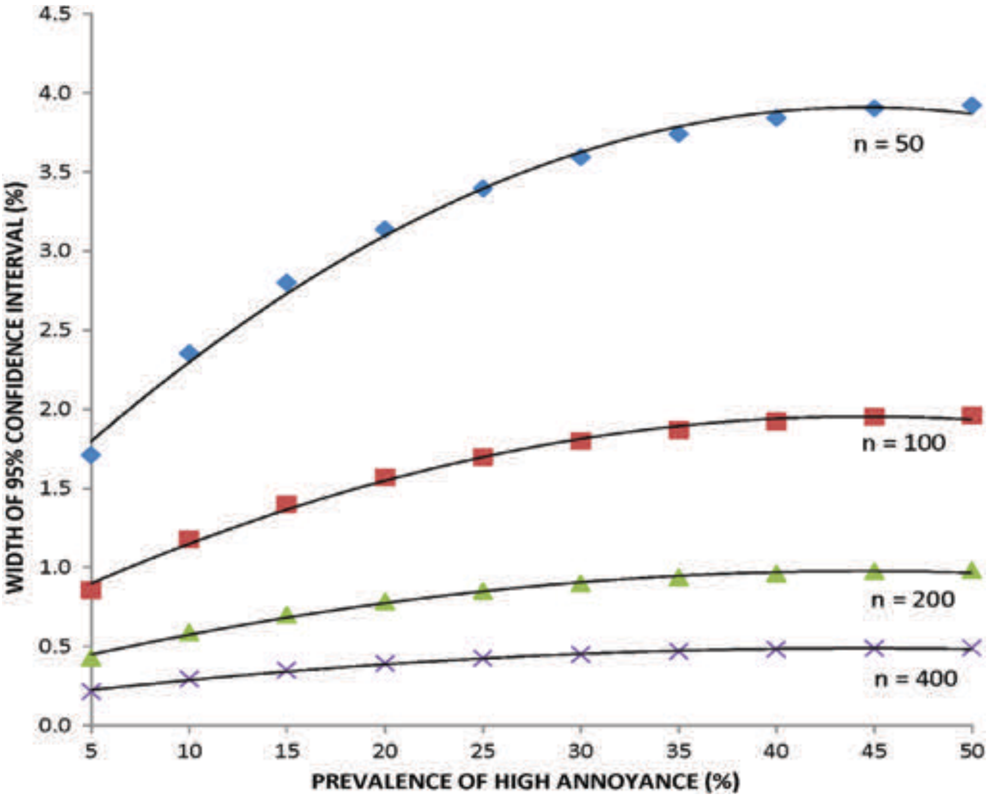


Figure 3-12. Widths of 95% confidence intervals around a range of binomial proportions, as a function of sample size.

for samples of n = 200 and greater. The figure also shows that a point of diminishing returns in reduction in confidence interval width is reached at a sample size of about 200. Since the precision of measurement is proportional to the square root of the sample size, further doublings of sample sizes yield only a factor of the square root of 2 (~1.4) improvements. In other words, impractically larger sample sizes would be required to reduce the widths of confidence intervals by useful amounts.

It is therefore apparent that interviewing sub-sites would preferably be able to yield at least 200 completed interviews. Since not every household at a potential interviewing site can be contacted, nor is necessarily willing to grant an interview, a useful interviewing site must contain at least several multiples of 200 households. If the sample incidence rate is as great as 50% (that is, if half of the sampling frame can be reached and is willing to grant an interview), then the minimum number of households at a site should be 400. If the sample incidence rate is lower, the minimum number of households at a site must be correspondingly greater.

3.7 Noise Measurement Methods

The social survey was accompanied by field noise measurements and INM estimates of helicopter noise levels. Noise measurements and recording of aircraft flight tracks started 1 week prior to the first date of interviewing and continued for the remainder of interviewing. The duration of interviewing was expected to be 3 to 4 days, but was extended in some cases to permit additional callbacks to yield adequate numbers of completed interviews.

Table 3-7. Noise metrics simultaneously measured.

FREQUENCY WEIGHTING	TIME AVERAGING			
	SLOW	FAST	IMPULSE	L_{eq}
A	X	X	X	X
C	X	X	X	X
1/3 Octave (12.5 to 20 kHz)				X
Audio (24 bit, 44.1 kHz)	Not Applicable			

The basic noise measurement instrumentation was the Larson Davis 824 precision Class 1 sound level meter. [Class 1 refers to the International Electrotechnical Commission's (2005) highest specification for precision sound level meters 2005]. Broadband audio recordings were made with a Zoom H2 digital recorder connected to the Direct Output of the L-D 824. The audio recorders use SD memory cards to store the audio signal in a standard audio WAV file format. The broadband audio files stored 24-bit samples at a rate of 44.1 kHz.

The goal of the field measurements was to continuously document simultaneous measurement of sound pressure levels in A- and C-weighted decibel units, along with one-third octave band sound pressure levels, and broadband audio for the duration of the measurements. The broadband audio recordings allowed for manual identification of noise sources and also preserved the noise environment near respondents' homes for further analysis. Table 3-7 identifies the noise metrics recorded during the measurement survey.

The acoustic measurements for Long Beach and Las Vegas were made simultaneously at four monitoring sites spaced throughout the survey area. The measurement sites were selected to collect data as nearly directly beneath the flight tracks and to the sideline of the corridors.

Field measurements of actual noise exposure were calibrated and supplemented INM-based estimates of aircraft noise exposure. The noise measurement data were used to calibrate INM predictions so that exposure predictions could be generated for each household that completed an interview. This was done by using INM to create a grid of points or INM "location points" for each noise metric of interest. The field measurements were used to create a decibel differential between predicted and measured values at the four measurement points and at INM grid or location points. This grid was used to estimate noise exposures at the homes of the social survey respondents. The longitude and latitudes of respondents' homes were coded in the sampling frame.

CHAPTER 4

Noise Exposure Estimation and Interviewing Methods

This chapter describes the conduct of noise measurements and interviews during July and September of 2015 in the cities of Long Beach, CA, and Las Vegas, NV, and during June of 2016 in Georgetown and North Arlington, VA, in the Washington, D.C., area.

4.1 Interviewing Areas, Helicopter Routes, and Noise Measurement Sites

Figures 4-1 through 4-3 show nominal helicopter flight routes and noise measurement sites for the three interviewing areas.

4.1.1 Description of Long Beach Study Area

The Long Beach study area was adjacent to the Redondo Avenue helicopter corridor, a voluntary route shown on aeronautical charts for the area. The route extends from LGB, just north of the study area, to the coast. Upon reaching the coast, helicopters turn east or west to follow it further. The route supports two-way traffic for both approaches and departures.

Overflown neighborhoods contain mostly single-family dwellings, with some small apartment buildings dispersed throughout the neighborhood. Redondo Avenue is a commercial street for the most part, with a few small commercial buildings scattered elsewhere throughout the study area. Homes in the study area range from classic California cottages built in the 1920s and 1930s, to mid-century small apartment buildings. Housing on streets nearer the coast is more expensive than elsewhere in the study area, while areas to the north of the study area contain more modestly priced homes.

The Redondo route is used for helicopter training, executive transport, tourism, and public safety flights. About fifteen overflights per day occur in the Redondo Avenue corridor, split about evenly between northbound and southbound flights.

For the sake of completeness, Figure 4-1 also shows the more lightly used Cherry Avenue corridor, which supports only about two overflights per day. Helicopter operations on both routes are generally flown at or about 500 feet above ground level (AGL) to avoid conflicts with nearby airport traffic.

Noise measurement sites for the Long Beach interviewing area were selected with the assistance of airport staff knowledgeable about nearby airspace uses.

4.1.2 Description of Las Vegas Study Area

The Las Vegas study area is composed largely of single-family homes constructed since the 1950s. The neighborhoods are typical low-density residential areas with a few condominiums

Figure 4-1. Helicopter routes (white double-ended arrows) and noise measurement sites (red stars) in Long Beach study area.

Figure 4-1a. Location of noise measurement sites at the Long Beach study area.

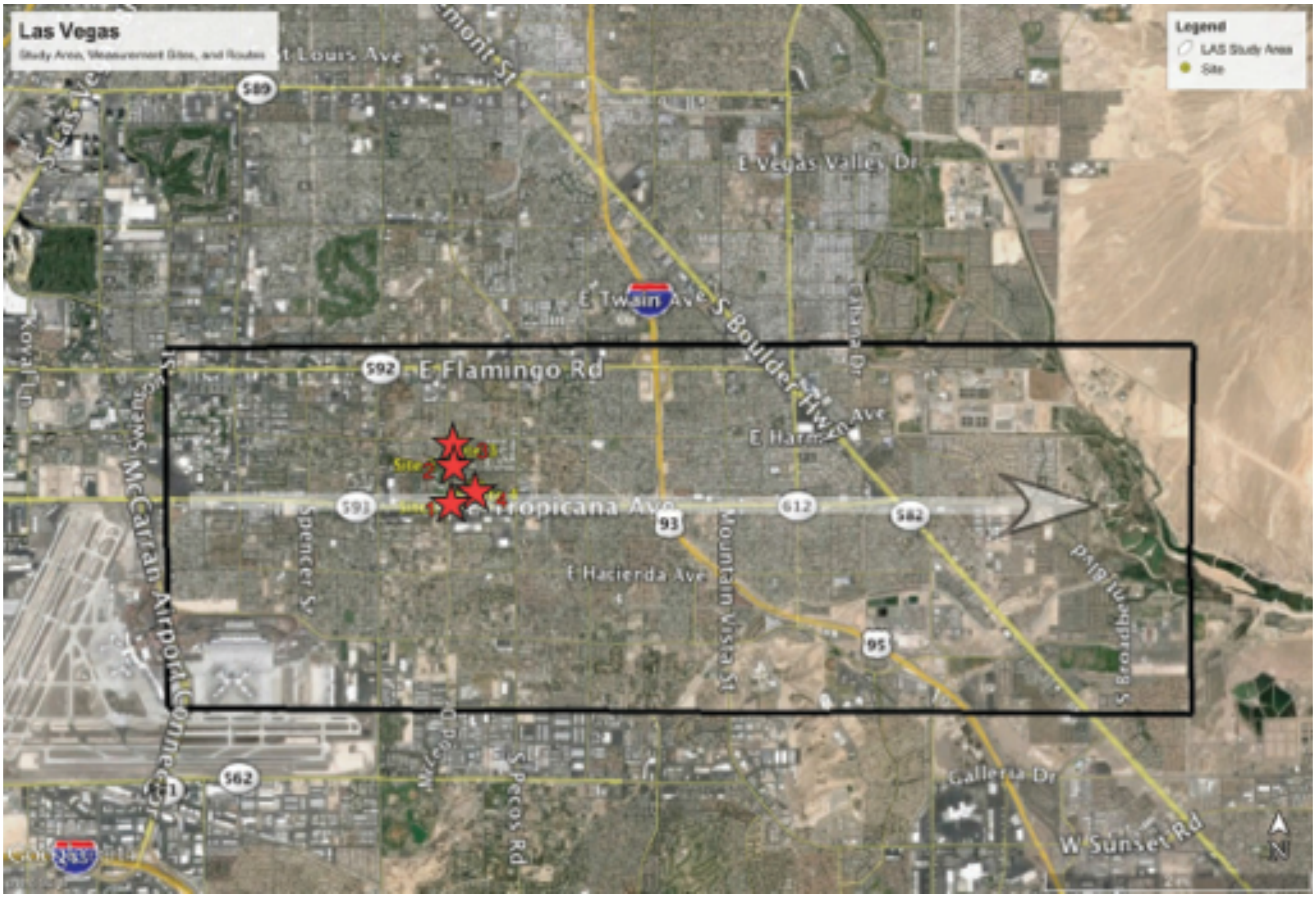


Figure 4-2. Helicopter route (white arrow) and noise measurement sites (red stars) in Las Vegas study area.

Figure 4-2a. Location of noise measurement sites at the Las Vegas study area.

Figure 4-3. Washington, D.C., study area.

and no distinctive features. Ground elevations on the west side of the study area are essentially the same as the airport elevation, but the terrain drops considerably on the east side of the study area. The area along Tropicana Avenue is generally commercial, with homes located behind commercial development.

Interviews were conducted with residents of homes along the Tropicana Avenue helicopter corridor. The corridor is immediately to the east of LAS and the Las Vegas strip, as shown in Figure 4-2. It is a one-way departure corridor used primarily by air tour operators and some public safety helicopters. The corridor supports approximately 150 overflights daily. The helicopter flight route is at an elevation of about 1,000 feet AGL in the western portion of the study area, but at greater altitudes AGL in the eastern portion (due to falling terrain). Residential land uses in the interviewing area are dominated by single-family detached dwellings, mixed with a smaller number of condominiums.

Noise measurement sites were selected by door-to-door canvassing in a single-family residential area adjacent to Tropicana Avenue. The neighborhood includes many fenced private yards, in which noise monitors could be securely installed and operated 24 hours per day.

4.1.3 Description of Washington, D.C., Study Area

The Washington, D.C., study area was composed primarily of single-family homes dating from the 1950s to newer homes located in Northern Arlington and Georgetown adjacent to the Potomac River. The study area is shown in Figure 4-3. The neighborhoods in Northern Arlington have the appearance of suburban neighborhoods, without distinctive or unique features. A few condominiums and apartment buildings are also found in the study area. The Georgetown interviewing area included a mix of retail uses, a university with a hospital heliport, and party wall (row) and single-family houses.

Interviews were conducted within an area paralleling the Potomac helicopter corridor above the river. The helicopter flight paths are at an elevation of about 500 feet AGL to avoid airspace used by fixed-wing arrivals at DCA and a departure route from DCA that also follows the river.

Helicopter noise exposure estimates were made by modeling rather than by direct measurement. Since the helicopter corridor is beneath heavily used departure and arrival corridors to DCA, any attempt to measure helicopter noise exclusively would be complicated by fixed-wing overflight noise. One of the unresolved issues is how well INM models BVI noise. As described in Chapter 5, aircraft noise exposure generated by fixed-wing traffic (primarily air carrier jets) at DCA exceeds noise exposure created by helicopters by about an order of magnitude in the interviewing area.

4.2 Noise Measurement Protocol

Two sets of sound level meters were installed at each of the noise monitoring sites in both Long Beach and Las Vegas. The primary measurements were made using four Larson Davis 831 noise monitors. These meters continuously archived a time series of sound pressure levels at one-second intervals. The metrics collected by the 831 monitors included A-weighted 1 second L_{eq}, C-weighted 1 second L_{eq}, and 1 second L_{eq} for each of the one-third octave bands from 6 Hz to 20 kHz. In addition, Larson Davis Model 824 meters at each site collected 1-second time histories of A-weighted and C-weighted L_{eq} values.

High-resolution digital audio recorders were attached to the audio outputs of the sound meters at each monitoring site. All meters were calibrated periodically before, during, and after the measurement period. Appendix D contains a more complete description of the measurement equipment, calibration, and measurement protocols.

4.3 Noise Modeling Methods

4.3.1 Long Beach

DNL contours and DNL values at each respondent's home were developed with INM 7.0d,[15] using radar flight tracks obtained from each airport. At Long Beach, all flight tracks were obtained and then filtered based on altitude and passage through the study area. Although FAA has instituted unique radar squawk codes for helicopters operating in the LA basin, these were inconsistently used during the time of the survey. An observer was therefore stationed at the south end of the Redondo corridor from 7:00 AM to 7:00 PM every day. The observer photographed and logged every visible helicopter overflight. Helicopter types were determined from these photographs, and used to assign types to each helicopter flight track database entry. Figure 4-4 shows the Long Beach radar tracks, while Figure 4-8 shows the INM modeled tracks.

4.3.2 Las Vegas

In Las Vegas, helicopter operators have voluntarily agreed to use unique squawk codes. Due to high compliance by operators, LAS was able to provide helicopter-only flight tracks for just the helicopters using the Tropicana corridor. Since the Las Vegas flight track database included the helicopter registration number, this was used to look up the helicopter type and update the flight track database with each helicopter type.

Figure 4-4. Radar flight tracks for 1 week prior to and during Long Beach survey.

4.3.3 Washington, D.C.

The DCA noise contours were generated using the INM study files previously developed for the "Runway Safety Area Improvements for Runways 15-33 and 04-22 Environmental Assessment." FAA's 2010 environmental assessment included year 2010 contours (based on actual operations) as well as a forecast contour for the year 2016. The 2016 contours for fixed-wing operations were used for current purposes. While a comparison of actual to forecast operations was not done as part of this effort, forecasting over such a short period is common. No major changes in fleet mix or other operating conditions affected the 2016 forecast. A doubling or halving of the operations would be required to change DNL by 3 dB. A 40% increase in operations would only cause a 1.5 dB increase in DNL. The 60 DNL contour closed just short of the study area, so the flight tracks over the Potomac used in the model were compared with the more recent flight tracks. This was done both because the study area was outside the focus of the EA and because it was unclear what changes in tracks occurred with the recent change due to NextGen procedures. The tracks along the Potomac were slightly modified for this study to better conform to the radar data observed during the study period. The change was minor, but aligned the helicopter model flight tracks to conform better to the radar tracks.

4.3.4 Modeling Process

The flight track databases, updated with aircraft type, were used to determine the number of operations by helicopter type, by time of day, and by the location of backbone flight tracks. Sub-track locations were developed from this information to model helicopter noise. Figures 4-4 and 4-5 show the radar flight tracks for Long Beach and Las Vegas, while Figures 4-6 and 4-7 show the helicopter tracks along the Potomac River and fixed-wing radar tracks for DCA, respectively. Figures 4-8, 4-9, and 4-10 show noise modeled backbone and sub-tracks for each helicopter noise model run. The fixed-wing INM noise model run was done using the year 2016 INM Study that Ricondo and Associates undertook as part of the EA for the Runway Safety Area project for Metropolitan Washington Airport Authority (MWAA).

The vertical profiles used for the helicopter modeling were based on the altitudes actually flown. The variations in average altitude for each study area were small. The altitudes were 550 feet AGL for LGB, 500 feet for DCA, and 1,037 feet for LAS. The profiles were the standard INM departure profiles, modified only to reflect level flight at the above altitudes and at the speeds given in the standard profiles for level flight.

Figure 4-5. Radar flight tracks for 1 week prior to and during Las Vegas survey.

Figure 4-6. Helicopter radar tracks during DCA survey.

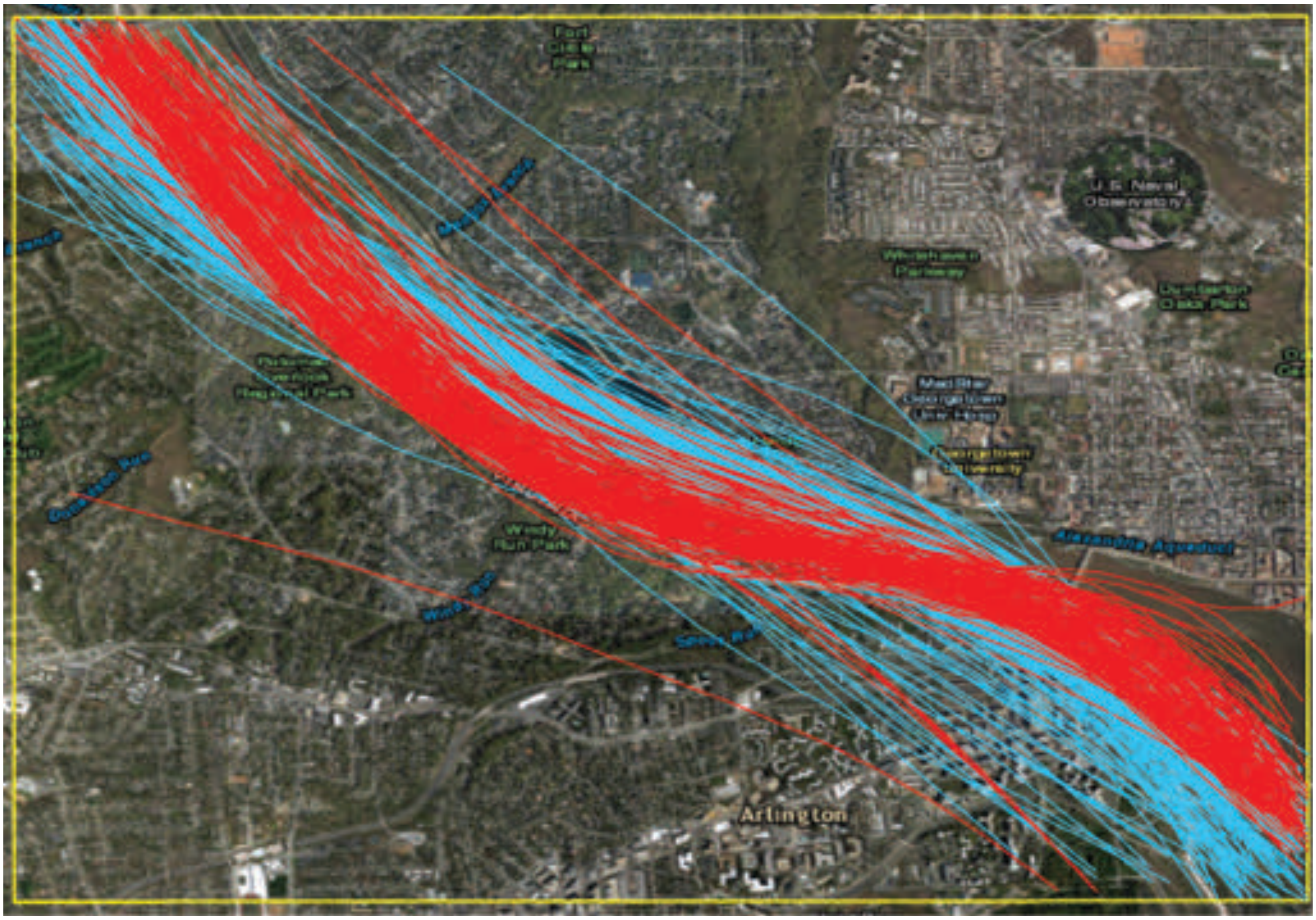


Figure 4-7. Radar tracks for fixed-wing aircraft, typical day during DCA survey (arrivals in red).

Figure 4-8. Noise model flight tracks for 1 week prior to and during Long Beach survey.

Figure 4-9. Noise model flight tracks for 1 week prior to and during Las Vegas survey.

