.3	9,878	640
5	52.8	5,865	144	51.5	5,865	146
6	55.3	6,938	239	52.7	6,938	242
7	56.8	11,787	498	56.7	11,787	491
8	54.9	8,712	284	52.9	8,712	288
9	53.1	10,082	257	52.2	10,082	257
10	50.6	8,903	161	51.6	8,903	144
11	46.8	6,034	64	48.0	6,034	62
12	43.7	2,009	14	46.9	2,009	14
13	39.1	3,153	11	49.3	3,153	11
14	44.6	3,996	31	44.0	3,996	33
15	48.6	4,545	62	43.4	4,545	68
16	48.4	5,140	68	43.7	5,140	74
17	50.4	4,969	87	46.1	4,969	95
18	51.2	1,286	25	47.8	1,286	26
19	49.5	2,389	37	49.3	2,389	32
20	44.8	5,949	48	46.1	5,949	41
21	43.6	2,193	15	46.3	2,193	12

People Potentially Awakened

The probable noise impact from sleep disturbance was evaluated based upon established research from field studies completed in the past 10 years. The applicable metric in this case is the SEL at individual points on the ground, because sleep disturbance is based on the noise level of one or more single flights. Approximately 60 dBA or above interior noise SEL is the level where the research has found sleep disturbance may occur. The sleep disturbance curve produced by the Federal Interagency Committee on Aircraft Noise (FICAN 1997) was presented earlier. This curve, showing indoor SEL, represents the upper limit of the observed field data, and should be interpreted as predicting the maximum percentage of people likely to be awakened for a given residential population. Using this data, the typical worst-case nighttime noise event was used to predict the likely degree of sleep disturbance each flight-track alternative would cause in the Seattle area.

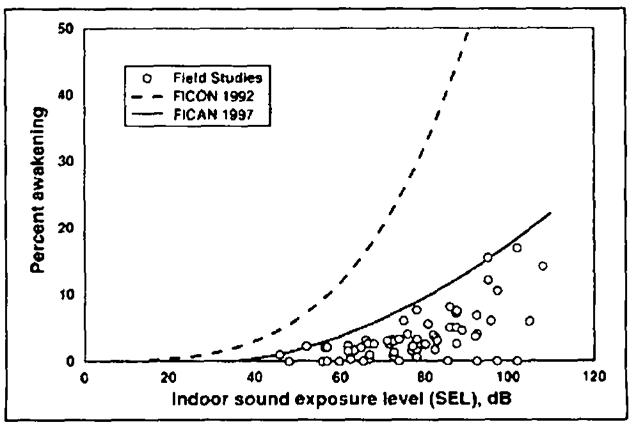


Table E11 Sleep Disturbance (Windows Open)

SEL Noise Contour	Percent Population Potentially Awakened (Open windows/closed)	Existing Actual Conditions		Track III.18B (FMS East Turn)	
		Open Windows # People Possibly Awakened	Closed Windows # of People Possibly Awakened	Open Windows # People Possibly Awakened	Closed Windows # of People Possibly Awakened
105	12%/10%	600	500	600	500
100	11%/9%	900	700	900	700
95	10%/8%	1,900	1,500	1,900	1,500
90	9%/7%	4,400	3,400	4,400	3,300
85	8%/6%	4,700	3,600	4,700	3,000

As the table above shows, the number of people possibly awakened as a result of this flight-track alternative would decrease within the lower SEL levels. Specifically, about 100 fewer people would possibly be awakened by SEL 90, and about 600 fewer people would be awakened by SEL 85 with windows closed. With windows opened, no quantifiable difference would exist.

People Potentially Experiencing Speech Interference

Speech interference is one of the issues most commonly mentioned by the public as a source of annoyance. The term applies not only to conversations, but also to listening to radio, television, and talking on the phone. For evaluation of speech interference, the Time Above (TA) is the selected metric, because it measures the number of minutes a day when the noise level exceeds 65 dBA, the noise level where speech interference begins to occur. The ability to communicate decreases as sound levels increase, unless individuals move closer to one another or raise their voices.

Population Exposed to Sound Above 65 dBA

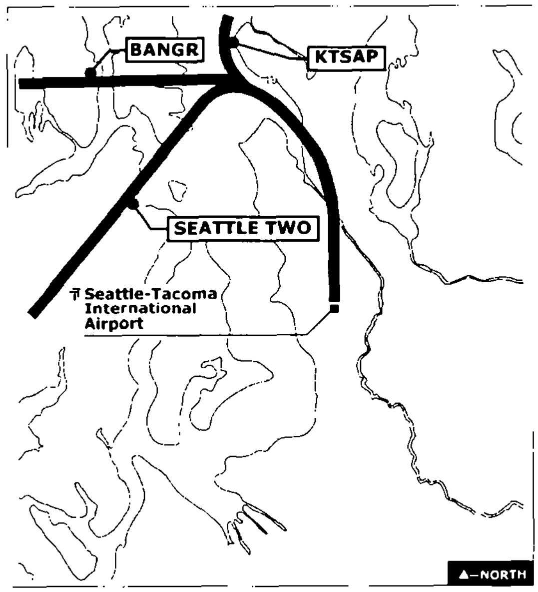
	Existing North Flow	III-18B (FMS East Turn)
Greater than 150 minutes per day	1,058	1,058
Greater than 120 minutes per day	9,379	9,379
Greater than 90 minutes per day	18,284	18,284
Greater than 60 minutes per day	41,131	41,131
Greater than 30 minutes per day	94,494	94,269
Greater than 10 minutes per day	211,114	204,146

The residences affected by 65 dBA would experience a reduction in time exposed at higher duration locations and an increase at lower duration locations. In comparison to existing conditions, the North-Flow FMS East Turn Alternative (III-18B) would not change the number of residences experiencing 60 minutes of noise above 65 dBA. Residences affected by fewer than 10 minutes above 65 dBA would be reduced by 3 percent.

Table E12 Speech Interference

Time Above 65 dBA (percentage)				
	Existing Actual Conditions		III-18B (FMS East Turn)	
Location	North-Flow Day	Annual	North-Flow Day	Annual
1	80.4	54.9	80.5	54.9
2	4.3	1.4	4.3	1.4
3	9.5	3.1	9.6	3.1
4	61.3	37.8	61.5	37.8
5	29.7	9.5	30.4	9.8
6	41.5	13.3	42.7	13.7
7	35.9	17.8	35.5	17.7
8	38.7	12.4	39.7	12.8
9	32.3	10.3	31.9	10.2
10	20.1	6.5	18.0	5.8
11	2.2	0.7	1.4	0.5
12	4.7	1.5	6.0	1.9
13	0.0	0.0	0.0	0.0
14	7.1	2.3	8.3	2.6
15	16.7	5.4	22.3	7.2
16	20.3	6.5	23.6	7.6
17	27.6	8.9	30.0	9.6
18	30.2	9.7	30.8	9.9
19	21.4	6.9	18.8	6.1
20	3.7	1.2	0.6	0.2
21	2.4	0.8	0.3	0.1

3.19 Use of the Elliott Bay Corridor for Jet Departures



This alternative involves implementing FMS procedures for all jet departure routes using Elliott Bay.

Currently, there are three procedures that utilize Elliott Bay for jet departure during north-flow conditions. These procedures are:

- ✓ ELMAA: Aircraft depart over Elliott Bay and then turn back to the south for Northern California destinations.
- ✓ BANGR: Aircraft depart over Elliott Bay and then head westward to destinations in Alaska and the orient.
- ✓ KTSAP: Aircraft depart over Elliott Bay and then turn northward up the Puget Sound until reaching 10,000 feet when the aircraft turns back to the east. The procedure is the noise-abatement procedure for nighttime eastbound aircraft.

Both BANGR and KTSAP have FMS procedures in place. Figure E19 presents flight tracks for SEATTLE TWO, where there is currently no FMS procedure. Figure E20 presents the flight tracks for the BANGR procedure both with and without FMS. It is necessary to have both FMS and traditional procedures in effect as many, mostly older, aircraft, are not FMS-equipped. The data show a much higher level of precision for the FMS procedure.

One of the region's most effective noise-abatement departure procedures involves following the Duwamish River to Elliott Bay. The optimum procedure involves overflying the industrial area and the over-water area to the maximum extent possible. FMS technology offers the opportunity to further improve this flight track, by keeping aircraft even closer to the optimum track along the river and through the middle of the Bay.

As discussed above, FMS technology enables aircraft to stay more closely to the established noise-abatement flight track. Because the Elliott Bay corridor is an over-the-water route, staying in the Bay and avoiding both West Seattle and Magnolia is a desirable action. This procedure would also reduce the overflights in the northern sections of Beacon Hill.

Before a new flight track could be implemented, the FAA would be required to review the impact. It is likely that a NEPA document would be required, which would require 12 to 18 months to complete. Following completion of the document, the FAA would be required to test and implement the track, which could take an additional year.

E.19 **Seattle Two Departure Without FMS**

During Operations Sub-committee meetings, the following alternatives were identified and evaluated separately:

III-19A	Increase departures in north flow through Elliott Bay
III-19B	Develop FMS procedures for all Elliott Bay departures

III-19A. Increase Departures in North Flow through Elliott Bay

Definition: The Operations Sub-committee requested the FAA to define the capacity of the Elliott Bay corridor. The purpose of this information is to determine whether it is possible to achieve an objective of the Committee: to direct additional north-flow departures into that corridor.

Currently about one-third of daytime traffic in north flow uses the Elliott Bay/Duwamish corridor. Of jet departures in a north flow for an average annual day in 1998, about 37 percent or 144 jet departures flew through the Elliott Bay corridor, 4 percent departed on a straight track through Seattle, and 59 percent took the East Turn. Nearly all nighttime north-flow departures between 10 p.m. and 6 a.m. follow the Elliott Bay corridor. In addition to handling the Sea-Tac traffic, the Elliott Bay corridor accommodates departures from Boeing Field, which account for approximately 50 additional jet departures per day and over 500 propeller aircraft departures.

The capacity of the Elliott Bay corridor is not easy to define, as the answer involves airspace along the Pacific coast considerably south of Seattle. Although the capability of the area between Bainbridge Island and Boeing Field is greater than the volume of aircraft currently flying through this airspace, sending a greater volume of aircraft from destinations currently not utilizing this corridor could place severe constraints on the air traffic controllers.

Currently, traffic bound for northern California and Oregon as well as cities in Alaska and the Pacific Rim is directed to the Elliott Bay corridor. Placing more traffic in this corridor would require diverting some of the aircraft on the east turn into this corridor. An evaluation of aircraft operating on the East Turn showed that departures to southern California cities represent about 20 percent of jet departures (42 departures daily) in north flow. Some of these flights were identified by the consulting team as possibilities to be turned west rather than east.

Discussions were conducted with FAA ATC to determine if the southern California jet departures could, in fact, be directed into Elliott Bay. ATC concluded, following a preliminary analysis, that it would not be possible to add the southern California traffic to this corridor due to limitations in the airspace south of Seattle. The reason for the ATC's position is that southern California aircraft approach their respective destinations from an easterly direction. These California cities are geographically east of Seattle, thus, if California flights departed to the west, controllers in either Seattle or south of Seattle would be required to coordinate crossing these departures back-over to the east.

Because of congestion in the southern California airspace, aircraft are often lined-up during busy periods for 400-600 miles into Los Angeles. As a result, the crossover back to the east would likely occur somewhere between Eugene, Oregon (so as to avoid interference with Portland's airspace) and north of the San Francisco Bay area airspace. This airspace is outside the control of FAA management in the Seattle area, and any changes would need to recognize overall airspace requirements in those busy locations. The evaluation of airspace issues outside the Seattle area is beyond the means of the consultants' effort for the Sea-Tac Airport FAR Part 150.

Impact: Modeling was not performed, as this action is not feasible at this time.

III-19B. Develop FMS Procedures for all Elliott Bay Departures

Definition: Development of FMS procedures for all Elliott Bay departures would require an FMS procedure for the SEATTLE TWO departure. This procedure would improve the accuracy of overflights of Bainbridge and Vashon Island as northern California departures proceed to their destination.

Impact: Modeling was not performed for this track, as it would not influence impacts within the annual DNL noise exposure contours. However, as is shown in Figure E20, the FMS technology could concentrate aircraft overflights over Puget Sound. Thus, noise would not be shifted to residential areas, and SEL and Time Above exposure would be expected to decrease.

An analysis of the measurement data shows that the aircraft, which currently disperse over neighborhoods north and south of Elliott Bay, would remain much more over water with this procedure in place. Currently without FMS, about 90 percent of the aircraft fly between Magnolia and Alki Point in a corridor about 8,000 feet wide. For FMS aircraft, the width of that corridor is less than 2,000 feet. As more aircraft entering the fleet are equipped with FMS, adherence to this procedure will become more common.

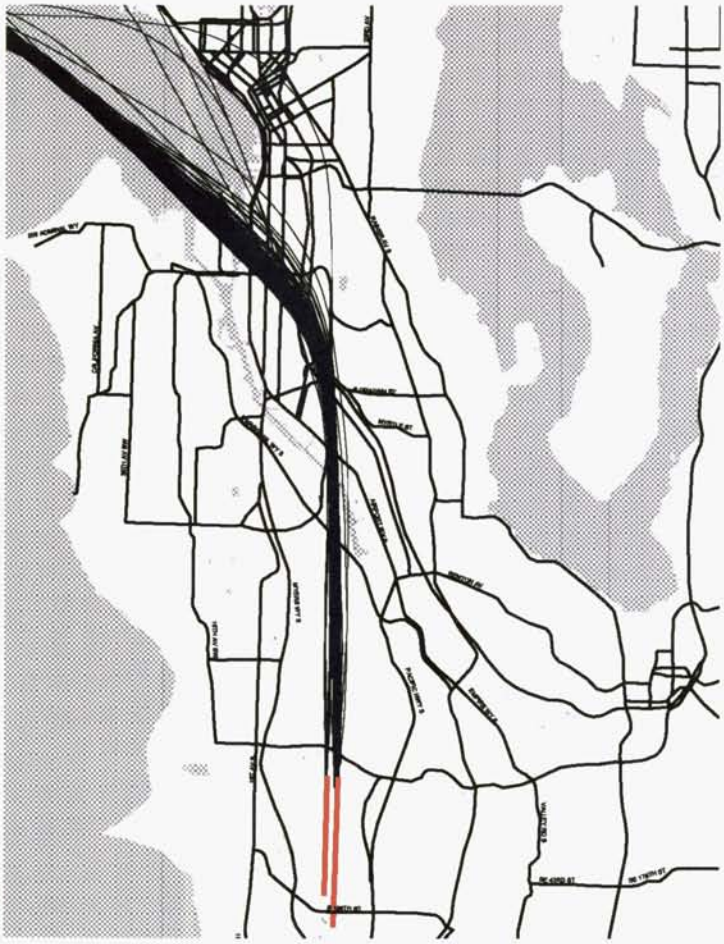
Before a new flight track could be implemented, the FAA would be required to review the impact. It is likely that a NEPA document would be required, which would require 12 to 18 months to complete. Following completion of the document, the FAA would be required to test and implement the track, which could take an additional year.

At this time, increased use of the Elliott Bay corridor (III-19A) is not possible due to capacity of the broader airspace. While there is capacity in the Duwamish/Elliott Bay itself, there is not sufficient capacity to direct the added traffic to their destinations.

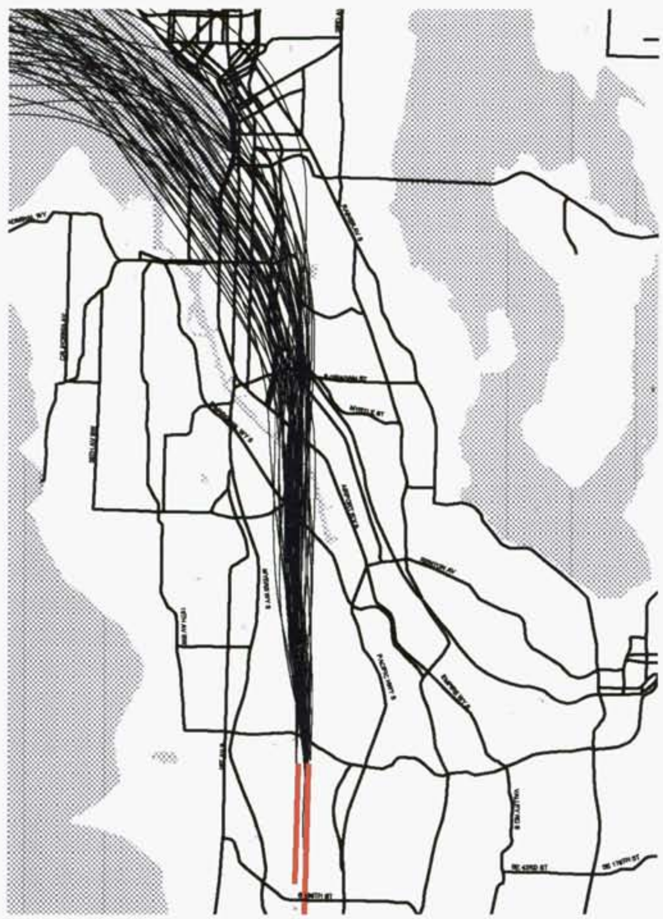
3.20 South-Flow Departure Tracks

This action would evaluate implementation of a "minimum population impact" flight track(s) for South Flow.

South-flow operations occur about 65 to 70 percent of the time. Westbound traffic follows one of two procedures with the air traffic designations:



Bangr Procedure With FMS



Bangr Procedure Without FMS

North 20000 0 20000 40000 Feet

E.20 **Bangr Procedure With FMS and Without FMS**

ELMAA for northern California destinations;
BANGR for destinations in Alaska and Asia.

In addition, there are four procedures for eastbound traffic:

MOUNTAIN4 for destinations to east coast cities;
BLUITT FMS procedure for eastbound;
SUMMA5 for central states;
SEATTLE2 for destinations to southern California.

South-flow westbound aircraft currently passes over Federal Way on the way to Puget Sound and ultimately to destinations in the northwest and south. Southbound departures continue on runway centerline (straight) south, while eastbound traffic turns east over central Auburn (near SR 18).

Over the years, communities south of the Airport have worked with the FAA to identify alternative tracks for south-flow departures. The FAA has not agreed to these changes for a variety of reasons including conflicts with the arrival aircraft and lack of consensus among all affected communities.

Shifting flights from communities south of the Airport (Des Moines and Federal Way) to industrial corridors or waterways could reduce the number of residences exposed to single-event noise levels and reduce noise exposure time.

However, the Port's existing Noise Remedy Program boundaries have been designed in such a manner so as to acquire the most severely affected residential properties, and to sound-insulate properties that are affected by 65 DNL and greater sound levels. A change in the south-flow departure corridor, depending upon how close to the Airport it would occur, could reduce noise to some of the most severely affected residences (but those which have been insulated) and increase noise exposure to residences along the new corridors. Therefore, before a new flight track or corridor could be implemented, the FAA would be required to review the impact. It is likely that a NEPA EIS would be required, which would require about 12 to 18 months to complete. Following completion of the EIS, the FAA would be required to test and implement the track, which could take an additional year.

During the Sub-committee meetings, the following alternatives were identified:

III-20A	Use of I-5 Corridor to minimize effects on people
III-20B	Use of dispersed tracks to minimize effects on people
III-20C	Nighttime west turn track through Commencement Bay

As was defined at the Sub-committee meeting in September 1999, the evaluation of the flight-track options considered, for each one separately:

- Probable number of overflights by geographic area
- Number of people likely to be annoyed by aircraft noise
- Number of people potentially awakened from aircraft noise
- Number of people experiencing potential speech interference

The following discussions summarize the impacts of the south-flow tracks options.

III-20A Use of the I-5 Corridor to Minimize Effects

Definition: The Operations Sub-committee recommended that all south-flow departures be turned into the Kent Valley, instead of flying straight for a distance, to direct aircraft over the Kent industrial corridor. This track would require aircraft to turn soon after departure to the east and then, when over the Kent Valley, turn south creating an "S" turn. Based on discussions with FAA ATC, substantial delays would occur from requiring all aircraft to turn into this corridor. Additional navigational equipment would also be required to achieve an "S" turn.

Delays would result, as increased separation and coordination would be required for the propeller aircraft, which would be required to turn sooner than defined by current procedures. As a result, propeller aircraft from Sea-Tac would be turned into the traffic using Boeing Field, which would require increased coordination and aircraft separation. Because of the high volume of commuter aircraft, substantial delays would result to ensure a safe operation. Because of these effects, this option was not considered further.

Discussions continued with FAA ATC to identify a procedure that might accommodate the Sub-committee's desire to have aircraft fly over the Kent Valley and Industrial Corridor. The FAA suggested two possible corridors that might achieve a similar effect. This procedure would be a split departure similar to that analyzed in north-flow East Turn. The first procedure would direct about 40 percent of departures along existing flight tracks. The second procedure would turn about 60 percent of departures along a 145 radial, reaching the easterly portion of the Kent Valley at about Kent-Des Moines Road. The 145 radial was chosen as it parallels traffic departing from Boeing Field.

Based on these two corridors, an evaluation of noise effects was performed.

Overall Noise Conditions

To evaluate the overall effectiveness in reducing noise exposure, annual DNL noise exposure contours were prepared, as well as a DNL contour reflecting an average day in south flow:

People Affected (1998 Housing Data)

	DNL Noise Exposure			
	Annual Noise Exposure		South Flow Day	
Contour	Existing	Track III-20A (I-5 Dual Track)	Existing	Track III-20A (I-5 Dual Track)
55 DNL	217,510	223,930	207,880	220,410
60 DNL	111,850	114,080	102,800	107,310
65 DNL	41,960	37,300	44,680	37,650
70 DNL	7,500	7,150	7,610	9,060
75 DNL	-	-	-	-

As the table above shows, the south-flow two-track alternative would result in more people being affected by noise levels above 55 DNL (about 3 percent more people). Within the 65 DNL and greater noise contour, however, residences affected would decrease by 11 percent. On south-flow days, the two-track alternative would result in a 6-percent increase in noise impacts relative to existing conditions within the 55 DNL contour, but a 15-percent reduction within the 65 DNL. Notably, within the 70 DNL, this alternative would increase impacts by19 percent relative to existing conditions.

Probable Number of Overflights

The table below presents the number of aircraft overflights for a south-flow day at each of the locations shown in Figure E21. The evaluation of the number of overflights was prepared to enable consideration of the intensity of each flight-track alternative relative to frequency of overflight.

Table E13 Number of Overflights

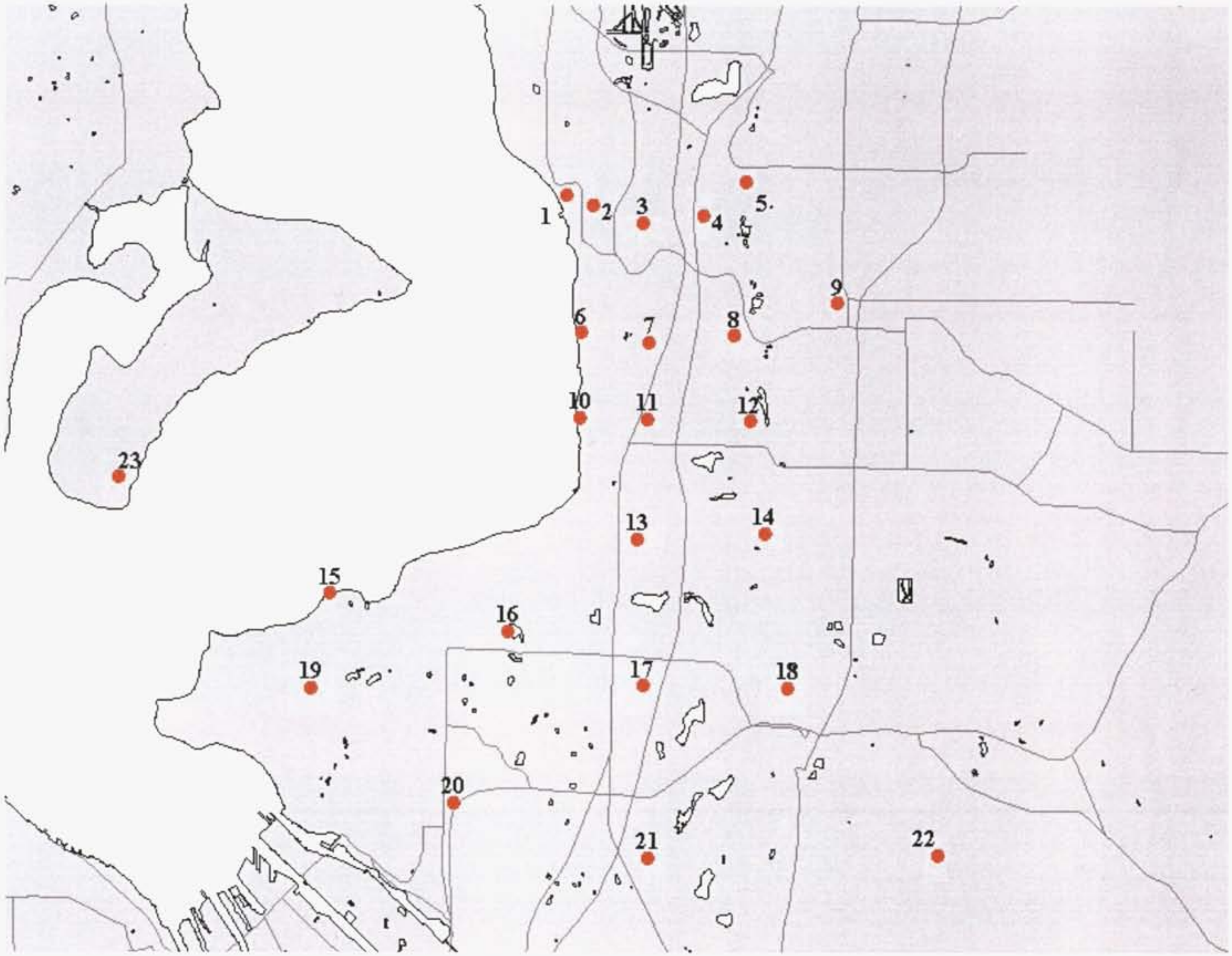
Location	Pop-ulation	Existing Procedures Number of flights exceeding the SEL				Track III.20A (Dual I-5 Tracks) Number of flights exceeding the SEL			
		90 SEL	85 SEL	80 SEL	75 SEL	90 SEL	85 SEL	80 SEL	75 SEL
1	4,243	13	71	148	258	9	41	103	209
2	4,743	67	149	225	314	34	83	179	251
3	7,139	150	286	331	335	100	221	276	329
4	6,086	28	91	186	297	88	174	275	333
5	600	4	20	90	160	7	49	130	223
6	4,849	30	78	179	287	13	39	92	183
7	6,488	119	166	299	333	57	95	215	288
8	4,594	4	21	75	188	62	113	205	285
9	7,615	-	-	5	27	-	4	15	77
10	3,219	29	77	167	275	11	35	83	146
11	6,517	103	151	280	332	48	75	183	244
12	3,521	1	14	50	142	57	95	179	263
13	6,813	89	145	229	327	37	65	112	186
14	3,646	0	8	28	106	19	89	150	238
15	3,984	0	3	23	55	0	3	23	55
16	6,336	5	28	59	145	5	27	51	103
17	4,775	10	87	132	250	3	28	64	137
18	1,166	3	18	42	96	10	73	104	179
19	2,666	2	26	51	100	2	26	51	100
20	4,917	-	3	27	58	-	3	24	51
21	3,396	5	60	65	128	1	9	14	33
22	7,639	1	4	23	38	2	9	58	104
23	414	-	-	-	4	-	-	-	4

Table E13 shows that, as expected, areas east of the existing flight corridors would experience increased overflights (specifically Sites 1, 5, 6, and 16). Sites 4, 13, 14, 15, and 17 would experience decreased number of overflights at higher sound levels relative to the existing condition.

