FLAGSTAFF PULLIAM AIRPORT

14 CFR PART 150 NOISE COMPATIBILITY STUDY

NOISE COMPATIBILITY PROGRAM

FLAGSTAFF PULLIAM AIRPORT

14 CFR Part 150
Noise Compatibility Study

NOISE COMPATIBILITY PROGRAM

Prepared For
The City of Flagstaff

By
Coffman Associates, Inc.

September 2005

The preparation of this document was financed in part through a planning grant from the Federal Aviation Administration (FAA) as approved under the Airport and Airway Improvement Act of 1982, as amended. The contents of this report 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 therein, nor does it indicate that the proposed development is environmentally acceptable in accordance with applicable public laws.

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Flagstaff, Arizona

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Preface
NOISE COMPATIBILITY PROGRAM

This document is the Noise Compatibility Program (NCP) prepared for Flagstaff Pulliam Airport, which is owned and operated by the City of Flagstaff, Arizona. The NCP is the second of two parts required for a Code of Federal Regulations (CFR) Title 14, Part 150 Noise Compatibility Study. It includes Chapters Five, Six, and Seven of the study, in addition to three appendices. The first volume, *Noise Exposure Maps* (NEM), was published in May 2004.

Chapter Five of the Noise Compatibility Program, Noise Abatement Alternatives, discusses and analyzes potential methods of reducing or shifting aircraft noise to be less disturbing to noise-sensitive areas.

Chapter Six, Land Use Alternatives, analyzes potential land use planning and zoning techniques to prevent the development of new noise-sensitive land uses in areas exposed to aircraft noise. Aircraft noise mitigation measures are also presented in Chapter Six.

Chapter Seven presents the Noise Compatibility Plan. The plan is organized into three elements: noise abatement, land use management, and program management. The first two elements are based on the findings from Chapters Four and Five. The program management element includes measures to administer, refine, and update the overall program as needed in the future.

Appendix A lists the members of the Planning Advisory Committee (PAC) who were consulted throughout the planning process.

Appendix B contains information regarding project coordination and local consultation.

Appendix C is the output from the Integrated Noise Model. This appendix is printed in the *Noise Exposure Maps* document.

Appendix D contains program implementation materials including sample building codes.

For the convenience of FAA reviewers, the FAA's official Noise Compatibility Program Checklist is included on pages iii through vii. The sponsor's certification statement is on page viii.

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NOISE COMPATIBILITY PROGRAM CHECKLIST

AIRPORT NAME: ***Flagstaff Pulliam Airport***
Flagstaff, Arizona

REVIEWER: _____

	Yes/No/NA	Page No. Other Reference
I. **IDENTIFICATION AND SUBMISSION OF PROGRAM:**		
A. Submittal is properly identified:		
1. Part 150 NCP?	Yes	Title Page; p. i
2. NEM and NCP together?	No	
3. Program revision?	No	
B. Airport and Airport Operator's name identified?	Yes	Title Page; p. i
C. NCP transmitted by airport operator cover letter?	Yes	
II. **CONSULTATION: [150.23]**		
A. Documentation includes narrative of public participation and consultation process?	Yes	Appendix B; supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"
B. Identification of consulted parties:		
1. all parties in 150.23(c) consulted?	Yes	Appendix A; Appendix B; and supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"
2. public and planning agencies identified?	Yes	Appendix A; Appendix B; and supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"
3. agencies in 2, above, correspond to those indicated on the NEM?	Yes	Appendix A; Appendix B; and supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"
C. Satisfies 150.23(d) requirements?		
1. documentation shows active and direct participation of parties in B, above?	Yes	Appendix B; supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"
2. active and direct participation of general public?	Yes	Appendix B; supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"
3. participation was prior to and during development of NCP and prior to submittal to FAA?	Yes	Appendix B; supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"

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	Yes/No/NA	Page No. Other Reference
4. indicates adequate opportunity afforded to submit views, data, etc.?	Yes	Appendix B; supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"
D. Evidence included of notice and opportunity for a public hearing on NCP?	Yes	Appendix B; supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"
E. Documentation of comments: 1. includes summary of public hearing comments, if hearing was held?	Yes	Appendix B; supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"
2. includes copy of all written material submitted to operator?	Yes	Appendix B; supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"
3. includes operator's responses/disposition of written and verbal comments?	Yes	Supplemental volume titled "Supporting Information on Project Coordination and Local Consultation"
F. Informal agreement received from FAA on flight procedures?	Yes	The local tower manager indicated qualified acceptance of noise abatement measures and was involved in the Planning Advisory Committee (PAC) meetings. FAA representative from Airports Division of the Western Pacific Region also attended PAC meetings and indicated qualified agreement with noise abatement measures.

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	Yes/No/NA	Page No. Other Reference
III. **NOISE EXPOSURE MAPS:[150.23, B150.3, 150.35(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?	N/A	
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.)		
1. Revised NEMs included with program?	N/A	
2. Has airport operator requested FAA to make a determination on the NEMs when NCP approval is made?	N/A	
C. If program analysis uses noise modeling:		
1. INM, HNM, or FAA-approved equivalent?	N/A	
2. Monitoring in accordance with A150.5?	N/A	
D. Existing condition and 5-year maps clearly identified as the official NEMs?	N/A	
IV. **CONSIDERATION OF ALTERNATIVES: [B150.7, 150.23(e)]**		
A. At a minimum, are the alternatives below considered?		
1. land acquisition and interests therein, including air rights, easements, and development rights?	Yes	Chapter 6, pp. 6-20 – 6-22. 6-24, 6-26
2. barriers, acoustical shielding, public building soundproofing?	Yes	Chapter 5, pp. 5-9 – 5-10
3. preferential runway system?	Yes	Chapter 5, pp. 5-3 – 5-4
4. flight procedures?	Yes	Chapter 5, pp. 5-5 – 5-7
5. restriction on type/class of aircraft (at least one restriction below must be checked)		
a. deny use based on Federal standards?	Yes	Chapter 5, pp. 5-14 – 5-17
b. capacity limits based on noisiness?	Yes	Chapter 5, pp. 5-20 – 5-21
c. noise abatement takeoff/approach procedure?	Yes	Chapter 5, pp. 5-10 – 5-14
d. landing fees based on noise or time of day?	Yes	Chapter 5, pp. 5-19
e. nighttime restrictions?	Yes	Chapter 5, pp. 5-16 – 5-19
6. other actions with beneficial impact?	Yes	Chapter 5, pp. 5-20 – 5-23
7. other FAA recommendations?	N/A	

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	Yes/No/NA	Page No. Other Reference
B. Responsible implementing authority identified for each considered alternative?	Yes	Chapter 5, pp. 5-28, 5-31, Chapter 6, Table 6B, p. 6-28
C. Analysis of alternative measures: 1. measures clearly described?	Yes	Chapter 5, pp. 5-4 – 5-40, Chapter 6, pp. 6-3 – 6-27
2. measures adequately analyzed?	Yes	Chapter 5, pp. 5-4 – 5-40, Chapter 6, pp. 6-3 – 6-27
3. adequate reasoning for rejecting alternatives?	Yes	Chapter 5, pp. 5-4 – 5-40, Chapter 6, pp. 6-3 – 6-27
D. Other actions recommended by the FAA: Should other actions be added? (list separately or on back of this form actions and discussions with airport operator to have them included prior to the start of the 180-day cycle)	N/A	
V. **ALTERNATIVES RECOMMENDED FOR IMPLEMENTATION: [150.23(e), B150.7(c), 150.35(b), B150.5]** A. Document clearly indicates: 1. alternatives recommended for implementation?	Yes	Chapter 7, pp. 7-2 – 7-14, Table 7D, p. 7-17 – 7-18
2. final recommendations are airport operators, not those of consultant or third party?	Yes	Sponsor's Certification, p. viii
B. Do all program recommendations: 1. relate directly or indirectly to reduction of noise and noncompatible land uses?	Yes	Chapter 7, pp. 7-2 – 7-14
2. contain description of contribution to overall effectiveness of program?	Yes	Chapter 7, pp. 7-2 – 7-14
3. noise/land use benefits quantified to extent possible?	Yes	Chapter 5, pp. 5-26 – 5-31, Chapter 7, pp. 7-15 – 7-16
4. include actual/anticipated effect on reducing noise exposure within noncompatible area shown on NEM?	Yes	Chapter 7,p. 7-14 – 7-16,
5. effects based on relevant and reasonable expressed assumptions?	Yes	Chapter 5, pp. 5-26 – 5-31, Chapter 7, pp. 7-2 – 7-14, Table 7D, p. 7-17 – 7-18
6. have adequate supporting data to support its contribution to noise/land use compatibility?	Yes	Chapter 5, Chapter 6, Chapter 7
C. Analysis appears to support program standards set forth in 150.35(b) and B150.5?	Yes	Chapter 5, Chapter 6, Chapter 7

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	Yes/No/NA	Page No. Other Reference
D. When use restrictions are recommended: 1. are alternatives with potentially significant noise/compatible land use benefits thoroughly analyzed so that appropriate comparisons and conclusions can be made?	N/A	No use restrictions recommended
2. use restrictions coordinated with APP-600 prior to making determination on start of 180 days?	N/A	
E. Do the following also meet Part 150 analytical standards: 1. formal recommendations which continue existing practices?	N/A	
2. new recommendations or changes proposed at end of Part 150 process?	Yes	Chapter 7, pp. 7-2 – 7-14
F. Documentation indicates how recommendations may change previously adopted plans?	Yes	Chapter 7, pp. 7-2 – 7-14
G. Documentation also: 1. identifies agencies which are responsible for implementing each recommendation?	Yes	Sponsor's Certification on p. viii. By approving NCP, City of Flagstaff has agreed to seriously consider implementation of the measures for which it has sole responsibility, provided funding is available. It has also agreed to encourage other organizations and agencies to take and recommend actions per NCP.
2. indicates whether those agencies have agreed to implement?	Yes	Chapter 7, pp. 7-2 – 7-14, Table 7D, p. 7-17 – 7-18
3. indicates essential government actions necessary to implement recommendations?	Yes	Chapter 7, pp. 7-2 – 7-14, Table 7D, p. 7-17 – 7-18
H. Timeframe: 1. includes agreed-upon schedule to implement alternatives?	Yes	Chapter 7, pp. 7-2 – 7-14, Table 7D, p. 7-17 – 7-18
2. indicates period covered by the program?	Yes	Chapter 7, p. 7-1, pp. 7-2 – 7-14, Table 7D, p. 7-17 – 7-18
I. Funding/Costs 1. includes costs to implement alternatives?	Yes	Chapter 7, pp. 7-2 – 7-14, Table 7D, p. 7-17 – 7-18
2. includes anticipated funding sources?	Yes	Chapter 7, pp. 7-2 – 7-14, Table 7D, p. 7-17 – 7-18
VI. **PROGRAM REVISION [150.23(e)(9)] Supporting documentation includes provision for revision?**	Yes	Chapter 7, p. 7-14

SPONSOR'S CERTIFICATION

The Noise Compatibility Program and accompanying documentation for Flagstaff Pulliam Airport, including the description of consultation and opportunity for public involvement, submitted in accordance with Code of Federal Regulations, Title 14, Part 150, are hereby certified as true and complete to the best of my knowledge and belief. It is also certified that this documentation is the City of Flagstaff's official Noise Compatibility Program for Flagstaff Pulliam Airport.

It is further certified, to the best of my knowledge and belief, that adequate opportunity has been afforded to interested persons to submit views, data, and comments concerning the correctness and adequacy of the Noise Compatibility Program and forecast aircraft operations.

_____
Date of Signature

_____
David W. Wilcox
City Manager, City of Flagstaff

FLAGSTAFF
PULLIAM AIRPORT

Chapter Five

NOISE ABATEMENT ALTERNATIVES

Chapter Five

NOISE ABATEMENT ALTERNATIVES

The *DOT/FAA Aviation Noise Abatement Policy of 1976, the Airport Safety and Noise Abatement Act of 1979,* and *the Airport Noise and Capacity Act of 1990* outline the framework for a coordinated approach to noise abatement and mitigation of noise impacts. Responsibilities are shared among airport users, aircraft manufacturers, airport proprietors, federal, state, and local governments, and residents of communities near the airport.

- The federal government has the authority and responsibility to control aircraft noise at the source, implement and enforce operational flight procedures, and manage the air traffic control system in ways that minimize noise impacts on populated areas.
- Aircraft manufacturers are responsible for incorporating quiet engine technology into new aircraft designs to meet federal noise standards.
- Airport proprietors are responsible for planning and implementing airport development actions designed to reduce noise. These include noise abatement ground procedures and improvements in airport design. Proprietors may also enact restrictions on airport use that do not unjustly discriminate against any user, impede the federal interest in safety and management of the air navigation system, unreasonably interfere with interstate commerce, or otherwise conflict with federal law.

- Local governments are responsible for land use planning, zoning, and building regulations to encourage development that is compatible with present and projected airport noise levels.

- Air carriers, all-cargo carriers, and commuter operators are responsible for retirement, replacement, or retrofitting of older aircraft to meet federal noise standards. They are also responsible for operating aircraft in ways that minimize the impact of noise on people.

- General aviation operators are responsible to use proper aircraft maintenance and flying techniques to minimize noise output.

- Air travelers and shippers generally should bear the cost of noise reduction, consistent with established federal economic and environmental policy which states that the adverse environmental consequences of a service or product should be reflected in its price.

- Residents of areas surrounding airports should seek to understand the aircraft noise problem and what steps can and cannot be taken to minimize its effect on people.

- Prospective residents of areas impacted by aircraft noise should be aware of the effect of noise and make their locational decisions with that in mind.

An airport noise abatement program has three primary objectives:

1. To reduce the noise-impacted population in the study area, within practical cost and legal constraints.

2. To minimize, where practical, the exposure of the local population to very loud noise events. These loud single events can occur even outside the DNL contours. They can annoy airport neighbors and warrant attention.

3. To ensure maximum compatibility of existing and future land uses with aircraft noise at the airport.

This chapter discusses and analyzes measures which may potentially abate noise in the Flagstaff Pulliam Airport area. It begins by screening the full range of potential noise abatement measures for possible use at Flagstaff Pulliam Airport. The screening criteria include the probable noise reduction over noise-sensitive areas, the potential for compromising safety margins and the ability of the airport to perform its intended function, and the potential for implementation considering the legal, political, and financial climate of the area. Measures which merit further consideration are analyzed in the second half of this chapter where detailed noise analyses are presented. The last section summarizes the results of the analysis by comparing the various alternatives.

POTENTIAL NOISE ABATEMENT MEASURES

A comprehensive list of potential noise abatement measures is shown in **Exhibit 5A**. 14 CFR Part 150 (Part 150) specifically requires most of these to be analyzed in noise compatibility studies for possible use at airports undertaking those studies. These techniques either (1) reduce the size of the noise contours or (2) they move the noise to other areas where it is less disruptive.

To reduce the size of the noise contours, the total sound energy emitted by the aircraft must be reduced. This can be done by modifying aircraft operating procedures or restricting the number or type of aircraft allowed to operate at the airport. Measures which can be used to shift the location of noise include runway use programs, special flight routes, and airport facility development. In short, potential noise abatement measures can be assigned to the following four categories:

- Runway Use and Flight Routing
- Airport Facilities
- Aircraft Operational Procedures
- Airport Regulations

RUNWAY USE AND FLIGHT ROUTING

The land use pattern around the airport provides clues to the design of arrival and departure corridors for noise abatement. By redirecting air traffic over compatible land uses, noise impacts may be significantly reduced in noncompatible areas.

Flagstaff Pulliam Airport has residential development off both ends of Runway 3-21. Two areas provide potential corridors for air traffic. A small undeveloped corridor exists to the northeast over the golf course and to the south over Interstate 17. Runway 3-21 is generally aligned with these corridors, yet certain directional operations could utilize these corridors for arrivals and departures for noise abatement to a greater extent.

Preferential Runway Use

Preferential runway use programs are intended to direct as much noise as possible over the least noise-sensitive areas. They accomplish this by favoring the runway or runways which lead traffic over compatibly developed areas.

FAA Order 8400.9 describes national safety and operational criteria for establishing runway use programs. It defines two classes of programs: *formal* and *informal*. A formal program must be defined and acknowledged in a Letter of Understanding between FAA's Flight Standards Division and Air Traffic Service, the airport proprietor, and the airport users. Once established, participation by aircraft operators is mandatory. Formal programs can be extremely difficult to establish, especially at airports with many different users. An informal

program is an approved runway use program which does not require the Letter of Understanding. Informal programs are typically implemented through a Tower Order and publication of the procedure in the Airport/Facility Directory. Participation in the program is voluntary.

- EVALUATION

Runway 21 is favored more than Runway 3. Seventy percent of aircraft operations arrive and depart on Runway 21. The use of Runway 21 (southwestern flow) more than Runway 3 is a function of wind conditions and the Airport's only precision instrument approach is to Runway 21. The current runway use is favorable for aircraft arrival noise abatement because of the small undeveloped corridor that exists to the northeast of the Airport.

Increasing the use of Runway 3 for arrivals and departures (northeastern flow) is problematic. First, winds favor a southwestern flow and encouraging pilots to take a tail wind component on arrivals and departures in not considered a safe practice. Second, arrivals are much more concentrated because aircraft must line up on runway centerline, and departures are somewhat more dispersed as aircraft begin to turn on course as they leave airport property. The location of residential development along runway centerline immediately west of Interstate 17, southwest of the airport, would receive a concentration of arrival noise instead of dispersed departure noise, which is what it is already being experienced. Most of the benefit of aircraft noise reduction technology has been focused on quieter engines. Because of this technology, the noise benefit occurs on departure when the aircraft engine thrust levels are highest. Therefore, aircraft arrival noise will not be much quieter than departure noise as new technology aircraft start to dominate the aviation fleet mix. Finally, the Runway 21 departure threshold is going to be shifted 1,800 feet to the northeast which will give aircraft additional distance to gain altitude before overflying the residential areas to the southwest.

- CONCLUSION

Current runway use is determined by wind conditions and the availability of a precision approach to Runway 21. Adjusting the runway use to favor Runway 3 would result in concentrating aircraft arrival noise over a select residential area southwest of the airport. Therefore, a preferential runway use program does not merit further consideration.

Rotational Runway Use

Rotational runway use is intended to distribute aircraft noise equally off all runway ends. At best, a rotational runway use program can only provide temporary relief for one group at the expense of another.

02MP09-5A-8/9/03

RUNWAY USE AND FLIGHT ROUTES

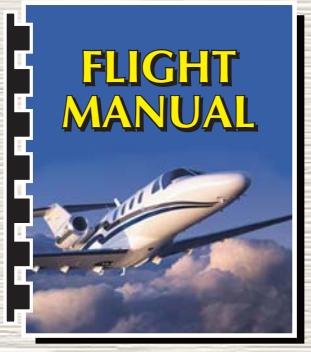
- Preferential Runway Use
- Departure Turns
- Visual Approach Procedures
- Instrument Approach Procedures
- Traffic Pattern Changes

FACILITIES DEVELOPMENT

- Runway Lengthening
- New Runways
- Displaced/Relocated Thresholds
- Approach Lighting
- Acoustical Shielding

AIRCRAFT OPERATING PROCEDURES

- Reduced Thrust Takeoffs
- Thrust Cutback Departures
- Minimum Approach Altitude
- Maximum Climb Departures
- Approach Flap Adjustments
- Two-Stage Descents
- Increased Approach Angle
- Limited Reverse Thrust



AIRPORT RESTRICTIONS AND REGULATIONS

- Nighttime Curfews
- Variable Landing Fees Based on Noise Level or Time of Day
- Capacity Limitations (Operational Cap or Noise Budget)
- Aircraft Type Restrictions Based on Noise Level
- Ground Activity Restrictions
- Training Activity Restrictions

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Exhibit 5A
POSSIBLE NOISE ABATEMENT TECHNIQUES

- EVALUATION

A basic consideration in evaluating a runway use program is wind direction and velocity. In general, aircraft should be aligned into the wind during landing and takeoff. Depending on the length of the runway, aircraft load and power, and outside air temperature, aircraft can accept light tailwinds and crosswinds. Weather data at Flagstaff Pulliam Airport indicates that while the prevailing winds are from the southwest, winds are light or calm a large portion of the time. By itself, this situation would lend support to a rotational runway use program.

A true rotational runway use program, however, is not possible at Flagstaff Pulliam Airport at this time because Runway 21 is currently the only runway with a precision instrument approach. Without the ability to rotate the arrival runway, a true rotational runway use program cannot be implemented. In addition, residential development along runway centerline immediately west of Interstate 17 to the southwest would receive more concentrated arrival noise due to the need to line up on runway centerline on approach instead of dispersed departure noise which is what it is already experiencing

- CONCLUSION

For reasons outlined above, a rotational runway use program is not feasible or advisable at Flagstaff Pulliam Airport. The prevailing winds and the only instrument approach are to Runway 21. The potential use of a rotational runway use program at Flagstaff Pulliam Airport should not be considered further.

Departure Turns

A common noise abatement technique is to route departing aircraft over noise-compatible areas immediately after takeoff. In order to be fully effective, the compatible corridor must be relatively wide and closely aligned with the runway so that turns over the area are practical.

- EVALUATION

Two noise-compatible corridors currently exist around Flagstaff Pulliam Airport; a small undeveloped corridor exists to the northeast over the golf course and to the south over Interstate 17. These are shown in **Exhibit 5B**. The corridor to the northeast is generally in line with Runway 3 and does not require a departure turn procedure. The corridor to the southwest would require a turn to the heading of approximately 170 degrees. A turn this close to the start of takeoff roll would be limited to piston aircraft weighing less than 12,500 pounds. Larger commercial turboprop and business jet aircraft would have difficulty making this turn safely on a consistent basis. Larger commercial turboprop and business jet aircraft would still have difficulty making a left turn over Interstate 17 with the planned runway 1,800-foot runway extension to the northeast. However, these aircraft will be higher over residential areas southwest of the airport with the planned runway extension to the northeast.

- CONCLUSION

Consideration should be given to establishing a left turn procedure over Interstate 17 for piston aircraft less than 12,500 pounds departing Runway 21. This would reduce the number of low overflights over the residential areas southwest of the airport. This alternative is studied in further detail in a later section of this chapter.

Visual and Offset Instrument Approaches

Approaches involving turns relatively close to the airport can sometimes be defined over noise-compatible corridors. These can be defined as either VFR (visual flight rule) approaches or non-precision instrument approaches. A stabilized, straight-in final approach of at least one mile should be provided. If large aircraft are involved, a longer straight-in final approach of two to three miles is needed.

- EVALUATION

At Flagstaff Pulliam Airport, a precision approach from the northeast already exists over undeveloped areas. Precision, non-precision, and VFR approaches from the southwest lack a long enough noise-compatible corridor that is generally aligned with Runway 3. Even with the advent of advanced navigational technology, the relative closeness of incompatible land uses to the airport prevents the avoidance of these areas southwest of the airport when using an instrument approach.

- CONCLUSION

The current precision approach from the northeast to Runway 21 is over undeveloped land and a golf course. The location of noise-sensitive land uses southwest of the airport prevents establishment of noise-abatement approaches to Runway 3. Additional approach procedures for noise abatement will not be considered further.

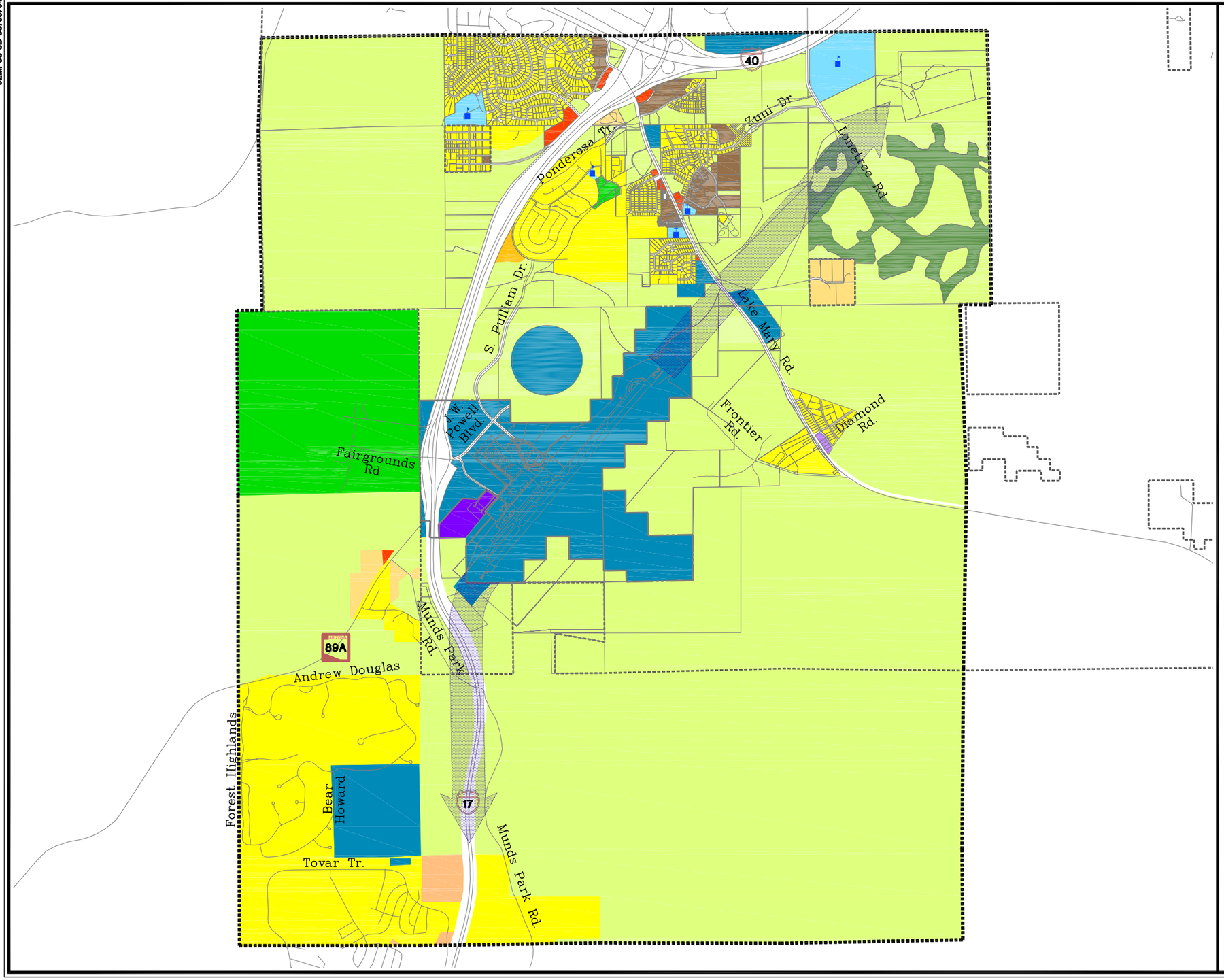
Midfield Departures

Midfield departures refer to aircraft beginning their engine spool-up and takeoff role from a point, usually a taxiway intersection (intersection takeoffs) near midfield. While these operations are usually undertaken to reduce taxi time, such operations can help centralize departure spool-up noise on the airfield.

- EVALUATION

At Flagstaff Pulliam Airport, due to the relatively short runway length and high elevation, midfield departures would inhibit nearly all aircraft from safely departing the airport. These operations are further jeopardized by the hot weather experienced in the region from late spring to early fall. In addition, residents located off the departure end of the airport would likely be impacted by greater levels of aircraft noise, since aircraft would not have sufficient distance in which to gain altitude prior to leaving the airfield. A noise contour analysis with 50 percent use of intersection takeoffs by

02MP09-5B-08/09/04



LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- Very Low Density Residential (0-0.9 du/ac)
- Low Density Residential (1-5 du/ac)
- Medium Density Residential (6-12 du/ac)
- High Density Residential (12+ du/ac)
- Residential Manufactured Housing
- Undeveloped
- Parks
- Golf Course
- Institutional
- Commercial (Neighborhood and Regional/Community)
- Office/Business Park/Light Industrial
- Hotels, Motels, and Bed & Breakfast
- Noise Sensitive Institutions
- School
- Place of Worship
- Compatible Corridor

Source: Flagstaff Geographic Information System, November 2002.
Aerial Photography, October 2002
Coffman Associates Field Survey, Sept. 30 to Oct. 3, 2002

NORTH

0 3000

SCALE IN FEET

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Exhibit 5B
NOISE COMPATIBLE CORRIDORS

single engine piston aircraft showed a slight increase in the noise contours to the south over residential areas. This slight increase was verified with a grid point analysis. However, it should be noted that the number of dwellings within the noise exposure contours did not change with the increased use of intersection takeoffs.

- CONCLUSION

While midfield takeoffs work well at some airports, factors such as the short runway, airport elevation, and seasonal climate conditions present serious safety implications for their use at Flagstaff Pulliam Airport. In addition, midfield takeoffs would increase noise slightly over residential areas to the south by reducing the distance aircraft have to gain altitude before leaving the airport. Their use at Flagstaff Pulliam Airport should be discouraged and will not be given additional consideration for noise abatement.

AIRPORT FACILITIES

In some cases, airport facilities can be developed to reduce airport noise in noise-sensitive areas. For example, runways can be built or lengthened to shift aircraft noise to compatible areas. Runway thresholds can be displaced or relocated to shift noise, and barriers can be built to shield noise-sensitive areas from aircraft noise on the ground at the airport.

New Runways and Runway Extensions

New runways aligned with compatible land development or runway extensions shifting aircraft operations further away from residential areas are proven means of noise abatement. New runways are most effective where there are large compatible areas near an airport and existing runways are aligned with residential areas.

- EVALUATION

Space for a crosswind runway exists near midfield at Flagstaff Pulliam Airport. However, the cost of relocating the airport facilities along the current flight line, cost of the runway, the limited impacts within the 65 DNL noise exposure contour (only 3 dwellings in 2008), and potential for impacts on park land located immediately north of the airport prevents this from being a viable alternative. Therefore, development of a crosswind runway solely for noise abatement is not a feasible alternative and will not be considered further.

A 1,800-foot runway extension is currently planned to the northeast of the airport. This runway extension is planned for construction within the five year planning horizon and was included in the 2008 noise exposure contours. While this planned runway extension is being done to safely accommodate commercial regional jets, it is prudent to assess the impact of

this runway extension on noise sensitive land uses around the airport. This detailed assessment is found in a later section of this chapter.

An extension to Runway 3-21 to the southwest for noise abatement is not viable for several reasons. First, noise-sensitive land uses are not located close in off the northeast runway centerline and within the noise exposure contours. Second, predominate runway use is to the southwest (approximately 70 percent of operation occur to the southwest on Runway 21) so the benefits of a runway extension would mostly be limited to undeveloped areas to the northeast. Finally, given the limited noise-sensitive impacts within the 65 DNL noise exposure contour (3 dwelling units), a runway extension for the sole purpose of noise abatement is not cost effective.

- CONCLUSION

Developing a crosswind runway alignment solely for noise abatement is not a cost-effective alternative. An 1,800-foot runway extension is already planned to the northeast to safely accommodate commercial regional jets; however, it is prudent to assess the impact of this runway extension on noise-sensitive land uses around the airport. A southwestern extension to Runway 3-21 would do little, if anything, to significantly reduce aircraft noise northeast of Flagstaff Pulliam Airport. Therefore, a southwest extension to Runway 3-21 does not merit further consideration.

Displaced And Relocated Thresholds

A displaced threshold involves the shifting of the touchdown zone for landings further down the runway. A relocated threshold involves shifting both the touchdown point and the takeoff initiation point. (In other words, the original runway end is completely relocated.) These techniques can promote noise abatement by effectively increasing the altitude of aircraft at any given point beneath the approach. The amount of noise reduction depends on the increased altitude which, in turn, depends on the length of the displacement. Another potential noise abatement benefit of runway displacement may be the increased distance between the aircraft and noise-sensitive uses adjacent to the runway from the point at which reverse thrust is applied after touchdown.

- EVALUATION

The determination of the amount of threshold displacement must consider the runway length required for landing in addition to the amount of noise reduction provided by the displacement. A considerable displacement is needed to produce a significant reduction in noise. (For example, if a runway threshold is displaced 1,000 feet, the altitude of an aircraft along the approach path would increase by only 50 feet). In conjunction with the aforementioned runway extension to the northeast, the Runway 21 threshold will be displaced 1,800 feet (keep-

ing the arrival point in its current location). This is due to safety factors for the instrument landing system (ILS). The effects of these changes are already reflected in the 2008 and 2025 noise contours/impacts.

Unlike threshold displacement, threshold relocation increases noise off the runway end opposite the relocation, because of the shift in the point of the takeoff. Aircraft would be at lower altitudes at any given downrange location after takeoff than they would be without the relocation.

- CONCLUSION

Threshold displacement and relocation generally offer only small noise reduction benefits. They are most helpful to residential areas located very near the end of the runway under the approach, a condition not present at Flagstaff Pulliam Airport. A threshold displacement is already planned as part of the runway extension at Flagstaff Pulliam Airport. Any reductions in arrival noise caused by threshold relocations would be offset by increases in departure noise off the opposite runway end. These techniques do not merit further consideration.

Acoustical Barriers

Acoustical barriers such as noise walls or berms are intended to shield areas from the noise of aircraft powering up for takeoff and rolling down the runway. It is also possible to use the orientation of buildings on the airport to provide a noise barrier to protect nearby residential areas from noise. Noise walls act best over relatively short distances, and their benefits are greatly affected by surface topography and wind conditions. The effectiveness of a barrier is directly related to the distance of the noise source from the receiver and the distance of each from the barrier itself, as well as the angle between the ends of the berm and the receiver.

While noise walls and berms can attenuate noise, they sometimes are criticized by airport neighbors because they obstruct views. Another common complaint is that airport noise can become more alarming, particularly noise from unusual events, because people are unable to see the cause of the noise.

- EVALUATION

At Flagstaff Pulliam Airport, noise walls or berms would be ineffective for the attenuation of aircraft noise. Given the distance and location of residential and most noise-sensitive development around the airport, there are no suitable areas for the effective placement of such barriers.

- CONCLUSION

Since noise barriers such as noise walls or berms do not offer noise reduction benefits to airborne aircraft or noise-sensitive development not located adjacent to the airport, these devices would be of little benefit at Flagstaff Pulliam Airport and will not receive further consideration.

Run-up Enclosures

An engine run-up enclosure is a special kind of noise barrier which can be appropriate at airports with aircraft engine maintenance operations. Engine run-ups are a necessary part of aircraft service and maintenance. They are necessary to diagnose problems and test the effectiveness of maintenance work. Run-up enclosures are designed so that aircraft can taxi or be towed into them. The structures are designed to absorb and deflect the noise from the run-up, thus reducing noise levels off the airport.

Run-up noise can be especially disturbing because it is so unpredictable.

While the noise from takeoffs and landings is relatively brief and has a particular pattern to which a person can adjust, the noise from a run-up is completely unpredictable. The duration of the run-up can vary from 30 seconds to several minutes, and the listener has no way of knowing how long any given run-up will be. If the run-up is at or near full power, the noise level can be extremely high.

- EVALUATION

Heavy aircraft maintenance that requires high thrust level engine run-ups is not done routinely Flagstaff Pulliam Airport. Therefore, a run-up enclosure is not necessary.

- CONCLUSION

Without large aircraft maintenance facilities at the airport, a run-up enclosure does not deserve further consideration.

AIRCRAFT OPERATIONAL PROCEDURES

Aircraft operating procedures which may reduce noise impacts include:

- Reduced thrust takeoffs
- Thrust cutbacks after takeoff
- Maximum climb departures
- Minimum approach altitudes
- Use of minimum flaps during approaches
- Steeper approach angles
- Limitations on the use of reverse thrust during landings

Reduced Thrust Takeoffs

A reduced thrust takeoff for jet aircraft involves takeoff with less than full thrust. A reduced power setting is used throughout both takeoff roll and climb. Use of the procedure depends on aircraft weight, weather and wind conditions, pavement conditions, and runway length. Since these conditions vary considerably, it is not possible to mandate safely the use of reduced thrust departures.

- EVALUATION

In practice, most airline and business jet operators use reduced thrust departures to conserve fuel, reduce engine wear, and abate noise. Additional efforts to encourage the use of deeper reduced thrust takeoffs would reduce safety margins and are unlikely to yield noise abatement benefits.

- CONCLUSION

Because of the safety implications of these procedures, they are best left to the discretion of pilots and aircraft operators.

Thrust Cutbacks for Jets

Standardized thrust cutback departure procedures have been established by each airline because of system wide operating needs and to promote noise abatement. While the procedures of each carrier differ somewhat, they all involve thrust reduction soon after takeoff and initial acceleration. This reduction normally occurs between 1,000 and 3,000 feet above the ground. The amount of thrust reduction depends on aircraft weight, temperature, and flap setting. A significant, but safe, reduction in thrust often can reduce noise within the 65 and 70 DNL noise contours, but also can increase noise down-range from the airport.

As a service to the general aviation industry, the National Business Aviation Association (NBAA) prepared noise abatement takeoff and arrival procedures for business jets. This program has virtually become an industry standard for operators of business jet aircraft since that time. The departure procedures are of two types: the standard procedure and the close-in procedure. They are illustrated in **Exhibit 5C**.

The NBAA standard departure procedure calls for a thrust cutback at 1,000 feet above ground level (AGL) and a 1,000 feet per minute climb to 3,000 feet altitude during acceleration and flap retraction. The close-in procedure is similar except that it specifies a thrust cutback at 500 feet AGL. While both procedures are effective in reducing noise, the locations of the reduction vary with each. The standard procedure results in higher altitudes and lower noise levels over down-range locations, while the close-in procedure results in lower noise near the airport. Many aircraft manufacturers have developed their own thrust cutback procedures. Neither NBAA procedure is intended to supplant a procedure recommended by the manufacturer and published in the aircraft operating manual.

- EVALUATION

While some airports have defined special thrust cutback departure procedures, this is frowned upon by the industry. Pilots fear the consequences of a proliferation of airport-specific procedures. As the number of procedures increased, it would become more and more difficult for pilots to become proficient at all of them and still maintain comfortable safety margins. It would

be like asking motorists to comply with a different set of braking and acceleration procedures at every intersection in the city. In any case, safety requires that the use of thrust cutbacks in any given situation must be left to the discretion of the pilot, based on weather and the operational characteristics of the aircraft.

Mandating the use of thrust cutbacks requires some type of verification. In order to ensure the use of these procedures, a permanent system of noise, flight track, and flight profile data acquisition is necessary. A system that could be appropriate at a single-runway airport would cost at least $600,000 and have annual operating and maintenance costs of approximately $85,000. Even with this system, it would be difficult to gauge the use of these procedures due to the high elevation and temperature extremes Flagstaff receives. In addition to the high cost and reliability issues, the mandated use of thrust cutbacks would require compliance with 14 CFR Part 161.

- CONCLUSION

Industry standard thrust cutback departure procedures and manufacturers' quiet flying procedures are already used by virtually all air carriers and many business jet operators. Procedures that allow aircraft to gain more altitude before reducing thrust levels are preferred given the location of noise-sensitive development around the airport. The airport should encourage the use of these procedures since they can produce noise reductions. Efforts to mandate the use of these procedures, however, are not advised. As a critical flight operation, the use of thrust cutbacks in any given situation should be left to the discretion of the pilot to avoid eroding safety margins.

Maximum Climb Departures

Maximum climb departures can help reduce noise exposure over populated areas some distance from an airport. The procedure requires the use of maximum thrust with no cutback on departure. Consequently, the potential noise reductions in the outlying areas are at the expense of significant noise increases closer to the airport.

- EVALUATION

The use of maximum climb, or best angle, departure procedures can, in some cases, help reduce noise exposure over populated areas some distance from the airport. This situation does not exist off of either runway end. Consequently, if this procedure were to be used, the potential noise reductions in the outlying areas are at the expense of dramatic noise increases to residential areas closer to the airport.

This type of procedure can also be costly to aircraft operators. The use of maximum climb procedures increases fuel usage, leading to increased air pollution, and can cause greater wear and tear on engines and equipment.

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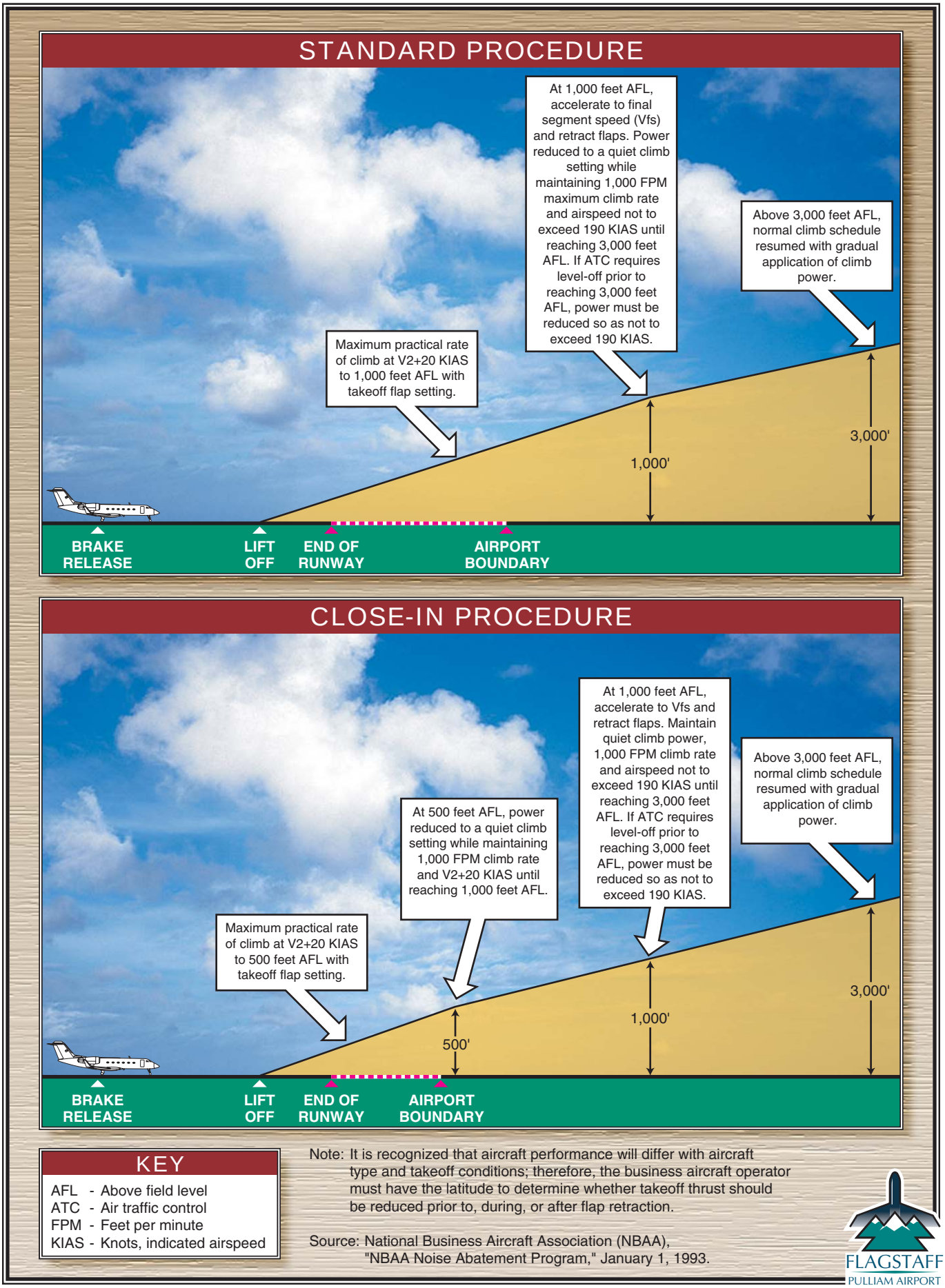

KEY

AFL - Above field level
ATC - Air traffic control
FPM - Feet per minute
KIAS - Knots, indicated airspeed

Note: It is recognized that aircraft performance will differ with aircraft type and takeoff conditions; therefore, the business aircraft operator must have the latitude to determine whether takeoff thrust should be reduced prior to, during, or after flap retraction.

Source: National Business Aircraft Association (NBAA), "NBAA Noise Abatement Program," January 1, 1993.

FLAGSTAFF PULLIAM AIRPORT

Exhibit 5C
NBAA NOISE ABATEMENT DEPARTURE PROCEDURES

- CONCLUSION

Future commercial regional jet and business jet aircraft operating at Flagstaff Pulliam Airport utilize some type of noise abatement departure procedure. Instituting maximum climb procedures would significantly increase fuel usage and engine wear, decrease safety margins, and create undue passenger discomfort. In addition, the noise benefit gained by the additional altitude would be offset by the additional thrust needed to maintain the higher rate of climb. Therefore, the use of maximum climb procedures for noise abatement will not be addressed further.

Minimum Approach Altitudes

These procedures entail an air traffic control (ATC) requirement that all positively-controlled aircraft approaches be conducted at a specified minimum altitude until the aircraft must begin its descent to land. This would affect only aircraft quite some distance from the airport and well outside the noise contours. Since aircraft on approach are using little power, they tend to be relatively quiet. Accordingly, increases in approach altitudes result in only very small reductions in single-event noise.

- EVALUATION

In the Flagstaff Pulliam area, altitudes of aircraft on approach are established to allow the safe mixing of aircraft operating under both visual flight rules (VFR) and instrument flight rules (IFR) and heading for many different airports. Adjustments in altitudes of aircraft could potentially create unsafe airspace and air traffic complications for other airports in the area.

- CONCLUSION

Raising approach altitudes into Flagstaff Pulliam Airport would produce only very small noise reductions well outside the 60 DNL noise contour and would be potentially complicated because of the air traffic in the area and the potential for aircraft interaction. This procedure does not merit further consideration.

Use of Minimum Flaps During Approach and Two-Stage Descent Profiles

Approach procedures to reduce noise impacts were attempted in the early days of noise abatement, but are no longer favorably received. The procedures include the minimal use of flaps in order to reduce power settings and airframe noise and the use of two-stage descent profiles.

- EVALUATION

These techniques raise safety concerns because they are nonstandard and require an aircraft to be operated outside of its optimal safe operating configuration. The higher sink rates and faster speeds reduce pilot reaction time and erode safety margins. They also increase stopping distances on the

runway and are especially inadvisable on relatively short runways. Some of these procedures actually have been found to increase noise because of power applications needed to arrest high sink rates.

- CONCLUSION

Because these procedures erode safety margins and are of little practical noise abatement benefit, they do not deserve further consideration at Flagstaff Pulliam Airport.

Reverse Thrust Restrictions

Thrust reversal is routinely used to slow jet aircraft immediately after touchdown. This is an important safety procedure which has the added benefit of reducing brake wear. Limits on the use of thrust reversal can reduce noise impacts off the sides of the runways, although they would not significantly reduce the size of the noise contours. Enforced restrictions on the use of reverse thrust, however, are not considered fully safe.

- EVALUATION

Given that noise-sensitive uses are not located adjacent to Flagstaff Pulliam Airport boundary, a restriction on thrust reversal would not produce significant benefits. Reverse thrust restrictions tend to erode landing safety margins given the relatively short runways at Flagstaff Pulliam Airport. In addition, limitations on the use of reverse thrust increase runway occupancy time and increase brake wear on aircraft.

- CONCLUSION

Mandated limitations on the use of reverse thrust are inadvisable at Flagstaff Pulliam Airport because of the reduced safety margins and the likelihood for only small benefits. As an operational flight procedure with a direct effect on safety, decisions about whether to use reverse thrust should be left to the discretion of pilots.

AIRPORT REGULATIONS

Part 150 requires that, in developing Noise Compatibility Programs, airports study the possible implementation of airport use restrictions to abate aircraft noise. (See 14 Code of Federal Regulations (CFR) Part 150, B150.7[b][5].) The courts have recognized the rights of airport proprietors to reduce their liability for aircraft noise by imposing restrictions which are reasonable and do not violate contractual agreements with the FAA, conditioning the receipt of federal aid. (These are known as "grant assurances.") In addition, constitutional prohibitions on unjust discrimination and the imposition of undue burdens on interstate commerce must be respected. The restrictions must also be crafted to avoid infringing on regulatory areas preempted by the federal government. Finally, the regulations must be evaluated under the requirements of 14 CFR Part 161.

Airport noise and access restrictions may be proposed by an airport operator in its Part 150 Noise Compatibility Program. The FAA has made it clear that the approval of a restriction in a Part 150 document would depend on the noise abatement benefit of the restriction at noise levels of 65 DNL or higher. Even if the FAA should accept a noise restriction as part of a Part 150 Noise Compatibility Program, the requirements of Part 161 would still need to be met before the measure could be implemented.

14 CFR Part 161

In the *Airport Noise and Capacity Act* (ANCA) of 1990, Congress not only established a national phase-out policy for Stage 2 aircraft above 75,000 pounds (see Part 91 and 161 discussion on page 1-5 of the *Noise Exposure Maps* document), but it also established analytical and procedural requirements for airports desiring to establish noise or access restrictions on Stage 2 or Stage 3 aircraft. Regulations implementing these requirements are published in Part 161.

Part 161 requires the following actions to establish a local restriction on Stage 2 aircraft:

- An analysis of the costs and benefits of the proposed restriction and alternative measures.

- Publication of a notice of the proposed restriction in the Federal Register and an opportunity for comment on the analysis.

While implementation of a Stage 2 aircraft operating restriction does not require FAA approval, the FAA does determine whether adequate analysis has been done and all notification procedures have been followed.

For restrictions on Stage 3 aircraft, Part 161 requires a much more rigorous analysis, as well as final FAA approval of the restriction. Before approving a local Stage 3 noise or access restriction, the FAA must make the following findings:

- The restriction is reasonable, nonarbitrary, and non-discriminatory.

- The restriction does not create an undue burden on interstate or foreign commerce.

- The restriction maintains safe and efficient use of navigable airspace.

- The restriction does not conflict with any existing federal statute or regulation.

- The applicant has provided adequate opportunity for public comment on the proposed restriction.

- The restriction does not create an undue burden on the national aviation system.