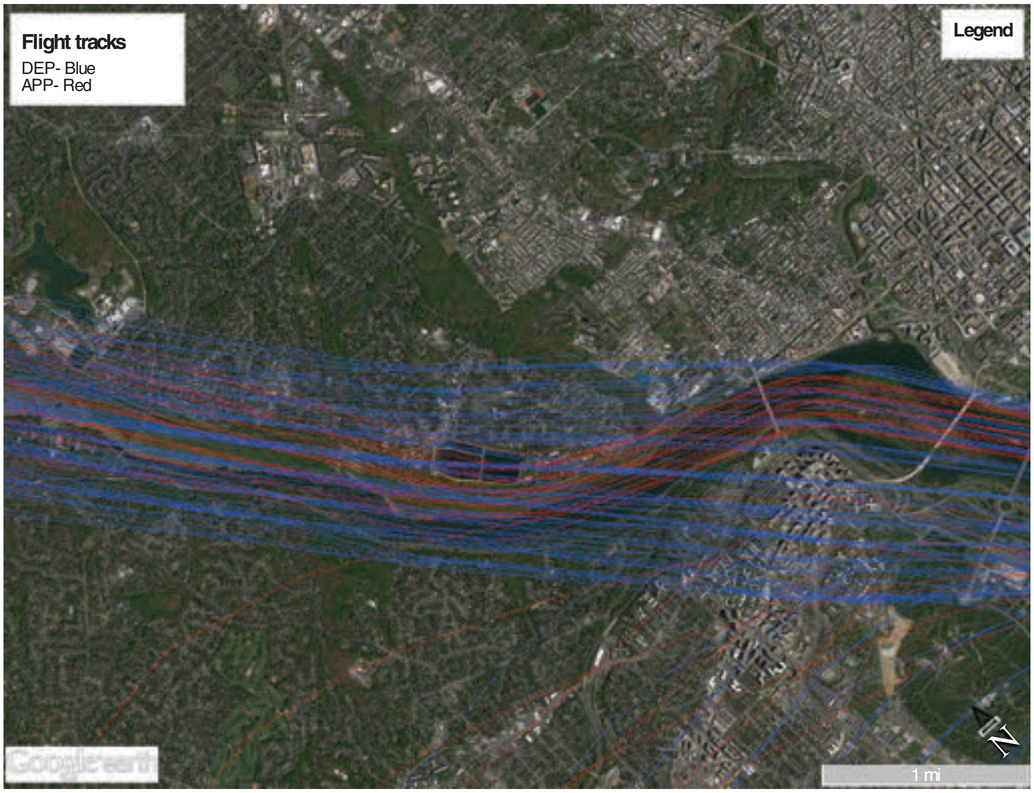


Figure 4-10. Helicopter noise model tracks for DCA survey modeling.

4.4 Estimation of Noise Exposure Values to Survey Respondents' Homes

Sampling frames prepared for each study area contained names and addresses for each household in the study area. This personally identifiable information was replaced by case numbers to comply with confidentiality requirements of the Institutional Review Board. Latitude and longitude coordinates then were coded into the noise model by case numbers. Point locations for respondents' residential addresses sufficed for purposes of calculating helicopter DNL values by case numbers and associated noise measurement locations.

4.5 Sampling Strategy

Several steps were required to prepare sampling frames for each study area. The first step was to develop preliminary definitions of helicopter-only noise contour bands adjacent to helicopter flight tracks at each airport. INM noise modeling was used to define these noise contour bands. Eight such preliminary helicopter noise exposure bands, shown in Figure 4-11, were identified at LGB. Seven such preliminary exposure bands were identified at LAS, as shown in Figure 4-12. The sampling bands in Washington D.C. are shown in Figure 4-13.

In each study area, households within the preliminary noise exposure bands were then identified from information contained in the two telephone databases (landline and cell phone) by latitude/longitude coordinates for the street addresses. This measure permitted a count of the number of interview-eligible sites within each noise contour band. The same latitude/longitude

Figure 4-11. Preliminary helicopter-only noise exposure bands in vicinity of helicopter flight tracks at LGB.

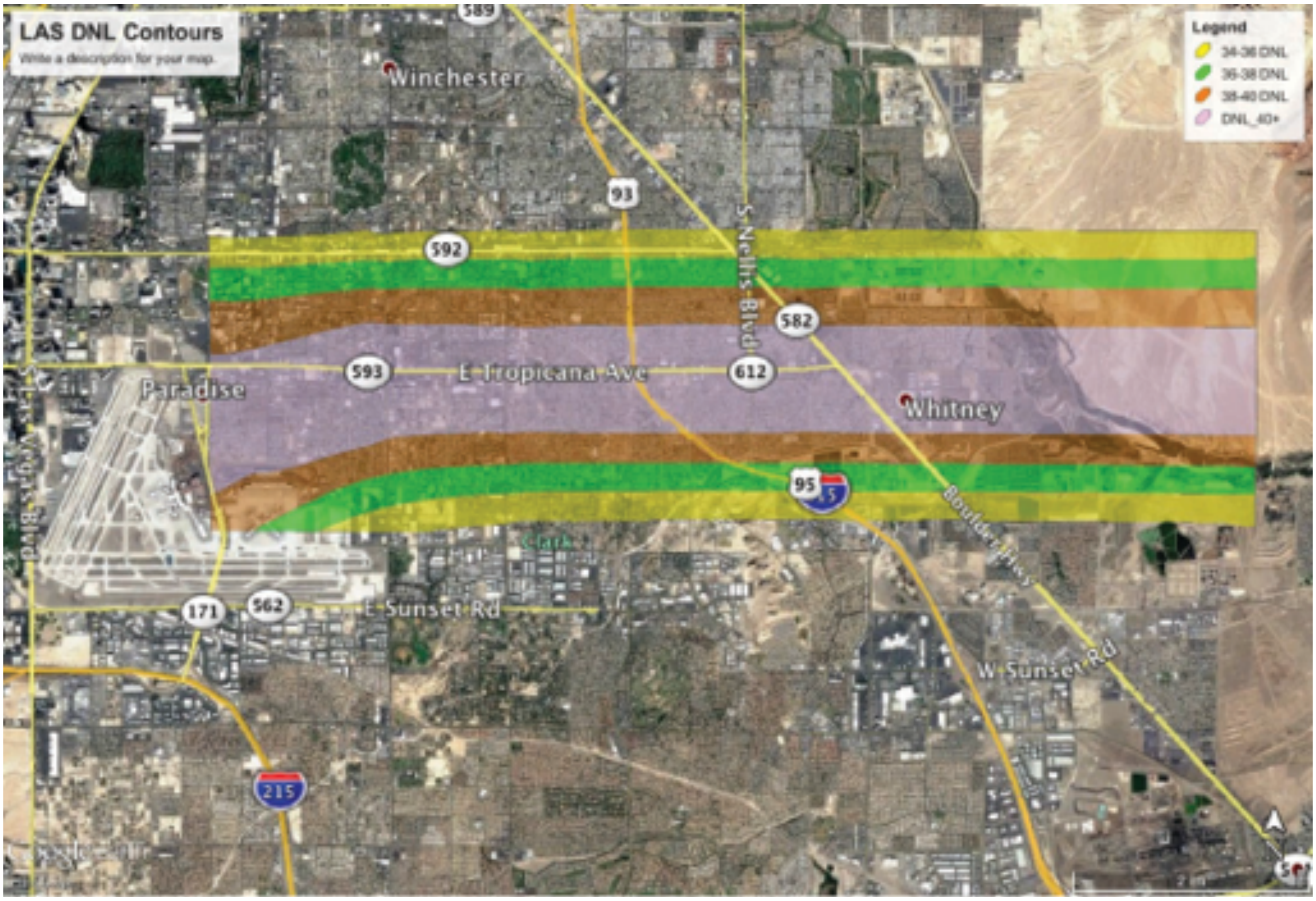


Figure 4-12. Preliminary helicopter-only noise exposure bands in vicinity of helicopter flight tracks at LAS.

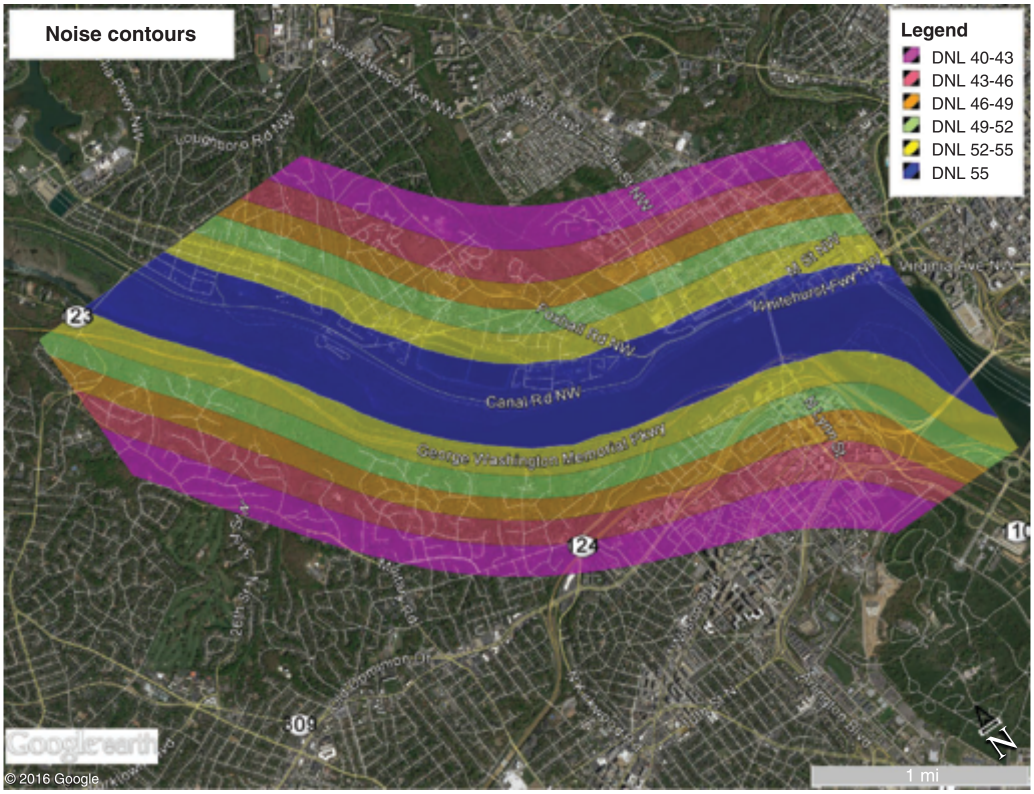


Figure 4-13. Noise exposure bands for DCA helicopter noise survey.

coordinates were later used by noise modeling software to refine the preliminary estimates of helicopter noise exposure for each respondent.

The landline and cell phone databases were compiled from public records and proprietary databases.[16]

The first of the two databases contained telephone-subscribing households in a nationwide, U.S. landline database (generally known as "Listed Landline" database). This database contains records of all known U.S. households subscribing to landline telephone service. A second database, containing records of wireless telephone subscribers, were drawn from a proprietary database of wireless phones containing more than 125 million wireless phones nationally. (The wireless phone database is one developed from data provided by cell phone users and collected by commercial users.)

A joint sampling frame was constructed from the telephone-subscribing households within areas eligible for interview in the two databases, from which a stratified (by expected helicopter noise exposure) random sample was then drawn. The LGB sample released for dialing contained 7,684 listed landline-subscribing households and 2,878 wireless-subscribing households. The LAS sample contained 4,688 listed landline-subscribing households and 3,135 wireless-subscribing households. The DCA sample contained 2,873 listed landline-subscribing households and 1,351 wireless-subscribing households. These were divided into replicates of 1,000 (listed landline) and 500 (wireless subscribing) telephone numbers for efficiency of use in computer-assisted telephone interviewing (CATI). In this context, replicate refers to a sub-sample of the entire database. The database was divided in these replicates for efficiency in achieving the minimum number of callbacks to each number where a respondent did not agree to an interview and to ensure no more calls were initiated than needed to achieve the sample goals.

4.6 Interviewing Procedures

A single structured telephone interview was sought from an adult member of each household within sample replicates released for interview contact attempts. The structured interview, introduced as a study of neighborhood living conditions, was based on a questionnaire containing fifteen items. The questionnaire is reproduced in Chapter 3, Table 3-5. Questions posed to respondents are shown in black; closed response categories and codings for them are shown in blue; and instructions to interviewers are shown in red.

CATI methods were used by a total of 152 trained and centrally supervised interviewers to make 18,385 interview contact attempts. As many as 15 contact attempts (an initial attempt followed by up to 14 callbacks at different times of day over a weeklong interviewing period) were made to households identified in the sampling frame. Interviewers sought to conduct an interview with any adult, verified household member. Fields (1993) has shown that demographic variables such as age, sex, social status, income, education, home ownership, dwelling type, and length of residence have no systematic effect on reports of noise-induced annoyance.

CHAPTER 5

Analyses of Noise Exposure Measurements and Interview Findings

For reasons previously described, helicopter noise exposure levels were estimated by both measurement and modeling at the Long Beach and Las Vegas sites, and by noise modeling alone in Washington, D.C.

5.1 Comparison of Measurement and Modeling Estimates of Exposure Levels at Long Beach and Las Vegas Survey Sites

The Long Beach and Las Vegas survey areas were fully developed residential areas, with substantial background noise. DNLs associated with helicopter operations were therefore estimated for measurement sites within each of these two survey areas by cumulating measured sound exposure level (SEL) values for each helicopter flyover during the week prior to interviewing. An analysis was then conducted on a flyover-by-flyover basis to determine whether noise levels recorded during flyovers represented helicopter-produced noise exposure or noise exposure produced by other noise sources.

5.1.1 Measured DNLs

The times of the closest point of approach (CPA) of helicopter flights to each monitoring site were entered into a database. The database also included all 1 second L_{eq} data (A-weighted, C-weighted, and ⅓ octave band) for a period of 1 minute prior to and 1 minute after the CPA time. Signal-to-noise ratios of flyovers were adequate to distinguish helicopter noise emissions from ambient noise near CPA times, but were difficult to unambiguously distinguish from background noise at greater distances and times before and after CPA.

SEL values as a function of distance for both A- and C-weighted SEL values were accordingly examined more closely. The examination showed that any noise event associated with a helicopter flight track that passed within a 3,000-foot radius of a monitoring point had a maximum A-weighted noise level (L_{max}) ≥ 55 dB, lasted at least 3 seconds, and could be attributed to a helicopter overflight. Measured noise levels that met these criteria were accumulated to compute daily, helicopter-only DNL values for each site. (C-weighted L_{max} values were not used for this purpose, because the background noise included substantial C-weighted noise.)

5.1.2 Modeled DNLs

Operational information and radar data recorded during the survey were then used to model DNL at each measurement site. This was used to compare modeled to measured DNL values. Several iterations of the model were completed so that at each site the modeled noise matched the

Table 5-1. Helicopter operations data.

Type of Helicopter	Average Daily Overflights		
	Day	Night	Total
Long Beach			
B206L	0.4	0.1	
R22	1.8	0.4	
R44	2.4	0.5	
S76	1.7	0.3	
SA350D	9.2	1.8	
	15.5	3.1	18.6
Las Vegas			
EC130	103.4	11.4	
SA350D	31.6	3.4	
	135.0	14.8	149.8
Washington, D.C.			
A109	3.4	0.0	
B212	5.0	0.0	
S61	1.6	0.0	
S70	3.6	0.0	
SA365N	4.6	0.0	
	18.2	0.0	18.2

measured DNL values. Locations of dispersed flight tracks and numbers of operations assigned to dispersed tracks in the modeling software were modeled to measured estimates of DNL values. Table 5-1 shows the numbers of helicopter operations by aircraft type and time of day.

Table 5-2 compares measured with modeled noise levels at the Long Beach and Las Vegas survey sites. Differences between measured and modeled DNL values were less than 2 dB, except at Site 4 in Long Beach.[17] Differences of this magnitude are well within (1) the overlapping uncertainty of measurement, (2) uncertainty in noise modeling, (3) the uncertainty inherent in the measurement system for SEL (approximately + 0.8 dB, per ISO 20906, Annex B), and (4) the sampling uncertainty for a short-term measurement period.

5.1.3 Relation of A-Weighted to C-Weighted SELs

A- and C-weighted SEL differences were computed for each flight in each study area using measurement data. Figures 5-1 and 5-2 plot A- and C-weighted SELs against each other at the two study sites. The two noise metrics are highly correlated at each site, despite the scatter about the regression line of about ±5 dB. The difference between A- and C-weighted SEL is greater at Las Vegas (approximately 10 dB difference) than at Long Beach (approximately 5 dB difference). This is almost certainly due to the absence of smaller Robinson rotorcraft from the Las Vegas fleet. The 1 second L_{eq} thresholds at LGB and LAS were 55 and 50 dB, respectively. The difference in threshold was due to ambient noise levels. The result was that most events correlated had

Table 5-2. Comparison of measured with modeled DNL values.

	DNL			
Study/Estimation Method	Site 1	Site 2	Site 3	Site 4
LGB Measured	47.1	48.8	47.9	44.7
LGB Modeled	46.0	47.5	49.7	49.3
Difference*	-1.1	-1.3	1.8	4.6
LAS Measured	52.0	50.6	48.7	52.9
LAS Modeled	53.0	49.1	46.8	52.9
Difference*	1.0	-1.5	-1.9	0.0

*Positive numbers indicate that the modeled DNL was greater than the measured DNL.

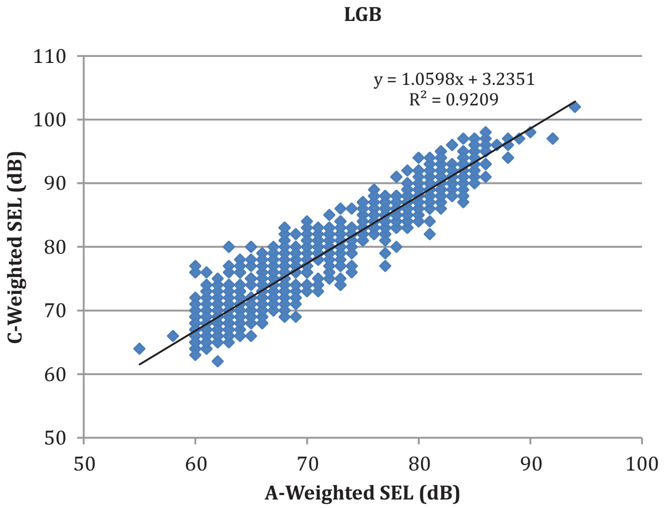


Figure 5-1. Comparison of measured A-weighted and C-weighted SELs of helicopter overflights in Long Beach interviewing area.

SELs above 60 and 55 dB, respectively. The handful of events with SELs below these levels were events that exceeded the threshold, but had very short durations.

Section 5.6 analyzes C-weighted and low-frequency exposure estimates in greater detail at the three survey sites.

5.2 Disposition of Contact Attempts

A total of 10,562 contact attempts (7,684 to land line telephones and 2,878 to wireless telephones) were made in Long Beach, and 7,803 contact attempts (4,668 to land line telephones and 3,135 to wireless telephones) in Las Vegas. For Washington D.C. 4,224 (2,873 landline and 1,351 wireless) contact attempts were made. Table 5-3 summarizes the outcomes of these

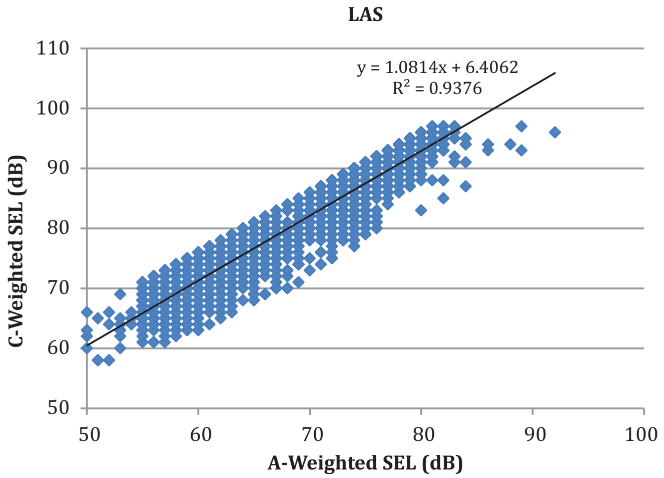


Figure 5-2. Comparison of measured A-weighted and C-weighted SELs of helicopter overflights in Las Vegas interviewing area.

Table 5-3. Interview completion and refusal rates by site and type (landline/wireless) of telephone service.

Sample Disposition	Long Beach		Las Vegas		Washington, D.C.	
	Landline	Wireless	Landline	Wireless	Landline	Wireless
Total Sample Released for Dialing	7,684	2,878	4,688	3,135	2,873	1,351
Non-Sample	3,511	419	2,713	1,028	1,137	553
Noncontact	1,913	1,022	0	0	1,244	390
Non-Sample + Noncontact	5,424	1,441	2,713	1,028	2,381	943
Contacted Sample	2,260	1,437	1,975	2,107	492	408
Refused Interviews	1,466	432	1,348	1,973	152	306
Completed Interviews	794	295	607	134	340	102
Interview Completion Rate	35.1%	20.5%	30.7%	6.4%	69.1%	20.7%
Interview Refusal Rate	64.9%	30.1%	68.2%	93.8%	30.9%	75.0%

interview contact attempts. The "non-sample" category includes disconnects, businesses and other non-residential telephone numbers, fax machines, modem lines, wrong addresses, changed numbers, and non-English speaking households. "Noncontacts" includes busy signals, no answer, call blocked, and answering machines after fifteen attempts to contact. The completion rates are calculated as {completed interviews/[total – (non-sample + noncontact)]}, while the refusal rates are calculated as {refused interviews/[total – (non-sample + noncontact)]}.

5.3 Locations of Respondents' Residences

The locations of households that completed interviews are shown in Figures 5-3, 5-4, 5-5, and 5-6 as green dots, enlarged sufficiently to preserve confidentiality of individual respondents. These figures also show the approximate locations of households in which respondents were highly annoyed by helicopter noise (and in the case of Washington, D.C., interviews, by fixed-wing aircraft noise.)

Households completing interviews were generally well dispersed geographically throughout the study areas, as were highly annoyed respondents. In Long Beach, some clustering of highly annoyed respondents was observed along the Redondo corridor, and along the northern section of the coastal route. Much less clustering was observed in Las Vegas along Tropicana Avenue, and in the Washington, D.C., area.

5.4 Analysis of Interview Responses

5.4.1 Tabulation of Responses

Table 5-4 displays responses to individual questionnaire items for the three interviewing sites, both separately and combined. (Percentage values may sum to less than 100 because invalid responses were omitted.) The reported results do not differentiate between respondents contacted by home landline and wireless telephones.

Table 5-5 shows similar information for mean estimated helicopter noise exposure levels and distances from flight corridors.

5.4.1.1 Narrative Account of Responses to Questionnaire Items

This sub-section summarizes responses to individual questionnaire items across sites in general terms. More detailed accounts of the findings are presented in the following subsections.