People Likely Annoyed

Based on the Schultz Curve, the accepted research on annoyance caused by aircraft noise, the population expected to be highly annoyed was calculated for each flight-track alternative. As one would expect, the percentage of people annoyed increases with the noise level. Because the percentage of annoyed people is proportional to the noise level, this methodology normalizes populations within each noise contour band according to their probable annoyance level. Using this methodology ensures that population predicted to be highly annoyed by any flight-track change is proportional to the noise level they would experience. This normalized or weighted population number is known as Level Weighted Population (LWP) and is based on the following equation:

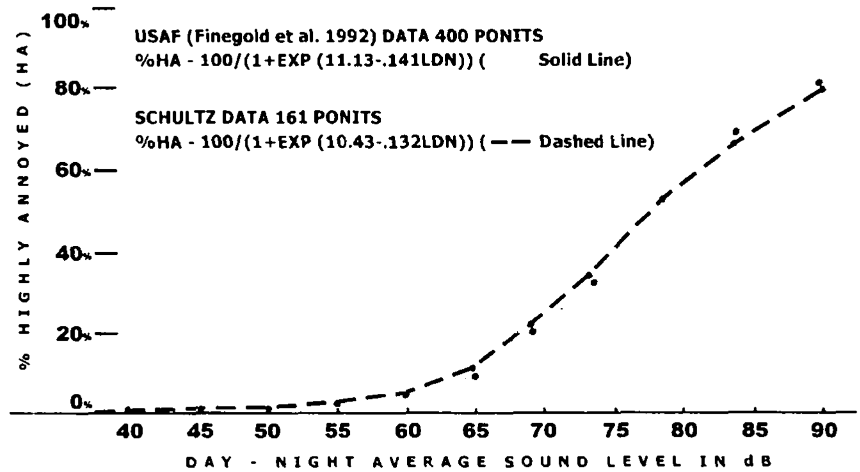
Figure E.21
South Points



Level Weighted Population = $\sum W_i P_i$

P_i = Number of People in each Noise Level Range

W_i = Weighting Factor in that range based upon annoyance curves



USAF	0.40	0.831	1.66	3.31	6.48	12.29	22.1	36.47	53.74	70.16	82.64
SCHULTZ	0.576	1.11	2.12	4.03	7.52	13.59	23.32	37.05	53.25	68.78	81.00

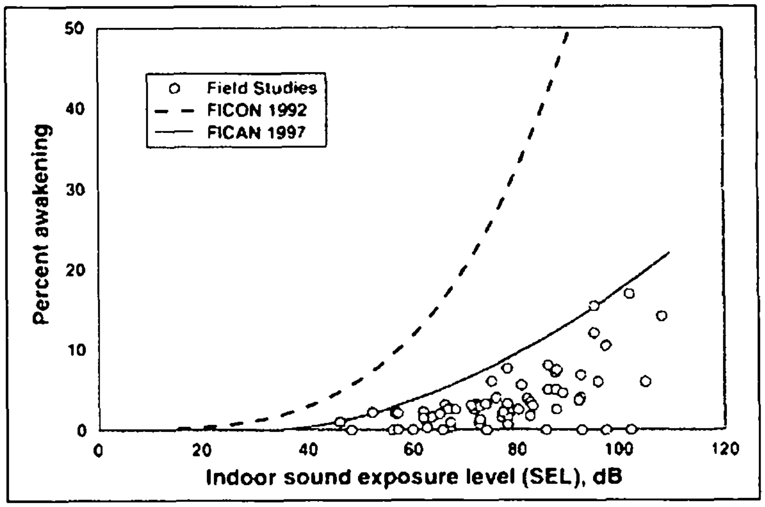
CALCULATED % HIGHLY ANNOYED (HA) POINTS

People Potentially Awakened

The probable noise impact from sleep disturbance was evaluated based upon established research from field studies completed in the past 10 years. The applicable metric in this case is the SEL at individual points on the ground, because sleep disturbance is based on the noise level of one or more single flights. Approximately 60 dBA or above interior noise SEL is the level where the research has found sleep disturbance may occur.

Table E14 Population Highly Annoyed

Location	Existing Actual Conditions			Track III.20A (I-5 Dual Tracks)		
	Sound Level (DNL)	Population at Location	# People Highly Annoyed	Sound Level (DNL)	Population at Location	# People Highly Annoyed
1	60.5	4,243	294	58.5	4,243	225
2	65.5	4,743	620	63.2	4,743	465
3	72.3	7,139	2,012	71.0	7,139	1,758
4	61.4	6,086	473	67.4	6,086	1,000
5	55.8	600	22	58.8	600	33
6	62.9	4,849	458	60.2	4,849	322
7	67.9	6,488	1,130	66.3	6,488	935
8	55.4	4,594	160	63.6	4,594	474
9	48.3	7,615	100	50.6	7,615	138
10	62.1	3,219	274	59.3	3,219	190
11	66.0	6,517	906	64.1	6,517	716
12	52.8	3,521	86	62.4	3,521	312
13	64.5	6,813	787	62.2	6,813	588
14	51.5	3,646	75	61.0	3,646	269
15	49.5	3,984	62	49.4	3,984	61
16	56.7	6,336	264	56.3	6,336	250
17	60.4	4,775	326	57.3	4,775	216
18	54.8	1,166	38	58.7	1,166	64
19	54.4	2,666	81	54.4	2,666	81
20	49.6	4,917	77	49.1	4,917	72
21	55.9	3,396	127	52.7	3,396	82
22	51.7	7,639	161	53.3	7,639	200
23	40.3	414	2	40.2	414	2



The sleep disturbance curve produced by the Federal Interagency Committee on Aircraft Noise (FICAN 1997) is reproduced here. This curve, showing indoor SEL, represents the upper limit of the observed field data, and should be interpreted as predicting the maximum percentage of people likely to be awakened for a given residential population. Using these data, the typical worst-case nighttime noise event was used to predict the likely degree of sleep disturbance each flight-track alternative would cause in the Seattle area.

Table E15 Sleep Disturbance

SEL Noise Contour	Percent Population Potentially Awakened (Windows Open/Closed)	Existing Actual Conditions		Track III.20A (I-5 Dual)	
		Open Windows # People Possibly Awakened	Closed Windows # of People Possibly Awakened	Open Windows # People Possibly Awakened	Closed Windows # of People Possibly Awakened
110	13%/11%	-		-	-
105	12%/10%	500	400	500	400
100	11%/9%	1,300	1,100	1,800	1,400
95	10%/8%	2,900	2,300	3,000	2,300
90	9%/7%	4,500	3,500	5,300	4,100
85	8%/6%	5,600	4,300	5,300	4,000

People Potentially Experiencing Speech Interference

Speech interference is one of the issues most commonly mentioned by the public as a source of annoyance. The term applies not only to conversations, but also to listening to radio, television, and talking on the phone. For evaluation of speech interference, the Time Above (TA) is the selected metric, because it measures the number of minutes a day when the noise level exceeds 65 dBA, the noise level where speech interference begins to occur. The ability to communicate decreases as sound levels increase, unless individuals move closer to one another or raise their voices.

People Exposed to Sound Above 65 dBA

	Existing Annual	III-20A (I-5/Duel Track)
Greater than 150 minutes per day	51	103
Greater than 120 minutes per day	4,243	1,166
Greater than 90 minutes per day	14,742	11,569
Greater than 60 minutes per day	44,872	31,304
Greater than 30 minutes per day	79,752	78,260
Greater than 10 minutes per day	149,391	153,850

The residences affected by 65 dBA would experience a reduction in time exposed at higher duration locations and an increase at lower duration locations. In comparison to existing conditions, the south-flow, two-track alternative (III-20A) would reduce the number of residences experiencing 90 minutes of noise above 65 dBA daily by about 37 percent. Residences affected by fewer than 10 minutes above 65 dBA daily would be increased by 3 percent.

TableE16 Speech Interference

	Time Above 65 dBA					
	Existing Actual Conditions			III-20A (I-5 Dual Tracks)		
Location	Population	South Flow	Annual	Population	South Flow	Annual
1	4,243	63.9	43.5	4,243	39.7	27.0
2	4,743	102.0	73.6	4,743	69.9	51.5
3	7,139	137.9	130.6	7,139	122.3	119.9
4	6,086	71.5	48.8	6,086	106.2	72.7
5	600	28.5	20.2	600	52.2	35.7
6	4,849	73.9	52.2	4,849	37.0	26.9
7	6,488	106.6	98.7	6,488	82.8	82.3
8	4,594	25	16.9	4,594	68.9	47.1
9	7,615	0	0	7,615	4.1	2.8
10	3,219	63.2	44.9	3,219	28.2	21.0
11	6,517	90.8	83.5	6,517	60.8	62.5
12	3,521	12.6	8.4	3,521	56.4	38.6
13	6,813	80.5	77.6	6,813	40.9	49.2
14	3,646	8.8	5.8	3,646	50.0	34.2
15	3,984	4.2	2.8	3,984	4.1	2.8
16	6,336	20.8	13.5	6,336	17.2	11.8
17	4,775	46.9	42.8	4,775	17.9	21.8
18	1,166	19.2	12.7	1,166	38.9	26.6
19	2,666	13.6	9.3	2,666	13.5	9.3
20	4,917	3.8	2.4	4,917	3.6	2.5
21	3,396	20.6	16.9	3,396	6.8	6.7
22	7,639	12.7	8.6	7,639	17.2	11.7
23	414	0	0	414	0.0	0.0

As Table E16 shows, locations 1,5, 6 and 16 (east of the current departure corridor) would experience an average annual day increase in noise above 65 dBA of 13 to 24 minutes a day. During south-flow days, these locations would experience an increase in sound above 65 dBA of 19 to 35 minutes per day. Conversely, locations directly under the existing runway centerline would experience the greatest reductions. On an average annual day, sites 9, 7, 8, 10, 4 and 13 would experience a reduction in time above 65 dBA from between 10 and 28 minutes per day. On south-flow departure days, this alternative would decrease exposure to 65 dBA by between 16 and 40 minutes per day.

III-20B South Flow Three Track Alternative

In addition to the two-track Alternative III-20A, the consultants identified a second procedure that could further reduce impacts, to those communities south of the Airport, by using the Kent Valley and Puget Sound. This track would effectively develop three corridors to the south: the two defined in Alternative III-20A, and a new westbound track, which would reach the Puget Sound more directly than the current procedure. Figure E22 depicts these corridors.

E.22 **Flight Track Showing Three Track Dispersion**

Departure Tracks

Overall Noise Conditions

Two noise contours were evaluated: the annual DNL noise exposure and an evaluation of the DNL on an average south-flow day.

Population Affected (1998 Housing Data)

	DNL Noise Exposure			
	Annual Noise Exposure		South-Flow Day	
	Existing	Track III-20B Three Track	Existing	Track III-20B Three Track
55 DNL	217,510	200,620	207,880	179,400
60 DNL	111,850	103,710	102,800	87,370
65 DNL	41,960	36,140	44,680	32,780
70 DNL	7,500	5,350	7,610	7,440
75 DNL	-	-	-	-

As the table above shows, the number of people affected on an annual average and an average south-flow day would decrease in all noise contours with this flight track scenario. On an annual basis, the population affected by 55 DNL would decrease by about 8 percent within 55 DNL, and 14 percent within 65 DNL, and 29 percent within 70 DNL relative to existing conditions. On an average south-flow day, the impacts would decrease about 14 percent, 27 percent and 2 percent in the 55, 65, and 70 DNL, respectively. Impacts would decrease in southern Des Moines and Federal Way, and increase in southern Normandy Park, western/eastern Des Moines, and southern SeaTac.

Probable Number of Overflights

The table below presents the number of aircraft overflights at each of the locations shown in Figure E21. The evaluation of the number of overflights was prepared to enable consideration of the intensity of each flight-track alternative relative to frequency of overflight.

Table E17 shows that, as expected, areas east of the existing flight corridors would experience increased overflights (locations 1, 5, 6, and 16). All other sites would experience decreased number of overflights at higher sound levels relative to the existing condition.

Table E17 Number of Overflights

Location	Pop-ulation	Existing Procedures Number of flights exceeding the SEL				Track III.20B (Three South Tracks) Number of flights exceeding the SEL			
		90 SEL	85 SEL	80 SEL	75 SEL	90 SEL	85 SEL	80 SEL	75 SEL
1	4,243	13	71	148	258	48	117	163	220
2	4,743	67	149	225	314	48	113	205	251
3	7,139	150	286	331	335	59	140	215	303
4	6,086	28	91	186	297	81	149	233	274
5	600	4	20	90	160	7	43	111	204
6	4,849	30	78	179	287	8	29	62	159
7	6,488	119	166	299	333	20	50	119	207
8	4,594	4	21	75	188	60	104	180	230
9	7,615	-	-	5	27	-	4	14	66
10	3,219	29	77	167	275	4	14	38	85
11	6,517	103	151	280	332	13	28	84	151
12	3,521	1	14	50	142	57	89	162	219
13	6,813	89	145	229	327	8	20	36	88
14	3,646	0	8	28	106	19	86	139	205
15	3,984	0	3	23	55	6	29	47	104
16	6,336	5	28	59	145	1	2	11	34
17	4,775	10	87	132	250	1	12	26	61
18	1,166	3	18	42	96	10	73	102	168
19	2,666	2	26	51	100	1	7	23	52
20	4,917	-	3	27	58	-	-	2	7
21	3,396	5	60	65	128	1	9	13	25
22	7,639	1	4	23	38	2	9	58	104
23	414	-	-	-	4	0	5	23	55

People Likely Annoyed

Based on the Schultz Curve, the accepted research on annoyance caused by aircraft noise, the population expected to be highly annoyed was calculated for each flight-track alternative. As one would expect, the percentage of people annoyed increases with the noise level. Because the percentage of annoyed people is proportional to the noise level, this methodology normalizes populations within each noise contour band according to their probable annoyance level. Using this methodology ensures that population predicted to be highly annoyed by any flight-track change is proportional to the noise level they would experience. This normalized or weighted population number is known as Level Weighted Population (LWP) and is based on the following equation:

Level Weighted Population = $\sum W_i P_i$

P_i = Number of People in each Noise Level Range

W_i = Weighting Factor in that range based upon annoyance curves

Table E18 Population Highly Annoyed

Location	Existing Actual Conditions			Track III.20B (Three South Tracks)		
	Sound Level (DNL)	Population at Location	# People Highly Annoyed	Sound Level (DNL)	Population at Location	# People Highly Annoyed
1	60.5	4,243	294	58.5	4,243	697
2	65.5	4,743	620	63.2	4,743	683
3	72.3	7,139	2,012	71.0	7,139	1,364
4	61.4	6,086	473	67.4	6,086	965
5	55.8	600	22	58.8	600	31
6	62.9	4,849	458	60.2	4,849	244
7	67.9	6,488	1,130	66.3	6,488	661
8	55.4	4,594	160	63.6	4,594	462
9	48.3	7,615	100	50.6	7,615	132
10	62.1	3,219	274	59.3	3,219	120
11	66.0	6,517	906	64.1	6,517	488
12	52.8	3,521	86	62.4	3,521	304
13	64.5	6,813	787	62.2	6,813	402
14	51.5	3,646	75	61.0	3,646	266
15	49.5	3,984	62	49.4	3,984	139
16	56.7	6,336	264	56.3	6,336	102
17	60.4	4,775	326	57.3	4,775	181
18	54.8	1,166	38	58.7	1,166	64
19	54.4	2,666	81	54.4	2,666	43
20	49.6	4,917	77	49.1	4,917	29
21	55.9	3,396	127	52.7	3,396	81
22	51.7	7,639	161	53.3	7,639	200
23	40.3	414	2	40.2	414	7

People Potentially Awakened

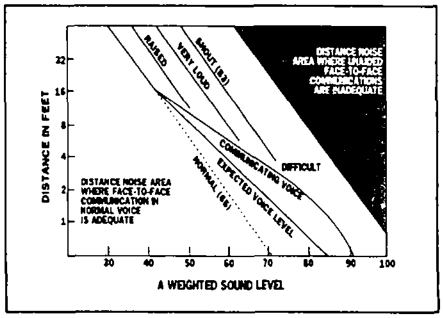
The probable noise impact from sleep disturbance was evaluated based upon established research from field studies completed in the past 10 years. The applicable metric in this case is the SEL at individual points on the ground, because sleep disturbance is based on the noise level of one or more single flights. Approximately 60 dBA or above interior noise SEL is the level where the research has found sleep disturbance may occur.

The sleep disturbance curve produced by the Federal Interagency Committee on Aircraft Noise (FICAN 1997) was presented earlier. This curve, showing indoor SEL, represents the upper limit of the observed field data, and should be interpreted as predicting the maximum percentage of people likely to be awakened for a given residential population. Using these data, the typical worst-case nighttime noise event was used to predict the likely degree of sleep disturbance each flight-track alternative would cause in the Seattle area.

Table E19 Sleep Disturbance

SEL Noise Contour	Percent Population Potentially Awakened (Windows Open/Closed)	Existing Actual Conditions		Track III.20B (Three South Tracks)	
		Open Windows # People Possibly Awakened	Closed Windows # of People Possibly Awakened	Open Windows # People Possibly Awakened	Closed Windows # of People Possibly Awakened
110	13%/11%	-		100	-
105	12%/10%	500	400	800	700
100	11%/9%	1,300	1,100	1,800	1,500
95	10%/8%	2,900	2,300	1,700	1,400
90	9%/7%	4,500	3,500	5,700	4,400
85	8%/6%	5,600	4,300	6,100	4,600

People Potentially Experiencing Speech Interference



Speech interference is one of the issues most commonly mentioned by the public as a source of annoyance. The term applies not only to conversations, but also to listening to radio, television, and talking on the phone. For evaluation of speech interference, the Time Above (TA) is the selected metric, because it measures the number of minutes a day when the noise level exceeds 65 dBA, the noise level where speech interference begins to occur. The ability to communicate decreases as sound levels increase, unless individuals move closer to one another or raise their voices. The figure to the right shows the relationship of noise in speech and communication.

Population Exposed to Sound Above 65 dBA

	Existing Annual	III-20B (Straight/145 Radial/Sound)
Greater than 150 minutes per day	51	64
Greater than 120 minutes per day	4,243	652
Greater than 90 minutes per day	14,742	4,858
Greater than 60 minutes per day	44,872	24,057
Greater than 30 minutes per day	79,752	67,000
Greater than 10 minutes per day	149,391	133,905

The residences affected by 65 dBA would experience a substantial reduction in time exposed. In comparison to existing conditions, the south-flow, three-track alternative (III-20B) would reduce the number of residences experiencing 90 minutes of noise above 65 dBA by about 46 percent. Residences affected by fewer than 10 minutes above 65 dBA would be reduced by 10 percent.

Table E20 Speech Interference

	Time Above 65 dBA					
	Existing Actual Conditions			III-20B (South Three Tracks)		
Location	Population	South Flow	Annual	Population	South Flow	Annual
1	4,243	63.9	43.5	4,243	62.7	42.8
2	4,743	102.0	73.6	4,743	76.6	56.1
3	7,139	137.9	130.6	7,139	95.9	101.8
4	6,086	71.5	48.8	6,086	90.2	61.7
5	600	28.5	20.2	600	49.2	33.7
6	4,849	73.9	52.2	4,849	26.1	19.4
7	6,488	106.6	98.7	6,488	52.2	61.3
8	4,594	25.0	16.9	4,594	63.6	43.5
9	7,615	0	0	7,615	4.1	2.8
10	3,219	63.2	44.9	3,219	12.2	10.1
11	6,517	90.8	83.5	6,517	33.4	43.7
12	3,521	12.6	8.4	3,521	54.0	37.0
13	6,813	80.5	77.6	6,813	17.2	33.0
14	3,646	8.8	5.8	3,646	48.9	33.5
15	3,984	4.2	2.8	3,984	13.0	8.9
16	6,336	20.8	13.5	6,336	3.1	2.1
17	4,775	46.9	42.8	4,775	10.7	16.9
18	1,166	19.2	12.7	1,166	38.9	26.6
19	2,666	13.6	9.3	2,666	3.4	2.3
20	4,917	3.8	2.4	4,917	0.2	0.2
21	3,396	20.6	16.9	3,396	6.8	6.7
22	7,639	12.7	8.6	7,639	17.2	11.7
23	414	0	0	414	5.2	3.6

III-20C Nighttime West-Turn Track Through Commencement Bay

The southerly flight track would generally follow the existing southern track until a point about 10 miles south of the Airport, where it would turn west/northwest and overfly the industrial area of the Port of Tacoma. It is estimated that between midnight and 5 a.m. this procedure could be implemented safely.

Probable Number of Overflights

Shifting these late-night flights from over Federal Way to the industrial, less residentially developed areas could reduce the number of residences exposed to single-event noise levels from these late-night operations. There are between 5 and 10 departures nightly that could be affected by such an option.

People Likely Annoyed

Because the track would be used only during the nighttime hours (midnight to 5 a.m.) there would be minimal effect on annoyance.

People Potentially Awakened

As shown in Figure E23, this track would minimize the effects on residential populations. As a result, the population potentially awakened would be reduced. To evaluate these conditions, single-event sound exposure level contours were overlayed on a population density map to compute the number of people within 80 SEL. The results, summarized below, show that there is a reduction in the number of people exposed to single-event noise levels when this procedure is utilized.