Based on FAA's interpretations of Part 161, the regulations do not apply to restrictions proposed only for aircraft weighing less than 12,500 pounds. Because these light aircraft, which include small, single-engine aircraft, are not classified under Part 36 as Stage 2

or 3, the FAA has concluded that the 1990 *Airport Noise and Capacity Act* was not intended to apply to them. (See "Airport Noise Report," Vol. 6, No. 18, September 26, 1994, p. 142.)

Very few Part 161 studies have been undertaken since the enactment of ANCA. **Table 5A** summarizes the studies that have been done to date.

Naples, Florida, is the latest airport to complete a Part 161 Study for the purposes of restricting Stage 2 aircraft under 75,000 pounds. The FAA officially found that Naples had satisfied all applicable Part 161 requirements. However, despite this finding, Naples' subsequent adoption of the restriction triggered an FAA ruling that the restriction violated a prior "grant assurance" that Naples made when accepting funding in the past. As a result of this ruling, the FAA has suspended Naples' eligibility to obtain further federal grants or to collect "passenger facility charges." Naples has exhausted administrative procedures for contesting this ruling and currently is preparing to file an appeal in court. The FAA's primary basis for finding that Naples had violated the grant assurance provision was that the ban is not adequately justified by existing non-compatible land uses. Specifically, the FAA objected to the fact that Naples based the calculation of benefits on reduction in population between the 60 and 65 DNL contours.

From the commercial service airport perspective, Bob Hope Airport (formerly Burbank-Glendale-Pasadena) recently submitted a partial draft analysis to the FAA for consideration. In May 2004, the FAA found that the proposal for a full curfew "would not be consistent with statutory requirements that a restriction be reasonable, nonarbitrary, and nondiscriminatory." Major factors leading the FAA to this conclusion included that a full curfew might discriminate against quieter aircraft that may not contribute measurably to noise exposure, objected to the use of "supplemental noise metrics to change the noise study area for analysis purposes beyond the boundaries of the 65 community noise equivalent level (CNEL)," and that the draft analysis did not specifically address the six statutory tests for a Stage 3 restriction (listed above). The Naples and Bob Hope Part 161 study precedents indicate that FAA is reviewing these studies in a very stringent manner, with the objective of placing high barriers to the adoption of restrictions.

Regulatory Options

Regulatory options discussed in this section include the following:

- Nighttime curfews and operating restrictions
- Landing fees based on noise or time of arrival
- Airport capacity limitations based on relative noisiness
- Noise budgets
- Restrictions based on aircraft noise levels

TABLE 5A
Summary of 14 CFR Part 161 Studies

Airport	Year		Cost	Proposal, Status
	Started	Ended		
Aspen-Pitkin County Airport Aspen, Colorado	N.A.	N.A.	N.A.	The study has not yet been submitted to FAA.
Kahului Airport, Kahului Maui, Hawaii	1991	1994	$50,000 (est.)	Proposed nighttime prohibition of Stage 2 aircraft pursuant to court stipulation. Cost-benefit and statewide impact analysis found to be deficient by FAA. Airport never submitted a complete Part 161 Study. Suspended consideration of restriction.
Minneapolis-St. Paul International Airport Minneapolis, Minnesota	1992	1992	N.A.	Proposed nighttime prohibition of Stage 2 aircraft. Cost-benefit analysis was deficient. Never submitted complete Part 161 study. Suspended consideration of restriction and entered into negotiations with carriers for voluntary cooperation.
Pease International Tradeport Portsmouth, New Hampshire	1995	N.A.	N.A.	Have not yet submitted Part 161 study for FAA review.
San Francisco International Airport San Francisco, California	1998	1999	$200,000	Proposing extension of nighttime curfew on Stage 2 aircraft over 75,000 pounds. Started study in May 1998. Submitted to FAA in early 1999 and subsequently withdrawn.
San Jose International Airport San Jose, California	1994	1997	Phase 1 - $400,000 Phase 2 - $5 to $10 million (est.)	Study undertaken as part of a legal settlement agreement. Studied a Stage 2 restriction. Suspended study after Phase 1 report showed costs to airlines at San Jose greater than benefits in San Jose. Never undertook Phase 2, system wide analysis. Never submitted study for FAA review.
Burbank-Glendale-Pasadena Airport	2000	Ongoing	Estimated cost is between $2 and $4 million.	Proposed curfew restricting all aircraft operations from 10:00 p.m. to 7 a.m. FAA issued comments on the preliminary Part 161 analysis and the study was stopped.
Naples Municipal Airport Naples, Florida	1999	2003	Estimated cost of $1.0 to $1.5 million for consulting and legal fees due to litigation.	Enactment of a total ban on Stage 2 general aviation jet aircraft under 75,000 pounds. The airport began enforcing the restriction on March 1, 2002. FAA has deemed the Part 161 study complete; however, FAA has ruled that the restriction violated federal grant assurances. Currently going through appeals process.
Van Nuys Airport Van Nuys, California	2004	Ongoing	$3 to $3.5 million	Proposing to prohibit Stage 2 aircraft from the airport and establish a curfew for Stage 3 aircraft.
Los Angeles International Airport Los Angeles, California	N.A.	N.A.	N.A.	The study has not begun. The purpose of the study will be to prohibit east departures from 12:00 a.m. to 6:30 a.m.

N.A. - Not available.
Sources: Telephone interviews with Federal Aviation Administration officials and staffs of various airports.

- Restrictions on touch-and-go operations or multiple approaches

- Restrictions on engine maintenance run-ups

Nighttime Curfews and Operating Restrictions

There are essentially three types of curfews or nighttime operating restrictions: (1) closure of the airport to all arrivals and departures (a full curfew); (2) closure to departures only; and (3) closure to arrivals and departures by aircraft exceeding specified noise levels.

- EVALUATION

The time during which nighttime restrictions could be applied varies. The DNL metric applies a 10-decibel penalty to noise occurring between 10:00 p.m. and 7:00 a.m. That period could be defined as a curfew period. A shorter period, corresponding to the very late night hours, from midnight to 6:00 a.m. could also be specified.

Full Curfews: While full curfews can totally resolve concerns about nighttime aircraft noise, they can be indiscriminately harsh. Not only would the loudest operations be prohibited, but quiet operations by light aircraft would also be banned by a full curfew. Full curfews also deprive the community of the services of some potentially important nighttime airport users.

Important economic reasons drive nighttime airport activity. Early morning departures are often attractive for business travelers who wish to reach their destinations with a large part of the workday ahead of them. Not only is this a personal convenience, but it can result in a significant savings in the cost of travel by reducing the need for overnight stays. Accordingly, early morning departures are often very popular. Similarly, late night arrivals are important in allowing travelers to return home without incurring the costs of another night away.

Prohibition of Nighttime Departures: The prohibition of nighttime departures would allow aircraft to return home, but would prohibit departures, which are generally louder than arrivals. Although somewhat less restrictive, this would have similar impacts at Flagstaff Pulliam Airport as a full curfew. It would interfere with corporations in their attempts to schedule early morning departures for the business travel market.

As with a full curfew, a nighttime prohibition on departures would restrict access to the airport by Stage 3 aircraft. This would require a full Part 161 analysis and FAA approval of the restriction before it could be implemented.

Nighttime Restrictions Based on Aircraft Noise Levels: Nighttime operating restrictions can be designed to apply to only those aircraft which exceed specified noise levels. If it is to be effective in reducing the size of the DNL noise contours, the restricted noise level would have to be set to restrict the loudest, most commonly used air-

craft at the airport. These restrictions would be subject to the special analysis procedures of Part 161. Any restrictions affecting Stage 3 aircraft would have to receive FAA approval.

- CONCLUSION

Curfews and nighttime operating restrictions can be an effective way to reduce the size of DNL noise contours around an airport. Because of the extra 10-decibel weight assigned to nighttime noise, removing a single nighttime operation is equivalent to eliminating 10 daytime operations. The effect on the noise contours can be significant.

A particularly troubling aspect of curfews and nighttime operating restrictions is their potential adverse effects on local general aviation and the region's economy. Additionally, implementation of nighttime restrictions can be costly, problematic, and require the completion, and subsequent FAA approval, of a Part 161 Study. FAA disapproval of a curfew is likely because there are limited impacts within the 65 DNL contour (only 3 dwellings in 2008). Therefore, curfews need not be considered further.

Noise-Based Landing Fees

Differential landing fees based on either the noise level or the time of arrival have been used at some airports as incentives to use quieter aircraft or to operate at less sensitive times. A variable schedule of landing fees would be established based on the relative loudness of the aircraft, with departures by loud aircraft at night being charged the most and arrivals by quiet aircraft during the day being charged the least. To avoid being discriminatory, the fee must relate to both the time of day and certificated approach noise levels. Fees from such a program can finance noise abatement activities. This restriction does not provide a noise abatement benefit unless the fees are high enough to actually discourage use of the airport by the loudest aircraft.

- EVALUATION

Flagstaff Pulliam Airport currently has a landing fee for transient aircraft weighing more than 12,500 pounds. Converting the existing landing fee structure to noise-based landing fees would be considered an airport noise restriction under Part 161. A Part 161 analysis would be required before such a fee system could be implemented. Any fee structure changes that would place a noise surcharge on Stage 3 aircraft would require FAA approval prior to implementation.

- CONCLUSION

A noise-based landing fee system is intended to provide strong incentives for aircraft owners to convert their fleets to quieter aircraft and to operate during the daytime hours. Converting the existing landing fee structure to a noise-based landing fee is vulnerable to legal challenges, and FAA disapproval is also likely because there are limited impacts within the 65 DNL

contour (only 3 dwellings in 2008). Therefore, noise-based landing fees will not receive additional consideration.

Capacity Limitations

Capacity limits, the third airport regulation option, has been used by some severely impacted airports to control cumulative noise exposure. This kind of restriction would impose a cap on the number of scheduled operations. This is only an imprecise way to control aircraft noise. For one thing, unscheduled operations would not be subject to the limit. In addition, the limit on scheduled operations actually provides no incentive for conversion to quieter aircraft. Rather, if passenger demand is increasing, it would encourage airlines to convert to larger aircraft, which often (but not always) tend to be noisier than smaller aircraft in the same Part 36 stage classification.

- EVALUATION

A cap on operations would not necessarily provide noise benefits. The forecast noise contours presented in Chapter Three provide an example. A comparison of the noise contours for forecast 2003 conditions and 2008 conditions (Table 3F on page 3-14 of the *Noise Exposure Maps* document) shows a slight decrease in the size of the 60, 65, 70, and 75 CNEL noise contours from 2003 to 2008. During that period, however, the number of annual aircraft operations is projected to increase from 59,478 to 70,500.

- CONCLUSION

Airport capacity limitations intended to control noise are too imprecise to guarantee effectiveness and are unlikely to achieve significant noise reductions. They can also limit air service to the community, interfering with the needs of the local economy. They can be difficult and expensive to administer. Since they inevitably would restrict access to the airport by Stage 3 aircraft, capacity limitations would be subject to Part 161 analysis and approval by the FAA. Airport capacity restrictions, therefore, do not merit additional analysis.

Noise Budgets

In the late 1980s, noise budgets gained attention as a potential noise abatement tool. After the enactment of ANCA, mandating the retirement of Stage 2 aircraft over 75,000 pounds, interest in noise budgets waned. Noise budgets are designed to limit airport noise and allocate noise among airport users. The intent is to encourage aircraft operators to convert to quieter aircraft or to shift operations to less noise-sensitive hours. Before ANCA, the intent was to encourage conversion to Stage 3 aircraft and to discourage the use of Stage 2 aircraft.

While noise budgets can be designed in many different ways, six basic steps are involved. First, the airport must set a target level of cumulative noise exposure, usually expressed in DNL, which it intends to achieve by a certain date. Second, it must determine how to express that overall noise level

in a way that would permit allocation among airport users. Third, it must design the allocation system. Fourth is the design of a monitoring system to ensure that airport users are complying with the allocations. Fifth is the establishment of sanctions for aircraft operators that fail to operate within their allocations. Sixth, the system should be fine-tuned based on actual experience. The only simple step in this process is the first, setting a goal. From that point, it becomes increasingly complex.

- EVALUATION

Different approaches can be used to define noise in a way which permits allocation. It is possible to use the DNL metric, or a variant, for this purpose. This has some advantages in that the FAA's Integrated Noise Model (INM) can be easily be used to derive DNL levels attributable to the average daily operations of the various airport operators. The INM database can be used to establish a basis for noise allocations based on aircraft type. An alternative is to use the effective perceived noise level (EPNL) metric. This is the metric used to certify aircraft noise levels for compliance with 14 CFR Part 36. Noise levels of various aircraft expressed in EPNL are published in FAA Advisory Circulars 36-1E and 36-2C. EPNL values for the aircraft used by each operator on an average day could be summed to define the total noise attributable to the operator.

The third step, the design of the allocation system, is the most difficult and the least subject to fair and objective definition. The allocations can be handled in different ways. They could be auctioned, but without careful controls this could cause serious problems. It could give the financially stronger carriers the opportunity to buy extra noise allocations for purposes of speculation or restraint of competition. Another way to allocate the noise would be through a lottery. A drawback with both of these methods is that they would not recognize past operating histories. It is also important that any allocation system include provisions for the entry of new carriers in order to have any chance of being legally permissible.

An allocation system based on the recent operating histories of each airline would probably be the fairest approach, but it would not be problem-free. To be as fair as theoretically possible, the allocation should be based on each carrier's contribution to existing noise levels at the airport and its past performance in helping to reduce that noise. If the allocation system is based only on current noise contribution, the carriers that have made significant investments in converting their fleets will be penalized in comparison with those which have not. The noisier airline, for example, could conceivably be given a competitive advantage because, if they were willing to convert to quieter aircraft, they would be able to increase their number of flights while still reducing their overall noise output. Carriers can also argue that their corporate aircraft operating procedures result in less noise than the operating procedures of their competitors and that this should be recognized in the noise allocation system.

After establishing the initial allocation system, it would be necessary to develop a schedule of declining noise allocations to each carrier in order to reach the overall noise-reduction goals of the program. Each carrier would have the flexibility to develop scheduling at any time of the day with any aircraft type, so long as its allocation is not exceeded. The use of quieter aircraft or operations during less noise-sensitive hours would result in increased flights per allocation.

The fourth step involves monitoring compliance with the noise allocations. Any monitoring system will require extensive bookkeeping. The simplest method would involve the monitoring of aircraft schedules. Total noise contribution by carrier would be summed for the reporting period based on the activity during the reporting period. Noise levels for each flight would be based on the certificated noise level, or the INM data base noise level, for each aircraft. While this system would require large amounts of staff time to administer, it would be relatively simple to computerize and would have the advantage of enabling carriers to plan their activities with a clear understanding of the noise implications of their decisions.

A theoretically more precise method of compliance monitoring, but a more expensive and complex method, would be to monitor actual aircraft noise levels. Actual noise from each aircraft operation would be recorded for each operator. The advantage of this approach is that it would be based on actual experience. A significant disadvantage, however, is that it could be quite difficult for carriers to make predictions about the noise impact of their scheduling decisions. Many variables influence the noise occurring from any particular aircraft operation, including the weather, pilot technique, and air traffic control instructions. In addition, the Airport Authority would have to purchase a monitoring and flight tracking system.

The fifth step is to establish a system of fines or other sanctions to levy against carriers which fail to operate within their assigned noise allocations. To be effective, the sanctions should be severe enough to provide a strong incentive to cooperate with the program.

In an era where all aircraft weighing more than 75,000 pounds are Stage 3, it is difficult to imagine how a noise budget could promote significant noise reduction without reducing air service in the community. While some Stage 3 aircraft are louder than others, some carriers operate with fleets almost completely composed of among the quietest Stage 3 aircraft. Depending on the noise allocation and the reduction target assigned to such a carrier, they might be able to meet the target only by eliminating flights.

- CONCLUSION

Noise budgets are complex methods for promoting airport noise reduction. They are particularly vulnerable to attack on grounds of discrimination and interference with interstate commerce. Noise budgets are extremely difficult to design in a way that will be seen as fair by all airport users and

are likely to be quite expensive to develop. Negotiations on noise budget design and noise allocations are likely to be long and contentious and would require the assistance of noise consultants and attorneys. The costs of administering the system also would be substantial. The bookkeeping requirements are complex and additional administrative staff would definitely be required.

At Flagstaff Pulliam Airport, a noise budget does not appear to be a practical option. The process would be long, expensive, and contentious. FAA disapproval is also likely because there are limited impacts within the 65 DNL contour (only 3 dwellings in 2008). Therefore, this alternative will not be discussed further.

Restrictions Based On Aircraft Noise Levels

Outright restrictions on the use of aircraft exceeding certain noise levels can reduce cumulative noise exposure at an airport. Aircraft producing noise above certain thresholds, as defined in Part 36, could be prohibited from operating at the airport at all or certain times of the day. A variation is to impose a non-addition rule, prohibiting the addition of new flights by aircraft exceeding the threshold level at all or certain times of the day. These restrictions would be subject to the special analysis procedures of Part 161. Any restrictions affecting Stage 3 aircraft would have to receive FAA approval.

Noise limits based on Part 36 certification levels have the virtue of being fixed national standards which are understood by all in the industry. They are average values, however, and do not consider variations in noise levels based on different methods of operating the aircraft. As an alternative, restrictions could be based on measured noise levels at the airport. This has the advantage of focusing on noise produced in a given situation and, in theory, gives aircraft operators increased flexibility to comply with the restrictions by designing special approach and departure procedures to minimize noise. It has the disadvantage of requiring extra administrative effort to design testing procedures, monitor tests, interpret monitoring data, and design the restrictions.

- EVALUATION

Whether threshold noise levels are based on Part 36 or measured results, care must be taken to ensure that the restriction does not fall with undue harshness on any particular operator. The feasibility of complying with the restriction, given existing technologies and equipment, must also be considered. Such a restriction would be subject to legal challenges and rejection by the FAA as unjust discrimination and potentially burdensome to interstate commerce.

- CONCLUSION

Restrictions based on noise levels could be viewed as discriminatory and,

therefore, be subject to litigation and rejection by the FAA because there are limited impacts within the 65 DNL contour (only 3 dwellings in 2008). In addition, the requirements of a costly 14 CFR Part 161 Study would have to be met before any restriction on Stage 2 business jets under 75,000 pounds or Stage 3 aircraft could be implemented.

Touch-and-Go Restrictions

Restrictions on touch-and-go or multiple approach operations can be effective in reducing noise when those operations are extremely noisy, unusually frequent, or occur at very noise-sensitive times of the day. At many airports, touch-and-go operations are associated with primary pilot training, although this type of operation is also done by licensed pilots practicing approaches.

- EVALUATION

Touch-and-go's and multiple approaches are frequently done at Flagstaff Pulliam Airport. In 2003, there were 16,033 local general aviation operations (generally involving multiple approaches or touch-and-go operations). The general aviation touch-and-go operations were done mainly by light, single-engine aircraft.

Restriction of touch and go operations would have legal ramifications as it would conflict with grant assurances, and might have legal ramifications as it could conflict with the terms of local fixed base operator leases.

- CONCLUSION

Multiple approaches and touch-and-go's are a necessary aspect of maintaining pilot proficiency. Flight schools located at Flagstaff Pulliam Airport need to perform such operations as part of pilot training programs. Restrictions on training operations would seriously impact the viability of these businesses and would be a violation of the airport's grant assurances. In addition, these operations are primarily performed during daytime hours when their activity is less likely to be an excessive burden to surrounding land uses. Therefore, restrictions on touch-and-go activity will not merit further discussion.

Engine Run-up Restrictions

Engine run-ups are a necessary and critical part of aircraft operation and maintenance. Engine run-ups are often more annoying than aircraft overflight noise because they are more unpredictable and usually last longer than overflights.

- EVALUATION

Because there are no large maintenance facilities at Flagstaff Pulliam Airport, engine maintenance run-ups are limited to the general aviation fixed base operators. Currently, an average of three to four maintenance run-ups occur per week at Flagstaff Pulliam Airport.

- CONCLUSION

Maintenance run-up activity is not common at Flagstaff Pulliam Airport and has not been a problem. Neither have pre-flight engine run-ups been cited as significant annoyances. Thus, restrictions on run-ups are not warranted.

Pre-flight run-ups are a necessary part of checking the aircraft before takeoff. Pre-flight run-ups have not been a significant source of annoyance around the airport.

SELECTION OF MEASURES FOR DETAILED EVALUATION

Preliminary screening of the complete list of noise abatement techniques indicated that some measures may be potentially effective in the Flagstaff Pulliam Airport area. These are evaluated in detail in this section.

EVALUATION CRITERIA

Two operational alternatives have been selected for detailed analysis. The noise analysis for each alternative was based on the 2008 baseline analysis presented in Chapter Three, "Aviation Noise Impacts." The 2008 baseline was chosen to offer a common base of comparison for all alternatives. This timeframe allows time for FAA review and approval of the final Noise Compatibility Program and any environmental assessments which may be required prior to implementation of the procedures. The alternatives are evaluated using the following criteria:

Noise Reduction Effects. The purpose of this evaluation is to reduce aircraft noise on people. A reduction in noise impacts, if any, over noise-sensitive areas is assessed.

Operational Issues. The effects of the alternative on the operation of aircraft, the airport, and local airspace are considered. Potential airspace conflicts and air traffic control (ATC) constraints are discussed, and the means by which they could be resolved are evaluated. Potential impacts on operating safety are also addressed. FAA regulations and procedures will not permit aircraft operation and pilot workload to be handled other than in a safe manner, but within this limitation, differences in safety margins occur. A significant reduction in safety margins will render an abatement procedure unacceptable.

Air Service Factors. These factors relate to a decline in the quality of air transportation service which would be expected from adoption of an abatement measure. Declines could possibly result from lowered capacity or rescheduling requirements.

Costs. Both the cost of operating aircraft to comply with the noise abatement measure and the cost of construction or operation of noise abatement facilities are considered. Estimated capital costs of implementing the noise abatement alternative, where relevant, are also presented.

Environmental Issues. Environmental factors related to noise are of primary concern in a Part 150 analysis. Procedures that involve a change in air traffic control procedures or increase noise over residential areas may require a separate environmental assessment.

Implementation Factors. The agency responsible for implementing the noise abatement procedure is identified. Any difficulties in implementing the procedure are discussed. This is based on the extent to which it departs from accepted standard operating procedures; the need for changes in FAA procedures, regulations, or criteria; the need for changes in airport administrative procedures; and the likelihood of community acceptance.

Upon completion of a review of each measure based on the above criteria, an assessment of the feasibility of each measure and the strategies required for its implementation are presented. At the end of the section, a summary comparison of the noise impacts of each alternative is presented. Recommendations as to alternatives which deserve additional consideration are presented.

ALTERNATIVE 1 - RUNWAY 21 LEFT TURN DEPARTURE PROCEDURE FOR AIRCRAFT LESS THAN 12,500 POUNDS

Goals

This alternative seeks to reduce overflights of noise-sensitive areas southwest of the airport by aircraft departing to the west, south, and east from Runway 21.

Procedure

Aircraft would be instructed to turn prior to reaching Interstate 17 when safe and practicable. This procedure would direct aircraft to follow the Interstate 17 until turning on final onto their final destination heading. By adjusting this portion of their departure, aircraft can utilize the existing corridor of over the highway to avoid low overflights of noise-sensitive development west of Interstate 17.

Commercial service turboprops, regional jets and business jet aircraft generally can not turn prior to Interstate 17 when departing Runway 21. Therefore, this procedure would be limited to piston propeller aircraft that weigh less than 12,500 pounds.

For noise modeling purposes, the 2008 baseline input was modified to reflect a departure turn for piston aircraft weighing less than 12,500 pounds.

Noise Effects

The noise contours presented in **Exhibit 5D** illustrate the effects of this procedure. Southwest of the airport, the 60 and 65 DNL noise contours shift slightly to the south relative to the 2008 baseline contours. There are no changes to the noise exposure contours to the south and southwest.

Table 5B presents the population impacts for this alternative. This alter-

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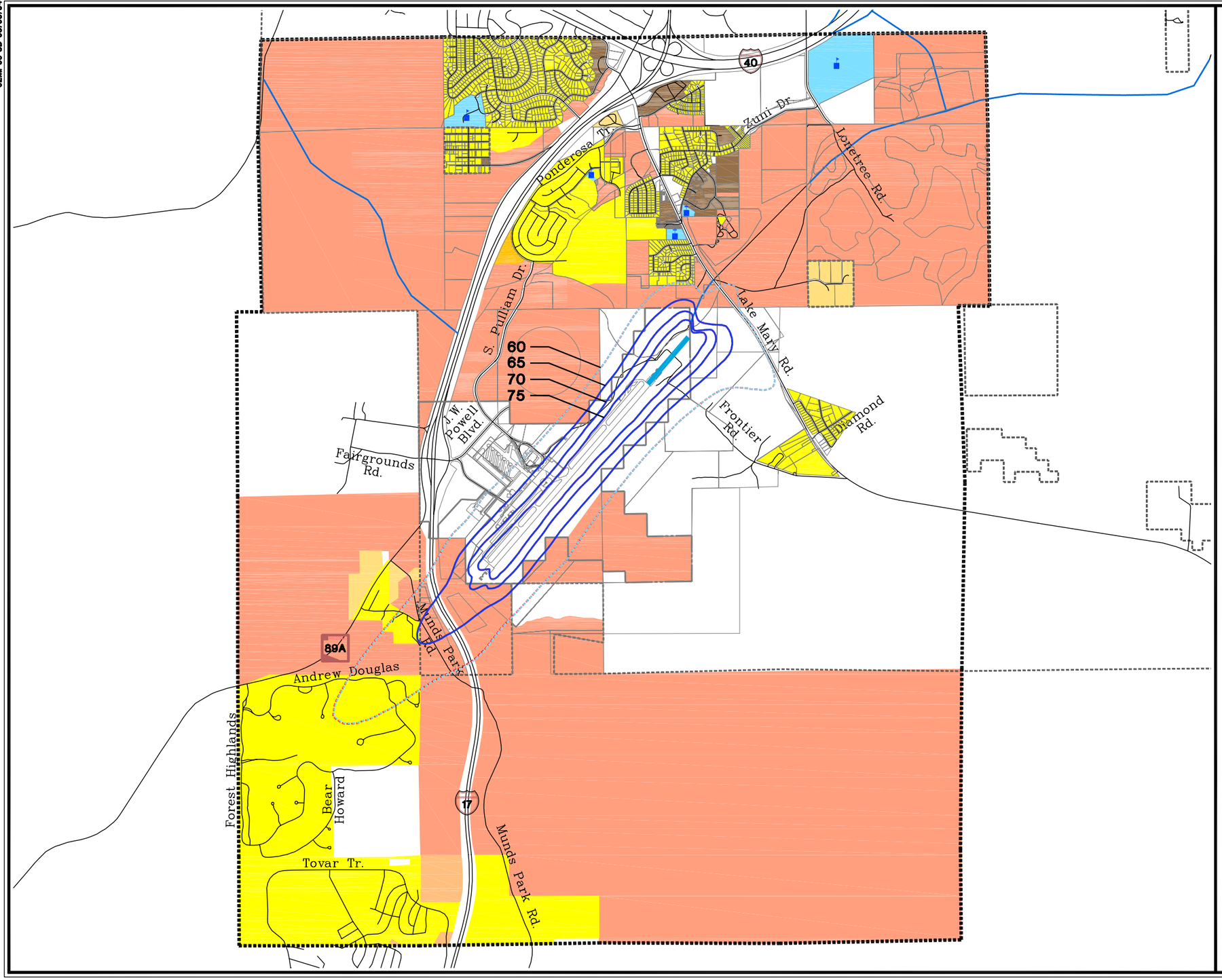

LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- Alt 1 - Noise Exposure Contour, Marginal Effect
- Alt 1 - Noise Exposure Contour, Significant Effect
- 2008 Noise Exposure Contour, Marginal Effect
- 2008 Noise Exposure Contour, Significant Effect
- Runway Extension Per 2003/04 Airport Master Plan Update
- Very Low Density Residential (0-0.9 du/ac)
- Low Density Residential (1-5 du/ac)
- Medium Density Residential (6-12 du/ac)
- High Density Residential (12+ du/ac)
- Residential Manufactured Housing
- Noise Sensitive Institutions
- Potential Noise-Sensitive Growth Risk Areas
- School
- Place of Worship

Source: Flagstaff Geographic Information System, November 2002.
Coffman Associates Analysis.

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Exhibit 5D
ALTERNATIVE 1 - RUNWAY 21 LEFT TURN DEPARTURE PROCEDURE

native impacts three less people above 60 DNL when compared to the 2008 baseline condition. This alternative reduces population impacts above 65 DNL by eight. The level-weighted population (LWP), an estimate of the number of people actually annoyed by noise, decreases from 189 to 176, a net change of 13 with the implementation of this departure turn procedure.

TABLE 5B
Population Impacted by Noise
Alternative 1 – Runway 21 Departure Procedure

DNL Range	2008 Baseline	Alternative 1	Net Change
Existing Population			
60-65	103	108	+5
65-70	8	0	-8
70-75	0	0	0
75+	0	0	0
Subtotal	111	108	-3
Potential Population[1]			
60-65	504	451	-53
65-70	156	156	0
70-75	5	5	0
75+	0	0	0
Subtotal	665	612	-53
Total	776	720	-56
LWP	189	176	-13
Noise-Sensitive Institutions			
Places of Worship	0	0	0
Medical Facilities	0	0	0
Schools	0	0	0
Other (Libraries, Museums, Community Centers, Hospitals, Nursing Homes)	0	0	0
Total Noise-Sensitive Institutions	0	0	0
Total Historic Resources	0	0	0

Notes: 1. Based on additional potential new dwelling units in 2008 reflecting current land use plans and zoning.
LWP – level-weighted population – is an estimate of the number of people actually annoyed by aircraft noise. It is computed by multiplying the population in each DNL range by the appropriate LWP response factor: 60-65 DNL = 0.205; 65-70 DNL = 0.376; 70-75DNL = 0.644; 75+ DNL = 1.000. See the **Technical Information Paper, *Measuring the Impact of Noise on People***, at the back of the *Noise Exposure Maps* document.

A breakdown of the increase or decrease in population from the 2008 baseline and Alternative 1 noise contours is presented in **Table 5C.** Alternative 1 presents a slight decrease in impacts on the existing population.

Approximately three people have less noise during the existing land use conditions with the use of this alternative. Given the potential for future development, the implementation of Alternative 1 would impact a total of 53 fewer individuals than the 2008 baseline operations.

Operational Issues

This procedure should have very little effect on airport operations since it is limited to piston aircraft weighing less than 12,500 pounds and these aircraft commonly turn prior to Interstate 17.

TABLE 5C
Population Increase or Decrease with Alternative 1

2008 vs. Alt. 1	60-65	65-70	70-75	75+	Net Impact
Existing Land Use	+5	-8	0	0	-3
Future Potential Land Use	-53	0	0	0	-53
Totals	-48	-8	0	0	-56

Air Service Factors

No negative air service factors are anticipated with the use of this alternative.

Costs

A preliminary environmental review and documentation will be required. The FAA and airport would incur administrative costs.

Environmental Issues

Based on the results of the preliminary environmental review, the FAA will determine the level of environmental analysis needed pursuant to the National Environmental Policy Act of 1969 and its implementing regulations.

Implementation

This procedure would primarily be implemented by the ATCT. A tower order would identify the turning procedure and define departure and turn instructions to be issued by controllers to aircraft departing Runway 21. Information regarding the procedure also could be published in a Notice to Airmen (NOTAM) and local pilot guides.

Conclusion

This alternative would reduce slightly existing noise-sensitive impacts above 60 DNL, as well as single-event overflights on residential areas southwest of the airport. The use of this procedure for noise abatement should receive additional consideration for implementation.

ALTERNATIVE 2 – ASSESSMENT OF THE NOISE-SENSITIVE IMPACTS OF NOT EXTENDING RUNWAY 3-21 1,800 FEET

Goals

This alternative seeks to assess the noise-sensitive impacts of not extending Runway 3-21 1,800 feet to the northeast.

Procedure

The 1,800-foot extension to Runway 3-21 to the northeast is being done to accommodate the commercial service providers' transition from turboprop aircraft to regional jet aircraft. If the runway extension is not built, commercial service providers would either drop service to Flagstaff or find another aircraft to accommodate the passenger demand. In this case, the aircraft most likely to be used in the future, if the runway is not extended, would be the Beech 1900. However, it would take approximately 700 additional annual operations by the 19-seat Beech 1900 aircraft to accommodate the same number of forecasted passengers than the 30 to 70 seat regional jet.

For noise modeling purposes, the 2008 baseline input was modified to reflect the current runway length of 6,999 feet and the change in aircraft fleet mix and operation previously described.

Noise Effects

The noise contours presented in **Exhibit 5E** illustrate the effects of this procedure. Southwest of the airport, the noise exposure contours as a whole shift to the southeast relative to the 2008 baseline contours. This is due to the removal of the 1,800-foot extension to the northeast.

Table 5D presents the population impacts for this alternative. This alternative impacts 32 more people above the 65 DNL contour when compared to the 2008 baseline condition. The level-weighted population (LWP), an estimate of the number of people actually annoyed by noise, increases from 189 to 219, a net change of 30 with the implementation of this alternative.

A breakdown of the increase or decrease in population from the 2008 baseline and Alternative 2 noise contours is presented in **Table 5E**. Alternative 2 presents a slight decrease in impacts on the existing population. Approximately eight people have less noise during the existing land use conditions with the use of this alternative. Given the potential for future development, the implementation of Alternative 2 would impact a total of 22 more individuals than the 2008 baseline operations. This is because the large area that could be developed with noise-sensitive land uses is located south of the airport.

TABLE 5D
Population Impacted by Noise
Alternative 2 – Assessment of Noise-Sensitive Impacts of not Extending Runway 3-21

DNL Range	2008 Baseline	Alternative 2	Net Change
Existing Population			
60-65	103	79	-24
65-70	8	40	+32
70-75	0	0	0
75+	0	0	0
Subtotal	111	119	+8
Potential Population[1]			
60-65	504	473	-31
65-70	156	177	+21
70-75	5	37	+32
75+	0	0	0
Subtotal	665	687	+22
Total	776	806	+30
LWP	189	219	+30
Noise-Sensitive Institutions			
Places of Worship	0	0	0
Medical Facilities	0	0	0
Schools	0	0	0
Other (Libraries, Museums, Community Centers, Hospitals, Nursing Homes)	0	0	0
Total Noise-Sensitive Institutions	0	0	0
Total Historic Resources	0	0	0

Notes: 1. Based on additional potential new dwelling units in 2008 reflecting current land use plans and zoning.
LWP – level-weighted population – is an estimate of the number of people actually annoyed by aircraft noise. It is computed by multiplying the population in each DNL range by the appropriate LWP response factor: 60-65 DNL = 0.205; 65-70 DNL = 0.376; 70-75DNL = 0.644; 75+ DNL = 1.000. See the **Technical Information Paper, *Measuring the Impact of Noise on People***, at the back of the *Noise Exposure Maps* document.

TABLE 5E
Population Increase or Decrease with Alternative 2

2008 vs. Alt. 2	60-65	65-70	70-75	75+	Net Impact
Existing Land Use	-24	+32	0	0	+8
Future Potential Land Use	-31	+21	+32	0	+22
Totals	-55	+53	+32	0	+30

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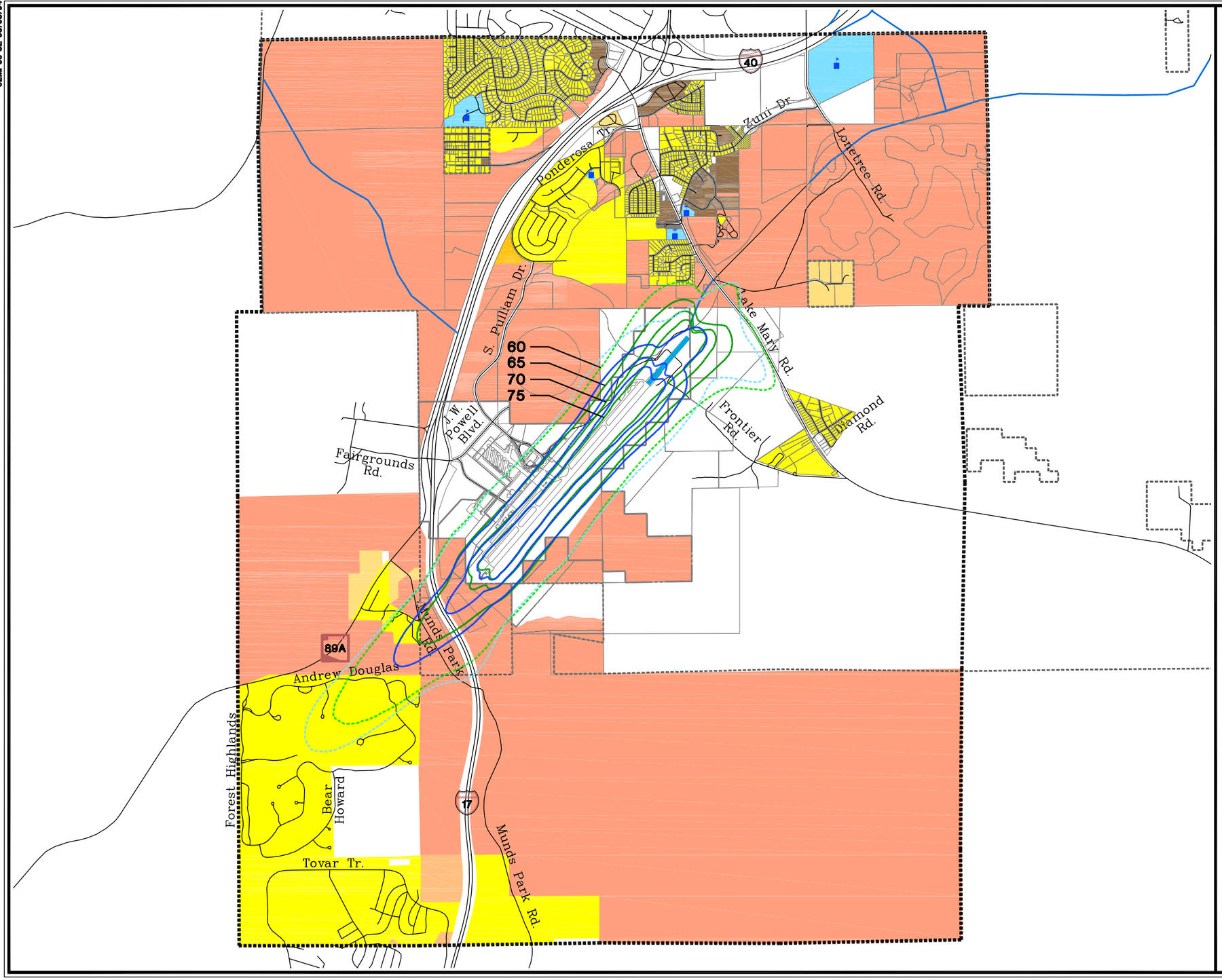

LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- Alt 2 - Noise Exposure Contour, Marginal Effect
- Alt 2 - Noise Exposure Contour, Significant Effect
- 2008 Noise Exposure Contour, Marginal Effect
- 2008 Noise Exposure Contour, Significant Effect
- Runway Extension Per 2003/04 Airport Master Plan Update
- Very Low Density Residential (0-0.9 du/ac)
- Low Density Residential (1-5 du/ac)
- Medium Density Residential (6-12 du/ac)
- High Density Residential (12+ du/ac)
- Residential Manufactured Housing
- Noise Sensitive Institutions
- Potential Noise-Sensitive Growth Risk Areas
- School
- Place of Worship

Source: Flagstaff Geographic Information System, November 2002.
Coffman Associates Analysis.

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Exhibit 5E

ALTERNATIVE 2 - ASSESSMENT OF THE NOISE-SENSITIVE IMPACTS OF NOT EXTENDING RUNWAY 3-21

Operational Issues

Regional jet aircraft would not be able to operate safely at Flagstaff Pulliam Airport.

Air Service Factors

Flagstaff would be in jeopardy of losing commercial air service.

Costs

Based upon the cost benefit assessment for the extension to Runway 3-21, the community of Flagstaff could lose over $27 million over the next 20 years, due to the loss/reduction of airline service.

Environmental Issues

The alternative of not extending Runway 3-21 will increase the existing population within the 65 DNL noise exposure contours by 32 people.

Implementation

The alternative of not extending Runway 3-21 will not require implementation.

Conclusion

This alternative would increase existing and future potential noise-sensitive impacts above 60 DNL on residential areas southwest of the airport. The alternative of not extending Runway 3-21 would jeopardize commercial air service and increase noise-sensitive impacts and should not be considered further.

ADDITONAL CONSIDERATIONS

During the public process, residents from the National Park Service area expressed concern over low aircraft overflights in Walnut Canyon National Monument. This issue was discussed during the Aviation Technical Conference held January 29, 2004. A potential solution to this issue is to make pilots aware of the Walnut Canyon National Monument by depicting the boundary of this monument on the Phoenix Sectional Aeronautical Chart. This would have the added benefit of requiring aircraft to fly higher over these communities. 14 CFR Part 91 outlines general aircraft operation and flight rules. Section 91.119 states that an aircraft flying over areas that are not congested may not be operated closer than 500 feet to any person, vessel, vehicle, or structure. However, FAA Advisory Circular 91-36C requests all aircraft to maintain a minimum altitude of 2,000 feet above the surface of National Parks, Monuments, Seashores, Lakeshores, and Recreation Areas administered by the National Park Service. Pursuing a change in the Phoenix Sectional Aeronautical Chart depicting Walnut Canyon National Monument boundaries (depicted in blue line and dotted line on the chart) deserves further consideration.

SUMMARY

This chapter has analyzed the range of potential noise abatement techniques for use at Flagstaff Pulliam Airport. The alternatives for additional consideration are listed in **Table 5F**. The results of this analysis must be reviewed by the Planning Advisory Committee (PAC) and the general public before final recommendations can be made. Final recommendations will be presented in Chapter Seven, the Noise Compatibility Plan.

TABLE 5F
Summary Of Noise Abatement Techniques Deserving Further Consideration

Noise Abatement Technique	Status	Cost
1. Runway 21 Departure Procedure for piston aircraft less than 12,500 pounds.	New	Administrative
2. Discourage intersection and midfield takeoffs	New	Promotional
3. The airport should encourage the use of industry standard thrust cutback departure procedures and manufacturers' quiet flying procedures. Procedures that allow aircraft to gain more altitude before reducing thrust levels are preferred given the location of noise-sensitive development around the airport.	New	Promotional
4. Pursuing a change in the Phoenix Sectional Aeronautical Chart depicting Walnut Canyon National Monument boundaries.	New	Administrative

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Chapter Six

LAND USE ALTERNATIVES

Chapter Six

LAND USE ALTERNATIVES

The evaluation of noise abatement alternatives in Chapter Five resulted in tentative proposals to promote aircraft noise abatement measures in the vicinity of Flagstaff Pulliam Airport. Nevertheless, even if such measures are implemented, land around the airport will continue to be impacted by aircraft noise.

The purpose of this chapter is to present various land use management alternatives that prevent or reduce these future noise impacts. The chapter begins with the identification of broad planning issues that will be addressed in the land use management plan. Alternative land use management techniques are then evaluated to determine their effectiveness in the Flagstaff Pulliam Airport study area. Finally, preliminary recommendations are presented. These recommendations are to be reviewed by the Planning Advisory Committee (PAC) and local citizens. The final land use management and noise abatement recommendations will be presented in Chapter Seven, Noise Compatibility Plan.

LAND USE ISSUES

Before presenting various land use management techniques that could be used to minimize or mitigate the impact of noise created by the airport on residents, the land use issues surrounding the airport must be identified. Three broad noise compatibility planning issues and their mitigation objectives for the Flagstaff Pulliam Airport study area have been identified. These issues are described below and have also been generally located on **Exhibit 6A.**

1. Aircraft noise impacts on noise-sensitive development within the 2003 65 DNL noise contour.

As described in Chapter Four of the Noise Exposure Map (NEM) document, approximately 14 dwelling units are contained within the 2003 65 DNL noise contour west of the airport. In 2008, this number drops to three dwelling units within the 65 DNL noise contour.

2. Maintain the compatible corridor to the northeast of the airport and the planned compatible development within the immediate airport environs.

There is an existing compatible corridor to the northeast of the airport. This area is planned for parks and other public land uses within the community's general plan but zoned for very low density residential land uses. Areas immediately surrounding the airport, while planned for compatible land uses, are zoned for very low density residential uses.

3. Overflight of existing residential development north and southwest of the airport.

Aircraft overflights typically cause low cumulative noise levels; however, overflights can also cause loud, annoying single events. The impacts of overflights on residential areas will be addressed primarily through noise abatement techniques discussed in Chapter Five.

AIRPORT INFLUENCE AREA

In considering potential land use compatibility measures, it is necessary to define the areas within which those policies should apply. The challenge is to define the area within which the airport now exerts, and in the future may exert, a significant influence on noise-sensitive land uses.

The State of Arizona also adopted legislation that provides for the disclosure of aviation activities to prospective buyers of real estate. In 1997, the state adopted legislation allowing airport sponsors to identify Airport Influence Areas (AIA) around public and commercial use airports. The establishment of an AIA is voluntary and requires a public hearing. The boundary of the AIA must be recorded with the county in which the airport resides.

In 1999, the Arizona State Legislature adopted additional aviation-related legislation requiring the state real estate department to prepare and maintain a series of maps depicting the traffic pattern airspace of each public airport in the state [Arizona Revised Statutes on Public Airport Disclosure (A.R.S. 28-8486)]. In counties with a population of more than 500,000 persons, the maps must include a depiction of the 60 DNL contour when one has been identified within either the airport master plan or in a noise

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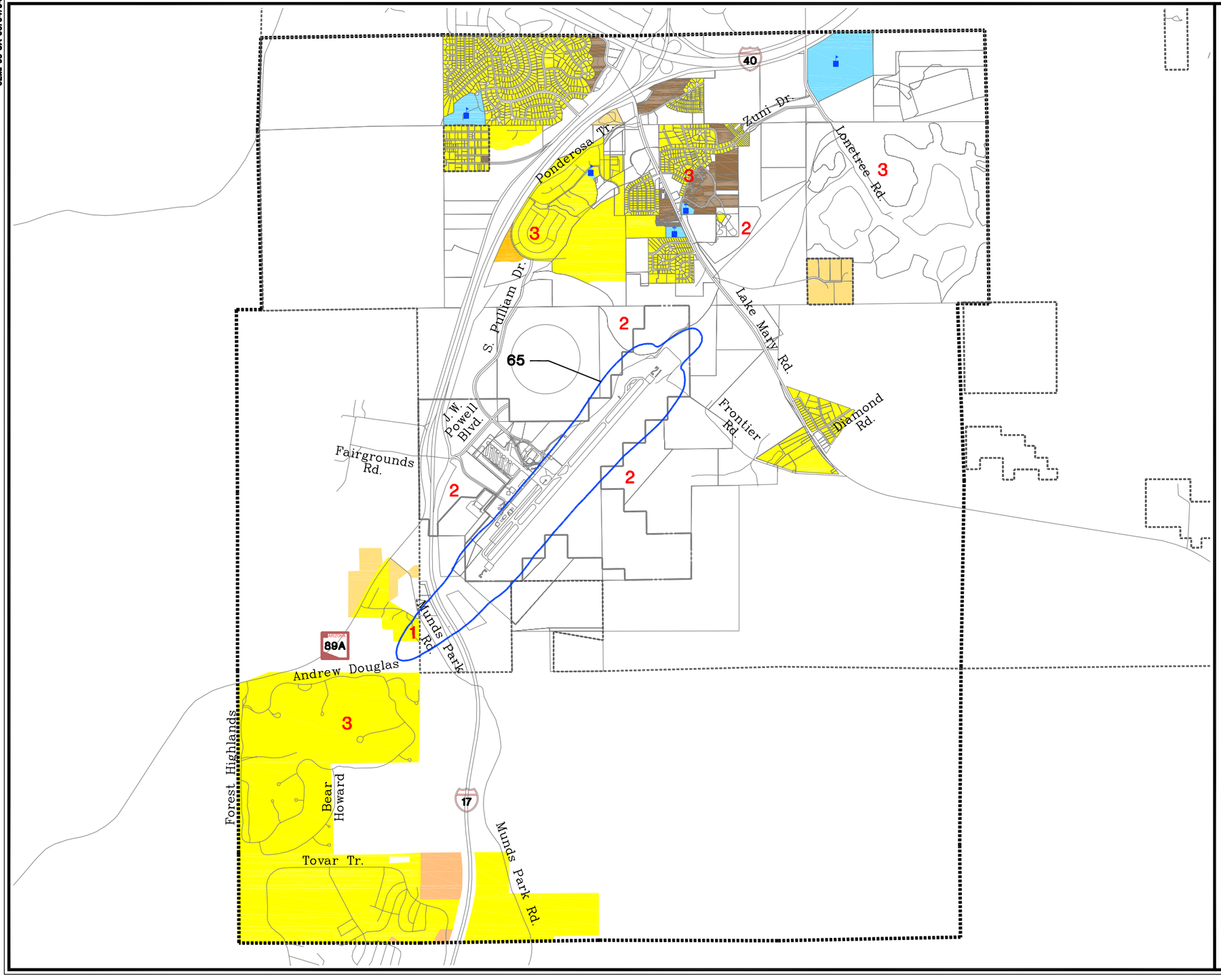

LEGEND

- Detailed Land Use Study Area
- County Boundary
- Municipal Boundary
- Airport Property
- 2003 Noise Exposure Contour, Significant Effect
- Very Low Density Residential (0-0.9 du/ac)
- Low Density Residential (1-5 du/ac)
- Medium Density Residential (6-12 du/ac)
- High Density Residential (12+ du/ac)
- Residential Manufactured Housing
- Noise Sensitive Institutions
- School
- Place of Worship
- 1 — Aircraft Noise Impacts on Noise Sensitive Development With in the 65 DNL Noise Contour.
- 2 — Maintain Compatible Corridor to the Northeast of the Airport and the Planned Compatible Development within the Immediate Airport Environ.
- 3 — Overflight of Existing Residential Development North and Southwest of the Airport.

Source: Flagstaff Geographic Information System, November 2002.
Coconino County Assessor Maps, November 2002.
Coffman Associates Analysis.