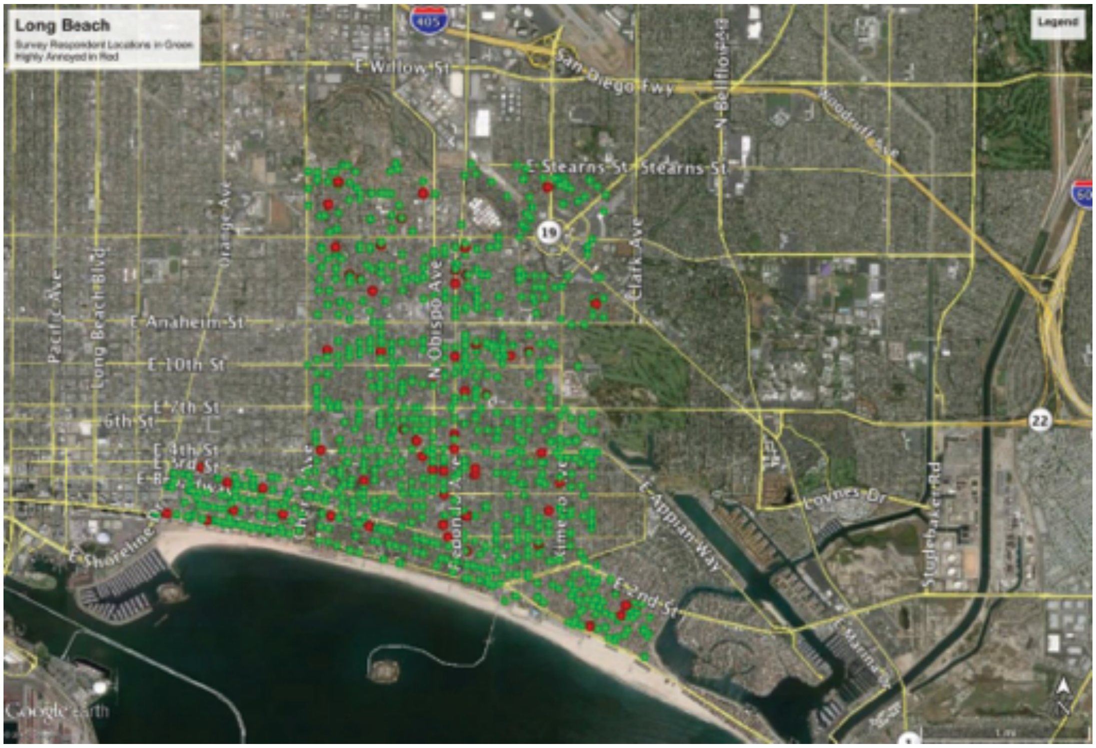


Figure 5-3. Approximate locations of Long Beach respondents (in green), and those highly annoyed by helicopter noise (in red).

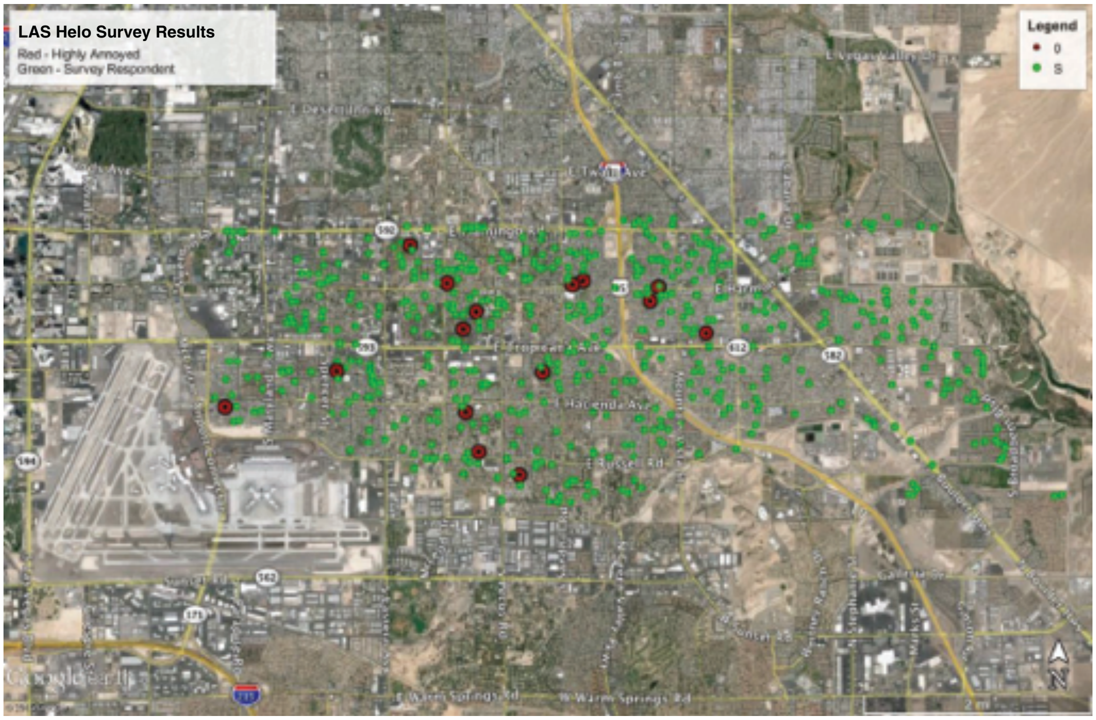


Figure 5-4. Approximate locations of Las Vegas respondents (in green), and those highly annoyed by helicopter noise (in red).

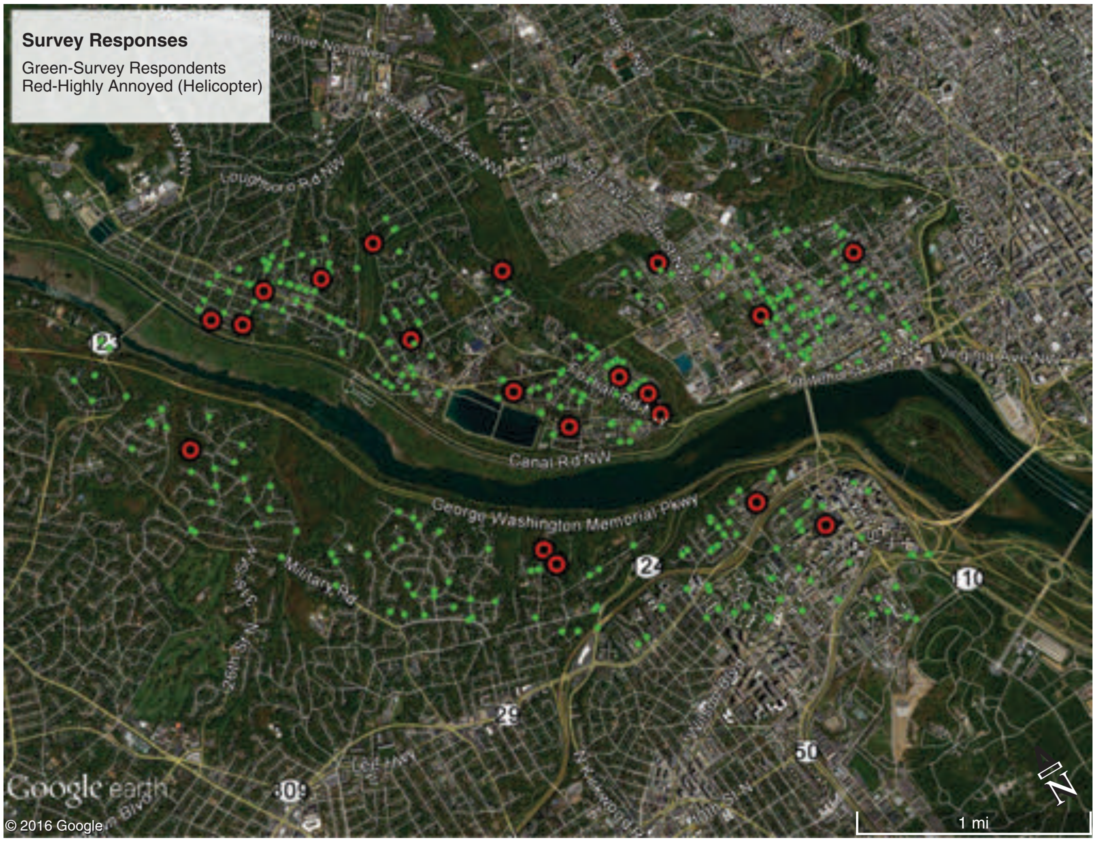


Figure 5-5. Approximate locations of Washington respondents (in green), and those highly annoyed by helicopters (in red).

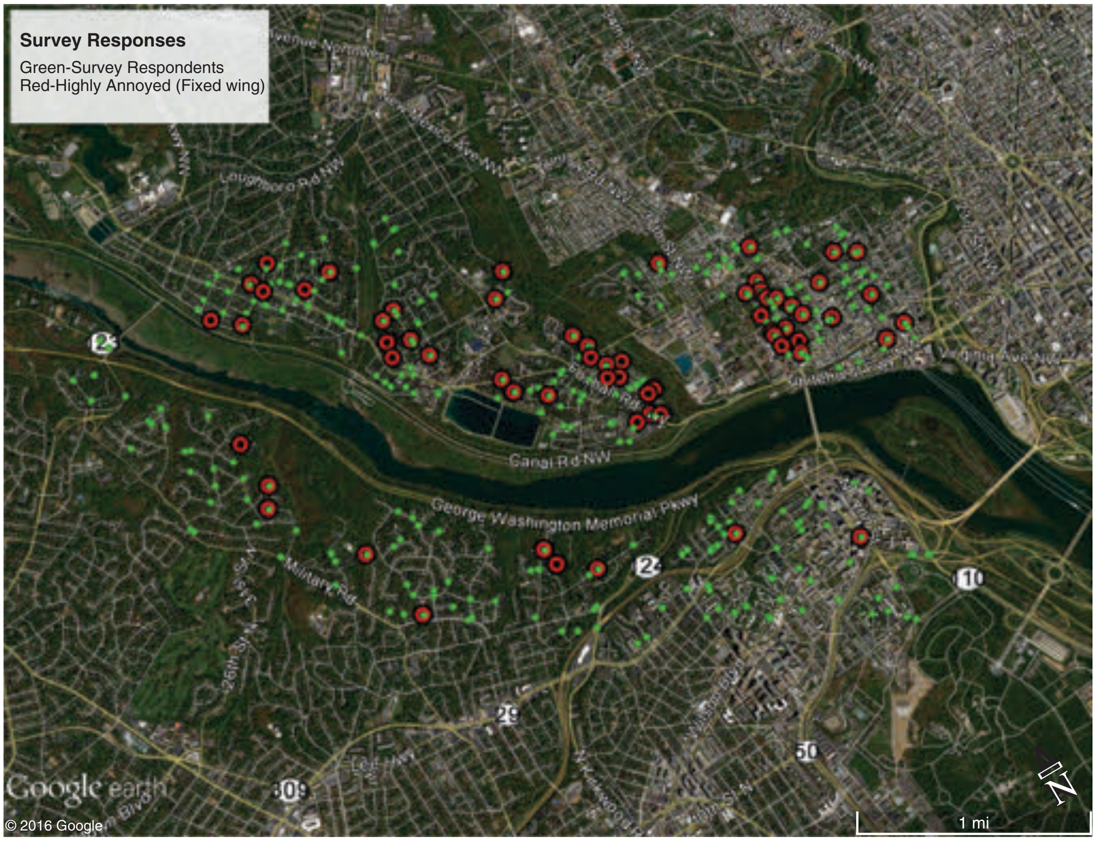


Figure 5-6. Approximate locations of Washington respondents (in green), and those highly annoyed by fixed-wing aircraft noise (in red).

Table 5-4. Questionnaire response percentages and frequencies.

QUESTIONNAIRE ITEM	CODING	LONG BEACH % (count) *N* = 1,089	LAS VEGAS % (count) *N* = 741	WASHINGTON % (count) *N* = 442	COMBINED SITES % (count) *N* = 2,272
1 Duration of residence	less than one year	2.6% (28)	2.7% (20)	2.7% (12)	2.6% (1,573)
	at least 1 year but less than 2 years	5.8% (63)	3.2% (24)	2.0% (9)	4.2% (98)
	2 to 5 years	23.0% (250)	19.8% (147)	18.6% (82)	21.2% (475)
	5 to 10 years	52.5% (572)	59.2% (439)	67.9% (300)	57.7% (1,311)
	more than 10 years	16.2% (176)	15.0% (111)	8.8% (39)	14.3% (326)
4 Characterization of neighborhood as quiet or noisy	Quiet	68.1% (742)	84.1% (623)	47.1% (208)	69.2% (1,573)
	quiet except for aircraft	4.2% (32)	6.1% (45)	31.9% (141)	10.2% (232)
	Noisy	24.4% (266)	8.6% (63)	3.4% (15)	17.9% (407)
4A Judged noisiness of neighborhood	quiet (from Item 4)	68.1% (742)	84.1% (623)	47.1% (208)	69.2% (1,573)
	Slightly noisy	2.8% (31)	1.8% (13)	1.1% (5)	2.2% (49)
	Moderately noisy	13.5% (147)	3.9% (29)	5.6% (38)	9.4% (214)
	Very noisy	4.2% (46)	1.6% (12)	5.0% (22)	3.5% (80)
	Extremely noisy	3.5% (38)	1.2% (9)	2.7% (12)	2.6% (59)
5A Annoyance of street traffic noise	not at all (from Item 5)	71.7% (781)	85.7% (635)	83.0% (367)	78.5% (1,783)
	Slightly	8.3% (90)	5.8% (43)	4.8% (21)	6.8% (154)
	Moderately	10.9% (119)	4.3% (32)	7.5% (33)	8.1% (184)
	Very	3.9% (43)	1.8% (13)	0.9% (4)	2.6% (60)
	Extremely	4.1% (45)	1.2% (9)	2.7% (12)	2.9% (66)
6A Frequency of notice of helicopter noise	not noticed (from Item 6) or less than once a day	36.9% (402)	51.4% (381)	47.5% (210)	43.7% (993)
	about once a day	17.0% (294)	19.3% (143)	18.6% (82)	22.8% (519)
	a few times a day	19.1% (208)	16.5% (122)	16.5% (73)	17.7% (403)
	several times or more per hour	4.5 (49)	6.3% (46)	5.0% (22)	5.1% (117)
7A Judged annoyance of helicopter noise	not at all (from items 6 and 7)	67.6% (736)	85.4% (633)	71.8% (317)	74.2% (1,686)
	Slightly	6.2% (67)	2.3% (17)	4.5% (20)	4.6% (104)
	Moderately	7.5% (82)	3.5% (26)	7.7% (34)	6.3% (142)
	Very	3.9 (42)	1.5% (11)	2.5% (11)	2.8% (64)
	Extremely	5.2 (57)	1.9% (14)	4.5% (20)	4.0% (91)
8A Frequency of notice of other aircraft noise	not noticed (from Item 8) or less than once a day	69.3% (755)	66.5% (493)	24.0% (106)	59.6% (1,354)
	once a day	14.2% (154)	12.8% (95)	12.2% (54)	13.3% (303)
	a few times a day	6.3% (69)	9.0% (67)	23.3% (103)	10.5% (239)
	several times or more per hour	1.4% (15)	6.1% (45)	31.4% (139)	8.8% (199)
9A Annoyed by aircraft other than helicopters	not at all (from Item 9)	86.5% (942)	90.6% (671)	50.5% (223)	80.8% (1,836)
	Slightly	2.2% (24)	2.3% (17)	5.2% (23)	2.8% (64)
	Moderately	2.8% (31)	1.6% (12)	14.7% (65)	4.8% (108)
	Very	1.1% (12)	0.8% (6)	7.9% (35)	2.3% (53)
	Extremely	1.8% (20)	1.2% (9)	15.2% (67)	4.2% (96)
10A Degree of annoyance with helicopter thumping or slapping sounds	not at all (from Item 10)	79.5% (866)	87.2% (646)	75.8% (335)	81.3% (1,847)
	Slightly	5.5% (60)	4.2% (31)	4.5% (20)	4.9% (111)
	Moderately	3.6% (39)	3.7% (20)	4.8% (21)	3.5% (80)
	Very	2.0% (22)	0.9% (7)	3.2% (14)	1.9% (43)
	Extremely	2.0% (22)	1.3% (10)	3.2% (14)	2.0% (46)
11A Annoyed by helicopter buzzing	not at all (from Item 11)	77.6% (845)	87.0% (645)	79.6% (352)	76.9% (1,747)
	Slightly	6.2% (67)	23.2% (24)	2.5% (11)	4.2% (95)
	Moderately	4.8% (52)	3.0% (22)	4.1% (18)	4.5% (102)
	Very	1.5% (16)	0.7% (5)	1.8% (8)	4.0% (92)
	Extremely	2.1% (23)	1.3% (10)	2.5% (11)	1.9% (44)
12A Annoyed by helicopter whining or tonal	not at all (from Item 12)	83.6% (910)	90.7% (672)	80.1% (354)	85.2% (1,936)
	Slightly	2.8% (31)	1.6% (12)	3.2% (14)	2.5% (57)
	Moderately	2.0% (22)	1.8% (13)	2.9% (13)	2.1% (48)
	Very	1.7% (19)	0.7% (5)	1.6% (7)	1.4% (31)
	Extremely	1.7% (18)	0.9% (7)	2.0% (9)	1.5% (34)
13A Annoyed by helicopter vibrations or rattling	not at all (from Item 13)	76.4% (832)	87.4% (648)	74.9% (331)	79.9%(1,811)
	Slightly	5.5% (60)	4.0% (30)	6.1% (27)	5.1% (117)
	Moderately	4.6% (50)	1.6% (12)	4.3% (19)	3.6% (81)
	Very	2.9% (32)	0.9% (7)	2.7% (12)	2.2% (51)
	Extremely	3.4% (37)	1.6% (12)	3.4% (15)	2.8% (64)
14 Frequency of notice of vibration or rattling noises	once a week or less	60.7% (661)	48.6% (360)	55.2% (244)	55.7% (1,265)
	once a day	7.8% (85)	4.7% (35)	5.9% (26)	6.4% (146)
	several times a day	5.6% (61)	4.0% (30)	6.3% (28)	5.2% (119)
15A Frequency of complaint	never (from Item 15)	96.2% (1,048)	98.1% (727)	92.5% (409)	96.1% (2,184)
	Once	0.5% (5)	0.1% (1)	1.1% (5)	0.5% (11)
	a few times	0.7% (8)	.05% (4)	1.6% (7)	0.8% (19)
	many times	0.4% (4)	0.8% (6)	1.1% (5)	0.7% (15)

Table 5-5. Means and standard deviations of respondents' helicopter noise exposure levels and distances from flight corridors.

MEASURE	Long Beach Mean (SD) *N*=1,089	Las Vegas Mean (SD) *N*=741	Washington Mean (SD) *N*=442	Combined Sites Mean (SD) *N*=2,272
Mean DNL Due to Helicopters (standard deviation of DNL)	40.3 (6.4)	43.8 (5.5)	43.3 (4.8)	42.0 (6.1)
Mean Distance from Flight Corridor, in Decimal Nautical Miles (standard deviation of distance from center of corridor)	0.42 (0.3)	0.49 (0.3)	0.42 (0.2)	0.44 (0.3)

SD = standard deviation.

Duration of Residence (Item 1). All of the neighborhoods in which interviewing was conducted were characterized by stable residential populations. Fewer than 3% of the respondents at any of the interviewing sites had lived at their current addresses for less than 6 months prior to the conduct of the present study, while half or more of the respondents had lived at their current addresses for 5 to 10 years. The populations of the interviewing sites were thus thoroughly familiar with helicopter noise exposure.

Characterization of Neighborhood as Quiet or Noisy (Item 4). Large majorities of respondents in Long Beach and Las Vegas described their neighborhoods as quiet. Nearly half of the respondents in Washington did as well. Nonetheless, nearly a quarter of the respondents in Long Beach described their neighborhood as noisy, and nearly a third of the respondents in Washington described their neighborhood as "quiet, except for aircraft noise."

Only small percentages of respondents at all sites described their neighborhoods as "highly" ("very" or "extremely") noisy: 7.7% in Long Beach and Washington, and 2.8% in Las Vegas. These figures closely resembled the percentages of respondents highly annoyed by traffic noise in Long Beach and Las Vegas (8.0% in Long Beach and 3% in Las Vegas), but were only about half (3.6%) of the percentage describing their neighborhoods as very or extremely ("highly") noisy in Washington.

Frequency of Notice of Helicopters (Item 6). Figure 5-7 shows how often respondents reported noticing helicopters in Long Beach, Las Vegas, and Washington, respectively. Only small minorities reported noticing helicopters more than a few times a day, and responses in the three survey areas were quite similar. This finding was unexpected because respondents at LAS were exposed to ten times as many helicopter operations as LGB.

Association between Helicopter Noise Annoyance and Interviewing Method. A 2 × 2 Chi-square analysis revealed no significant difference in reports of high annoyance by helicopter noise and the respondent's form of telephone subscription (wireless or landline) in the combined data from the three interviewing sites, $p = .561$. Likewise, no statistically significant differences in the prevalence of high annoyance were observed at any of the three data collection sites individually, $p > .17$.

Annoyance with Specific Characteristics of Helicopter Noise (Items 10–12). *Blade Slap* Roughly 80% of all respondents indicated in questionnaire Item 10 that they were not annoyed in any degree by main rotor impulsive noise ("thumping or slapping"). Only about 4% of respondents across sites described themselves as highly annoyed by such sounds.

Tail Rotor/Sideline Noise A similar percentage of respondents indicated in questionnaire Item 9 that they were not at all annoyed by "buzzing" noises (of the sort often created by tail

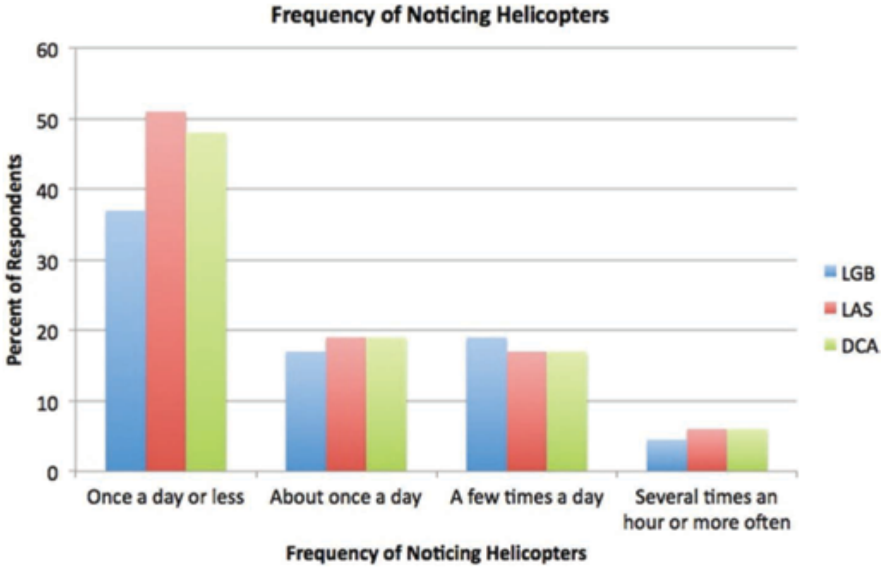


Figure 5-7. Frequency of notice of helicopters at interviewing sites.

rotors or interactions of the tail rotor with the main rotor wake). Only about 6% of respondents across sites described themselves as highly annoyed by such sounds.

Whining or Tonal Noise Slightly higher percentages of respondents (85%) at all sites indicated that they were not at all annoyed by whining or tonal noise (presumably jet engine inlet noise). Only about 3% of respondents across sites described themselves as highly annoyed by whining or tonal sounds.

Annoyance Due to Helicopter-Induced Vibration and Rattling (Items 13–14). About 80% of all respondents were not annoyed in any degree by helicopter-induced vibration and rattling sounds in their homes. Five percent of all respondents described themselves as highly annoyed by vibration or rattling.