Operation	Flow	Procedure	Population (SEL 80)
Departure	South	Existing Corridor	93,000
Departure	South	Tacoma Sound	78,000

People Potentially Experiencing Speech Interference

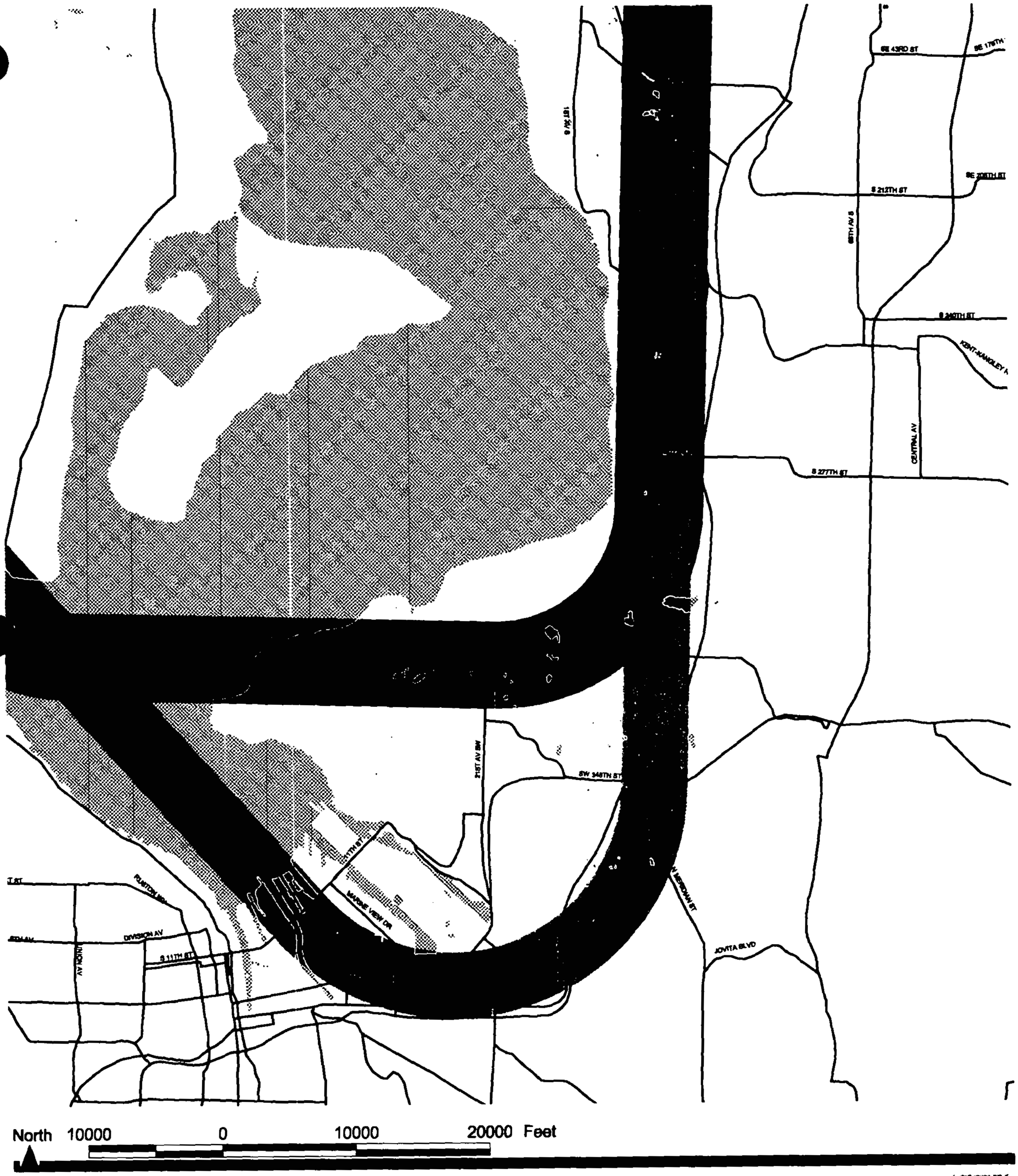
Because the track would be used only during the nighttime hours (midnight to 5 a.m.) there would be minimal effect on speech and communication.

3.21 Nighttime EVA Air Special Voluntary Procedure

The operation of EVA Air during the nighttime hours is of special concern to communities. This flight is a heavy B747 that both arrives and departs during the late-night hours The EVA Air flight is a very heavy, long distance, 3:30 a.m. departure to Taipei, which has caused considerable annoyance and complaints by residents. This alternative focuses on possible methods to minimize the impact of this flight by maximizing the use of Elliott Bay for departures and arrivals. For south-flow departures, the aircraft would be vectored over a minimum population flight path passing through the Port of Tacoma.

Working with the FAA and the airline, a special procedure could be developed for the operation of this aircraft.

Examples of the flight paths for the nighttime EVA Air flight are presented in Figures E24 and E25 for south-flow and north-flow conditions, respectively. The south-flow track map shows the aircraft currently arriving from the east (New York) on a track over north Seattle. South departures turn to the west over Federal Way, while north-flow departures turn through Elliott Bay. Currently, these flights do not always fly the Elliott Bay procedure properly over the Bay because of their weight, and as a result, stray to the north over Queen Anne and Magnolia.



E.23 **Commencement Bay Track, 12am-5am**

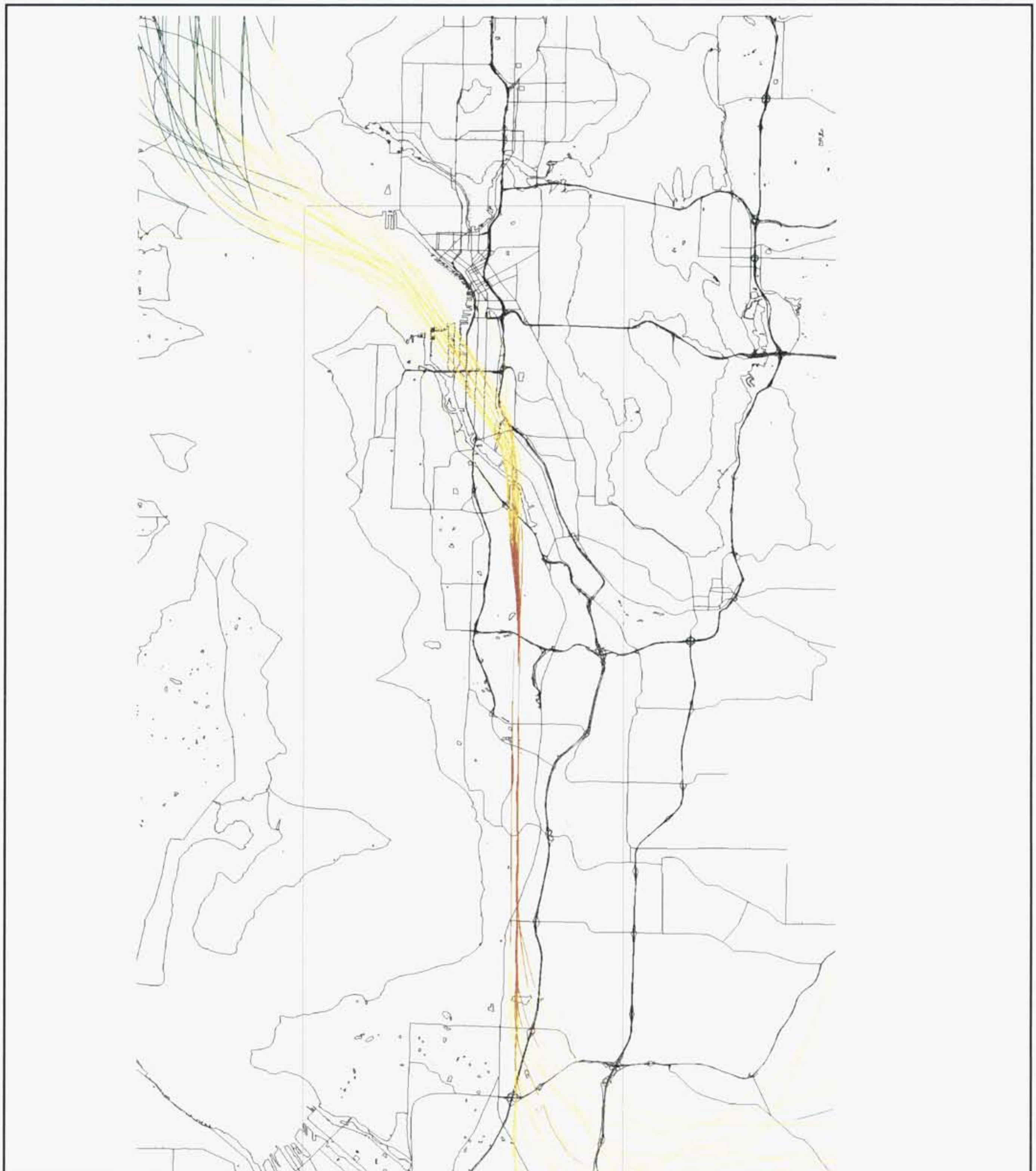
Figure E.24
Seattle Tacoma International Airport Part 150 Noise Study
Eva Air Nighttime Operations (Southflow)

Port of Seattle
Seattle-Tacoma International Airport

Prepared Nov-00

Figure E.25
Seattle Tacoma International Airport Part 150 Noise Study
Eva Air Nighttime Operations (Northflow)

Port of Seattle
Seattle-Tacoma
International Airport



Prepared Nov-00

To reduce that level of annoyance of the EVA Air flight, three options are being considered. The following table presents the population exposed to 80 SEL for these alternatives:

- ✓ Current south-flow Federal Way turn
- ✓ South-flow Tacoma Sound Turn (described in Alternative III.19)
- ✓ North-flow Elliott Bay turn.

Operation	Flow	Procedure	Population (SEL 80)
Departure	South	Federal Way Turn (Current)	93,000
Departure	South	Tacoma Sound Turn	78,000
Departure	North	Elliott Bay	51,000

As is shown in the table above, there is a much smaller population impact when the aircraft departs through Elliott Bay. However, when it is not able to negotiate the optimum path through Elliott Bay, due to its heavy climb performance, benefits are reduced, and areas in Queen Anne and Magnolia experience overflights.

The ability of this aircraft to depart to the north is also constrained due to a number of factors. Because the prevailing wind direction is from the south, and because the runway also slopes to the south, heavy aircraft need to depart to the south a higher percentage of the time as compared to other aircraft. Thus, for south departures, the Tacoma Sound turn provides for some reduction in the population over the Federal Way turn.

Implementation of this action, in any form, would be by the FAA. Mandated use of these procedures would likely trigger FAR Part 161 issues (see previous discussions of FAR Part 161). As a result, this procedure could be considered as a voluntary procedure.

3.22 South-Flow Nighttime Elliot Bay Arrival Procedure Using GPS/FMS

This alternative involves procuring and installing a Differential GPS (Global Positioning System) at Sea-Tac for the purpose of developing a high precision arrival route using Elliott Bay during the low activity nighttime period. Using GPS, aircraft would follow a curved approach through Elliott Bay rather than the straight-in ILS (Instrument Landing System) approach during nighttime low activity periods. This procedure would be similar to the track that is recommended for the FMS Duwamish/Elliott Bay departure procedure.

This nighttime arrival procedure would apply to aircraft arriving from the east and north. Arrivals at Sea-Tac currently use the standard ILS approach involving a straight line toward the Airport before hitting the outer marker at King County International Airport (about five miles from the runway) and descending on the glide slope until landing. The current south-flow arrival route brings aircraft over the University District, Capitol Hill, the north end of Beacon Hill, and other neighborhoods before reaching the Airport.

For this procedure to occur, a number of steps must occur:

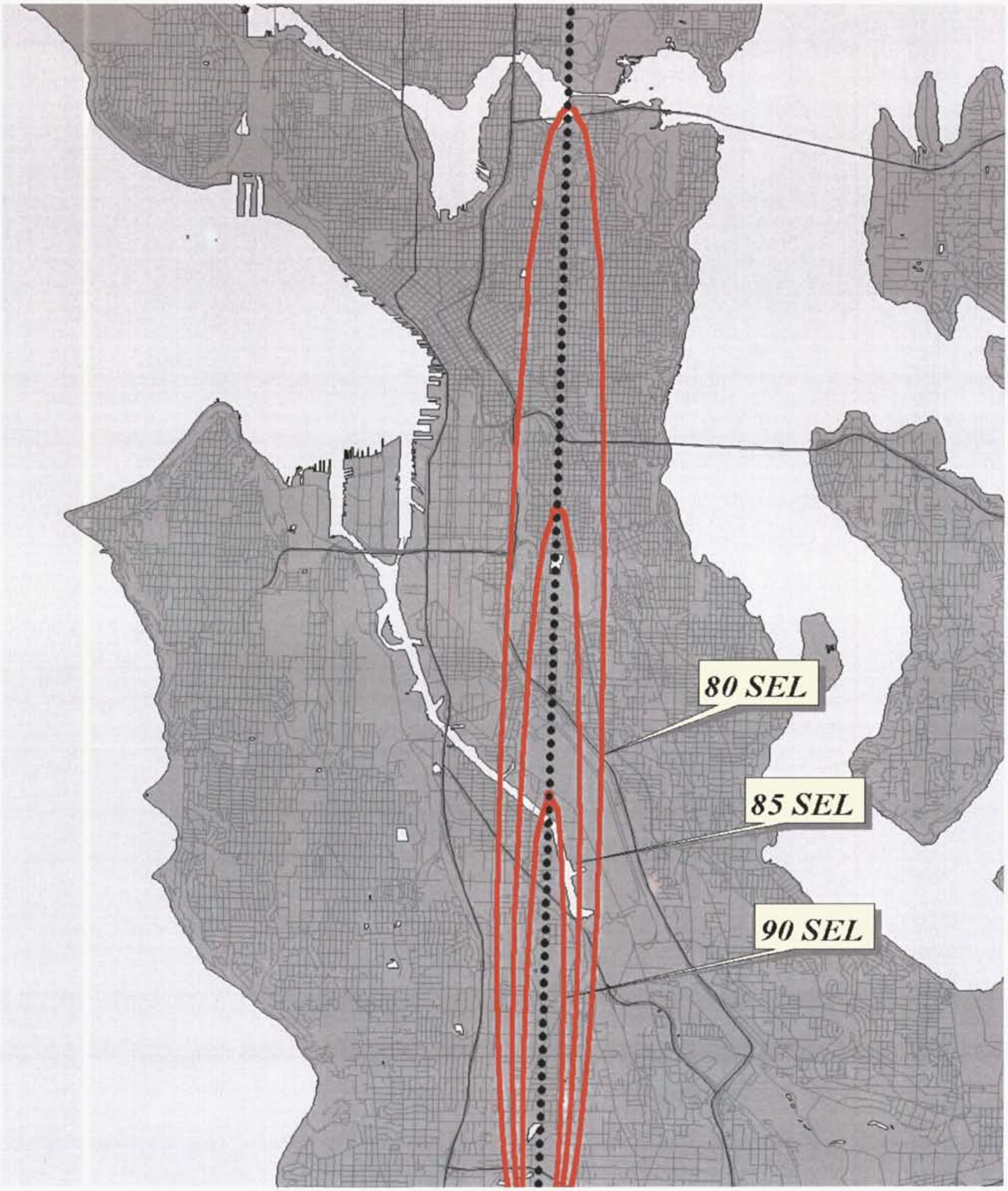
1. The Port of Seattle must purchase and install a Differential GPS.
2. The FAA must then develop these procedures.
3. Airlines must have the equipment capable of operating this procedure installed in aircraft.
4. The use of the procedure must be shown to be effective in allowing aircraft to fly the precise flight path, or the measure will not provide the desired noise reduction.

Due to all these steps, it is estimated that this measure would take at least two years to implement.

Using an Elliott Bay arrival route would avoid the neighborhoods north of the Airport offering relief from noise during sensitive nighttime hours. An example of the B747-400 aircraft single-event noise exposure contours for an approach using the straight-in procedure is presented in Figure E26. An example of the single-event noise exposure contour for an aircraft using the curved approach through Elliott Bay is shown in Figure E27. The population analysis shows that the number of people exposed to an approach SEL of 80 dBA or greater is reduced by 65 percent when using the Elliott Bay approach at night. This is a reduction from approximately 53,000 to 18,000 people.

Figure E.26
Seattle Tacoma International Airport Part 150 Noise Study
B747400 Southflow Straight Approach through Elliot Bay
SEL (80 85 90)

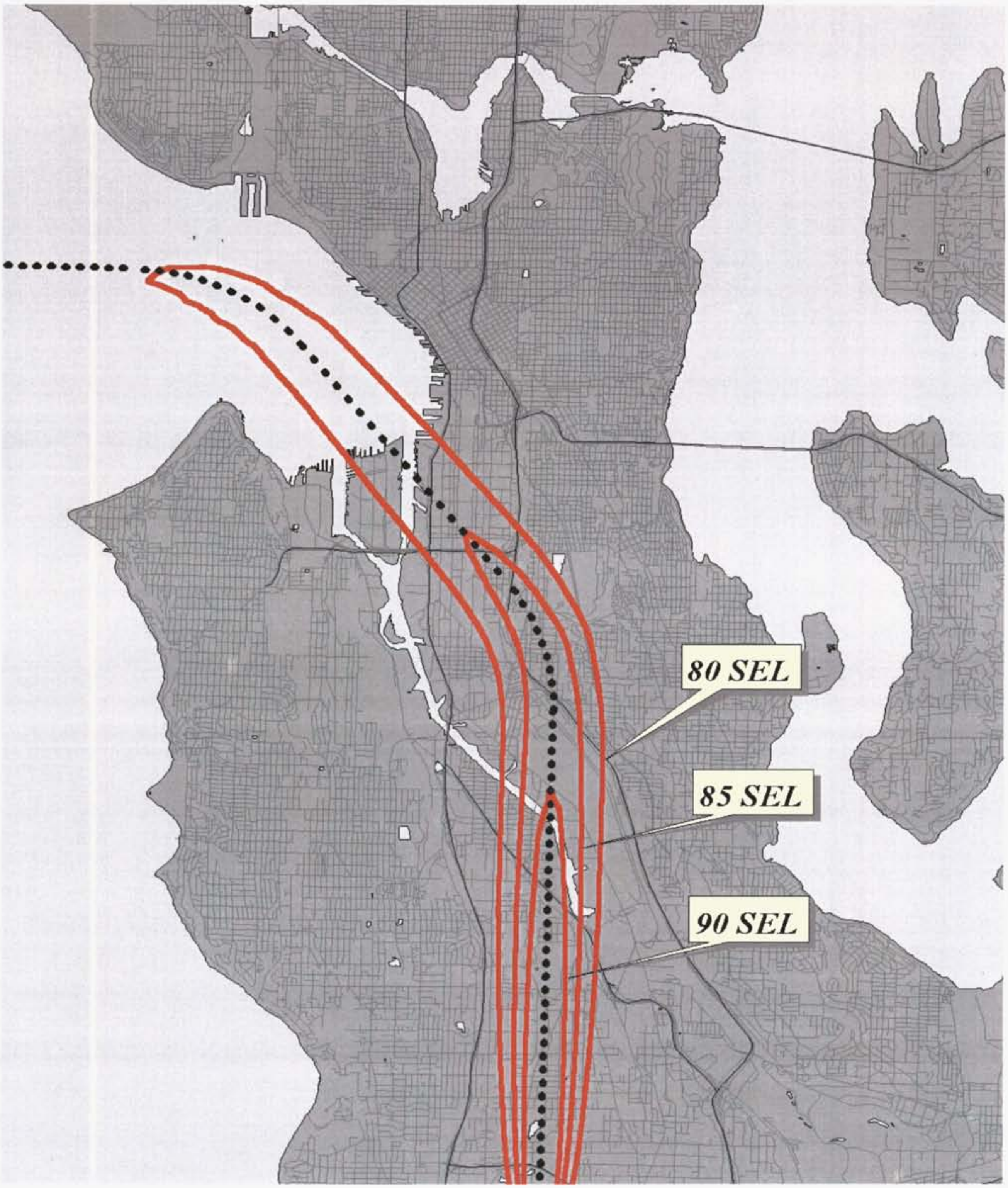
Port of Seattle
Seattle-Tacoma
International Airport



Prepared Nov-00

Figure E.27
Seattle Tacoma International Airport Part 150 Noise Study
Southflow Curved Approach through Elliot Bay
SEL (80 85 90)

Port of Seattle
Seattle-Tacoma
International Airport



Prepared Nov-00

Based on the noise reduction predicted, the Elliott Bay GPS arrival procedure is recommended for further evaluation. The ability of aircraft to regularly fly the prescribed procedure must be demonstrated prior to implementation.

3.23 South-Flow Nighttime Elliot Bay Arrival Procedure Using GPS/FMS for Aircraft Arriving from the Southwest

This procedure would be similar to the previous GPS/FMS Elliott Bay arrival, except that it would apply to aircraft arriving from the southwest.

South-flow arrivals from the southwest currently travel north of Sea-Tac over Puget Sound and then turn east around Elliott Bay, in good weather, and further north in poorer weather. Depending on the weather, volume of traffic, and aircraft sequencing, arrivals are turned east over the Bay or over Magnolia and points to the north before turning south where they pass over the University District, Capitol Hill, Beacon Hill, and other residential areas. Examples of flight tracks for this arrival procedure are presented in Figure E28.

The new GPS FMS arrival procedure would allow aircraft to maintain a flight path over Elliott Bay and the Duwamish River corridor, and would be available for FAA to use during lower traffic levels and potentially during moderate traffic levels when weather and air traffic volumes allow. A new technology, curved-arrival flight track would reduce noise levels in neighborhoods around Magnolia and north of the Airport (Capital Hill, University District, and Beacon Hill). The amount of noise reduction would clearly depend on how often the procedure is implemented. Single-event noise exposure contours for this procedure are shown in the discussion of Alternative 3.22.

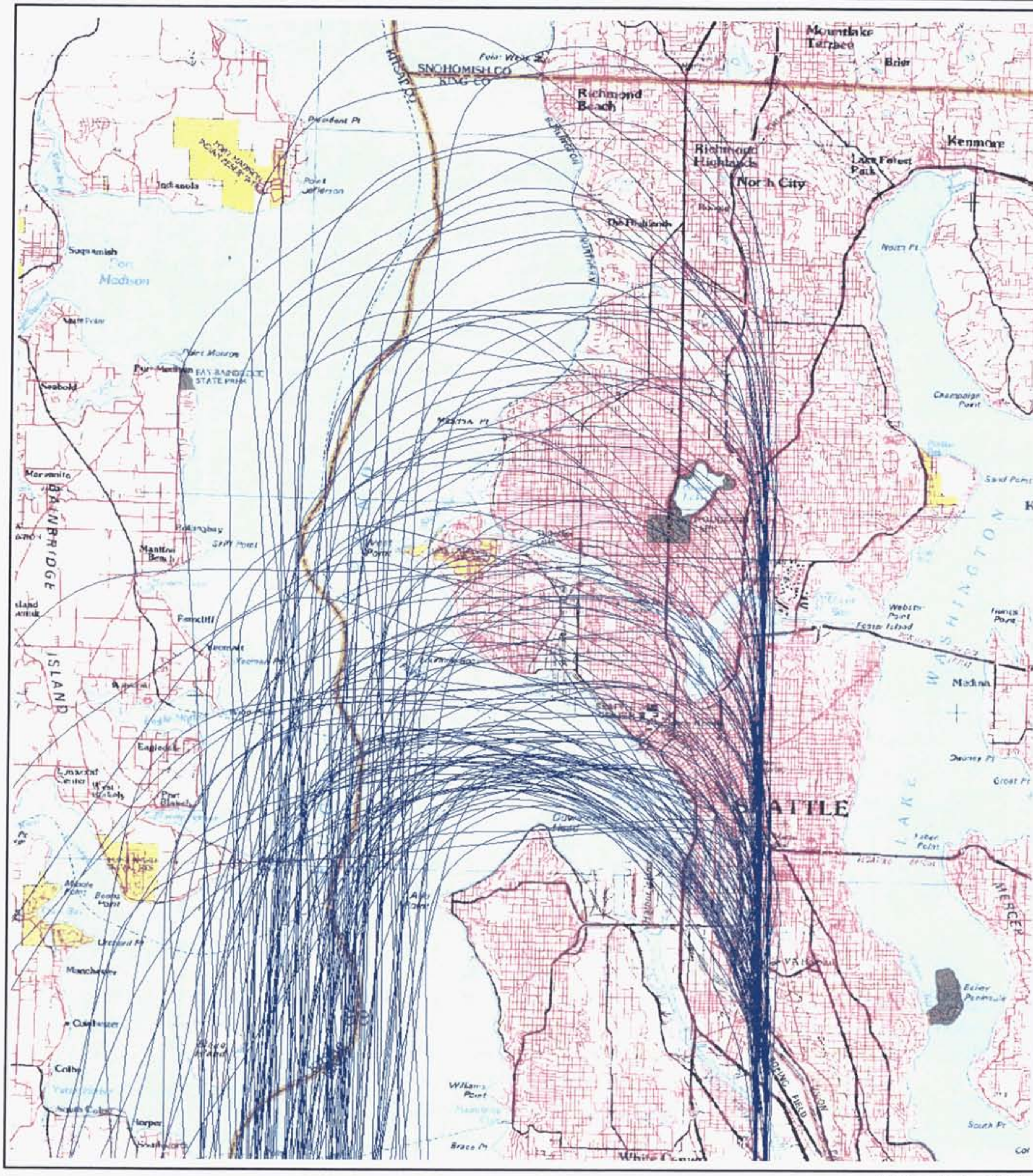
Figure E28

Seattle-Tacoma International Airport

Jet Arrival Flight Paths Runway 16L/R from Southern Origins

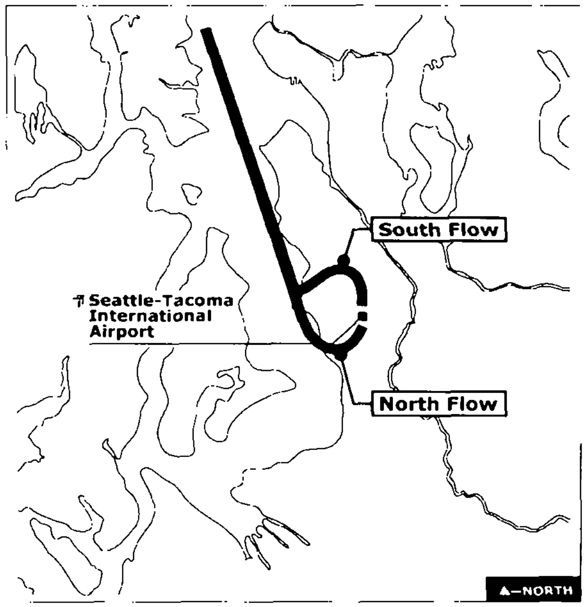
Fall 1998 and Winter 1999 Flight Tracks

Port of Seattle
Seattle-Tacoma International Airport



Prepared May 2000

3.24 Coastal Arrivals in Propeller Aircraft



This alternative involves working with air traffic controllers to more efficiently space large jet aircraft, so that low performance propeller aircraft can be sequenced into the arrival flow more easily. This action will minimize the time that propeller aircraft fly at low altitudes over communities west of the Airport.