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Exhibit 6A
LAND USE ISSUES AREA

study prepared in accordance with airport noise compatibility planning. These maps are to be provided to the public on request. The purpose of the maps is similar to the purpose of the AIA maps in that they are intended to provide disclosure of the presence of the airport as well as the potential influence the airport will have on surrounding property.

The AIA for Flagstaff Pulliam Airport is depicted on **Exhibit 6B**. The AIA boundary is based on areas which receive overflight activity from the airport as well as the airport's Part 77 surface. Prior to the development of land for residential uses within a portion of the AIA, avigation easements are signed to help ensure awareness of the potential impacts of the airport.

The City of Flagstaff has taken the AIA one step further with the adoption of the *Pulliam Airport Avigation Area Zone and Avigation Easement Policy* in September 1995. This policy is contained within the *City's Land Development Code*. This zone includes all property within an approximate one-mile square radius of the airport. Owners of property within this zone are required to dedicate an avigation easement to the City of Flagstaff prior to one of the following events:

- Annexation into the City of Flagstaff
- Rezoning of property
- Approval of a subdivision plat or replat
- Approval of a conditional use permit request
- Approval of variance report
- Approval of a lot split application
- Approval of a general plan amendment
- Issuance of a building permit for a residential unit wherein the proposed construction activity is equal to or in excess of fifty percent of the existing dwelling square footage or fifty percent of the appraised valuation if the unit as set forth by the county assessor.

The city has worked actively with Coconino County in obtaining avigation easements for those areas outside of the city limits. The boundary of the Avigation Area Zone is depicted on **Exhibit 6B**.

LAND USE MANAGEMENT TECHNIQUES

This section outlines the land use management techniques that are used to promote noise compatibility. These techniques are grouped under three headings: **policy** and **regulatory** techniques which guide future development, and **expenditure** techniques which involve potential payments for mitigation assistance. Examples of each of these techniques are illustrated in **Exhibit 6C**.

The potential suitability of each technique is discussed in this chapter and evaluated by two factors: effectiveness and feasibility. The criteria used for judging effectiveness include near and long term suitability to address the land use issues discussed at the beginning of this chapter. If a technique appears to be effective, and does not create undesirable side effects,

the feasibility of implementing it is evaluated. Feasibility criteria include cost to local governments and citizens, eligibility for FAA financial aid, political acceptability, state statutory authorization, and administrative ease or complexity.

POLICY TECHNIQUES

Policy techniques which can be used to guide future development include:

- The community's comprehensive plan; and,
- Project review guidelines.

Comprehensive Plan

A community's comprehensive plan establishes policies for the development and improvement of the community. It provides the basis for the local zoning ordinance, which contains the regulations that govern the use and development of land.

- EVALUATION

Typically, when a community utilizes airport noise contours for land use planning purposes, any new contours that are developed for an airport as part of an airport master plan or Part 150 Study will be incorporated into the various land use planning documents to ensure consistency between the airport and community's planning documents. However, within the past few years, airports have experienced shrinking in the noise contours as the louder aircraft are phased out of the nation's aircraft fleet mix. The smaller noise contours present potential problems for both cities and airports as, if the land use planning policies are not changed, noise-sensitive development will occur in closer proximity to the airport. This development is problematic in a number of ways. First, the adoption of the smaller contours does not provide an adequate buffer should the fleet mix utilizing the airport change. The introduction of one, stage two business jet, can drastically change the noise contours. Secondly, the larger contours allowed for not only a noise-related buffer, but also a buffer from the visual impact of the aircraft passing overhead. As noise-sensitive development happens closer to the airport, the visual impact of the aircraft passing overhead becomes greater as the aircraft are often at a lower altitude due to their proximity to the airport.

Two jurisdictions, the City of Flagstaff and Coconino County, currently undertake comprehensive planning efforts within the project study area. The *Flagstaff Area Regional Land Use and Transportation Plan,* prepared by the City of Flagstaff and Coconino County, is an expansion of, and an update to, the existing city and county general and comprehensive plans. The purpose of the plan is to provide a regional approach to planning in the Flagstaff region.

Within the Community Facilities and Services Element of this plan, the Airport Noise Sensitive Zone is established as the areas within the 60 DNL noise contour established within

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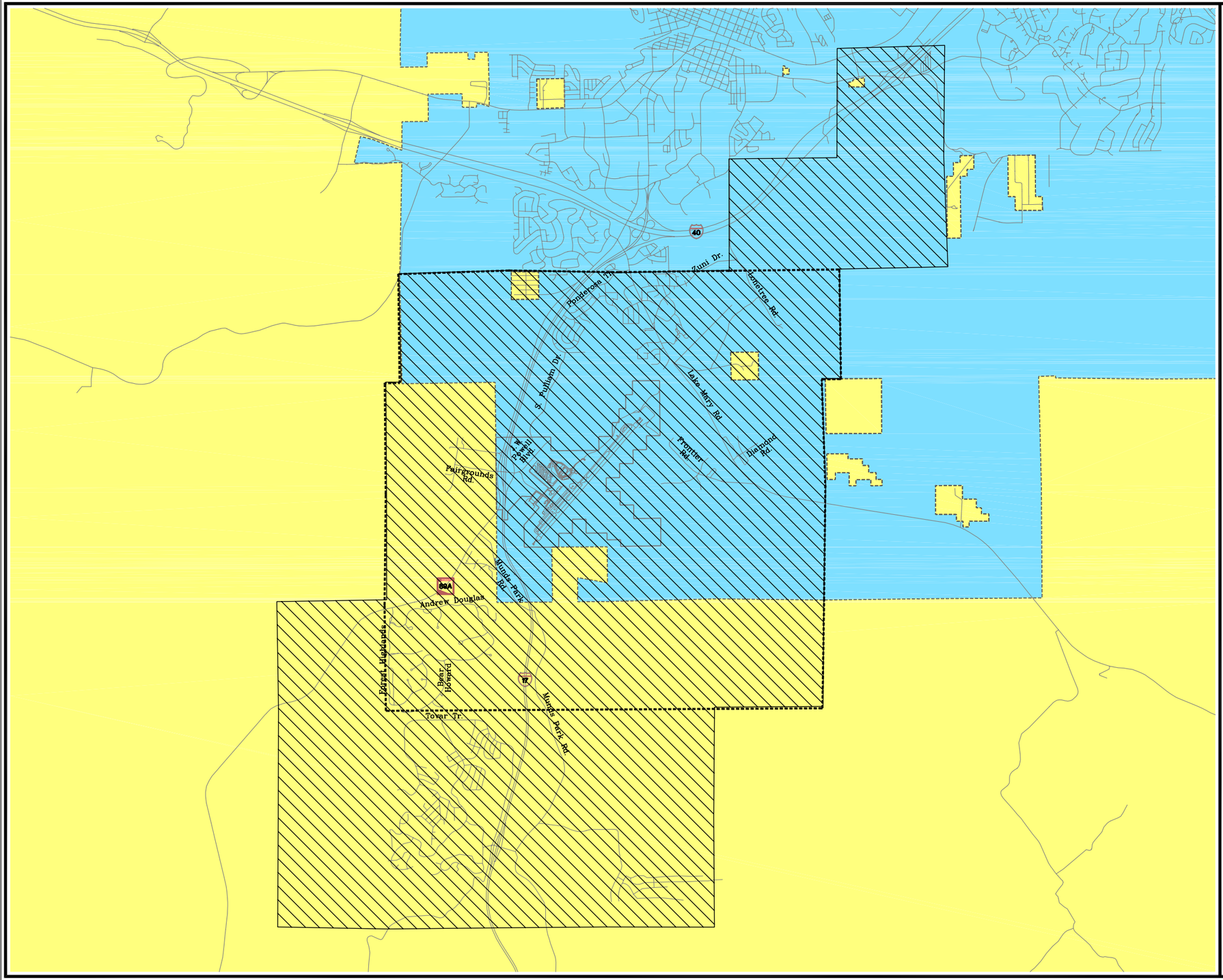

LEGEND

- Municipal Boundary
- Airport Property
- Avigation Easement Area Zone
- City of Flagstaff
- County of Coconino
- Airport Influence Area

Source: Flagstaff Geographic Information System, November 2002.
Coffman Associates Analysis.

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Exhibit 6B
AIRPORT INFLUENCE AREA

02MP09-6C-8/9/03

POLICIES

- Comprehensive / General Plan
- Project Review Guidelines

CHECKLIST FOR REVIEW OF NOISE-SENSITIVE DEVELOPMENT PROJECTS

✓ 1. Is proposed land use "noise-sensitive"?

✓ 2. If yes, is proposed land use in 60 DNL contour? (If so, route application to Airport Manager.)

_ 3. Is sound insulation proposed?

_ 4. Can site be arranged to reduce noise exposure?

REGULATIONS

- Compatible Use Zoning
- Zoning Changes - Residential Density
  - Large Lots, Planned Unit Development
- Airport Noise Overlay Zoning
- Subdivision Regulations
- Building Codes
- Transfer of Development Rights
- Environmental Zoning
- Fair Disclosure By Sellers

EXPENDITURES

- Property Acquisition
- Noise and Avigation Easement Purchase
- Development Rights Purchase
- Purchase Assurance
- Sales Assistance
- Sound Insulation

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Exhibit 6C
LAND USE TECHNIQUES TO PROMOTE
NOISE COMPATIBILITY

TECHNIQUES FOR GUIDING NEW DEVELOPMENT TO PREVENT FUTURE NOISE IMPACTS

POLICY TECHNIQUES - Non-regulatory governmental actions to encourage noise-compatible development near airport.

Comprehensive Planning: Policies supporting land use compatibility near airport. Involves land use plans and policies to guide consideration of rezonings, variances, conditional uses, public projects.

Project Review Guidelines: Adoption of guidelines which ensure that noise compatibility issues are considered during reviews of development proposals.

REGULATORY TECHNIQUES - Local land use regulations requiring compatible development in airport area.

Compatible Use Zoning: Commercial, industrial, agriculture, or open space zoning.

Zoning Changes, Residential Density: Large-lot zoning or planned unit development.

Noise Overlay Zoning: Special regulations within high-noise areas.

Subdivision Regulations: Require dedication of noise and avigation easements, plat notes.

Building Codes: Require sound insulation in new construction.

Transfer of Development Rights: Zoning framework to authorize private sale of development rights to encourage sparse development in high-noise areas.

Environmental Zoning: Environmental protection zoning to support airport land use compatibility.

Fair Disclosure Regulations: Require seller to notify buyer of aircraft noise.

TECHNIQUES FOR MITIGATING EXISTING NOISE IMPACTS

EXPENDITURE TECHNIQUES - Because of high costs, these techniques are usually applied only within 65 DNL contour where Federal funding assistance may be available.

Property Acquisition: Outright purchase of property.

Noise and Avigation Easement Purchase: Purchase of easement only.

Development Rights Purchase: Purchase of rights to develop property.

Purchase Assurance: Airport acts as buyer of last resort, then resells property and retains easements.

Sales Assistance: Provide assistance to property owners in selling homes. Airport retains noise easements.

Sound Insulation: Installation of sound insulation in existing homes and noise-sensitive institutions.

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Exhibit 6C (Continued)
LAND USE TECHNIQUES TO PROMOTE
NOISE COMPATIBILITY

the *1991 Flagstaff Pulliam Airport Master Plan*. Residential development is discouraged within this zone in the interest of protecting not only the airport, but also the general public. A review of the planned land use within the 1991 and 2003 60 DNL noise contours indicates that there are a number of parcels contained within the 60 DNL noise contour which are planned for residential land uses. These parcels are planned for very low density residential land uses and are located southwest of the airport as depicted on **Exhibit 6D**. Consideration could be given to re-designating these undeveloped parcels to a compatible land use.

In order to protect the general public from non-compatible development around an airport that is experiencing smaller noise contours, some communities opt to incorporate hybrid noise contours into their land use plans. These hybrid contours can be a reflection of the previous contours as well as the anticipated future noise condition for the airport. Incorporation of a hybrid contour often provides the community with an equal level of protection from impacts resulting from operation of the airport.

As depicted on **Exhibit 6E**, the 2003 60 DNL contour prepared for Flagstaff Pulliam Airport is much larger to the south than the 1991 60 DNL noise contour, and the 1991 60 DNL noise contour is much larger to the north than the 2003 60 DNL noise contour. To ensure that the areas surrounding the airport are developed in a compatible manner, consideration could be given to incorporating a hybrid 60 DNL noise contour into the general plan. The hybrid contour could consist of a combination of the 1991 and 2003 noise contours as depicted on **Exhibit 6E**. Consideration could also be given to incorporating the 65 DNL noise contour into the general plan. The FAA strongly discourages the development of noise-sensitive land uses within this noise contour; therefore, consideration could be given to explicitly forbidding noise-sensitive development within these significantly noise-impacted areas. **Exhibit 6E** depicts a hybrid 65 DNL noise contour which consists of the 2003 65 DNL noise contour to the south and the 2008 65 DNL noise contour to the north.

- CONCLUSION

Consideration could be given by the City of Flagstaff and Coconino County to re-designating undeveloped parcels contained within the 60 DNL noise contour to a compatible land use. Consideration could also be given to incorporating a hybrid 60 DNL noise contour into the *Flagstaff Area Regional Land Use and Transportation Plan* in lieu of the 1991 60 DNL noise contour which is currently referenced in the plan. Consideration could also be given to incorporating a hybrid 65 DNL noise contour into the plan. Noise-sensitive development could be explicitly forbidden within this contour.

This is a viable alternative.

Project Review Guidelines

Planning commissions and local governing bodies are often required to use their own discretion and judgement in making recommendations and decisions on community development issues such as general plan amendments, rezonings, variances, conditional use applications, subdivision applications, and proposed public improvement projects. The exercise of this discretion is constrained by the legal requirements of the applicable ordinances. Where opportunities remain for planning commissions and governing bodies to use their own discretion in the review of development proposals, it may be appropriate to adopt procedures ensuring the consideration of noise compatibility issues in their deliberations.

- EVALUATION

The City of Flagstaff has established project review guidelines through the *City of Flagstaff Land Development Code*. As required by the development code, a Development Review Board has been established to review development proposals to ensure that all applicable city code requirements are met. As part of the review, the project's potential impact on natural resources such as forest canopy, moderate and steep slopes, and floodplains are evaluated. Consideration could be given to incorporating noise-related criteria into the existing guidelines for development within the AIA. Potential criteria to be incorporated is described later in this section.

Coconino County has not established project review guidelines for the review of projects within the unincorporated portions of the county. It may not be feasible for the county to enact project review guidelines for the entire county due to its size. However, consideration could be given to incorporating review guidelines within the *Flagstaff Area Regional Land Use and Transportation Plan*. Since this plan includes all of the areas contained within the airport's AIA and avigation area zone, should review guidelines be incorporated, all projects within the Flagstaff Pulliam Airport AIA would undergo some type of airport noise review. These guidelines would reflect what is currently in place in the City of Flagstaff and would help to ensure that the areas south of the airport undergo project review. The guidelines would be appropriate for insertion into the Land Use Element of the general plan. The process would add some cost or administrative burden to the county's review process. Since review guidelines are already in place in the City of Flagstaff, the administrative burden would be realized during the amendment process to the Land Development Code and the various plan review checklists.

A simple checklist containing the following criteria could be prepared for Coconino County and the City of Flagstaff could simply revise their existing checklists. The following criteria are suggested for consideration in reviewing development proposals within the AIA.

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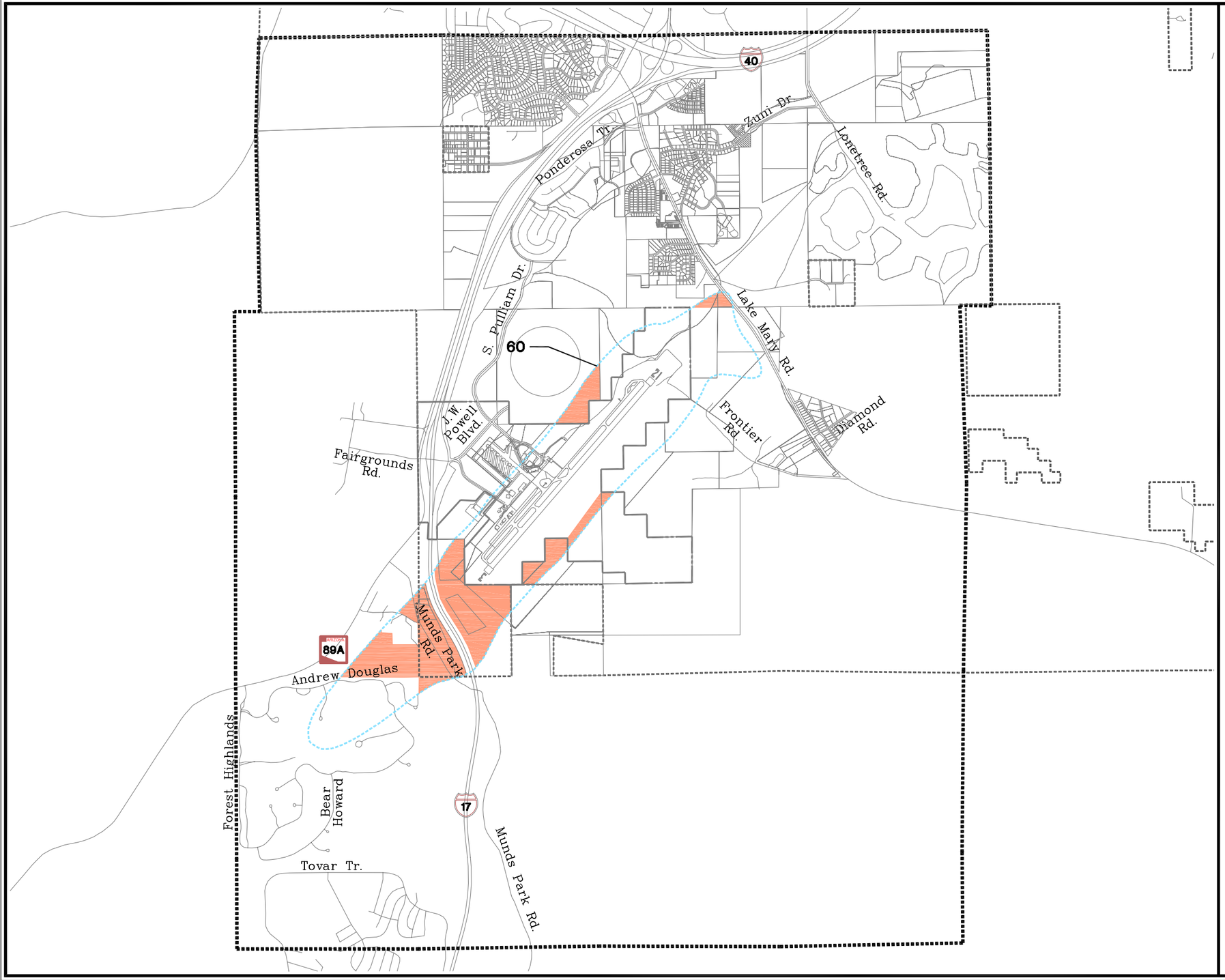

LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- 2003 Noise Exposure Contour, Marginal Effect
- Potential Noise Sensitive Growth

Source: Flagstaff Area, Regional Land Use and Transportation Plan, November 2001.
Flagstaff Geographic Information System, November 2002.
Coffman Associates Analysis.

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Exhibit 6D
UNDEVELOPED AREAS PLANNED FOR RESIDENTIAL LAND USE WITHIN THE 2003 60 DNL NOISE CONTOUR

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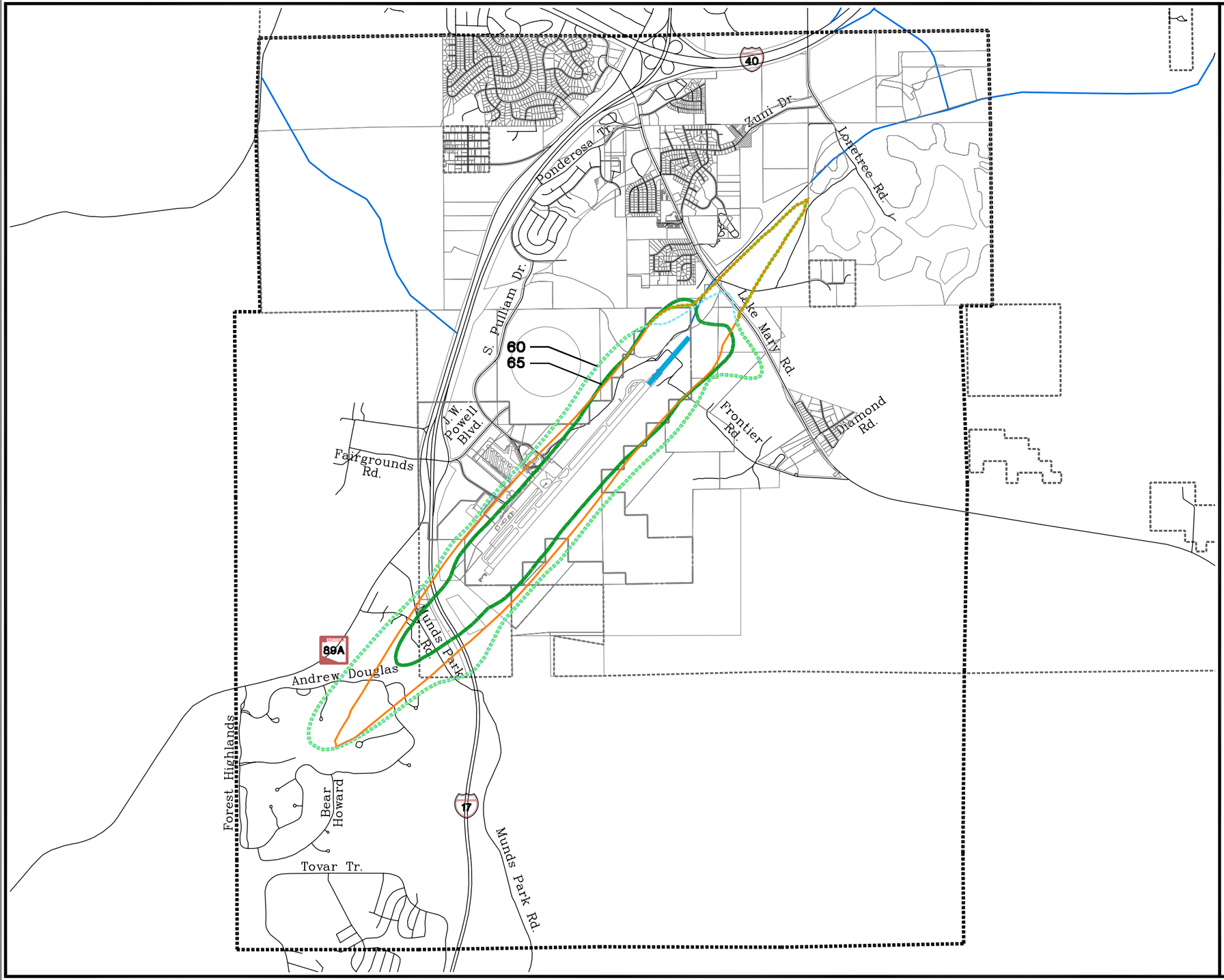

LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- 2003 60 DNL Noise Exposure Contour
- 1991 60 DNL Noise Exposure Contour
- Hybrid 60 DNL Noise Exposure Contour
- Hybrid 65 DNL Noise Exposure Contour

Source: Flagstaff Geographic Information System, November 2002.
Coffman Associates Analysis.

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Exhibit 6E
HYBRID NOISE CONTOURS
FOR THE GENERAL PLAN

- Advise the airport management of development proposals involving noise-sensitive land uses within the AIA.

- Require the issuance of avigation easements for all development within the airport's avigation area zone.

- Determine the sensitivity of the subject land use to aircraft noise levels based on their proximity to the 60 DNL noise contour.

- Locate noise-sensitive public facilities outside the 60 DNL contour whenever possible as previously described.

- Discourage the approval of rezonings, exceptions, variances, and conditional uses which introduce noise-sensitive development into areas located within close proximity to the 60 DNL noise contour.

- Where noise-sensitive development within the 60 to 65 DNL contour must be permitted, encourage developers to incorporate the following measures into their site designs.

  (1) Where noise-sensitive uses will be inside a larger, mixed-use building, locate noise-sensitive activities on the side of the building opposite the prevailing direction of aircraft flight.

  (2) Where noise-sensitive uses are part of a larger, mixed-use development, use the height and orientation of compatible uses, and the height and orientation of landscape features, such as natural hills, ravines, and man-made berms, to shield noise-sensitive uses from ground noise generated at the airport.

- CONCLUSION

The City of Flagstaff and Coconino County could consider incorporating airport land use compatibility guidelines into the *Flagstaff Area Regional Land Use and Transportation Plan* for review of development projects within the AIA. These would be appropriately included in the general plan. The City of Flagstaff's existing project review guidelines contained within the *City of Flagstaff's Land Use Code* could be revised to reflect the suggested noise-related criteria.

This is a viable alternative.

REGULATORY TECHNIQUES

Regulatory techniques are land use and development controls established through local legislation. These techniques include:

- Compatible Use Zoning
- Zoning Changes/Residential Density
- Airport Compatibility Overlay Zoning
- Subdivision Regulations
- Building Codes
- Transfer of Development Rights
- Environmental Zoning
- Fair Disclosure Regulations

Compatible Use Zoning

The most common zoning technique in noise compatibility planning is to eliminate residential zoning from the noise-impacted area and replace it with a commercial, industrial, open space, or other compatible zoning designation.

A potential limitation of compatible use zoning is the need to balance the supply of industrial and commercial-zoned land with demand. If the market for commercial or industrial land is weak, and if the property owners perceive that they are unable to develop or use their land, they can exert political pressure or, in extreme cases, sue in court to force rezoning of their land. This could occur if the total supply of commercial and industrial land vastly exceeds demand, or if the land which has been zoned for commercial and industrial use is not suited for that use because of site problems, such as poor access or inadequate water and sewer service.

In making rezoning decisions, the impact of the proposed zoning on the neighboring area must also be recognized. Problems can occur where the vacant land being considered for commercial or industrial zoning is near an established residential area. The residents may strongly object to the intrusion of non-residential uses into their neighborhood.

- EVALUATION

A number of undeveloped parcels currently designated as parks or open space are contained within the hybrid 60 and 65 DNL noise contours and are currently zoned in a manner which would allow residential development. These parcels fall under the jurisdiction of both the City of Flagstaff and Coconino County as depicted on **Exhibit 6F**. Most of the parcels east of Interstate 17 are planned for industrial or commercial land uses; nevertheless, to ensure compatible development, consideration could be given to rezoning these parcels. Much of the area zoned for residential land uses west of Interstate 17 is currently developed. Consideration could be given to rezoning the remaining undeveloped areas to a compatible zoning designation.

When possible, the areas that are zoned for compatible uses should be maintained. These areas are primarily under the jurisdiction of the City of Flagstaff.

- CONCLUSION

The City of Flagstaff and Coconino County could consider rezoning the undeveloped parcels, under their jurisdiction and within the 60 DNL contour, to a zoning designation which would be compatible with airport operations (i.e., open space, commercial, or industrial). The rezoning could apply to the entire parcel or could only affect the portion of the parcel contained within the 60 DNL noise contour as depicted on **Exhibit 6F**.

Additionally, the City of Flagstaff and Coconino County could consider maintaining the compatible zoning

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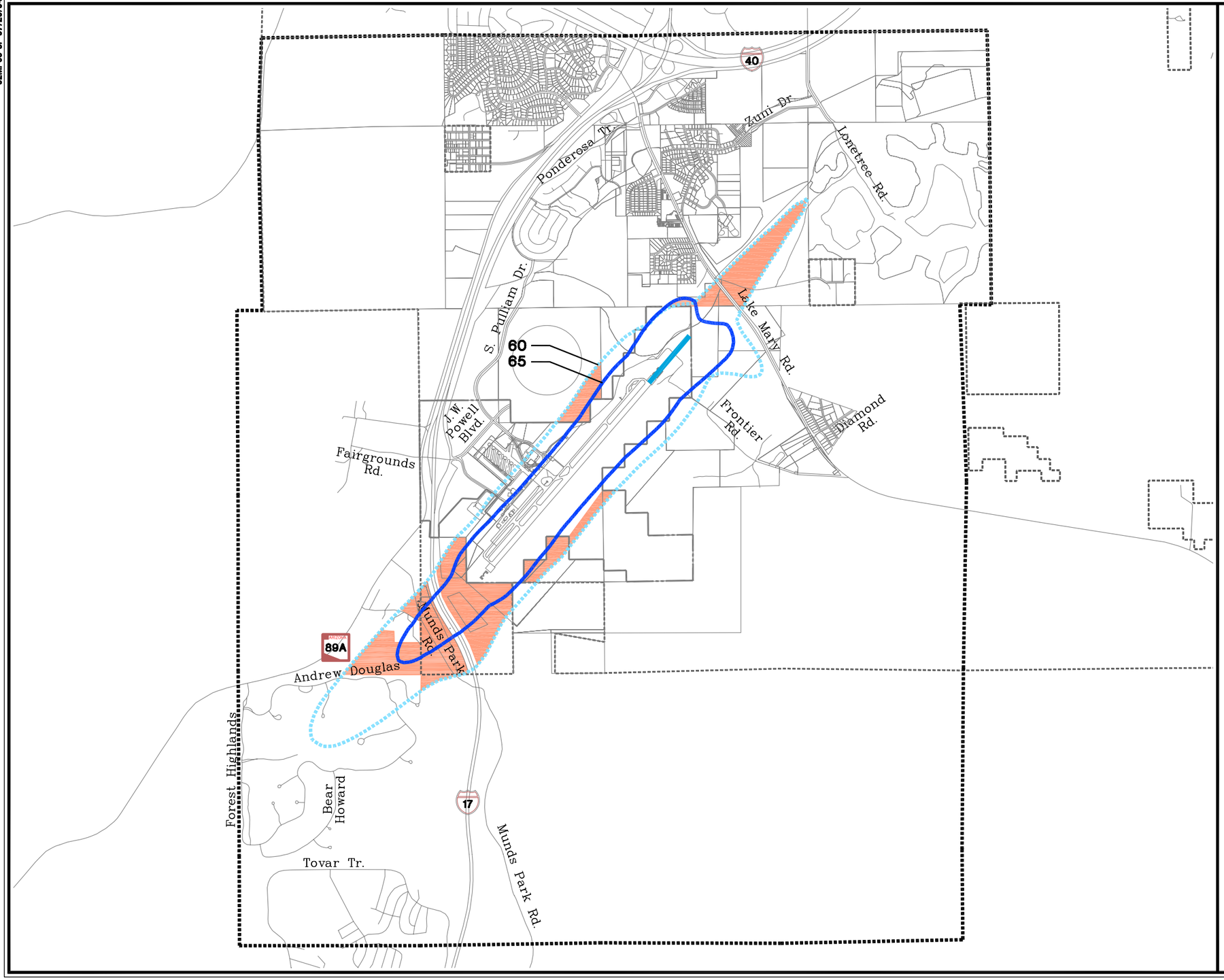

LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- Hybrid Noise Exposure Contour, Marginal Effect
- Hybrid Noise Exposure Contour, Significant Effect
- Zoned for Very Low Density Residential (0 - 0.9 du/ac)

Source: Flagstaff Geographic Information System, November 2002.
Coconino County Assessor Maps, November 2002.
Coffman Associates Analysis.

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Exhibit 6F

UNDEVELOPED AREA ZONED FOR NON-COMPATIBLE LAND USES WITHIN THE HYBRID 60 AND 65 DNL NOISE CONTOURS

designations for those areas contained in the city limits within the 60 DNL contour.

This is a viable alternative.

Change in Residential Density

Another way of using conventional zoning to promote noise compatibility is to reduce the potential number of future residents in the high noise area, rather than preventing residential development altogether. This can be done by reducing the permitted housing densities in the noise-impacted areas.

- EVALUATION

The undeveloped areas within the 60 DNL contour are already zoned for low density residential or agriculture. Both of these zoning classifications are designed to allow lower density developments; therefore, reducing residential zoning density for undeveloped land is not applicable.

- CONCLUSION

This alternative need not be considered further.

Airport Compatibility Overlay Zoning

Airport compatibility overlay zoning (sometimes called "combining zoning") is intended to provide a layer of special purpose regulations to address special environmental constraints, or problems, by setting performance standards to protect the public. Overlay zoning involves the creation of one or more special zoning districts that supplement or combine with the regulations of the general purpose zoning districts. These controls are often used, for example, to regulate the height of structures within runway approach areas and in other areas near the airport, or to promote development which is compatible with aircraft noise levels. Airport compatibility overlay zoning is used around many airports in the country to establish special land use controls whose purpose is to protect the public's health, safety, and welfare from conflicts that may arise between aviation and urban development.

Airport compatibility overlay zoning regulations are usually established as "combining" regulations in that the underlying zoning (i.e., residential, commercial, industrial, etc.) remains in place and is supplemented by the overlay zone. The land within the overlay zone is subject to the requirements of two zoning districts – the underlying zone and the overlay zone. The strictest requirements of both zones apply to the affected property.

The intention of airport compatibility overlay zoning is to avoid the problems associated with incompatible development in high noise areas. Regulations in airport compatibility overlay zones can prohibit noise-sensitive uses, as long as the underlying zone permits enough other land uses to provide an opportunity for the

economically viable use of the land. The regulations can also require sound insulation in the construction of noise-sensitive uses.

Airport compatibility overlay zoning is administered by the local land use regulatory agency. In areas where noise crosses jurisdictional boundary lines, it is helpful to local developers if the jurisdictions cooperate with a unified approach to overlay zoning. The boundary may follow the actual contours, or, for the sake of simplified administration, nearby streets, property lines, or natural features.

Among the advantages of airport compatibility overlay zoning are the simplicity of the required amendments, the simplicity of administration, the clear relationship of the regulations to their purpose, and the minimal impact of the regulations on the application of the zoning ordinance in other parts of the community.

Boundaries of airport compatibility overlay zones can be determined in a number of ways, based on local perception. Boundaries such as the airport's noise contours, approach zones, or common overflight areas are often used.

- EVALUATION

In addition to the AIA and avigation area zone, the City of Flagstaff has adopted an Airport Overlay District. The purpose of this district is to ensure compatible development within airport environs. Both land use and height restrictions are outlined within the overlay district. Furthermore, the district is provided to inform landowners and future landowners of the potential affect of airport operations on their property.

This overlay district consists of three Airport Noise Impact Areas and one Clear Zone Area. The purpose of the Clear Zone Area is to regulate the height of structures within the airport environs. The boundaries of the Airport Noise Impact Areas regulate land uses within the three impact areas. According to the *City of Flagstaff Land Development Code*, these impact areas change automatically as new contours are developed as part of Airport Master Plan Updates. The boundaries of the three noise impact areas are depicted on **Exhibit 6G** and described as follows:

- AP-1 contains the areas within the 60 to 65 DNL noise contour. Within this zone, noise-sensitive land uses are allowed; however, measures to achieve a reduction of 25 or 30 dB must be incorporated into design and construction of structure.

- AP-2 contains the areas within the 65 to 70 DNL noise contour. Within this zone, noise-sensitive development is discouraged. The absence of viable alternative development options should be determined and an evaluation indicating that a demonstrated community need for residential use would not be met if development were prohibited in these areas and should be conducted prior to

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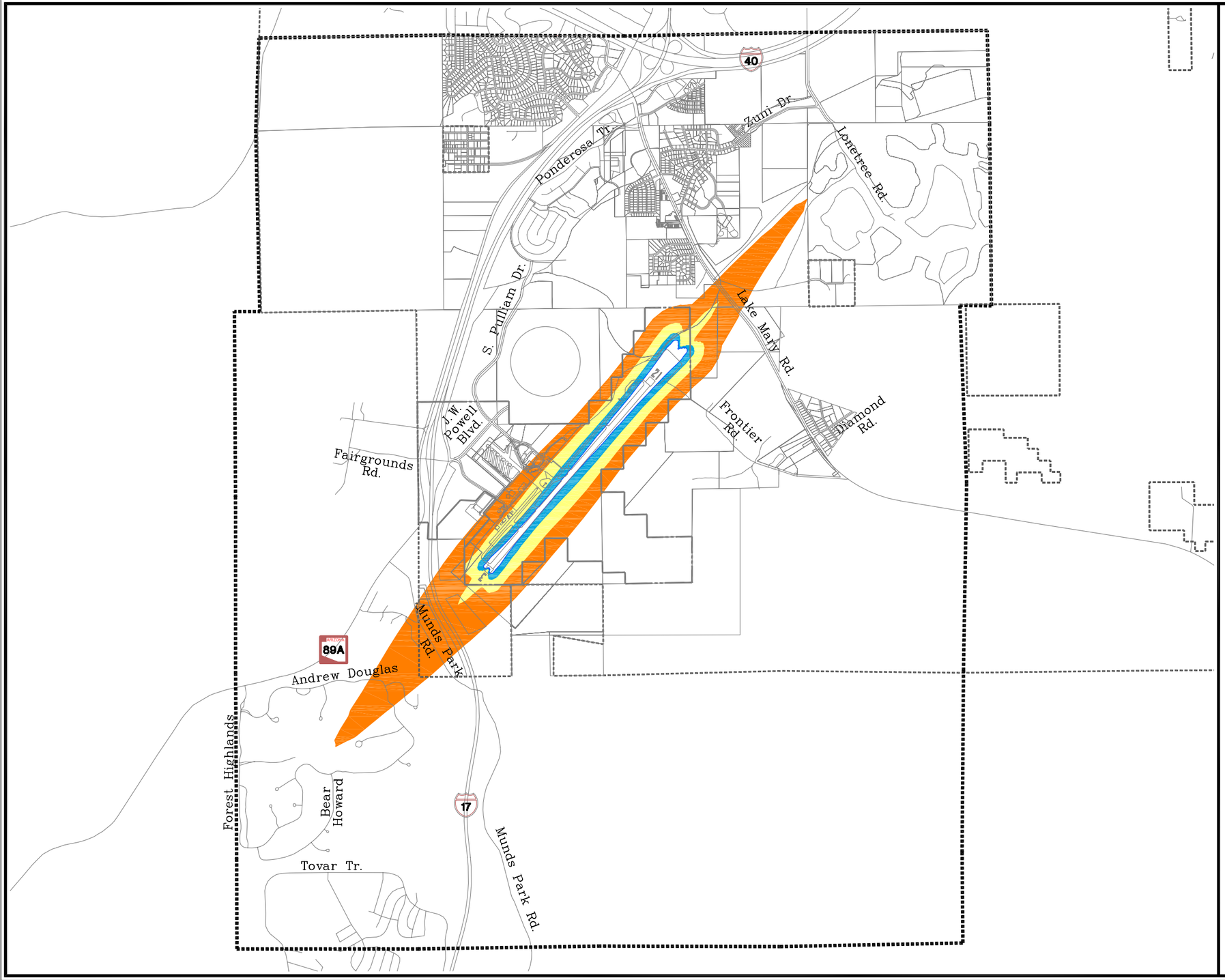

LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- AP1 (60-65 DNL Contour)
- AP2 (65-70 DNL Contour)
- AP3 (70-75 DNL Contour)

Source: Flagstaff Geographic Information System, November 2002.
Coffman Associates Analysis.

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Exhibit 6G
EXISTING AIRPORT OVERLAY DISTRICTS

approvals. Measures to achieve a reduction of 25 or 30 dB must be incorporated into design and construction of any noise-sensitive structures allowed to be constructed in this zone.

- AP-3 contains the areas within the 70 to 75 DNL noise contour. Residential development within this zone is not allowed. The development of other noise-sensitive land uses is strongly discouraged.

According to the existing Airport Overlay District regulations, the boundaries of the various noise impact areas will automatically change to reflect the new noise contours being prepared for the airport. This automatic change could be problematic as the new noise contours are significantly smaller to the northeast and the 65 DNL noise contour is significantly larger to the southwest. Consideration could be given to revising the existing regulations in a manner which would not require a periodic change in the overlay boundaries as new contours are prepared in the future. Consideration could also be given to incorporating hybrid noise contours as outlined previously within the general plan discussion. These hybrid contours would relate to physical boundaries such as parcels or streets instead of the actual contour as depicted on **Exhibit 6H**. This would assist in the enforcement of the overlay zone as it would eliminate any questions as to the actual boundaries of the overlay zone. The hybrid noise contour boundaries allow for areas which are currently protected to remain within an overlay zone and also incorporates the "worst case" scenario from the 1991, 2003, and 2008 noise contours.

It is also suggested that the allowed land uses within the various overlay zones be modified in a manner which would not allow noise-sensitive development within the 65 DNL noise contour. This would ensure compatible development within the 65 DNL noise contour as recommended by the FAA. Currently, the regulations allow noise-sensitive development within this contour as long as sound insulation is incorporated into the design and construction of the structure. **Table 6A** contains potential revisions to the allowed uses within the various Airport Impact Noise Areas. Where the proposed and current allowed uses differ, the current allowed uses are shown in parenthesis. Finally, it is suggested that the boundary of the avigation easement area be incorporated into the overlay zoning. This boundary could be designated as AP-0.

Currently, Coconino County has informally adopted the city's avigation easement zone and requires avigation easements prior to development approval within the zone. Consideration could be given to taking this zone one step farther by establishing an overlay zone for those areas within the noise impact areas in unincorporated Coconino County.

TABLE 6A
Potential Revised Airport Overlay District

Land Use	AP-0	AP-1 (Approx. the 60-65 DNL)	AP-2 (Approx. the 65-70 DNL)	AP-3 (Approx. the 70-75 DNL)
Ranching and Forestry	Y[6]	Y[4,6]	Y[4,6]	Y[5,6]
Residential:				
Single-family	Y[6]	25[6]	N (25[1])	N
Cluster	Y[6]	25[6]	N (25[1])	N
Planned	Y[6]	25[6]	N (25[1])	N
Manufactured Housing	Y[6]	N	N	N
Commercial Apartments	Y[6]	25[6]	N (25[1])	N
Fraternities/Sororities	Y[6]	25[6]	N (25[1])	N
Industrial Uses	Y[6]	Y[6]	Y[6]	Y[2,6]
Commercial Retail	Y[6]	Y[6]	Y[6]	Y[5,6]
Heavy Retail/Heavy Services	Y[6]	Y[6]	Y[6]	Y[2,6]
Offices and Services	Y[6]	Y[6]	Y[6]	Y[6]
Institutional Uses:				
Hospitals, nursing homes	Y[6]	N	N	N
Other medical facilities	Y[6]	N (Y)	N (Y)	N (25[6])
Governmental	Y[6]	Y*[6]	Y*[6]	25*[6]
Educational	Y[6]	N	N	N
Miscellaneous	Y[6]	Y[6]	Y[6]	25[6]
Cultural, including churches	Y[6]	N (Y*)	N (25*)	N (30*[6])
Nature exhibits	Y[6]	Y*[6]	Y*[6]	N
Public assembly	Y[6]	N (Y[6])	N (Y[6])	N
Auditoriums, concert halls	Y[6]	Y[6]	25[6]	30[6]
Outdoor music shells, amphitheaters	Y[6]	N (Y*[6])	N	N
Outdoor sports arenas, spectator sports	Y[6]	Y[6]	Y[3,6]	Y[3,6]
Golf courses	Y[6]	Y*[6]	Y*[6]	25*[6]
Resorts and group camps	Y[6]	Y*[6]	Y*[6]	N
Parks	Y[6]	Y*[6]	Y*[6]	Y*[6]
Other	Y[6]	Y*[6]	Y*[6]	Y*[6]

TABLE 6A (Continued)
Potential Revised Airport Overlay District

Notes:		
Y		Yes. Land use and related structures compatible without restrictions.
Y*		Yes, with restrictions. Measures to achieve a reduction of 25 dB must be incorporated into the design and construction of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.
N		No. Land use and related structures are not compatible and shall be prohibited.
25 or 30		Land use and related structures generally compatible; measures to achieve a reduction of 25 or 30 dB must be incorporated into design and construction of structure.
25* or 30*		Land uses generally compatible; however, measures to achieve overall reduction do not necessarily solve noise difficulties and additional evaluation is warranted.
1	(a)	Although local conditions may require residential use, it is discouraged in AP-2 and strongly discouraged in AP-3. The absence of viable alternative development options should be determined and an evaluation indicating that a demonstrated community need for residential use would not be met if development were prohibited in these areas and should be conducted prior to approvals.
	(b)	Where the City determines that residential uses must be allowed, measures to achieve outdoor-to-indoor noise level reduction of at least 25 dB (AP-2) and 30 dB (AP-3) should be incorporated into building codes and be considered on individual approvals.
	(c)	Noise level reduction criteria will not eliminate outdoor noise problems. However, building location and site planning, design and use of berms and barriers can help mitigate outdoor noise exposure, particularly from ground level sources. Measures that reduce noise at a site should be used wherever practicable in preference to measures which only protect interior spaces.
2		Measures to achieve a net level reduction 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		Land use is considered compatible, provided special sound reinforcement systems are installed which mitigates indoor sound impacts.
4		These buildings intended for human occupancy require a net level reduction of 25 dB.
5		Residential buildings require a net level reduction of 30 dB.
6		The issuance of an avigation easement is required prior to development approval.
( )		Where the proposed and current allowed uses differ, the current allowed uses are shown in parentheses.

- CONCLUSION

The City of Flagstaff could consider minor revisions to the existing Airport Overlay District to reduce the potential of noise-sensitive land use impacts. Coconino County could consider enacting a formal Airport Overlay District for those portions of the airport's AIA and avigation easement zone contained within unincorporated Coconino County.

Subdivision Regulations

Subdivision regulations control the platting of land by setting standards for site planning, lot layout, and the design of utilities and public improvements.

They can encourage compatible development around an airport by requiring the consideration of aircraft noise during the plat review by public officials. This might take the form of requiring further noise attenuation features in the site plan or a decrease or shift in the density of portions of the development.

Subdivision regulations are not well-suited to addressing needs for noise attenuation, although they can be used to inform prospective future property owners of the risk of aircraft noise. In some communities, noise levels are shown on the final subdivision plats either by drawing the noise contours on the plats or by assigning noise levels to the lots. This makes the noise information a matter of public record. An important disadvantage is that, while the plat is recorded and on file forever, noise levels can change.

Another approach is to write a note on the plat, or record a covenant with the plat, stating that the property is subject to potentially disruptive aircraft noise and advising consultation with local planning officials and the airport proprietor to get current information about the noise situation. As a practical matter, however, buyers of property rarely look at the plats.

Subdivision regulations can help protect the airport from the risk of noise damage suits while providing for notice to potential buyers of property by requiring, as a condition of subdivision approval, the dedication of noise and avigation easements and non-suit covenants in high-noise areas. This is similar to requirements for the dedication of street right-of-way or utility easements usually found in subdivision regulations.

An easement is a limited right to use property owned by another. A noise and avigation easement gives the airport, as owner of the easement, the right to direct aircraft over the property and, thus, to make noise. These easements serve notice that the property is subject to aircraft noise which may, at times, infringe on a resident's enjoyment of property and may, depending on the degree of acoustical treatment of the dwelling and the individual's sensitivity to noise, affect his or her well-being. The easement should state clearly that noise levels might increase in the future and that flight patterns or operating times might change. A noise and avigation easement often includes a covenant waiving the property owner's right to sue the airport proprietor for disturbances caused by aircraft noise.

The subdivision review process is an ideal time to secure easements and require the recording of covenants. In this way, subdivision regulations could be used in support of airport compatibility overlay zoning.

- EVALUATION AND CONCLUSION

The City of Flagstaff is utilizing other means for acquiring avigation easements within the established Avigation Area Zone. Both the city and Coconino County actively pursue the

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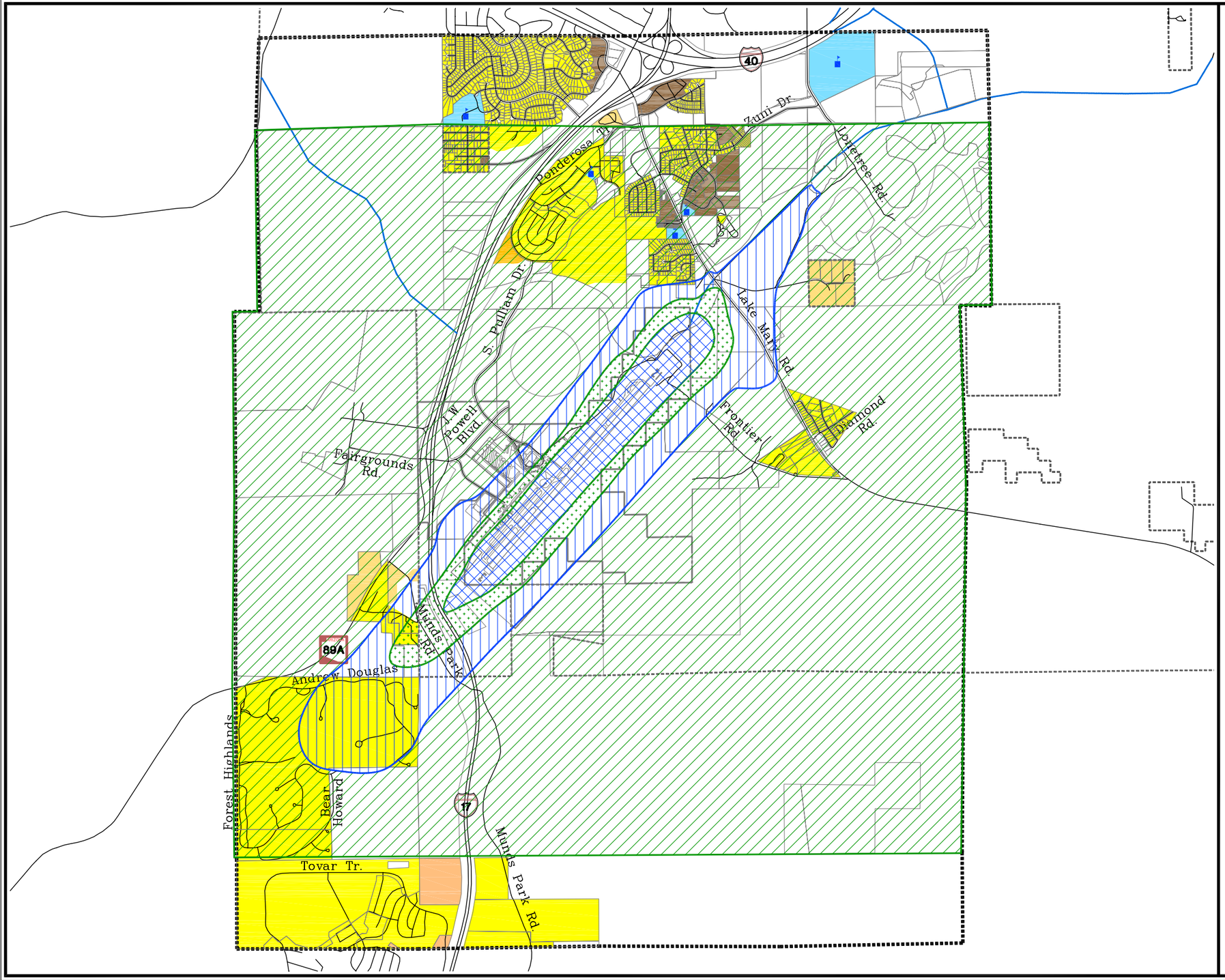

LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- Very Low Density Residential (0-0.9 du/ac)
- Low Density Residential (1-5 du/ac)
- Medium Density Residential (6-12 du/ac)
- High Density Residential (12+ du/ac)
- Residential Manufactured Housing
- Noise Sensitive Institutions
- School
- Place of Worship
- AP-0
- AP-1
- AP-2
- AP-3

Source: Coffman Associates Analysis.