A one-way analysis of variance conducted on responses made by Long Beach and Las Vegas respondents revealed a statistically significant difference in distance to flight track between respondents who were and were not annoyed to any degree by in-home vibration and rattling, $F(1, 1718) = 6.17$, $p = .013$. The absolute difference was quite small, however, $\eta^2 = .004$, with a 95% confidence interval (CI) extending from <.001 to .011. Those who reported no annoyance lived farther from the flight track ($M = 0.45$ nm, $SD = 0.27$) than those who lived closer to the flight track ($M = 0.41$ nm, $SD = 0.27$).

Frequency of Complaint (Item 15). Only about 4% of all respondents overall reported that they had complained about helicopter noise. Only in Washington did more than 1% of respondents report having complained more than once.

5.4.1.2 Evidence Relevant to Hypotheses Identified During Planning for the Current Study

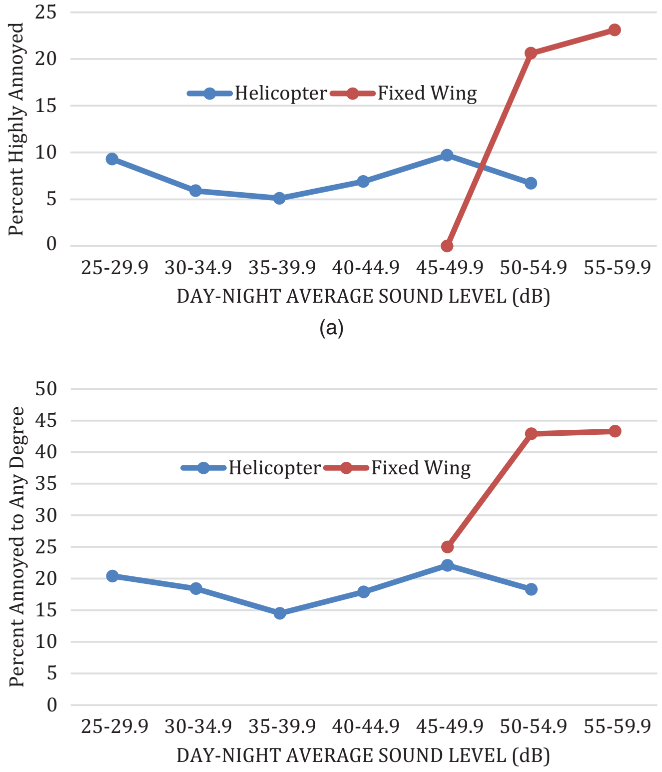
Seven hypotheses were identified in Chapter 2 of this report. Evidence concerning these hypotheses is discussed below.

Hypothesis 1. Decibel for decibel, rotary-wing aircraft is more annoying than fixed-wing aircraft. Washington was the only interviewing site at which respondents were exposed to appreciable amounts of cumulative noise due to both helicopter and fixed-wing overflights. Figure 5-8 plots (a) percentages of respondents highly annoyed by helicopter and fixed-wing aircraft noise, and (b) percentages of respondents annoyed to any degree in Washington.

Note that cumulative exposure to aircraft noise was greater for fixed-wing aircraft than helicopters in Washington, D.C., and that the expected relationship between noise and annoyance is more evident for fixed-wing aircraft. Note also that only 4 of the 442 respondents reporting high annoyance were exposed to fixed-wing aircraft noise levels in the 45–50 dB range, calling into question the reliability of the 0% high annoyance data point.

In only one range of cumulative noise levels (~50–55 dB) did substantial numbers of respondents report high annoyance to both fixed-wing aircraft and helicopters. The rates of 21% high annoyance for fixed-wing aircraft and 7% for helicopters were substantially different. The rates for annoyance to any degree appear to be quite similar for helicopters and fixed-wing aircraft in the 45–50 dB range, but higher for fixed-wing aircraft other than helicopters in the 50–55 dB range at 43% and 18%, respectively.

The question of whether fixed-wing or helicopter noise was the more annoying at the Washington, D.C., interviewing site was addressed by comparing aircraft noise source responses to helicopter responses (note the higher noise level of fixed-wing aircraft noise in Figure 5-8). Of the 398 cases available for analysis, 44 cases had missing values on one or both of the annoyance measures. The two measures of annoyance were logarithmically transformed prior to inferential analysis due to strong positive skewness. The fixed-wing aircraft generated greater annoyance, as described in detail in the next paragraph.



(a)

(b)

Figure 5-8. Proportion of respondents (a) highly annoyed and (b) annoyed to any degree by helicopter and fixed-wing aircraft noise at Washington study site.

Repeated-measures analysis of variance with varying covariates revealed significantly greater annoyance due to fixed-wing aircraft noise (after adjusting for fixed-wing DNL) than helicopter noise (after adjusting for helicopter DNL), $F(1, 396) = 23.70$, $p < .001$, partial $\eta^2 = .06$ with 95% confidence limits from .02 to .11. On an original scale in which 0 = not at all annoying or not noticing noise source to 4 = extremely annoying, mean annoyance for helicopter noise (log) was 0.108 ($SD = 0.217$) and the mean annoyance for fixed-wing aircraft noise (log) was 0.255 ($SD = 0.292$). The greater annoyance reported for exposure to fixed-wing aircraft, although statistically significant, was small, at less than one standard deviation difference in annoyance between the two noise sources. This evidence is both meager and inconclusive. It could well be more the product of recent changes in the fixed-wing flight patterns than differences in perceived annoyance relative to helicopter noise. (Changes in noise exposure associated with the changes in flight tracks were fully accounted for in the noise modeling done for this analysis.)

5.4.1.3 Annoyance by Helicopter Versus Fixed-Wing Aircraft Noise at Long Beach and Las Vegas

A similar analysis was conducted at the Long Beach and Las Vegas interviewing sites by once again adjusting for the frequency of noticing helicopter noise and fixed-wing aircraft noise as covariates to determine which aircraft type was more annoying. Of the 1,507 cases available for analysis, 323 cases were missing values on one or more of the four measures. Repeated-measures analysis of variance with varying covariates revealed significantly greater annoyance due to helicopter noise (after adjusting for frequency of noting helicopter noise) than fixed-wing aircraft noise (after adjusting for frequency of noticing fixed-wing or helicopter noise), $F(1, 1505) = 31.04$, $p < .001$, partial $\eta^2 = .04$ with 95% confidence limits from .02 to .06. On an original scale in which 0 = not at all annoying or not noticing noise source to 4 = extremely annoying, the mean annoyance for helicopter noise (log) was 0.087 ($SD = 0.20$) and mean annoyance for fixed-wing aircraft noise (log) was 0.021 ($SD = 0.11$). These findings assume no difference in actual loudness of the two types of aircraft noise in the two locations beyond differences in frequency of noticing them.

5.4.1.4 Dosage-Response for High Annoyance

The three panels of Figure 5-9 show proportions of respondents highly annoyed by helicopter noise within seven categories of DNL at all three interviewing sites.

Binary logistic regression analysis showed a statistically significant relationship between high annoyance (very or extremely annoyed by helicopter noise) and the sound level to which respondents were exposed in Long Beach, but not in the Las Vegas or Washington, D.C., data collection sites. Among the 1,089 Long Beach respondents, 1,050 were at home during the week before data collection and 99 of them were highly annoyed by helicopter noise (Table 5-4 and Table 5-6). A small (Nagelkerke $R^2 = .019$) but significant dosage-response relationship was observed, $\chi^2(1, N = 1{,}050) = 9.28$, $p = .002$. The odds ratio (B_e) was 1.107, with 95% confidence limits from 1.061 to 1.327. The dosage-response relationship was not statistically significant at Long Beach, $p = .538$ or in Washington, $p = .143$.

5.4.1.5 Annoyance to any Degree due to Helicopter Noise

A 2 × 3 (annoyance to any degree by data collection site) analysis of variance predicting helicopter DNL revealed statistically significant main effects of annoyance and site, but not their interaction (Figure 5-10). Helicopter noise exposure was greater for those reporting being at least slightly annoyed ($M = 43.47$, SE = 0.339) than those who were at home but reported no annoyance ($M = 42.26$, $SE = 42.26$), $F(1, 2191) = 10.83$, $p = .001$. However, the relationship accounted for little variance in noise exposure, partial $\eta^2 = .005$ with 95% confidence limits from .001 to .012. Data collection site also predicted differences in noise exposure, $F(2, 2191) = 50.97$, $p < .001$, partial $\eta^2 = .044$ with 95% confidence limits from .012 to .063. Noise exposure differences are presented in Table 5-5.

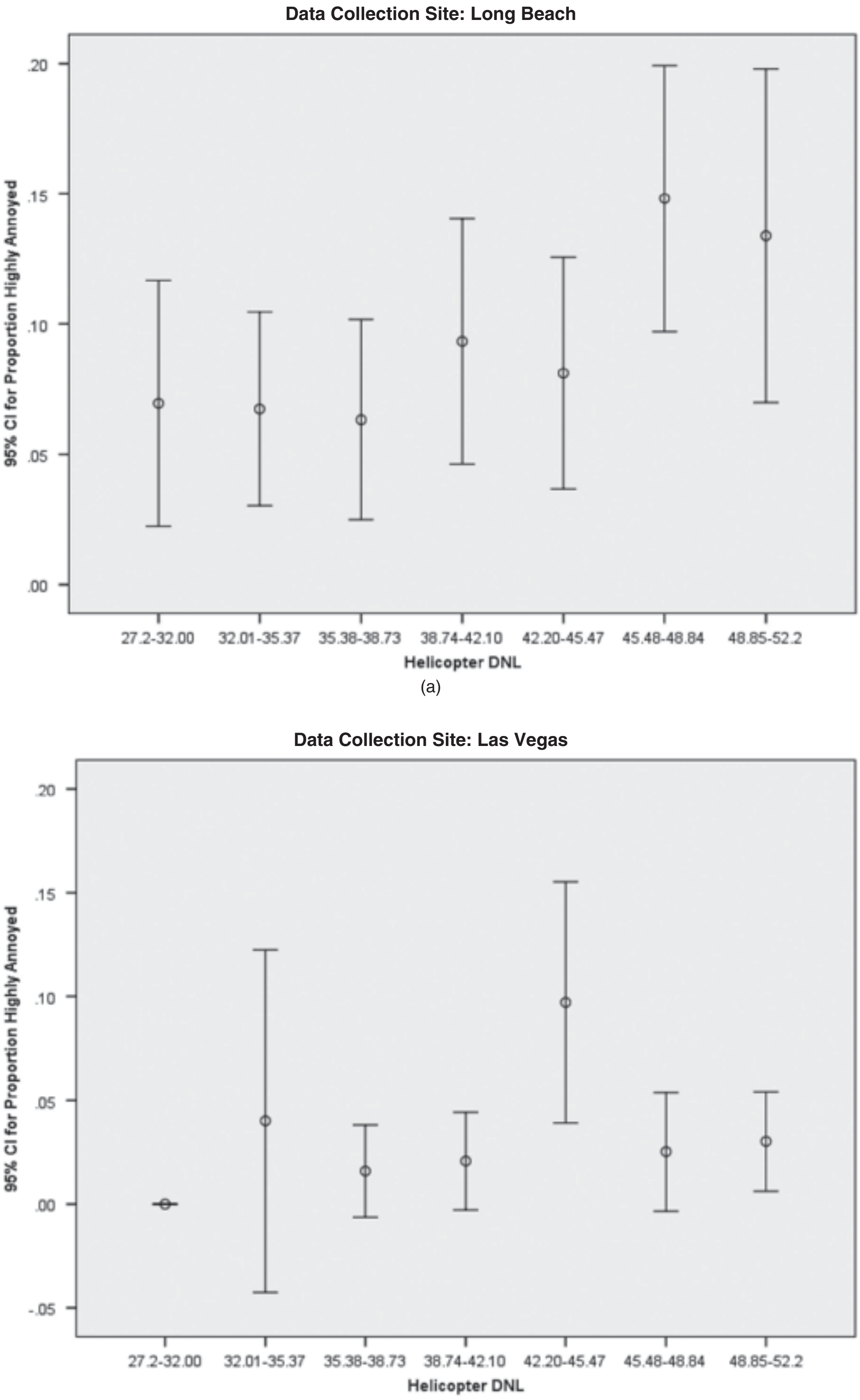


Figure 5-9. Proportions (with 95% CIs) of respondents highly annoyed by helicopter noise within (a) Long Beach and (b) Las Vegas.

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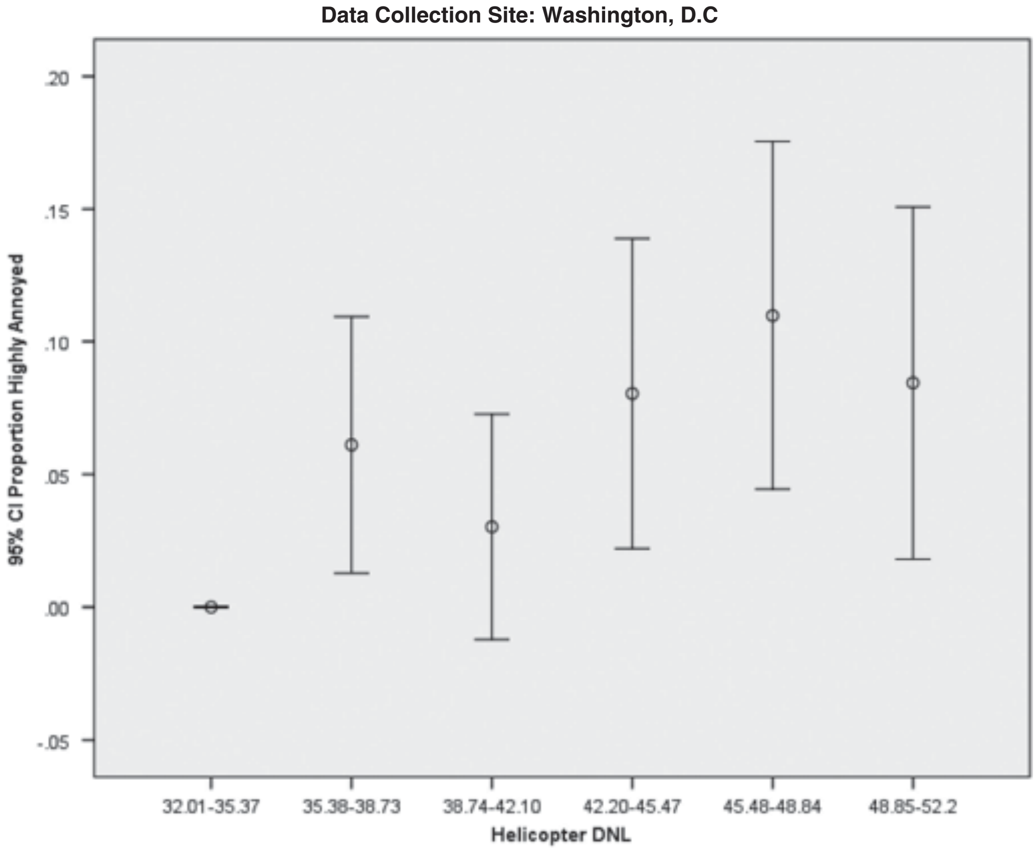

(c)

Figure 5-9. (Continued) Proportions (with 95% CIs) of respondents highly annoyed by helicopter noise within (c) D.C. data collection sites.

Table 5-6. Summary of logistic regression analyses of proportion highly annoyed by various helicopter noises for three data collection sites.

Noise Type	Site	HA/*N*[a]	*B*	Standard Error	Wald	df	*p*	Nagelkerke R^2	Odds Ratio (B_e)	95% CI for Odds Ratio	
										Lower	Upper
In-home vibration/ rattling	LGB	69/1050	0.059	0.066	0.811	1	.368	.002	1.061	0.933	1.206
	LAS	19/728	0.081	0.145	0.315	1	.575	.002	1.085	0.817	1.440
	DCA	27/419	0.194	0.132	2.148	1	.143	.013	1.214	0.937	1.573
Thumping and Slapping	LGB	44/1050	0.145	0.083	3.08	1	.079	.010	1.156	0.983	1.359
	LAS	17/728	0.138	0.356	0.79	1	.374	.006	1.148	0.846	1.558
	DCA	28/419	0.188	0.138	1.84	1	.174	.012	1.207	0.920	1.583
Buzzing	LGB	39/1050	0.360	0.092	8.03	1	.005	.030	1.297	1.084	1.553
	LAS	18/728	-0.051	0.157	0.10	1	.748	.001	0.951	0.698	1.295
	DCA	19/419	0.219	0.168	1.69	1	.192	.014	1.244	0.896	1.728
Whining	LGB	37/1050	0.069	0.088	0.61	1	.436	.002	1.071	0.901	1.274
	LAS	12/728	0.199	0.190	1.10	1	.294	.010	1.221	0.841	1.771
	DCA	16/419	-0.037	0.176	0.045	1	.832	<.001	0.963	0.683	1.360

[a] HA = Number of respondents highly annoyed; *N* = Number of valid responses; *B* = the customary symbol for slope; "Wald" = the value of a Wald test for the significance of the slope; "df" = the usual abbreviation for degrees of freedom; *p* = the customary symbol for significance; "Nagelkerke R^2" is an adjusted coefficient of determination; the odds ratio is a measure of an association of exposure and an outcome; CI = confidence interval.

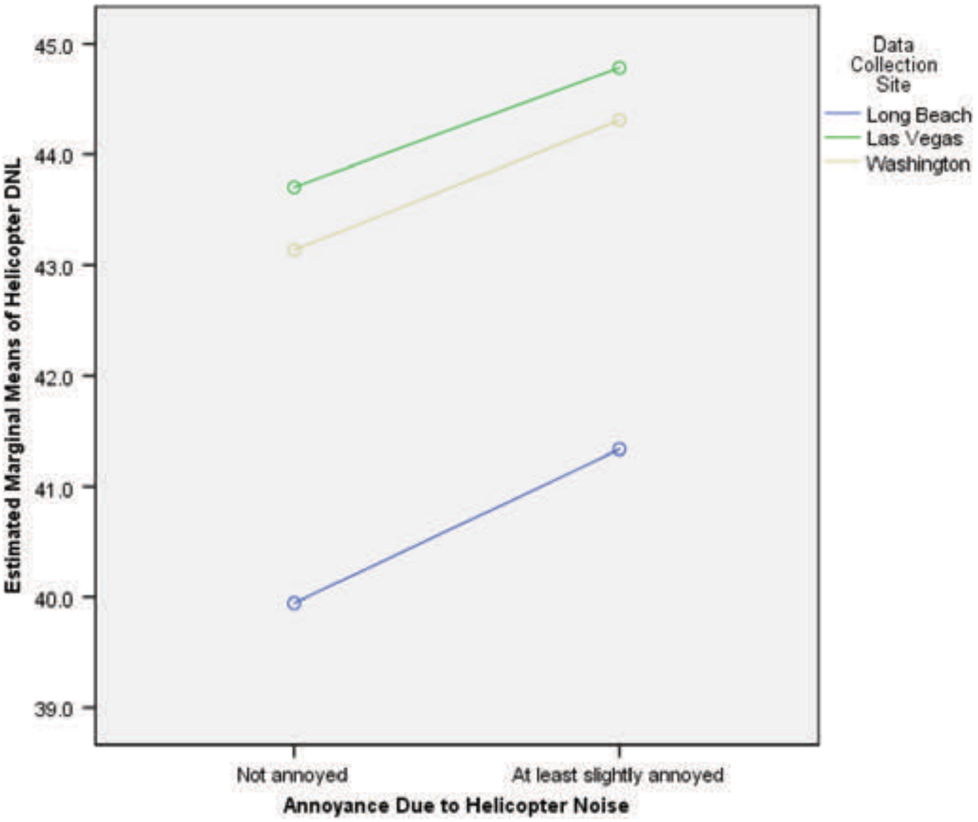

Figure 5-10. Prediction of helicopter DNL by reported annoyance due to helicopter noise and data collection site.

Hypothesis 2. The prevalence of annoyance due to rotary-wing noise is most appropriately predicted in units of A-weighted cumulative exposure. At only one of the three interviewing sites was there a good correlation between annoyance and the A-weighted decibel. Neither the C-weighted nor the helicopter-adjusted LFSL exhibited any greater correlation with annoyance. At the Las Vegas and Washington, D.C., interviewing sites, annoyance was unrelated to dose, as measured by the A-weighted, C-weighted, or the helicopter-adjusted LFSL.

At the Washington, D.C., interviewing site, a controversy over relocated fixed-wing tracks may have obscured any dependence of annoyance on dose.[18] The low doses of helicopter noise for the three studies cannot be ignored, however. It would have been advantageous to have surveyed a community with higher helicopter noise dose (greater than 60 DNL). To do that, a survey would have had to occur around a military facility. The research panel restricted the surveys to civil helicopter routes thus limiting the noise dose to DNL below 60 dB. See Section 5.6 for details on the low-frequency analysis.

Hypothesis 3. Main rotor impulsive noise controls the annoyance of helicopter noise (and hence requires an impulsive noise "correction" to A-weighted measurements). Noise measurements included A- and C-weighted impulsive noise levels. The difference between these and non-impulsive A- and C-weighted levels differed only by constants. However, the civil helicopters measured in this study do not produce the main rotor impulsive noise levels that military helicopters can produce in certain flight regimes. That is not to say there were none, but that the levels were not as pronounced as with heavier helicopters. This hypothesis would be better tested where there were heavy military helicopter operations so that the impulsive noises were more pronounced. Therefore, no clear conclusion could be drawn from these surveys.

Hypothesis 4. The prevalence of annoyance due to helicopter noise is heavily influenced by indoor secondary emissions (rattle and vibration) due to its low-frequency content. Binary logistic regression analyses were conducted for high annoyance due to in-home vibration/rattling as well as other helicopter sounds: BVI (thumping or slapping), buzzing, and whining. Table 5-6 summarizes these analyses.

No statistically significant relationship was observed between annoyance due to in-home vibration and rattling and annoyance due to noise level alone. The dosage-response relationship between helicopter noise exposure and annoyance due to "buzzing" noises differed significantly from chance in Long Beach, but not in Las Vegas or Washington, D.C. Figures 5-11 through 5-14 show proportions of reports of high annoyance for each of the specific noise types.