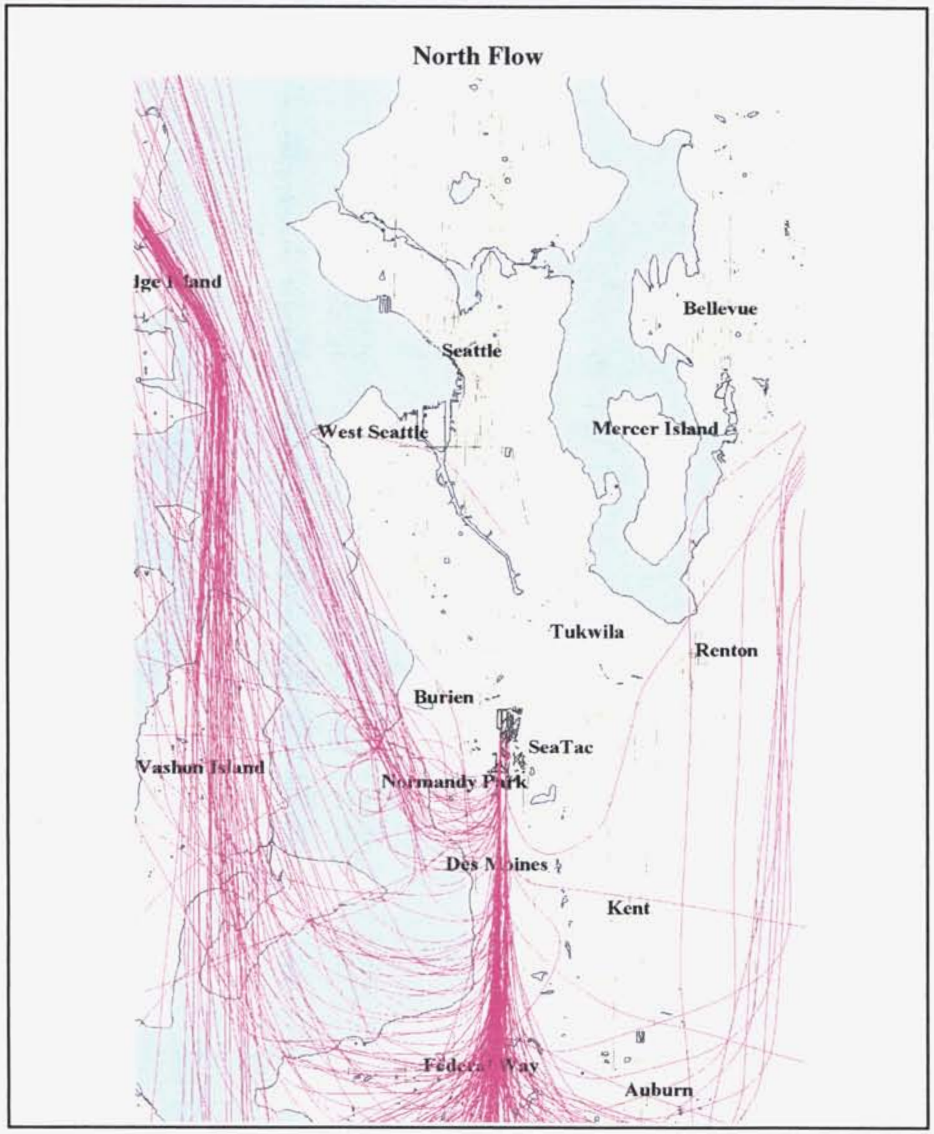
Slower performing propeller aircraft are vectored just west of the Airport, following a track parallel to the coastline, just inland. This track enables these lighter aircraft to land quickly when spacing between the high performance jet aircraft is available. These are generally single-engine and light twin-engine propeller aircraft arriving from the northwest, operating at low altitudes over Burien and Normandy Park. During better weather conditions, there are approximately 20 to 30 landings per day of this type.

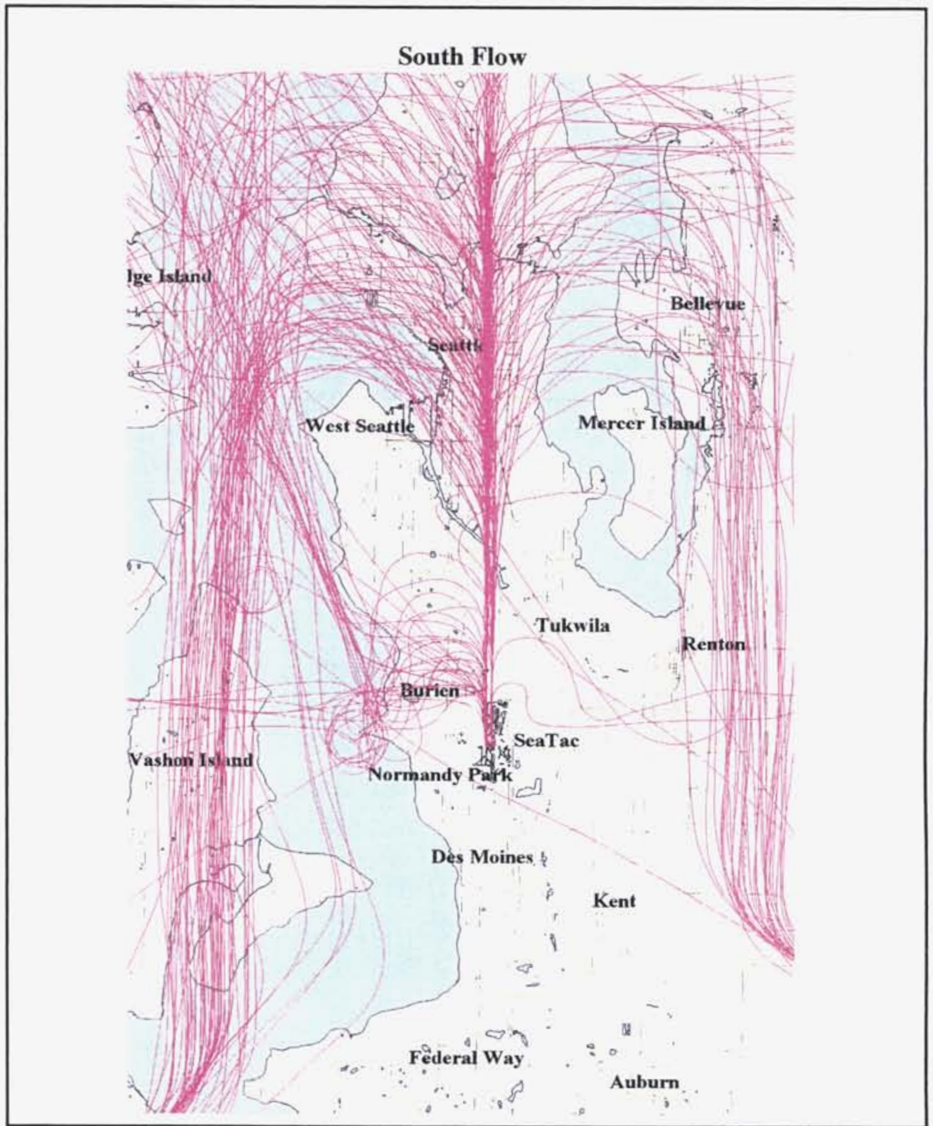
Examples of the flight tracks for propeller aircraft are presented in Figure E29. These figures show arrival tracks in both south- and north-flow conditions. Flight tracks indicate aircraft circle overhead while waiting for proper spacing.

Propeller aircraft operate at low altitudes and can be annoying, from a noise stanspoint, over communities west of the Airport. Reducing the time that they remain at low altitudes over Burien and Normandy Park will reduce exposure. These aircraft are approaching and occasionally holding at lower altitudes for extended periods.

Figure E.29
Seattle Tacoma International Airport Part 150 Noise Study
Period: Sample Periods in August 1998
Small Propeller Aircraft Coastal Arrivals

Port of Seattle
Seattle-Tacoma International Airport





Prepared Apr-99

Aircraft Operations Actions

The following aircraft operational actions were examined:

✓ **POWER AND FLAP MANAGEMENT**

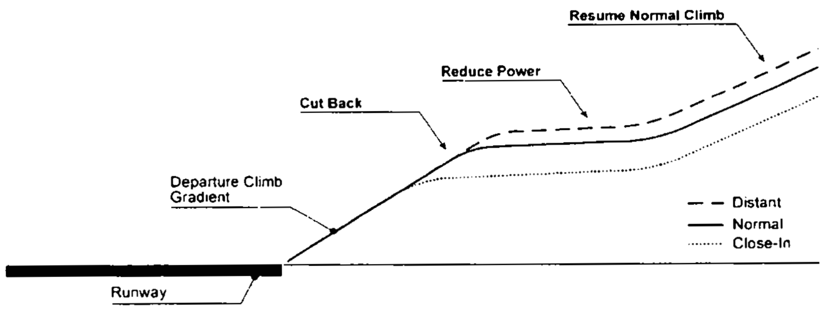
- Change in Departure Climb Profile (AC 93-53) – close-in versus distant procedures.
- Change in approach descent profile.
- Location of application of normal climb power at 3,000 feet AGL.
- Fly Quiet program to publish information about which airlines operate with the least noise impact.

✓ **THRUST REVERSE USE**

- Limited use of reverse thrust.

4.1 Change in Departure Climb Profile

A departure thrust cutback is a procedure where the aircraft's thrust or power setting is reduced soon after departure in an effort to reduce noise levels on the ground. Although use of a power cutback procedure can reduce noise at certain locations, it can also shift noise from close-in to further away from the Airport, or vice-versa. Because all noise abatement departure profiles (NADPs) involve a power cutback, this analysis explores the impact of alternative altitudes where this cutback could occur in the Seattle region.



The FAA has worked to develop and standardize aircraft NADPs. FAA Advisory Circular 91-53A (FAA AC 91-53A) establishes standards and operational guidelines for implementation of these procedures. Key features of AC 91-53A are:

1. Each aircraft operator may develop a maximum of two NADPs for each airplane type nation wide. These are designated as either a "Close-in community NADP" or a "Distant community NADP." The terms "Close-in" and "Distant" refer to the physical distance from an airport runway to the community. A "Close-in community NADP" is designed to reduce noise at locations close to an airport. A "Distant community NADP" is designed to reduce noise at locations distant from an airport. These terms are relative, and allow each operator to develop procedures that provide the greatest noise benefit to their individual destinations.

2. For each NADP, the operator should specify the altitude above field elevation (AFE) at which takeoff thrust or airplane configuration change, excluding landing gear retraction, is initiated. The absolute minimum altitude at which throttle reduction may be initiated is 800 feet AFE.

3. The minimum thrust setting for each aircraft type is to be determined based upon the minimum engine out-climb gradients.

4. The thrust reduction will be maintained to an altitude of 3,000 feet AFE or until the airplane has been fully transitioned to the en route configuration (whichever occurs first), then transition to normal en route climb procedures may be initiated.

5. Airports may request airlines to use the appropriate NADP to reduce noise for either a close-in or a distant community.

Although NADPs are defined in terms of community location, the actual point of thrust reduction is determined by aircraft altitude. This is a key safety consideration as aircraft climb performance varies by aircraft type and weight. The designation of altitude to determine the location at which the reduction in thrust occurs ensures that departing aircraft are at a safe altitude prior to reducing power.

At Sea-Tac, the NADP is determined by each airline. Currently the cutback is between the close-in and distant procedure. Data indicate that at Sea-Tac, a power cutback occurs at 1,000 to 1,200 feet (versus the 800 feet for the close-in or 1,500 feet for the distant procedures). Alaska Airlines, the largest operator at the Airport, performs a cutback at about 1,000 feet.

In response to the requirements of AC 91-53A major airlines have developed NADPs. These standardized procedures recommend that thrust reductions commence at 800 feet AFE for the close-in and 1,500 feet AFE for the distant community NADP. Although the actual location on the ground of thrust reduction varies from flight to flight, as a practical matter, thrust reductions typically occur in the vicinity of one nautical mile (nm) from brake release for the close-in procedure and at approximately three nautical miles from brake release for the distant procedure.

The departure thrust cutback significantly decreases aircraft noise emissions in the vicinity of the cutback, but the decrease in noise levels is accompanied by a corresponding decrease in aircraft climb performance. Changes in climb performance result in lower flyover altitudes compared to a typical or normal departure procedure. The amount of decrease in altitude can be assessed through computer simulation.

The top of Figure E30 depicts the altitude (AFE) at points along the departure path for a sample MD80 departing Sea-Tac as determined by the Integrated Noise Model (INM). Three departure procedures are shown representing "normal" or typical departure, the close-in and the distant procedures defined by AC 91-53A.

Noise levels at any given receptor are primarily a function of the loudness of the noise source, and the distance from the noise source to the receiver. Thus, noise levels increase as the distance between the source and the receptor decreases, and reducing departure thrust also reduces aircraft altitude. Therefore, departure thrust cutback reduces noise on the ground when the reduction in noise at the source (power cutback) is greater than the detrimental effect caused by the decrease in distance between the noise source and the receptor (reduced altitude).

FAA AC 91-53A specifies that normal climb power will be re-applied at an altitude of 3,000 feet AFE, or when the airplane has been fully transitioned to the en route configuration, whichever occurs first. At Sea-Tac, the re-application of normal climb thrust would occur in the vicinity of three to six nautical miles from the beginning of takeoff.

Locations where normal climb thrust is re-applied may experience an increase in noise above what would be experienced during a typical departure due to lower aircraft altitude and the re-application of normal climb thrust.

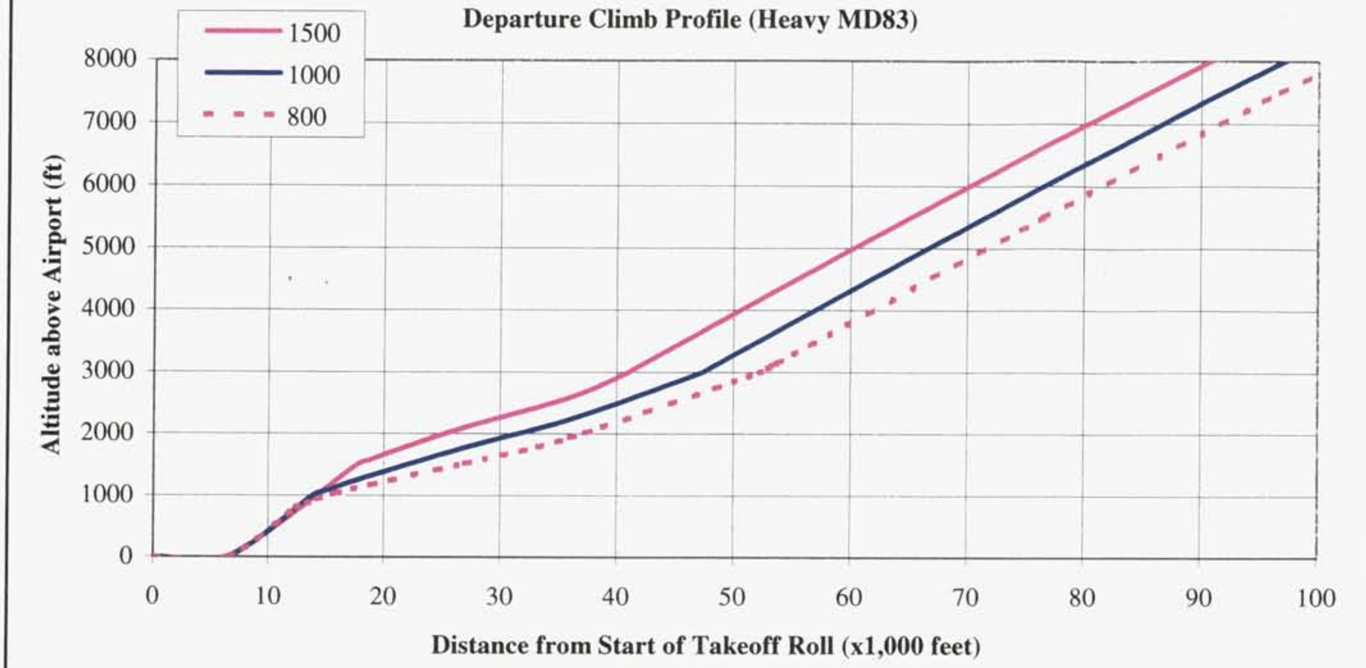
To assess the cumulative effect of alternative NADPs, single-event noise levels were determined along the departure path for three departure procedures:

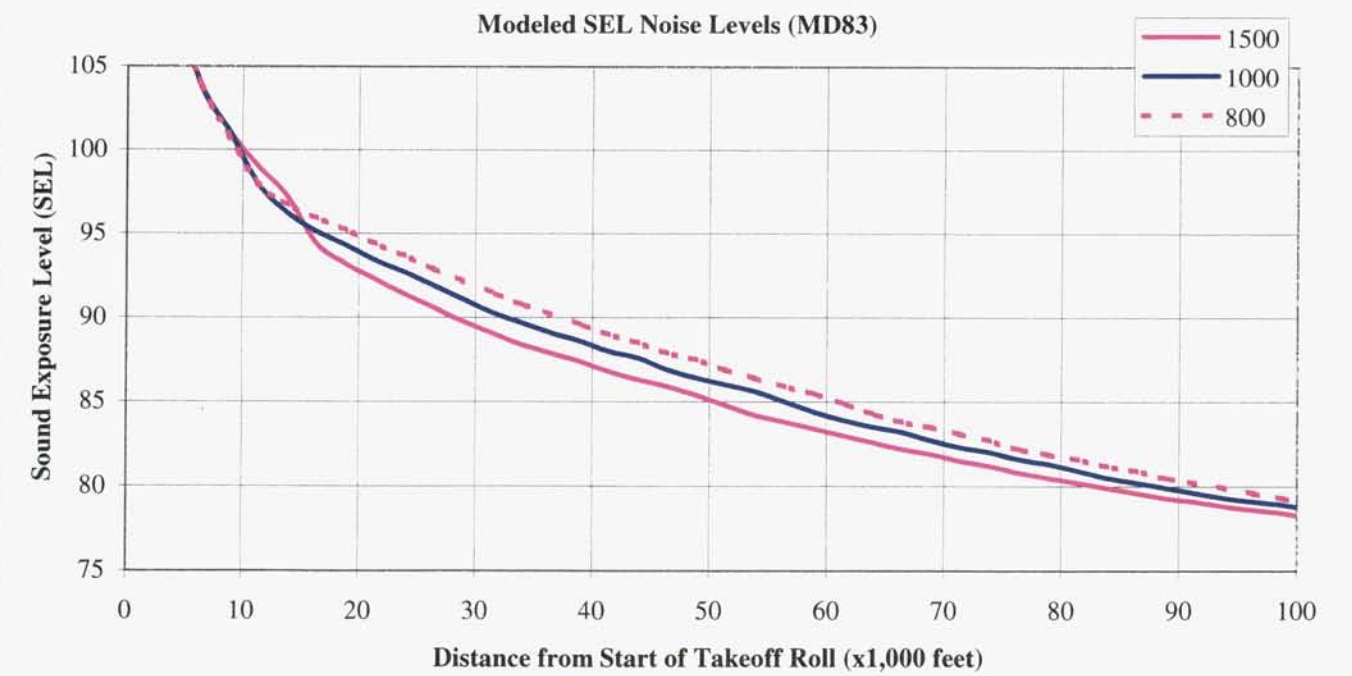
- A typical departure with no noise abatement power cutback,
- The close-in NADP, and
- The distant NADP.

The INM, calibrated to conditions at Sea-Tac by means of field noise measurement data, was used to predict and compare noise levels from these procedures. The results of this analysis for the MD83 aircraft are shown in the bottom of Figure E30

As shown in the bottom of Figure E30, single-event departure noise levels would be reduced at locations near the Airport if a close-in NADP were implemented at Sea-Tac; however, noise levels in the more distant communities would increase.

Figure E.30
Seattle-Tacoma International Airport
Departure Climb Rates and Changes in Noise for each Departure Procedure
Heavy MD83 Aircraft





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Implementation of a distant NADP would increase the noise levels closer to the Airport, while reducing them further away.

Three variations on departure profiles are possible at Sea-Tac. All variations were evaluated under the worst-case condition, that is, a departure in a louder Stage 3, narrow-body jet aircraft. Generally, the louder Stage 3 narrow-body aircraft produce the highest noise levels, have the poorest climb performance, and would provide the greatest benefit from a cutback procedure. Wide-body aircraft are typically so heavy that the potential cutback is too small to have any appreciable noise reduction benefit.

The following is a description of each NADP variant.

1. **Current Sea-Tac Departure Procedure**: Pilots currently apply takeoff power until reaching about 1,000 to 1,200 feet above field level when they cut back power to reduce noise levels on the ground. Regular climb power is re-applied when reaching an altitude of 3,000 feet. Figure E31 shows the points where a heavy MD80 reaches 1,000 feet and then 3,000 feet.

   Figure E32 shows single-event noise exposure contours (SEL) for an MD80 aircraft departing to the southwest and to the northeast with a cutback at 1,000 feet. This is representative of the lower altitude cutbacks currently used at Sea-Tac, which generally occur in the 1,000-to-1,200-foot range. This is also the procedure used by Alaska Airlines, so it is the most common procedure at Sea-Tac.

2. **Close-In Departure Procedure**: Using this procedure, aircraft would apply full power until reaching an altitude of 800 feet when they cutback and re-apply regular power at 3,000 feet. Figure E31 shows the points where a typical MD80 reaches 800 feet and then 3,000 feet when flying this procedure.

   An example of the typical noise levels from a procedure with a cutback at 800 feet is presented on the left side of Figure E33 for south flow and north flow. This figure presents the single-event noise contour (SEL) for an MD80 aircraft departing to the southwest and to the northeast, and shows where the changes in noise level would occur with this procedure. In general, there is a noise decrease in the areas in green (close-in to the Airport), where noise levels would decline by 1 to 2 dBA. The areas in red (more distant from the Airport) would experience an increase in noise of 1 to 2 dBA. All other areas would experience a change of less than 1 dBA.

   Alaska Airlines conducted an actual operational test of this procedure at Sea-Tac during the week of February 1, 1999. Test results for the one-day sample were not conclusive, due to the small sample and the pilots' unfamiliarity with the new procedure. The relatively small change in noise that occurs with this 200-foot difference in cutback altitude was not measurable and not practical to test.