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Exhibit 6H
PROPOSED NOISE OVERLAY ZONES

issuance of these easements prior to development approval within those areas contained within the zone.

This alternative need not be considered further.

Building Codes

Building codes regulate the construction of buildings, setting standards for materials and construction techniques to protect the health, welfare, and safety of residents. Codes address structural concerns, ventilation, and insulation, each of which influences the noise attenuation capabilities of a building. Building codes commonly apply to both new construction and major alterations.

Building codes can require sound insulation in the construction of noise-sensitive uses in areas subject to high aircraft noise levels. Requirements for sound insulation customarily are applied within the 65 DNL contour with increasingly stringent standards in the 70 and 75 DNL contours. Most sound insulation code standards describe in detail the required improvements needed to achieve a given level of noise reduction.

- EVALUATION

Building codes have been adopted in each of the jurisdictions within the study area. Additional regulations, related to noise in the vicinity of Flagstaff Pulliam Airport, have not been adopted by either the City of Flagstaff or Coconino County.

While the zoning alternatives discussed previously would reduce the risk of future noise-sensitive development in the study area, special sound insulation measures may be appropriate in case infill noise-sensitive development should occur. Sound insulation standards would be an effective way to enhance land use compatibility in the airport area, especially if used as part of a comprehensive land use management approach. The Airport Overlay Zoning could declare which noise-sensitive uses should be sound-insulated within each overlay zone. The specific construction standards would be described in the building code and it would be the duty of the local building inspectors to ensure that sound insulation is properly installed.

The additional administrative burdens posed by sound insulation standards are not necessarily costly as most local communities already have a building inspection process. It is possible that a need for additional inspections could increase the costs to local regulatory agencies; however, these costs should be covered through inspection fees. Proper administration of these requirements is critical and would require careful inspections and special training for building inspectors.Sound insulation may cost local builders more than conventional construction; however, most of the additional cost results from the need for acoustical windows. Other sound insulation construction techniques should result in only very minor, if any, cost increase, as they involve primarily special installation techniques with a minimum of unusual or expensive materials. The additional

cost of a sound-insulated home is of real value for the future homeowner, as a properly sound-insulated home is not only quieter, but also highly energy-efficient. Therefore, the additional costs of sound insulation may be recouped through the marketing process.

At least three approaches may be taken to setting specific sound insulation standards. These are the utilization of: (1) prescriptive standards; (2) flexible standards; or (3) performance standards. These standards are discussed in the following sections. **Table 6A** could be used to determine which noise-sensitive land uses should be sound-insulated within each overlay zone.

Prescriptive Standards: These are perhaps the most commonly used approach to sound insulation standards. The existing building code could be amended to set forth specific construction standards intended to achieve a given level of noise reduction. It would be the duty of the local building inspectors to ensure that the correct materials are used and construction is done properly. After installation and a successful inspection, the building is presumed to be able to achieve the targeted level of noise reduction.

Flexible Code Standards: These standards would describe the required "sound transmission class" (STC) rating of all building components. STC is a system for rating the effectiveness of partitions, floors, ceilings, windows, and doors in attenuating the transmission of sound. The ratings are determined through standardized laboratory tests of sound transmission at various frequencies. The higher the STC rating, the better the sound reduction. A builder would be free to use any materials desired as long as evidence is provided that the required STC rating has been met.

Jurisdictions desiring to undertake such an approach should retain the assistance of a qualified acoustical engineer in developing the standards. The objective of the regulations should be to specify the STC ratings of various building components needed to achieve an overall noise level reduction of 25 to 30 decibels, depending on the noise contour where the proposed development is located.

Performance Standards: A performance-based standard would focus on the final result to be achieved by the construction. The standard would describe the required outdoor-to-indoor noise reduction. The builder could use any materials or techniques he desires as long as he can certify that the plans and final construction meet the standard. This would require the assistance of an acoustical engineer in designing the building and checking construction. It would also require testing the building after construction.

The performance standards could be set in the zoning ordinance and would be particularly easy to administer in the case of conditional uses, special uses, and planned developments. These kinds of developments are already subject to special reviews and performance standards.

The advantage of this approach is that the builder has the flexibility to design the building as he deems best. It also avoids the complexity of drafting, adopting, and administering special sound insulation building code amendments. In addition, verification of compliance with the requirements is the responsibility of the builder and his engineer. The disadvantage is that the cities would have to verify the certifications made by the builder and the engineer. Builders also may lack confidence in regulations which are subject to case-by-case verification and approval.

- CONCLUSION

The City of Flagstaff and Coconino County could consider amending their respective building codes to incorporate prescriptive noise standards. Implementation of this alternative would not only protect future noise-sensitive development within the 60 DNL noise contour, but would also protect structures that undergo extensive remodeling or reconstruction as these types of construction typically require a building permit and inspections. A sample building code is contained within **Appendix D**.

This is a viable alternative.

Transfer of Development Rights

Land ownership actually includes a bundle of rights to the use of that land. These include rights of access, mineral rights, limited rights to the airspace above the land, and rights to develop the land. Transfer of development rights (TDR) is based on the idea that each right has a market value which can be separated and sold without selling the entire property.

TDR was developed as a way to preserve environmentally important areas without having to buy them with public funds. The technique begins by dividing the municipality into sending and receiving zones. The sending zones are areas where environmental preservation and minimal development are desired, and the receiving zones are areas where additional development is preferred. Development rights, measured in terms of development density, are assigned through the zoning ordinance. If developers in the receiving areas can get additional development rights, they are allowed to build to higher densities than normally allowed by the zoning ordinance. They would buy these rights from landowners in the sending zones. In this way, the public can benefit from preserving environmentally valuable land, the owner of that land can be paid for preserving it, and developers can reap higher profits.

Based on experience with these programs around the country, several conditions for the successful use of TDR have been identified. The receiving districts must be capable of immediate development; the regulatory process must have integrity and be trusted by developers; the regulatory agency must be able to inform and help property owners and developers; and programs must be as simple as possible and

facilitate the self-interest of all involved parties. (See "Making TDR Work," by Peter J. Pizor, in the *Journal of the American Planning Association*, Vol. 52, No. 2, Spring 1986.)

A variation of TDR is density transfer zoning. This allows developers of several large tracts of land to move their allotted densities among tracts to reduce densities in areas worthy of preservation. This differs from TDR because only one owner is involved in the transfer, and a system for sale and purchase of development rights is not required. Density transfer zoning often can be achieved through creative use of the planned unit development process.

In rapidly growing areas with large amounts of vacant land, TDR can be an effective tool for airport land use compatibility planning. At no cost to the taxpayers, it can neatly deal with the problem of what to do with land in high noise zones when there are no practical alternatives to residential development.

TDR is a very complicated technique that is difficult to justify solely for the purposes of airport land use compatibility. If a local jurisdiction is already using or considering TDR, airport compatibility criteria could be included with other environmental criteria in the design of the program.

- EVALUATION

TDR is not currently being used in the City of Flagstaff or Coconino County. Current land use planning, in addition to potential revisions to conventional land use regulations, can adequately meet the need for compatible development in the airport area.

This is not a viable alternative.

- CONCLUSION

This option need not be considered further.

Environmental Zoning

Special zoning regulations to preserve environmentally-sensitive areas or protect development from environmental hazards can also promote land use compatibility near airports. Floodplain overlay zoning, which restricts or prohibits development in all or part of the floodplain, is the most common form of environmental zoning.

Other environmental zoning regulations may include steep slope zoning, requiring low development densities and special construction standards, wetland preservation zoning limiting densities and the design of drainage facilities, and groundwater recharge zones limiting building density and lot coverage. All can be used to restrict the development of noise-sensitive uses in environmentally-sensitive areas that are also impacted by aircraft noise.

- EVALUATION

Environmental zoning regulations that are currently in place within the

Flagstaff Pulliam Airport environs are in the form of overlay zones which were created to protect encroachment of the floodplains within the City of Flagstaff as well as areas of moderate to steep slopes and forested areas. The locations of these zones are not in areas which are significantly impacted by aircraft operations; therefore, environmental zoning is not a viable means of promoting land use compatibility.

This is not a viable alternative.

- CONCLUSION

This option need not be considered further.

Fair Disclosure Regulations

Fair disclosure regulations are not actually land use regulations. They are intended to ensure that prospective buyers of property are informed that the property is or will be exposed to potentially disruptive aircraft noise. It is not uncommon around even major airports for newcomers to report having bought property without having been informed about airport noise levels.

At the most formal level, fair disclosure can be implemented through regulations requiring the seller or his agent to provide a notice of aircraft noise exposure on the real estate listing sheet and at the time that a sales contract is executed. In addition, any easements should be revealed at the time of closing. Although these measures are intended to protect buyers of property from being unaware of aircraft noise, a potential problem is that they can be difficult to enforce.

Fair disclosure regulations can place a serious responsibility on real estate agents and lenders. If the regulations are properly drafted, however, the responsibilities of real estate agents and sellers are clearly defined and should be limited simply to disclosing the airport noise levels or overlay districts affecting the property and directing buyers to airport officials for more information.

Another approach to fair disclosure is to require the recording of a fair disclosure agreement and covenant at the time of rezoning or subdivision plat approval. The agreement would require the property owner to disclose the airport noise situation to prospective buyers. As a covenant running with the land, this requirement would bind all future property owners.

- EVALUATION

As discussed within the AIA section at the beginning of this chapter, the State of Arizona has adopted legislation that requires the disclosure of aviation activities to prospective buyers of real estate. The requirements of these pieces of legislation will help to ensure that future residents of the area are aware of the potential impact the airport may have on their property. Additional means of fair disclosure which are feasible are discussed within the Airport Noise Overlay and Subdivision Regulations sections of this chapter.

- CONCLUSION

This alternative does not need to be considered further.

EXPENDITURE TECHNIQUES

Land use management techniques involving direct expenditures include the following:

- Property Acquisition
- Sound Insulation
- Noise and Avigation Easement Purchase
- Purchase Assurance
- Sales Assurance
- Development Rights Acquisition

These measures are usually considered as a last resort because they are expensive, often disruptive, and sometimes controversial. They are most often justified when noise impacts are severe and cannot be mitigated through aircraft noise abatement alone. These measures are potentially eligible for FAA funding assistance through the noise set-aside of the Federal Airport Improvement Program (AIP) if they are part of an FAA-approved Part 150 Noise Compatibility Program. In general, to be eligible for FAA approval, these programs can apply only to areas within the 65 DNL noise contour based on existing conditions or the five-year forecast conditions, whichever is greater. Historically, properties within noise contours exceeding 65 DNL have received much higher priority for mitigation funding than properties located within lesser contours (i.e., 55 and 60 DNL noise contours); therefore, the evaluation of properties contained only within the 65 DNL noise contour will be evaluated within the following expenditure techniques.

The 2003 65 DNL noise contour will be used during evaluation of the various expenditure techniques. This contour is the largest to the southwest and contains the largest number of population impacts.

Property Acquisition

Acquisition and clearance of noise-sensitive land uses impacted by high noise levels is one method of ensuring noise compatibility around an airport. The intent of acquisition is to remove residents from severely noise-impacted areas and to prevent incompatible uses from being developed near the airport. This can be an effective way to ensure complete noise compatibility around an airport, although it can be very expensive.

Under federal regulations, land may be acquired for noise mitigation, with funding through the noise set-aside of the AIP, if it is within the locally deemed contour of significance and has been developed for noise-sensitive land uses. As previously mentioned, properties within noise contours exceeding 65 DNL have received much higher priority for mitigation funding than properties located within lesser noise contours (i.e., 55 and 60 DNL noise contours).

Acquisition of undeveloped land may also be eligible if compatible use zoning

and subsequent compatible development are not considered practical. The FAA actively supports airport ownership of land impacted by noise above 70 DNL. While acquisition of areas impacted by noise down to 65 DNL is eligible for federal funding assistance, it can be difficult to establish a high priority with the FAA for funding the acquisition of property outside the 70-75 DNL contour. Eligible sponsors for grant funding of a land acquisition program include airport proprietors, other public agencies, and quasi-public agencies such as industrial development corporations.

Typically, property acquisition for noise mitigation is accomplished through voluntary programs. The purchasing agency notifies property owners in a given area when it is ready to negotiate the purchase of their land and homes. Property owners are assured that the airport will buy their land, assuming a fair price can be negotiated. Under a purely voluntary program, property owners are under no obligation to participate and may decide to remain in their homes. If the acquisition is part of a comprehensive redevelopment project, it may be necessary for the purchasing agency to reserve the right to use its eminent domain authority.

If federal funds are used for property acquisition, the airport must comply with the *Federal Uniform Relocation Assistance and Real Property Acquisition Policies Act* (See 49 CFR, Part 24). Under these regulations, the fair market value of the home is established through two professional appraisals. The homeowner is also entitled to reimbursement of moving expenses and compensation for other relocation expenses (such as closing costs and incidental expenses for a new home, and compensation for a higher interest rate on the new mortgage) up to a maximum of $22,500. If the maximum relocation benefit, in addition to the sale price of the home, is not enough to assure the displaced person of acquiring comparable housing or, in any case, decent, safe, and sanitary housing, additional relocation payments may be available, subject to a case-by-case review.

In addition to clearing noise-sensitive land uses, property acquisition can also be used to promote the development of compatible uses. Land parcels can be bought, consolidated, re-zoned, and sold or leased for redevelopment of compatible industrial, commercial, and recreational uses. Redevelopment of noise-impacted property can ensure land use compatibility near the airport while promoting economic development. This can involve a full urban renewal or community redevelopment program or the simple sale of land for private development. A large-scale redevelopment program is potentially very complicated and would be successful only if a variety of local conditions are favorable.

- EVALUATION

Property acquisition costs are eligible for 95 percent federal funding. The remaining 5 percent is often covered through the airport's capital budget and

with matching funds from the Arizona Department of Transportation. As depicted on **Exhibit 6J**, 14 single-family homes are located within the 2003 65 DNL noise contour. These properties are all located southwest of the airport.

When considering the costs and benefits of purchasing these significantly noise-impacted homes, one must realize that 11 of the 14 homes currently contained within the 65 DNL in 2003 are not contained within the 2008 65 DNL noise contour. In 2008, there are only three homes within the 65 DNL noise contour. This decrease in impacts is a result of the planned runway extension to the northeast.

The runway extension is planned to be complete by 2006; therefore, noise impacts to dwelling units would likely be reduced prior to 2008. Due to the time lapse between the preparation of this document and FAA approval, it is likely that the acquisition funds would not be available until late 2005. Therefore, any proposed acquisition of those properties outside the 2008 DNL noise contour would not be feasible. Based on this information, the dwelling units contained within the 2008 65 DNL noise contour will be analyzed within this study.

The cost of acquiring these properties is based on a number of assumptions. First, it is assumed that the single-family homes are owner-occupied. Secondly, it is assumed that it would cost approximately $200,000 to acquire each of the homes. The allowable relocation costs for the owner-occupied dwellings would not exceed $22,500.

Based on the above assumptions, the purchase of the noise-impacted properties in the areas adjacent to airport property would cost approximately $667,500 based on the following information:

- Purchase of 3 single-family homes within the 65 DNL noise contour at a total cost of $600,000.
- Relocation of 14 single-family households at a maximum cost of $67,500.

- CONCLUSION

Consideration could be given to acquiring the 3 single-family homes contained within the 2008 65 DNL noise contour.

Acoustical Treatment

Dwellings and other noise-sensitive buildings can be acoustically-treated, or sound-insulated, to reduce interior noise levels. Sound insulation typically can improve the outdoor-to-indoor noise level reduction of a structure by five to ten decibels. Sound insulation may involve thermal insulation and weatherproofing, the baffling of vents and mail slots, the installation of solid-core wood doors or foam-core steel doors, the installation of acoustical windows with special noise attenuation characteristics, the installation of new interior walls along existing walls, and the installation and use of year-round air conditioning and ventilation systems.

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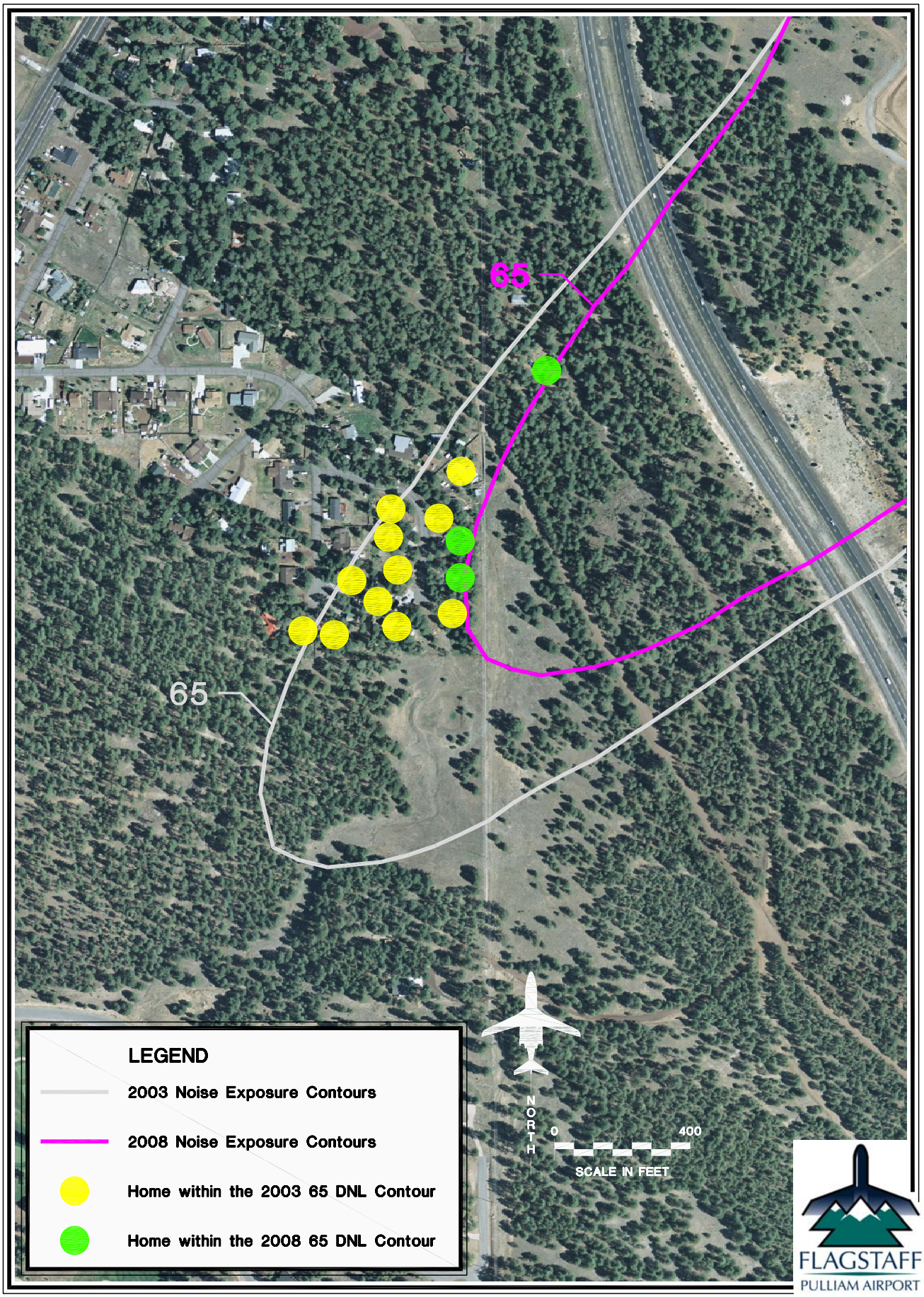


Exhibit 6J
POTENTIAL RESIDENTIAL ACQUISITION OR SOUND INSULATION AREA

Fresh air circulation systems or air conditioning systems are necessary if the full benefits of sound insulation are to be realized. This enables windows and doors to be closed throughout the year. If air conditioning is to be fully effective for sound insulation, the residents must accept the costs and inconvenience of operating the system until the heating season begins. As an alternative, a forced fresh air circulation system, capable of a complete change of air twice every hour and a 20 percent change of new fresh air every hour, equipped with acoustical baffling or other treatment of the air inlets, would permit closed doors and windows when neither air conditioning nor heating are required. Most forced air heating systems can be adapted to this purpose. The FAA requires that property owners and residents be notified of the utility and maintenance costs associated with any heating or air conditioning systems installed as part of a sound insulation program.

The FAA will assist in funding sound insulation of noise-sensitive buildings within the 65 DNL contour if the buildings cannot achieve an outdoor-to-indoor noise level reduction of 20 decibels or more. (Within the 70 DNL contour, the noise level reduction threshold increases to 25 decibels, and within the 75 DNL contour, to 30 decibels.) Sound insulation projects must be designed to achieve at least a five-decibel improvement in noise level reduction. The target is to reduce interior noise levels to 45 DNL or less. Sometimes, a supplementary criterion is used in actual project design to ensure that interior noise levels from individual overflights do not exceed a Sound Exposure Level (SEL) of 65 dB. (This is an estimate of the average speech interference level.)

- EVALUATION

Typical acoustical treatment measures include the installation of acoustical doors and windows, insulation, and forced air heating and air conditioning systems. The estimated average cost of treating homes is approximately $20,000 each and the average cost of treating apartment dwellings is $5,000 each. This covers the costs of acoustical treatment, engineering, and administrative expenses. Acoustical treatment costs are eligible for 95 percent federal funding. The remaining 5 percent is covered through the airport's operating budget and with matching funds from the Arizona Department of Transportation.

The acquisition of the three single-family homes contained within the 2003 65 DNL contour as depicted on **Exhibit 6J** was proposed. Should it be determined that purchasing these units is not a viable alternative, consideration could be given to sound-insulating the structures. This would result in the insulation of three homes at an estimated cost of $20,000 each for a total cost of $60,000. As a condition of sound insulation, the property owner could be required to sign a noise and avigation easement if one has not already been signed.

- CONCLUSION

As a means of reducing the impact of noise on residences, consideration could be given to sound-insulating the properties contained within the 2008 65 DNL noise contour.

Purchase of Noise and Avigation Easements

Noise and avigation easements give an airport the right to direct aircraft over property, creating related annoyances, without the threat of a lawsuit. These easements run with the land and serve as a limited means of notifying prospective property owners of the impact of airport noise. The purchase of noise and avigation easements within the 65 DNL is eligible for federal funding assistance through the noise set-aside of the Airport Improvement Program (AIP). Purchase of noise and avigation easements over existing homes may be appropriate if noise is so disturbing that it substantially interferes with the full enjoyment of the property. It may also be appropriate where, as part of a noise abatement or airport development program, noise is introduced to areas which formerly were not impacted.

The advantages of purchasing noise and avigation easements include some legal protection for the airport and limited fulfillment of fair disclosure objectives. An additional benefit is that they compensate airport neighbors who have been heavily impacted by noise and who may have lost some of the potential enjoyment of their property.

A disadvantage of an avigation easement purchase program is its potentially high cost. There is also a risk that despite the expense of purchasing the easements, the airport may become the target of complaints, controversy, political pressure, and even lawsuits, if the noise environment or the attitude of easement grantors changes substantially. Of course, the purchase of a noise and avigation easement does not mitigate noise; it merely compensates people for the inconvenience caused by noise.

- EVALUATION

The City of Flagstaff currently requires that avigation easements be placed on all new residential development within the avigation easement zone.

The ability of the City to acquire avigation easements as a condition of development reduces the need for a separate avigation easement purchase program.

This is not a viable alternative.

Purchase Assurance

Purchase assurance programs are intended to assure homeowners in noise-impacted areas that they will be able to sell their property for fair market value. The airport proprietor would acquire the property if the homeowner was unable to sell it on the open market. The airport would then sell the home and retain an avigation easement after making sound

insulation or other property improvements.

Purchase assurance programs are most appropriate where there is a widespread concern that homeowners have difficulty selling homes because of noise intrusion. They are appropriate where the noise levels are not so severe as to make the neighborhood unlivable, or where it is impractical or otherwise inappropriate to acquire and clear neighborhoods.

A purchase assurance program allows the airport to address the concerns of people who are very annoyed by aircraft noise and who desire to leave the neighborhood without suffering financial loss. It can be fairly economical as, in many areas, property values do not experience declines because of aircraft noise. Thus, it may be possible for the airport to sell the home at or near the cost of purchase.

Purchase assurance programs can be fairly complex and time-consuming to administer. They also open up the risk that the airport will have to become a property manager or landlord if market conditions make it difficult to sell homes. The program should be carefully staged to prevent a glut of applicants at any one time. Otherwise, an adverse reaction in the larger real estate market could be caused.

- EVALUATION AND CONCLUSION

A purchase assurance program has many disadvantages:

- The program would require considerable administrative support.

- The airport would have to pay closing costs when purchasing and reselling the home, a relatively unproductive use of its mitigation funds.

- The property purchased by the airport would be removed from the tax rolls during the time it takes to acoustically treat the home, remedy code deficiencies, and sell the home.

- A considerable amount of the airport's mitigation funds would be tied up between the time the airport buys and sells the home.

- The airport would be responsible for the maintenance and security of the property while the property is in the airport's possession.

- As the property owner, the airport would be liable for the cost of all code deficiency repairs.

Purchase assurance would add to the administrative costs of the mitigation program and would impede cash flow by tying up relatively large amounts of money after acquisition and before resale. Therefore, purchase assurance should not be considered.

Sales Assistance

With a sales assistance program, the airport would offer to supplement any

bona fide purchase offer up to an amount equal to fair market value. These programs are typically structured very much like purchase assurance programs except that the airport never takes title to the property. The airport guarantees the property owner of receiving the appraised value, or some increment thereof, regardless of the final sales price that is negotiated with a buyer. In order to prevent collusion between buyer and seller, to the detriment of the airport, the airport must approve the listing price for the home and any downward adjustments of that price. In return for participation in the program, the airport could require the property owners to give the airport an avigation easement. In other respects, the program guidelines would be similar to those described above for purchase assurance programs.

- EVALUATION AND CONCLUSION

Similar to the purchase assistance program, sales assistance programs are difficult to administer and tie up large amounts of mitigation funding for extended periods of time. Therefore, sales assistance should not be considered.

Development Rights Acquisition

The ownership of land involves the ownership of a bundle of rights to the use of that land and to develop it to the extent permitted by government regulations such as zoning, health and safety laws, and environmental laws. A property owner can sell some of these rights while still retaining title to the land. For example, a property owner surrenders some of the rights to their property when he or she grants someone an easement or sells the mineral rights to the property. One of the rights a property owner can sell is the right to develop the property for urban uses.

A different legal instrument, which has substantially the same effect as the purchase of development rights, is a restrictive land use easement. Purchase of such an easement can extinguish the rights to develop the property, rather than simply transfer them to another owner. This distinction can be important when the intent is to totally prevent the possibility of future development. (Theoretically, one might be able to argue that development rights that have been purchased from a property owner by the government could conceivably be sold back to that property owner at some point in the future.)

The purchase of development rights or restrictive land use easements is appropriate when there is insufficient legal justification to use zoning to prevent incompatible uses or where there is strong local opposition to the use of zoning. Development rights purchase can also be an alternative to fee simple acquisition. This is especially appropriate where the land is undeveloped and being farmed or used for private recreation.

The advantage of purchasing development rights is that complete

protection from incompatible development can be assured, and the property owners can receive compensation for any perceived loss. In addition, the property can be kept in private ownership, in productive use, and on the tax rolls while protecting the airport from incompatible development.

The main disadvantage is the potentially high cost of the development rights, in return for which the buyer receives only a very limited interest in the property. In urban areas where property owners have a reasonable basis for development expectations, development rights can cost nearly as much as the full fee title. In rural areas, on the other hand, development rights can be an economical alternative to fee simple acquisition.

- EVALUATION AND CONCLUSION

Purchase of development rights is generally appropriate only in large undeveloped areas. This situation is present in the Flagstaff Pulliam Airport study area; however, most of the vacant land surrounding the airport is owned by governmental bodies. This option need not be considered further.

PRELIMINARY LAND USE ALTERNATIVES

Table 6B presents the preliminary list of land use management alternatives which deserve consideration. These are to be reviewed by the Planning Advisory Committee (PAC), airport management, and the public. Refinements to these preliminary measures may be necessary before the final plan is developed. In addition, more detailed consideration for the implementation of these recommend-ations is necessary.

TABLE 6B
Land Use Management Alternatives Deserving Further Consideration
Flagstaff Pulliam Airport

Description	*Cost*	*Implementing Agency*
1. *General Plan*. Consideration could be given to re-designating undeveloped parcels within the 60 DNL noise contour to a compatible land use	Administrative	City of Flagstaff Coconino County
2. *General Plan*. Consideration could be given to incorporating hybrid 60 and 65 DNL noise contours into the general plan in lieu of the currently referenced noise contours prepared in 1991.	Administrative	City of Flagstaff Coconino County
3. *Project Review Guidelines*. The City of Flagstaff could consider revising their current project review guidelines to incorporate noise-related criteria.	Administrative	City of Flagstaff
4. *Compatible Use Zoning*. Consideration could be given to maintaining the compatible zoning designations within the 60 DNL noise contour.	Administrative	City of Flagstaff Coconino County
5. *Compatible Use Zoning*. Consideration could be given to rezoning undeveloped parcels within the 60 DNL noise contour to a compatible zoning designation.	Administrative	City of Flagstaff Coconino County
6. *Airport Overlay Zoning*. The City of Flagstaff could consider minor revisions to the existing Airport Overlay District. Coconino County could consider enacting an Airport Overlay District for areas contained within the airport's AIA.	Administrative	City of Flagstaff Coconino County
7. *Building Codes*. Consideration could be given to amending the jurisdiction's respective building codes to incorporate prescriptive noise standards.	Administrative	City of Flagstaff Coconino County
8. *Property Acquisition*. Consideration could be given to acquiring the homes contained within the 2008 65 DNL noise contour.	$667,500	FAA (95%) ADOT (2.5%) City of Flagstaff (2.5%)
9. *Acoustical Treatment*. Consideration could be given to sound insulating the homes contained within the 2008 65 DNL noise contour.	$60,000	FAA (95%) ADOT (2.5%) City of Flagstaff (2.5%)

FLAGSTAFF
PULLIAM AIRPORT

Chapter Seven

NOISE COMPATIBILITY PLAN

Chapter Seven

NOISE COMPATIBILITY PLAN

The updated 14 CFR Part 150 Noise Compatibility Program (NCP) for Flagstaff Pulliam Airport 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. Part 150 requires that the program 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. This NCP has been developed based on a ten-year planning period.

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 NCP includes three elements that are aimed at satisfying this objective.

- The **Noise Abatement Element** includes noise abatement measures selected from the alternatives evaluated in Chapter Five, Noise Abatement Alternatives.

- The **Land Use Management Element** includes measures to mitigate or prevent noise impact on existing noise-impacted land uses and future land use development in the Airport environs. Potential land use management techniques were evaluated in Chapter Six, Land Use Alternatives.

- The **Program Management Element** includes procedures and documents for implementing the recommended noise abatement and land use measures, monitoring the progress of the program, and updating the NCP.

Each measure of the NCP is summarized in **Table 7D** at the end of this chapter. Included in the table is a brief description of each recommended measure, the entity responsible for implementing each measure, cost of each measure, proposed timing of measure implementation, and potential sources of funding.

NOISE ABATEMENT ELEMENT

Recommended noise abatement measures are described within this section and summarized in **Table 7D** at the end of this chapter.

1. Runway 21 Departure Procedure for piston aircraft weighing less than 12,500 pounds.

Description. This measure is intended to route departing air traffic over compatibly developed land uses. Piston aircraft weighing less than 12,500 pounds departing Runway 21 will be directed by the Airport Traffic Control Tower (ATCT) to make a left turn when safe and practicable upon reaching Interstate 17. This departure procedure will be conducted below 3,000 feet above ground level (AGL). The intent is to prevent overflight of residential development southwest of the airport.

Implementation Actions. The Airport needs to request a field evaluation of this procedure to determine its effectiveness in mitigating noise concerns. Per *Paragraph 311n* of FAA *Order 1050.1E Environmental Impacts: Policies and Procedures*, testing of arrival and departure procedures occurring below 3,000 feet AGL can be categorically excluded from further National Environmental Protection Act (NEPA) review. Pending the results of the test, this procedure may be eligible for an additional categorical exclusion under *Paragraph 311p* of FAA *Order 1050.1E,* which states that the establishment of new procedures that routinely route aircraft over non-noise sensitive areas can be categorically excluded.

Costs and Funding. Developing and evaluating this procedure would involve administrative costs for both the Airport and FAA.

Timing. It is expected that this would take place following FAA's approval of the Noise Compatibility Plan. This is projected for 2005.

2. Discourage intersection and midfield takeoffs.

Description. At Flagstaff Pulliam Airport, due to the relatively short runway length and high elevation, midfield departures would inhibit nearly all aircraft from safely departing the airport. These operations are further jeopardized by the hot weather experienced in the region from late spring to early fall. In addition, residents located off the departure end of the airport would likely be impacted by greater levels of aircraft noise, since aircraft would not have suf-

ficient distance in which to gain altitude prior to leaving the airfield.

Implementation Actions. The Airport should include this recommended procedure in the pilot guide.

Costs and Funding. The Airport will incur promotional costs for developing and distributing a pilot guide. These costs are addressed in Program Management Measure #1.

Timing. This element would begin following FAA approval of the NCP. This is expected to be in 2005.

3. Promote use of Industry Standard Thrust Cutback Procedures.

Description. The Airport should promote the use of manufacturer's standard noise abatement procedure for jets departing the airport. Due to the location of noise-sensitive land uses, a thrust cutback procedure that results in higher altitudes and lower noise levels over down-range locations is preferred. Therefore, NBAA Standard Procedure or aircraft manufacturer's distant thrust cutback procedure should be encouraged when safe and practicable. These operations should be flown at the pilot's discretion and consistent with safety procedures.

Implementation Actions. The Airport should promote the use industry standard thrust cutback procedures in the pilot guide.

Costs and Funding. The Airport will incur promotional costs for developing and distributing a pilot guide. These costs are addressed in Program Management Measure #1.

Timing. This element would begin following FAA approval of the NCP. This is expected to be in 2005.

4. Promote use of Aircraft Owners and Pilots Association (AOPA) Noise Awareness Steps by light single and twin-engine aircraft.

Description. The AOPA encourages quiet and neighborly flying by distributing generalized noise abatement procedures for use by propeller aircraft. The AOPA Noise Awareness Steps have recommendations on how to fly the aircraft, as well as where to fly. Most of the steps provide guidance on pilot technique when maneuvering near noise-sensitive areas. The steps also encourage cooperation with the airport staff on noise abatement issues. These procedures are listed in **Appendix D** of this document.

Implementation Actions. The Airport should include the AOPA (Noise Awareness Steps) in the pilot guide.

Costs and Funding. The Airport will incur promotional costs for developing and distributing a pilot guide. These costs are addressed in Program Management Measure #1.

Timing. This element would begin following FAA approval of the NCP. This is expected to be in 2005.

5. Change Phoenix Sectional Aeronautical Chart to depict the location of Walnut Canyon National Monument.

Description. To reduce low aircraft overflights of Walnut Canyon National Monument, its location should be depicted on the Phoenix Section Aeronautical Chart. This would alert pilots to maintain a minimum altitude of 2,000 feet above the surface of the monument in accordance with FAA Advisory Circular 91-36D.

Implementation Actions. Flagstaff Pulliam Airport should work with the FAA to make changes to the aeronautical chart.

Costs and Funding. Changing the chart would involve administrative costs for both the Airport and FAA.

Timing. Changes to sectional aeronautical charts take a substantial amount of time to prepare and process. The required changes for this measure are project to occur in 2005.

NOISE CONTOURS

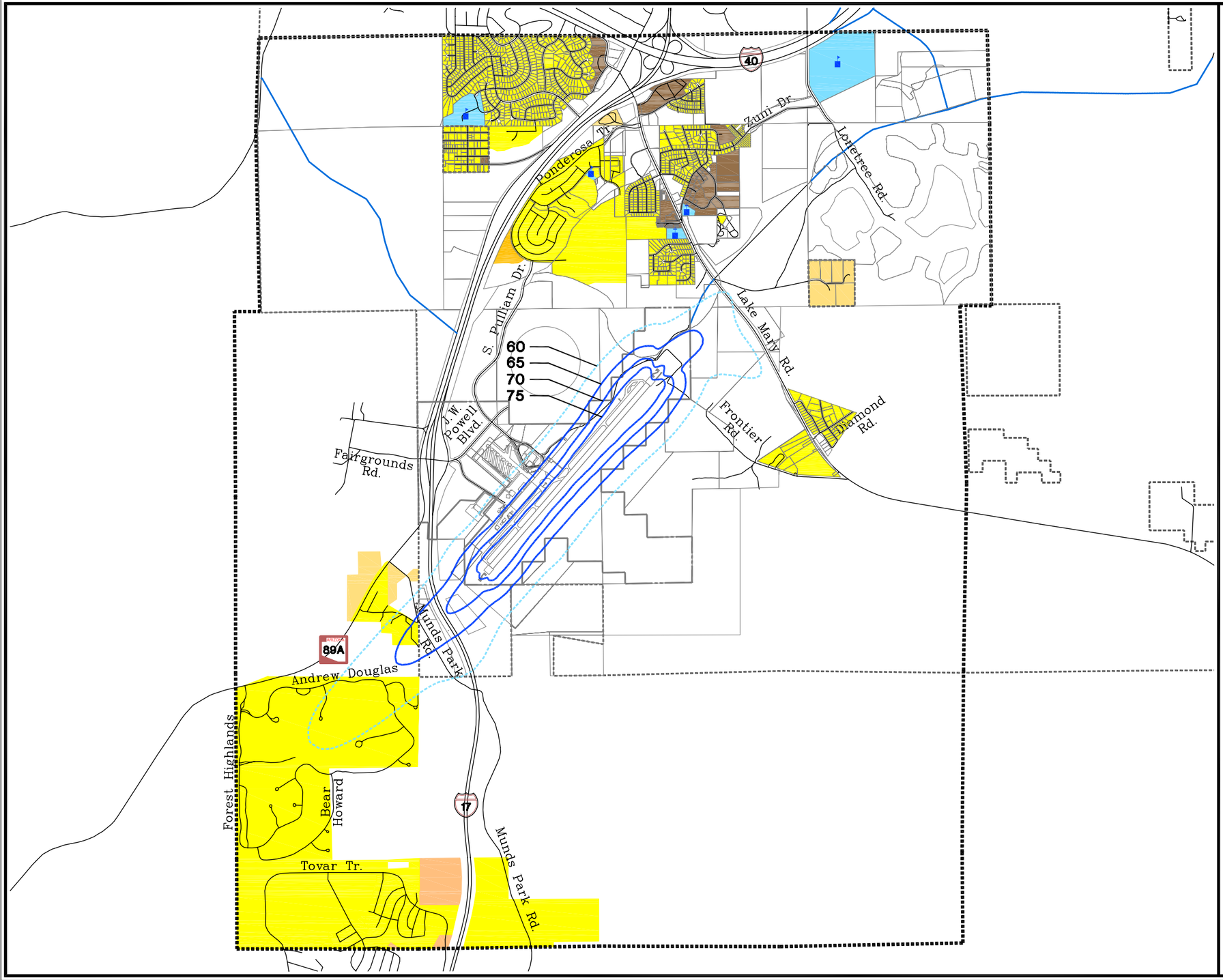
The recommended noise abatement measures do not involve any changes that would alter the 2003 baseline noise exposure contours shown in **Exhibit 7A**. Noise contours projected for the years 2008 and 2025, however, would change with implementation of the proposed new noise abatement measures. The updated future noise contours are shown in **Exhibits 7B** and **7C**. The primary change for both 2008 and 2025 is a slight shift to the southwest on the Runway 3 end of the contour. The shift is due to the new departure procedure from Runway 21. A comparison of the noise impacts of the Noise Compatibility Plan contours with the baseline contours is presented later in this chapter.

LAND USE MANAGEMENT ELEMENT

Chapter Six considered nine land use management alternatives for further consideration. Two of these alternatives, land acquisition and sound insulation, were eliminated. Only three homes remain within the 65 DNL noise contour in 2008. These homes are part of an established, cohesive neighborhood. Should these homes be purchased, they essentially would be removed which would not only disrupt an established neighborhood, but could potentially also expose remaining residences to increased ground noise. Developing a sound insulation program is typically a very costly and time-consuming task. Considering the number of homes eligible for sound insulation and the fact that noise complaints at the airport are not received from individuals residing within the 65 DNL noise contour, it was determined that it is not feasible to pursue the formulation of a sound insulation program. Additionally, many of the homes in the area are well-insulated due to seasonal temperature extremes.

The recommended land use mitigation measures for the vicinity of Flagstaff Pulliam Airport are presented on the following pages and summarized within **Table 7D**.

02MF09-7A-10/12/04



LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- 2003 Noise Exposure Contour, Marginal Effect
- 2003 Noise Exposure Contour, Significant Effect
- Very Low Density Residential (0-0.9 du/ac)
- Low Density Residential (1-5 du/ac)
- Medium Density Residential (6-12 du/ac)
- High Density Residential (12+ du/ac)
- Residential Manufactured Housing
- Noise-Sensitive Institutions
- School
- Place of Worship

Source: Flagstaff Geographic Information System, November 2002.
Coffman Associates Analysis.

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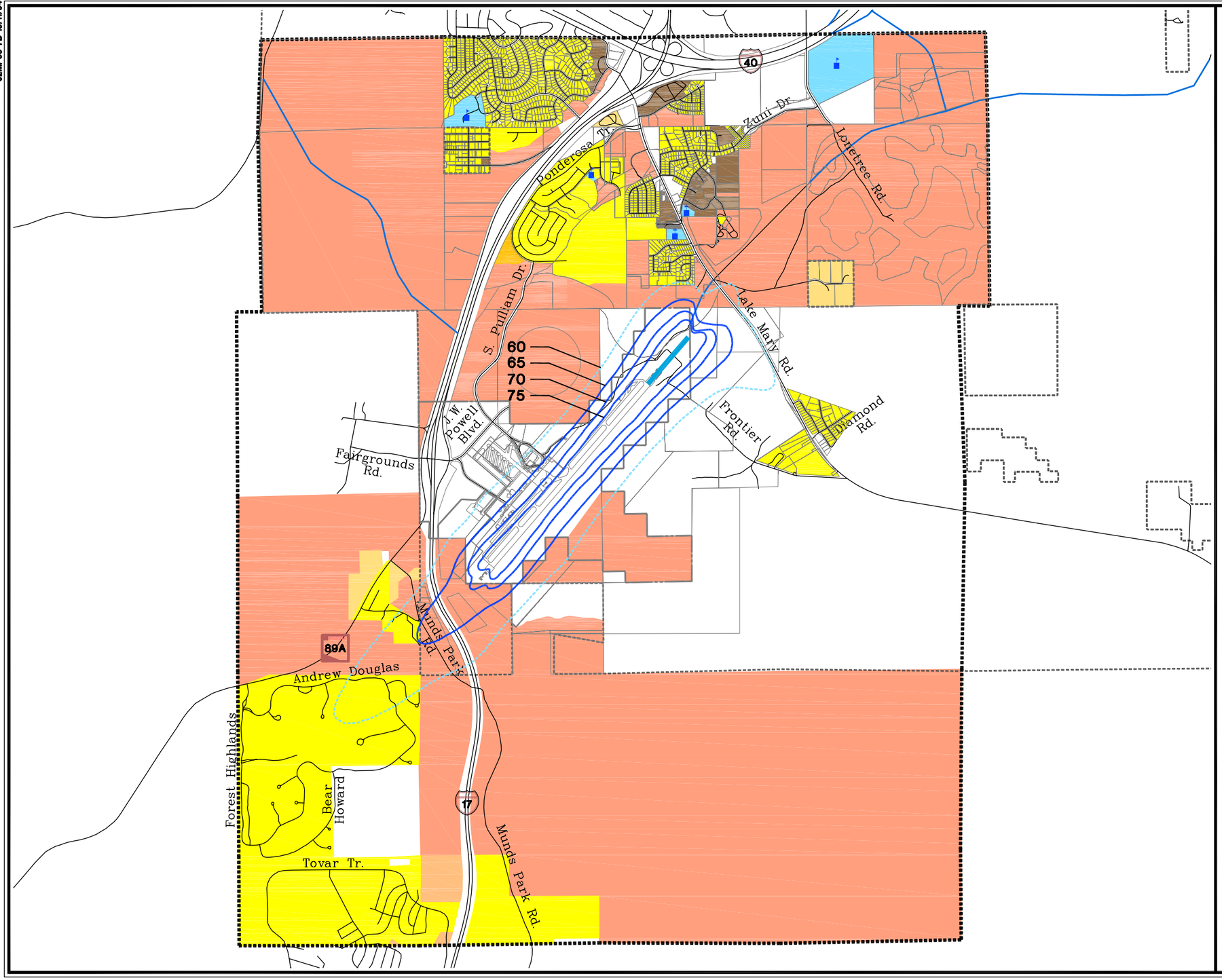
FLAGSTAFF PULLIAM AIRPORT

Exhibit 7A
2003 NOISE EXPOSURE CONTOUR WITH NOISE-SENSITIVE LAND USE

02MP09-7B-10/11/04



LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- 2008 Noise Exposure Contour, Marginal Effect
- 2008 Noise Exposure Contour, Significant Effect
- Runway Extension Per 2003/04 Airport Master Plan Update
- Very Low Density Residential (0-0.9 du/ac)
- Low Density Residential (1-5 du/ac)
- Medium Density Residential (6-12 du/ac)
- High Density Residential (12+ du/ac)
- Residential Manufactured Housing
- Noise-Sensitive Institutions
- Potential Noise-Sensitive Growth Risk Areas
- School
- Place of Worship

Source: Flagstaff Geographic Information System, November 2002.
Coffman Associates Analysis.

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Exhibit 7B
2008 NOISE EXPOSURE CONTOUR WITH NOISE-SENSITIVE LAND USE

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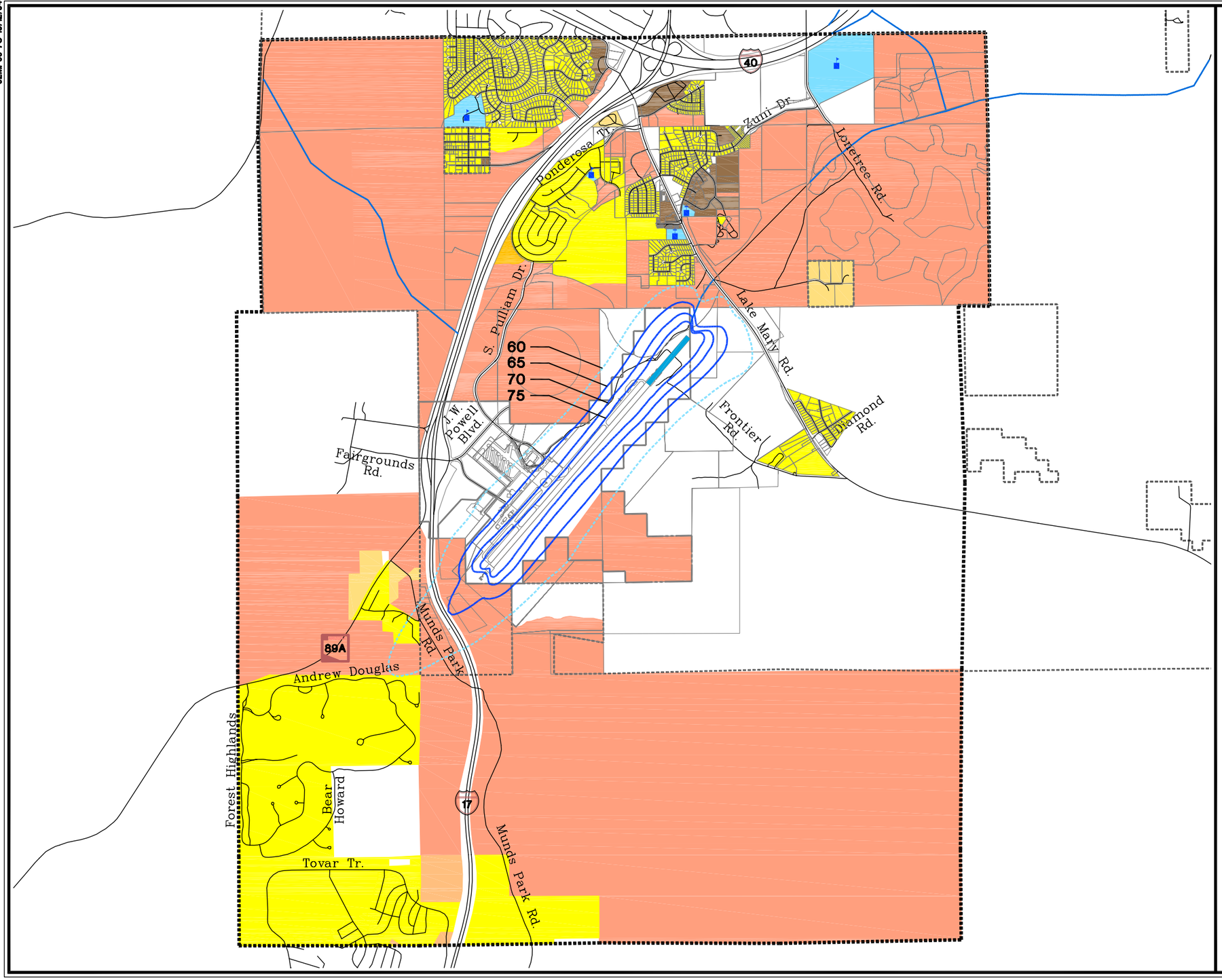

LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- 2025 Noise Exposure Contour, Marginal Effect
- 2025 Noise Exposure Contour, Significant Effect
- Runway Extension Per 2003/04 Airport Master Plan Update
- Very Low Density Residential (0-0.9 du/ac)
- Low Density Residential (1-5 du/ac)
- Medium Density Residential (6-12 du/ac)
- High Density Residential (12+ du/ac)
- Residential Manufactured Housing
- Noise-Sensitive Institutions
- Potential Noise-Sensitive Growth Risk Areas
- School
- Place of Worship

Source: Flagstaff Geographic Information System, November 2002.
Coffman Associates Analysis.