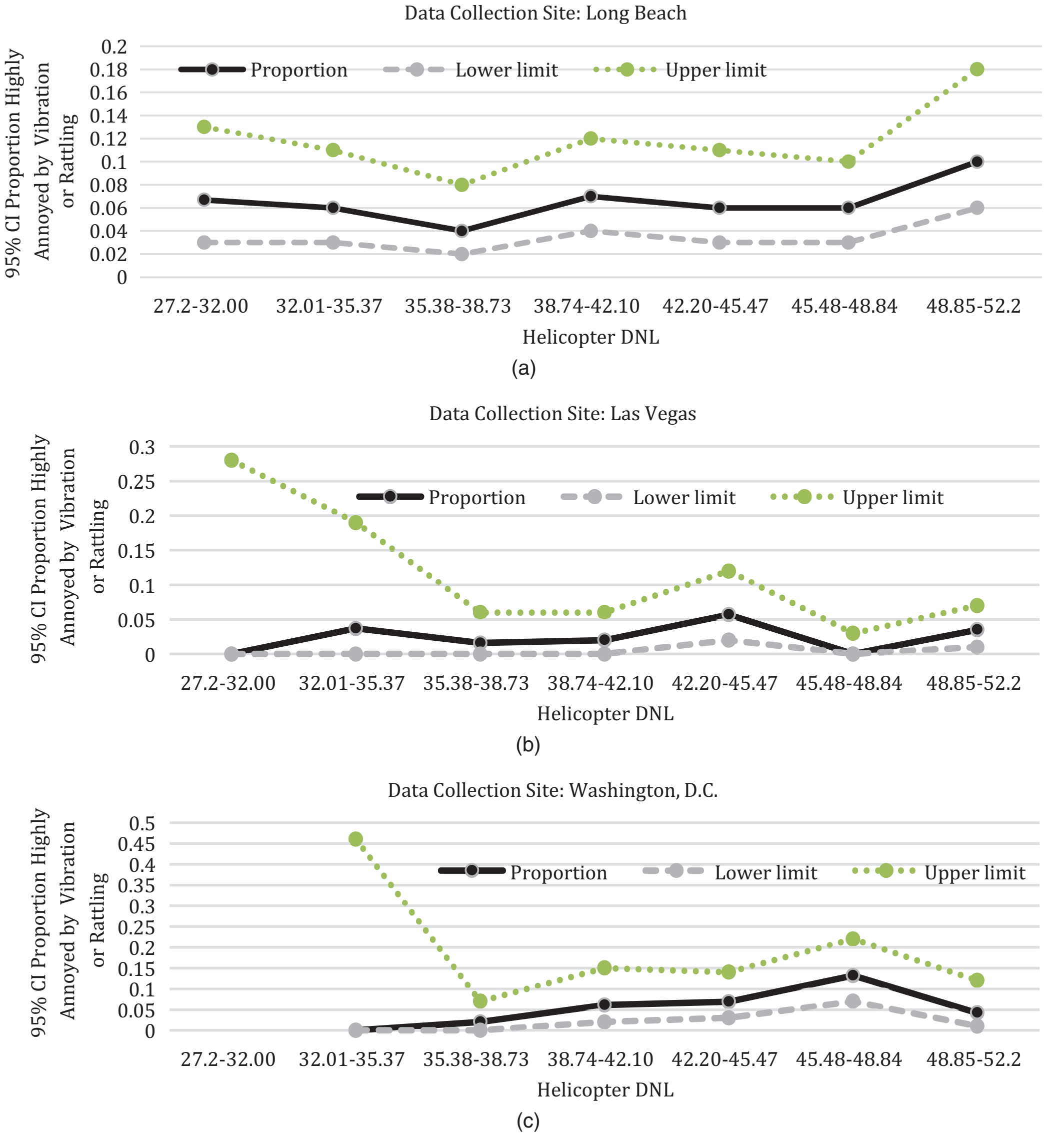

Figure 5-11. Proportion (with 95% CIs) of respondents highly annoyed by helicopter in-home vibration or rattling within (a) Long Beach, (b) Las Vegas, and (c) D.C. interviewing sites. Asymmetric CIs were calculated using the Clopper-Pearson method.

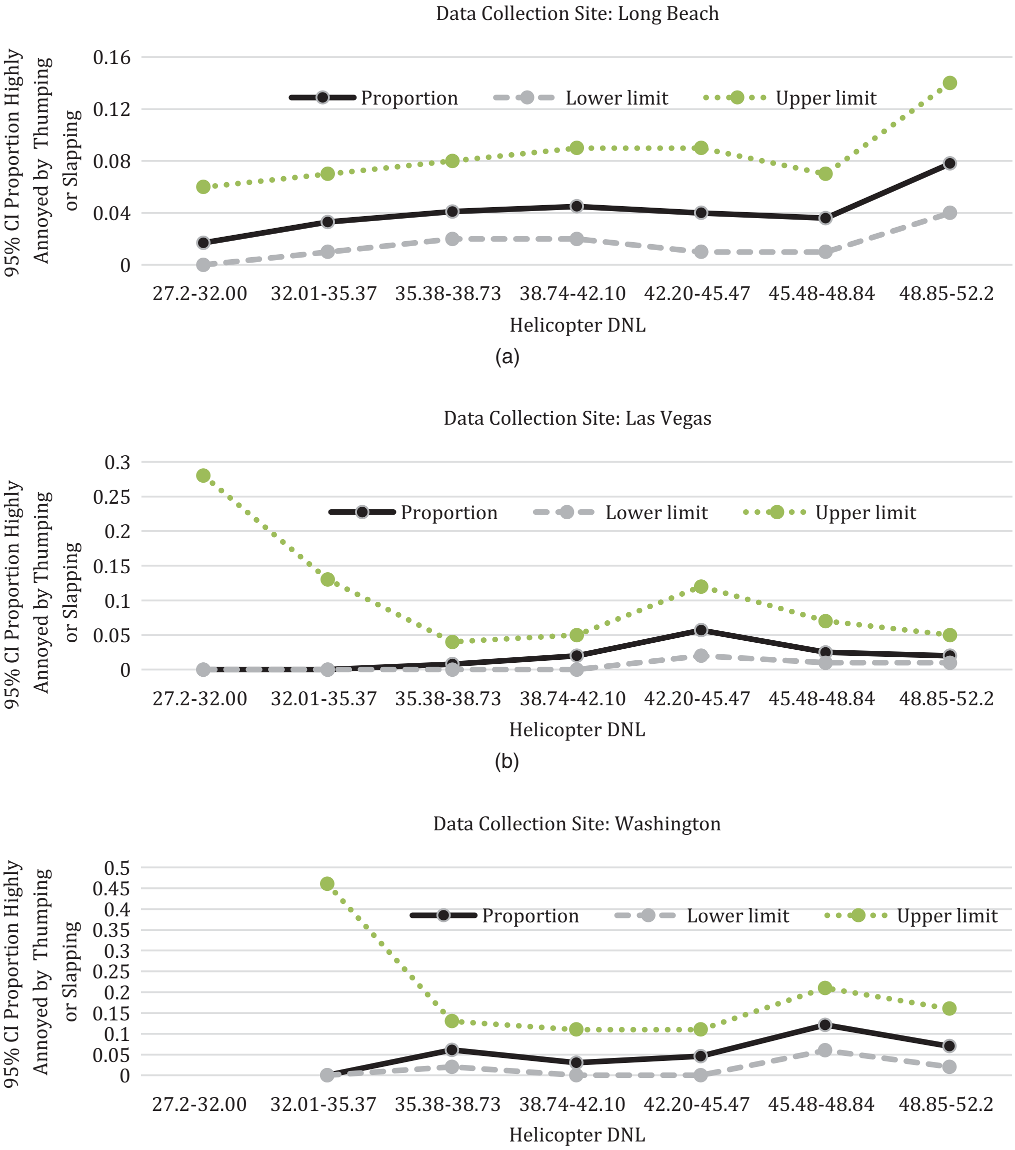

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Figure 5-12. Proportion (with 95% CIs) of respondents highly annoyed by helicopter thumping and slapping (BVI) noise at (a) Long Beach, (b) Las Vegas, and (c) D.C. interviewing sites. Asymmetric CIs were calculated using the Clopper-Pearson method.

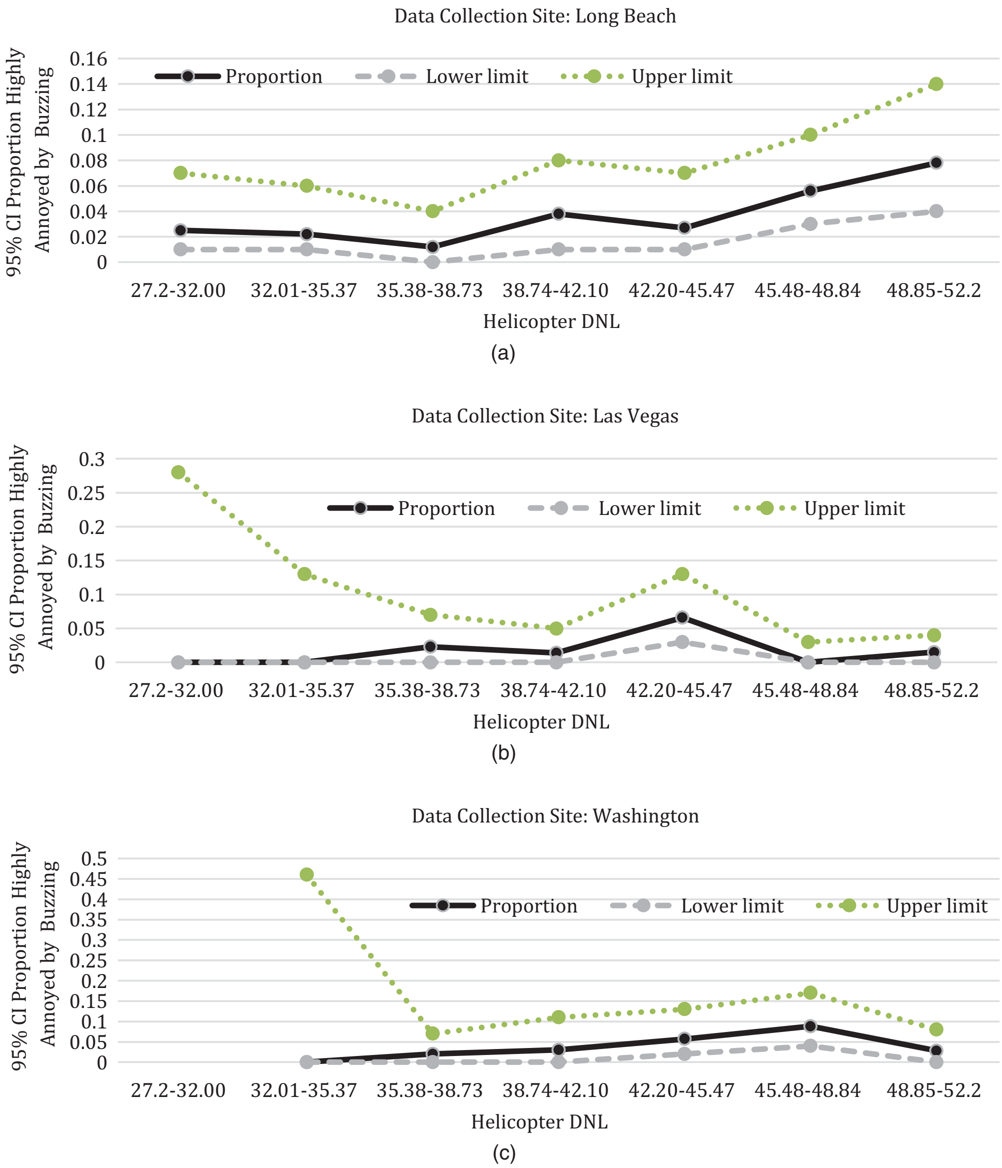
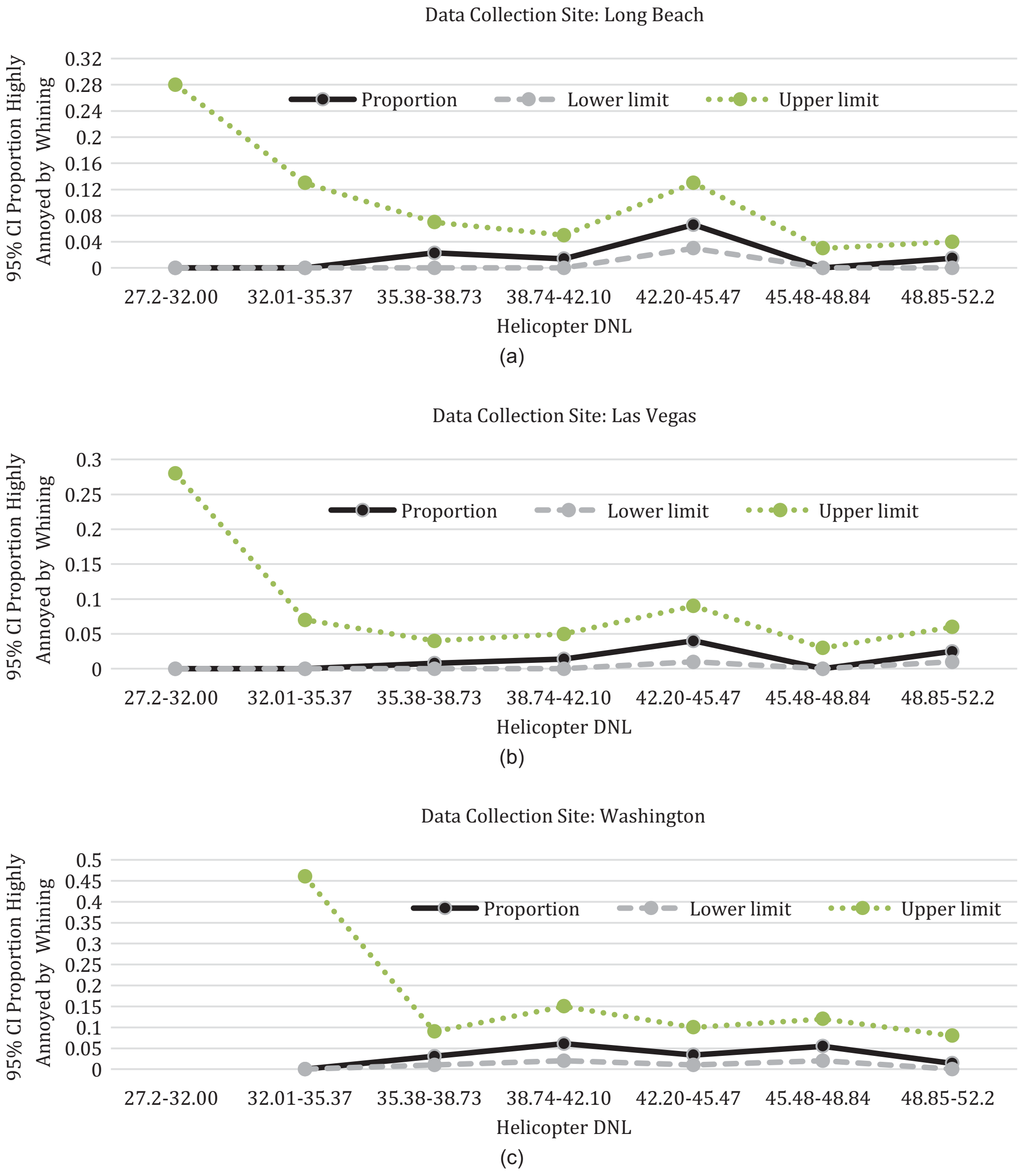


Figure 5-13. Proportion (with 95% CIs) of respondents highly annoyed by helicopter buzzing noise within (a) Long Beach, (b) Las Vegas, and (c) D.C. interviewing sites. Asymmetric CIs were calculated using the Clopper-Pearson method.



(a)

(b)

(c)

Figure 5-14. Proportion (with 95% CIs) of respondents highly annoyed by helicopter whining noise within (a) Long Beach, (b) Las Vegas, and (c) D.C. data collection sites. Asymmetric CIs were calculated using Clopper-Pearson method.

The logistic regression of buzzing noises on helicopter noise exposure was the only one that was unlikely to have arisen by chance alone, but even it accounted for very little variance in the relationship between annoyance and exposure. In the apparent absence of any strong association between helicopter noise exposure and annoyance at the low exposure levels that were available for study, it is likely that nonacoustic factors may have controlled community response to helicopter noise at the study sites.

Hypothesis 5. The prevalence of annoyance due to helicopter noise is heavily influenced by nonacoustic factors. It is clear from the differences in response in the Long Beach and Las Vegas communities that nonacoustic factors strongly influence community response in these communities. Las Vegas had approximately ten times the number of flights, albeit at a higher altitude, and yet a substantially reduced fraction of the population were highly annoyed. The higher altitude effect on DNL (in the range of a 3 to 4 dB reduction) was nowhere near the effect of the higher number of operations on DNL (plus 10 dB). Aircraft fleet mix cannot account for the difference either. In Washington, D.C., the public concern over moved fixed-wing flight tracks negated the dosage-response effect for both fixed-wing and helicopter noise. No acoustic factors can account for these differences. Note that the literature (Fidell et al. 2011) discusses a myriad of nonacoustic factors that can contribute to people's attitude to noise. The primary nonacoustic factors are fear and distrust. Certainly, the low altitudes of helicopters could be contributing to fear. Other factors that may be playing a role are expectations, invasion of privacy, the apparent need for the helicopter operations, or a perception that not enough is being done to control helicopter noise.

Predicting Helicopter Noise Annoyance from Annoyance Due to Other Noise Sources. As an indication of possible individual differences and/or response bias, a binary multiple logistic regression examined whether high annoyance by fixed-wing aircraft and high annoyance by traffic noise (very or extremely annoyed) predicted whether an individual was highly annoyed by helicopter noise. Site was included as a predictor, along with interactions between site and the other two sources of noise annoyance to account for differences among sites. Data for this analysis were provided by 2,197 of the 2,272 respondents (others reported not being at home during the period in question). The eight-predictor model showed prediction of high annoyance that was significantly better than would be expected by chance, $\chi^2\,(8, N = 2{,}197) = 178.59, p < .001$. The fit of the model to the data was very good, Hosmer-Lemeshow $\chi^2\,(2, N = 2{,}197) = 0.531, p = .767$ (where $p = 1.0$ indicates perfect fit); the variance in high annoyance due to helicopter noise is accounted for moderately well, Nagelkerke $R^2 = .20$. Table 5-7 shows the results of the logistic regression.

Table 5-7. Logistic regression analysis of high annoyance due to helicopter noise as a function of high annoyance due to other noise sources, data collection site, and interactions.

Variable	*B*	Standard Error	Wald	df	*p*	Odds ratio (B_e)	95% CI for OR	
							Lower	Upper
LGB vs. DCA	1.406	0.429	10.74	1	**.001**	4.078	1.760	9.452
LAS vs. DCA	0.143	0.487	0.09	1	.789	1.153	0.444	2.996
Fixed-wing aircraft	2.685	0.465	33.36	1	**<.001**	14.658	5.894	36.457
Traffic	2.159	0.701	9.49	1	**.002**	8.667	2.193	34.243
LGB vs. DCA by fixed-wing aircraft	-0.354	0.506	0.34	1	.560	0.702	0.214	2.303
LAS vs. DCA by fixed-wing aircraft	0.023	0.816	<0.01	1	.978	1.023	0.207	5.064
LGB vs. DCA by traffic	-0.825	0.758	1.19	1	.276	0.438	0.099	1.936
LGB vs. DCA by traffic	0.643	0.897	0.51	1	.474	1.902	0.328	11.036
Constant	-4.000	0.410						

B = the customary symbol for slope; "Wald" = the value of a Wald test for the significance of the slope; "df" = the usual abbreviation for degrees of freedom; *p* = the customary symbol for significance; the odds ratio is a measure of an association of exposure and an outcome; CI = the confidence interval; OR = odds ratio.

Reporting high annoyance with helicopter noise is predicted by reports of high annoyance by traffic and fixed-wing noise sources, and by whether respondents lived in Long Beach versus Washington, D.C. Respondents who were highly annoyed by fixed-wing aircraft noise were almost fifteen times more likely to be highly annoyed by helicopter noise than those who were not highly annoyed by fixed-wing aircraft noise. Respondents who were highly annoyed by traffic noise were more than 8.5 times as likely to be annoyed by helicopter noise. Residents of Long Beach were about four times more likely to be highly annoyed by helicopter noise than were residents of D.C. (An earlier analysis, not shown, indicated that residents of Long Beach were about three times as likely to be highly annoyed by helicopter as those living in Las Vegas, $p < .001$.) None of the interactions between site and noise type differed significantly from chance, $p > .05$. Thus, the analysis suggests fairly strong individual differences in reporting high annoyance due to different noise sources.

In other words, a respondent who reported high annoyance to any other noise source was much more likely to be annoyed by helicopters. This adds to the common belief in varying levels of noise sensitivity, but it does not rule out that this may be associated with nonacoustic variables such as expectations.

Hypothesis 6. The prevalence of annoyance due to helicopter noise is heavily influenced by proximity to helicopter flight paths. Binary logistic regression analysis was used to determine whether proximity to the flight track influences a high degree of annoyance due to helicopter flight paths. At Long Beach, the dosage-response relationship was small (Nagelkerke $R^2 = .018$) but statistically significant, $\chi^2(1, N = 1{,}050) = 8.70, p = .003$. Odds ratio ($B_e$) was 0.279 (indicating a negative relationship between distance and annoyance) with 95% confidence limits from 0.117 to 0.662. The dosage-response relationship failed to approach statistical significance at Long Beach, $p = .664$. Thus, proximity to flight path is as good a predictor of high annoyance as noise level. The relationship of annoyance to distance is discussed further in Section 5.5.2.

Hypothesis 7. Complaints lodged about helicopter noise are more reliable predictors of the prevalence of annoyance than measures of exposure to helicopter noise or proximity to helicopter flight paths. ***Complaints by Annoyance.*** Only a very few respondents (2.6%) indicated that they had ever registered complaints (Item 15). However, a Chi-square analysis of whether respondents complained by whether they were at least slightly annoyed by helicopter noise revealed a statistically significant relationship, $\chi^2(1, N = 2{,}167) = 73.70, p < .001$, Cramer's $V = .19$. Among the 1,937 respondents who reported no annoyance by helicopter noise, 1.3% complained; of the 330 respondents who reported at least slight annoyance by helicopter, 9.4% registered complaints. Thus, a reasonably clear relationship was found between the prevalence of annoyance (in any degree) and complaint behavior.

Complaints by Noise Exposure. A 2 × 2 analysis of variance examined whether complaining (yes or no) was related to noise exposure or site or their interaction. There was no statistically significant difference in noise exposure for those who did and did not complain, $p = .722$, nor was there a significant interaction with the site $p = .649$. The difference between sites was statistically significant, $F(2, 2155) = 5.36, p = .005$ but small, $\eta^2 = .005$.

Note that this correlation analysis refers to noise complaints as those provided in the survey response, i.e., did the responder file a noise complaint. This analysis is not referring to the noise complaints filed with the airports. Unfortunately, the noise complaints collected by the airports either did not segregate helicopter complaints from fixed-wing, were not geocoded and available for GIS analysis, or both.

5.4.1.6 Additional Relationships with Helicopter Noise Exposure

Were Helicopters Noticed? A between-subjects two-way (site by notice of helicopters) analysis was conducted of noise exposure. Statistically significant main effects for both site and frequency category were observed, but no interactions were noted, as seen in Figure 5-15.