Figure E31
Seattle Tacoma International Airport Part 150 Noise Study
Example of Aircraft Altitudes for Different Departure Procedures
Heavy MD80 Departure

Port of Seattle
Seattle-Tacoma International Airport

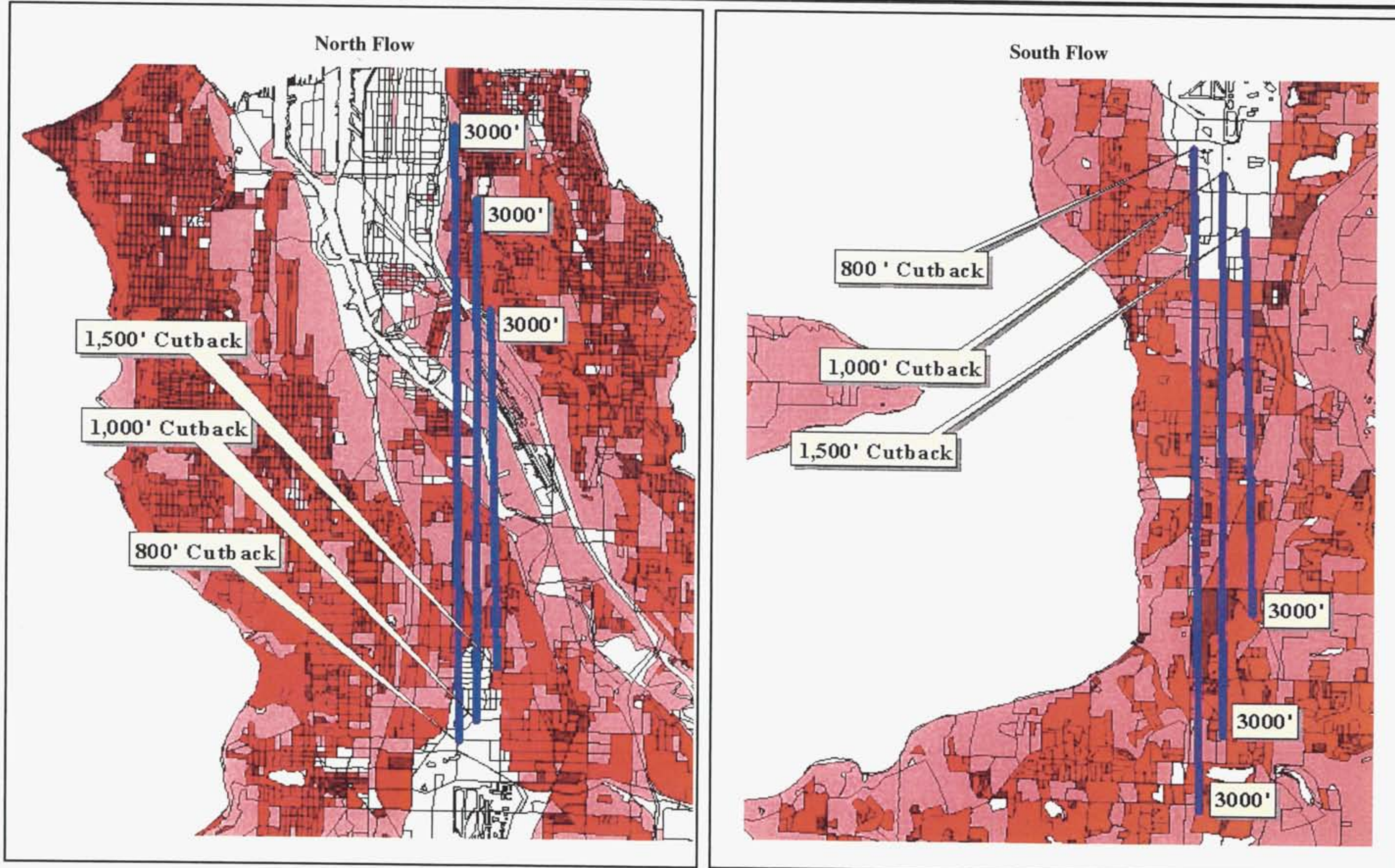

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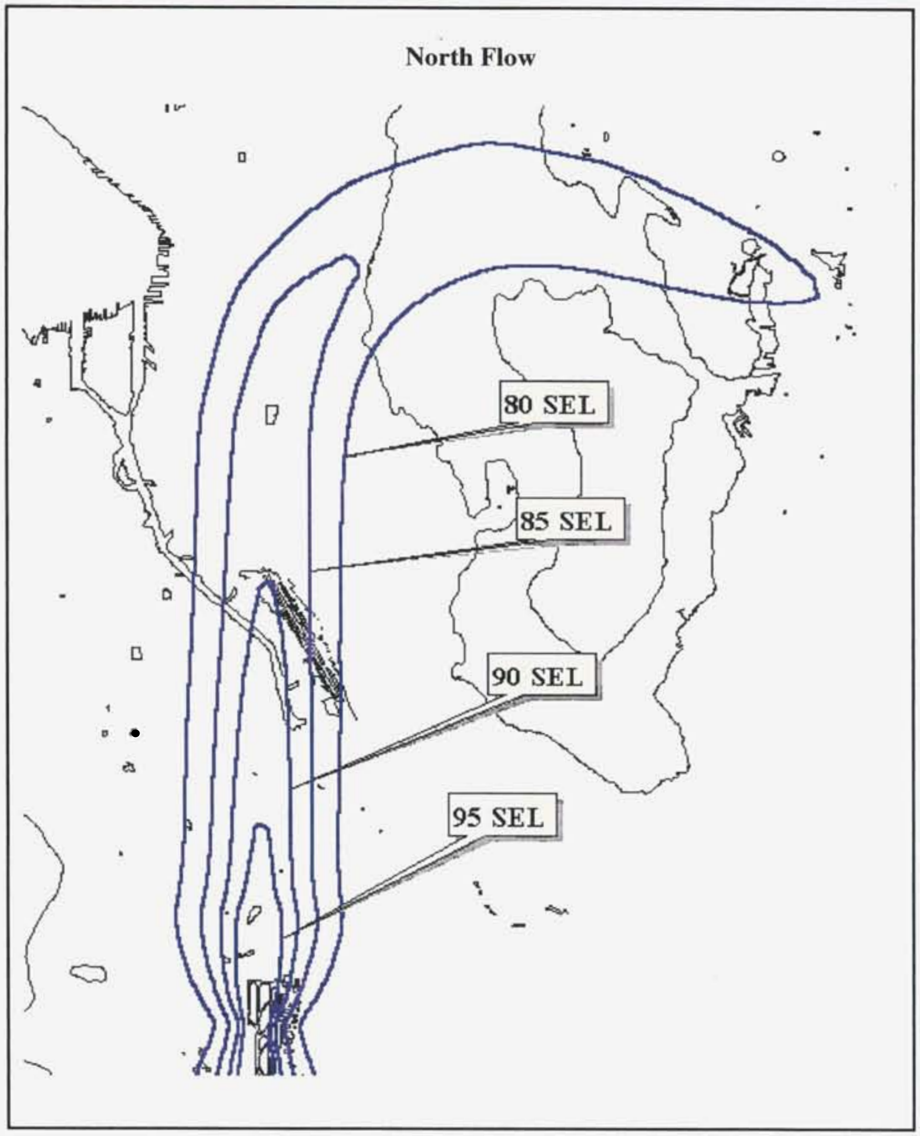
Figure E32
Seattle Tacoma International Airport Part 150 Noise Study
Existing Conditions SEL Noise Contour (1,000' cutback)
Heavy MD80 Departure

Port of Seattle
Seattle-Tacoma International Airport



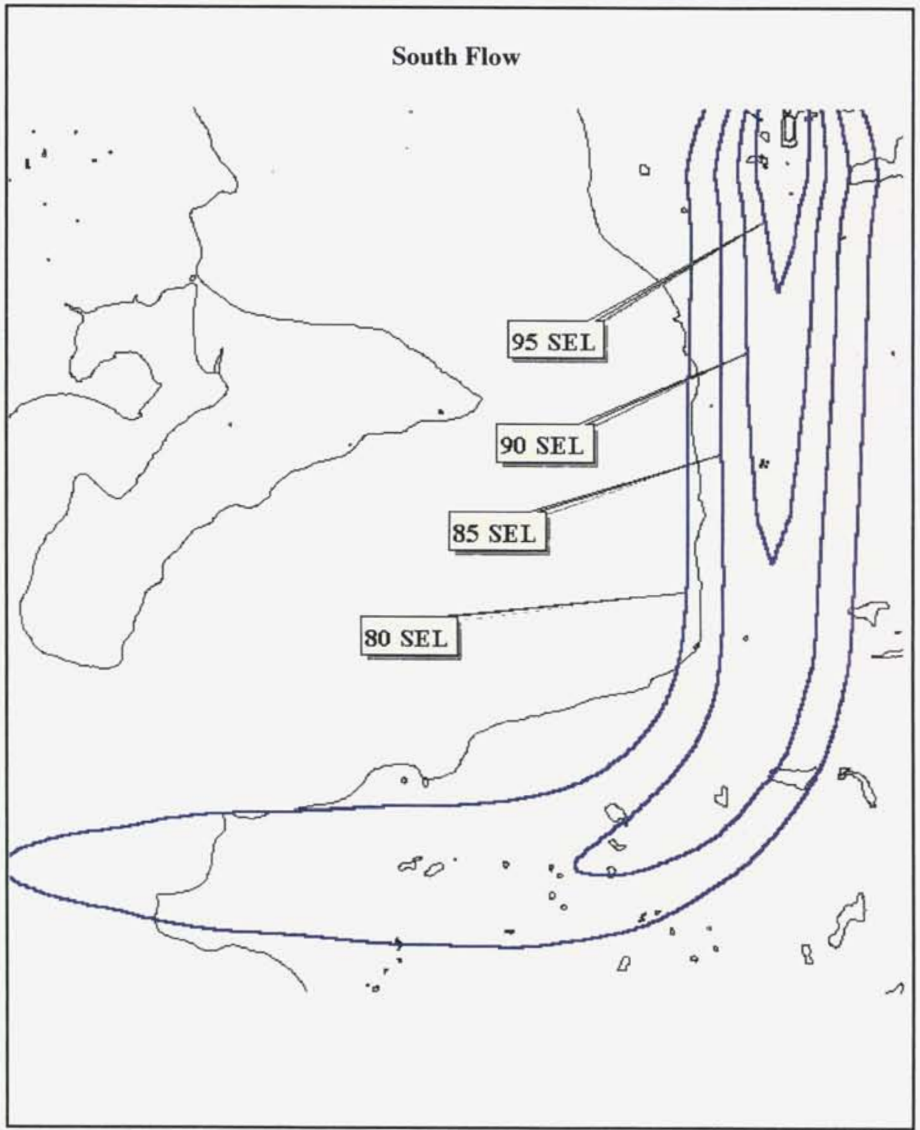


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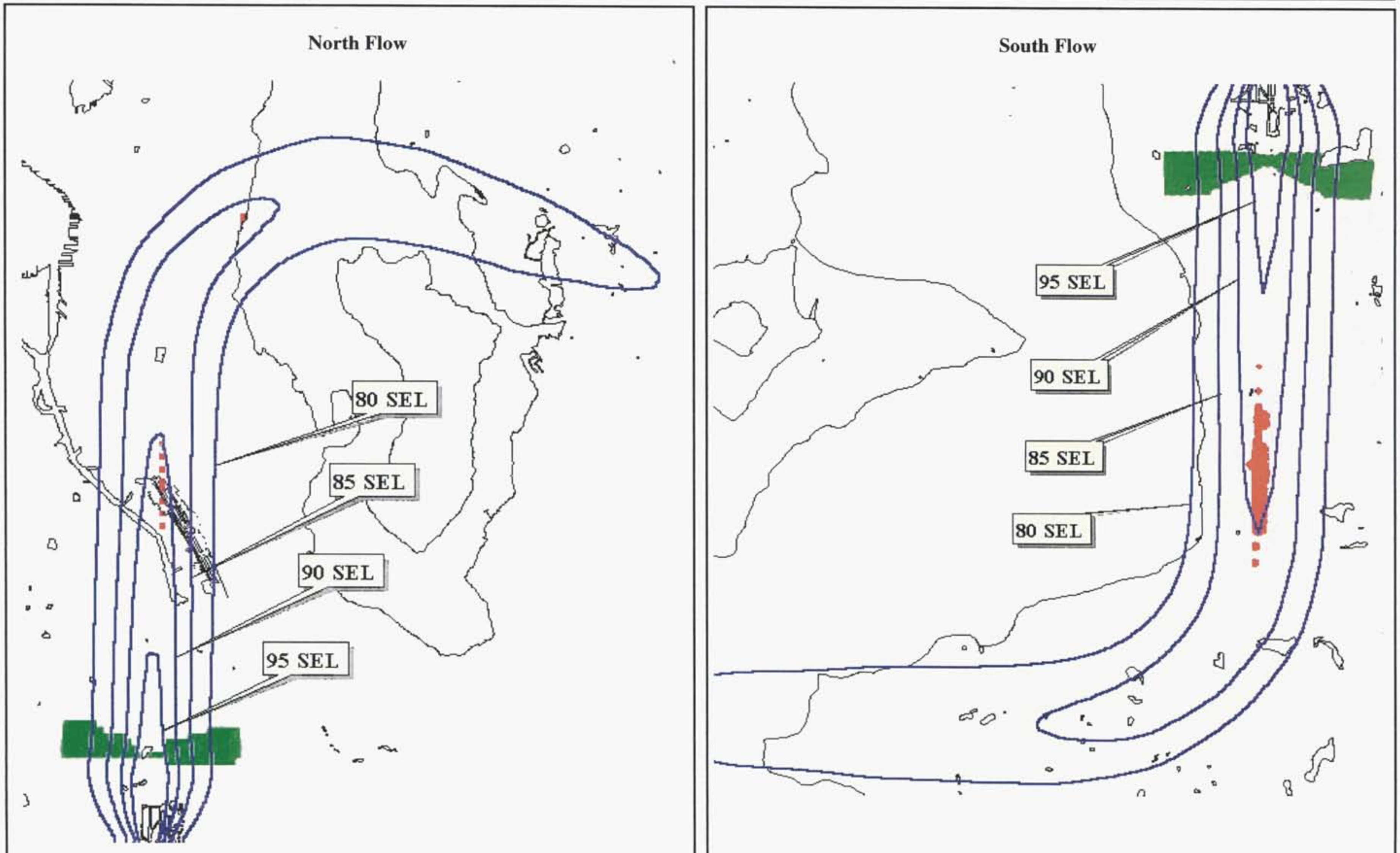
Figure E33
Seattle Tacoma International Airport Part 150 Noise Study
Example of Change in Noise with 800 Foot Cutbacks
Heavy MD80 Departure

Port of Seattle
Seattle-Tacoma International Airport



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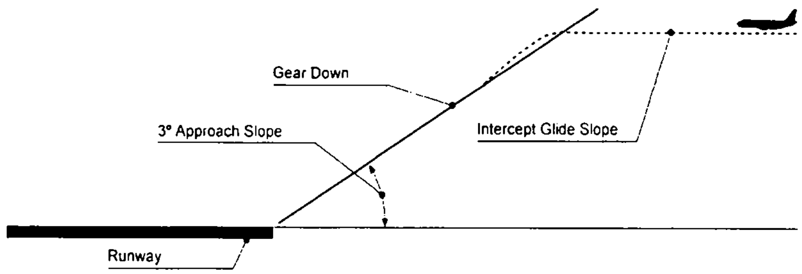
3. **Farther Out Procedure**: This procedure is a variant on the current Sea-Tac departure, the only difference being that full power would remain until aircraft reach an altitude of 1,500 feet before the cutting back. Regular power would again resume at an altitude of 3,000 feet. Figure E31 shows the points where a typical MD80 reaches 1,500 feet and then 3,000 feet when flying this procedure.

   An example of typical noise levels from a procedure with a cutback at 1,500 feet is presented on the right side of Figure E34 for south flow and for north flow. This is representative of a higher altitude of cutback than currently used at Sea-Tac. This figure presents the single-event noise exposure contour (SEL) for an MD80 aircraft departing to the southwest and to the northeast, and shows where changes in noise level would occur. In general, there is a noise decrease in the areas in green (more distant from the Airport) where the noise levels would decline by 1 to 2 dBA. The areas in red (close in to the Airport) would experience an increase in noise of 1 to 2 dBA. All other areas would experience a change of less than 1 dBA.

4.2 Change in Approach Descent Procedure

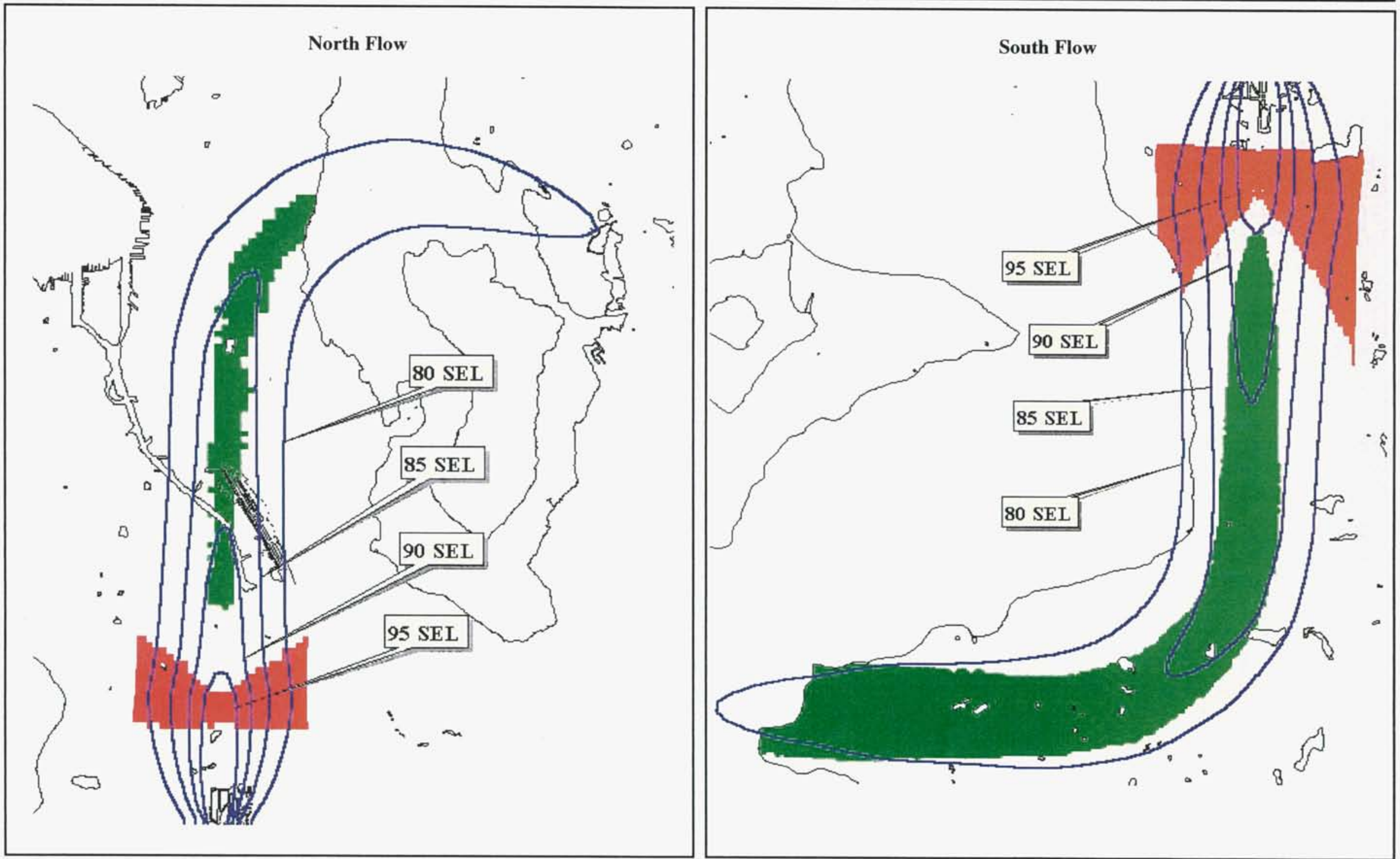


Changes in approach descent procedures are considered to increase the altitude of aircraft over noise-sensitive areas under the arrival path. As the diagram above illustrates, to intercept the glide slope, pilots fly under the glide slope until the aircraft intercepts the signal. The aircraft may then be slightly above and below the signal beam as the aircraft adjusts to the correct angle. In some cases the aircraft intersects the glide slope at a lower altitude than other aircraft. These lower aircraft have been a concern, from a noise impact perspective, of citizens in some areas under arrival paths.

Under instrument conditions, aircraft use the glide slope and the angle of the glide slope to line up on the runway and descend at the proper speed and angle to touch down on the runway at the correct point. This arrival method is required under Instrument Flight Rules (IFR), or poor weather conditions. Though not required, most commercial-service aircraft use the glide slope approach even during Visual Flight Rules (VFR), or clear weather conditions. However, during VFR, aircraft intercept the glide slope, set flaps, and drop the landing gear at various stages in

Figure E34
Seattle Tacoma International Airport Part 150 Noise Study
Example of Change in Noise with 1,500 Foot Cutback
Heavy MD80 Departure

Port of Seattle
Seattle-Tacoma International Airport



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the landing process. Generally the flaps and landing gear are set at a distance of about five miles or greater from the Airport. This analysis investigates which landing methods might result in the lowest noise impact to communities under the approach corridors.

The angle of descent or glide slope angle at Sea-Tac is three degrees, as it is with almost every other airport in the country. Aircraft are designed to land using the three-degree glide slope to ensure safety and passenger comfort.

Aircraft approaching the runway at a lower altitude than is established by the glide slope can cause increased noise on the ground, and the point where aircraft intercept the glide slope can affect this altitude. An example of the runway centerline intercept for Runway 16L jet arrivals is presented in Figure E35, which shows that aircraft intercept the glide slope at various locations along the arrival path.

To keep aircraft more closely on the ideal glide slope angle of approach, two possible mitigation approaches can be considered. The first is to increase compliance with the existing glide slope approach, and the second is encouraging aircraft to intercept the glide slope at an earlier point, or higher altitude.

1. **Adherence to Existing Glide Slope Procedure:** The purpose of this measure is to keep aircraft as close as possible to the ideal arrival profile as established by the glide slope's three-degree angle of descent. Adherence to this arrival profile currently differs between aircraft on visual and instrument approaches; however, in each case, there is a distribution of aircraft both above and below the "ideal" profile.

   Three figures illustrate jet aircraft arrival flight tracks (Figures E36-E38). The first shows arrivals using Elliott Bay, which is primarily a VFR approach; the second shows the straight-in arrival approach, which is primarily an IFR approach, and the third is in north flow, which is also primarily VFR. These graphs demonstrate the distribution of individual flight tracks around the solid line representing the actual three-degree angle of descent.

   The bottom portions of these figures show the same flight tracks in a grid density plot with the darkest tone representing the highest concentration of tracks. Although the grid density analysis indicates that the highest concentration of flights is on the glide slope, it also demonstrates that a significant and measurable number of flights approach the Airport below that three-degree angle.

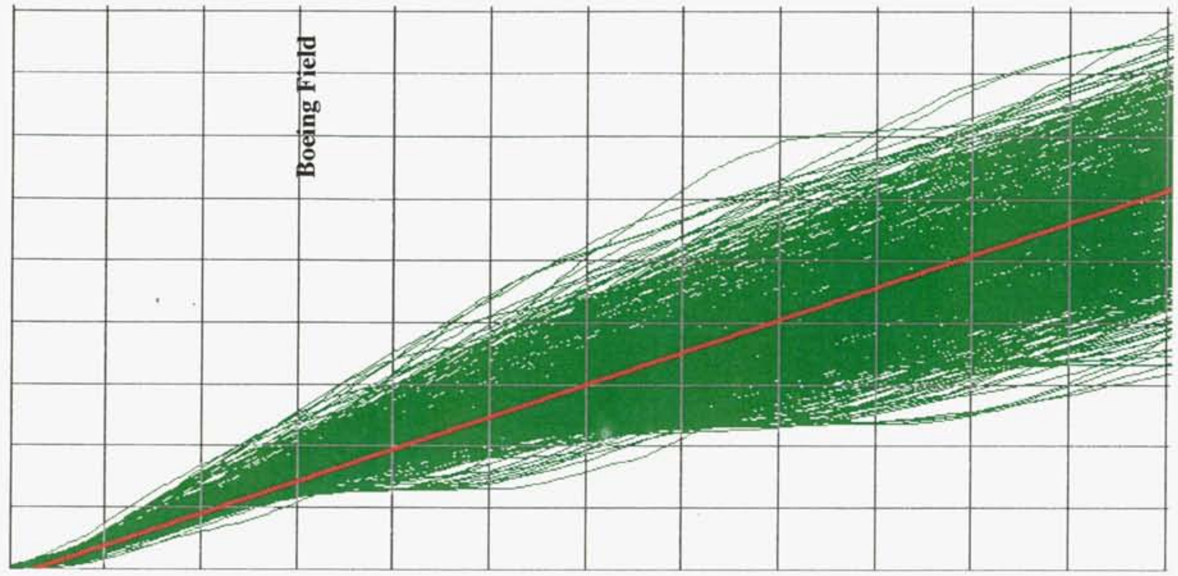
   On average, keeping arriving aircraft on the three-degree glide slope approach would reduce single-event arrival noise by 1dBA. Although this amount of noise reduction would not be noticeable, the actual reduction on the noisiest or lowest arriving aircraft could be as high as 3 dBA, which would be audible in the community. In addition, the planes would be less visually intrusive.