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Exhibit 7C
2025 NOISE EXPOSURE CONTOUR WITH NOISE-SENSITIVE LAND USE

1. **Consideration should be given to re-designating undeveloped parcels within the hybrid 60 DNL noise contour to a compatible land use designation such as commercial, industrial, or designated open space as detailed in the *Flagstaff Area Regional Land Use and Transportation Plan*.**

Description. As depicted on **Exhibit 7D**, a number of undeveloped parcels within the hybrid 60 DNL noise contour are planned for potential residential land uses. The City of Flagstaff and Coconino County should consider revising the general plan in a manner which would not allow noise-sensitive development. This could be accomplished by re-designating the parcels for commercial, industrial, or designated open space.

Implementation Actions. Implementation of this alternative would require an amendment to the *Flagstaff Area Regional Land Use and Transportation Plan*.

Costs and Funding. Adoption of this measure would involve administrative expenses for the City of Flagstaff and Coconino County. These expenses would have to be paid out of the various jurisdictions' operating budgets.

Timing. Amendments to general plans take time to prepare and process. The required amendments for this measure are projected for 2006.

2. **Consideration should be given to incorporating hybrid 60 and 65 DNL noise contours into the general plan in lieu of the currently referenced noise contours prepared in the 1991 *Flagstaff Area Regional Land Use and Transportation Plan.***

Description. Typically, when a community utilizes airport noise contours for land use planning purposes, any new contours that are developed for an airport as part of an airport master plan or Part 150 Study will be incorporated into the various land use planning documents to ensure consistency between the airport and community's planning documents. However, within the past few years, airports have experienced fluctuation in the noise contours as the louder aircraft are phased out of the nation's aircraft fleet mix. The smaller noise contours present potential problems for both cities and airports as, if the land use planning policies are not changed, noise-sensitive development will occur in closer proximity to the airport. This development is problematic in a number of ways. First, the adoption of the smaller contours does not provide an adequate buffer should the fleet mix utilizing the airport change. The introduction of one, older generation Stage Two business jet, can drastically change the noise contours. Secondly, the larger contours allowed for not only a noise-related buffer, but also a buffer from the visual impact of the aircraft passing overhead. As noise-sensitive development happens closer to the airport, the visual impact of the aircraft passing overhead becomes greater as the aircraft are often at a lower altitude due to their proximity to the airport.

Within the Community Facilities and Services Element of this plan, the Air-

port Noise Sensitive Zone is defined as the area within the 60 DNL noise contour as established in the *1991 Flagstaff Pulliam Airport Master Plan*. Residential development is discouraged within this zone in the interest of protecting not only the airport, but also the general public. A comparison of the 1991 noise contours and those prepared as part of this study indicates that in many areas the noise contours have begun to shrink.

In order to protect the general public from non-compatible development around an airport with fluctuating noise contours, some communities opt to incorporate hybrid noise contours into their land use plans. These hybrid contours can be a reflection of the previous contours as well as the anticipated future noise condition for the airport. Incorporation of a hybrid contour often provides the community with an equal level of protection from impacts resulting from operation of the airport.

To ensure that the areas surrounding the airport are developed in a compatible manner, consideration should be given to incorporating a hybrid 60 and 65 DNL noise contour into the general plan. The hybrid contour would consist of a combination of the 1991, 2003, and 2008 noise contours. Recommended land uses within these two hybrid contours would mirror what is presented within the overlay zoning discussion later on in this chapter.

Implementation Actions. Implementation of this alternative would require an amendment to the *Flagstaff Area Regional Land Use and Transportation Plan*.

Costs and Funding. Adoption of this measure would involve administrative expenses for the City of Flagstaff and Coconino County. These expenses would have to be paid out of the various jurisdictions' operating budgets.

Timing. Amendments to general plans take time to prepare and process. The required amendments for this measure are projected for 2006.

3. The City of Flagstaff should consider revising their current project review guidelines to incorporate noise-related criteria. It would also be suitable to include these guidelines within the *Flagstaff Area Regional Land Use and Transportation Plan*.

Description. The City of Flagstaff has established project review guidelines through the *City of Flagstaff Land Development Code*. As required by the development code, a Development Review Board has been established to review development proposals to ensure that all applicable city code requirements are met. As part of the review, the project's potential impact on natural resources such as forest canopy, moderate and steep slopes, and floodplains are evaluated. Consideration should be given to incorporating noise-related criteria into the existing guidelines for development within the airport's designated airport influence area (AIA). Potential criteria to be incorporated are described later in this section.

Coconino County has not established project review guidelines for the review of projects within the unincorporated portions of the county. It may not be

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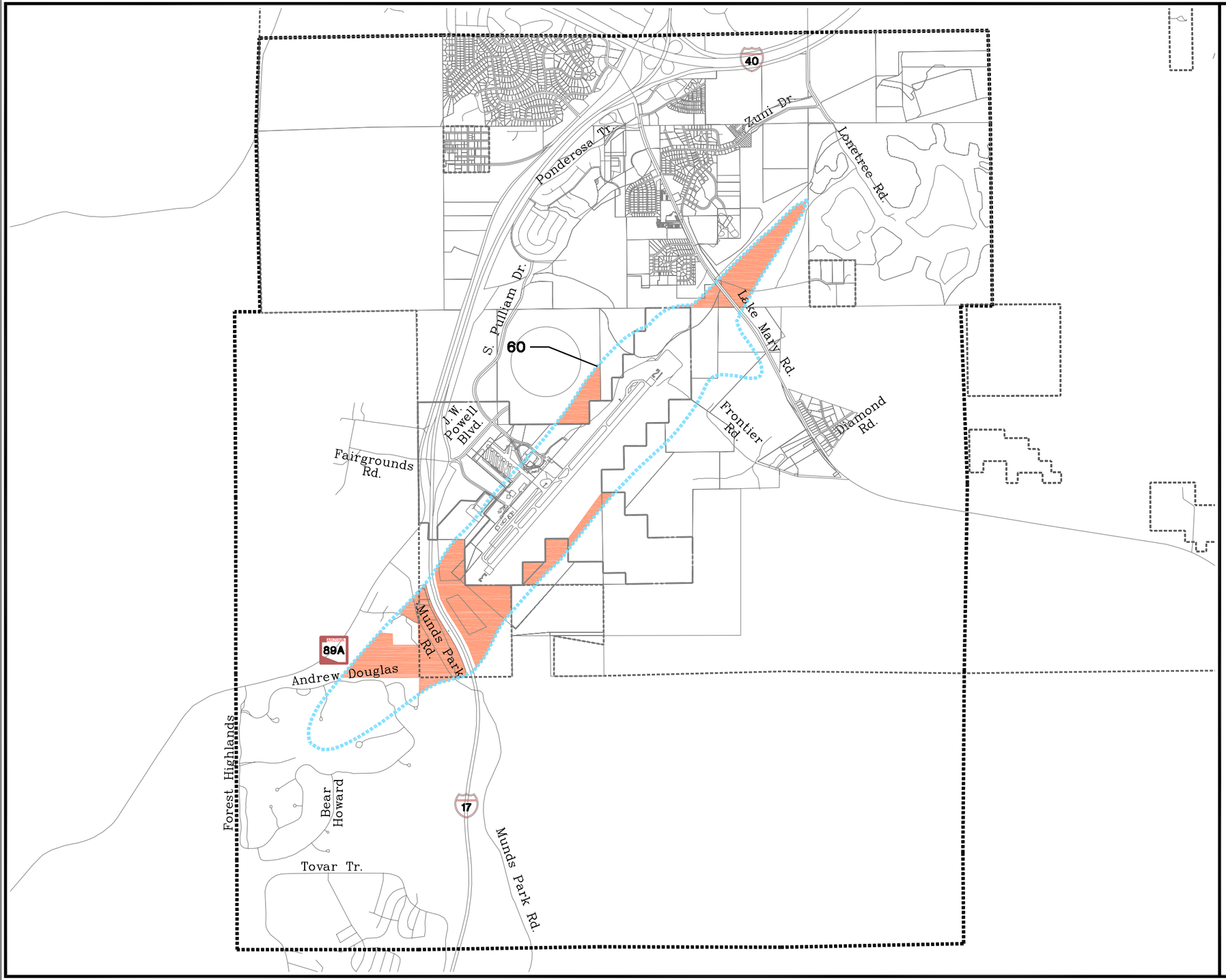

LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- Hybrid 60 DNL Noise Exposure Contour, Marginal Effect
- Potential Noise-Sensitive Growth

Source: Flagstaff Area, Regional Land Use and Transportation Plan, November 2001.
Flagstaff Geographic Information System, November 2002.
Coffman Associates Analysis.

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FLAGSTAFF PULLIAM AIRPORT

Exhibit 7D
UNDEVELOPED PARCELS WITHIN HYBRID 60 DNL NOISE CONTOUR DESIGNATED AS RESIDENTIAL LAND USE

feasible for the county to enact project review guidelines for the entire county due to its size. However, consideration could be given to incorporating review guidelines within the *Flagstaff Area Regional Land Use and Transportation Plan.* Since this plan includes all the areas contained within the airport's AIA, should review guidelines be incorporated, all projects within the Flagstaff Pulliam Airport AIA would undergo some type of airport noise review. These guidelines would reflect what is currently in place in the City of Flagstaff and would help to ensure that the areas south of the airport undergo project review. The guidelines would be appropriate for insertion into the Land Use Element of the general plan. The process would add some cost or administrative burden to the county's review process. Since review guidelines are already in place in the City of Flagstaff, the administrative burden would be realized during the amendment process to the Land Development Code and the various plan review checklists.

A simple checklist containing the following criteria could be prepared for Coconino County and the City of Flagstaff could simply revise their existing checklists. The following criteria are suggested for consideration in reviewing development proposals within the AIA.

- Advise the airport management of development proposals involving noise-sensitive land uses within the AIA.

- Require the issuance of avigation easements for all development within the AIA.

- Determine the sensitivity of the subject land use to aircraft noise levels based on their proximity to the 60 DNL noise contour.

- Locate noise-sensitive public facilities outside the 60 DNL contour whenever possible as previously described.

- Discourage the approval of rezonings, exceptions, variances, and conditional uses which introduce noise-sensitive development into areas located within close proximity to the 60 DNL noise contour.

- Where noise-sensitive development within the 60 to 65 DNL contour must be permitted, encourage developers to incorporate the following measures into their site designs.

  (1) Where noise-sensitive uses will be inside a larger, mixed-use building, locate noise-sensitive activities on the side of the building opposite the prevailing direction of aircraft flight.

  (2) Where noise-sensitive uses are part of a larger, mixed-use development, use the height and orientation of compatible uses, and the height and orientation of landscape features, such as natural hills, ravines, and man-made berms, to shield noise-sensitive uses from ground noise generated at the airport.

Implementation Actions. Implementation of this alternative would require an amendment to the *Flagstaff Area*

Regional Land Use and Transportation Plan.

Costs and Funding. Adoption of this measure would involve administrative expenses for the City of Flagstaff and Coconino County. These expenses would have to be paid out of the various jurisdictions' operating budgets.

Timing. Amendments to general plans take time to prepare and process. The required amendments for this measure are projected for 2006.

4. The City of Flagstaff and Coconino County should maintain compatibly-zoned areas within the 60 DNL noise contour.

Description. A number of areas within the hybrid 60 DNL noise contour are currently zoned for compatible land uses. When possible, the areas that are zoned for compatible use should be maintained.

Implementation Actions. This measure would be implemented by the City of Flagstaff and Coconino County.

Costs and Funding. This measure would involve administrative expenses. Funding would come from the operating budgets of the various jurisdictions.

Timing. This is an on-going measure with no implementation time frame.

5. The City of Flagstaff and Coconino County should rezone undeveloped parcels within the hybrid 60 DNL noise contour to a compatible zoning designation.

Description. As depicted on **Exhibit 7E**, a number of parcels within the hybrid 60 DNL noise contour are currently zoned in a manner which would allow residential development. The City of Flagstaff and Coconino County should consider rezoning these parcels to a zoning classification which does not allow residential or other noise-sensitive development.

Implementation Actions. This measure would be implemented by the City of Flagstaff and Coconino County through an amendment to their respective zoning ordinances.

Costs and Funding. This measure would involve administrative expenses. Funding would come from the operating budgets of the various jurisdictions.

Timing. Amendments to zoning ordinances take time to prepare and process. The required amendments for this measure are projected for 2006.

6. The City of Flagstaff should consider revising its existing Airport Overlay District to reflect the results of the noise analysis conducted as part of this Part 150 Study. Additionally, Coconino County should consider enacting an Airport Overlay District for areas contained within the AIA.

Description. Within the *City of Flagstaff Land Development Code*, the City of Flagstaff has adopted an Airport Overlay District. The purpose of this district is to ensure compatible development within airport environs. Both

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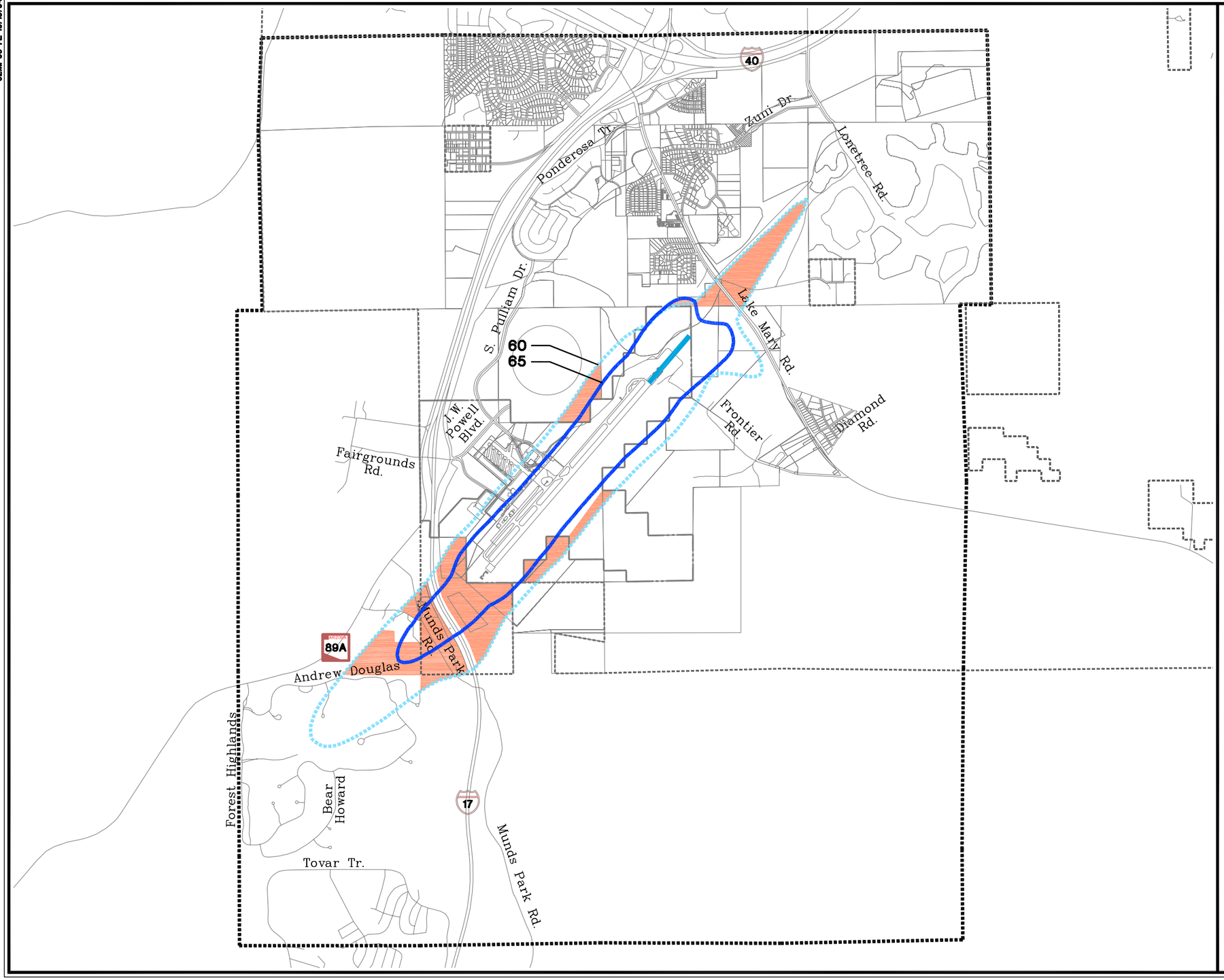

LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- Hybrid Noise Exposure Contour, Marginal Effect
- Hybrid Noise Exposure Contour, Significant Effect
- Zoned for Very Low Density Residential (0 - 0.9 du/ac)

Source: Flagstaff Geographic Information System, November 2002.
Coconino County Assessor Maps, November 2002.
Coffman Associates Analysis.

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Exhibit 7E
UNDEVELOPED AREA ZONED FOR NON-COMPATIBLE LAND USES WITHIN THE HYBRID 60 AND 65 DNL NOISE CONTOURS

land use and height restrictions are outlined within the overlay district. This overlay district consists of three Airport Noise Impact Areas and one Clear Zone Area. The purpose of the Clear Zone Area is to regulate the height of structures within the airport environs. The boundaries of the Airport Noise Impact Areas regulate land uses within the three impact areas. According to the *City of Flagstaff Land Development Code*, these impact areas change automatically as new contours are developed as part of airport master plan updates. The boundaries of the three noise impact areas are as follows:

- AP-1 contains the areas within the 60 to 65 DNL noise contour. Within this zone, noise-sensitive land uses are allowed; however, measures to achieve a reduction of 25 or 30 dB must be incorporated into design and construction of structure.

- AP-2 contains the areas within the 65 to 70 DNL noise contour. Within this zone, noise-sensitive development is discouraged. The absence of viable alternative development options should be determined and an evaluation indicating that a demonstrated community need for residential use would not be met if development were prohibited in these areas and should be conducted prior to approvals. Measures to achieve a reduction of 25 or 30 dB must be incorporated into design and construction of any noise-sensitive structures allowed to be constructed in this zone.

- AP-3 contains the areas within the 70 to 75 DNL noise contour. Residential development within this zone is not allowed. The development of other noise-sensitive land uses is strongly discouraged.

According to the existing Airport Overlay District regulations, the boundaries of the various noise impact areas will automatically change to reflect the new noise contours being prepared for the airport. This automatic change could be problematic as the new noise contours are significantly smaller to the northeast and the 65 DNL noise contour is significantly larger to the southwest. Therefore, consideration should be given to revising the existing regulations in a manner which would not require a periodic change in the overlay boundaries as new contours are prepared in the future. Consideration should also be given to incorporating hybrid noise contours as outlined previously within the general plan discussion. These hybrid contours would relate to physical boundaries such as parcels or streets instead of the actual contour as depicted on **Exhibit 7F**. This would assist in the enforcement of the overlay zone as it would eliminate any questions as to the actual boundaries of the overlay zone. The hybrid noise contour boundaries allow for areas which are currently protected to remain within an overlay zone and also incorporate the "worst case" scenario from the 1991, 2003, and 2008 noise contours.

It is also suggested that the allowed land uses within the various overlay

zones be modified in a manner which would not allow noise-sensitive development within the 65 DNL noise contour. This would ensure compatible development within the 65 DNL noise contour as recommended by the FAA. Currently, the regulations allow noise-sensitive development within this contour as long as sound insulation is incorporated into the design and construction of the structure. **Table 7A** contains the recommended revisions to the allowed uses within the various Airport Impact Noise Areas. Where the proposed and current allowed uses differ, the current allowed uses are shown in parentheses. Finally, it is suggested that the boundary of the avigation easement area be incorporated into the overlay zoning. This boundary could be designated as AP-0. This zone would include those areas contained within the Avigation Area Zone. All development within this zone should require the issuance of an avigation easement.

Currently, Coconino County has informally adopted the city's Avigation Area Zone and requires avigation easements prior to development approval within the zone. Consideration should be given to taking this zone one step further by establishing an overlay zone for those areas within the noise impact areas in unincorporated Coconino County.

Implementation Actions. This measure would be implemented by the City of Flagstaff and Coconino County through an amendment to the respective zoning ordinances.

Costs and Funding. This measure would involve administrative expenses. Funding would come from the operating budgets of the various jurisdictions.

Timing. Amendments to zoning ordinances take time to prepare and process. The required amendments for this measure are projected for 2006.

7. The City of Flagstaff and Coconino County should consider amending their respective building codes to incorporate prescriptive noise standards.

Description. Building code amendments incorporating prescriptive noise standards should be considered by the City of Flagstaff and Coconino County. Implementation of this alternative would not only protect future noise-sensitive development within the 60 DNL noise contour, but would also protect structures that undergo extensive remodeling or reconstruction, as these types of construction typically require a building permit and inspections. A sample building code is contained within **Appendix D**.

Prescriptive noise standards are perhaps the most commonly used approach to sound insulation standards. The existing building code would be amended to set forth specific construction standards intended to achieve a given level of noise reduction. It would be the duty of the local building inspectors to ensure that the correct materials are used and construction is done properly. After installation and a successful inspection, the building is presumed to be able to achieve the targeted level of noise reduction.

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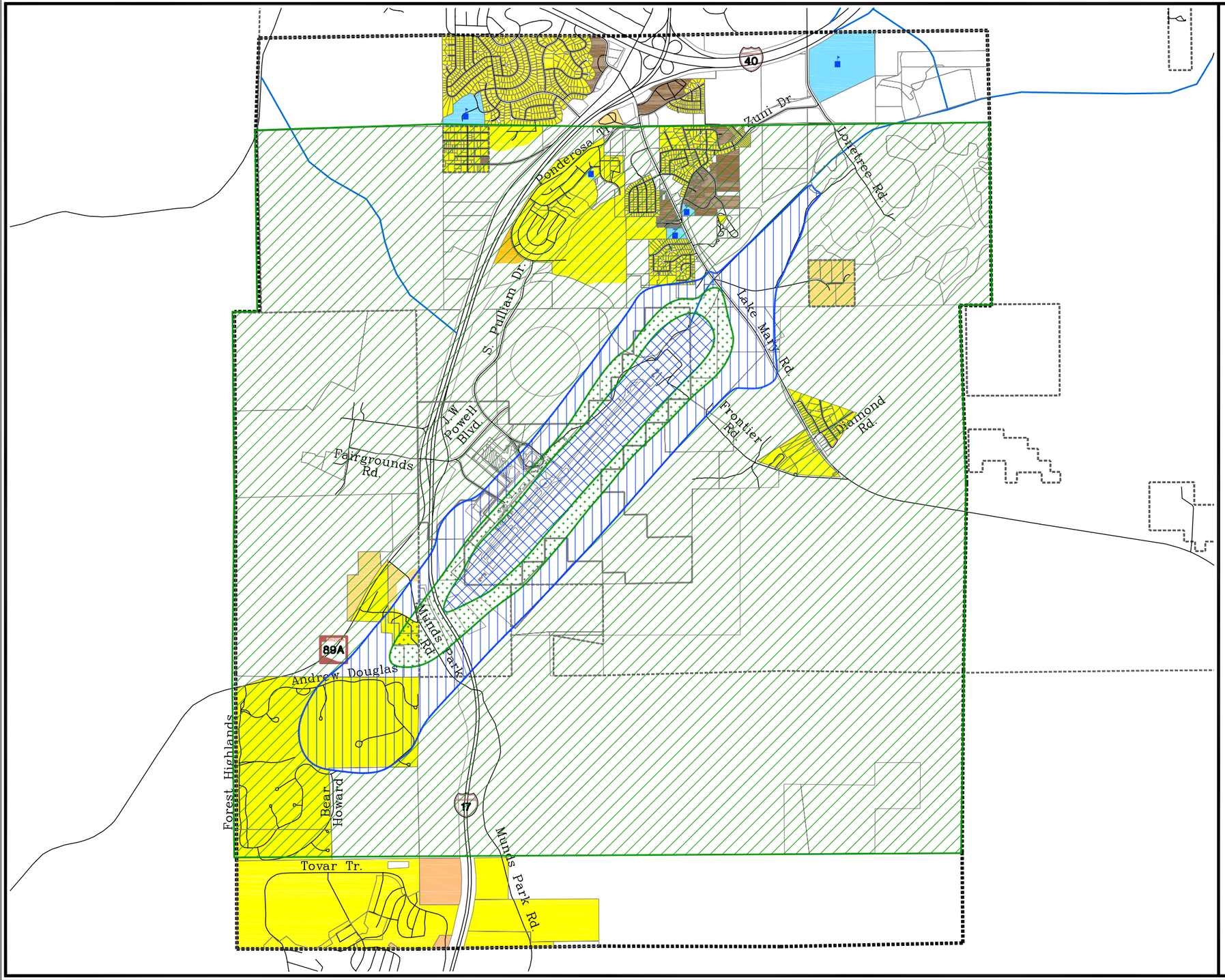

LEGEND

- Detailed Land Use Study Area
- Municipal Boundary
- Airport Property
- Very Low Density Residential (0-0.9 du/ac)
- Low Density Residential (1-5 du/ac)
- Medium Density Residential (6-12 du/ac)
- High Density Residential (12+ du/ac)
- Residential Manufactured Housing
- Noise-Sensitive Institutions
- School
- Place of Worship
- AP-0
- AP-1
- AP-2
- AP-3

Source: Coffman Associates Analysis.

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Exhibit 7F
RECOMMENDED NOISE OVERLAY ZONES

Implementation Actions. Before adopting the recommended regulations, the city and county should test their respective building standards to determine how much noise level reduction is being achieved by standard construction. It is possible that standard, energy-efficient construction is capable of achieving a noise level reduction of 25 decibels, especially if the structure is equipped with a central air system. If so, no special building code amendments would be needed.

TABLE 7A
Recommended Revised Airport Overlay District

Land Use	AP-0	AP-1 (Approx. the 60-65 DNL)	AP-2 (Approx. the 65-70 DNL)	AP-3 (Approx. the 70-75 DNL)
Ranching and Forestry	Y[6]	Y[4,6]	Y[4,6]	Y[5,6]
Residential:				
Single-family	Y[6]	25[6]	N (25[1])	N
Cluster	Y[6]	25[6]	N (25[1])	N
Planned	Y[6]	25[6]	N (25[1])	N
Manufactured Housing	Y[6]	N	N	N
Commercial Apartments	Y[6]	25[6]	N (25[1])	N
Fraternities/Sororities	Y[6]	25[6]	N (25[1])	N
Industrial Uses	Y[6]	Y[6]	Y[6]	Y[2,6]
Commercial Retail	Y[6]	Y[6]	Y[6]	Y[5,6]
Heavy Retail/Heavy Services	Y[6]	Y[6]	Y[6]	Y[2,6]
Offices and Services	Y[6]	Y[6]	Y[6]	Y[6]
Institutional Uses:				
Hospitals, nursing homes	Y[6]	N	N	N
Other medical facilities	Y[6]	N (Y)	N (Y)	N (25[6])
Governmental	Y[6]	Y*[6]	Y*[6]	25*[6]
Educational	Y[6]	N	N	N
Miscellaneous	Y[6]	Y[6]	Y[6]	25[6]
Cultural, including churches	Y[6]	N (Y*)	N (25*)	N (30*[6])
Nature exhibits	Y[6]	Y*[6]	Y*[6]	N
Public assembly	Y[6]	N (Y[6])	N (Y[6])	N
Auditoriums, concert halls	Y[6]	Y[6]	25[6]	30[6]
Outdoor music shells, amphitheaters	Y[6]	N (Y*[6])	N	N
Outdoor sports arenas, spectator sports	Y[6]	Y[6]	Y[3,6]	Y[3,6]
Golf courses	Y[6]	Y*[6]	Y*[6]	25*[6]
Resorts and group camps	Y[6]	Y*[6]	Y*[6]	N
Parks	Y[6]	Y*[6]	Y*[6]	Y*[6]
Other	Y[6]	Y*[6]	Y*[6]	Y*[6]

TABLE 7A (Continued)
Recommended Revised Airport Overlay District

Notes:		
Y		Yes. Land use and related structures compatible without restrictions.
Y*		Yes, with restrictions. Measures to achieve a reduction of 25 dB must be incorporated into the design and construction of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.
N		No. Land use and related structures are not compatible and shall be prohibited.
25 or 30		Land use and related structures generally compatible; measures to achieve a reduction of 25 or 30 dB must be incorporated into design and construction of structure.
25* or 30*		Land uses generally compatible; however, measures to achieve overall reduction do not necessarily solve noise difficulties and additional evaluation is warranted.
1	(a)	Although local conditions may require residential use, it is discouraged in AP-2 and strongly discouraged in AP-3. The absence of viable alternative development options should be determined and an evaluation indicating that a demonstrated community need for residential use would not be met if development were prohibited in these areas and should be conducted prior to approvals.
	(b)	Where the City determines that residential uses must be allowed, measures to achieve outdoor-to-indoor noise level reduction of at least 25 dB (AP-2) and 30 dB (AP-3) should be incorporated into building codes and be considered on individual approvals.
	(c)	Noise level reduction criteria will not eliminate outdoor noise problems. However, building location and site planning, design and use of berms and barriers can help mitigate outdoor noise exposure, particularly from ground level sources. Measures that reduce noise at a site should be used wherever practicable in preference to measures which only protect interior spaces.
2		Measures to achieve a net level reduction 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		Land use is considered compatible, provided special sound reinforcement systems are installed which mitigates indoor sound impacts.
4		These buildings intended for human occupancy require a net level reduction of 25 dB.
5		Residential buildings require a net level reduction of 30 dB.
6		The issuance of an avigation easement is required prior to development approval.
( )		Where the proposed and current allowed uses differ, the current allowed uses are shown in parentheses.

If the test shows that special building code standards are needed, the city and county would have to enact the regulations through an amendment to their respective building codes. If the suggested standards are adopted, the city and county should train their building inspectors to inspect for proper sound attenuation. A consultant skilled in the design and administration of sound insulation could be retained to provide this training.

Costs and Funding. This measure would involve administrative expenses. Funding would come from the operating budgets of the various jurisdictions. After adoption of sound insulation standards, the city and county would incur increased administrative costs for inspection of plans and construction of buildings requiring sound insulation. The city and county should consider setting the inspection fees to cover any additional expense.

Timing. The City of Flagstaff and Coconino County should arrange for a test of current residential standards after city approval of the NCP. If needed, amendments to building codes take time to prepare and process. The required amendments for this measure are projected for 2006.

PROGRAM MANAGEMENT ELEMENT

The success of the Noise Compatibility Program requires a continuing effort to monitor compliance and identify new or unanticipated problems and changing conditions. Three program management measures are recommended for Flagstaff Airport. The City of Flagstaff Transportation Department, Aviation Division, as Airport operator, is responsible for implementing these measures. They are discussed below and summarized in **Table 7D**.

1. Publish a pilot guide.

Description. A pilot guide describing airport noise abatement information should be prepared for wide distribution to pilots using Flagstaff Pulliam Airport. The guide should include an aerial photo showing the airport and the surrounding area, pointing out noise-sensitive land uses and preferred noise abatement procedures. It could also include other information about the airport that pilots would find useful. The guide should be suitable for insertion into a Jeppesen manual so that pilots will be able to conveniently use it.

Airport management should distribute copies to all owners of aircraft based at the airport and to the fixed base operators so they can offer them to transient pilots.

Implementation. The City of Flagstaff is responsible for arranging for publication of the pilot guide.

Costs and Funding. The Airport will incur administrative and print expenses to develop and produce the pilot guide. This cost will be covered under the Airport operating budget. The initial development cost is estimated to be $5,000. Three subsequent updates are expected, each costing $2,500, for a total of $7,500. The total cost for this measure is estimated to be $12,500.

Timing. Publication of a pilot guide is planned for 2005.

2. Monitor implementation of the Part 150 Noise Compatibility Program.

Description. The Airport management must monitor compliance with the Noise Abatement Element. This will involve checking periodically with airport users and the local Tower Manager regarding compliance with the procedures.

The Airport should continue to monitor noise complaints from residents. By collecting complaint data, the Airport can monitor the impact of program management changes on the number and type of complaints.

It may be necessary to arrange for noise monitoring, noise modeling, or flight track analysis to study issues that might arise in the future.

The Airport should also maintain communications with planning officials from Flagstaff to follow their progress in implementing the requested measures of the Land Use Management Element.

Implementation Actions. No specific implementation actions are required other than those discussed in the description of this measure.

Timing. This should be done as necessary.

3. Update *Noise Exposure Maps* and *Noise Compatibility Program*.

Description. The Airport management should review the Noise Compatibility Program and consider revisions and refinements as necessary. A complete plan update will be needed periodically to respond to changing conditions in the local area and in the aviation industry. This can be anticipated every seven to ten years.

An update may be needed sooner, however, if major changes occur. An update may not be needed until later if conditions at the Airport and in the surrounding area remain stable.

Proposed changes to the NCP should be reviewed by the FAA and all affected aircraft operators and local agencies. Proposed changes should be submitted to the FAA for approval after local consultation and a public hearing to comply with Part 150.

Even if the NCP does not need to be updated, it may become necessary to update the *Noise Exposure Maps* (NEMs).

Part 150 requires the NEMs to be updated if any change in the operation of the Airport would create a substantial, new non-compatible use or would significantly reduce noise over existing non-compatible uses.

Implementation Actions. No specific implementation actions, other than those discussed above, are required.

Costs and Funding. Costs of a complete update of the Noise Compatibility Program are estimated at $400,000. This would be eligible for up to 95 percent funding from the FAA. An additional 2.5 percent of the cost would be eligible for funding from the Arizona Department of Transportation. The City of Flagstaff would be responsible for the remaining 2.5 percent. This would come from the Airport's capital budget.

Timing. This should be done as necessary. Updates are typically needed every seven to ten years, depending on how much change occurs at the Airport and in the local area. For planning purposes, one update can be expected over the next 10 years.

RESIDUAL NOISE IMPACTS

The recommended noise abatement and land use management programs will reduce the cumulative aircraft noise ex-

posure impact now and in the future. A review of the residential impacts from the Noise Compatibility Plan is presented below.

NOISE-SENSITIVE LAND USE

Table 7B shows the number of dwelling units exposed to noise for baseline conditions and after implementation of the Noise Compatibility Plan. For 2003 baseline conditions, 44 dwelling units are impacted by noise above 60 DNL.

In the year 2008, the total number of homes exposed to noise above 60 DNL without the plan would be 294 with noise-sensitive growth risk areas included. If the recommended plan is fully implemented, the number of dwellings impacted by noise in the year 2008 would decrease to 42.

The number of dwelling units within the 65 DNL contour in 2003 is 14. Without the plan in 2008, it is estimated that 64 dwelling units would be located within the 65 DNL contour. With the plan, there are no dwelling units

TABLE 7B
Dwelling Units Exposed to Noise
With Noise Compatibility Plan Versus Baseline Conditions

	Baseline Noise (Without Plan)			With Noise Compatibility Plan	
	2003	**2008**[1]	**2025**[1]	**2008**[2]	**2025**[2]
Existing					
60-65 DNL	30	39	21	42	21
65-70 DNL	14	3	0	0	0
70-75 DNL	0	0	0	0	0
Future Potential					
60-65 DNL	--	191	166	0	0
65-70 DNL	--	61	28	0	0
70-75 DNL	--	0	0	0	0
Total	44	294	215	42	21

[1] Totals include noise-sensitive growth risk areas.
[2] Assumes noise-sensitive growth risk areas will be developed with land uses that are compatible with aircraft noise if the plan is implemented and dwellings are required.
Source: Coffman Associates analysis.

In 2025, it is estimated that 28 dwelling units will be within the 65 DNL contour without the plan. With the plan, there will be no dwelling units within this contour.

Table 7C shows the population exposed to noise with implementation of the Noise Compatibility Plan in comparison with baseline conditions. For 2003 baseline conditions, 116 people are impacted by noise above 60 DNL.

In 2008, it is estimated that 776 people will be within the 60 DNL contour without the plan. With the plan, this number decreases to 111. The Level Weighted Population (LWP), an estima-

tion of the number of people actually annoyed by noise, in this area changes from 189 without the plan to 23 with the plan.

In 2025, it is estimated 567 people will reside within the 60 DNL contour without the Noise Compatibility Plan. With the plan, this number drops to 55.

The LWP in 2025 without the plan is 129 people, while the LWP with the plan is 11.

TABLE 7C
Population Exposed to Noise
With Noise Compatibility Plan Versus Baseline Conditions

	Baseline Noise (Without Plan)			With Noise Compatibility Plan	
	2003	**2008**[2]	**2025**[2]	**2008**[3]	**2025**[3]
Existing					
60-65 DNL	79	103	55	111	55
65-70 DNL	37	8	0	0	0
70-75 DNL	0	0	0	0	0
Future Potential					
60-65 DNL	--	504	438	0	0
65-70 DNL	--	156	74	0	0
70-75 DNL	--	5	0	0	0
Total	116	776	567	111	55
LWP[1]	30	189	129	23	11

[1] LWP - level-weighted population is an estimate of the number of people actually annoyed by noise. The actual population within each 5-DNL range is multiplied by the appropriate response factor to compute LWP. The factors are: 60-65 DNL - .205; 65-70 DNL - .376; 70-75 DNL - .644; 75+ DNL - 1.00. See the Technical Information Paper, *Measuring the Impact of Noise on People*.
[2] Totals include noise-sensitive growth risk areas.
[3] Assumes noise-sensitive growth risk areas will be developed with land uses that are compatible with aircraft noise if the plan is implemented.
Source: Coffman Associates analysis.

SUMMARY

The Noise Compatibility Program for Flagstaff Pulliam Airport is summarized in **Table 7D**. The total cost of the program is estimated at $412,500. Most of the costs are associated with the update of the plan ($400,000). Other significant costs include the publication of a pilot guide ($12,500).

Most of the cost ($380,000) would be eligible for FAA funding through the noise set aside portion of the Federal Airport Improvement Program. Approximately 2.5 percent ($10,000) of the Noise Compatibility Plan update costs would be eligible for funding through the Arizona Department of Transportation's fund matching program. The remaining costs ($22,500) would come from Flagstaff Pulliam Airport's capital and operating budgets.

TABLE 7D
Summary of Noise Compatibility Program, 2004-2014
Flagstaff Pulliam Airport

Measure	Cost to Airport Or Government	Direct Cost to Users	Timing	Lead Responsibility	Potential Funding Sources
NOISE ABATEMENT ELEMENT					
1. Runway 21 Departure Procedure for piston aircraft weighing less than 12,500 pounds.	Administrative	None	2005	Flagstaff Pulliam Airport	Airport Operating Budget and FAA
2. Discourage intersection and midfield takeoffs.	Promotional	None	2005	Flagstaff Pulliam Airport	Airport Operating Budget
3. Promote use of Industry Standard Thrust Cut-Back Procedures	Promotional	None	2005	Flagstaff Pulliam Airport	Airport Operating Budget
4. Promote use of Aircraft Owners and Pilots Association (AOPA) Noise Awareness Steps by light single and twin-engine aircraft.	Promotional	None	2005	Flagstaff Pulliam Airport	Airport Operating Budget
5. Change the Phoenix Sectional Aeronautical Chart to depict the location of Walnut Canyon National Monument.	Administrative	None	2005	Flagstaff Pulliam Airport	Airport Operating Budget
LAND USE MANAGEMENT ELEMENT					
1. Within the *Flagstaff Area Regional Land Use and Transportation Plan*, consideration should be given to re-designating undeveloped parcels within the hybrid 60 DNL noise contour to a compatible land use designation such as commercial, industrial, or designated open space.	Administrative[1]	None	2006[2]	City of Flagstaff and Coconino County	City of Flagstaff Operating Budget and Coconino County Operating Budget
2. Within the *Flagstaff Area Regional Land Use and Transportation Plan*, consideration should be given to incorporating hybrid 60 and 65 DNL noise contours into the general plan in lieu of the currently referenced noise contours prepared in 1991.	Administrative[1]	None	2006[2]	City of Flagstaff and Coconino County	City of Flagstaff Operating Budget and Coconino County Operating Budget
3. The City of Flagstaff should consider revising their current project review guidelines to incorporate noise-related criteria. It would also be suitable to include these guidelines within the *Flagstaff Area Regional Land Use and Transportation Plan*.	Administrative[1]	None	2006[2]	City of Flagstaff and Coconino County	City of Flagstaff Operating Budget and Coconino County Operating Budget
4. The City of Flagstaff and Coconino County should maintain compatibly-zoned areas within the 60 DNL noise contour.	Administrative	None	Ongoing	City of Flagstaff and Coconino County	City of Flagstaff Operating Budget and Coconino County Operating Budget

TABLE 7D (Continued)

Measure	Cost to Airport Or Government	Direct Cost to Users	Timing	Lead Responsibility	Potential Funding Sources
5. The City of Flagstaff and Coconino County should rezone undeveloped parcels within the hybrid 60 DNL noise contour to a compatible zoning designation.	Administrative[1]	None	2006[2]	City of Flagstaff and Coconino County	City of Flagstaff Operating Budget and Coconino County Operating Budget
6. The City of Flagstaff should consider revising its existing Airport Overlay District to reflect the results of the noise analysis conducted as part of this Part 150 Study. Additionally, Coconino County should consider enacting an Airport Overlay District for areas contained within the AIA.	Administrative[1]	None	2006[2]	City of Flagstaff and Coconino County	City of Flagstaff Operating Budget and Coconino County Operating Budget
7. The City of Flagstaff and Coconino County should consider amending their respective building codes to incorporate prescriptive noise standards.	Administrative[1]	None	2006[2]	City of Flagstaff and Coconino County	City of Flagstaff Operating Budget and Coconino County Operating Budget
PROGRAM MANAGEMENT ELEMENT					
1. Publish a pilot guide.	$12,500 ($5,000 for initial publication, $2,500 for three subsequent updates)	None	2005	City of Flagstaff	Airport Operating Budget
2. Monitor implementation of the Part 150 Noise Compatibility Program.	Administrative	None	2005	City of Flagstaff	Airport Operating Budget
3. Update Noise Exposure Maps and Noise Compatibility Program	$400,000	None	2015	City of Flagstaff	95 % FAA, 2.5% Arizona Department of Transportation, and 2.5% Flagstaff Pulliam Airport Capital Budget
		Funding Source		**Amount**	**Percent**
Total Cost and Funding Source		FAA		$380,000	92.1%
		Arizona Department of Transportation		$10,000	2.4%
		City of Flagstaff Capital Budget		$10,000	2.4%
		City of Flagstaff Operating Budget		$12,500	3.1%
		Total Cost		$412,500	100.0%

[1] It is difficult to estimate the costs for amendments to a jurisdiction's general plans, Airport land use plans, zoning ordinances, subdivision regulations, and building codes. Depending on whether or not the amendment is undertaken separately, or in conjunction with the other suggested amendments, the costs will vary significantly. These expenses would include drafting an amendment, and staff time for presenting the findings to the various City or County officials. These expenses would have to be paid out of the various jurisdictions' operating budgets.

[2] Amendments to general plans, Airport land use plans, zoning ordinances, subdivision regulations, and building codes take time to prepare and process. It is anticipated that implementation of this amendment will be pursued 12 to 18 months after FAA approval of the Part 150 Noise Compatibility Program. This is expected to be within the 2006 to 2007 time frame.

FLAGSTAFF
PULLIAM AIRPORT

Appendix A

WELCOME TO THE PLANNING ADVISORY COMMITTEE

Appendix A

WELCOME TO THE PLANNING ADVISORY COMMITTEE

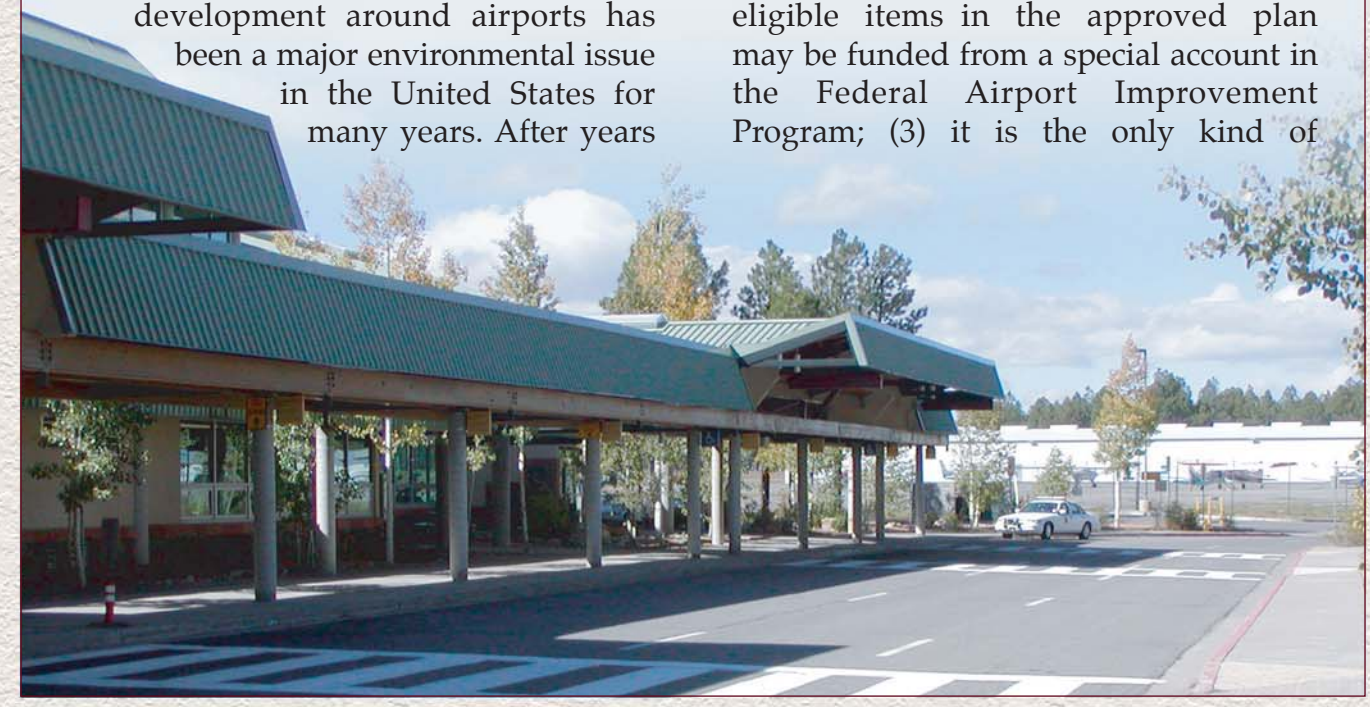
FLAGSTAFF
PULLIAM AIRPORT

The City of Flagstaff and its consultant, Coffman Associates, Inc., are pleased to welcome you to the Planning Advisory Committee (PAC) for the Part 150 Noise Compatibility Study Update. We appreciate your interest in this Study. Over the next several months you will be able to make an important contribution to the project. We believe that you will find your participation with the committee to be an interesting and rewarding experience.

WHAT IS A NOISE COMPATIBILITY STUDY?

The impact of aircraft noise on development around airports has been a major environmental issue in the United States for many years. After years of study and demonstration programs, Congress authorized full-scale Federal support for airport noise compatibility programs through the Aviation Safety and Noise Abatement Act of 1979. In response to that Act, the Federal Aviation Administration (FAA) adopted 14 Code of Federal Regulation (CFR), Part 150 to set minimum standards for the preparation of such studies.

A Noise Compatibility Program is intended to promote aircraft noise control and land use compatibility. Three things make such a study unique: (1) it is the only comprehensive approach to preventing and reducing airport noise and community land use conflicts; (2) eligible items in the approved plan may be funded from a special account in the Federal Airport Improvement Program; (3) it is the only kind of



airport study sponsored by the FAA primarily for the benefit of airport neighbors.

The principal objectives of any Noise Compatibility Program are to:

- Identify the current and projected aircraft noise levels and their impact on the airport environs.

- Propose ways to reduce the impact of aircraft noise through changes in aircraft operations or airport facilities.

- In undeveloped areas where aircraft noise is projected to remain, encourage future land use which is compatible with the noise, such as agriculture, commercial or industrial.

- In existing residential areas which are expected to remain impacted by noise, determine ways of reducing the adverse impacts of noise.

- Establish procedures for implementing, reviewing, and updating the plan.

WHAT IS THE ROLE OF THE COMMITTEE?

The PAC will play an important role in the Noise Compatibility Study. We want to benefit from your unique viewpoints, to have access to the people and resources you represent, to work with you in a creative atmosphere, and to gain your support in achieving results. Specifically, your role in the PAC is as follows:

- Sounding Board - The consultants need a forum in which to present information, findings, ideas, and recommendations during the course of the study. Everyone involved with the study will benefit from this forum because it allows diverse interests an opportunity to experience the viewpoints, ideas, and concerns of other members directly.

- Linkage to the Community-Each of you represents one or more constituent interests -- neighborhood residents, local businesses, public agencies, and aviation users. As a committee member, you can bring together the consultant and the people you represent, you can inform your constituents about the study as it progresses, and you can bring into the committee the views of others.