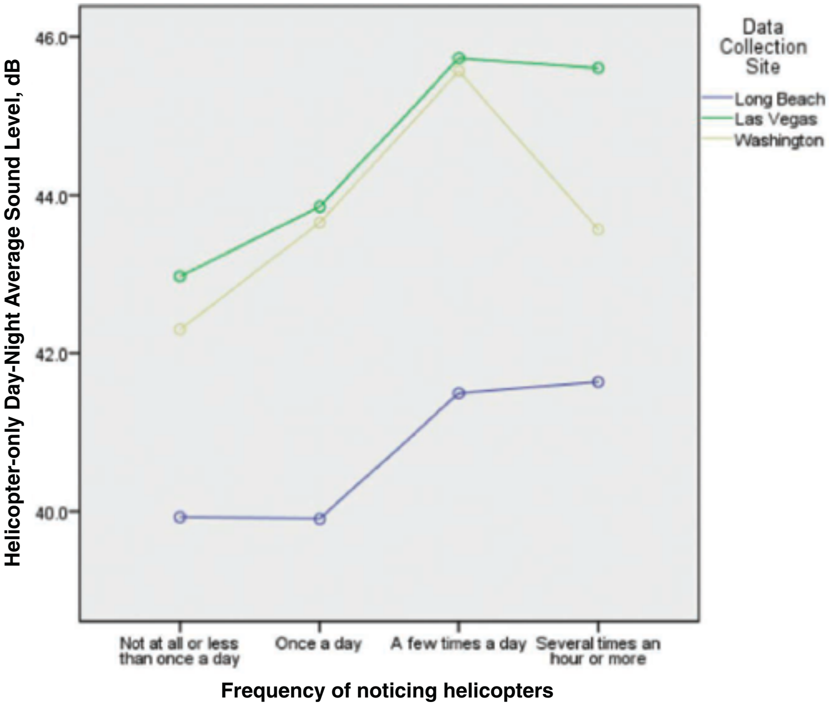


Figure 5-15. Plot of noticing helicopters as a function of DNL.

Helicopter noise exposure was greater for those who noticed helicopters ($M = 43.27$, SE = 0.192) than for those who did not notice helicopters ($M = 41.73$, SE = 0.191), $F(1, 2107) = 32.17$, $p < .001$, but the relationship was weak, partial $\eta^2 = .02$, with 95% confidence limits from .01 to .03. Figure 5-9a, b, and c show that the ranges of helicopter noise exposure levels, from the low 30 dB to low 50 dB range, was similar at all three sites.

Frequency of Notice of Helicopters. Categories of frequency of noticing helicopters are in Table 5-3. A between-subjects two-way (site by frequency category) analysis was conducted of noise exposure, with planned trend analysis. Statistically significant main effects were observed for both site and frequency category, but no interactions were noted.

The relationship between noise exposure and categories of frequency of noticing helicopters was statistically significant, $F(3, 2020) = 17.34$, $p < .001$, but moderate, partial $\eta^2 = .025$, with 95% confidence limits from .01 to .04. Linear and cubic trends were statistically significant, with $p < .001$ and .013, respectively. As seen in Figure 5-16, the trend is at least speculatively consistent with a sigmoidal dosage-response function. In any event, over a small dynamic range noticeability increased with increasing DNL.

5.5 Relationships Among DNL, Distance, and Percent Highly Annoyed

This section examines two relationships observed in the data. The first shows the relationship between the modeled DNL during the week prior to interview and the distance from the flight corridor centerline. The second shows the relationship between annoyance and DNL during the week prior to interview. DNL and distance from a noise source are obviously highly correlated, but annoyance could conceivably be more closely related to proximity to direct overflights.

5.5.1 DNL Versus Distance Relationships

Figures 5-16 through 5-18 show DNL versus distance relationships for Long Beach, Las Vegas, and Washington D.C., respectively. They show orderly reductions in SELs with distance. The Long Beach data has the greater variance likely due to a much greater dispersion of flight tracks within a corridor and the existence of two corridors affecting the survey area, the Cherry Avenue corridor, and the split in the Redondo corridor into a westbound and eastbound leg at the coastline. For those respondents living directly under the corridor (i.e., within 0.1 nm of the centerline) the sound exposure does not change appreciably with distance. At 1 nm from centerline, DNL dropped by 19 and 17 dB, respectively, for Long Beach and Las Vegas.

5.5.2 Dosage-response Relationships

The following paragraphs describe dosage-response relationships between SELs and the prevalence of annoyance.

5.5.2.1 Washington, D.C.

Figures 5-19 through 5-22 show relationships between (A-weighted) DNL and the prevalence of high annoyance observed among respondents at the Washington, D.C., interview site. Separate relationships are shown for fixed- and rotary-wing aircraft. The first relationship, for fixed-wing aircraft, shows the percent highly annoyed in Figure 5-19 and the number of respondents in Figure 5-20. Figure 5-21 (for helicopters) shows the percent highly annoyed. Figure 5-22 shows the number of respondents for helicopters.

Figure 5-23 shows the annoyance of exposure to helicopter noise as a function of reciprocal distance [20 Log (1/distance), where distance is in nautical miles]. Thus, 0 dB on the logarithmic scale indicates 1 nautical mile. The multiplier of 20 was chosen because at distances greater that

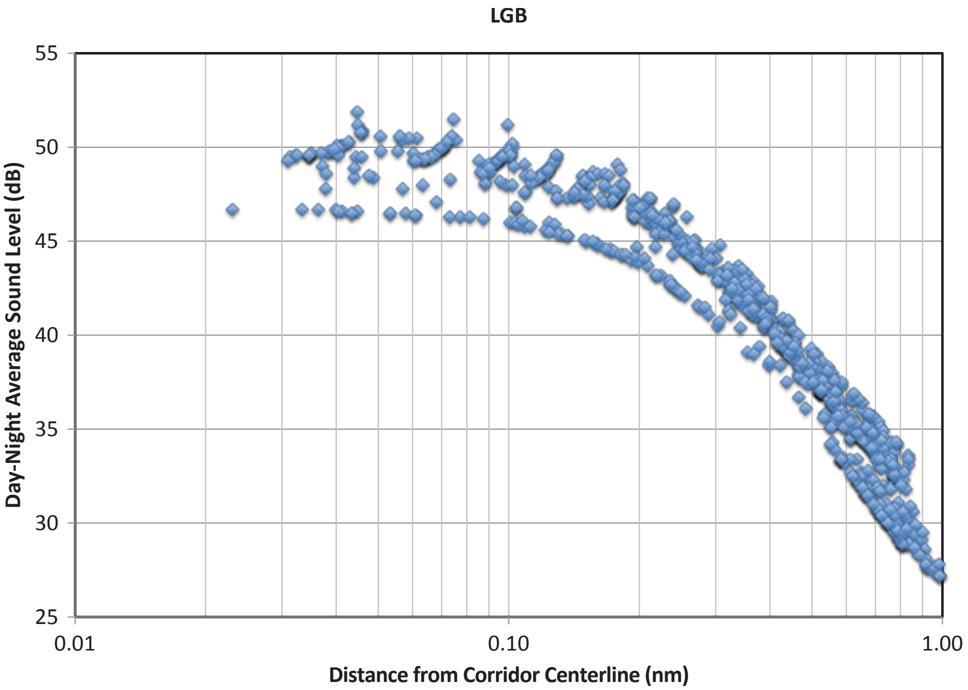


Figure 5-16. INM-generated DNLs for each respondent at LGB as a function of respondent distance from two flight corridor centerlines.

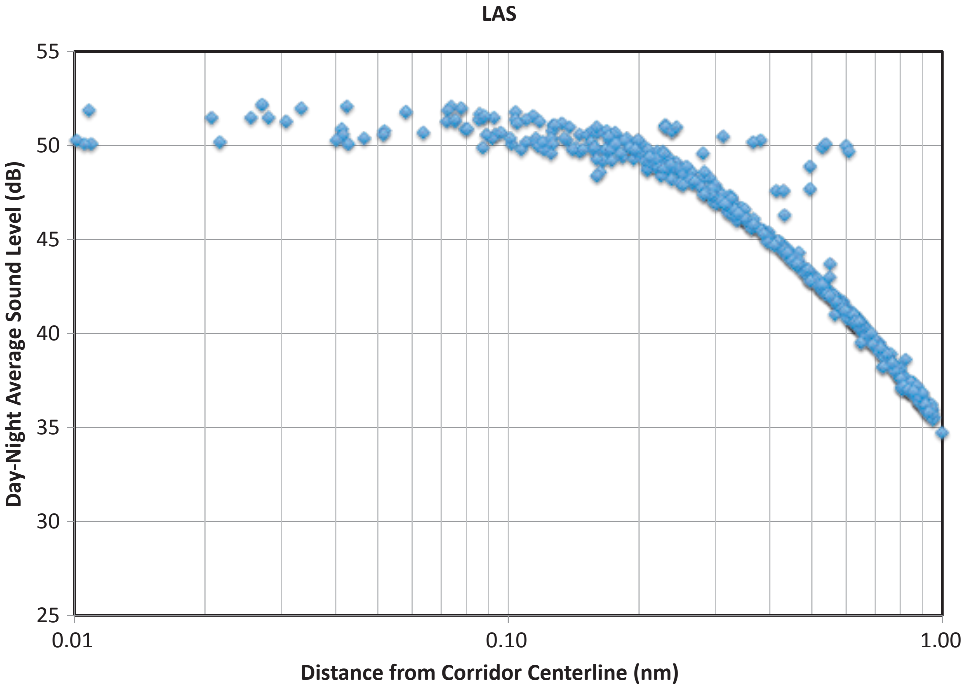


Figure 5-17. INM-generated DNLs for each respondent at LAS as a function of respondent distance from flight corridor centerlines.

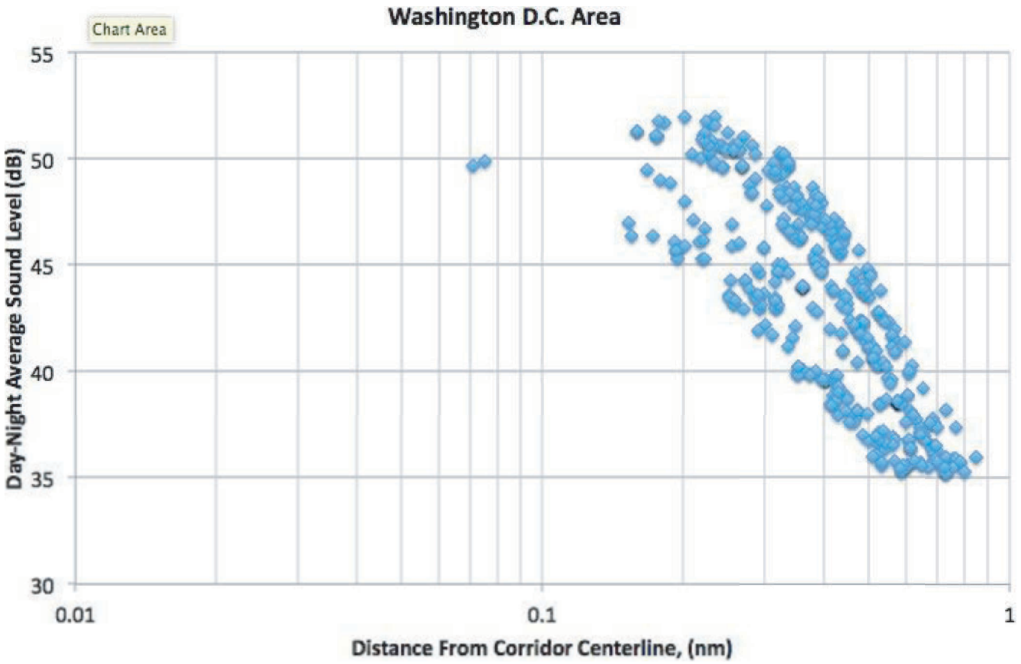


Figure 5-18. INM-generated DNLs for each respondent at DCA as a function of respondent distance from flight corridor centerline.

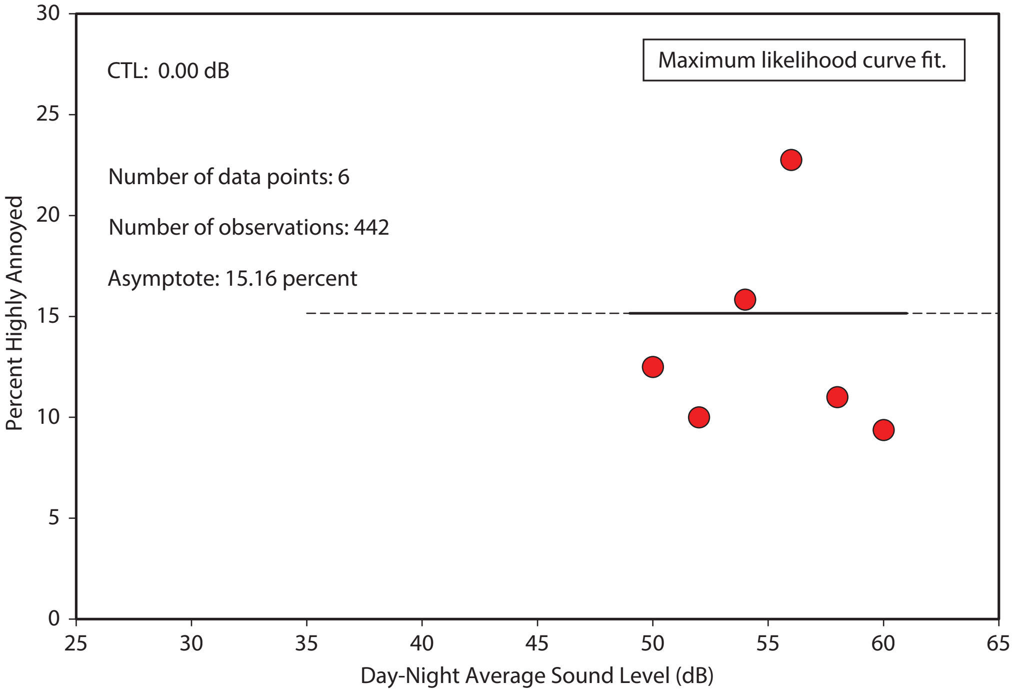


Figure 5-19. Percent of respondents highly annoyed at the Washington, D.C., interview site as a function of A-weighted DNL for fixed-wing aircraft.

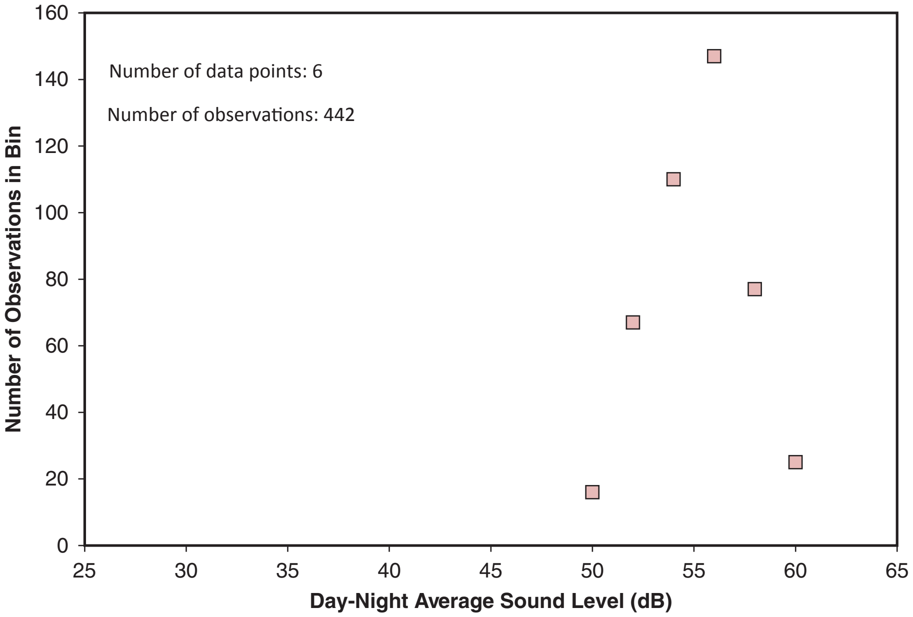


Figure 5-20. Number of respondents in each fixed-wing noise exposure category at the Washington, D.C., interview site (Bin = histogram bin).

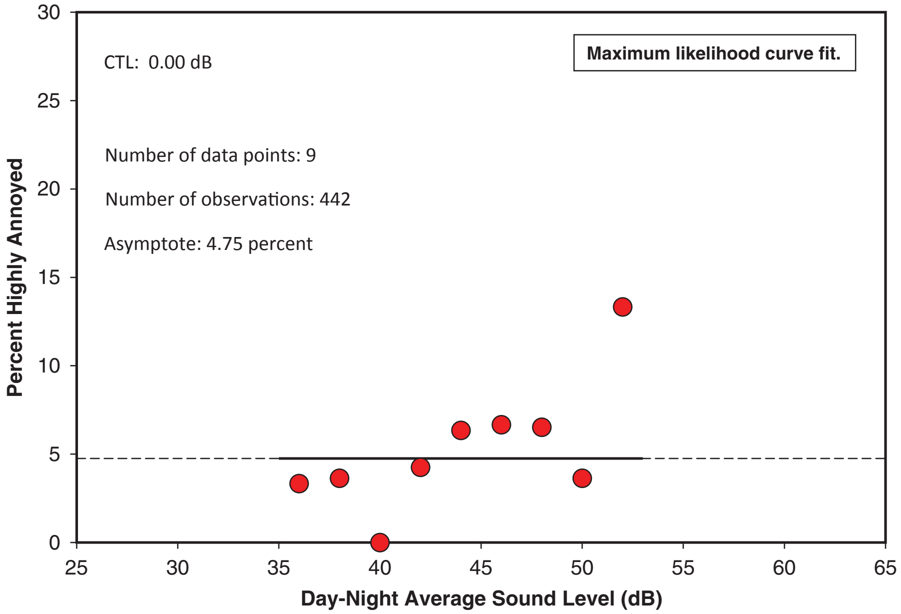


Figure 5-21. Percent of respondents highly annoyed at the Washington, D.C., interview site as a function of A-weighted DNL for helicopters.

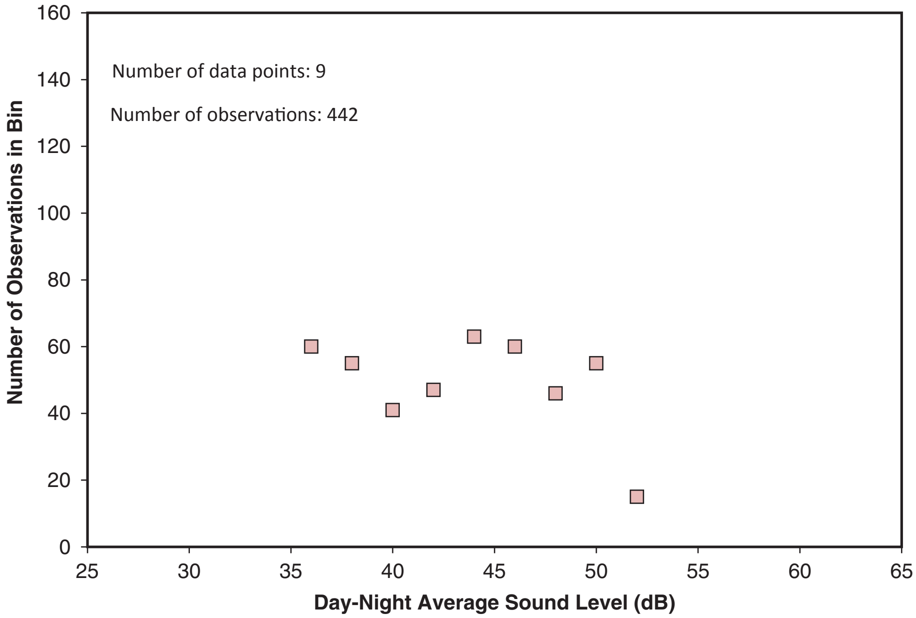


Figure 5-22. Number of respondents in each helicopter noise exposure category at the Washington, D.C., interview site.

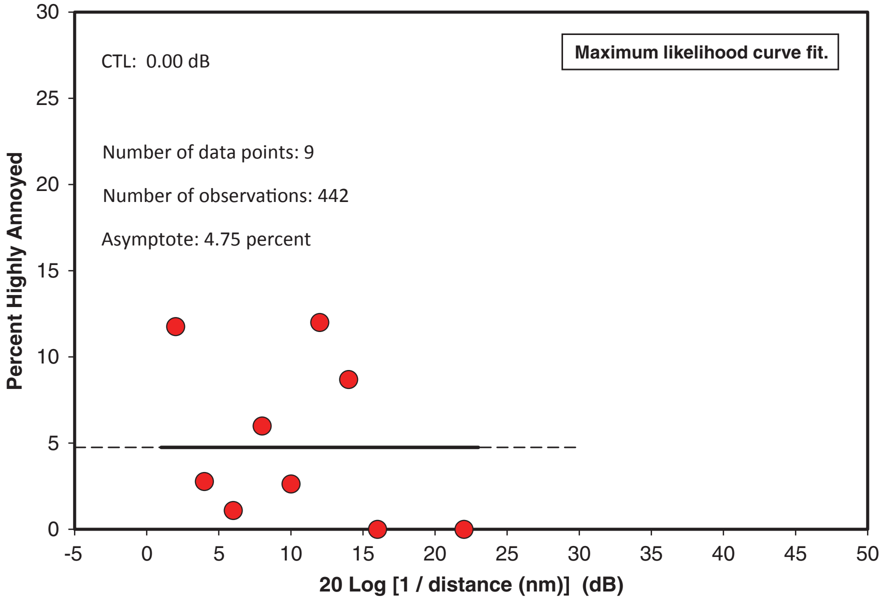


Figure 5-23. Percent of respondents highly annoyed at the Washington, D.C., interview site as a function of distance from helicopter corridor.

a few hundred feet, most INM noise-power-distance (NPD) curves drop off at that rate when SEL is plotted as a function of log [distance]. Figure 5-24 shows the number of interviews at each distance.

5.5.2.2 Las Vegas

Both A- and C-weighted measurements of DNL were available for analysis at the Las Vegas interviewing site. Wind-related, low-frequency noise measurement artifacts were less severe at LAS

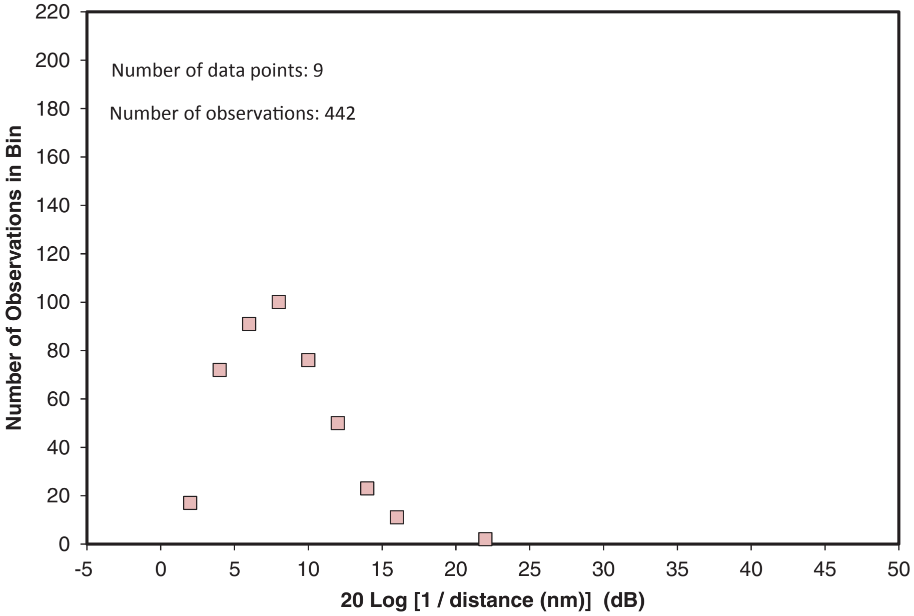


Figure 5-24. Number of respondents in each helicopter noise exposure category at the Washington, D.C., interview site.