Figure E35
Seattle-Tacoma International Airport
Typical Approach Tracks to Runways 16L and 16R
November 20, 1998 -- Jet Aircraft Only

Port of Seattle
Seattle-Tacoma International Airport

Prepared Mar-2000

Figure E.36 Approach Profile Side View Plot
Seattle-Tacoma International Airport
Period: August 17th, 1998 through August 24th, 1998
Filter: Jet Arrivals South Flow Runway 16L and 16R (Elliott Bay)



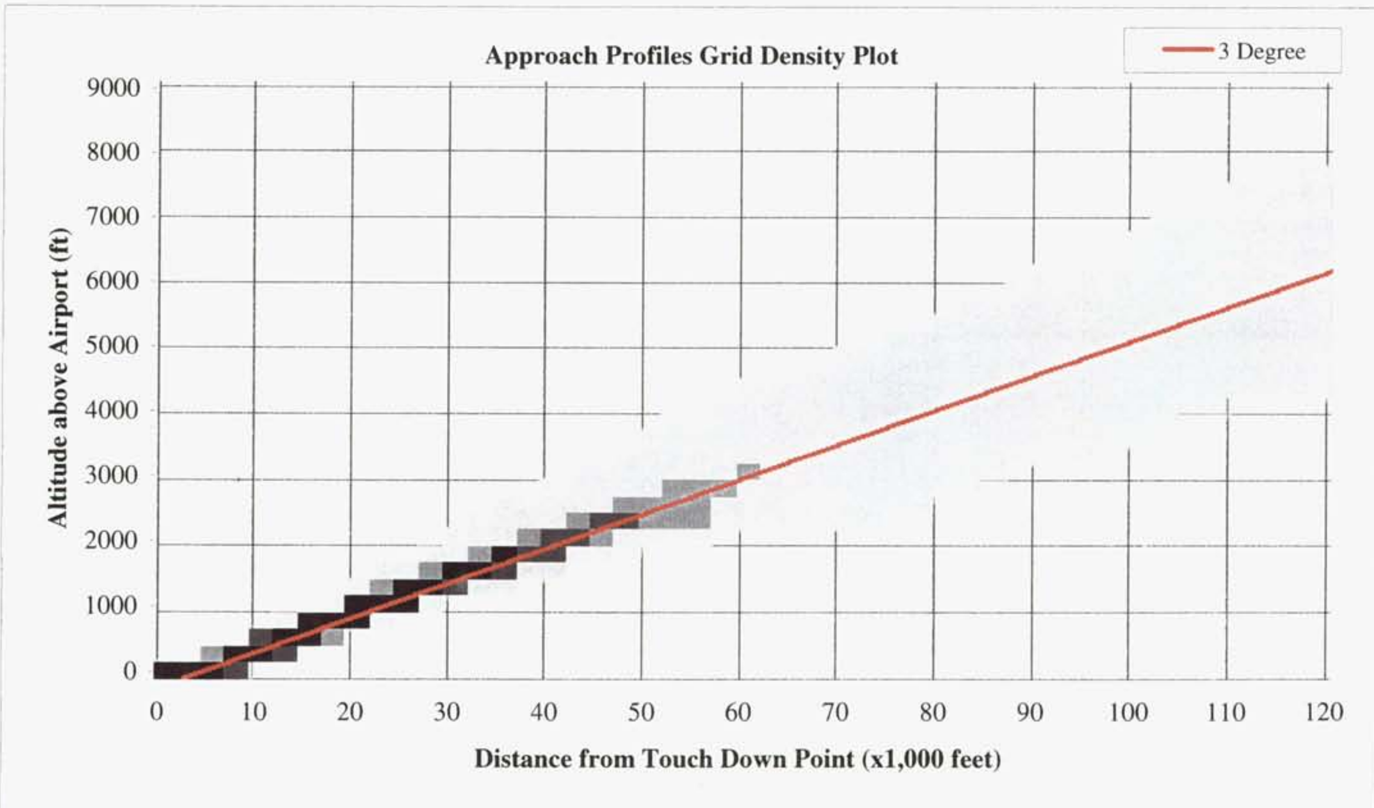
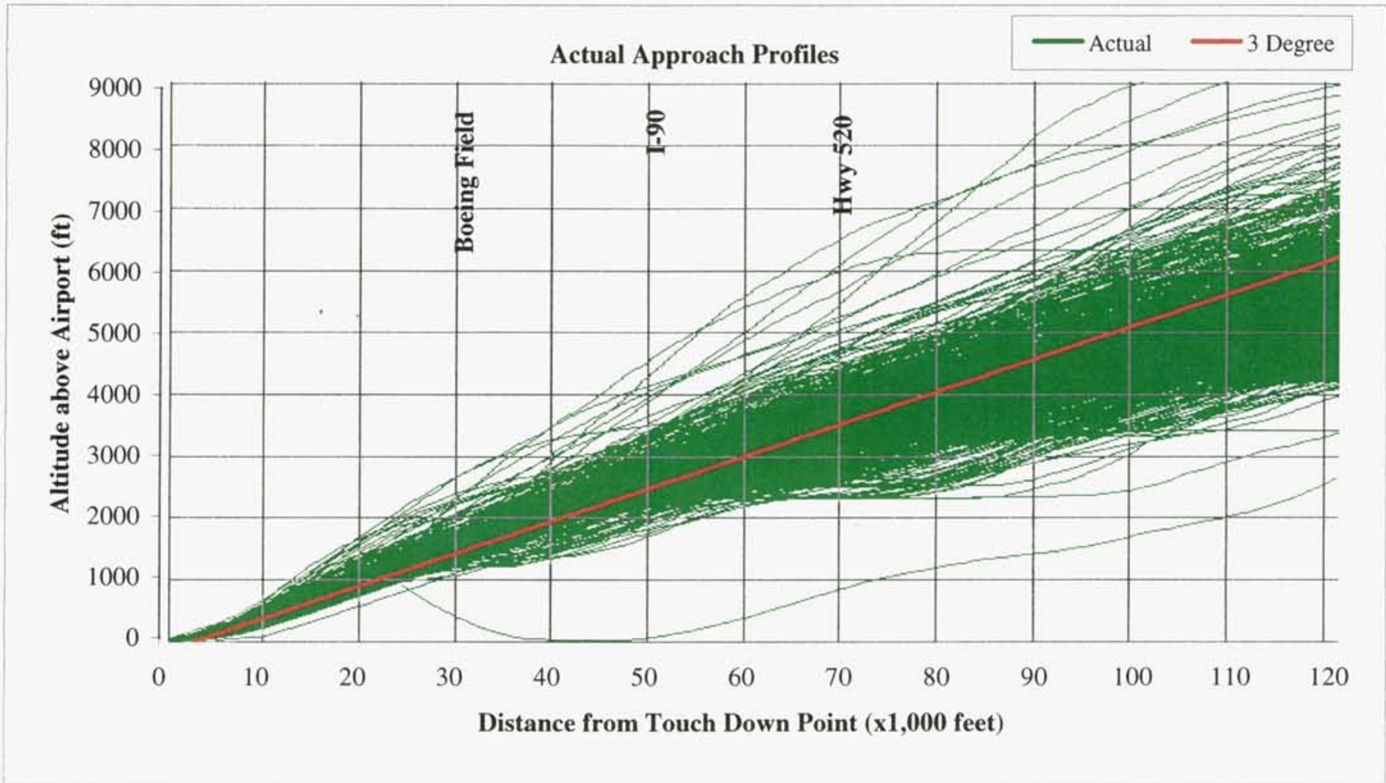


Figure E.37 Approach Profile Side View Plot
Seattle-Tacoma International Airport
Period: August 17th, 1998 through August 24th, 1998
Filter: Jet Arrivals South Flow Runway 16L and 16R (Straight In)



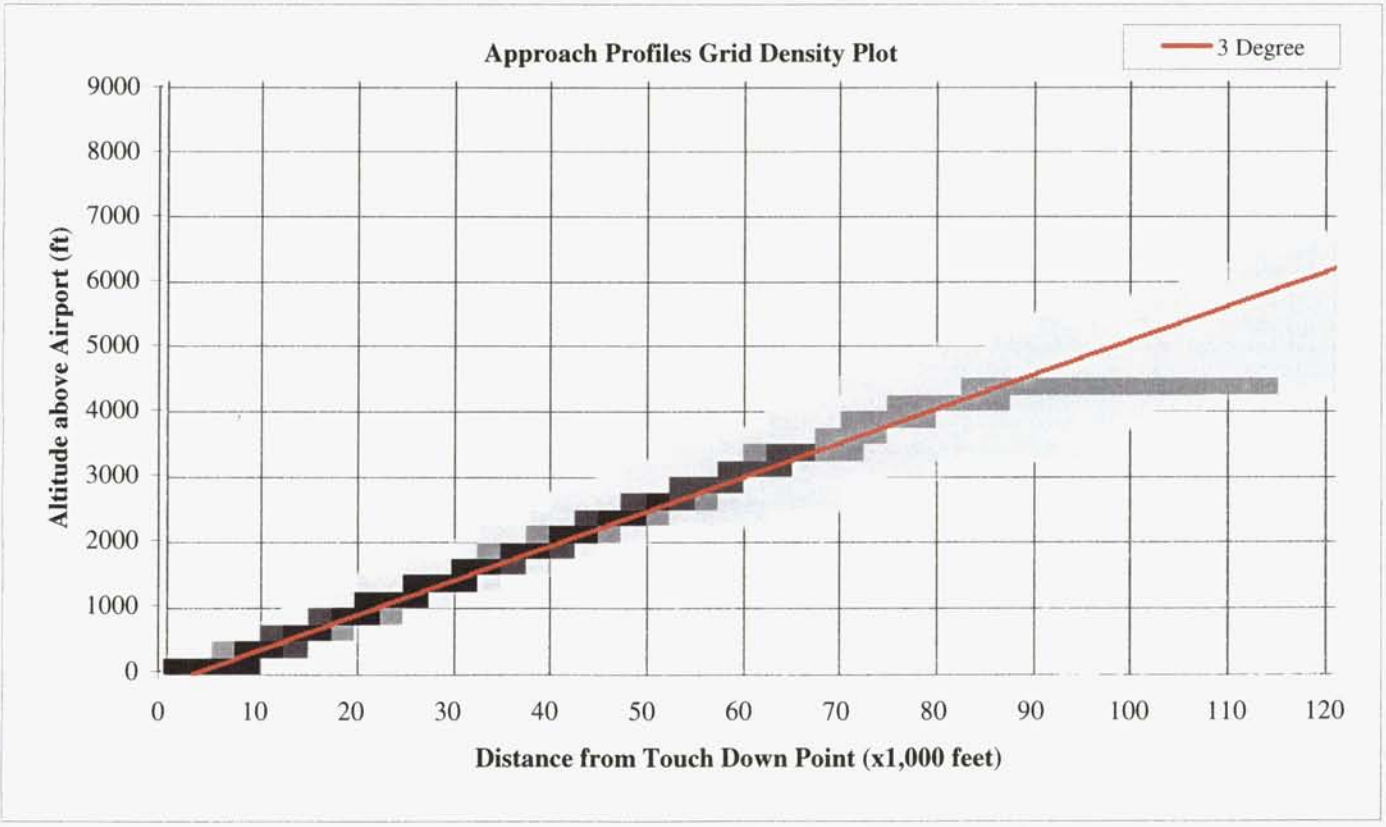
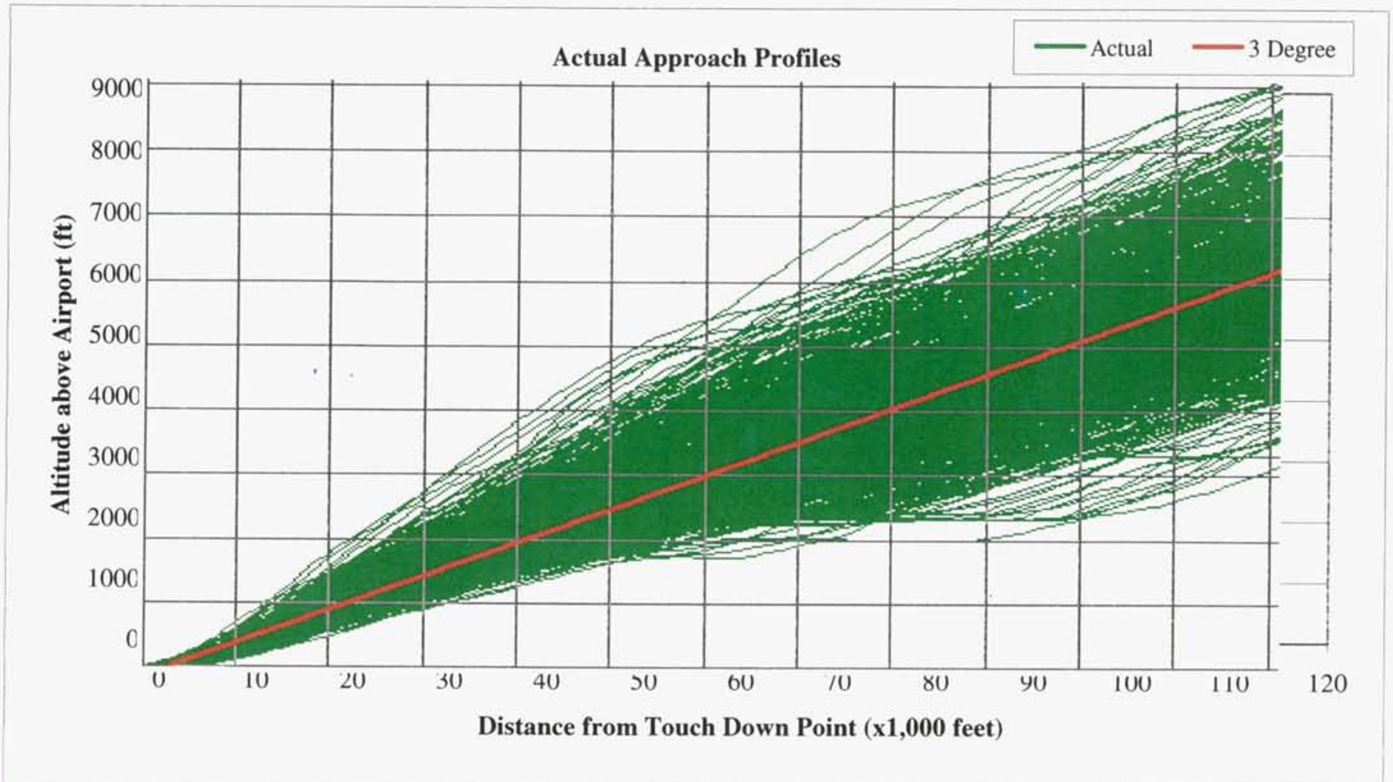
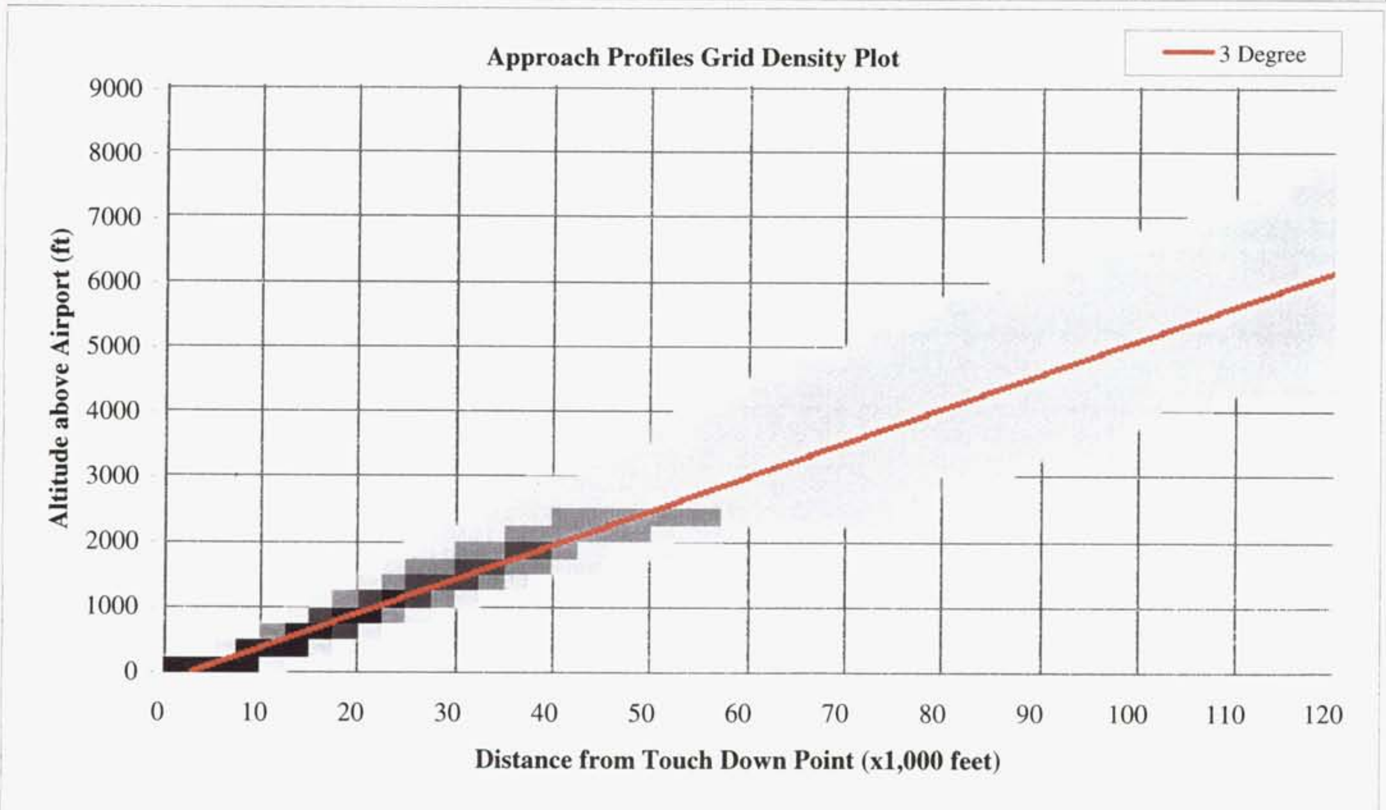


Figure E.38 Approach Profile Side View Plot
Seattle-Tacoma International Airport
Period: August 17th, 1998 through August 24th, 1998
Filter: Jet Arrivals North Flow Runway 34L and 34R (Straight In)





2. **Change Glide Slope Intercept to Higher Altitude**: Aircraft currently intercept the glide slope at about 4,500 feet AGL. Many citizens have suggested the concept of having aircraft intercept the glide slope at an earlier point when their altitude is higher, perhaps 5,500 feet. This approach could theoretically keep aircraft more closely on the ideal descent profile and reduce the "dips" that sometimes occur as they intercept the glide slope beam.

   Discussing this idea with the FAA has lead to the conclusion that changing the point of glide slope intercept may impact the capacity and efficiency of the airspace. In addition, aircraft entering the arrival stream from Elliott Bay now intercept the glide slope closer to the Airport and at a lower altitude than this proposal would require. To require Elliott Bay arrivals to the glide slope at an altitude of approximately 5,000 feet would mean directing them further north over all the communities between Elliott Bay and the straight-in approach path.

Based on these findings, the Port could develop approach profile monitoring to be included as an integral piece of the Fly Quiet program for the purpose of achieving more average profiles for aircraft that are lower than the average. The Port could use the data from this monitoring as feedback to airlines and FAA regarding adherence to the ideal arrival glide slope profile.

Radar flight tracks can be used to identify which flights are lower than the ideal arrival profile by airline, aircraft type, flight number, and time of day. Reports of these flights can be used to communicate with airline management, chief pilots, and FAA ATC personnel to encourage compliance with the glide slope angle of approach.

4.3 Location of Application of Normal Climb Power at 3,000 feet

This action is the same as Action 4.1

4.4 Departure and Arrival Procedure – Fly Quiet

Please refer to Action 3.8. This alternative is similar to flight corridors and tracks, but utilizing departure and arrival procedures to evaluate specific aircraft noise levels in relationship to average noise levels.

4.5 Limited Use of Reverse Thrust

Noise from the use of jet-engine thrust reverse is another important source of ground noise at the Airport. Its effects are more noticeable in the nighttime hours when other aircraft noise sources are less frequent.

Reverse thrust redirects the flow of the jet-engine exhaust toward the front of the aircraft. Reversing the power in this way slows the aircraft when on the ground. Pilots use reverse thrust for braking and to maintain directional control.

A typical landing procedure involves the pilot deploying the thrust reverse shortly after the main landing gear has touched down. Air spoilers (flaps on the top of the wing surface) are applied to increase drag to help slow the aircraft and to disturb the airflow over the wing to reduce lift. Power is judiciously applied to the engines up to a maximum allowable power setting of 85 to 90 percent. Pilots will utilize reverse thrust to slow the aircraft at a rate that is appropriate for landing conditions. The power that is applied relative to each engine can be adjusted to maintain directional control. After the aircraft has slowed to braking speed, use of thrust reverse can be discontinued and the aircraft brakes are applied to further slow the aircraft to a speed suitable for exiting the runway. Reverse thrust is most effective at high speed soon after touchdown.

Large or heavier aircraft require greater use of thrust reverse in order to slow the additional aircraft weight. Short runways or the opportunity of exiting the runway at early taxiways can also require greater use of thrust reverse. During periods of poor braking action (such as, a wet or icy runway), the deceleration provided by reverse thrust becomes even more important. Under these conditions, reverse thrust is deployed longer in order to slow the aircraft to a lower speed before brakes are applied.

Noise events from thrust-reverser use have unique characteristics that differ from other aircraft operations. Thrust-reverser noise is a short-duration event that starts and ends relatively quickly. There can also be great variability in the noise level from one event to another. The characteristics of thrust-reverser noise are summarized below:

- ✓ Short-duration noise event (typically averages 20 to 25 seconds).
- ✓ Quick on-set and drop-off rates for the noise.
- ✓ Frequency characteristics include a large low-frequency component.
- ✓ Large variability of the noise level from event to event.
- ✓ Magnitude of the noise is typically lower than departure noise.

The following alternatives are proposed for consideration.

Reduced Use of Thrust Reverse. The thrust-reverser use procedures are specific to each airline. Alaska Airlines has been using a thrust-reverser procedure for nighttime operations to minimize the noise from thrust-reverser use.

Effect of Taxiway Use on Thrust-Reverser Noise. The runway length available for stopping the aircraft can also affect the amount of noise generated from thrust-reverser use. For example, narrow-body aircraft landing on Runway 16R use Taxiway N to exit the runway (see Figure E1). This taxiway is positioned at a suitable stopping distance and minimizes taxi time to the terminal. During peak activity periods, use of this taxiway also minimizes delays by reducing the amount of time the aircraft are on the runway. With a longer available stopping distance, pilots have the option of using less reverse thrust. This has the effect of increasing the duration of the noise event, however, the maximum noise level can be lower.

In general, a pilot will not want to slow the aircraft too quickly, because this causes the aircraft to taxi at a slow speed to the runway exit location.

Noise Management Actions

The following noise program management actions were examined:

- ✓ **LANDING FEES**
  Noise-related landing fees

- ✓ **NOISE MONITORING**
  Expand the existing noise monitoring system with more stations

- ✓ **CITIZEN PARTICIPATION**
  Establish citizen complaint mechanism
  Establish community participation program

5.1 Noise-Related Landing Fees

At all commercial airports in the United States, aircraft weight is used to determine the fee for landing at an individual airport. As a means of encouraging or discouraging noisier operations, differential-landing fees might be levied based on the noise levels of particular aircraft types. That is, the noisiest aircraft would pay more than the quietest; either always, or during particularly noise-sensitive periods such as nighttime.

At Sea-Tac, fees and charges are levied to users and tenants of the Airport according to the "Basic Airline Agreement." At U.S. airports, landing fees (the cost paid by airlines to land and depart from an airport) are based on aircraft weight – a price per 1,000 lbs. The method by which airport fees (in addition to landing fees, there are rents, concession agreements, and other tenant fees) are calculated is subject to airline challenge, as well as to special federal regulation and oversight. This agreement at Sea-Tac expires in 2001.

A primary principle of federal regulations covering airfield charges is that they are to be based on cost recovery only. That is, the total fees charged by the Airport cannot exceed the cost of operating the airfield. Thus, if some noisier operations were to become more expensive, other quieter operations would have to cost less, and the entire landing fee structure of the Airport would change.

To vary from traditional landing weight-based practice by creating a noise-based landing fee would involve an extensive justification, evaluation, and review process. At a minimum this could include an FAR Part 161 study of noise benefits versus economic costs, and most likely a separate review under the federal aviation rates and charges regulations.

Noise benefits from a change in landing fee structure would depend entirely on airline reaction to the imposition of differential fees. In other words, if the incremental fee during noise-sensitive periods were less than the profit generated by a particular flight, then the airline would not change its aircraft type. Under those circumstances, a differential fee would have no impact on noise.

Also, as a general rule, landing fees are a small percentage of the total cost of an aircraft operation. Fuel, salaries, maintenance, and similar costs are considerably more significant. Therefore, a change in landing fee, unless it is very large, is not likely to affect airline scheduling.

Other items under consideration in this Study would seem to offer more potential for real noise benefit, as well as federal approval.

5.2 Noise Monitoring – Expand the Existing System

The purpose of a noise monitoring system is to gather reliable and consistent noise data over a considerable period of time. These data are then used to evaluate any change in conditions over time, to identify specific problem flights or ground operations, to respond to citizen complaints, to monitor aircraft adherence to established flight tracks, and to keep a continuous record of noise levels in neighborhoods surrounding the Airport.

The Port of Seattle is currently in the process of procuring a new and expanded noise monitoring system for Sea-Tac that has been designed and specified by means of a public process. An advisory committee helped identify locations for the 25 new monitors replacing the 11 old monitors. In addition to microphone location, the committee helped establish the type of information they wished to be collected and reported on a regular basis.

The noise monitoring system is a key tool for the Airport and citizens to track unusual events as well as changes in the noise environment over time.

5.3 Establish a Citizen Complaint Mechanism

Citizens who live around airports are keenly aware of any unusual events. When an aircraft operation or sustained activity occurs which they consider to be especially loud and annoying, or if they wish to have information about some sort of airport-related activity, a complaint telephone number is available. Airport staffs answering and/or monitoring this line are responsible for responding to inquiries and complaints. Records are kept of all calls by date, time, address, and subject. These records can be helpful in the analysis of the noise environment around the Airport.

Sea-Tac has a complaint telephone number located in the noise abatement office (206-433-5393 or 1-800-826-1147). Complaints are either answered live or recorded and then responded to after answers have been researched.

Although answering and recording complaints does not alleviate noise in itself, actions taken as a result of complaints can be helpful. For example, complaints about aircraft which seem to be straying from established flight tracks may be followed by a letter to a particular airline reminding them of the proper procedure and the annoyance which results from deviation.

5.4 Establish a Citizen Participation Process

Citizen participation is a key component of policy development in public agencies. The Port of Seattle is a strong believer in this principle and has participated in and encouraged citizen participation in the development of all its noise-abatement programs. From the first mediation process that resulted in the current noise regulations and insulation programs to the current Part 150 Study Update, no significant noise-abatement initiative has been undertaken without citizen participation, often in the form of a committee representing the key constituencies.

F Issues/Actions and Recommendations

Seattle-Tacoma International Airport

FAR Part 150 Study Update

Issues/Actions and Recommendations

Issues/Actions and Recommendations

Introduction

This Section presents the recommended noise abatement plan, which includes the issues to be addressed, the actions/recommendations to be taken to address those issues, the responsible parties involved for implementing those actions and recommendations, the Airport action to be taken, the time frame for implementation and the effectiveness of each. The issues and actions will become the recommended Noise Compatibility Program. The issues that require a new action are those recommendations that are intended to be implemented pursuant to this Study. This Section also recommends which Noise Exposure Map should be used for the basis of the Noise Compatibility Program. In addition, the Future Noise Exposure Map is presented, along with the impacts associated with it.