- Resource - An airport noise compatibility study is very complex; it has an almost unlimited demand for information. Many of you have access to specialized information and can ensure that it is used in the study to its fullest potential.

- Think Tank - "Too many cooks spoil the broth" reflects the difficulty committees have in writing a report. On the other hand, "two heads are better than one" tells us that creative thinking is best accomplished by a group of

concerned people who represent a diversity of backgrounds and views on a subject. We need all of the creative input we can get. PAC member ideas have literally "made the difference" on other studies of this type across the country.

- Critical Review - The study team needs their work scrutinized closely for accuracy, completeness of detail, clarity of thought, and intellectual honesty. We want you to point out any shortcomings in our work and to help us improve on it.

- Implementation - A Part 150 Noise Compatibility Plan depends on the actions of many different agencies and organizations for implementation. Each of you has a unique role to play in implementing the plan and demonstrating leadership among your constituent interests. Inform and educate them about the importance of your effort on their behalf and work with them to see that the final plan is carried out.

WHO IS ON THE COMMITTEE?

Many organizations have been contacted and invited to designate representatives to serve on the PAC. The attached list of invited officials and organizations shows a broad range of interests to be represented -- local businesses and residents, pilots, fixed-base operators, national aviation organizations, Federal Aviation Administration, and state and local governments.

HOW WILL THE PAC OPERATE?

The PAC will operate as informally as possible -- no compulsory attendance, and no voting. The meetings will be conducted by the consultant and will be called at milestone points in the study (a total of four) when committee input is especially needed. Ordinarily, meetings will be scheduled with sufficient advance notice to permit you to arrange your schedule.

To keep you informed of the proceedings at the PAC meetings, we will prepare summary minutes and will distribute them after each meeting. These will be particularly helpful if you are unable to attend a meeting.

We will hold four public information workshops during the preparation of the study so that we may report to the community at large and elicit their views and input. We strongly urge you to represent the PAC at the evening workshops. The workshops will be organized to maximize the opportunity for two-way communication. At these important meetings, you will have the chance to hear from local citizens and share your views and expertise with them.

Prior to each PAC meeting, the consultant will distribute working papers to you. These are draft chapters of the Noise Compatibility Study, and they will be a focus for discussion at the

meetings. In addition, we will provide an outline of the subjects to be covered in the next phase of the project so that you may interject your ideas and concerns and have them addressed in the next working paper.

To help you keep your materials organized, we will give you a study workbook (a three-ring binder with a special cover and tab dividers) to hold working papers, technical information papers, PAC membership lists, meeting notes, and other resource material.

WHERE CAN YOU GET MORE INFORMATION?

For specific information about the study, please contact:

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FLAGSTAFF PULLIAM AIRPORT
MASTER PLAN &
F.A.R. PART 150 NOISE COMPATIBILITY STUDY
PLANNING ADVISORY COMMITTEE (PAC)

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FLAGSTAFF PULLIAM AIRPORT MASTER PLAN & F.A.R. PART 150 NOISE COMPATIBILITY STUDY PLANNING ADVISORY COMMITTEE (PAC)			
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Ms. Kate Coffin Station Manager	**America West / Mesa Airlines**	6200 S. Pulliam Drive Flagstaff, AZ 86001	
Mr. Marc Gosik Manager	**ATCT**	5960 S. Liberator Lane Flagstaff, AZ 86001	(928) 774-7435
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	Kachina Village		
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Mr. John Beerling	**Pine Canyon**	1211 W. Warner Rd., Ste. 109 Tempe, AZ 85284	

FLAGSTAFF PULLIAM AIRPORT MASTER PLAN & F.A.R. PART 150 NOISE COMPATIBILITY STUDY PLANNING ADVISORY COMMITTEE (PAC)			
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Mr. Terry Hanson Chairman	**Arizona Military Airspace Working Group (AMAWG)**	7224 N. 139th Drive Luke Air Force Base, AZ 85309	(623) 856-5856 (623) 856-7096 f

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Appendix B

SUPPORTING INFORMATION ON PROJECT COORDINATION AND LOCAL CONSULTATION

Appendix B
SUPPORTING INFORMATION ON PROJECT COORDINATION AND LOCAL CONSULTATION

Part 150
Noise Compatibility Study
Flagstaff Pulliam Airport

As part of the planning process, the consultant offered to the public, airport users, and local, state and federal agencies the opportunity to review and comment on the Noise Compatibility Program (NCP). Materials prepared by the consultant were submitted for local review, discussion, and revision at several points during the process.

Much of the local coordination was handled through a special study committee formed specifically to provide advice and feedback on the Part 150 Noise Compatibility Study. Known as the Planning Advisory Committee (PAC), it included representatives from all affected groups including local residents, airport users, officials from the City of Flagstaff and Coconino County, aviation organizations, fixed base operators, U.S. Forest Service, and the Federal Aviation Administration (FAA). At several points during the process, the PAC reviewed, discussed, and suggested revisions to the material prepared by the consultant.

The PAC reviewed and commented on working papers prepared by the consultant and provided guidance for the next phases of the study. Most comments were made orally during the meetings, but some were followed by written confirmation. All comments were appropriately incorporated into this document or otherwise addressed. A list of PAC members is presented in Appendix A.

The PAC met four times during the preparation of the Noise Compatibility Study. During the first two meetings, the PAC focused on the Noise Exposure Maps document. The final two meetings pertained to the NCP.

The first NCP meeting was held on August 25, 2004. Chapter Five, Noise Abatement Alternatives and Chapter 6, Land Use Alternatives were discussed at this meeting. Various alternatives concerning program measures for noise abatement and land use were discussed at this meeting.

The final PAC meeting was held on November 11, 2004. Chapter Seven, Noise Compatibility Program was presented. The Noise Abatement Management, Land Use Management, and Program Management elements were discussed at this meeting.

Following the PAC meetings, the general public was invited to a series of Public Information Workshops. These workshops were structured as an informal open-house, with display boards and information posted throughout the meeting room. The meetings allowed residents to acquire information about the Part 150 process, baseline noise analysis, alternative analysis, and proposed recommendations, ask questions, and express concerns. The meetings were also intended to encourage two-way communication between the airport staff, consultants, and local residents.

In addition to the PAC meetings, the consultant also convened two special technical conferences to assist in the initial development of noise abatement and land use alternatives on January 30, 2004,. The Aviation Technical Conference included representatives from the Federal Aviation Administration, Airport Traffic Control Tower, local airport users, and national aviation organizations. The Land Use Technical Conference included representatives from the all local land use planning agencies in the airport area.

Written and verbal contacts were also made between project management staff and officials of local, state, and federal agencies, representatives of various aviation user groups, and local residents. These were related to the day-to-day management of the project, as well as the resolution of specific questions and concerns arising from the working papers.

A supplemental volume entitled, "Supporting Information on Project Coordination and Local Consultation," contains detailed information in support of the NCP document. It includes copies of meeting announcements, summary notes from the meetings, sign-in sheets, written comments received on the study, a transcript of the public hearing, and responses to questions and comments raised at the public hearing and official public comment period.

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Appendix D

IMPLEMENTATION MATERIALS

Appendix D
IMPLEMENTATION MATERIALS

This appendix includes the following materials for the implementation of the Noise Compatibility Program:

- AOPA Noise Awareness Steps
- Sample building code amendment

AIRCRAFT OWNERS AND PILOTS ASSOCIATION
(AOPA)
NOISE AWARENESS STEPS

Following are some general guidelines and techniques to minimize the noise impact produced by aircraft operating near the ground:

1. If practical, avoid noise-sensitive areas such as residential areas; open-air assemblies (e.g., sporting events and concerts), and national park areas. Make every effort to fly at or above 2,000 feet over the surface of such areas when overflight cannot be avoided.

2. Consider using a reduced power setting if flight must be low because of cloud cover or overlying controlled airspace or when approaching the airport of destination. Propellers generate more noise than engines; flying with the lowest practical rpm setting will reduce the aircraft's noise level substantially.

3. Perform stalls, spins, and other practice maneuvers over uninhabited terrain.

4. Many airports have established specific noise abatement procedures. Familiarize yourself and comply with these procedures.

5. Work with airport managers and fixed-base operators to develop procedures to reduce the impact on noise-sensitive areas.

6. To contain aircraft noise within airport boundaries, avoid performing engine runups at the ends of runways near housing developments. Instead, select a location for engine runup closer to the center of the field.

7. On takeoff, gain altitude as quickly as possible without compromising safety. Begin takeoffs at the start of a runway, not at an intersection.

8. Retract the landing gear either as soon as a landing straight ahead on the runway can no longer be accomplished or as soon as the aircraft achieves a positive rate of climb. If practical, maintain best-angle-of-climb airspeed until reaching 50 feet or an altitude that provides clearance from terrain or obstacles. Then accelerate to best-rate-of-climb airspeed. If consistent with safety, make the first power reduction at 500 feet.

9. Fly a tight landing pattern to keep noise as close to the airport as possible. Practice descent to the runway at low power settings and with as few power changes as possible.

10. If a VASI or other visual approach guidance system is available, use it. These devices will indicate a safe glidepath and allow a smooth, quiet descent to the runway.

11. If possible, do not adjust the propeller control for flat pitch on the downwind leg; instead, wait until short final. This practice not only provides a quieter approach, but also reduces stress on the engine and propeller governor.

12. Avoid low-level, high-power approaches, which not only create high noise impacts, but also limit options in the event of engine failure.

Note: These recommendations are general in nature; some may not be advisable for every aircraft in every situation. No noise reduction procedure should be allowed to compromise flight safety.

Source: *AOPA's Aviation USA - 1994*

SAMPLE BUILDING CODE AMENDMENT ESTABLISHING SOUND INSULATION STANDARDS*

SECTION 1.00. PURPOSE. The purpose of this chapter is to safeguard life, health, property, and public welfare by establishing uniform sound insulation performance standards to protect persons within hotels, motels, apartment houses, attached and detached single-family dwellings, and within other buildings where noise-sensitive activities are affected by excessive aircraft noise at ***Flagstaff Pulliam Airport***. Effects of airborne noise include but are not limited to persistent interference with speech and sleep. This chapter is intended to be a companion to the adopted zoning ordinance establishing airport compatibility overlay zones and limiting land use in these zones.

SECTION 2.00. DEFINITIONS. The special terms used in these provisions are defined as follows:

2.01. Day-Night Average Sound Level (DNL): The 24-hour average sound level, in A-weighted decibels, for the period from midnight to midnight, obtained after the addition of ten decibels to sound levels for the periods between 10 p.m. and 7 a.m., local time, as averaged over one year. It is the Federal Aviation Administration's standard metric for determining the cumulative exposure of individuals to noise.

2.02. Decibel (dB): A unit of measure of a sound expressed from a calibrated sound level meter utilizing an A-level weighting scale.

2.03. Noise: Sound from aircraft or other sources which interferes with speech and hearing, or is intense enough to damage hearing, or is otherwise annoying.

2.04. NLR: Outdoor to indoor noise level reduction to be achieved through incorporation of sound insulation in structure.

2.05. Interior Noise Level: Sound level of noise in any habitable room with windows and doors closed.

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* SOURCE:
U.S. Air Force Recommendations for Insulation of Residential Structures Against Aircraft Noise, Undated. As cited in Cleveland Hopkins International Airport F.A.R. Part 150 Noise Compatibility Study, Appendix L.

2.06. OITC Rating: Outdoor Indoor Transmission Class - a description of the noise level reduction, in decibels, achieved by a product or construction assembly. The OITC rating system was developed by the American Society of Testing Materials. It takes into account the influence of environmental noise, such as transportation-related noise, on the product being tested. It takes into account a wider range of frequencies that the STC rating which better reflect the spectrum of exterior noise. This is a new rating system than the STC rating. Increasingly, manufacturers are testing their products using the OITC system.

2.07. STC Rating: Sound Transmission Class - a single number rating of the sound transmission loss (TL-- the reduction of sound energy passing through a building material) of a wall or structure which attempts to account for the variation in TL with frequency. The STC rating system was developed by the American Society of Testing Materials. It is the rating system traditionally used by manufacturers and designers.

SECTION 3.00. SCOPE.

3.01. Structures Requiring Protection: Compliance with these standards shall be required for structures and land uses as noted in the Table of Land Use Compatibility Standards.

3.02. Type of Construction Affected: These standards shall apply to new construction of structures and land uses as noted in Subsection 3.01. The standards also shall apply to reconstruction, remodeling, or additions to existing buildings of the types mentioned above when the value of the improvement exceeds 50 percent of the value of the existing structures. Where noise-sensitive activities are carried on in only a portion of new or reconstructed commercial building, only those areas judged noise-sensitive need be protected.

SECTION 4.00. BUILDING REQUIREMENTS FOR A MINIMUM NOISE LEVEL REDUCTION (NLR) OF 25 dB.

4.01. Compliance: Compliance with the following standards shall be deemed to meet the requirements of the Airport Compatibility Overlay Zoning Ordinance for structures in which an NLR of 25 dB is required.

4.02. General:

a. Brick veneer, masonry blocks, or stucco exterior walls shall be constructed airtightly. All joints shall be grouted or caulked airtightly.

b. At the penetration of exterior walls by pipes, ducts, or conduits, the space between the wall and pipes, ducts, or conduits shall be caulked or filled with mortar.

c. Window and/or through-the-wall ventilation units shall not be used.

d. Through-the-wall/door mail boxes shall not be used.

4.03. Exterior Walls:

a. Exterior walls other than as described in this Subsection shall have a laboratory sound transmission class rating of at least STC-39. (See Table 1 at the end of this Chapter for examples.)

b. Masonry walls having a surface weight of at least 25 pounds per square foot do not require a furred (stud) interior wall. At least one surface of concrete block walls shall be plastered or painted with heavy "bridging" paint.

c. Stud walls shall be at least four inches in nominal depth and shall be finished on the outside with siding-on-sheathing, stucco, or brick veneer.

(1) Interior surface of the exterior walls shall be of gypsum board or plaster at least ½-inch thick, installed on the studs.

(2) Continuous composition board, plywood, or gypsum board sheathing at least ½-inch thick shall cover the exterior side of the wall studs behind wood, or metal siding. Asphaltic or wood shake shingles are acceptable in lieu of siding.

(3) Sheathing panels shall be butted tightly and covered on the exterior with overlapping building paper. The top and bottom edges of the sheathing shall be sealed.

(4) Insulation material at least two inches thick shall be installed continuously throughout the cavity space behind the exterior sheathing and between wall studs. Insulation shall be glass fiber or mineral wool.

4.04. Windows:

a. Windows other than as described in this Subsection shall have a laboratory sound transmission class rating of at least STC-28. (See Table 2.)

b. Glass shall be at least 3/16-inch thick.

c. All operable windows shall be weather-stripped and airtight when closed so as to conform to an air infiltration test not to exceed 0.5 cubic foot per minute per foot of crack length in accordance with ASTM E-283-65-T.

d. Glass of fixed-sash windows shall be sealed in an airtight manner with a non-hardening sealant, or a soft elastomer gasket or glazing tape.

e. The perimeter of window frames shall be sealed airtightly to the exterior wall construction with a sealant conforming to one of the following Federal Specifications: TT-S-00227, TT-S-00230, or TT-S-00153.

f. The total area of glass in both windows and doors in sleeping spaces shall not exceed 20 percent of the floor area.

4.05. Doors:

a. Doors, other than as described in this Subsection, shall have a laboratory sound transmission class rating of at least STC-28. (See Table 3.)

b. All exterior side-hinged doors shall be solid-core wood or insulated hollow metal at least 1-3/4-inch thick and shall be fully weather-stripped.

c. Exterior sliding doors shall be weather-stripped with an efficient airtight gasket system with performance as specified in Paragraph 4.04.c. The glass in the sliding doors shall be at least 3/16-inch thick.

d. Glass in doors shall be sealed in an airtight non-hardening sealant, or in a soft elastomer gasket or glazing tape.

e. The perimeter of door frames shall be sealed airtightly to the exterior wall construction as described in Paragraph 4.04.e.

4.06. Roofs:

a. Combined roof and ceiling construction other than described in this Subsection and Subsection 4.07 shall have a laboratory sound transmission class rating of at least STC-39.

b. With an attic or rafter space at least six-inches deep, and with a ceiling below, the roof shall consist of closely butted ½-inch composition board, plywood, or gypsum board sheathing topped by roofing as required.

c. If the underside of the roof is exposed, or if the attic or rafter spacing is less than six inches, the roof construction shall have a surface weight of at least 25 pounds per square foot. Rafters, joists, or other framing may not be included in the surface weight calculation.

d. Window or dome skylights shall have a laboratory sound transmission class rating of at least STC-28. (See Table 2.)

4.07. Ceilings:

a. Gypsum board or plaster ceilings at least ½-inch thick shall be provided where required by Paragraph 4.06.b above. Ceilings shall be substantially airtight, with a minimum number of penetrations.

b. Glass fiber or mineral wool insulation at least two inches thick shall be provided above the ceiling between joists.

4.08. Floors:

a. Openings to any crawl spaces below the floor of the lowest occupied rooms shall not exceed two percent of the floor area of the occupied rooms.

4.09. Ventilation:

a. A mechanical ventilation system shall be installed that will provide the minimum air circulation and fresh air supply requirements for various uses in occupied rooms without the need to open any windows, doors, or other openings to the exterior.

b. Gravity vent openings in the attic shall not exceed the code minimum in number and size.

c. If a fan is used for forced ventilation, the attic inlet and discharge openings shall be fitted with sheet metal transfer ducts of at least 20 gauge steel, which shall be lined with one-inch thick coated glass fiber, and shall be at least five feet long with one 90-degree bend.

d. All vent ducts connecting the interior space to the outdoors, excepting domestic range exhaust ducts, shall contain at least a five-foot length of internal sound absorbing duct lining. Each duct shall be provided with a bend in the duct such that there is no direct line of sight through the duct from the venting cross-section to the room-opening cross-section.

e. Duct lining shall be coated glass fiber duct liner at least one-inch thick.

f. Domestic range exhaust ducts connecting the interior space to the outdoors shall contain a baffle plate across the exterior termination which allows proper ventilation. The dimensions of the baffle plate shall extend at least one diameter beyond the line of sight into the vent duct. The baffle plate shall be of the same material and thickness as the vent duct material.

g. Fireplaces shall be provided with well-fitted dampers.

SECTION 5.00. BUILDING REQUIREMENTS FOR A MINIMUM NOISE LEVEL REDUCTION (NLR) OF 30 dB.

5.01. Compliance: Compliance with the following standards shall be deemed to meet the requirements of the Airport Compatibility Overlay Zoning Ordinance for structures in which an NLR of 30 dB is required.

5.02. General:

a. Brick veneer, masonry blocks, or stucco exterior walls shall be constructed airtightly. All joints shall be grouted or caulked airtightly.

b. At the penetration of exterior walls by pipes, ducts, conduits, the space between the wall and pipes, ducts, or conduits shall be caulked or filled with mortar.

c. Window and/or through-the-wall ventilation units shall not be used.

d. Operational vented fireplaces shall not be used.

e. All sleeping spaces shall be provided with either a sound-absorbing ceiling or a carpeted floor.

f. Through-the-wall/door mailboxes shall not be used.

5.03. Exterior Walls:

a. Exterior walls other than as described in this Subsection shall have a laboratory sound transmission class rating of at least STC-44. (See Table 1).

b. Masonry walls having a surface weight of at least 40 pounds per square foot do not require a furred (stud) interior wall. At least one surface of concrete block walls shall be plastered or painted with heavy “bridging” paint.

c. Stud walls shall be at least four inches in nominal depth and shall be finished on the outside with siding-on-sheathing, stucco, or brick veneer.

(1) Interior surface of the exterior walls shall be of gypsum board or plaster at least ½-inch thick, installed on the studs. The gypsum board or plaster may be fastened rigidly to the studs if the exterior is brick veneer or stucco. If the exterior is siding-on-sheathing, the interior gypsum board or plaster must be fastened resiliently to the studs.

(2) Continuous composition board, plywood, or gypsum board sheathing shall cover the exterior side of the wall studs behind wood, or metal siding. The sheathing and facing shall weigh at least four pounds per square foot.

(3) Sheathing panels shall be butted tightly and covered on the exterior with overlapping building paper. The top and bottom edges of the sheathing shall be sealed.

(4) Insulation material at least two inches thick shall be installed continuously throughout the cavity space behind the exterior sheathing and between wall studs. Insulation shall be glass fiber or mineral wool.

5.04. Windows:

a. Windows other than as described in this Subsection shall have a laboratory sound transmission class rating of at least STC-33. (See Table 2).

b. Glass of double-glazed windows shall be at least 1/8-inch thick. Panes of glass shall be separated by a minimum three-inch air space.

c. Double-glazed windows shall employ fixed sash or efficiently weather-stripped operable sash. The sash shall be rigid and weather-stripped with material that is compressed airtightly when the window is closed so as to conform to an infiltration test not to exceed 0.5 cubic foot per minute per foot of crack length in accordance with ASTM E-283-65-T.

d. Glass of fixed-sash windows shall be sealed in an airtight manner with a non-hardening sealant, or a soft elastomer gasket or glazing tape.

e. The perimeter of window frames shall be sealed airtightly to the exterior wall construction with a sealant conforming to one of the following Federal Specifications: TT-0227, TT-S-00230, or TT-S-00153.

f. The total area of glass of both windows and exterior doors in sleeping spaces shall not exceed 20 percent of the floor area.

5.05. Doors:

a. Doors, other than as described in this Subsection, shall have a laboratory sound transmission class rating of at least STC-33. (See Table 3.)

b. Double door construction is required for all door openings to the exterior. Openings fitted with side-hinged doors shall have one solid-core wood or insulated hollow metal core door at least 1 3/4-inch thick separated by an airspace of at least four inches from another door, which can be a storm door. Both doors shall be tightly fitted and weather-stripped.

c. The glass of double-glazed sliding doors shall be separated by a minimum four-inch airspace. Each sliding frame shall be provided with an efficiently airtight weather-stripping material as specified in Paragraph 5.04.c.

d. Glass of all doors shall be at least 3/16-inch thick. Glass of double sliding doors shall not be equal in thickness.

e. The perimeter of door frames shall be sealed airtightly to the exterior wall construction as indicated in Subsection 5.04.e.

f. Glass of doors shall be set and sealed in an airtight non-hardening sealant, or a soft elastomer gasket or glazing tape.

5.06. Roofs:

a. Combined roof and ceiling construction other than described in this Subsection and Subsection 5.07. shall have a laboratory sound transmission class rating of at least STC-44.

b. With an attic or rafter space at least six inches deep, and with a ceiling below, the roof shall consist of closely butted ½-inch composition board, plywood, or gypsum board sheathing topped by roofing as required.

c. If the underside of the roof is exposed, or if the attic or rafter spacing is less than six inches, the roof construction shall have a surface weight of at least 40 pounds per square foot. Rafters, joists, or other framing may not be included in the surface weight calculation.

d. Window or dome skylights shall have a laboratory sound transmission class rating of at least STC-33. (See Table 2.)

5.07. Ceilings:

a. Gypsum board or plaster ceilings at least ½-inch thick shall be provided where required by Paragraph 5.06.b above. Ceilings shall be substantially airtight, with a minimum number of penetrations.

b. Glass fiber or mineral wool insulation at least two inches thick shall be provided above the ceiling between joists.

5.08. Floors:

The floor of the lowest occupied rooms shall be slab on fill, below grade, or over a fully enclosed basement. All door and window openings in the fully enclosed basement shall be tightly fitted.

5.09. Ventilation:

a. A mechanical ventilation system shall be installed that will provide minimum air circulation and fresh air supply requirements for various uses in occupied rooms without the need to open any windows, doors, or other openings to the exterior.

b. Gravity vent openings in attic shall not exceed code minimum in number and size. The openings shall be fitted with transfer ducts at least three feet in length containing internal sound absorbing duct lining. Each duct shall have a lined 90-degree bend in the duct such that there is no direct line of sight from the exterior through the duct into the attic.

c. If a fan is used for forced ventilation, the attic inlet and discharge openings shall be fitted with sheet metal transfer ducts of at least 20 gauge steel, which shall be lined with one-inch thick coated glass fiber, and shall be at least five feet long with one 90-degree bend.

d. All vent ducts connecting the interior space to the outdoors, excepting domestic range exhaust ducts, shall contain at least a 10-foot length of internal sound absorbing duct lining. Each duct shall be provided with a lined 90-degree bend in the duct such that there is no direct line of sight

through the duct from the venting cross-section to the room opening cross- section.

e. Duct lining shall be coated glass fiber duct liner at least one-inch thick.

f. Domestic range exhaust ducts connecting the interior space to the outdoors shall contain a baffle plate across the exterior termination which allows proper ventilation. The dimensions of the baffle plate shall extend at least one diameter beyond the line of sight into the vent duct. The baffle plate shall be of the same material and thickness as the vent duct material.

g. Building heating units with flues or combustion air vents shall be located in a closet or room closed off from the occupied space by doors.

h. Doors between occupied space and mechanical equipment areas shall be solid core wood or 20 gauge steel hollow metal at least 1 3/4-inch thick and shall be fully weather-stripped.

SECTION 6.00. BUILDING REQUIREMENTS FOR A MINIMUM NOISE LEVEL REDUCTION (NLR) OF 35 dB.

6.01. Compliance.

Compliance with the following standards shall be deemed to meet the requirements of the Airport Compatibility Overlay Zoning Ordinance for structures in which an NLR of 35 dB is required.

6.02. General:

a. Brick veneer, masonry blocks, or stucco exterior walls shall be constructed airtightly. All joints shall be grouted or caulked airtightly.

b. At the penetration of exterior walls by pipes, ducts, or conduits, the space between the wall and pipes, ducts, or conduits shall be caulked or filled with mortar.

c. Window and/or through-the-wall ventilation units shall not be used.

d. Operational vented fireplaces shall not be used.

e. All sleeping spaces shall be provided with either a sound absorbing ceiling or a carpeted floor.

f. Through-the-wall/door mailboxes shall not be used.

g. No glass or plastic skylight shall be used.

6.03. Exterior Walls:

a. Exterior walls other than as described in this Subsection shall have a laboratory sound transmission class rating of at least STC-49. (See Table 1.)

b. Masonry walls having a surface weight of at least 75 pounds per square foot do not require a furred (stud) interior wall. At least one surface of concrete block walls shall be plastered or painted with heavy "bridging" paint.

c. Stud walls shall be at least four inches in nominal depth and shall be finished on the outside with siding-on-sheathing, stucco, or brick veneer.

(1) Interior surface of the exterior walls shall be of gypsum board or plaster at least ½-inch thick, installed on studs. The gypsum board or plaster may be fastened rigidly to the studs if the exterior is brick veneer. If the exterior is stucco or siding-on-sheathing, the interior gypsum board or plaster must be fastened resiliently to the studs.

(2) Continuous composition board, plywood, or gypsum board sheathing shall cover the exterior side of the wall studs behind wood or metal siding. The sheathing and facing shall weigh at least four pounds per square foot.

(3) Sheathing panels shall be butted tightly and covered on the exterior with overlapping building paper. Top and bottom edges of the sheathing shall be sealed.

(4) Insulation material at least 3-1/2-inches thick shall be installed continuously through the cavity space behind the exterior sheathing and between wall studs. Insulation shall be glass fiber or mineral wool.

6.04. Windows:

a. Windows other than as described in this Subsection shall have a laboratory sound transmission class rating of at least STC-38. (See Table 2.)

b. Double-glazed windows shall employ fixed sash. Glass of double-glazed windows shall be at least 1/8-inch thick. Panes of glass shall be separated by a minimum three-inch space and shall not be equal in thickness.

c. Glass of windows shall be sealed in an airtight manner with a non-hardening sealant, or a soft elastomer gasket or glazing tape.

d. The perimeter of window frames shall be sealed airtightly to the exterior wall construction with a sealant conforming to one of the following Federal Specifications: TT-S-00227, TT-S-00230, or TT-S-00153.

e. The total area of glass of both windows and exterior doors in sleeping spaces shall not exceed 20 percent of the floor area.

6.05. Doors:

a. Doors, other than as described in this Subsection, shall have a laboratory sound transmission class rating of at least STC-38. (See Table 3.)

b. Double door construction is required for all door openings to the exterior. The door shall be side-hinged and shall be solid-core wood or insulated hollow metal, at least 1 3/4-inch thick, separated by a vestibule at least three feet in length. Both doors shall be tightly fitted and weather-stripped.

c. The perimeter of door frames shall be sealed airtightly to the exterior wall construction as specified in Paragraph 6.04.d.

6.06. Roofs:

a. Combined roof and ceiling construction other than described in this Subsection shall have a laboratory sound transmission class rating of at least STC-49.

b. With an attic or rafter space at least six inches deep, and with a ceiling below, the roof shall consist of closely butted ½-inch composition board, plywood, or gypsum board sheathing topped by roofing as required.

c. If the underside of the roof is exposed, or if the attic or rafter spacing is less than six inches, the roof construction shall have a surface weight of at least 75 pounds per square foot. Rafters, joists, or other framing may not be included in the surface weight calculation.

6.07. Ceilings:

a. Gypsum board or plaster ceilings at least ½-inch thick shall be provided where required by Subsection 6.06. Ceilings shall be substantially airtight, with a minimum number of penetrations. The ceiling panels shall be mounted on resilient clips or channels. A non-hardening sealant shall be used to seal gaps between the ceiling and walls around the ceiling perimeter.

b. Glass fiber or mineral wool insulation at least 3-1/2 inches thick shall be provided above the ceiling between joists.

6.08. Floors:

The floors of the lowest occupied rooms shall be slab on fill or below grade.

6.09. Ventilation:

a. A mechanical ventilation system shall be installed that will provide the minimum air circulation and fresh air supply requirements for various uses in occupied rooms without need to open any windows, doors, or other openings to the exterior.

b. Gravity vent openings in attic shall not exceed code minimum in number and size. The openings shall be fitted with transfer ducts at least six feet in length containing internal sound absorbing duct lining. Each duct shall have a lined 90-degree bend in the duct such that there is no direct line of sight from the exterior through the duct into the attic.

c. If a fan is used for forced ventilation, the attic inlet and discharge openings shall be fitted with sheet metal transfer ducts of at least 20 gauge steel, which shall be lined with one-inch thick coated glass fiber, and shall be at least 10 feet long with one 90-degree bend.

d. All vent ducts connecting the interior space to the outdoors excepting domestic range exhaust ducts, shall contain at least 10 feet length of internal sound absorbing duct lining. Each duct shall be provided with a lined 90-degree bend in the duct such that there is no direct line of sight through the duct from the venting cross-section to the room-opening cross-section.

e. Duct lining shall be coated glass fiber duct liner at least one-inch thick.

f. Domestic range exhaust ducts connecting the interior space to the outdoors shall contain a baffle plate across the exterior termination which

allows proper ventilation. The dimensions of the baffle plate shall extend at least one diameter beyond the line of sight into the vent duct. The baffle plate shall be of the same material and thickness as the vent duct material.

g. Building heating units with flues or combustion air vents shall be located in a closet or room closed off from the occupied space by doors.

h. Doors between occupied space and mechanical equipment areas shall be solid-core wood or 20 gauge steel hollow metal at least 1 3/4-inches thick and shall be fully weather-stripped.

TABLE 1

SOUND TRANSMISSION CLASS (STC)
OF SOME COMMON EXTERIOR WALL CONSTRUCTIONS

	Description	Weight lbs./ft.^{2}	STC
(a)	Stucco on wire lath over tar paper. Wood studs, 16 in. o.c., 5/8 in. gypboard on inside face of studs.	5.0	39
(b)	Same as (a), but staggered studs	5.2	46
(c)	Common curtainwall spandrel panel; 16 ga. sheet metal exterior with insulation and 5/8 in. gypboard interior	7.8	41
(d)	4-1/2 in. brick - ½ in. plaster both sides	55	48
(e)	4 in. light weight concrete block unpainted	24	29
(f)	4 in. lightweight concrete block sealed with two coats of paint	24	45
(g)	Same as (e), but 8 in. dense	50	55
(h)	Same as (f), but 8 in. dense	50	55
(I)	4 in. dense poured concrete	50	51
(j)	8 in. dense poured concrete	100	57
(k)	Fluted 18 ga. sheet metal for prefabricated building	4.4	28

Source: Santa Clara County Airport Land Use Commission (ALUC), Land Use Plan for Area Surrounding Santa Clara County Airports, County of Santa Clara (CA) Planning Department, August 1973.

TABLE 2

SOUND TRANSMISSION CLASS (STC)
OF SOME COMMON WINDOW CONSTRUCTION AND MATERIALS

	Description	Weight lbs./ft.^{2}	STC
(a)	Double-hung window, wood frame, 3/32-in. glass	--	23
(b)	Louvered window, 1/4-in. window glass	--	17
(c)	Aluminum sliding window, 3/32-in. glass	--	19
(d)	Steel frame, casement window, 3/32-in. glass	--	21
(e)	Approximate limit of TL for (a) through (d) if caulked and permanently sealed	--	27
(f)	Approximate TL for constructions (a) through (d) if new 1/4-in. plate is added in separate frame. Old window sealed, min. 2-1/2 in. airspace	--	42
(g)	Double-glazed aluminum window 7/32-in. and 1/4-in. glass; 2-1/2 in. airspace	--	43
(h)	1/8-in. sheet glass, sealed	1.6	31
(i)	1/4-in. plate glass, sealed	3.2	32
(j)	1/4-in. acoustic glass, sealed	3.2	35
(k)	½-in. acoustic glass, sealed	3.2	35
(l)	1/4-in. - 3/16-in. glass in neoprene gasket aluminum frames; 2-1/2 in. airspace	5.7	41
(m)	Same as (l), but 1/4-in. - 7/32-in. glass; 3-3/4 in. airspace	6.1	49
(n)	3-5/8 in. thick glass blocks	--	43

Source: Santa Clara County Airport Land Use Commission (ALUC), Land Use Plan for Area Surrounding Santa Clara County Airports, County of Santa Clara (CA) Planning Department, August 1973.

TABLE 3

SOUND TRANSMISSION CLASS (STC)
OF SOME COMMON EXTERIOR DOORS

	Description	Weight lbs./ft.^{2}	STC
(a)	1-3/4 in. hollow-core wood. No weatherstripping. 5/16-in. crack at threshold.	2.5	15
(b)	Same as (a), 1/16-in. crack	2.5	16
(c)	Same as (b), weatherstripped	2.5	19
(d)	Same as (b), sealed	2.5	20
(e)	1-3/4 in. paneled door. No weatherstripping. 1/16-in. crack at threshold	5.0	20
(f)	Same as (e), weatherstripped	5.0	23
(g)	Same as (e), sealed	5.0	24
(h)	1-3/4 in. solid-core door. No weatherstripping. 1/16-in. crack at threshold	7.0	19
(I)	Same as (h), weatherstripped	7.0	25
(j)	Same as (h), sealed	7.0	31
(k)	Wood sound door. Neoprene seals and drop threshold	6.6	37
(l)	Metal sound door. Neoprene seals and drop threshold	7.9	42

Source: Santa Clara County Airport Land Use Commission (ALUC), Land Use Plan for Area Surrounding Santa Clara County Airports, County of Santa Clara (CA) Planning Department, August 1973.

Coffman Associates
Airport Consultants

TECHNICAL INFORMATION PAPER

Glossary of Noise Compatibility Terms

TECHNICAL INFORMATION PAPER

GLOSSARY OF NOISE COMPATIBILITY TERMS

A-WEIGHTED SOUND LEVEL - A sound pressure level, often noted as dBA, which has been frequency filtered or weighted to quantitatively reduce the effect of the low frequency noise. It was designed to approximate the response of the human ear to sound.

AMBIENT NOISE - The totality of noise in a given place and time — usually a composite of sounds from varying sources at varying distances.

APPROACH LIGHT SYSTEM (ALS) - An airport lighting facility which provides visual guidance to landing aircraft by radiating light beams in a directional pattern by which the pilot aligns the aircraft with the extended centerline of the runway on the final approach for landing.

ATTENUATION - Acoustical phenomenon whereby a reduction in sound energy is experienced between the noise source and receiver. This energy loss can be attributed to atmospheric conditions, terrain, vegetation, and man-made and natural features.

AZIMUTH - Horizontal direction expressed as the angular distance between true north and the direction of a fixed point (as the observer's heading).

BASE LEG - A flight path at right angles to the landing runway off its approach end. The base leg normally extends from the downwind leg to the intersection of the extended runway centerline. See "traffic pattern."

CNEL - The 24-hour average sound level, in A-weighted decibels, obtained after the addition of 4.77 decibels to sound levels between 7 p.m. and 10 p.m. and 10 decibels to sound levels between 10 p.m. and 7 a.m., as averaged over a span of one year. In California, it is the required metric for determining the cumulative exposure of individuals to aircraft noise. Also see "Leq" and "DNL".

COMMUNITY NOISE EQUIVALENT LEVEL - See CNEL.

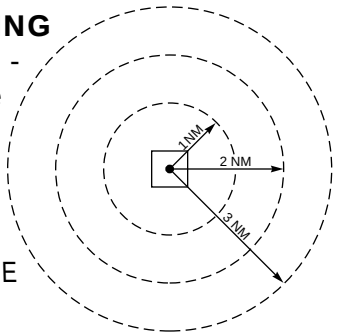
CROSSWIND LEG - A flight path at right angles to the landing runway off its upwind end. See "traffic pattern."

DAY-NIGHT AVERAGE SOUND LEVEL - See DNL.

DECIBEL (dB) - The physical unit commonly used to describe noise levels. The decibel represents a relative measure or ratio to a reference power. This reference value is a sound pressure of 20 micropascals which can be referred to as 1 decibel or the weakest sound that can be heard by a person with very good hearing in an extremely quiet room.

DISPLACED THRESHOLD - A threshold that is located at a point on the runway other than the designated beginning of the runway.

DISTANCE MEASURING EQUIPMENT (DME) - Equipment (airborne and ground) used to measure, in nautical miles, the slant range distance of an aircraft from the DME navigational aid.



DNL - The 24-hour average sound level, in A-weighted decibels, obtained after the addition of ten decibels to sound levels for the periods between 10 p.m. and 7 a.m. as averaged over a span of one year. It is the FAA standard metric for determining the cumulative exposure of individuals to noise. Also see "Leq."

DOWNWIND LEG - A flight path parallel to the landing runway in the direction opposite to landing. The downwind leg normally extends between the crosswind leg and the base leg. Also see "traffic pattern."

DURATION - Length of time, in seconds, a noise event such as an aircraft flyover is experienced. (May refer to the length of time a noise event exceeds a specified dB threshold level.)

EASEMENT - The legal right of one party to use a portion of the total rights in real estate owned by another party. This may include the right of passage over, on, or below the property; certain air rights above the property, including view rights; and the rights to any specified form of development or activity, as well as any other legal rights in the property that may be specified in the easement document.

EQUIVALENT SOUND LEVEL - See Leq.

FINAL APPROACH - A flight path in the direction of landing along the extended runway centerline. The final approach normally extends from the base leg to the runway. See "traffic pattern."

FIXED BASE OPERATOR (FBO) - A provider of services to users of an airport. Such services include, but are not limited to, hangaring, fueling, flight training, repair and maintenance.

GLIDE SLOPE (GS) - Provides vertical guidance for aircraft during approach and landing. The glide slope consists of the following:

1. Electronic components emitting signals which provide vertical guidance by reference to airborne instruments during instrument approaches such as ILS, or

2. Visual ground aids, such as VASI, which provide vertical guidance for VFR approach or for the visual portion of an instrument approach and landing.

GLOBAL POSITIONING SYSTEM - See "GPS."

GPS - GLOBAL POSITIONING SYSTEM - A system of 24 satellites used as reference points to enable navigators equipped with GPS receivers to determine their latitude, longitude, and altitude. The accuracy of the system can be further refined by using a ground receiver at a known location to calculate the error in the satellite range data. This is known as Differential GPS (DGPS).

GROUND EFFECT - The attenuation attributed to absorption or reflection of noise by man-made or natural features on the ground surface.

HOURLY NOISE LEVEL (HNL) - A noise summation metric which considers primarily those single events which exceed a specified threshold or duration during one hour.

INSTRUMENT APPROACH - A series of predetermined maneuvers for the orderly transfer of an aircraft under instrument flight conditions from the beginning of the initial approach to a landing, or to a point from which a landing may be made visually.

INSTRUMENT FLIGHT RULES (IFR) -Rules governing the procedures for conducting instrument flight. Also a term used by pilots and controllers to indicate type of flight plan.

INSTRUMENT LANDING SYSTEM (ILS) - A precision instrument approach system which normally consists of the following electronic components and visual aids:

1. Localizer.
2. Glide Slope.
3. Outer Marker.
4. Middle Marker.
5. Approach Lights.

Ldn - (See DNL). Ldn used in place of DNL in mathematical equations only.

Leq - Equivalent Sound Level. The steady A-weighted sound level over any specified period (not necessarily 24 hours) that has the same acoustic energy as the fluctuating noise during that period (with no consideration of a nighttime weighting.) It is a measure of cumulative acoustical energy. Because the time interval may vary, it should be specified by a subscript (such as Leq 8) for an 8-hour exposure to workplace noise) or be clearly understood.

LOCALIZER - The component of an ILS which provides course guidance to the runway.

MERGE - Combining or merging of noise events which exceed a given threshold level and occur within a variable selected period of time.

MISSED APPROACH COURSE (MAC) - The flight route to be followed if, after an instrument approach, a landing is not effected, and occurring normally:

1. When the aircraft has descended to the decision height and has not established visual contact, or

2. When directed by air traffic control to pull up or to go around again.

NOISE CONTOUR - A continuous line on a map of the airport vicinity connecting all points of the same noise exposure level.

NONDIRECTIONAL BEACON (NDB) -A beacon transmitting nondirectional signals whereby the pilot of an aircraft equipped with direction finding equipment can determined his bearing to and from the radio beacon and home on or track to or from the station. When the radio beacon is installed in conjunction with the Instrument Landing System marker, it is normally called a Compass Locator.

NONPRECISION APPROACH - A standard instrument approach procedure providing runway alignment but no glide slope or descent information.

PRECISION APPROACH - A standard instrument approach procedure providing runway alignment and glide slope or descent information.

PRECISION APPROACH PATH INDICATOR (PAPI) - A lighting system providing visual approach slope guidance to aircraft during a landing approach. It is similar to a VASI but provides a sharper transition between the colored indicator lights.

PROFILE - The physical position of the aircraft during landings or takeoffs in terms of altitude in feet above the runway and distance from the runway end.

PROPAGATION - Sound propagation refers to the spreading or radiating of sound energy from the noise source. Propagation characteristics of sound normally involve a reduction in sound energy with an increased distance from source. Sound propagation is affected by atmospheric conditions, terrain, and man-made and natural objects.

RUNWAY END IDENTIFIER LIGHTS (REIL) - Two synchronized flashing lights, one on each side of the runway threshold, which provide rapid and positive identification of the approach end of a particular runway.

RUNWAY USE PROGRAM - A noise abatement runway selection plan designed to enhance noise abatement efforts with regard to airport communities for arriving and departing aircraft. These plans are developed into runway use programs and apply to all turbojet aircraft 12,500 pounds or heavier. Turbojet aircraft less than 12,500 pounds are included only if the airport proprietor determines that the aircraft creates a noise problem. Runway use programs are coordinated with FAA offices as outlined in Order 1050.11. Safety criteria used in these programs are developed by the Office of Flight Operations. Runway use programs are administered by the Air Traffic Service as “Formal” or “Informal” programs.

RUNWAY USE PROGRAM (FORMAL) - An approved noise abatement program which is defined and acknowledged in a Letter of Understanding between FAA - Flight Standards, FAA - Air Traffic Service, the airport proprietor, and the users. Once established, participation in the program is mandatory for aircraft operators and pilots as provided for in F.A.R. Section 91.87.

RUNWAY USE PROGRAM (INFORMAL) - An approved noise abatement program which does not require a Letter of Understanding

and participation in the program is voluntary for aircraft operators/pilots.

SEL - Sound Exposure Level. SEL expressed in dB, is a measure of the effect of duration and magnitude for a single-event measured in A-weighted sound level above a specified threshold which is at least 10 dB below the maximum value. In typical aircraft noise model calculations, SEL is used in computing aircraft acoustical contribution to the Equivalent Sound Level (Leq), the Day-Night Sound Level (DNL), and the Community Noise Equivalent Level (CNEL).

SINGLE EVENT - An occurrence of audible noise usually above a specified minimum noise level caused by an intrusive source such as an aircraft overflight, passing train, or ship's horn.

SLANT-RANGE DISTANCE - The straight line distance between an aircraft and a point on the ground.

SOUND EXPOSURE LEVEL - See SEL.

TACTICAL AIR NAVIGATION (TACAN) -An ultra-high frequency electronic air navigation system which provides suitably-equipped aircraft a continuous indication of bearing and distance to the TACAN station.

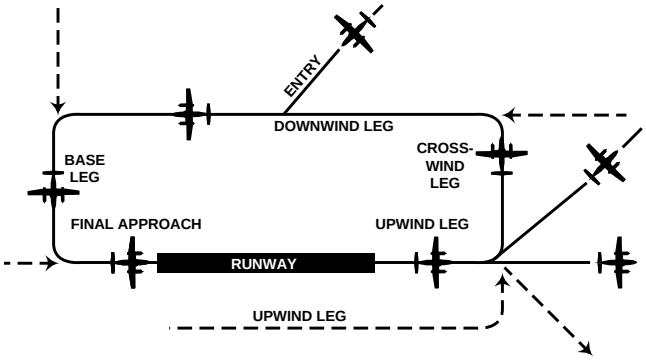
TERMINAL RADAR SERVICE AREA (TRSA) - Airspace surrounding designated airports wherein ATC provides radar vectoring, sequencing, and separation on a full-time basis for all IFR and participating VFR aircraft. Service provided in a TRSA is called Stage III Service.

THRESHOLD - Decibel level below which single event information is not printed out on the noise monitoring equipment tapes. The noise levels below the threshold are, however, considered in the accumulation of hourly and daily noise levels.

TIME ABOVE (TA) - The 24-hour TA noise metric provides the duration in minutes for which aircraft-related noise exceeds specified A-weighted sound levels. It is expressed in minutes per 24-hour period.

TOUCHDOWN ZONE LIGHTING (TDZ) -Two rows of transverse light bars located symmetrically about the runway centerline normally at 100 foot intervals. The basic system extends 3,000 feet along the runway.

TRAFFIC PATTERN - The traffic flow that is prescribed for aircraft landing at or taking off from an airport. The components of a typical traffic pattern are the upwind leg, crosswind leg, downwind leg, base leg, and final approach.

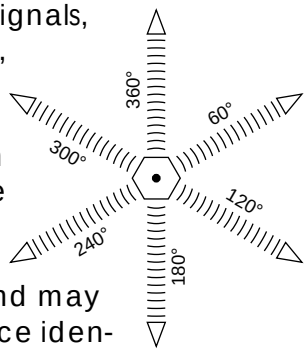


UNICOM - A nongovernment communication facility which may provide airport information at certain airports. Locations and frequencies of UNICOM's are shown on aeronautical charts and publications.

UPWIND LEG - A flight path parallel to the landing runway in the direction of landing. See "traffic pattern."

VECTOR - A heading issued to an aircraft to provide navigational guidance by radar.

VERY HIGH FREQUENCY OMNIDIRECTIONAL RANGE STATION (VOR) - A ground-based electric navigation aid transmitting very high frequency navigation signals, 360 degrees in azimuth, oriented from magnetic north. Used as the basis for navigation in the national airspace system. The VOR periodically identifies itself by Morse Code and may have an additional voice identification feature.



VERY HIGH FREQUENCY OMNIDIRECTIONAL RANGE STATION/TACTICAL AIR NAVIGATION (VORTAC) - A navigation aid providing VOR azimuth, TACAN azimuth, and TACAN distance-measuring equipment (DME) at one site.

VICTOR AIRWAY - A control area or portion thereof established in the form of a corridor, the centerline of which is defined by radio navigational aids.

VISUAL APPROACH - An approach wherein an aircraft on an IFR flight plan, operating in VFR conditions under the control of an air traffic control facility and having an air traffic control authorization, may proceed to the airport of destination in VFR conditions.

VISUAL APPROACH SLOPE INDICATOR (VASI) - An airport lighting facility providing vertical visual approach slope guidance to aircraft during approach to landing by radiating an directional pattern of high intensity red and white focused light beams which indicate to the pilot that he is on path if he sees red/white, above path if white/white, and below path if red/red. Some airports serving large aircraft have three-bar VASI's which provide two visual guide paths to the same runway.

VISUAL FLIGHT RULES (VFR) - Rules that govern the procedures for conducting flight under visual conditions. The term VFR is also used in the United States to indicate weather conditions that are equal to or greater than minimum VFR requirements. In addition, it is used by pilots and controllers to indicate type of flight plan.

VOR - See "Very High Frequency Omnidirectional Range Station."

VORTAC - See "Very High Frequency Omnidirectional Range Station/Tactical Air Navigation."

YEARLY DAY-NIGHT AVERAGE SOUND LEVEL - See DNL.