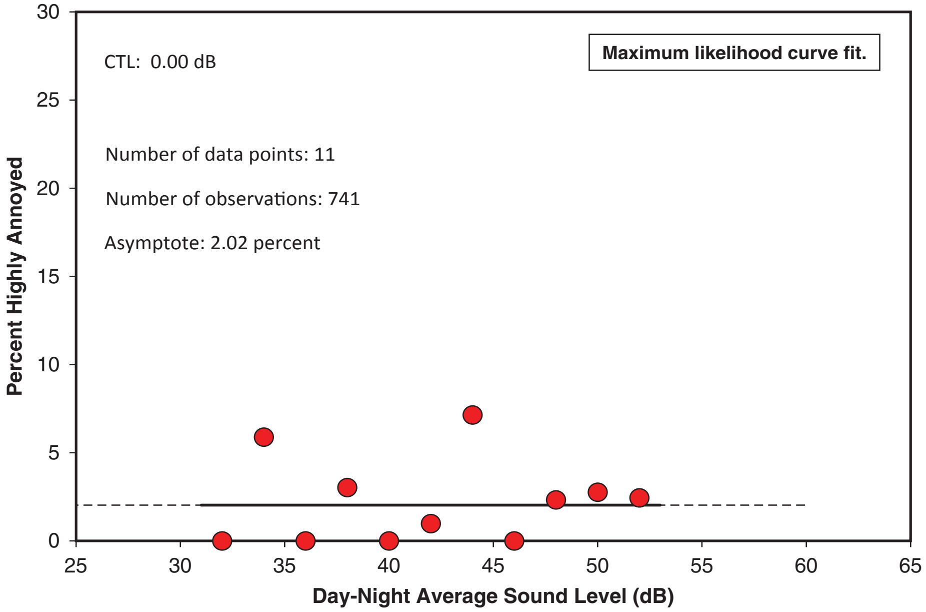


Figure 5-25. LAS, percent highly annoyed as a function of A-weighted DNL for helicopters.

than at LGB. Figure 5-25 plots the prevalence of percent highly annoyed against (A-weighted) DNL. Figure 5-26 shows the number of survey respondents in each exposure bin. No obvious trend of increasing annoyance with increasing noise level was observed: annoyance is nearly constant at all noise exposure levels. If there is a sigmoid function to the data for Las Vegas, the increase in annoyance with dose must occur at much higher noise levels than were encountered in LAS. The result is that all of the data are on the asymptote. This asymptote is at about 2 percent highly annoyed independent of noise exposure. Significantly, the asymptote does not go to zero at low noise exposure levels.

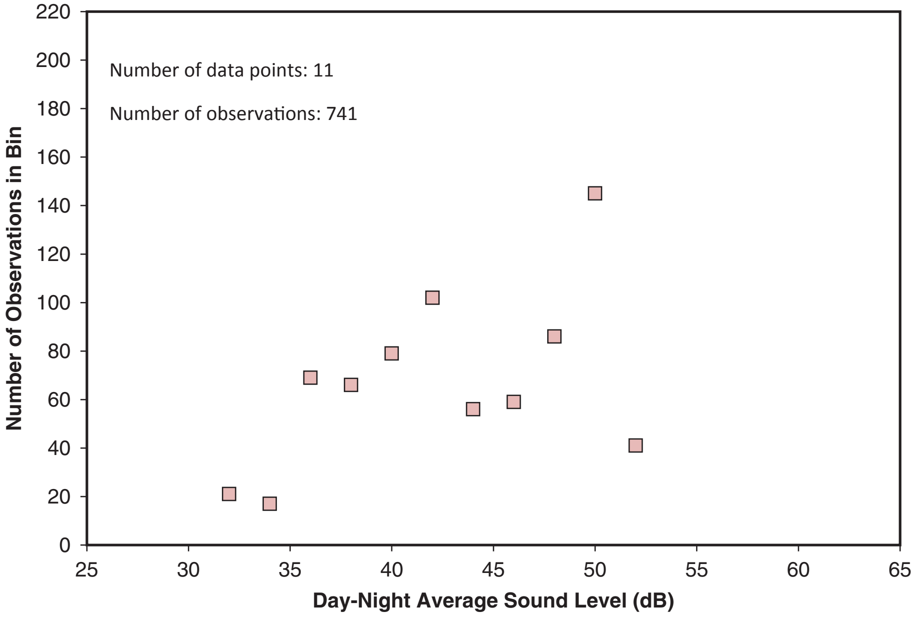


Figure 5-26. LAS, number of respondents for each helicopter survey point.

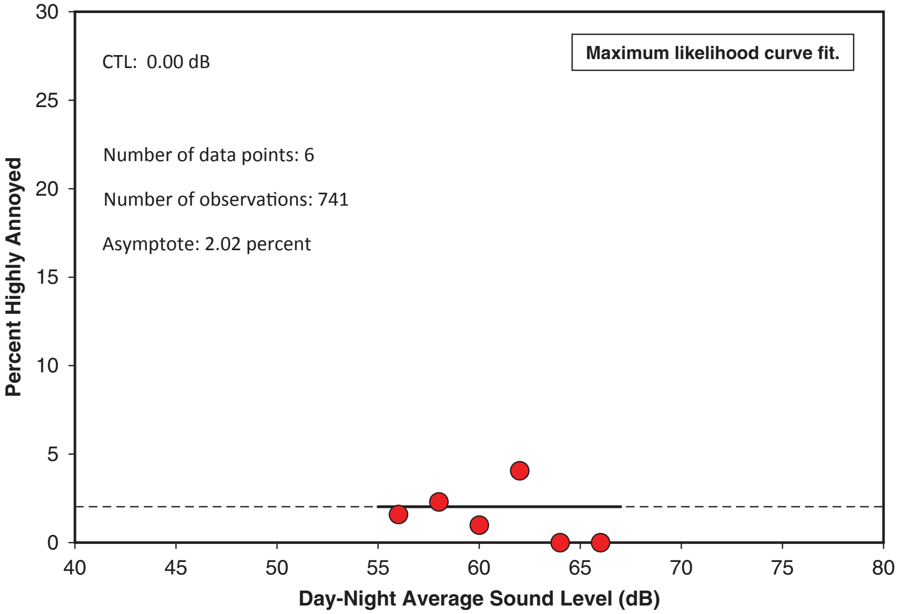


Figure 5-27. LAS, percent highly annoyed as a function of C-weighted DNL for helicopters.

Figure 5-27 shows the percent highly annoyed as a function of the C-weighted DNL. The C-weighting includes low-frequency noise far more effectively than does the A-weighting. Figure 5-28 shows the number of survey respondents for each survey bin. The C-weighted DNL response curve is similar to the A-weighted DNL, or in other words, flat. The asymptote shows a flat 2% highly annoyed independent of noise exposure, even accounting for the low-frequency noise.

In the hypothesis that annoyance response is a function of acoustic and nonacoustic parameters, nonacoustic parameters must be the dominating response.

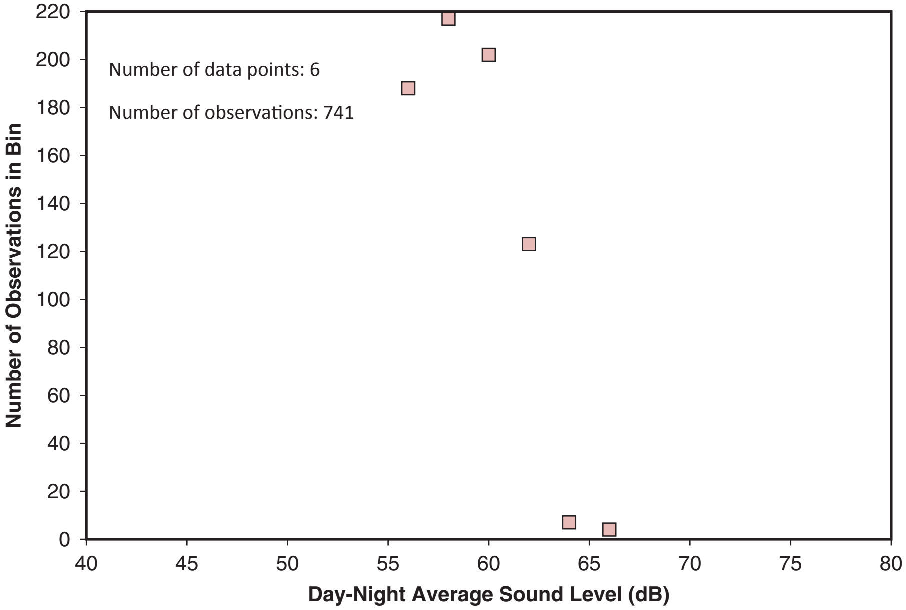


Figure 5-28. LAS, number of respondents for each helicopter C-weighted survey point.

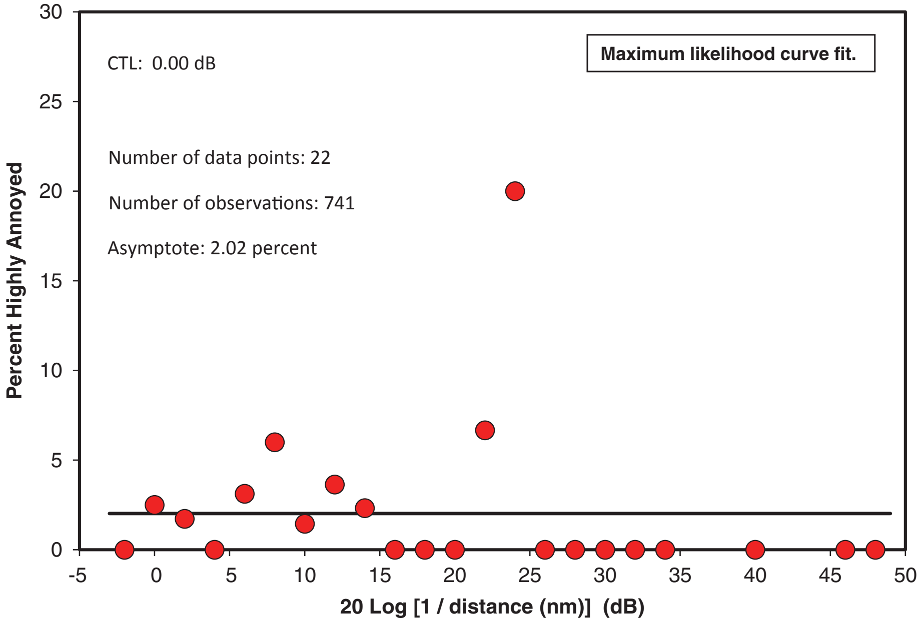


Figure 5-29. LAS, percent highly annoyed as a function of distance from helicopter corridor.

Figure 5-29 shows response as a function of reciprocal distance in the same manner as for Washington, D.C. Other than a singular point, there is no clear trend of increasing annoyance with decreasing distance to the helicopter corridor. Figure 5-30 shows the number of survey respondents for each survey bin.

5.5.2.3 Long Beach

Dosage-response graphs for Long Beach are shown in Figures 5-31 and 5-33 for the A-weighted DNL and reciprocal distance, respectively. Figures 5-32 and 5-34 show the number of respondents for each survey point.

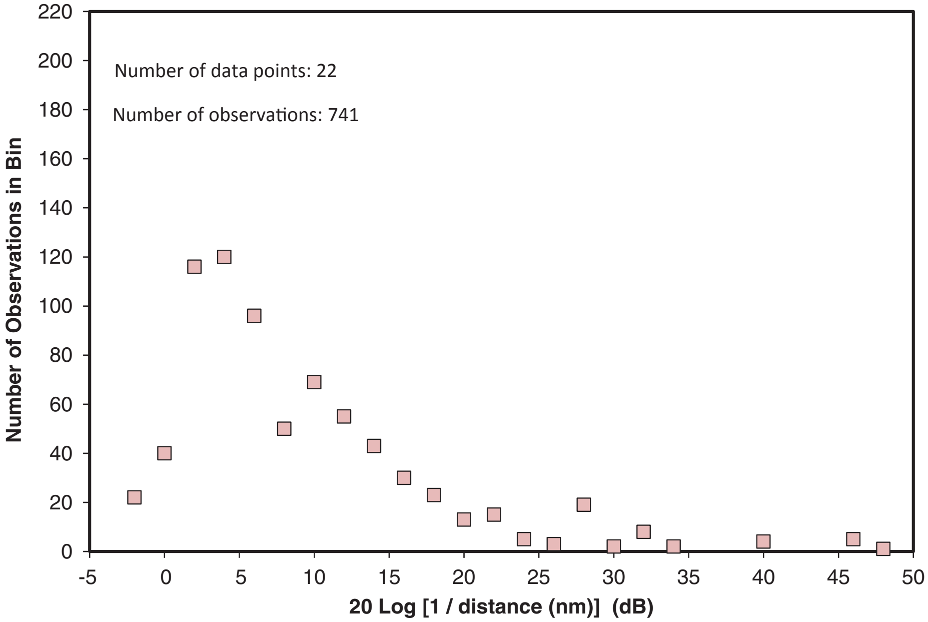


Figure 5-30. LAS, number of respondents for each helicopter distance.

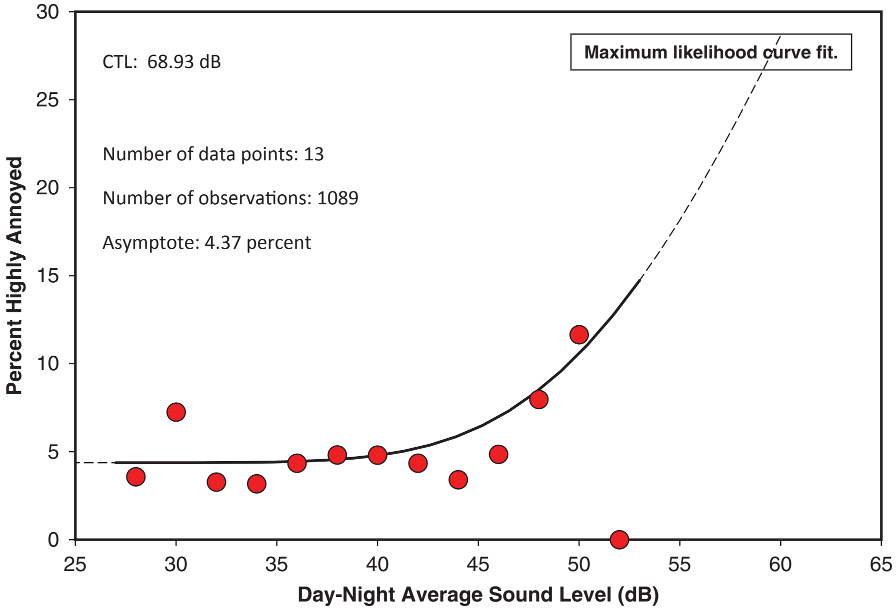


Figure 5-31. LGB, percent highly annoyed as a function of A-weighted DNL for helicopters.

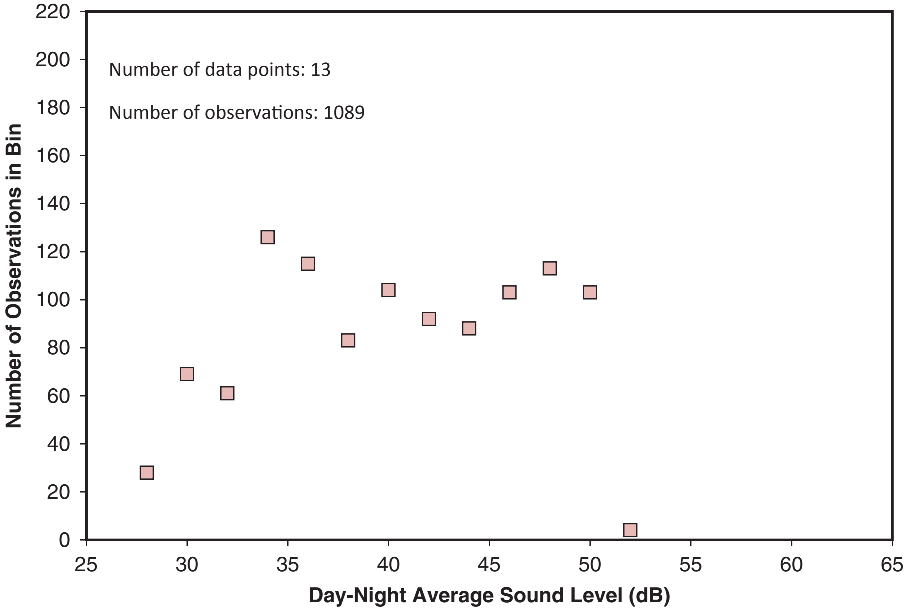


Figure 5-32. LGB, number of respondents for each helicopter survey point.

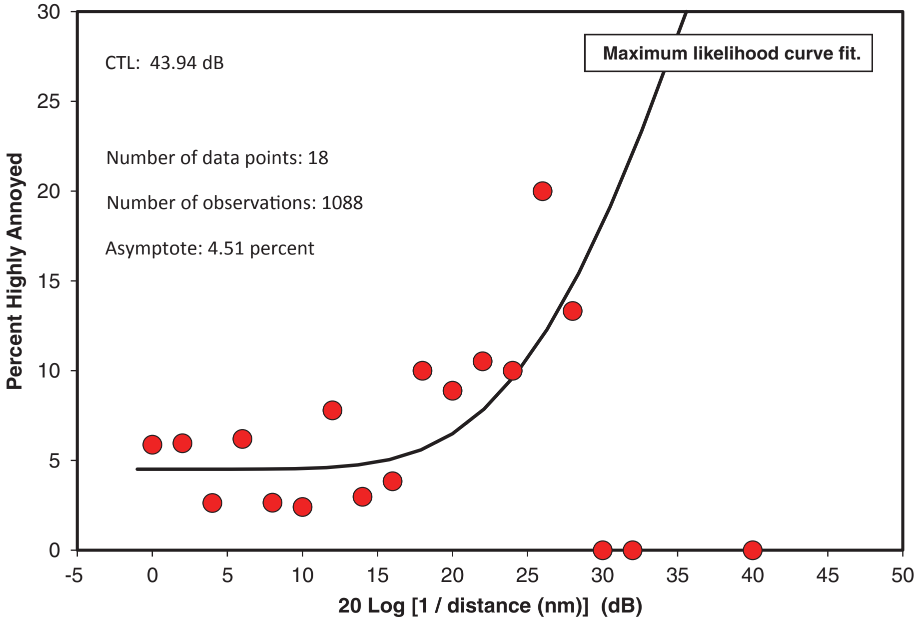


Figure 5-33. LGB, percent highly annoyed as a function of distance from helicopter corridor.

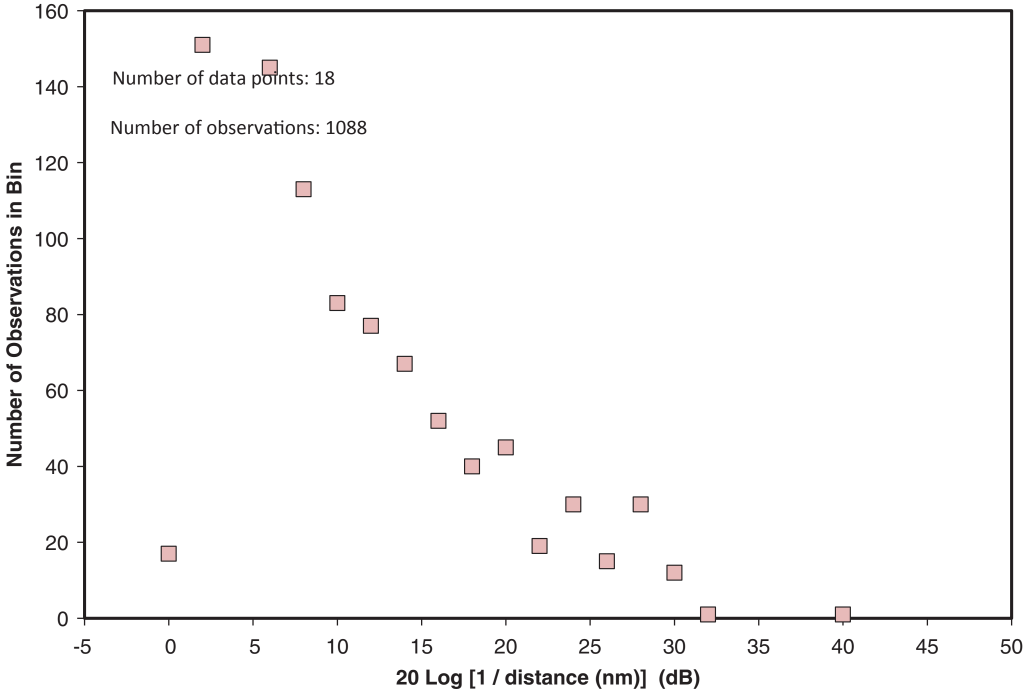


Figure 5-34. LGB, number of respondents for each helicopter distance.

The Long Beach dosage-response curve shows an increasing level of annoyance with increasing A-weighted DNL. This was the only survey site of the three sites where this clear trend is shown. Of note is the fact that the percent highly annoyed does not go to zero at lower noise exposures, but, in fact, the asymptote flattens out at about 4 percent highly annoyed no matter how low the DNL. Again, the hypothesis that annoyance response is composed of acoustic and nonacoustic response suggests that there are nonacoustic reasons that 4 percent of the population is highly annoyed with helicopters independent of noise dose.

Figure 5-33, the relation of percent highly annoyed to the reciprocal of distance, also shows a trend of higher annoyance with closer distance, but with much higher unexplained scatter in the data at higher DNL.

5.5.3 Dosage-response Relationship for Combined Sites

Figure 5-35 shows the dosage-response results for all three sites on the same plot. The solid lines represent the actual range of survey data and the dashed lines represent the curve developed from data extrapolated further out. Clearly each site is unique, indicating that each community has a unique response. The presence of residual annoyance as shown by the asymptote is a significant finding. It may indicate that the reason for apparent elevated helicopter complaints over those of fixed-wing has little to do with people's differing sensitivity to noise levels from the two sources.

However, whatever is underlying the observed residuals results in people being annoyed where similar levels from fixed-wing aircraft would likely result in zero high annoyance (meaning the helicopter annoyance is spread over a much larger geographic area than would otherwise have been predicted). Even a few percent highly annoyed over a vastly larger land area could add up to a "critical mass" of annoyed citizens. This is an unexpected but very real phenomenon.