The recommendations included in this section are amendments to the Noise Compatibility Program for Seattle-Tacoma International Airport approved in 1985 and amended in 1993, as approved by the Federal Aviation Administration in May 1994. They consist of changes to the existing program as well as the addition of new program elements. For ease of reference, each proposed amendment is presented using the same identification system as utilized in the 1985 and 1993 documents. Measures not amended by this FAR Part 150 Study remain in effect as approved measures.

A recommended implementation schedule and sequence, in both narrative and graphic form, indicating the roles and responsibilities of the many parties involved in the Noise Compatibility Program for Seattle-Tacoma International Airport will be presented in a subsequent chapter.

Noise Compatibility Program Map

The Existing Noise Exposure Map (1998) reflects the largest DNL noise contours generated for the Study. They are larger than the Future Noise Exposure Map (2004) contours, resulting in more non-compatible land uses being eligible for mitigation programs. As such, the Existing Noise Exposure Map will be used to define the boundaries for all new programs recommended in this Study. It is possible, that at some future date, the future noise contours may approach the size of the existing noise contours. The likelihood of this happening, however, is not very high. Therefore, it is recommended that the aircraft noise contours depicted on the Existing Noise Exposure Map be used as the basis for the Noise Compatibility Program recommendations in this Part 150 Study.

Future Noise Exposure Map

The Future Noise Exposure Map is based on the Future Noise Contour and reflects the implementation of the recommendations that follow. The following table presents the number of acres of different land use types that would be found within the Future Noise Exposure Map contours, based upon the existing land use and the recommendations implemented, assuming that all single family homes within the 65 DNL contour would be sound attenuated and therefore considered compatible. Sound attenuated residential structures are considered compatible with the DNL noise contours inside the 65 and 70 DNL noise contours.

The Future Noise Exposure Map is illustrated on Figure F1, *FUTURE NOISE EXPOSURE MAP, 2004*. The specific noise abatement recommendations are contained on the pages following the Future Noise Exposure Map. They are categorized as Amended Actions and New Actions for each specific noise abatement recommendation. Some are administrative in nature while others are land use or operational in nature.

Table F1
FUTURE NOISE EXPOSURE WITH EXISTING LAND USE
Sea-Tac International Airport FAR Part 150 Study

Land Use	**DNL 65 Contour**		**DNL 70 Contour**		**DNL 75 Contour**		**Total**	
Residential	2,141	Ac	341	Ac	0	Ac	2,482	Ac
People	19,143		2,540		0		21,683	Ac
House. Units	7,823		1,116		0		8,939	Ac
Churches	6		9		0		15	
Schools	11		6		0		17	
Libraries	0		1		0		1	
Health Care	3		9		0		3	
Com/Retail	271	Ac	54	Ac	4	Ac	329	Ac
Open Space	715	Ac	291	Ac	60	Ac	1,066	Ac
Govt./Public	240	Ac	47	Ac	0	Ac	287	Ac
Airport	386	Ac	827	Ac	1,100	Ac	2,313	Ac
Water	85	Ac	0	Ac	0	Ac	85	Ac
Manufacture	263	Ac	67	Ac	13	Ac	343	Ac
Total	**4,101**	**Ac**	**1,627**	**Ac**	**1,178**	**Ac**	**6,734**	**Ac**

Contour totals do not include rights-of-way.

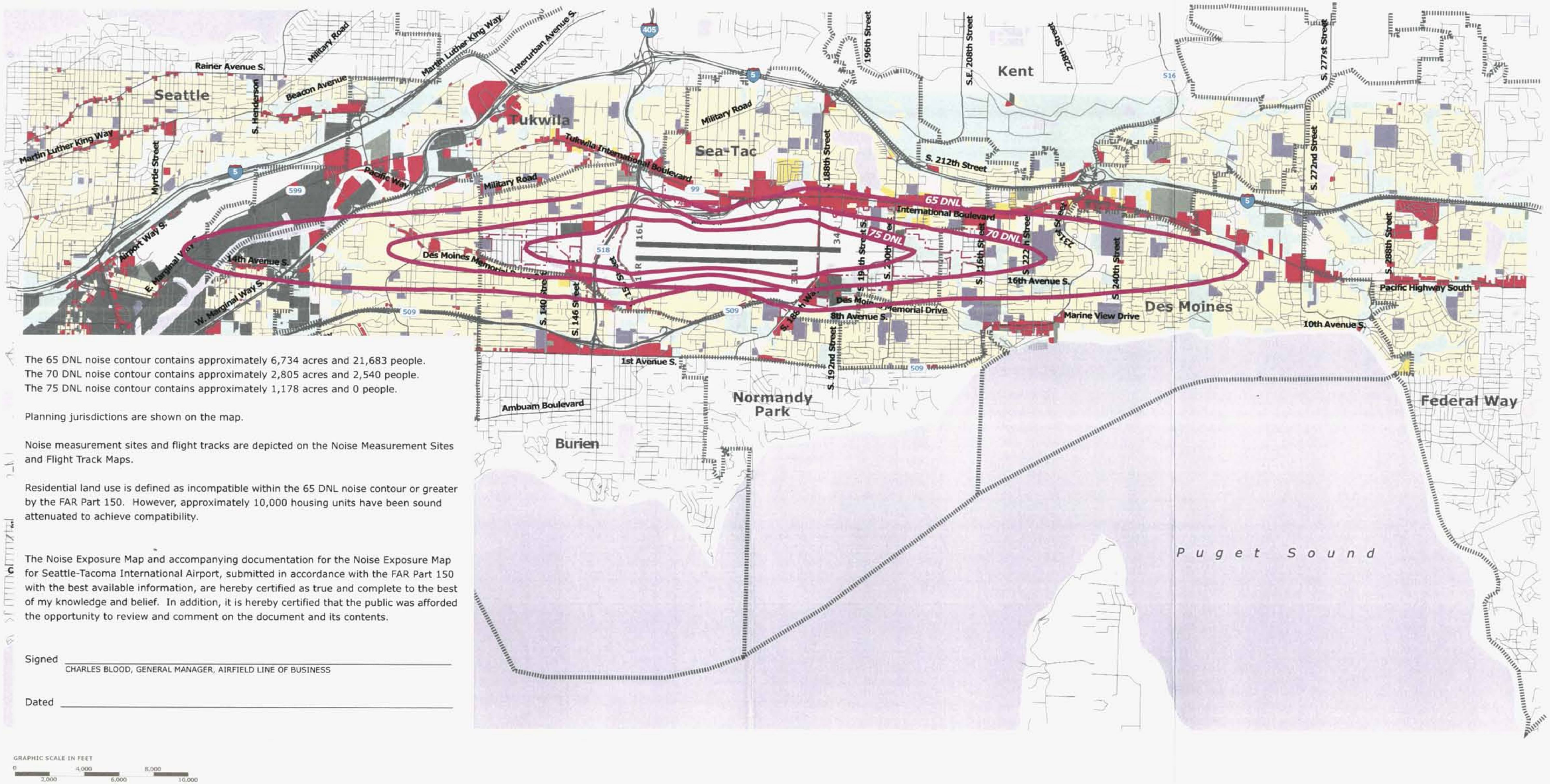
SOURCE: Master Plan EIS, Seattle-Tacoma International Airport, BDC Analysis

Recommended Actions

The Recommendations are summarized as follows.

Measure A-6	**Establish Follow-up Public Committee**
Measure A-7	**Establish Noise Barriers/Run-up Enclosure**
Measure A-9	**Encourage Voluntary Phase Out of Stage 2 Jet Aircraft Under 75,000 lbs.**
Measure A-10	**Maintenance Run-up Regulations**
Measure A-11	**Preferential Runway Use**
Measure A-12	**Development/Implementation of Fly Quiet Program**
Measure A-13	**Evaluate Increased Use of The Duwamish/Elliot Bay Corridor with FMS**
Measure A-14	**Nighttime Use of Commencement Bay Departure**
Measure A-15	**Use of FMS Procedures**
Measure A-16	**Use of Ground Equipment**
Measure A-17	**Raise Altitude Where Aircraft Intercept Glide Slope**
Measure M-2a	**Noise Compatibility Program Boundary**
Measure M-2b	**Insulation of Schools**
Measure M-2c	**Multi-Family Developments**
Measure M-2d	**Manufactured (Mobile) Homes**
Measure M-10	**Operations Review and NEM Updates**
Measure M-11	**Approach Transition Zone Acquisition**
Measure M-12	**Prepare Cooperative Development Agreements**
Measure M-13	**Amend Community Plans and Zoning Ordinances**

It is the intent of the Port of Seattle to implement future noise mitigation programs as quickly as possible. However, it must be remembered that this will depend very heavily on the availability of funds and resources.



The 65 DNL noise contour contains approximately 6,734 acres and 21,683 people.
The 70 DNL noise contour contains approximately 2,805 acres and 2,540 people.
The 75 DNL noise contour contains approximately 1,178 acres and 0 people.

Planning jurisdictions are shown on the map.

Noise measurement sites and flight tracks are depicted on the Noise Measurement Sites and Flight Track Maps.

Residential land use is defined as incompatible within the 65 DNL noise contour or greater by the FAR Part 150. However, approximately 10,000 housing units have been sound attenuated to achieve compatibility.

The Noise Exposure Map and accompanying documentation for the Noise Exposure Map for Seattle-Tacoma International Airport, submitted in accordance with the FAR Part 150 with the best available information, are hereby certified as true and complete to the best of my knowledge and belief. In addition, it is hereby certified that the public was afforded the opportunity to review and comment on the document and its contents.

Signed ______________________________
CHARLES BLOOD, GENERAL MANAGER, AIRFIELD LINE OF BUSINESS

Dated ______________________________

Figure F1 **Future Noise Exposure Map (2004) DNL Noise Contours with Existing Land Use**

- Single-Family Residential
- Multi-Family residential
- Mobile Home Park
- Commercial
- Public Facilities
- Governmental Services
- Water Resources and Recreation
- Airport
- Industrial
- Open Space, Parks, Cemeteries
- Agricultural Land and Freeways

Source: Basemap compiled from Tiger Line Data, 1994.
Generalized Existing Land Use, Gambrell Urban, Inc., EIS Master Plan, 1997. Noise Contours—BCS International.

A-6: ESTABLISH FOLLOW-UP PUBLIC COMMITTEE

ISSUE	Formulation of Fly Quiet Program and Evaluation of other Noise Abatement Programs.
AMENDED ACTION	The 1985 Part 150 established a public committee to address noise issues, which was transitioned into SNAC subsequent to Mediation. This Action is to convene a committee to monitor programs implemented as a result of the Part 150 Study after its completion.
COMMENTS	This Action will be very useful in helping develop and evaluate the Fly Quiet Program, as described in Measure A-12, and other noise abatement/mitigation actions that may arise. The Port has had a history of working with representative public committees on noise issues and this will be a continuation of that policy.
COST	The cost for the Committee could be included in the normal operating expenses of the Port.
RESPONSIBLE PARTIES	The Port is responsible for determining the formulation of the committee and committee administration. Other parties may be responsible for appointing members of the committee. Committee members are responsible for attending and participating in committee functions.
PORT ACTION	The Port will develop the committee structure and representation process. The Port will initiate the appointment process.
TIME FRAME	This Action can occur within the first six months of approval of the FAR Part 150 Study. It can also be implemented without regard to any other recommendation

A-7: ESTABLISH NOISE BARRIERS/RUN-UP ENCLOSURE

ISSUE

Reduce noise impacts from ground operations.

AMENDED ACTION

The 1985 Part 150 recommended the use of airport facilities for noise buffering of ground noise. This Action amends that to construct a noise barrier in the North cargo hardstand area of the Airport. The siting of the noise wall will be addressed during the environmental review process for the North End Development Program, which is examining space issues in the north cargo area, to ensure the wall provides maximum noise reduction. Incorporate noise barriers into future cargo area design and development, where feasible and effective. In addition, the Port will complete a siting/feasibility study for a Ground Run-up Enclosure (GRE) by December 31, 2001. Issues to be addressed include: atmospheric conditions, location, orientation and percentage of use.

COMMENTS

These Actions will help reduce impacts from noise levels associated with ground operations for various elements of the community. The North Cargo area experiences ground noise due to engine start, engine idle and taxiing, and auxiliary and ground power units. The barrier is to be designed to shield nearby communities from this noise and should be constructed of absorptive material. The noise barrier must be constructed so that movement of aircraft would not be restricted. The noise reduction of the barrier is anticipated to be in the range of 3 to 5 dBA, depending upon terrain and distances, with most areas potentially achieving 5 dBA of noise reduction.

The GRE is a three-sided enclosure, with no roof, where aircraft taxi to for the purpose of conducting an engine run-up. The GRE could offer reduction of noise levels by up to 15 dBA for local communities. No locations exist that would eliminate all run-up noise from every area adjacent to the Airport.

COST

The cost for the noise barrier is approximately $500,000 and the cost for the GRE ranges from approximately $3 to $7 million, depending on final design.

RESPONSIBLE PARTIES

The Port is responsible for design and construction of the noise barriers, for using facility designs to help reduce noise levels, and for conducting the siting/feasibility study for the GRE. The airlines would be responsible for using the GRE if it is constructed.

PORT ACTION

The Port will evaluate and identify a location for the GRE in conjunction with the over-all landside planning process. If it is found that the noise reduction from a GRE will be meaningful, and if a suitable location is found, construction will begin at the earliest possible time. The Port will initiate the design and construction process of the noise barriers as soon as feasible.

TIME FRAME

This noise barrier design and implementation can begin once the environmental work for the North Cargo Area is completed. The GRE site evaluation and determination can begin immediately. Construction cannot be initiated until a suitable location is found.

A-9: ENCOURAGE VOLUNTARY PHASE OUT OF STAGE 2 JET AIRCRAFT UNDER 75,000 LBS.

ISSUE

Phase Out of Noisier Aircraft, especially at Night.

AMENDED ACTION

The 1985 Part 150 recommended compliance with FAR Part 36 standards. This Action amends that through the voluntary phase out of Stage 2 jet aircraft operating at the Airport. Aircraft operating at Sea-Tac and meeting this criteria are currently older business jets and the F-28 commercial jet. Jet aircraft weighing less than 75,000 lbs. were exempt from the Stage 2 aircraft phase out mandated under the Airport Noise and Capacity Act (ANCA) of 1990. . This Action involves the Port of Seattle working with the operators and airlines to voluntarily limit operations by aircraft weighing less than 75,000 pounds, noise certified under FAR Part 36 as Stage 2, especially between the hours of 10 pm and 7 am.

COMMENTS

Horizon Airlines, operator of the F-28 aircraft at Sea-Tac, has recently announced an expedited schedule for the replacement of these aircraft. Horizon Airlines has indicated a willingness to work with the Port in voluntarily phasing these aircraft out based upon delivery dates of new Stage 3 aircraft. The intent of this Action is to shift the F-28 aircraft from the nighttime hours first by replacing them with quieter aircraft and then replace them with Stage 3 aircraft on other routes during the day, once they are phased out of the nighttime operations.

COST

The cost for the Action will be minimal as the airline is planning on replacing the F-28 as soon as possible. The Action is to replace nighttime operations as a first priority.

RESPONSIBLE PARTIES

The Port is responsible for working with Horizon to accomplish this as soon as possible and encouraging them to replace nighttime operations first.

PORT ACTION

The Port will work with the corporate operators and airlines to monitor the activities by these aircraft and to encourage the replacement of them.

TIME FRAME

This Action is anticipated to start in the near future with the availability of aircraft and is anticipated to be completed by the end of 2001.

A-10: MAINTENANCE RUN-UP REGULATIONS

ISSUE

Reduce noise impacts from engine run-ups required as part of maintenance of aircraft.

NEW ACTION

This New Action addresses maintenance run-ups and recommends several changes to run-up related activities. These include:

- Prohibiting run-ups during the overnight hours of midnight to 6:00 a.m.
- Include language that allows run-ups in the shoulder hours of 10:00 PM to Midnight and 6:00 AM to 7:00 AM only if necessary for a departure within two-and-a-half hours from scheduled run-up.
- Increase fines for violations to the run-up regulations to $1,000 for the first violation. Doubling each time thereafter, within a 12-month timeframe, to a maximum of $8,000 per occurrence.
- Implement new fine structure once new noise monitoring system has been fully installed and tested for reliability.
- Include run-up monitoring in Fly quiet program;
- Work with airlines to restrict run-ups on weekend mornings before 9:00 AM unless needed for a departure within two-and-a-half hours of scheduled departure.

COMMENTS

These Actions will help reduce impacts from ground noise sources as they relate to engine maintenance run-ups. The increase in fines is intended to discourage run-ups during critical time periods.

The benefits of these changes to the existing Sea-Tac regulation are:

- The proposed run-up rule provides an unequivocal restricted period from midnight to 6 AM. During this most sensitive nighttime period, even two-minute run-ups would not be allowed.

- The fines proposed would act as a deterrent from violating this rule.

- Scheduled departures in the shoulder periods would be protected.

- This proposed regulation offers local communities the comfort of a protected period into the future.

Although a Ground Run-up Enclosure (GRE) has been considered for Sea-Tac in the course of this Part 150 Study, it has not been fully recommended as a proposal for adoption. There are questions on the noise reductions that could be achieved with such a structure considering the unique atmospheric conditions of the Pacific Northwest, and the fact that no site has yet been identified to locate such a structure. The Part 150 recommendation is to conduct a feasibility/siting study to determine the noise reduction that can reasonably be expected and to see if a location can be found that would meet both the physical and meteorological conditions required for successful operation of a GRE.

As a result, there is currently no certainty that a GRE will be constructed at Sea-Tac. Even if a location is identified that is appropriate for the majority of aircraft types on which run-ups are most often conducted, and which would be effective under most Seattle weather conditions, construction of such a facility would take some time. By contrast, this run-up regulation change would be effective immediately and would provide noise abatement to adjoining neighborhoods until the GRE is completed. If, at that time, the regulation is redundant, it can be amended or removed.

Several issues have been raised during the formulation of this amendment that raised questions as to whether or not this recommendation would trigger an FAR Part 161 analysis. FAR Part 161 analysis is required if it appears that a recommendation will restrict access to an airport. Based on this criteria, the recommendations to change the Airport's rules and regulations regarding engine maintenance run-ups, is not seen as triggering an FAR Part 161 analysis. The specific issues surrounding this recommendation are discussed below.

- Exceptions – The proposed run-up regulation does not include exceptions, but that may be feasible under emergency situations.
- Safety – There is no reason to believe that this regulation would affect safety.
- Airline Schedules – This proposed regulation would not be expected to inhibit airline schedules, as it allows greater flexibility in allowing maintenance run-ups during the shoulder hours. This is equally true for Stage 2 (under 75,000 lb. aircraft) and Stage 3 aircraft.
- Delays – As all scheduled departures would be able to occur, there is no reason that this proposed regulation would cause delays.
- Shift of operations to another airport – There is no reason for airlines to shift any flights to another airport, as their schedules can be met under this regulation.
- Consultation – Staff has consulted with the airlines that perform the majority of engine maintenance run-ups at Sea-Tac (Alaska, Horizon and Northwest Airlines). Jointly they are responsible for more than 70% of run-ups. These airlines concur with the proposal and prefer it to the either the existing rule, or the one proposed by the CAC/TAC. In addition, the proposed rule modifications were presented in public hearing for the Part 150 and in hearings at the Port Commission level. There were no negative comments to the proposed rule received by any of the airlines either in writing or verbally.
- Maintenance businesses - There is no reason to believe that any maintenance business on the Airport would be adversely affected by this regulation. Alaska Airlines is the

only airline that operates a maintenance base at Sea-Tac Airport and they were involved in the discussions to develop this regulation. No other maintenance businesses are located at the Airport.

COST

The cost to implement these changes is minimal and would consist of updating rules and regulations. The cost to the airline for violating such restrictions is sufficient to discourage violations.

RESPONSIBLE PARTIES

The Port is responsible for amending its rules and regulations to reflect the amended restrictions. The airlines are responsible for complying with the restrictions.

PORT ACTION

The Port will amend its rules and regulations as soon as possible and distribute them to the tenant airlines.

TIME FRAME

This Action can be initiated immediately and is not dependent upon any other Action.

A-11: PREFERENTIAL RUNWAY USE

ISSUE

Increase utilization of an existing noise abatement corridor

NEW ACTION

This New Action implements a preferential runway system, during the nighttime hours, for operations through the North Flow Nighttime Noise Abatement Corridor. This would be operational when traffic and other conditions permit as determined by the FAA. When conditions permit, during nighttime hours, departures can be shifted from south to the north, thus utilizing the established noise abatement corridor[1]. This would be at the discretion of the FAA and would be premised on safe and efficient operating conditions.

COMMENTS

This Action will help reduce the number of residents exposed to aircraft noise impacts during critical nighttime hours, by rerouting aircraft over an industrial area and waterway. This Action will not affect the 65 DNL noise contour. The Port only favors this Action if the use of FMS procedures is standard for these departures.

COST

The cost to implement this Action is minimal, as some flights operate this way currently.

RESPONSIBLE PARTIES

The Port is responsible for requesting that the FAA utilize this procedure when possible and the FAA is responsible for directing traffic during favorable conditions. The operators are responsible for helping to implement the procedure during favorable conditions.

PORT ACTION

The Port will request that the FAA evaluate and implement this procedure during favorable conditions.

TIME FRAME

This Action can be implemented as soon as the FAA responds to the Ports request, finalizes whatever necessary procedural requirements there are and develops criteria for implementation.

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[1] Noise abatement corridor is a term used by the Port of Seattle to identify flight patterns that are more favorable from a noise impact perspective.

A-12: DEVELOPMENT/IMPLEMENTATION OF FLY QUIET PROGRAM

ISSUE

Encourage greater compliance with noise abatement procedures, work with operators to reduce single event noise levels, and continue to raise awareness of citizens noise concerns with the FAA and operators.

NEW ACTION

The Fly Quiet Program should be developed to:

- Monitor adherence to ideal noise abatement flight tracks
- Evaluate success of airlines, aircraft types and other variables
- Establish goals and track level of improvement over time
- Offer incentives for improvement

The Fly Quiet Program should include the following elements:

- Aircraft noise should be related to its effects on people including such factors as annoyance, speech interference and sleep disturbance
- Comparative fleet quality between airlines should also be included
- The program should utilize measured data from the Airport's noise monitoring system
- A method of normalizing data to account for airlines that most efficiently serve the region's air transportation needs should be developed.
- Incentives of sufficient importance that airlines will take notice of the results, and
- Pilots and air traffic controllers should be included, if possible.

COMMENTS

A Fly Quiet Program has the potential of reducing single event noise levels and encouraging greater compliance with preferential flight corridors and procedures. The program could potentially result in overall reductions in cumulative noise levels in some focused areas around the Airport as well. Identification of how individual aircraft operate at specific locations compared to the way the majority of aircraft operate, can help encourage the noisier operations to lower noise levels and/or adhere to established flight tracks. It is important to note that the safety and efficiency of the air traffic system will always take precedence. The specific elements and reporting techniques will be developed with the follow-on committee. The Fly Quiet Program cannot become fully implemented until the new Noise Monitoring System has been tested and is operational.

COST

The cost for this Action will be part of existing staff functions. The Noise Monitoring System is currently being installed.

RESPONSIBLE PARTIES

The Port is responsible, through consultation with the follow-on committee, for developing the final elements of the Program, for obtaining the relevant data from the Noise Monitoring System and for preparing reports. The follow-on committee is responsible for helping develop the elements and working with the Port in evaluating the results. FAA and operators are responsible for trying to follow the Fly Quiet recommendations.

PORT ACTION

The Port will evaluate and identify, in conjunction with the follow-on committee, the elements of the Fly Quiet Program, evaluate the Noise Monitoring System and initiate the Program.

TIME FRAME

The elements of the Fly Quiet Program can be identified and developed as soon as the follow-on committee is established. The Program cannot be initiated until installation of the Noise Monitoring System is completed.

A-13: EVALUATE INCREASED USE OF THE DUWAMISH/ELLIOTT BAY CORRIDOR WITH FMS

ISSUE

Reduce aircraft over flights of residential areas.

NEW ACTION

The Port encourages the FAA to pursue options for determining the feasibility of increased use of the Duwamish/Elliott Bay Corridor. No further analysis of this alternative to determine the potential benefits and/or increased impacts can be determined until the possible options are defined. The increasing availability of FMS technology ensures that the rate of adherence to an optimum flight track will increase over time.

COMMENTS

This Action is one that offers the likeliest potential for reducing overall noise impacts on the population of the Seattle area. This is especially true if a procedure is used with FMS technology to keep the aircraft tightly within the noise abatement corridor. The new Noise Monitoring System, currently being installed at Sea-Tac, will be able to produce detailed reports of adherence to this track if implemented. The Duwamish/Elliott Bay flight pattern is already established as a noise abatement procedure and is the preferred procedure for flights during the nighttime hours. However, there are communities located on the edges of Elliott Bay, as well as communities located on the west side of Puget Sound, that may potentially receive additional noise with this Action. Since there is no indication of the nature or number of flights, which may move to the Duwamish/Elliott Bay Corridor, no analysis has been completed to quantify the potential benefits and/or increased impacts of this change.