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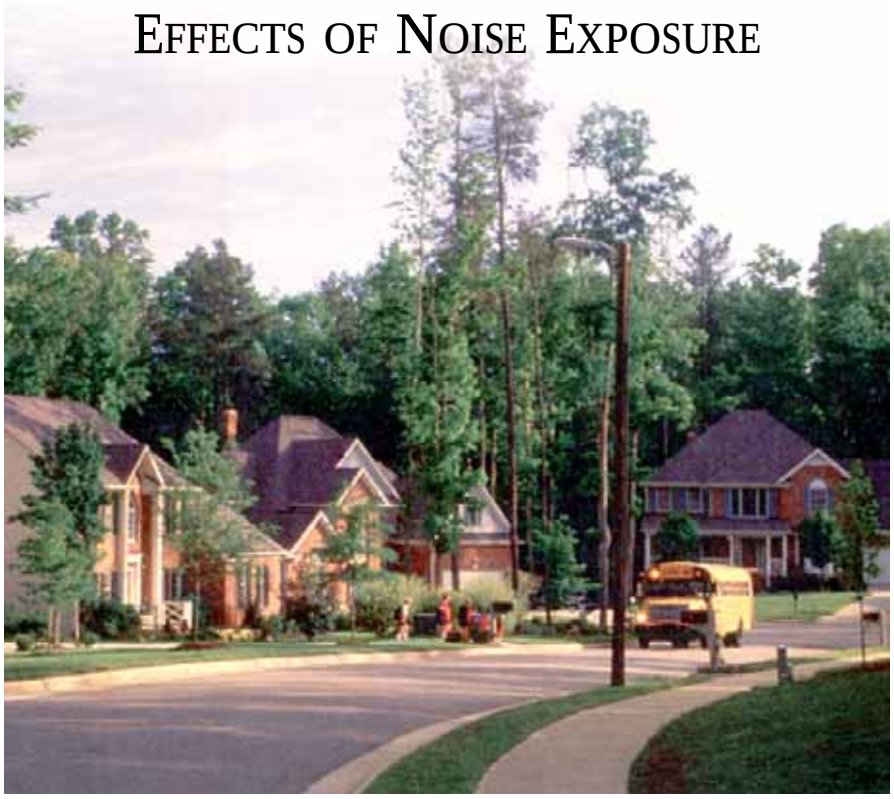
TECHNICAL INFORMATION PAPER

Effects of Noise Exposure

TECHNICAL INFORMATION PAPER

EFFECTS OF NOISE EXPOSURE



Aircraft noise can affect people both physically and psychologically. It is difficult, however, to make sweeping generalizations about the impacts of noise on people because of the wide variations in individual reactions. While much has been learned in recent years, some physical and psychological responses to noise are not yet fully understood and continue to be debated by researchers.

Studies which examined hearing loss among people living near airports found that, under normal circumstances, people in the community near an airport are at no risk of suffering hearing damage from aircraft noise.

EFFECTS ON HEARING

Hearing loss is the major health danger posed by noise. A study published by the U.S. Environmental Protection Agency (1974) found that exposure to noise of 70 Leq or higher on a continuous basis, over a very long time, at the human ear's most damage-sensitive frequency, may result in a very small but permanent loss of hearing. (Leq is a pure noise dosage metric, measuring cumulative noise energy over a given time.)

In Aviation Noise Effects (Newman and Beattie, 1985, pp. 33-42), three studies are cited which examined hearing

Airport noise in areas off airport property is far too low to be considered potentially damaging to hearing. Those most at risk [of hearing loss] are personnel in the transportation industry, especially airport ground staff.

loss among people living near airports. They found that, under normal circumstances, people in the community near an airport are at no risk of suffering hearing damage from aircraft noise.

The Occupational Safety and Health Administration (OSHA) has established standards for permissible noise exposure in the work place to guard against the risk of hearing loss. Hearing protection is required when noise levels exceed the legal limits. The standards, shown in **Table 1**, establish a sliding scale of permissible noise levels by duration of exposure. The standards permit noise levels of up to 90 dBA for eight hours per day without requiring hearing protection. The regulations also require employers to establish hearing conservation programs where noise levels exceed 85 Leq during the 8-hour workday. This involves the monitoring of work place noise, the testing of employees' hearing, the provision of hearing protectors to employees at risk of hearing loss, and the establishment of a training program to inform employees about the effects of work place noise on hearing and the effectiveness of hearing protection devices.

TABLE 1

PERMISSIBLE NOISE EXPOSURE - OSHA STANDARDS

DURATION PER DAY, HOURS	SOUND LEVEL dBA SLOW RESPONSE	DURATION PER DAY, HOURS	SOUND LEVEL dBA SLOW RESPONSE
8	90	$1\frac{1}{2}$	102
6	92	1	105
4	95	$\frac{1}{2}$	110
3	97	$\frac{1}{4}$ or less	115
2	100		

Source: 29 CFR Ch. XVII, Section 1910.95(b)

Experience at other airports has shown that even at sites with cumulative noise exposure near 75 DNL, the total time noise levels exceed 80 dBA typically ranges from 10 to 20 minutes, far below the critical hearing damage thresholds (Coffman Associates 1993, pp. 2-11). This supports the conclusion that airport noise in areas off airport property is far too low to be considered potentially damaging to hearing.

With respect to the risk of hearing loss, the authors of an authoritative summary of the research conclude: "Those most at risk [of hearing loss] are personnel in the transportation industry, especially airport ground staff.

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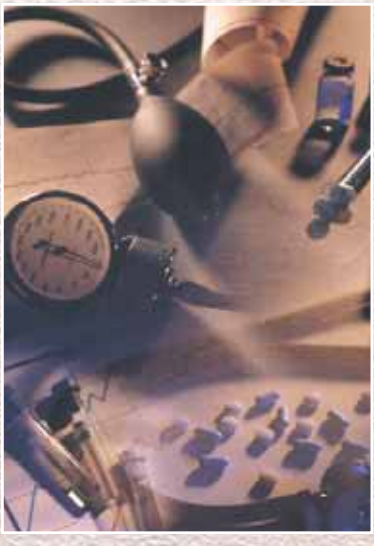

There is no strong evidence that noise has a direct causal effect on such health outcomes as cardiovascular disease, reproductive abnormality, or psychiatric disorder.

Beyond this group, it is unlikely that the general public will be exposed to sustained high levels of transportation noise sufficient to result in hearing loss. Transportation noise control in the community can therefore not be justified on the grounds of hearing protection." (See Taylor and Wilkins 1987.)

NON-AUDITORY HEALTH EFFECTS

It is sometimes claimed that aviation noise can harm the general physical and mental health of airport neighbors. Effects on the cardiovascular system, mortality rates, birth weights, achievement scores, and psychiatric admissions have been examined in the research literature. The question of pathological effects remains unsettled because of conflicting findings based on differing methodologies and uneven study quality. It is quite possible that the contribution of noise to pathological effects is so low that it has not been clearly isolated. While research is continuing, there is insufficient scientific evidence to support these concerns (Newman and Beattie 1985, pp. 59-62). Taylor and Wilkins (1987, p. 4/10) offer the following conclusions in their review of the research.

The evidence of non-auditory effects of transportation noise is more ambiguous, leading to differences of opinion regarding the burden of prudence for noise control. There is no strong evidence that noise has a direct causal effect on such health outcomes as cardiovascular disease, reproductive abnormality, or psychiatric disorder. At the same time, the evidence is not strong enough to reject the hypothesis that noise is in someway involved in the multi-causal process leading to these disorders. . . . But even with necessary improvements in study design, the inherent difficulty of isolating the effect of a low dose agent such as transportation noise within a complex aetiological system will remain. It seems unlikely, therefore, that research in the near future will yield findings which are definitive in either a positive or negative direction. Consequently, arguments for transportation noise control will probably continue to be based primarily on welfare criteria such as annoyance and activity disturbance.

Recent case studies on mental illness and hypertension indicate that this conclusion remains valid. Yoshida and Nakamura (1990) found that long-term exposure to

Reviews of laboratory research on sleep disturbance report that the level of noise which can cause awakenings or interfere with falling asleep ranges from 35 dBA to 80 dBA, depending on the sleep stage and variability among individuals.

sound pressure levels above 65 DNL may contribute to reported ill effects on mental well-being. This case study, however, concluded that more research is needed because the results also contained some contrary effects, indicating that in some circumstances, ill effects were negatively correlated with increasing noise.

Griefahn (1992) studied the impact of noise exposure ranging from 62 dBA to 80 dBA on people with hypertension. She found that there is a tendency for vasoconstriction to increase among untreated hypertensive people as noise levels increase. However, she also found that beta-blocking medication prevented any increase in vasoconstriction attributable to noise. She concluded that while noise may be related to the onset of hypertension, especially in the presence of other risk factors, hypertensive people do not run a higher risk of ill-health effects if they are properly treated.

A three-year study sponsored by the European Commission titled Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health (RANCH) studied nearly 3,000 children in schools located near busy roads and airports. The study evaluated the effects of chronic noise exposure on children's reading development. The study suggests that long-term noise exposure can delay a child's reading age up to two months. Additionally, the study found that persistent noise exposure increases the level of annoyance in children. While the effect was found to be significant, researchers felt it was small in magnitude and that the long-term effects remain unclear.

SLEEP DISTURBANCE

There is a large body of research documenting the effect of noise on sleep disturbance, but the long-range effects of sleep disturbance caused by nighttime airport operations are not well understood. It is clear that sleep is essential for good physical and emotional health, and noise can interfere with sleep, even when the sleeper is not consciously awakened. While the long-term effect of sleep deprivation on mental and physical function is not clear, it is known to be harmful. It is also known that sleepers do not fully adjust to noise disruption over time. Although they may awaken less often and have fewer conscious memories of disturbance, noise-induced shifts in sleep levels continue to occur.

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Research has shown that, when measured through awakenings, people tend to become somewhat accustomed to noise.

Reviews of laboratory research on sleep disturbance report that the level of noise which can cause awakenings or interfere with falling asleep ranges from 35 dBA to 80 dBA, depending on the sleep stage and variability among individuals (Newman and Beattie 1985, pp. 51-58; Kryter 1984, pp. 422-431). There is evidence that older people tend to be much more sensitive to noise-induced awakenings than younger people. Research has shown that, when measured through awakenings, people tend to become somewhat accustomed to noise. On the other hand, electroencephalograms, which reveal information about sleep stages, show little habituation to noise. Kryter describes these responses to noise as "alerting responses." He suggests that because they occur unconsciously, they may simply be reflexive responses, reflecting normal physiological functions which are probably not a cause of stress to the organism.

Most studies of sleep disturbance have been conducted under controlled laboratory conditions. The laboratory studies do not allow generalizations about the potential for sleep disturbance in an actual airport setting, and, more importantly, the impact of these disturbances on the residents. Furthermore, the range of sound levels required to cause sleep disturbance, ranging from a whisper to a shout (35 dB to 80 dB), and the prevalence of sleep disruption in the absence of any noise, greatly complicates the making of reasonable generalizations about the effect of noise on sleep.

Fortunately, some studies have examined the effect of nighttime noise on sleep disturbance in actual community settings. One report summarizes the results of eight studies conducted in homes (Fields 1986). Four studies examined aircraft noise, the others highway noise. In all of them, sleep disturbance was correlated with cumulative noise exposure metrics such as Leq and L10. All studies showed a distinct tendency for increased sleep disturbance as cumulative noise exposure increased. The reviewer notes, however, that sleep disturbance was very common, regardless of noise levels, and that many factors contributed to it. He points out that, "the prevalence of sleep disturbance in the absence of noise means that considerable caution must be exercised in interpreting any reports of sleep disturbance in noisy areas."

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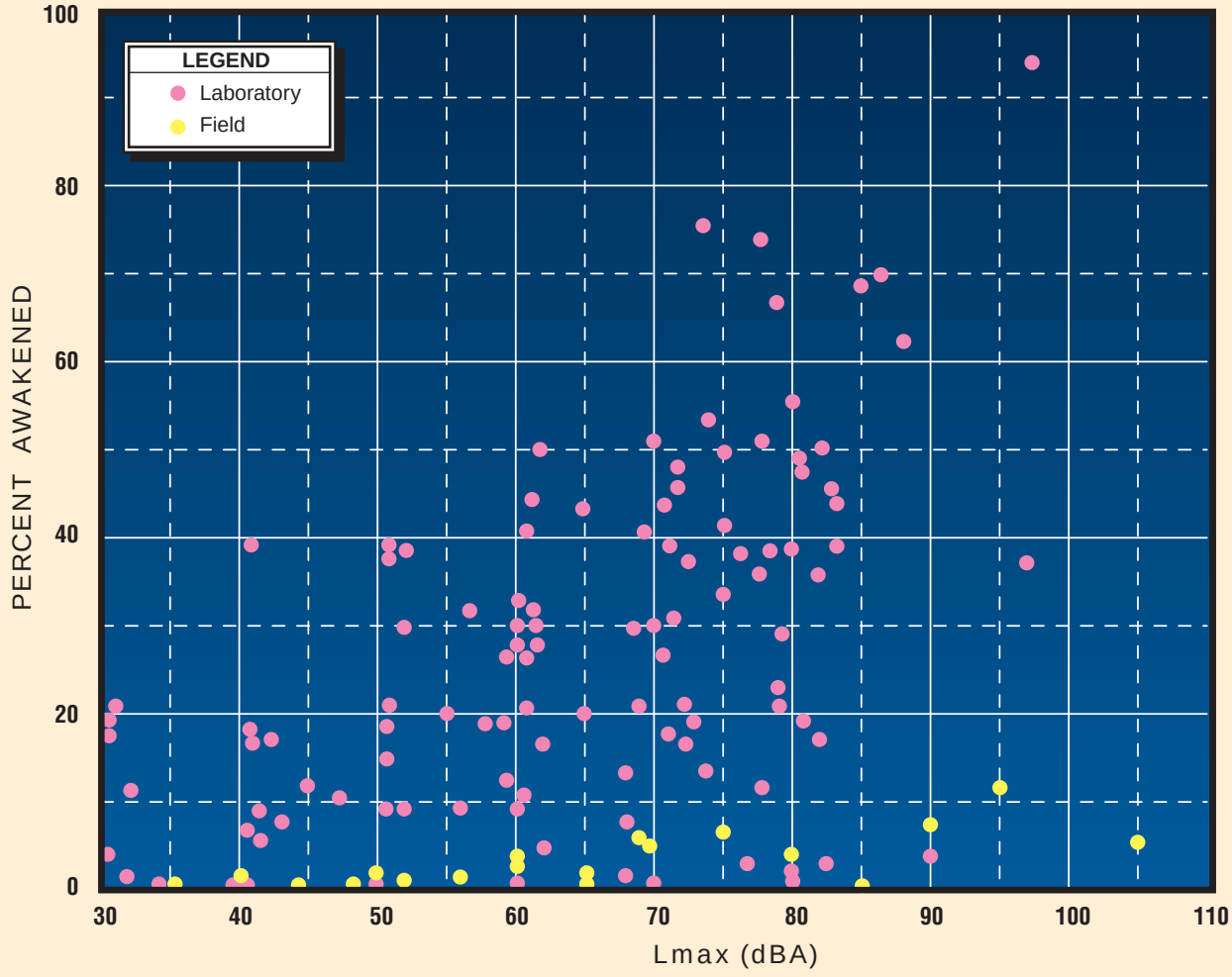
A recent review of the literature, Pearsons, et al. (1990), compared the data and findings of laboratory and field studies conducted in the homes of subjects. They found that noise-induced awakenings in the home were much less prevalent than in the laboratory. They also found that much higher noise levels were required to induce awakenings in the home than in the laboratory. **Exhibit A** compares the percentage of people awakened at different sound levels in laboratory and field studies. The graph clearly shows a marked tendency for people in laboratory settings to be much more sensitive to noise than in their homes. The reason for the large difference is apparently that people in their homes are fully habituated to their environment, including the noise levels.

EXHIBIT A

COMPARISON OF AWAKENING DUE TO NOISE EVENTS FROM LABORATORY VERSUS FIELD STUDIES



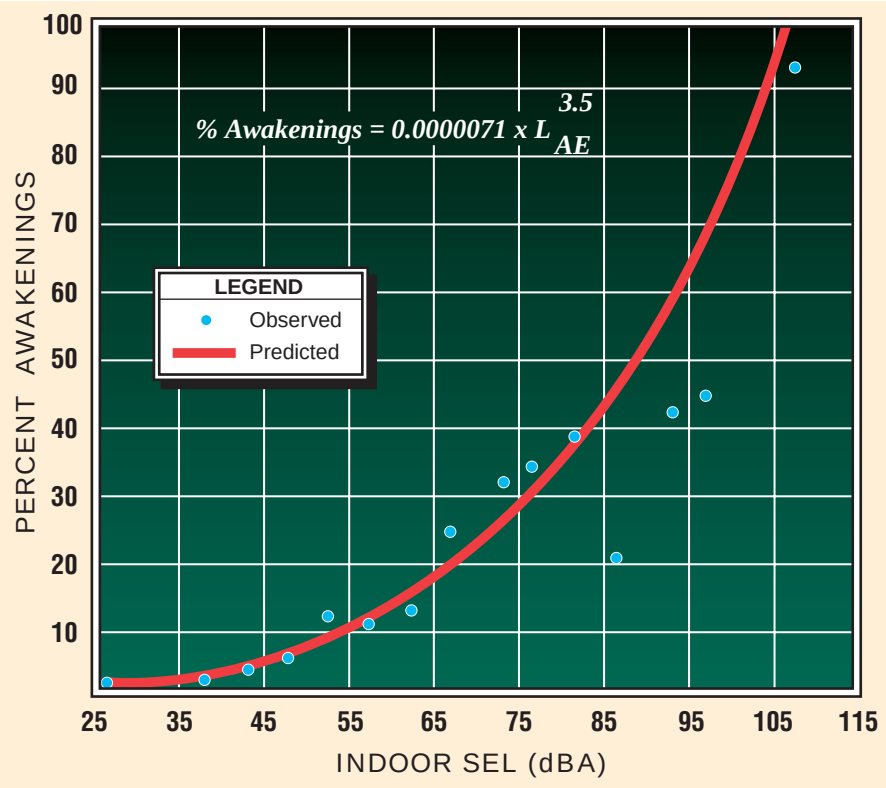
Source: Pearson, K.S. et al. 1990.

The findings of many of these sleep disturbance studies are of little usefulness to policy-makers and airport residents. For them, the important question is, "When does sleep disturbance caused by environmental noise become severe enough to constitute a problem in the community?"

Finegold et al. (1994) reviewed the data in the Pearsons report of 1990 and developed a regression analysis. As shown in **Exhibit B**, an exponential curve was found to fit the categorized data reasonably well. They recommend that this curve be used as a provisional means of predicting potential sleep disturbance from aircraft noise. They caution that because the curve was derived using Pearsons' laboratory, as well as in-home data, the predictions of sleep disruption in an actual community setting derived from this curve are likely to be high.

EXHIBIT B

FINEGOLD'S SLEEP DISTURBANCE CURVE



Source: Finegold et al. 1994.
Note: Based on laboratory and field data reported in Pearsons et al. 1989.

The findings of many of these sleep disturbance studies, while helping to answer basic research questions, are of little usefulness to policy-makers and airport residents. For them, the important question is, "When does sleep disturbance caused by environmental noise become severe enough to constitute a problem in the community?" Kryter (1984, pp. 434-443) reviews in detail one important study that sheds light on this question. The Directorate of Operational Research and Analysis (DORA) of the British Civil Aviation Authority conducted an in-depth survey of 4,400 residents near London's Heathrow

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The 65 DNL contour defines a noise impact envelope which encompasses all of the area within which significant sleep disturbance may be expected.

and Gatwick Airports over a four-month period in 1979 (DORA 1980). The study was intended to answer two policy-related questions: "What is the level of aircraft noise which will disturb a sleeping person?" and "What level of aircraft noise prevents people from getting to sleep?"

Analysis of the survey results indicated that the best correlations were found using cumulative energy dosage metrics, namely Leq. Kryter notes that support for the use of the Leq metric is provided by the finding that some respondents could not accurately recall the time association of a specific flight with an arousal from sleep. This suggests that the noise from successive overflights increased the general state of arousability from sleep.

With regard to difficulty in getting to sleep, the study found 25 percent of the respondents reporting this problem at noise levels of 60 Leq, 33 percent at 65 Leq, and 42 percent at 70 Leq. The percentage of people who reported being awakened at least once per week by aircraft noise was 19 percent at 50 Leq, 24 percent at 55 Leq, and 28 percent at 60 Leq. The percentage of people bothered "very much" or "quite a lot" by aircraft noise at night when in bed was 22 percent at 55 Leq and 30 percent at 60 Leq. Extrapolation of the trend line would put the percentage reporting annoyance at 65 Leq well above 40 percent.

DORA concluded with the following answers to the policy-related questions: (1) A significant increase in reports of sleep arousal will occur at noise levels at or above 65 Leq; (2) A significant increase in the number of people reporting difficulty in getting to sleep will occur at noise levels at or above 70 Leq. Kryter disagrees with these findings. He believes that a more careful reflection upon the data leads to the conclusion that noise levels approximately 10 decibels lower would represent the appropriate thresholds — 55 and 60 Leq.

At any airport, the 65 DNL contour developed from total daily aircraft activity will be larger than the 55 Leq developed from nighttime activity only. (At an airport with only nighttime use, the 65 DNL contour will be identical with the 55 Leq contour because of the effect of the 10 dB penalty in the DNL metric.) Thus, the 65 DNL contour defines a noise impact envelope which encompasses all of the area within which significant sleep disturbance may be expected based on Kryter's interpretation of the DORA findings discussed above.A

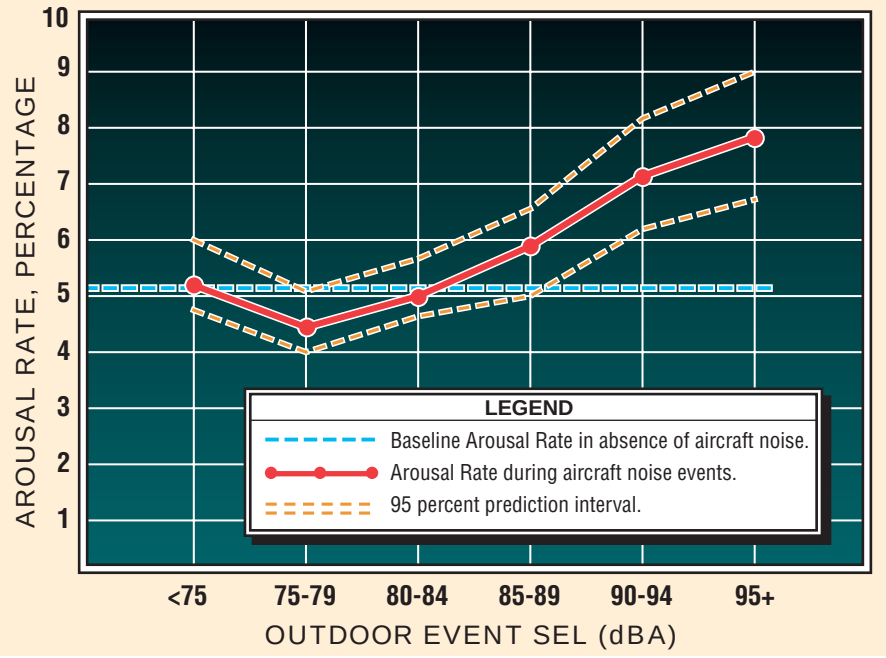
Researchers found that for aircraft noise events below 90 SEL, as measured outdoors, there was likely to be no measurable increase in rates of sleep disturbance.

recent study was conducted by the British Civil Aviation Authority to examine the relationship of nighttime aircraft noise and sleep disturbance near four major airports — Heathrow, Gatwick, Stansted, and Manchester (Ollerhead, et al. 1992). A total of 400 subjects were monitored for a total of 5,742 subject-nights. Nightly awakenings were found to be very common as part of natural sleep patterns. Researchers found that for aircraft noise events below 90 SEL, as measured outdoors, there was likely to be no measurable increase in rates of sleep disturbance. (The indoor level can be roughly estimated as approximately 20 to 25 decibels less than the outdoor level.) Where noise events ranged from 90 to 100 SEL, a very small rate of increase in disturbance was possible. Overall, rates of sleep disturbance were found to be more closely correlated with sleep stage than with periods of peak aircraft activity. That is, sleep was more likely to be disrupted, from any cause, during light stages than during heavy stages.

Exhibit C shows the relationship between arousal from sleep and outdoor sound exposure levels (SELs) found in the 1992 British study. The results have been statistically adjusted to control for the effects of individual variability in sleep disturbance. The study found that the arousal

EXHIBIT C

RELATIONSHIP BETWEEN AVERAGE SLEEP DISTURBANCE AND AIRCRAFT NOISE LEVEL



Source: Ollerhead, J.B. et al. 1992, p. 25.
Note: Estimates controlled for the effects of individual arousability.

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While vibration contributes to annoyance reported by residents near airports, especially when it is accompanied by high audible sound levels, it rarely carries enough energy to damage safely constructed structures.

rate for the average person, with no aircraft noise, was 5.1 percent. Aircraft noise of less than SEL 90 dBA was found not to be statistically significant as a cause of sleep disturbance. (According to the study, this would correspond to an Lmax of approximately 81 dBA. Lmax is the loudest sound the human ear would actually hear during the 90 SEL noise event. The interior Lmax would be approximately 20 to 25 decibels less — roughly 56 to 61 dBA.) The 95 percent prediction interval is shown on the graph not to rise above the 5.1 percent base arousal rate until it is above 90 dBA. Again, it should be emphasized that these conclusions relate to the average person. More easily aroused people will be disturbed at lower noise levels, but they are also more likely to be aroused from other sources (Ollerhead, et al. 1992).

STRUCTURAL DAMAGE

Structural vibration from aircraft noise in the low frequency ranges is sometimes a concern of airport neighbors. While vibration contributes to annoyance reported by residents near airports, especially when it is accompanied by high audible sound levels, it rarely carries enough energy to damage safely constructed structures. High-impulse sounds such as blasting, sonic booms, and artillery fire are more likely to cause damage than continuous sounds such as aircraft noise. A document published by the National Academy of Sciences suggested that one may conservatively consider noise levels above 130 dB lasting more than one second as potentially damaging to structures (CHABA 1977). Aircraft noise of this magnitude occurs on the ramp and runway and seldom, if ever, occurs beyond the boundaries of a commercial or general aviation airport.

The risk of structural damage from aircraft noise was studied as part of the environmental assessment of the Concorde supersonic jet transport. The probability of damage from Concorde overflights was found to be extremely slight. Actual overflight noise from the Concorde at Sully Plantation near Dulles International Airport in Fairfax County, Virginia was recorded at 115 dBA. No damage to the historic structures was found, despite their age. Since the Concorde causes significantly more vibration than conventional commercial jet aircraft, the risk of structural damage caused by aircraft noise near airports is considered to be negligible (Hershey et al. 1975; Wiggins 1975).

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The psychological impact of aircraft noise is a more serious concern than direct physical impact.

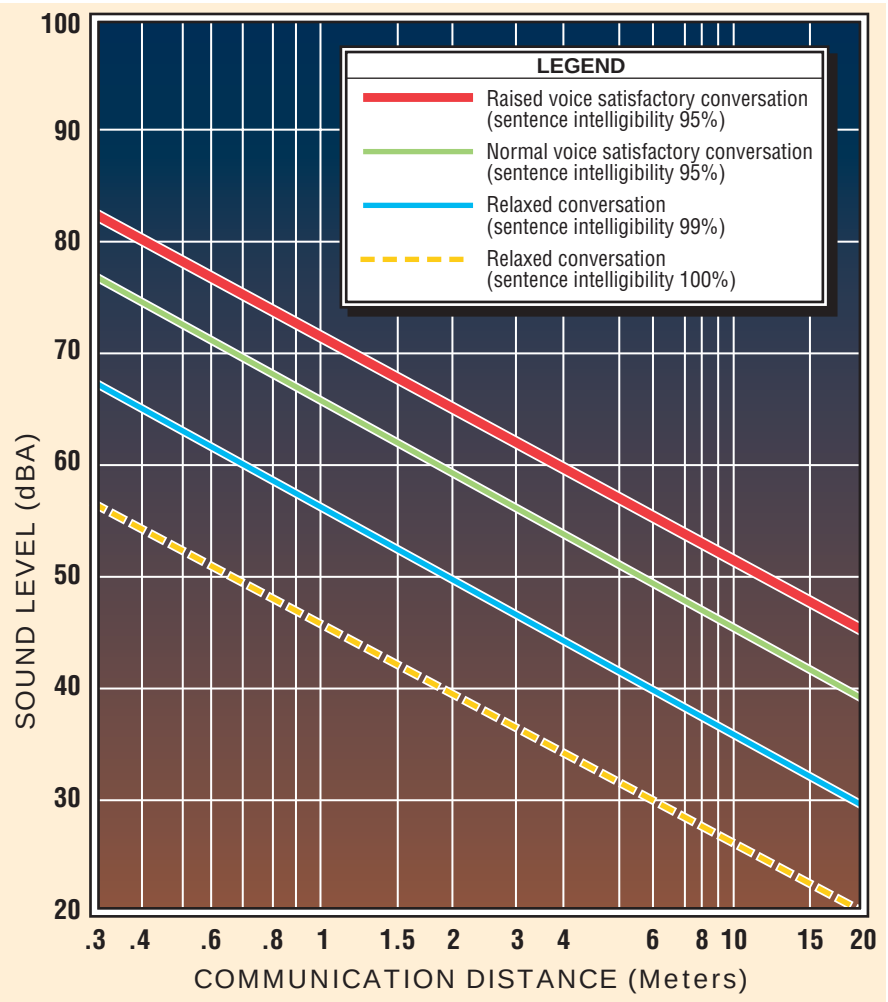
OTHER ANNOYANCES

The psychological impact of aircraft noise is a more serious concern than direct physical impact. Studies conducted in the late 1960s and early 1970s found that the interruption of communication, rest, relaxation, and sleep are important causes for complaints about aircraft noise. Disturbance of television viewing, radio listening, and telephone conversations are also sources of serious annoyance.

Exhibit D shows the relationship between sound levels and communicating distance for different voice levels. Assuming a communicating distance of 2 meters, communication becomes unsatisfactory with a steady

EXHIBIT D

MAXIMUM DISTANCES OUTDOORS OVER WHICH CONVERSATION IS SATISFACTORILY INTELLIGIBLE IN STEADY NOISE



Source: U.S. Environmental Protection Agency, 1974. Cited in Caltrans, 1993.

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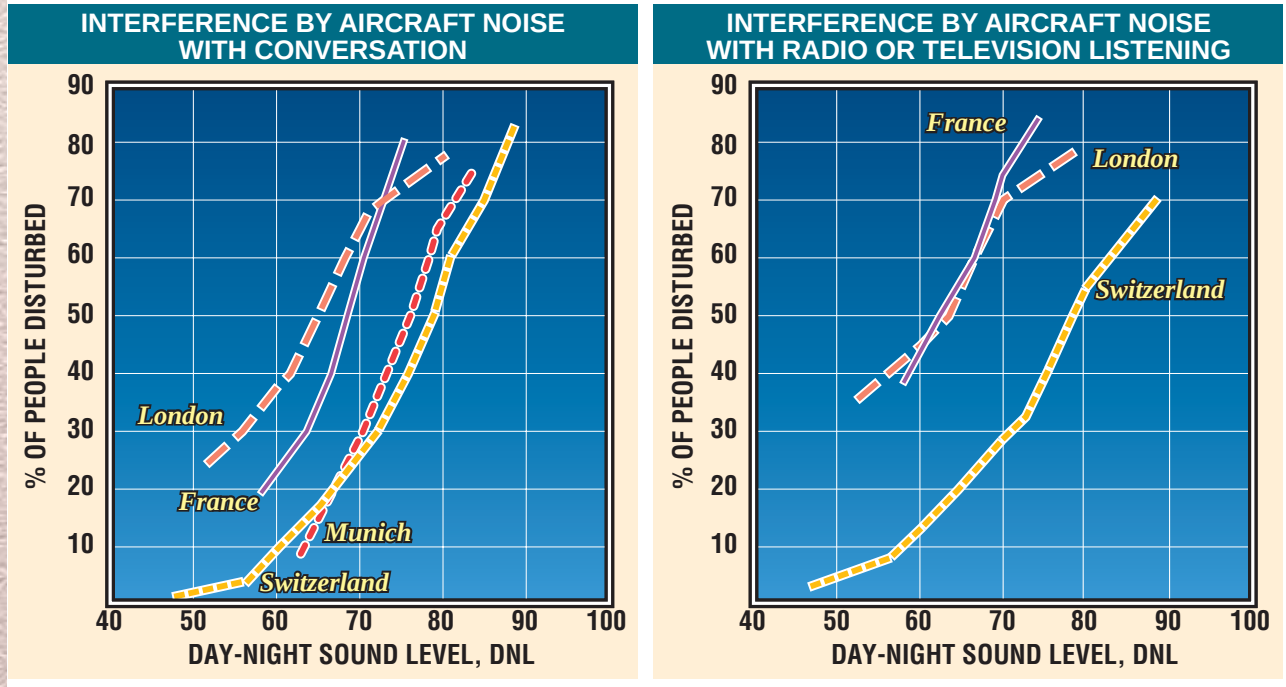
noise level above approximately 65 decibels. At 65 decibels, a raised voice is required to maintain satisfactory conversation. Another way to interpret this is that a raised voice would be interrupted by a sound event above 65 decibels. A normal voice would be interrupted, at 2 meters, by a sound event of 60 decibels.

Exhibit E shows the impact of aircraft noise on conversation and radio or television listening. These results, summarized by Schultz (1978), were derived from surveys conducted in London, France, Munich, and Switzerland. Differences in the amount of disturbance reported in each study are based on how each survey defined disturbance. The British study counted mild disturbance, the French moderate disturbance, and the German and Swiss great disturbance.

EXHIBIT E

INTERFERENCE BY AIRCRAFT NOISE WITH VARIOUS ACTIVITIES



Note: Differences in amount of interference reported are related to how individual surveys defined interference. London counted mild disturbance, France moderate disturbance, and Munich and Switzerland great disturbance.

Source: Shultz, T.J. 1978.

In the case of conversation disruption, nine percent were greatly annoyed by noise of 60 DNL in the Swiss study. About 12 to 16 percent of those in the Swiss and German studies considered themselves to be greatly disturbed by aircraft noise of 65 DNL. At 75 DNL, 40 to 50 percent

Individual human response to noise is highly variable and is influenced by many emotional and physical factors.

considered themselves greatly disturbed. In the French study, 23 percent considered themselves moderately disturbed by aircraft noise at 60 DNL, 35 percent at 65 DNL, and 75 percent at 75 DNL. In the British study, 37 percent were mildly disturbed by aircraft noise at 60 DNL, 50 percent at 65 DNL, and about 72 percent at 75 DNL.

Regarding interference with television and radio listening, about 13 percent in the Swiss study were greatly disturbed by aircraft noise above 60 DNL, 21 percent at 65 DNL, and 40 percent at 75 DNL. In the British and French studies, 42 to 45 percent were mildly to moderately disturbed by noise at 60 DNL, 55 percent at 65 DNL, and 75 to 82 percent at 75 DNL.

In some cases, noise is only an indirect indicator of the real concern of airport neighbors — safety. The sound of approaching aircraft may cause fear in some people about the possibility of a crash. This fear is a factor motivating some complaints of annoyance in neighborhoods near airports around the country. (See Richards and Ollerhead 1973; FAA 1977; Kryter 1984, p. 533.) This effect tends to be most pronounced in areas directly beneath frequently used flight tracks (Gjestland 1989).

The EPA has also found that continuous exposure to high noise levels can affect work performance, especially in high-stress occupations. Based on the FAA's land use compatibility guidelines, discussed in the Technical Information Paper on Noise and Land Use Compatibility, these adverse affects are most likely to occur within the 75 DNL contour.

Individual human response to noise is highly variable and is influenced by many factors. These include emotional variables, feelings about the necessity or preventability of the noise, judgments about the value of the activity creating the noise, an individual's activity at the time the noise is heard, general sensitivity to noise, beliefs about the impact of noise on health, and feelings of fear associated with the noise. Physical factors influencing an individual's reaction to noise include the background noise in the community, the time of day, the season of the year, the predictability of the noise, and the individual's control over the noise source.

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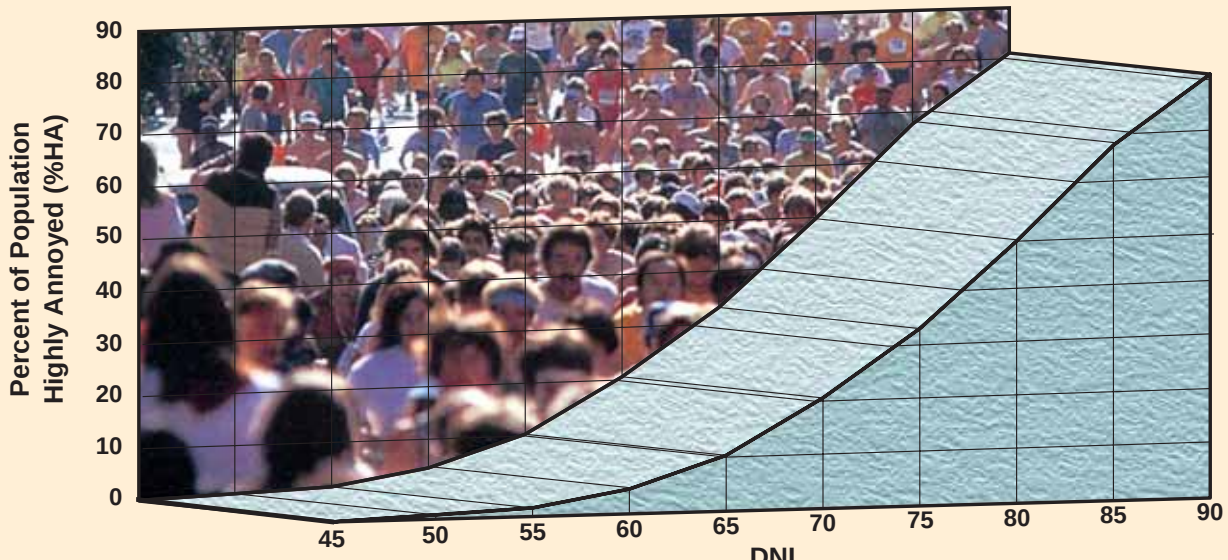
AVERAGE COMMUNITY RESPONSE TO NOISE

Although individual responses to noise can vary greatly, the average response among a group of people is much less variable. This enables us to generalize about the average impacts of aircraft noise on a community despite the wide variations in individual response.

Many studies have examined average residential community response to noise, focusing on the relationship between annoyance and noise exposure. (See DORA 1980; Fidell et al. 1989; Finegold et al. 1992 and 1994; Great Britain Committee on the Problem of Noise 1963; Kryter 1970; Richards and Ollerhead 1973; Schultz 1978; U.S. EPA 1974.) These studies have produced similar results, finding that annoyance is most directly related to cumulative noise exposure, rather than single-event exposure.

EXHIBIT F

PERCENTAGE OF POPULATION HIGHLY ANNOYED BY GENERAL TRANSPORTATION NOISE



Equation for Curve: $\%HA = \frac{100}{1 + e^{(11.13 - .14\,Ldn)}}$

PERCENT HIGHLY ANNOYED AT SELECTED NOISE LEVELS

DNL	45	50	55	60	65	70	75	80	85	90
%HA	0.8%	1.6%	3.1%	6.1%	11.6%	20.9%	34.8%	51.7%	68.4%	81.3%

Source: Finegold et al. 1992 and 1994.

Annoyance has been found to increase along an S-shaped or logistic curve as cumulative noise exposure increases, as shown in **Exhibit F**. Developed by Finegold et al. (1992 and 1994), it is based on data derived from a

The updated Schultz Curve shows that annoyance is measurable beginning at 45 DNL, where 0.8 percent of people are highly annoyed. It increases gradually to 6.1 percent at 60 DNL. Starting at 65 DNL, the percentage of people expected to be highly annoyed increases steeply from 11.6 percent up to 68.4 percent at 85 DNL.

number of studies of transportation noise (Fidell 1989). It shows the relationship between DNL levels and the percentage of people who are highly annoyed. Known as the "updated Schultz Curve" because it is based on the work of Schultz (1978), it represents the best available source of data for the noise dosage-response relationship (FICON 1992, Vol. 2, pp. 3-5; Finegold et al. 1994, pp. 26-27).

The updated Schultz Curve shows that annoyance is measurable beginning at 45 DNL, where 0.8 percent of people are highly annoyed. It increases gradually to 6.1 percent at 60 DNL. Starting at 65 DNL, the percentage of people expected to be highly annoyed increases steeply from 11.6 percent up to 68.4 percent at 85 DNL. Note that this relationship includes only those reported to be "highly annoyed." Based on other research, the percentages would be considerably higher if they also included those who were "moderately or mildly annoyed" (Richards and Ollerhead 1973; Schultz 1978).

SUMMARY

The effects of noise on people include hearing loss, other ill health effects, and annoyance. While harm to physical health is generally not a problem in neighborhoods near airports, annoyance is a common problem. Annoyance is caused by sleep disruption, interruption of conversations, interference with radio and television listening, and disturbance of quiet relaxation.

Individual responses to noise are highly variable, making it very difficult to predict how any person is likely to react to environmental noise. The average response among a large group of people, however, is much less variable and has been found to correlate well with cumulative noise dosage metrics such as Leq, DNL, and CNEL. The development of aircraft noise impact analysis techniques has been based on this relationship between average community response and cumulative noise exposure.

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TECHNICAL INFORMATION PAPER

Measuring the Impact of Noise on People

TECHNICAL INFORMATION PAPER

MEASURING THE IMPACT OF NOISE ON PEOPLE

In aircraft noise analysis, the effect of noise on residents near airports is often the most important concern.

In aircraft noise analysis, the effect of noise on residents near airports is often the most important concern. While certain public institutions and, at very high noise levels, some types of businesses may also be disturbed by noise, people in their homes are typically the most vulnerable to noise problems.

The most common way to measure the impact of noise on residents is to estimate the number of people residing within the noise contours. This is done by overlaying noise contours on census block maps or on maps of dwelling units. The number of people within each 5 DNL range (e.g., from 65 to 70 DNL, from 70 to 75 DNL, etc.) is then estimated.

This is the approach required in F.A.R. Part 150 noise compatibility studies. While it has the advantage of simplicity, it has one disadvantage: it implicitly assumes that all people are equally affected by noise, regardless of the noise level they experience. Clearly, however, the louder the noise, the greater the noise problem. As noise increases, more people become concerned about it, and the concerns of each individual become more serious.

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Although individual responses to noise can vary greatly, the average response among a group of people is much less variable. This enables us to generalize about the average impacts of aircraft noise on a community despite the wide variations in individual response.

AVERAGE COMMUNITY RESPONSE TO NOISE

Individual human response to noise is highly variable and is influenced by many factors. These include emotional variables, feelings about the necessity or preventability of the noise, judgments about the value of the activity creating the noise, an individual's activity at the time the noise is heard, general sensitivity to noise, beliefs about the impact of noise on health, and feelings of fear associated with the noise.

Physical factors influencing an individual's reaction to noise include the background noise in the community, the time of day, the season of the year, the predictability of the noise, and the individual's control over the noise source.

Although individual responses to noise can vary greatly, the average response among a group of people is much less variable. This enables us to generalize about the average impacts of aircraft noise on a community despite the wide variations in individual response.

Many studies have examined average community response to noise, focusing on the relationship between annoyance and noise exposure. (See DORA 1980; Fidell et al. 1989; Finegold et al. 1992 and 1994; Great Britain Committee on the Problem of Noise 1963; Kryter 1970; Richards and Ollerhead 1973; Schultz 1978; U.S. EPA 1974.) These studies have produced similar results, finding that annoyance is most directly related to cumulative noise exposure, rather than single-event exposure.

Annoyance has been found to increase along an S-shaped or logistic curve as cumulative noise exposure increases, as shown in **Exhibit A**. This graph shows the percentage of residents either somewhat annoyed or seriously annoyed by noise of varying DNL levels. It was developed from research in the early 1970s (Richards and Ollerhead 1973). It is interesting that the graph indicates that at even extremely low noise levels, below 45 DNL, a very small percentage of people remain annoyed by aircraft noise. Conversely, the graph shows that while the percentage of people annoyed by noise exceeds 95 percent at 75 DNL, it only approaches, and does not reach, 100 percent even at the extremely high noise level of 85 DNL.

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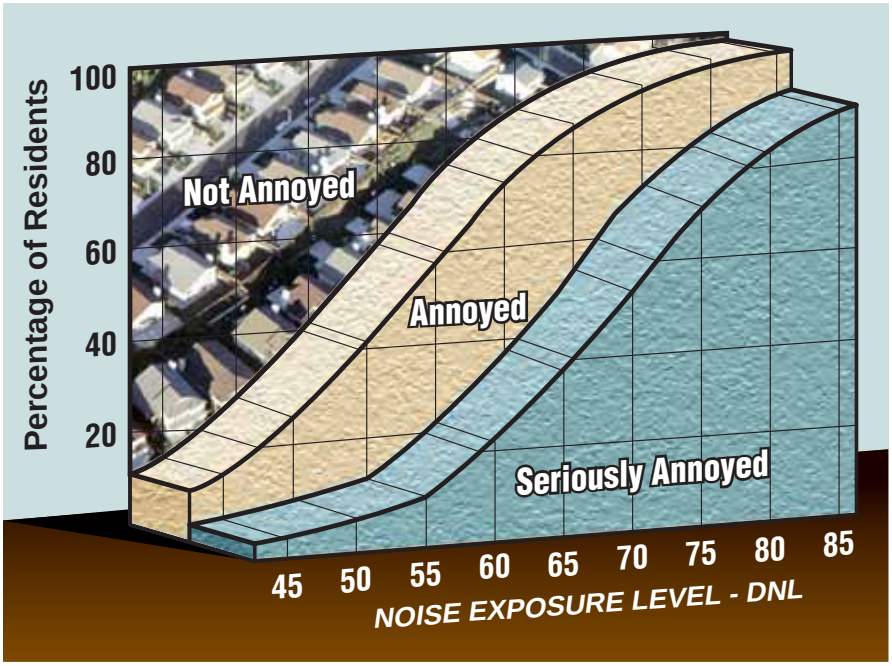
EXHIBIT A

ANNOYANCE CAUSED BY AIRCRAFT NOISE IN RESIDENTIAL AREAS



Source: Richards and Ollerhead 1973, p.31

Starting at 65 DNL, the percentage of people expected to be highly annoyed increases steeply from 11.6 percent up to 68.4 percent at 85 DNL.

A similar graph is shown in **Exhibit B**. Developed by Finegold et al. (1992 and 1994), it is based on data derived from a number of studies of transportation noise (Fidell 1989). It shows the relationship between DNL levels and the percentage of people who are highly annoyed. Known as the "updated Schultz Curve" because it is based on the work of Schultz (1978), it represents the best available source of data for the noise dosage-response relationship (FICON 1992, Vol. 2, pp. 3-5; Finegold et al. 1994, pp. 26-27).

The updated Schultz Curve shows that annoyance is measurable beginning at 45 DNL, where 0.8 percent of people are highly annoyed. It increases gradually to 6.1 percent at 60 DNL. Starting at 65 DNL, the percentage of people expected to be highly annoyed increases steeply from 11.6 percent up to 68.4 percent at 85 DNL. Note that this relationship includes only those reported to be "highly annoyed." Based on the findings shown in **Exhibit A**, the percentages would be considerably higher if they also included those who were "moderately annoyed."

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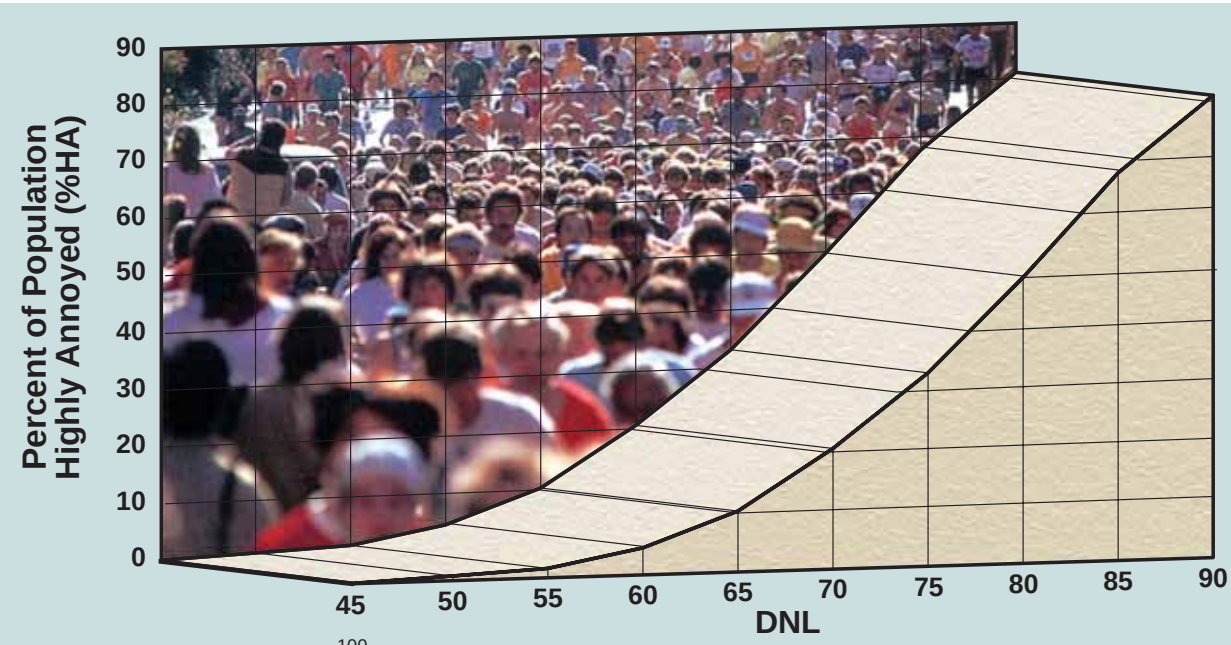
EXHIBIT B

PERCENTAGE OF POPULATION HIGHLY ANNOYED BY GENERAL TRANSPORTATION NOISE



Equation for Curve: $\%HA = \frac{100}{1 + e^{(11.13 - .14\,Ldn)}}$

PERCENT HIGHLY ANNOYED AT SELECTED NOISE LEVELS

DNL	45	50	55	60	65	70	75	80	85	90
%HA	0.8%	1.6%	3.1%	6.1%	11.6%	20.9%	34.8%	51.7%	68.4%	81.3%

Source: Finegold et al. 1992 and 1994.

THE DEVELOPMENT OF WEIGHTING FUNCTIONS

Recognizing the tendency of annoyance response rates to increase systematically as noise increases, researchers in the 1960s began developing weighting functions to help estimate the total impact of noise on a population (CHABA 1977, p. B-1). The population impacted by noise at a given level would be multiplied by the appropriate weighting function. The higher the noise level, the higher the weighting function. The results for all noise levels would be added together. The sum would be a single number purported to represent the net impact of noise on the affected population.

The CHABA report (p. VII-5) recommended the use of the original Schultz Curve as the basis for developing weighting functions. It recommended that weighting functions be developed by calculating the percentage

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Based on the response curve shown in Exhibit A, the weighting functions can be considered as roughly equivalent to the proportion of people likely to be either highly annoyed or somewhat annoyed by noise.

of people likely to be highly annoyed by noise at various DNL levels. These values were then converted to weighting functions by arbitrarily setting the function for 75 DNL at 1.00. Functions for the other noise levels were set in proportion to the percent highly annoyed. The results of applying these weighting functions to a population was known as the "sound level-weighted population" impacted by noise, or the "level-weighted population."

UPDATED LEVEL-WEIGHTED POPULATION FUNCTIONS

As discussed above, the original Schultz Curve has been updated to take into account additional studies of community response to noise. The updated curve is shown in **Exhibit B**. Coffman Associates has updated the weighting functions developed by CHABA (1977, p. B-7) to correspond with the updated Schultz Curve. **Table 1** shows the percentage of people likely to be highly annoyed by aircraft noise for 5 DNL increments ranging from 45 to 80 DNL. It also shows weighting functions for use in calculating level-weighted population. These were developed by setting the function for the 75 to 80 DNL range at unity (1.000). The other functions were computed in proportion to the values for "percent highly annoyed."

TABLE 1

PERCENT HIGHLY ANNOYED AND WEIGHTED FUNCTION BY DNL RANGE

DNL RANGE	AVERAGE PERCENT HIGHLY ANNOYED	WEIGHTING FUNCTION
45-50	1.19%	0.028
50-55	2.36%	0.055
55-60	4.63%	0.107
60-65	8.87%	0.205
65-70	16.26%	0.376
70-75	27.83%	0.644
75-80	43.25%	1.000

Based on the response curve shown in **Exhibit A**, the weighting functions can be considered as roughly equivalent to the proportion of people likely to be either highly annoyed or somewhat annoyed by noise.

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The response to noise among a group of people varies systematically with changes in noise levels. As noise increases, the proportion of people disturbed by noise increases.

EXAMPLE USE OF LEVEL-WEIGHTED POPULATION

In airport noise compatibility planning, the level-weighted population (LWP) methodology is particularly useful in comparing the results of different noise analysis scenarios. Since the percentage of people who are highly annoyed increases with increasing noise levels, the LWP values may differ between operating scenarios even though the total population within the noise impact boundary is equal. An example below illustrates the LWP methodology. Scenarios A and B show the effects of two airport operating scenarios. While the population subject to noise above 65 DNL is the same for both, Scenario B has a lower LWP because fewer people are impacted by the higher noise levels.

TABLE 2

LEVEL-WEIGHTED POPULATION METHODOLOGY - EXAMPLE

	SCENARIO A			SCENARIO B		
DNL Range	LWP Factor	Population	LWP	LWP Factor	Population	LWP
65-70	.376	x 2,000	= 752	.376	x 3,000	= 1,128
70-75	.644	x 1,400	= 902	.644	x 700	= 451
75+	1.000	x 600	= 600	1.000	x 300	= 300
Total		4,000	2,254		4,000	1,879

SUMMARY

The response to noise among a group of people varies systematically with changes in noise levels. As noise increases, the proportion of people disturbed by noise increases. This relationship has been estimated and is presented in the "updated Schultz Curve" shown in **Exhibit B**.

The data in the updated Schultz Curve can be used to develop weighting functions for computing the numbers of people likely to be annoyed by noise. This is especially useful in comparing the net impact of different noise scenarios.

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TECHNICAL INFORMATION PAPER

Aircraft Noise and Land Use Compatibility Guidelines

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AIRCRAFT NOISE AND LAND USE COMPATIBILITY GUIDELINES

DNL accumulates the total noise occurring over a 24-hour period, with a 10 decibel penalty applied to noise occurring between 10:00 p.m. and 7:00 a.m.

In past years, noise has become a recognized factor in the land use planning process for cities, metropolitan planning organizations, counties, and states. Significant strides have been made in the reduction of noise at its source; however, noise cannot be entirely eliminated. Local, state, and federal agencies, in recognition of this fact, have developed guidelines and regulations to address noise within the land use planning process.

The fundamental variability in the way individuals react to noise makes it impossible to accurately predict how any one individual will respond to a given noise level. However, when one considers the community as a whole, trends emerge which relate noise to annoyance. This enables us to make reasonable evaluations of the average impacts of aircraft noise on a community.

According to scientific research, noise response is most readily correlated with noise as measured with cumulative noise metrics. A variety of cumulative noise exposure metrics have been used in research studies over the years. In the United States, the DNL (day-night noise level) metric has been widely used. DNL accumulates the total noise occurring over a 24-hour period, with a 10 decibel penalty applied to noise occurring between 10:00 p.m. and 7:00 a.m. DNL correlates well with average community response to

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Research has shown that even at extremely high noise levels, there are at least some people, albeit a small percentage, who are not annoyed. Conversely, it also shows that at even very low noise levels, at least some people will be annoyed.

noise. (For more information on noise measurement, see the TIP entitled, "The Measurement and Analysis of Sound.")

In California, the CNEL (community noise equivalent level) metric is used instead of the DNL metric. The two metrics are very similar. DNL accumulates the total noise occurring during a 24-hour period, with a 10 decibel penalty applied to noise occurring between 10:00 p.m. and 7:00 a.m. The CNEL metric is the same except that it also adds a 4.77 decibel penalty for noise occurring between 7:00 p.m. and 10:00 p.m. There is little actual difference between the two metrics in practice. Calculations of CNEL and DNL from the same data generally yield values with less than a 0.7 decibel difference (Caltrans 1983, p. 37).

The results of studies on community noise impacts show that the number of people expressing concerns with noise increases as the noise level increases. The level of concern increases along an S-shaped curve, as shown in **Exhibit A**. Research has shown that even at extremely high noise levels, there are at least some people, albeit a small percentage, who are not annoyed. Conversely, it also shows that at even very low noise levels, at least some people will be annoyed.

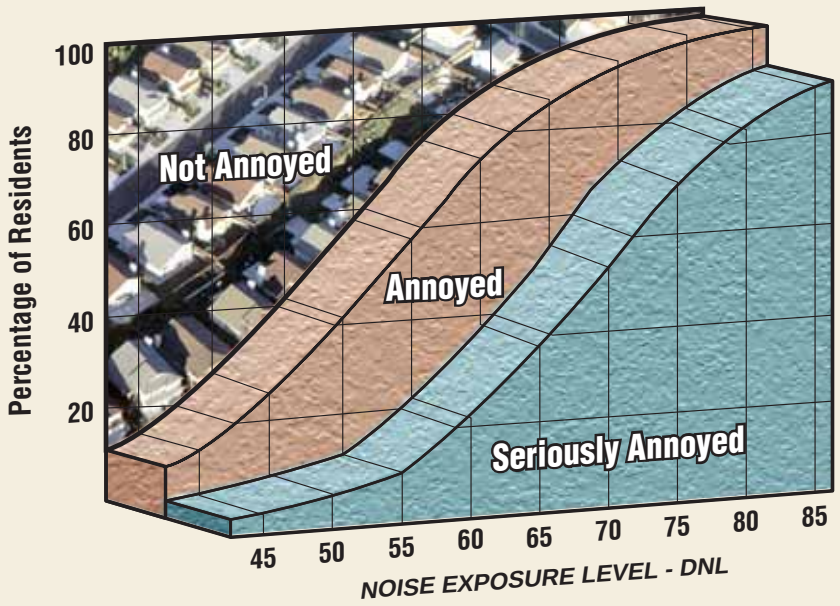
AMBIENT NOISE LEVEL AS A FACTOR OF ANNOYANCE LEVEL

Noise analysts have speculated that the overall ambient noise level in an environment determines to what degree people will be annoyed by a given level of aircraft noise. That is, in a louder environment it takes a louder level of aircraft noise to generate complaints than it does in a quieter environment.

Kryter (1984, p. 582) reviewed some of the research on this question. He noted that the effects of laboratory tests and attitude surveys on this question are somewhat inconclusive. A laboratory test he reviewed found that recordings of aircraft noise were judged to be less intrusive as the background road traffic noise was increased. On the other hand, an attitude survey in the Toronto Airport area found that the effects of background noise were not significant.

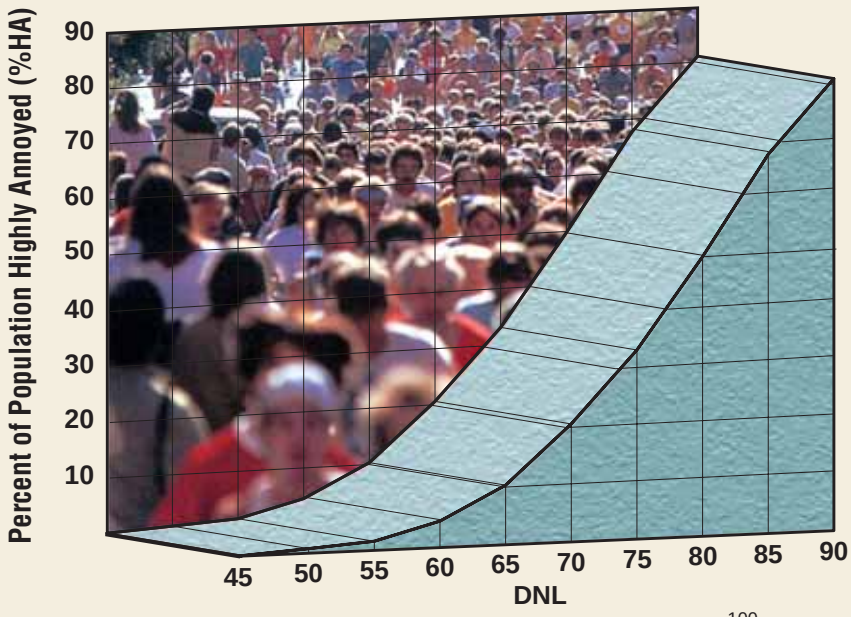
Noise analysts have speculated that the overall ambient noise level in an environment determines to what degree people will be annoyed by a given level of aircraft noise.

ANNOYANCE CAUSED BY AIRCRAFT NOISE IN RESIDENTIAL AREAS



Source: Richards and Ollerhead 1973, p.31

UPDATED SCHULTZ CURVE



Equation for Curve: $\%HA = \frac{100}{1 + e\,(11.13 - .14\,Ldn)}$

Source: Finegold et al. 1992 and 1994.

The studies reviewed by Kryter were intended to evaluate whether or not background noise provided some degree of masking of aircraft noise. They did not, however, take into consideration the subjects' rating of the overall quality of the noise environment.

The U.S. Environmental Protection Agency (EPA) has provided guidelines to address the question of background noise and its relationship to aircraft noise.

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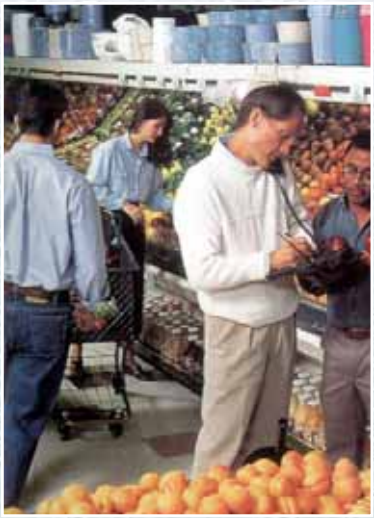


The degree of annoyance which people suffer from aircraft noise varies depending on their activities at any given time.

The EPA has determined that complaints can be expected when the intruding DNL exceeds the background DNL by more than 5 decibels (U.S. EPA 1974). The California Department of Transportation (Caltrans 2000, pp. 7- 24 - 7-25) notes that the level of background (ambient) noise should be used in determining the suitable aircraft noise contour of significance. Specifically, adjustments have been made in areas with quiet background noise levels of 50 to 55 CNEL. In those cases, aircraft CNEL contours are prepared down to 55 or 60 CNEL, and land use compatibility criteria are adjusted to apply to those areas. The State of Oregon Department of Aviation (Oregon 2003) also requires the preparation of noise contours down to the 55 DNL level. This noise contour is used to establish the noise impact boundary for air carrier airports within the state.

The Federal Interagency Committee on Noise (FICON 1992, p. 2-6) examined the question of background noise and its relationship to perceptions of aircraft noise. It reviewed the research in this field, concluding that there was a basis for believing that, in addition to the magnitude of aircraft noise, the difference between background noise and aircraft noise was in some way related to human perceptions of noise disturbance. It noted, however, that there was insufficient scientific data to provide authoritative guidance on the consideration of these effects. FICON advocated further research in this area.

LAND USE COMPATIBILITY GUIDELINES

The degree of annoyance which people suffer from aircraft noise varies depending on their activities at any given time. People rarely are as disturbed by aircraft noise when they are shopping, working, or driving as when they are at home. Transient hotel and motel residents seldom express as much concern with aircraft noise as do permanent residents of an area. The concept of "land use compatibility" has arisen from this systematic variation in human tolerance to aircraft noise. Since the 1960s, many different sets of land use compatibility guidelines have been proposed and used. This section reviews some of the more well known guidelines.

FEDERAL LAND USE COMPATIBILITY GUIDELINES

The U.S. Department of Housing and Urban Development (HUD) first published noise assessment requirements in 1971 for evaluating the acceptability of sites for housing assistance.

FAA-DOD Guidelines

In 1964, the Federal Aviation Administration (FAA) and the U.S. Department of Defense (DOD) published similar documents setting forth guidelines to assist land use planners in areas subjected to aircraft noise from nearby airports. These guidelines, presented in **Table 1**, establish three zones and the expected responses to aircraft noise from residents of each zone. In Zone 1, areas exposed to noise below 65 DNL, essentially no complaints would be expected although noise could be an occasional annoyance. In Zone 2, areas exposed to noise between 65 and 80 DNL, individuals may complain, perhaps vigorously. In Zone 3, areas in excess of 80 DNL, vigorous complaints would be likely and concerted group action could be expected.

TABLE 1

CHART FOR ESTIMATING RESPONSE OF COMMUNITIES EXPOSED TO AIRCRAFT NOISE - 1964 FAA-DOD GUIDELINES

NOISE LEVEL	ZONE	DESCRIPTION OF EXPECTED RESPONSE
Less than 65 DNL	1	No complaints would be expected. The noise may, however, interfere occasionally with certain activities of the residents.
65 to 80 DNL	2	Individuals may complain, perhaps vigorously. Concerted group action is possible.
Greater than 80 DNL	3	Individual reactions would likely include repeated, vigorous complaints. Concerted group action might be expected.

Source: U.S. DOD 1964. Cited in Kryter 1984, p. 616.

HUD Guidelines

The U.S. Department of Housing and Urban Development (HUD) first published noise assessment requirements in 1971 for evaluating the acceptability of sites for housing assistance. These requirements contained standards for exterior noise levels along with policies for approving HUD-supported or assisted housing projects in high noise areas. In general, the requirements established three zones: an acceptable zone where all projects could be approved, a normally unacceptable zone where

mitigation measures would be required and where each project would have to be individually evaluated for approval or denial, and an unacceptable zone in which projects would not, as a rule, be approved.

In 1979, HUD issued revised regulations which kept the same basic standards, but adopted new descriptor systems which were considered advanced over the old system. **Table 2** summarizes the revised HUD requirements.

TABLE 2

SITE EXPOSURE TO AIRCRAFT NOISE
1979 HUD REQUIREMENTS

ACCEPTABLE CATEGORY	DAY-NIGHT AVERAGE SOUND LEVEL	SPECIAL APPROVALS AND REQUIREMENTS
Acceptable	Not exceeding 65 dB	None
Normally Unacceptable	Above 65 dB but not exceeding 75 dB	Special approvals, environmental review, attenuation
Unacceptable	Above 75 dB	Special approvals, environmental review, attenuation

Source: U.S. HUD 1979

Veterans Administration Guidelines

The Veterans Administration has established policies and procedures for the appraisal and approval of VA loans relative to residential properties located near major civilian airports and military air bases. The agency's regulations, contained within M26-2, Change 15, state that "the VA must recognize the possible unsuitability for residential use of certain properties and the probable adverse effect on livability and/or value of homes in the vicinity of major airports and air bases. Such adverse effects may be due to a variety of factors including noise intensity." **Table 3** contains the VA's noise zones and associated development requirements and limitations.

EPA Guidelines

The U.S. Environmental Protection Agency published a document in 1974 suggesting maximum noise exposure levels to protect public health with an adequate margin of safety. These are shown in **Table 4**. They note that the risk of hearing loss may become a concern with exposure

TABLE 3

VETERANS ADMINISTRATION NOISE GUIDELINES NOVEMBER 23, 1992

NOISE ZONE	CNR (Composite Noise Rating)	NEF (Noise Exposure Forecasts)	DNL (Day/Night Average Sound Level)
1	Under 100	Under 30	Under 65
2	100-115	30-40	65-75
3	Over 115	Over 40	Over 75

Specific Limitations:

(1) Proposed or existing properties located in zone 1 are generally acceptable as security for VA-guaranteed loans.

(2) Proposed construction to be located in zone 2 will be acceptable provided:

- (a) Sound attenuation features are built into the dwelling to bring the interior DNL of the living unit to 45 decibels or below.
- (b) There is evidence of market acceptance of the subdivision.
- (c) The veteran-purchaser signs a statement which indicates his/her awareness that (1) the property being purchased is located in an area adjacent to an airport, and (2) the aircraft noise may affect normal livability, value, and marketability of the property.

(3) Proposed subdivisions located in zone 3 are not generally acceptable. The only exception is a situation in which VA has previously approved a subdivision, and the airport noise contours are subsequently changed to include the subdivision in zone 3. In such cases, VA will continue to process loan applications provided the requirements in the above subparagraphs (2) are met.

(4) Existing dwellings in zones 2 and 3 are not to be rejected because of airport influence if there is evidence of acceptance by a fully informed veteran.

Source: Veterans Administration, M26-2, June 1992

TABLE 4

SUMMARY OF NOISE LEVELS IDENTIFIED AS REQUISITE TO PROTECT PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY - 1974 EPA GUIDELINES

EFFECT	LEVEL	AREA
Hearing loss	75 DNL and above	All areas
Outdoor activity interference and annoyance	55 DNL and above	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis of use.
	59 DNL and above	Outdoor areas where people spend limited amounts of time, such as school years, playgrounds, etc.
Indoor activity interference and annoyance	45 DNL and above	Indoor residential areas
	49 DNL and above	Other indoor areas with human activities such as schools, etc.

Note: All Leq values from EPA document were converted by FAA to DNL for ease of comparison. (DNL=Leq(24) + 4 dB).

Source: U.S. EPA 1974. Cited in FAA 1977a, p. 26.

LAND USE GUIDANCE CHART I: AIRPORT NOISE INTERPOLATION

LAND USE GUIDANCE ZONES (LUG)	NOISE EXPOSURE CLASS	INPUTS: AIRCRAFT NOISE ESTIMATING METHODOLOGIES				HUD NOISE ASSESSMENT GUIDELINES (1977)	SUGGESTED NOISE CONTROLS
		Ldn DAY-NIGHT AVERAGE SOUND LEVEL	NEF NOISE EXPOSURE FORECAST	CNR COMPOSITE NOISE RATING	CNEL COMMUNITY NOISE EQUIVALENT LEVEL		
A	MINIMAL EXPOSURE	0 TO 55	0 TO 20	0 TO 90	0 TO 55	"CLEARLY ACCEPTABLE"	NORMALLY REQUIRES NO SPECIAL CONSIDERATIONS
B	MODERATE EXPOSURE	55 TO 65	20 TO 30	90 TO 100	55 TO 65	"NORMALLY ACCEPTABLE"	LAND USE CONTROLS SHOULD BE CONSIDERED
C	SIGNIFICANT EXPOSURE	65 TO 75	30 TO 40	100 TO 115	65 TO 75	"NORMALLY UNACCEPTABLE"	NOISE EASEMENTS, LAND USE, AND OTHER COMPATIBILITY CONTROLS RECOMMENDED
D	SEVERE EXPOSURE	75 & HIGHER	40 & HIGHER	115 & HIGHER	75 & HIGHER	"CLEARLY UNACCEPTABLE"	CONTAINMENT WITHIN AIRPORT BOUNDARY OR USE OF POSITIVE COMPATIBILITY CONTROLS RECOMMENDED

Source: FAA 1977b, p. 12.

to noise above 74 DNL. Interference with outdoor activities may become a problem with noise levels above 55 DNL. Interference with indoor residential activities may become a problem with interior noise levels above 45 DNL. If we assume that standard construction attenuates noise by about 20 decibels, with doors and windows closed, this corresponds to an exterior noise level of 65 DNL.

FAA Land Use Guidance System

In 1977, FAA issued an advisory circular on airport land use compatibility planning (FAA 1977b). It describes land use guidance (LUG) zones corresponding to aircraft noise of varying levels as measured by four different noise metrics **(Exhibit B)**. It also includes suggested land use noise sensitivity guidelines **(Exhibit C)**.

In **Exhibit B**, LUG Chart I, four land use guidance zones are described, corresponding to DNL levels of 55 or less (A), 55 to 65 (B), 65 to 75 (C), and 75 and over (D). LUG Zone

In 1979, the Federal Interagency Committee on Urban Noise (FICUN), including representatives of the Environmental Protection Agency, the Department of Transportation, the Housing and Urban Development Department, the Department of Defense, and the Veterans Administration, was established to coordinate various federal programs relating to the promotion of noise-compatible development.

A is described as minimal exposure, normally requiring no special noise control considerations. LUG Zone B is described as moderate exposure where land use controls should be considered. LUG Zone C is subject to significant exposure, and various land use controls are recommended. In LUG Zone D, severe exposure, containment of the area within airport property, or other positive control measures, are suggested.

In LUG Chart II, **Exhibit C**, most noise-sensitive uses are suggested as appropriate only within LUG Zone A. These include single-family and two-family dwellings, mobile homes, cultural activities, places of public assembly, and resorts and group camps. Uses suggested for Zones A and B include multi-family dwellings and group quarters; financial, personal, business, governmental, and educational services; and manufacturing of precision instruments. In Zones C and D, various manufacturing, trade, service, resource production, and open space uses are suggested.

Federal Interagency Committee on Urban Noise

In 1979, the Federal Interagency Committee on Urban Noise (FICUN), including representatives of the Environmental Protection Agency, the Department of Transportation, the Housing and Urban Development Department, the Department of Defense, and the Veterans Administration, was established to coordinate various federal programs relating to the promotion of noise-compatible development. In 1980, the Committee published a report which contained detailed land use compatibility guidelines for varying DNL noise levels (FICUN 1980). The work of the Interagency Committee was very important as it brought together for the first time all federal agencies with a direct involvement in noise compatibility issues and forged a general consensus on land use compatibility for noise analysis on federal projects.

The Interagency guidelines describe the 65 DNL contour as the threshold of significant impact for residential land uses and a variety of noise-sensitive institutions (such as hospitals, nursing homes, schools, cultural activities, auditoriums, and outdoor music shells). Within the 55 to 65 DNL contour range, the guidelines note that cost and

LAND USE GUIDANCE CHART II: LAND USE NOISE SENSITIVITY INTERPOLATION

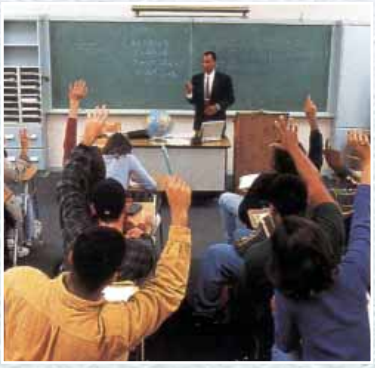
LAND USE		LUG ZONE[1]
SLUCM No.	Name	Suggested
10	**Residential**	**A-B**
11	Household units.	
11,11	Single units - detached.	A
11,12	Single units - semi attached.	A
11,13	Single units - attached row.	B
11,21	Two units - side-by-side.	A
11,22	Two units - one above the other.	A
11,31	Apartments - walk up.	B
11,32	Apartments - elevator.	B-C
12	Group quarters.	A-B
13	Residential hotels.	B
14	Mobile home parks or courts.	A
15	Transient lodgings.	C
19	Other residential.	A-C
20	**Manufacturing[2]**	**C-D**
21	Food and kindred products-manufacturing.	
22	Textile mill products-manufacturing.	C-D
23	Apparel and other finished products made from fabrics, leather, and similar materials-manufacturing.	C-D
24	Lumber and wood products (except furniture)-manufacturing.	C-D
25	Furniture and fixtures-manufacturing.	C-D
26	Paper and allied products-manufacturing.	C-D
27	Printing, publishing, and allied industries.	C-D
28	Chemicals and allied products-manufacturing.	C-D
29	Petroleum refining and related industries.[3]	C-D
30	**Manufacturing[2]**	
31	Rubber and miscellaneous plastic products-manufacturing.	C-D
32	Stone, clay, and glass products-manufacturing.	C-D
33	Primary metal industries.	D
34	Fabricated metal products-manufacturing.	D
35	Professional, scientific, and controlling instruments: photographic and optical goods; watches and clocks-manufacturing.	B
39	Miscellaneous manufacturing.	C-D
40	**Transportation, communications, and utilities**	
41	Railroad, rapid rail transit, and street railway transportation.	D
42	Motor vehicle transportation.	D
43	Aircraft transportation.	D
44	Marine craft transportation.	D
45	Highway and street right-of-way.	D
46	Automobile parking.	D
47	Communication.	A-D
48	Utilities.	D
49	Other transportation communications and utilities.	A-D

LAND USE		LUG ZONE[1]
SLUCM No.	Name	Suggested
50	**Trade[4]**	
51	Wholesale trade.	C-D
52	Retail trade-building materials, hardware, and farm equipment.	C
53	Retail trade-general merchandise.	C
54	Retail trade-food.	C
55	Retail trade-automotive, marine craft, aircraft and accessories.	C
56	Retail trade-apparal and accessories.	C
57	Retail trade-furniture, home furnishings, and equipment.	C
59	Retail trade-eating and drinking. Other retail trade.	C-D
60	**Services[4]**	
61	Financial, insurance, and real estate services.	B
62	Personal services.	B
63	Business services.	B
64	Repair services.	C
65	Professional services.	B-C
66	Contract construction services.	C
67	Governmental services.	B
68	Educational services.	A-B
69	Miscellaneous services.	A-C
70	**Cultural, entertainment, and recreational**	
71	Cultural activities and nature exhibitions.	A
72	Public assembly.	A
73	Amusements.	C
74	Recreational activities.[5]	B-C
75	Resorts and group camps.	A
76	Parks.	A-C
79	Other cultural, entertainment, and recreational.[5]	A-B
80	**Resource production and extraction**	
81	Agriculture.	C-D
82	Agricultural related activities.	C-D
83	Forestry activities and related services.	D
84	Fishing activities and related services.	D
85	Mining activities and related services.	D
89	Other resource production and extraction.	C-D
90	**Undeveloped land and water areas**	
91	Undeveloped and unused land area (excluding noncommercial forest development).	D
92	Noncommercial forest development.	D
93	Water areas.	A-D
94	Vacant floor area.	A-D
95	Under construction.	A-D
99	Other undeveloped land and water areas.	A-D

1 Refer to Land Use Guidance Chart I, Exhibit C-1.
2 Zone "C" suggested maximum except where exceeded by self generated noise.
3 Zone "D" for noise purposes; observe normal hazard precautions.
4 If activity is not in substantial, air-conditioned building, go to next higher zone.
5 Requirements likely to vary - individual appraisal recommended.

SLUCM: *Standard Land Use Coding Manual*, U.S. Urban Renewal Administration and Bureau of Public Roads, 1965.

Source: FAA 1977b, p. 14.



The ANSI standard acknowledges the potential for noise effects below the 65 DNL level, describing several uses as "marginally compatible" with noise below 65 DNL.

feasibility factors were considered in defining residential development and several of the institutions as compatible. In other words, the guidelines are not based solely on the effects of noise. They also consider the cost and feasibility of noise control.

ANSI Guidelines

In 1980, the American National Standards Institute (ANSI) published recommendations for land use compatibility with respect to noise (ANSI 1980). Kryter (1984, p. 621) notes that no supporting data for the recommended standard is provided.

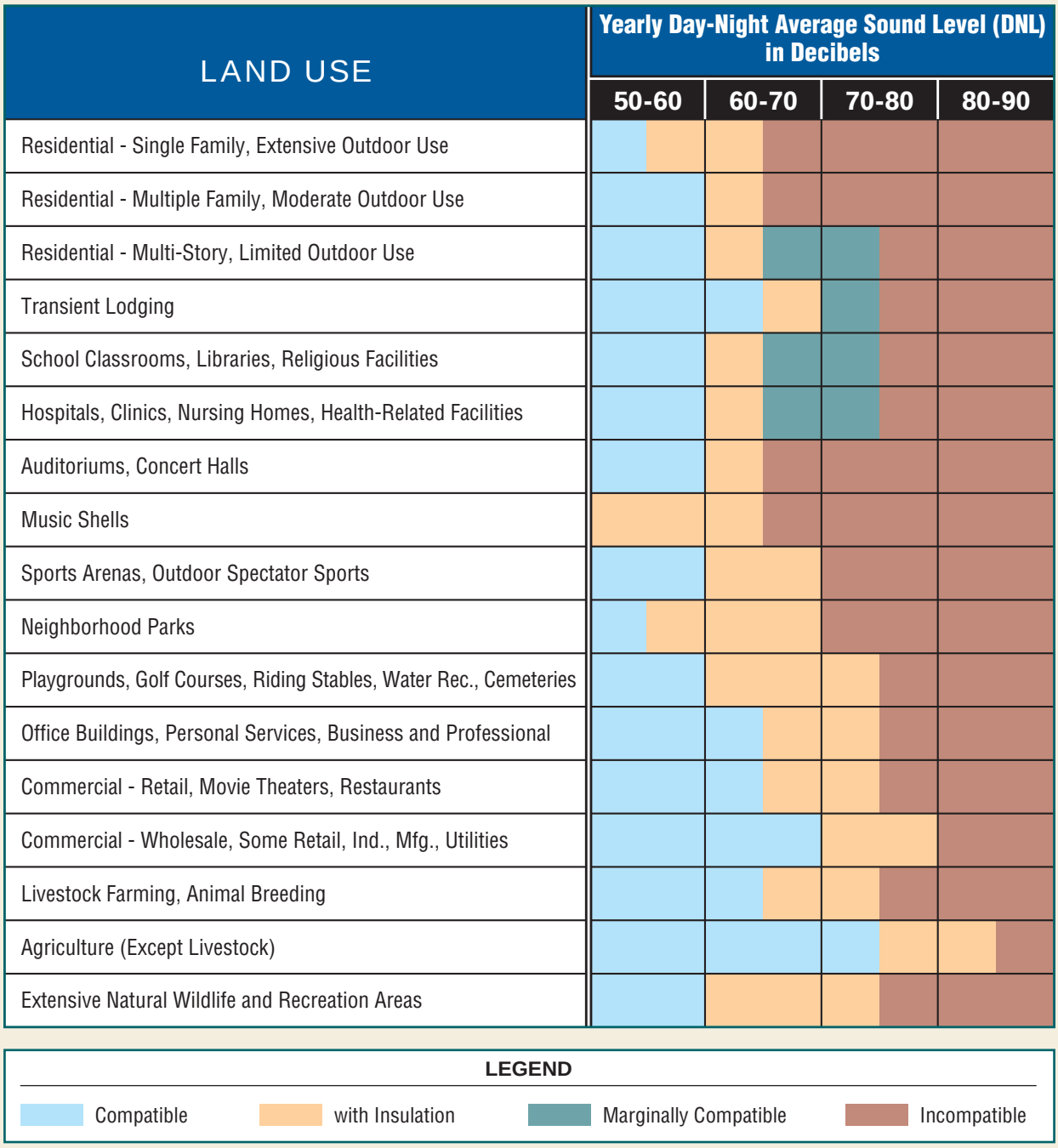
The ANSI guidelines are shown in **Exhibit D**. While generally similar to the Federal Interagency guidelines, there are some important differences. First, ANSI's land use classification system is less detailed. Second, the ANSI standard acknowledges the potential for noise effects below the 65 DNL level, describing several uses as "marginally compatible" with noise below 65 DNL. These include single-family residential (from 55 to 65 DNL), multi-family residential, schools, hospitals, and auditoriums (60 to 65 DNL), and outdoor music shells (50 to 65 DNL). Other outdoor activities, such as parks, playgrounds, cemeteries, and sports arenas, are described as marginally compatible with noise levels as low as 55 or 60 DNL.

14 CFR Part 150 Guidelines

The FAA adopted a revised and simplified version of the Federal Interagency guidelines when it promulgated Title 14, Part 150 of the Code of Federal Regulations in the early 1980s. (The Interim Rule was adopted on January 19, 1981. The final rule was adopted on December 13, 1984, published in the Federal Register on December 18, and became effective on January 18, 1985.) Among the changes made by FAA include the use of a coarser land use classification system and the deletion of any reference to any potential for noise impacts below the 65 DNL level.

The determination of the compatibility of various land uses with various noise levels, however, is very similar to the Interagency determinations.

LAND USE COMPATIBILITY WITH YEARLY DAY-NIGHT AVERAGE SOUND LEVEL AT A SITE FOR BUILDINGS AS COMMONLY CONSTRUCTED



Source: ANSI 1980. Cited in Kryter 1984, p. 624.

Exhibit E lists the Part 150 land use compatibility guidelines. These are only guidelines. Part 150 explicitly states that determinations of noise compatibility and regulation of land uses are purely local responsibilities.

14 CFR PART 150 LAND USE COMPATIBILITY GUIDELINES

LAND USE	Yearly Day-Night Average Sound 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]	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
Government 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

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The designations contained in this table do not constitute a federal determination that any use of land covered by the program is acceptable 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.

See other side for notes and key to table.

14 CFR PART 150 LAND USE COMPATIBILITY GUIDELINES

KEY

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, 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 and 30 dB, respectively, 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 special sound reinforcement systems are installed.

6 Residential buildings require a NLR of 25.

7 Residential buildings require a NLR of 30.

8 Residential buildings not permitted.

Source: ***14 CFR Part 150***, Appendix A, Table 1.

SELECTED STATE LAND USE COMPATIBILITY GUIDELINES

State of Oregon

The State of Oregon's Airport Planning Rule (APR) establishes a series of local government requirements and rules which pertain to aviation facility planning. These requirements are intended to promote land use compatibility around airports as well as promote a convenient and economic system of airports in the state. To assist local governments and airports in meeting the requirements of the APR, the Oregon Department of Aviation published the *Airport Land Use Compatibility Guidebook* in January 2003.

The State of Oregon recognizes that, in some instances, land use controls and restrictions that apply to the 65 DNL may be appropriate for applications to areas impacted by noise levels above 55 DNL.

The Oregon guidelines contained within the guidebook, as they relate to land use compatibility around airports, are based on administrative regulations of the Department of Environmental Quality, adopted by the Oregon Environmental Quality Commission in 1979 (Oregon Administrative Rules, Chapter 340, Division 35, Section 45). Although the FAA regards the 65 DNL contours and above as significant, the State of Oregon considers the 55 and 60 DNL contours as significant. The state recognizes that, in some instances, land use controls and restrictions that apply to the 65 DNL may be appropriate for applications to areas impacted by noise levels above 55 DNL. For example, a rural area exposed to 55 to 65 DNL noise levels may be more affected by these levels than an urban area. This is because there is typically a higher level of background noise associated with an urban area (Oregon 2003). Air carrier airports are required to do studies defining the airport impact boundary, corresponding to the 55 DNL contour. Where any noise-sensitive property occurs within the noise impact boundary, the airport must develop a noise abatement program.

An Oregon airport noise abatement program may include many different recommendations for promoting land use compatibility. These include changes in land use planning, zoning, and building codes within the 55 DNL contour. In addition, disclosure of potential noise impacts may be required and purchase of land for non-noise sensitive public uses may be permitted within the 55 DNL contour.

Within the 65 DNL contour, purchase assurance, voluntary relocation, soundproofing, and purchase of land is permitted.

State of California

California law sets the standard for the acceptable level of aircraft noise for persons residing near airports at 65 CNEL (California Code of Regulations, Title 21, Division 2.5, Chapter 6). The 65 CNEL criterion was chosen for urban residential areas where houses are of typical construction with windows partially open. Four types of land uses are defined as incompatible with noise above 65 CNEL: residences, schools, hospitals and convalescent

The guidelines contained within the California Airport Land Use Planning Handbook suggest that no new residential uses should be permitted within the 65 CNEL noise contour.

homes, and places of worship. These land uses are regarded as compatible if they have been insulated to assure an interior sound level, from aircraft noise, of 45 CNEL. They are also to be considered compatible if an avigation easement over the property has been obtained by the airport operator.

California noise insulation standards apply to new hotels, motels, apartment buildings, and other dwellings, not including detached single-family homes. They require that "interior noise levels attributable to outdoor sources shall not exceed 45 decibels (based on the DNL or CNEL metric) in any habitable room." In addition, any of these residential structures proposed within a 60 CNEL noise contour requires an acoustical analysis to show that the proposed design will meet the allowable interior noise level standard. (California Code of Regulations, Title 24, Part 2, Appendix Chapter 35.)

In the *California Airport Land Use Planning Handbook* (Caltrans 2002), land use compatibility guidelines are suggested for use in the preparation of comprehensive airport land use plans. The guidelines suggest that no new residential uses should be permitted within the 65 CNEL noise contour. In quiet communities, it is recommended that the 60 CNEL should be used as the maximum permissible noise level for residential uses. At rural airports, it is noted that 55 CNEL may be suitable for use as a maximum permissible noise level for residential uses.

These guidelines are similar to those proposed in earlier editions of the *Airport Land Use Planning Handbook*. However, the 2003 handbook provides much more definitive guidance for compatible land use planning around airports.

State of Florida

In 1990, the State of Florida passed legislation which created the Airport Safety and Land Use Compatibility Study Commission. The charge to this commission was to assure that airports in Florida will have the capacity to accommodate future growth without jeopardizing public health, safety, and welfare. One of the Commissions' recommendations was to require the Florida Department

Within the State of Florida's Airport Compatible Land Use Guidance for Florida Communities, it was requested that each local government prohibit new residential development and other noise-sensitive uses for areas within the 65 DNL contour. Where practical, new residential development should be limited in areas down to the 55 DNL contour.

of Transportation (FDOT) to establish guidelines regarding compatible land use around airports. In 1994, FDOT responded to this recommendation by publishing a guidance document entitled *Airport Compatible Land Use Guidance for Florida Communities*.

As part of this document's conclusions, it was recommended that all commercial service airports, or airports with significant numbers of general aviation operations, establish a noise compatibility planning program in accordance with the provisions of F.A.R. Part 150. All communities within the airport environs should participate in the preparation of this program. It was requested that each local government prohibit new residential development and other noise-sensitive uses for areas within the 65 DNL contour. Where practical, new residential development should be limited in areas down to the 55 DNL contour.

State of Wisconsin

Wisconsin State Law 114.136 was established to give local governments the authority to regulate land uses within three miles of the airport boundary. These land use controls supercede any other applicable zoning limits by other jurisdictions that may apply to the area surrounding the airport. To assist airports with the development of land use controls, the Wisconsin Department of Transportation (WisDOT) published a document titled *Land Use Planning Around Airports in Wisconsin* in 2001. Various land use tools such as avigation easements, noise overlay zones, height and hazard zoning, and subdivision regulations are presented within the land use planning guide. WisDOT has recognized that the types of airport compatible land uses depend on the location and size of the airport as well as the type and volume of aircraft using the facility. The 65 DNL contour should be used as a starting point for land use regulations, but lesser contours should be considered if deemed necessary.

The 1985 Wisconsin Act 136 takes State Law 114.136 one step further by requiring counties and municipalities to depict airport locations and areas affected by aircraft operations on official maps. The law also requires the zoning authority to notify the airport owner of any proposed zoning changes within the airport environs.

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Within the Airports and Compatible Land Use document, jurisdictions are encouraged to work with airports to ensure that airport noise is factored into land use decisions for the protection of the health, safety, and welfare of its residents.

State of Washington

In 1996, Washington State Senate Bill 6442 was passed. This bill requires that every city, town, and county, having a general aviation airport in its jurisdiction, discourage the siting of land uses that are incompatible with airport operations. Policies protecting airport facilities must be implemented within the comprehensive plan and development regulations. Formal consultation with the aviation community is required and all plans must be filed with the Washington State Department of Transportation Aviation Division (WADOT). To assist jurisdictions with establishing appropriate land use planning tools and regulations, WADOT published a revised *Airports and Compatible Land Use* document in February 1999. Within this planning document, jurisdictions are encouraged to work with airports to ensure that airport noise is factored into land use decisions for the protection of the health, safety, and welfare of its residents.

TRENDS IN LAND USE COMPATIBILITY GUIDELINES

In recent years, citizen activists, anti-noise groups, and environmental organizations have become concerned that the current methods of assessing aircraft noise are not sufficient. Among the concerns is that 65 DNL does not adequately represent the true threshold of significant noise impact. It has been argued that the impact threshold should be lowered to 60 or even 55 DNL, especially in areas of quiet background noise and in areas impacted by large increases in noise (ANR, V. 4, N. 12, p. 91; V. 5, No. 3, p. 21; V. 5, N. 11, p. 82). The purpose of this section is to provide a time line of events which, taken together, indicate a distinct movement toward the consideration of airport noise impacts below the 65 DNL level.

Y E A R

1992

In the 1992 session of Congress, a bill was introduced to lower the threshold for non-compatible land uses from 65 to 55 DNL (ANR, V. 4, N. 11, p. 83). The bill, however, was not passed. In 1995, a bill (HR 1971) was introduced in the House of Representatives to require the Department of Transportation to develop a plan to reduce the number of people residing within the 60 DNL contours around airports by 75 percent by January 1, 2001 (ANR, V. 7, N.

13, p. 101). This bill was not passed either. Nevertheless, these developments indicate concerns about aircraft noise below 65 DNL are coalescing into specific proposals to address the situation.

Also in 1992, an important arbitration proceeding between Raleigh-Durham International Airport and airport neighbors was concluded. Residents residing between the 55 and 65 DNL contours were awarded compensation for noise damages. This was apparently the first time damages had been awarded beyond the 65 DNL contour at any domestic airport (ANR V. 4, No. 14, p. 107). While, strictly speaking, this case sets no legal precedent, it provides further evidence that a change in the definition of the threshold of significant noise impact may be gathering momentum.

After the arbitration was concluded, the Raleigh-Durham Airport Authority developed a model noise ordinance that would require new housing between the 55 and 60 DNL contours to be sound-insulated to achieve an outdoor-to-indoor noise level reduction of 30 dB. Between the 60 and 65 DNL contours, a 35 dB reduction would be required. The model ordinance was proposed for use by local governments exercising land use control. (See ANR, V. 6, N. 3, p. 17.)

In August 1992, the Federal Interagency Committee on Noise (FICON 1992) issued its final report. FICON included representatives of 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 for the assessment of aircraft noise in environmental studies. The Committee advocated the continued use of the DNL metric as the principal means of assessing long-term aircraft noise exposure. It further reinforced the designation of 65 DNL as the threshold of significant impact on non-compatible land use. FICON recognized, however, the potential for noise impacts down to the 60 DNL level, providing guidance for analyzing noise between 60 and 65 DNL in reports prepared under the National Environmental Policy Act (NEPA). This includes environmental assessments and environmental impact statements. (It does not include F.A.R. Part 150 studies.) FICON offered this explanation for this action (FICON 1992, p. 3-5).

1992 (cont.)

There are a number of reasons for moving in this direction at this time. First, the Schultz Curve [see the bottom panel in **Exhibit A**] recognizes that some people will be highly annoyed at relatively low levels of noise. This is further evidenced from numerous public response forums that some people living in areas exposed to DNL values less than 65 dB believe they are substantially impacted (U.S. EPA 1991). Secondly, the FICON Technical Subgroup has shown clearly that large changes in levels of noise exposure (on the order of 3 dB or more) below DNL 65 dB can be perceived by people as a degradation of their noise environment. Finally, there now exist computational techniques that allow for cost-effective calculation of noise exposure and impact data in the range below DNL 65 dB.

The specific FICON recommendation was as follows (FICON 1992, p. 3-5):

If screening analysis shows that noise-sensitive areas will be at or above DNL 65 dB and will have an increase of DNL 1.5 dB or more, further analysis should be conducted of noise-sensitive areas between DNL 60-65 dB having an increase of DNL 3 dB or more due to the proposed airport noise exposure.

FICON further recommended that if any noise-sensitive areas between 60 and 65 DNL are projected to have an increase of 3 DNL or more as a result of the proposed airport noise exposure, mitigation actions should be included for those areas (FICON 1992, p. 3-7). The FICON recommendations represent the first uniform guidelines issued by the federal government for the consideration of aircraft noise impacts below the 65 DNL level. At this time, these remain recommendations and are not official policy.

1995

The Federal Transit Administration (FTA) released a guidance document entitled *Transit Noise and Vibration Impact Assessment*. Within this document, FTA cites the EPA recommendation of 55 DNL to develop their curve of impact. Further, FTA states that they use the FAA criteria of 65 DNL to define their curve of severe impact.

1996

The American National Standards Institute (ANSI) recommends 55 DNL as the criterion level for housing and similar noise-sensitive land uses within their report *ANSI Quantities and Procedures for Description and Measurement of Environmental Sounds - Part 3: Short-Term Measurements with an Observer Present*.

The International Organization for Economic Cooperation and Development suggests the following environmentally sustainable transport noise levels: 55 DNL in urban areas and 50 DNL in rural areas.

1998

Within the Federal Railroad Administration's (FRA) *High-Speed Ground Transportation Noise and Vibration Impact Assessment*, the same criteria used by the FTA is used to assess impacts of new, high-speed trains.

In this same year, the Surface Transportation Board (STB) utilizes 55 DNL as a threshold of impact within the Draft Environmental Impact Statement for the proposed Conrail acquisition by Norfolk Southern Railway Company.

The World Bank Group (WBG) set noise limits for general industrial projects to ensure that projects they fund, such as iron and steel manufacturing and thermal power plants, do not negatively impact noise-sensitive development. The WBG set their threshold of impact at 55 DNL.

1999

The Federal Energy Regulatory Commission adopts a revision to their regulations (Part 157) which states "the noise attributable to any new compressor stations, compression added to an existing station, or any modification, upgrade, or update of an existing station, must not exceed a day-night level (Ldn) of 55 dBA at any pre-existing noise-sensitive area."

The World Health Organization's *Guidelines for Community Noise* recommends a "criteria of annoyance" daytime threshold of 55 DNL and nighttime threshold of 50 DNL for residential areas.

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RECENT DEVELOPMENTS AT THE FAA

Early in 2003, the FAA announced the establishment of the Center of Excellence for Aircraft Noise Mitigation. This research center is a partnership between academia, industry, and government. Part of the center's focus will be on what level of noise is significant as well as other noise metrics that can be used to assess the impact of aircraft noise on individuals.

In the late 1990s, the Naples Airport Authority determined that the short-term viability of the airport was in jeopardy due to the noise impacts at the airport. An F.A.R. Part 150 Study determined that the majority of the noise complaints were from individuals which reside outside the 65 DNL noise contour and were, therefore, not eligible for federal mitigation funding.

For several decades, the airport authority had led efforts to balance the competing needs of airport users with those of the surrounding community and had adopted numerous measures to control noise and limit incompatible land uses surrounding the facility. The surrounding jurisdictions had gone as far as to adopt the 60 DNL noise contour as the threshold of significant impact and had limited development within this contour.

Naples adopted a ban on Stage 2 aircraft under 75,000 pounds in June 2000 pursuant to the Noise Act and its implementing regulations, commonly referred to as Part 161. The restriction at Naples is important not only because it was the first, but also because it was, and is, the subject of several challenges, the results of which may prove precedential for other airport operators' efforts to address local noise issues.

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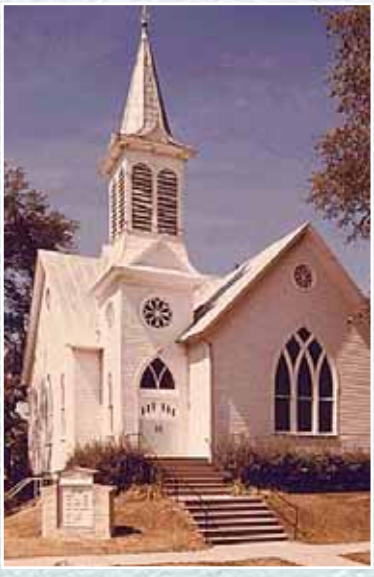
On March 10, 2003, the FAA ruled that the ban on Stage 2 business jet operations imposed by Naples Airport Authority violates federal grant assurance obligations. This ruling came after years of research and debate regarding the restriction at Naples Airport.

CONCLUSIONS

This technical information paper has presented information on land use compatibility guidelines with



There is a strong and long-lasting consensus among various government agencies that 65 DNL represents an appropriate threshold for defining significant impacts on non-compatible land use. Nonetheless, both research and empirical evidence suggest that noise at levels below 65 DNL is often a concern.

respect to noise. It is intended to serve as a reference for the development of policy guidelines for F.A.R. Part 150 Noise Compatibility Studies.

There is a strong and long-lasting consensus among various government agencies that 65 DNL represents an appropriate threshold for defining significant impacts on non-compatible land use. Nonetheless, both research and empirical evidence suggest that noise at levels below 65 DNL is often a concern. Increased concern about these lower levels of noise has been registered in public forums across the country. Official responses by public agencies indicate at least a partial acknowledgment of these concerns. Indeed, according to many agencies and organizations as well as in the states of Oregon, Florida, Wisconsin, and California, airport noise analysis and compatibility planning below the 65 DNL level is strongly advised or required.

In urbanized areas with relatively high background noise levels, 65 DNL continues to be a reasonable threshold for defining airport noise impacts. In suburban and rural locations, lower noise thresholds deserve consideration. Given emerging national trends and the experience at many airports, it can be important to assess aircraft noise below 65 DNL, especially in areas with significant amounts of undeveloped land where land use compatibility planning is still possible. Future planning in undeveloped areas around airports should recognize that the definition of critical noise thresholds is undergoing transition. In setting a prudent course for future land use near airports, planners and policy-makers should try to anticipate these changes.

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