COST

The cost for this Action should be minimal as it is currently being implemented for nighttime operations. It cannot be fully known until the FAA provides more information.

RESPONSIBLE PARTIES

The Port is responsible for requesting that the FAA look into the feasibility of increasing the number of flights through the Duwamish/Elliott Bay Corridor from an operational and safety standpoint. The Port will pursue t his Action item separate from the Part 150 Study. The

FAA would be responsible for addressing the Port's request and providing the Port with the information to evaluate the noise impacts of increased use of the Duwamish/Elliott Bay Corridor.

PORT ACTION

The Port has requested that the FAA pursue the determination of feasibility for increasing use of this corridor. The Port has chosen to not include this item in the NCP and to pursue this separately from the remainder of the Part 150 process and subsequent approval. Once the Study by the FAA has been completed, the Port will review the findings and make a determination as to what the next steps it will take on this issue.

TIME FRAME

The Port has initiated the request to the FAA for further evaluation of alternatives for increasing the use of the Duwamish Corridor. The FAA has since responded to this request and the Port will address this item under a separate process. No specific timeframe exists for this item.

Since the draft of this document, the FAA has worked with the Port of Seattle in a parallel process to evaluate the potential of increasing flights through the Duwamish/Elliott Bay Corridor. The FAA completed their analysis and issued their findings on December 19, 2000.

The FAA analysis concluded that it was feasible, from an operational standpoint, to increase operations through the Duwamish/Elliott Bay Corridor. However, the implementation of such an action would greatly impact the efficiency of the air traffic system in the region and degrade safety. The Port of Seattle Commission reviewed the findings and in a letter to the FAA, dated April 19, 2001, agreed with the FAA findings that no viable alternative exists for increasing flights through the Duwamish/Elliott Bay Corridor.

This item requires no further action.

A-14: NIGHTTIME USE OF COMMENCEMENT BAY DEPARTURE

ISSUE

Reduce aircraft over flights of residential areas.

AMENDED ACTION

Study and coordination of the nighttime (midnight to 5 am) use of Commencement Bay corridor on a more regular basis. This Action should be studied and the decision on implementation should be deferred until coordination with representatives of Pierce County has occurred.

COMMENTS

A Commencement Bay departure track is not an existing published procedure, but is occasionally flown by aircraft. The Action is to increase the use of the track between the hours of midnight and 5 a.m. Greater use of this track would reduce impacts of south flow nighttime departures for most residents living south of the Airport. Discussions with the FAA indicated that traffic levels during extended daytime periods (from 5 a.m. to midnight) would be too high to allow use of this procedure for all flights, although it would likely be possible to use the procedure between midnight and 5 a.m. to a greater degree.

COST

The cost for the Action should be minimal. Study, coordination and evaluation can be done using existing staff and resources.

RESPONSIBLE PARTIES

The Port is responsible for initiating coordination with Pierce County to further discuss this item. Once this coordination is complete, the Port would need to coordinate with the FAA if it appears that a recommendation to move forward on implementing this procedure seems likely. If the Port of Seattle makes a recommendation to move forward with this measure, the FAA would be responsible for determining the feasibility, safety, and efficiency of proposed alternative.

PORT ACTION

The Port has chosen to not include this item in the NCP and to pursue this separately from the remainder of the Part 150 process and subsequent approval. Once the coordination has taken place with Pierce County representatives, the Port will review the findings and make a determination as to what the next steps it will take on this issue.

TIME FRAME

This Action can be initiated once coordination has occurred and a decision is made regarding a recommendation for the implementation of the procedure. No specific timeframe exists for this item.

A-15: USE OF FMS PROCEDURES

ISSUE

Reduce aircraft noise levels on residential areas.

AMENDED ACTION

This Action is to encourage the use of FMS procedures over non-populated areas and to discourage the development of new FMS procedures over populated areas, and to support development of FMS procedures for all north flow departures turning west to improve compliance with the identified noise abatement corridor. FMS flight tracks have the potential to become very narrow on straight portions of the flight track. When turning, however, the differing operating characteristics of the aircraft will cause dispersion.

COMMENTS

This Action would not impact new residents. As stated above, FMS technology can reduce the width of a flight track allowing the aircraft to remain over more compatible land uses such as Elliott Bay. Not all aircraft are equipped with FMS and are not capable of flying such a procedure. It should be noted, however, that FMS is the emerging navigation technology and most aircraft procedures in the country will increasingly rely on it during the next decade or so as more and more aircraft are being FMS equipped

COST

The cost for this Action is minimal as it is a continuation and expansion of an existing procedure.

RESPONSIBLE PARTIES

The Port is responsible for initiating coordination with the FAA and airlines on the expanded use of these procedures. If a recommendation is made by the Port of Seattle to pursue this measure, the FAA would be responsible for determining the feasibility, safety, and efficiency of alternative. The airlines will be responsible for implementing such procedures, when established, with properly equipped aircraft.

PORT ACTION

The Port will initiate coordination with the FAA and the airlines immediately upon approval of the Study.

TIME FRAME

This Action can be initiated immediately upon approval by the FAA.

A-16: USE OF GROUND EQUIPMENT

ISSUE

Reduction of noise impacts from ground operations at the Airport.

NEW ACTION

This Action will be to install power and conditioned air in existing and newly constructed gates to minimize use of auxiliary power units/ground power units (APUs/GPUs). Once power and conditioned air are installed at gates, airlines should be required to use these services.

COMMENTS

In flight and during taxiing, aircraft electrical demands and HVAC (heating, ventilation and air conditioning) needs are powered by the engines. The aircraft's internal battery system is designed to be used for emergency needs or limited use when on the ground. Therefore, when an aircraft is parked at a gate with the engines off, alternative sources of power are necessary for electrical, pre-conditioned air, and air compression for engine starts. Various methods for providing necessary alternative power range from auxiliary power units located on the aircraft to fixed power sources located at the gates. At Sea-Tac, APU noise was not found to be significant during the day when noise from aircraft arrivals and departures is dominant. However, during the nighttime hours, when other sources of noise are reduced, the potential for impacts from APU operations is greater. The use of APUs is most prevalent among the passenger aircraft. Cargo aircraft generally do not need auxiliary power to load aircraft and therefore do not use APU/GPU units on a regular basis. It is recommended at this time that fixed power and conditioned air be installed at passenger gates and not in areas used by cargo aircraft.

COST

This item has been included in the Airport's overall upgrade and is scheduled to begin in 2003 timeframe. Power is available at most gates and pre-conditioned air will be supplied from a central plant that is being constructed as part of the Central Terminal Expansion project at the Airport.

RESPONSIBLE PARTIES

The Port would be responsible for providing these needs at the passenger gates.

PORT ACTION

The Port will ensure that design of such features is included in new gates as well as existing gates once the central plant is constructed. Once both power and pre-conditioned air are available at gates, the Port will require the airlines to use these features.

TIME FRAME

These Actions can be initiated as the construction of the Central Terminal project progresses.

A-17: RAISE ALTITUDE WHERE AIRCRAFT INTERCEPT GLIDE SLOPE

ISSUE

Reduce aircraft noise levels on residential areas.

NEW ACTION

Through the Fly Quiet Program, the subsequent Follow-On Committee will work with the operators and the FAA toward a goal of having aircraft on the glide slope as far out as possible while not adversely impacting capacity. When aircraft are on arrival to the Airport, they are utilizing the glide slope and the angle of the glide slope to line up on the runway and descend at the proper rate of speed and angle to touch down on the runway. This is usually done under instrument flying conditions, but almost all-commercial service aircraft and cargo aircraft fly the glide slope even during clear weather conditions (VFR). All glide slope angles at the Airport are at three degrees. This is consistent with almost every other airport in the country. Aircraft are designed to operate at an approximate three-degree glide slope for safety, efficiency of aircraft movement, performance of the aircraft, and comfort to the passengers.

COMMENTS

Depending on flap and power settings, aircraft may be quieter when descending on the glide slope. A different intercept position may determine how long an aircraft is on the glide slope. This can vary with weather conditions. The farther out an aircraft intercepts the glide slope, the quieter the approach may be as the aircraft will not need to adjust speed, flaps, etc. as much.

COST

The cost for implementing this Action is minimal and the Port and the FAA will work together to have aircraft intercept the glide slope as far out as possible.

RESPONSIBLE PARTIES

The Port is responsible for working with the FAA to ask them to implement such an Action, the FAA is responsible for working with the approaching aircraft to assist them in intercepting the glide slope as far out as possible.

PORT ACTION

The Port will work with the FAA to achieve the desired goal.

TIME FRAME

This element will be discussed as part of the Fly Quiet Program with the subsequent Follow-On Committee.

M-2a: NOISE COMPATIBILITY PROGRAM BOUNDARY

ISSUE

Reduce inside noise levels for residences.

AMENDED ACTION

The 1985 Part 150 identified the existing Noise Remedy Boundary. In this Action, the Port will focus efforts on more highly impacted residential uses located within the 70 DNL with new programs. This will allow the Port to accurately mitigate the noise impacts based on the current noise environment for the next 5-7 years. These will be reevaluated when the next Part 150 Study Update occurs. The Port will continue to work with King County International Airport on combined noise impacts of both airports.

COMMENTS

Although the 1998 65 DNL contour will be used to identify the boundary of the Noise Compatibility Program recommendations from this Part 150 Study, the 1985 Noise Remedy Boundary will stay in effect for single-family homes. The noise contours are getting smaller and the Actions proposed in this FAR Part 150 Study address noise sensitive uses in louder noise contours. No change in the Noise Remedy Boundary is recommended for single-family homes.

COST

There is no cost associated with this Action.

RESPONSIBLE PARTIES

The Port will continue its existing responsibilities for sound attenuation of single-family homes within the existing Noise Remedy Boundary.

PORT ACTION

The Port will take no new Action at this time.

TIME FRAME

The Port will complete the existing sound attenuation program as soon as possible.

M-2b: INSULATION OF SCHOOLS

ISSUE

Reduce inside noise levels for schools.

AMENDED ACTION

This Action is to sound attenuate schools within the 1998 65 DNL noise contour.

COMMENTS

This Action will help reduce interior noise levels for schools within the 1998 65 DNL noise contour. The Port and the FAA are working with the Highline School District on developing a sound attenuation program for that District. Once an agreement is reached, the program elements should apply for all schools within the 65 DNL. The Port has already insulated several private schools within the contours where agreements were reached on criteria, and the Port continues to insulate classrooms at Highline Community College.

COST

The cost to implement this Action is estimated to be between approximately $50 to $100million.

RESPONSIBLE PARTIES

The Port is responsible for designing the Program, notifying the eligible facilities, determining eligibility, and providing sound attenuation construction. The schools are responsible for notifying the Port of their intention to participate in the Program and agreeing upon the criteria.

PORT ACTION

The Port has an established sound attenuation program in place and can initiate the process as soon as approval by the FAA and agreement is reached with the remaining schools. The process will continue based on the availability of funds.

TIME FRAME

Owners of such facilities that are potentially eligible can be notified as soon as the criteria is agreed upon and the Action is approved by the FAA, attenuation can be initiated as soon as funds are available.

M-2c: MULTI-FAMILY DEVELOPMENTS

ISSUE

Reduce inside noise levels for multi-family developments.

AMENDED ACTION

The 1993 Part 150 recommended a pilot project to sound attenuate a multi-family (greater than four units) structure. That pilot project was completed and this Action is to sound attenuate all owner-occupied multi-family structures within the 1998 70 DNL noise contour.

COMMENTS

There are approximately 300 owner-occupied multi-family units within the 1998 70 DNL noise contour. Owner occupied multi-family units, commonly referred to as condominiums or town homes, are being considered differently than renter occupied multi-family units, commonly referred to as apartments, for two major reasons: apartments are considered a business because the units are rented for profit and they are typically not a permanent residence and the residents are generally more mobile, and owner occupied multi-family residents typically have more monetary investment in their units. Such structures must meet the same eligibility criteria, standards and construction requirements, as do single-family homes within the Noise Remedy Boundary. Those units within the loudest noise contour should be given first priority.

COST

The cost for sound attenuating owner occupied multi-family structures within the 1998 70 DNL contour is estimated to be approximately $7 to $10 million.

RESPONSIBLE PARTIES

The Port is responsible for notifying the residents that would be eligible for sound attenuation, determining eligibility and providing sound attenuation construction. The residents are responsible for notifying the Port of their intention to participate in the Program.

PORT ACTION

The Port will identify those units that would be eligible based on noise contours, establish eligibility criteria and notify those residents who may be eligible. The Port would establish the Program and provide the attenuation construction.

TIME FRAME

The units within the contour can be identified shortly after approval of the Program by the FAA. Priorities can be developed and standards set. Actual sound attenuation will be dependent upon availability of funds.

M-2d: MANUFACTURED (MOBILE) HOMES

ISSUE

Reduce the number of mobile homes within the 1998 65 and 70 DNL contours.

AMENDED ACTION

The 1993 Part 150 recommended that the Port offer financial assistance for the removal of mobile homes for those residents that are living in a Park that the owner has decided to close. In exchange for this assistance, the Park owner would sign an Avigation Easement to ensure that a noise compatible use would replace the Park. This Action will amend that measure in two ways: first, the Port will purchase manufactured/mobile home parks (MMHP) within the 1998 70 DNL noise contour and provide relocation assistance to the residents of those parks in accordance with the Uniform Relocation and Real Property Acquisition Polices Act, as amended; and second, the Port will continue to offer financial assistance for the removal of mobile homes to those residents residing in parks, where the park owner has decided to close the park, located in the 1998 65 to 70 DNL. The Port should amend the existing program/policy (Port of Seattle Commission Resolution No. 3257) to include increases in amounts based on inflationary values.

COMMENTS

These Actions will help reduce noise impacts to mobile home residents with the 65 DNL noise contour. The 1993 Part 150 did not recommend purchase of any mobile home parks. However, it set certain criteria (including the granting of an avigation easement) for providing assistance to residents residing in parks the park owner has decided to close. In 1999 the Port amended that Action with *Resolution 3257* which increased the amount of money that could be available to assist such residents in relocating their mobile homes up to a maximum of $12,000 (see Resolution 3257 in the Appendix). This Action is intended to promote and encourage a land use change from a non-compatible use to a compatible use. As with the sound attenuation program, this depends on the voluntary commitment of the property owner.

COST

The cost to purchase the mobile home parks (seven parks with approximately 425 units) within the 1998 70 DNL contour is estimated to be approximately $40 to $50 million. The cost to assist relocating mobile homes (approximately 600) within the 65 DNL noise contour is approximately $10.3 million.

RESPONSIBLE PARTIES

The Port is responsible for designing and implementing the purchase program through the use of Consultants or existing staff. The mobile home park owners within the 1998 65 DNL noise contour are responsible for meeting the eligibility criteria. The jurisdictions with authority over the parks have the responsibility of ensuring the park owners redevelop with a compatible use.

PORT ACTION

The Port will identify parks eligible for purchase, develop criteria and policies for acquisition, and hire Consultants/assign staff to implement acquisition policies. The Port will work with the jurisdictions to provide assistance to eligible residents within parks wishing to close. The Port will work with the jurisdictions to ensure redevelopment for compatible use.

TIME FRAME

The mobile home park acquisition can begin as soon as the FAA approves the Program and funds are allocated for purchase. The mobile home relocation assistance is contingent upon the park owner desiring to close the park and meeting the established criteria.

M-10: OPERATIONS REVIEW AND NEM UPDATES

ISSUE

Update and Review of the FAR Part 150 Study.

AMENDED ACTION

The FAR Part 150 Study is a five-year program recommended to be reevaluated at the end of the five-year period. In addition, if there is a significant change in either aircraft types or numbers of operations, or significant new facilities, then it is recommended that the Study will be reevaluated prior to the end of the five-year time frame. The proposed new runway may be operational shortly beyond the time frame of this FAR Part 150 Study. As soon as that runway is operational, an update of this Part 150 should be initiated.

COMMENTS

The FAR Part 150 Program is a five-year program that will be reevaluated at the end of the five-year period. As per the Part 150 regulation, if there is a significant change in either aircraft types, numbers of operations or airport facilities that significantly change the noise levels, then the Study will be reevaluated prior to the end of the five-year timeframe.

COST

The cost of monitoring the information set forth in this section will be borne out of normal Port operating budget. Consultant assistance for various elements would be approximately $30,000.

RESPONSIBLE PARTIES

The Port would be responsible for updating and monitoring the FAR Part 150 Study at the five-year increments or when there is a significant change in aircraft types or numbers of operations. The Federal Aviation Administration could help fund the update if there are funds available for such planning.

PORT ACTION

Based on the monitoring activities described, the Port will reevaluate the program when there is a significant change in operations, aircraft types or the new runway, or at the end of the five-year timeframe. The Port will continue to publish the results of its evaluation in the Noise Abatement Quarterly Report.

TIME FRAME

The Port will continue its monitoring program and plan for a full update at the end of the fifth-year after submittal or earlier if necessary as per FAR Part 150. However, if the new runway is anticipated to be operational shortly after the five-year timeframe, the update should take place soon after the runway is operational.

Consultation

Seattle-Tacoma International Airport

FAR Part 150 Study Update

Consultation

Consultation

Introduction

The Seattle Tacoma International Airport (Sea-Tac) FAR Part 150 Study Update involved an extensive public consultation and involvement process, with many several components far exceeding the requirements of the regulation. This inclusive tone was set by the Port from the very beginning by organizing the Citizens and Technical Advisory Committees membership prior to the hiring of a Consultant. In an unusual step, members of the Citizens and Technical Advisory Committees also took part in the Consultant Selection process and helped select the Consulting Team.

The elements of the public consultation and involvement process were:

- Public Involvement Plan
- Two Advisory Committees
- Three Subcommittees
- Six Open Houses
- Meetings with Elected Officials
- Meetings with Individual Citizens
- Six Newsletters
- Website
- Numerous Working Papers and Technical Outlines
- Working Papers Available in Public Libraries
- An Extensive Technical Document
- Six Port of Seattle Commission meetings
- Two public hearings: one for the flight track component and one for the Noise Compatibility Program

The Public Involvement Plan is found in Appendix Two. The following is a brief description of the activities conducted in each of those categories.

Advisory Committees

The public involvement process began with the establishment of two committees: the Citizens and the Technical Advisory Committees. Composition of the Citizens Advisory Committee (CAC) was developed to include representatives from the eight jurisdictions immediately surrounding the Airport and the 13 King County Council Districts. Members of the CAC are listed in Appendix One. Composition of the Technical Advisory Committee (TAC) was developed to include representatives of the Planning Departments from the eight communities immediately surrounding the Airport, Airport users, King County International Airport, Puget Sound Regional Council, the Highline School District, and the Highline Community Hospital. Members of the TAC are listed in Appendix One.

These two committees met separately at the beginning of the Study. As the Study progressed, three Subcommittees were formed comprised of members from both the CAC and TAC to address issues relating to land use, operations, and data. As a result, the CAC and TAC were merged into an umbrella advisory committee to which the Subcommittees reported their activities and recommendations. All together the CAC, TAC and joint committee met 16 times.

Subcommittees:

The three Subcommittees, Data, Land Use and Operations, were open to any CAC/TAC member. Several people participated in more than one Subcommittee, and the Subcommittee meeting's were open to the general public. Each Committee and Subcommittee meeting was chaired by a Port Staff member or Consulting Team member at the request of the Committee members. The offer was made at the beginning of the Study to have the chairperson of the Committee meetings be a member of the CAC or TAC, however, Committee members did not favor this idea. Issues of concern to the different groups represented on the committees was presented and discussed during the meetings. Technical information and documentation were developed, discussed, and regularly revised according to Committee discussion and comments.

One of the major components of the Part 150 Study is the evaluation of reasonable alternatives, both land use and operational/facility alternatives, to reduce noise impacts and achieve greater land use compatibility. Alternatives were developed based on several factors:

- FAR Part 150 requirements,
- Puget Sound Regional Council resolution,
- Input from the public during Open Houses,
- Input from the Committee members and
- Consultant recommendations.

Each alternative was assigned to an appropriate Subcommittee for evaluation and recommendation. Members of each Subcommittee considered technical papers and presentations carefully on each subject matter. The type of analysis conducted was heavily influenced by the comments and questions from the Subcommittees. Most analysis completed, especially that provided to the Operations Subcommittee, far exceeded any analysis completed in previous Part 150 Studies.

The process for arriving at recommendations involved several steps:

1.Once the analysis was complete, Subcommittees considered each alternative and made recommendations on actions to be considered by the Port of Seattle.

2. These recommendations were then brought to the full CAC/TAC for their concurrence. The Citizens Advisory Committee also presented its own Paper on alternatives and recommendations, which is found in Appendix Seven.

3. The CAC/TAC recommendations were presented to and considered by the Port Staff and Management for concurrence. A Summary Matrix of these Recommendations is found in Appendix Nine, with separate Land Use Subcommittee Recommendations found in Appendix Eight.

4. Port Staff then made its recommendations based on the CAC/TAC recommendations.

5. The Staff recommendations were presented at the Open House and Public Hearing to solicit public comment, and then forwarded to the Port Commission.

About 40 Part 150 alternative actions were considered using this process, with several items including multiple sub-alternatives or options. The three Subcommittees met for a total of 30 meetings. Their membership is included in Appendix One and minutes of meetings appear in Appendix Three.

Open Houses

Six Open Houses were held during the Study where members of the public were able to interact directly with Airport and consulting staff on their noise related concerns. Display boards were available to present information being discussed among the different committees. At all Open House members of the public were afforded the opportunity to provide written comments, have their questions answered, and to take away printed material on the items being discussed. Public input from these Open Houses was influential in prioritizing issues during the Study.

The Open Houses took place in public schools near the Airport and were advertised in local daily and weekly newspapers, on the Study's Website, as well as in the Part 150 Update Newsletter mailed to approximately 5,000 area residents.

In addition to the scheduled Open Houses, Port Staff and Consultants attended numerous community and civic meetings to update and explain the Study findings, recommendations, and process. These meetings were attended by citizens, elected officials, civic groups, and community organizations, and were organized to present the Study findings to date.

Newsletters

Six newsletters were devoted to this Part 150 Study: four of a special publication called *Update* and two issues of a Port of Seattle newsletter called *Forum.*

Topics covered included everything from "What is a Part 150 Study?" to Final Recommendations. Contour maps and technical information was provided as well as information on Open Houses, the Study's Website, a list of committee members, and Port of Seattle staff working on the Study.

Website

Early in the Study a website was created to provide broad access to schedules, technical data, and other pertinent information. Among the items posted on this website were:

- Questions and answers
- Public Involvement Plan
- Technical Papers
- Minutes from all CAC/TAC and Subcommittee meetings
- Schedules
- Notices of Open Houses
- Comment Form.

Technical Outlines and Papers

Several technical Outlines and Working Papers were prepared and presented throughout the course of the Study. These included Inventory, Forecasts and Noise Analysis Working Papers, several Technical Outlines on Operational and Facility Alternatives, a Land Use Alternatives Technical Outline, as well as a Funding Source Memorandum. The Technical Outlines were updated and expanded during the many subcommittee meetings on the various subjects. The Technical Outlines served as the basis for the Alternatives Chapters in this document.

Public Hearings

Two public hearings were held in conjunction with this Study. The first was limited to the issue of flight tracks. The Port of Seattle Commission decided to consider this issue earlier than the rest of the recommendations in order to accelerate FAA review of this item. A Public Hearing on Port staff's recommendations on flight track issues was conducted by the Port Commission on May 18, 2000. The Public hearing was held in the Large Auditorium at Sea-Tac Airport from 6:00 pm to 11:45 pm. Several hundred people attended the hearing with 78 people providing public testimony. First reading of Resolution No. 3401, addressing Commission's decision on flight tracks, occurred on June 13, 2000, in a public open session. Second and final reading of Resolution No. 3401 was held on June 27, 2000 in a public open session. Staff Recommendations concerning flight tracks is found in Appendix Ten, comments to the Staff Recommendations are found in Appendix Eleven, and the Commission Resolution concerning flight tracks is found in Appendix Twelve.

The second series of Public Hearings addressed the Noise Compatibility Program recommendations by Port staff. The Noise Compatibility Program contains recommendations on operations and land use issues addressed in the Study. A Public Hearing was held in conjunction with an Open House on September 27, 2000. The Open House/Public Hearing was held in the Highline High School Performing Arts Center from 4:00 pm to 8:00 pm. Approximately 100 people attended. The Open House format consisted of display boards indicating the Staff Recommendations, the Existing and Future Noise Exposure Maps, and specific Noise Compatibility Program elements. Members of the Port Staff and Consulting Team were available to answer questions and listen to public comments and input. Comment sheets were available for recording written comments on the recommendations (see Appendix Fifteen). In addition, a court reporter was available to take verbal comments in an adjacent room. Approximately 20 people made verbal comments, which are contained in the transcript found in Appendix Fourteen. Responses to all pertinent comments, both verbal and written, are found in Appendix Sixteen.

Subsequent to the Open House/Public Hearing, the Port Staff presented recommendations to the Port of Seattle Commissioners in an open public meeting on November 14, 2000. Port Commissioners held first reading of Resolution No. 3443 on November 28, 2000, in a public open session. Second reading and final passage of Resolution No. 3443 was held on December 12, 2000, in a public open session. A copy of the Port Resolution adopting the FAR Part 150 recommendations and forwarding the complete document, including the Noise Exposure Maps and Noise Compatibility Program, to the Federal Aviation Administration is found in Appendix Seventeen.