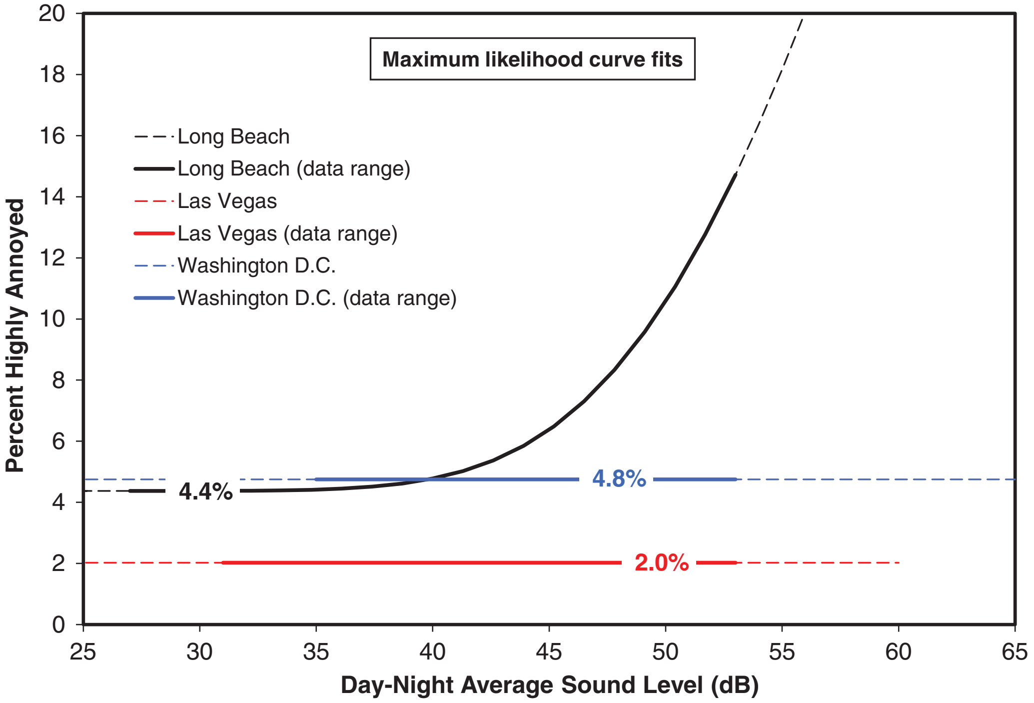


Figure 5-35. Composite results for all three sites.

5.6 Results of Low-Frequency Noise Analysis

Low-frequency noise emissions of helicopters are of particular concern as identified in Chapter 1 of this report. Fixed-wing jet aircraft noise consists of broadband noise spread over the audio spectrum, but helicopter noise is characterized by distinct frequency characteristics. Most helicopter noise is concentrated at lower frequencies. The following sections describe the results of the low-frequency noise analysis.

5.6.1 Measuring Low-Frequency Helicopter Noise

Most sound level meters include the ability to measure A- and C-weighted decibels, and using C-weighted decibels will capture the low-frequency components of helicopter noise. The downside to using the C-weighted decibel is that it does not identify if the noise is down in the range where rattle and vibration are induced which, as identified by the Low-Frequency Noise Expert Panel, is at frequencies below 80 Hz inclusive.

A more advanced method of identifying LFSLs is by measuring noise in ⅓ octave bands. This produces not one measure of a sound level, but 36 individual measures of a sound level, one for each ⅓ octave band from 6 Hz to 20,000 Hz. An even more advanced method using narrow band analysis divides the spectrum into 400 narrow bands for even higher resolution.

Another consideration in the measurement of helicopter noise is the time weighting. This is a complex topic that is difficult to simplify. Basically, the human response to a changing sound level is not instantaneous. In the days of sound level meters with a moving needle, the time averaging was done using a “slow” or a “fast” response that controlled how fast the needle moved. Slow response was generally used and was designed to approximate the human ear response to changing sound. Another weighting was developed for very short duration noise, such as a gunshot. This time weighting is called impulse weighting. With the advent of digital sound measurement devices, the slow and fast weightings are obsolete and instead a 1-second equivalent sound level is measured. This represents all of the acoustic energy contained within 1 second of time no matter how sudden the sound is. But short duration sounds such as gunshots or the impulsive noise of a helicopter noise is averaged into that 1 second. During LAS and LGB measurement programs the A- and C-weighted impulsive noise was also measured along with the 1 second equivalent sound level data.

5.6.2 Modeling the Low-Frequency Noise Level of Helicopters

The INM and now AEDT include the capability to calculate both A-weighted and C-weighted noise levels as well as noise levels based on EPNL, a ⅓ octave band based metric that was developed to reflect human perception of noisiness, not loudness, that includes penalties for pure tones. However, the database of aircraft noise levels built into INM and AEDT do not have data for frequencies below 50 Hz. One goal of this analysis is to determine if this deficiency precludes meaningful use of INM and AEDT for low-frequency studies of helicopter noise (note that there is no issue with the database as it is for A-weighted metrics).

5.6.2.1 Noise Measurement Data Collected for this Study

Noise measurements were made during the LAS and LGB studies. The measurement systems, described earlier, included the measurement of the A- and C-weighted decibel and the ⅓ octave band data from 6 Hz to 20,000 Hz. The impulse A- and C-weighted sound pressure level was also recorded. A special discussion of measuring low-frequency noise is warranted here. Sound measurement systems consist of a microphone and windscreen combination connected by cable to the recording sound level meter. The windscreen is designed to remove the sounds of the wind passing over the microphone grid. In general, and what was used for this study, a 4-inch windscreen made of open cell foam is used. As wind speed increases, the noise of the wind over the windscreen increases, especially at low frequencies. During the measurements at Las Vegas, wind was consistently very low and made a better dataset to test response to low-frequency noise. The Long Beach data, while having periods of calm was more generally windy, consistent with the coastal location: two weather fronts moved in through the study area during the survey. For this reason, the low-frequency response data were analyzed using the Las Vegas data.

5.6.2.2 Processing the LFSL Data

The measurement system collected data for each 1 second of every day that include the aforementioned A-weighted, C-weighted, and ⅓ octave band data. These data were used to build a large database that included all the data for all four sites for the 7 days of measurement. The following method was used to analyze the data:

1. Aircraft radar data was obtained from the airport. Helicopter noise events were identified by matching the noise event time to the time of helicopter point of closest approach to the noise monitoring site.
2. A database was generated that included only helicopter noise events at each site. Each event consisted of the helicopter type and one record of data for each second of the noise event. The events were defined by the time at which the A-weighted level exceeded 55 dB and the time at which the event noise dropped below 55 dBA. This threshold allowed for isolating the helicopter noise from ambient noise as well as possible. Since all four measurement sites were in quiet residential areas, ambient noise levels were low with only passing cars as a significant intrusion. The database consisted of 110,821 1-second records in the helicopter event database.
3. For each 1-second record, the C-weighted sound pressure level was calculated using all of the available ⅓ octave bands and once again not using any ⅓ octave data below 50 Hz (to simulate the C-weighted data as would be computed by INM or AEDT).
4. For each 1-second record the LFSL was computed for that 1 second using the original definition of LFSL and expanding the definition of LFSL to include lower ⅓ octave bands. LFSL was recalculated with lower frequency bands down to and including 16 Hz, 10 Hz, and 6 Hz.
5. For each helicopter noise event at each site the SEL was computed using the A, C, and LFSL scale and using the A-weighted and C-weighted impulse scales.

5.6.3 Results of Low-Frequency Data Analysis

An example of the sound spectrum in terms of ⅓ octave band sound pressure level is shown in Figure 5-36. The spectrum shown is for 1-second records with the highest LFSL, most strongly influenced by the high levels in the 20 and 25 Hz ⅓ octave bands.

5.6.3.1 Frequencies Used for LFSL Calculations

The LFSL calculation was run using the original definition of 25 to 80 Hz as well as using lower frequency bands of 16 Hz, 10 Hz, and 6 Hz. There was significant difference between LFSL calculations based on 25 and 16 Hz lower bands, typically in the range of 5 dB. The difference between LFSL based on 16, 10, or 6 Hz was about 0.1 dB. Therefore, for the purposes of this study, LFSL was redefined as the arithmetic average of the ⅓ octave band sound pressure levels from 16 to 80 Hz and is labeled LFSL_{16}.

5.6.4 Comparison of Low-Frequency Metrics to A-Weighted Metric

Table 5-8 lists the various noise exposure metrics for the four measurement sites in Las Vegas. Included are the energy average SEL for all helicopter events in terms of the A, C, impulse A, and

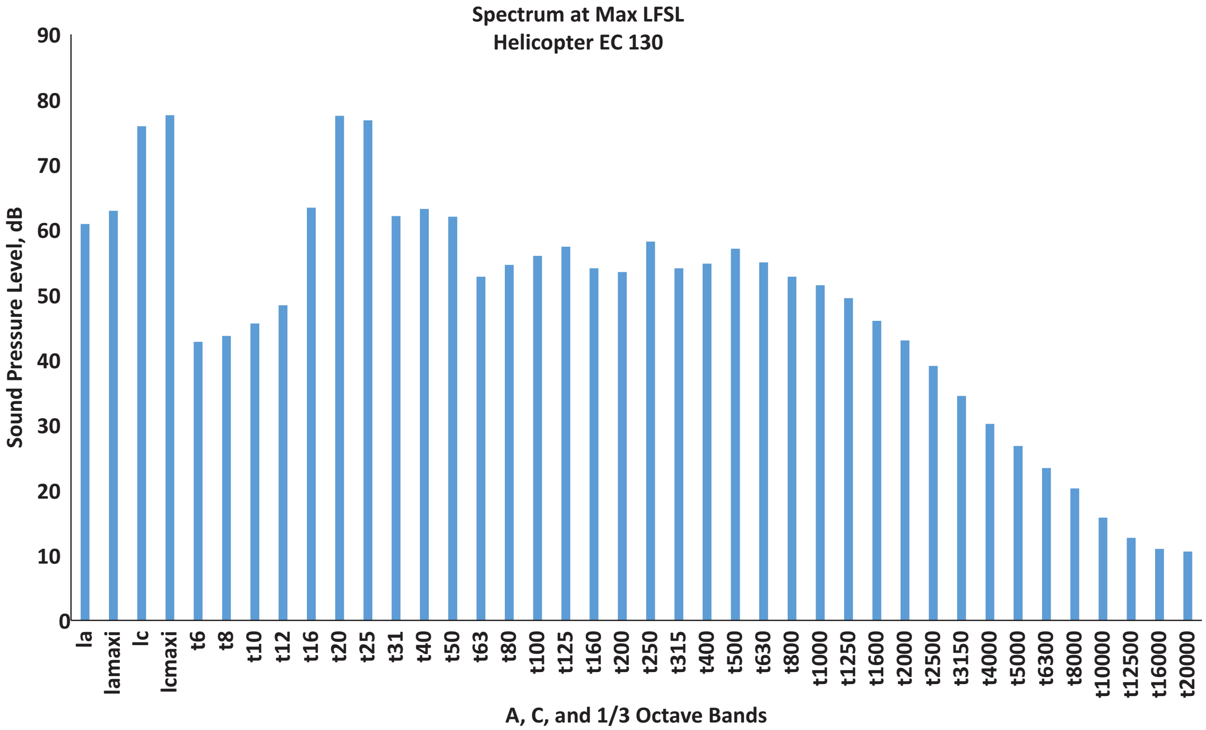


Figure 5-36. Sample spectrum for typical helicopter at the LAS interviewing site.

impulse C scales. Also calculated and shown is the SEL for C-weighting using only the frequency data available in INM and AEDT, i.e., frequencies above 50 Hz inclusive.

Note that the distance from the measurement site to the centerline of the helicopter corridor is also provided. The sites are not numbered in order of distance.

The first observation is that the SEL computed using only the INM/AEDT frequencies differs substantially from the true C-weighted SEL. This is important because it means that INM or AEDT can not be used for analyzing low-frequency noise in the study. INM nor AEDT can be used to compute C-weighted DNL for the social survey data. However, the measurement data can be used to convert the A-weighted DNL data computed by the noise model into C-weighted DNL. Figure 5-37 shows the relation of A-weighted SEL to C-weighted SEL as a function of distance to the helicopter tracks. The attenuation of sound with distance is highly dependent on the sound frequencies. For example, if the air temperature is 15 degrees, the sound frequency is

Table 5-8. A-weighted and low-frequency metrics at four measurement sites in LAS.

		Energy Average					Maximum of All Events		Arithmetic Average of Max LFSL	
Site	Close Appr. ft	A-weighted SEL	C-weighted SEL	SELcinm	A-weighted impulse SEL	C-weighted impulse SEL	LFSL	$LFSL_{16}$	LFSL	$LFSL_{16}$
1	394	77.3	87.4	83.1	85.4	90.9	85.0	87.6	74.0	78.6
2	1,864	74.7	89.0	82.7	78.6	91.6	84.7	87.1	74.3	79.1
3	2,419	73.3	86.3	80.3	77.2	88.9	81.7	84.3	72.1	76.8
4	762	77.3	87.7	82.8	86.6	91.6	85.5	89.9	73.4	78.8

Note: SELcinm is a C-weighted SEL, as calculated by FAA's INM (now AEDT) software. INM has no information about the acoustic energy of aircraft noise in frequency regions lower than the 50 Hz ⅓ octave band.

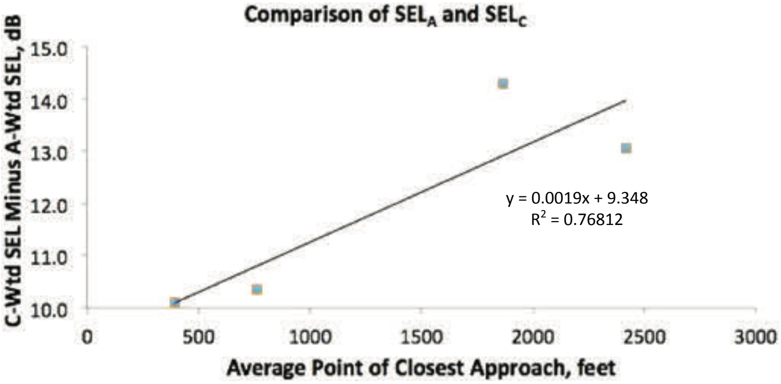


Figure 5-37. The relation of A- and C-weighted SEL for the LAS measurement data. (Wtd = weighted.)

50 Hertz, and if the atmosphere relative humidity is 40% then the attenuation due to this atmosphere is 0.111 dB per km. For the same conditions but for 500 Hertz, the attenuation is 2.18 dB per km, and at 5,000 Hertz, the attenuation is 69.7 dB per km. So, in this example, the attenuation over any reasonable distance from a helicopter (e.g., 500 or 1,000 meters) at the lowest frequencies is essentially 0; at middle frequencies, it is a few dB; and at high frequencies, nearly all of the sound is eliminated.

The A-weighted and C-weighted metric differs with distance because the atmosphere absorbs high-frequency sounds very efficiently and is very poor at absorbing low-frequency sounds. At larger distances, the low-frequency component of helicopter noise is heard more than the higher frequencies, which affect the A-weighted metric more, because the atmosphere has absorbed the high-frequency sounds.

The difference between A-weighted and C-weighted SEL as a function of distance can be used to convert the social survey receptor A-weighted DNL to an estimate of C-weighted DNL. This was calculated, and then used to create a C-weighted dosage-response curve, shown in Figure 5-28.

As evidenced from Table 5-8 and Figure 5-37, the C-weighted metric has a higher value than the A-weighted metric due to the concentration of low-frequency noise in the range of 16 to 80 Hz.

Table 5-9 also shows the energy average SEL in terms of the A-weighted impulse scale and C-weighted impulse scale. Again, these values are also significantly higher than the normal A-weighted SEL. Figure 5-38 plots the A-weighted impulse SEL against the normal A-weighted SEL. Impulse weighting, even with the heavy discounting of low-frequency noise by the A scale, shows a significant increase in level.

Lastly, the $LFSL_{16}$ can be compared to the energy average A-weighted SEL. This is a bit of mixed comparison and is done with some caution. SEL is a measure of exposure, i.e., the acoustic energy

Table 5-9. Differences in A-weighted and low-frequency metrics, LAS.

		Differences Relative to A-Weighted SEL			
Site	Close Appr. ft	C-weighted SEL - A-weighted SEL	Average max $LFSL_{16}$ - A-weighted SEL	A-weighted impulse SEL - A-weighted SEL	C -weighted impulse SEL - A-weighted SEL
1	394	10.1	1.3	8.1	13.6
2	1,864	14.3	4.4	3.8	16.9
3	2,419	13.1	3.5	3.9	15.7
4	762	10.4	1.4	9.3	14.2

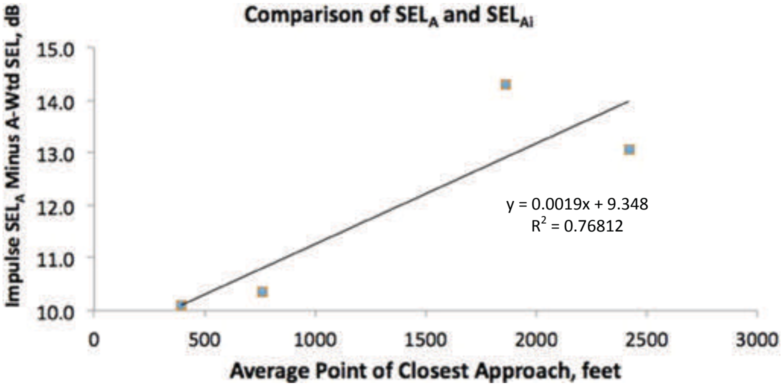


Figure 5-38. Relation of A- and A-weighted impulse SEL (SEL_{Ai}) for LAS measurement data.

during an entire event. LFSL is defined as a value at the time of a maximum. LFSL was defined this way because rattle either occurs or does not occur and any attempt to average LFSL, energy or arithmetic, will blur the ability to predict rattle. Figure 5-39 compares A-weighted SEL with $LFSL_{16}$. This comparison shows that the low-frequency components of helicopter noise have a significant potential to cause rattle that cannot be predicted from A-weighted SEL.

5.6.4.1 Summary of Low-Frequency Noise Analysis

Figures 5-37 through 5-39 all have nearly identical slopes. That means that C-weighted, A-weighted impulse, and $LFSL_{16}$ have nearly identical relationships to the A-weighted decibel. This means that understanding response to civil helicopter noise will not be enhanced by using special low-frequency or impulse metrics.

Table 5-8 summarizes the differences between the various metrics.

5.7 Noise Complaint Data

5.7.1 Long Beach Helicopter Noise Complaints

Table 5-10 shows the year 2015 helicopter noise complaints as recorded by the city of Long Beach. Of these 878 complaints, 89 occurred during the month of July (during which the survey was done). There is also another helicopter noise complaint database being built by the FAA as part of the LA Helicopter Initiative for all of the LA area. The City of Long Beach provides its

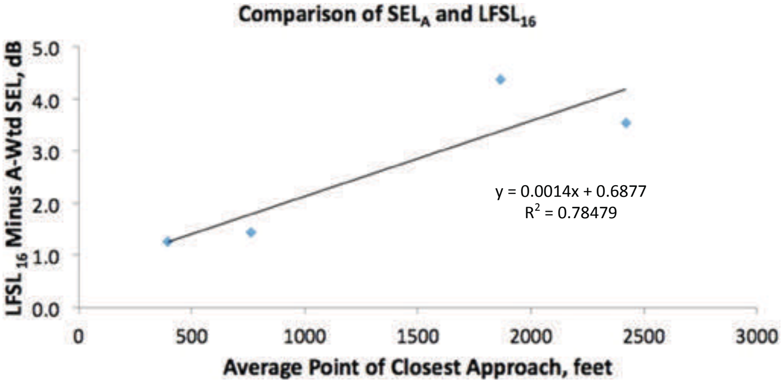


Figure 5-39. Relationship of A-weighted SEL to $LFSL_{16}$.

Table 5-10. Long Beach helicopter complaints during the year 2015.

Month	Helicopter Complaints
January	38
February	23
March	29
April	32
May	28
June	79
July	89
August	131
September	59
October	174
November	136
December	60

Source: LGB Airport Noise Office.

complaint data to the FAA, so the Long Beach data is a subset of the FAA database. The FAA database included 110 Long Beach complaints during the survey period. The Long Beach and the FAA databases include a field for address but it is often populated with a telephone number and not an address. For those 110 complaints in Long Beach during the social survey that did include at least a street name, the majority are in the study area.

5.7.2 Las Vegas Helicopter Noise Complaints

Clark County Division of Aviation recorded 3,963 noise complaints during the year 2015, of which 59 were helicopter noise complaints. None of the noise complaints were in the survey area, although two were just outside the study area (Source: Memorandum, Department of Aviation, "October, November, December and Annual 2015 Noise Complaint Reports," Clark County Division of Aviation, January 28, 2016).

5.7.3 Washington, D.C., Area Helicopter Noise Complaints

The MWAA reported a total of 8,670 noise complaints for all aircraft in the year 2015. Of these, 343 were from Arlington and 7,930 were from NW Washington (Source: "2015 Annual Aircraft Noise Report," MWAA, undated). The MWAA does not segregate noise complaints by fixed-wing or helicopter and there is not a way to recover which complaints were helicopter based.

CHAPTER 6

Conclusions and Discussion

This chapter discusses conclusions that may be drawn about the major hypotheses investigated in the current study.

Hypothesis 1: Decibel for decibel, rotary-wing aircraft noise is more annoying than fixed-wing aircraft noise.

No compelling evidence was found for the "excess" annoyance of civil helicopter noise with respect to that of fixed-wing aircraft noise. A likely reason for the absence of such evidence is that the study was conducted at interviewing sites with relatively low levels of helicopter noise exposure. If the study had been conducted in communities overflown by noisier military helicopters, the conclusion might have differed. Interviewing sites with relatively low levels of cumulative exposure to helicopter noise were not selected for study by preference, but rather because sites with greater levels of civil helicopter noise exposure could not be located, or were unsuitable for interviewing for lack of residential exposure.

The majority of the urban residential population overflown by scheduled civil helicopter operations is exposed to helicopter noise during cruise conditions, during straight and level flight at altitude. Even though maneuvering helicopters can be more complex and variable noise sources than fixed-wing aircraft in the vicinity of landing pads, the character of their noise emissions in the cruise regime may not differ as greatly in character from that of fixed-wing aircraft.

In the Washington, D.C., interviewing area, a notably greater rate of annoyance was observed for fixed-wing aircraft than for helicopters. Because noise exposure due to fixed-wing aircraft was considerably greater than that for helicopters in Washington, D.C., it was not possible to draw inferences about the relative annoyance of the two noise sources on a decibel-for-decibel basis.

A greater annoyance prevalence rate for helicopters than for fixed-wing aircraft was observed only in the Long Beach study area, but the respondents in the study area were exposed to very little fixed-wing traffic noise.

For the one site at which a reasonable dosage-response function could be inferred for annoyance due to exposure to helicopter noise, the DNL at which 50% of the population would be highly annoyed by helicopter noise was estimated at 69 dB. That is 4 dB less than the grand average for the 44 fixed-wing aircraft ($L_{dn} = 73.4$ dB, per Fidell et al. 2011). An indirect inference can therefore be drawn that helicopter noise is 4 dB less tolerable (quite likely for nonacoustic reasons) than the noise produced by fixed-wing aircraft.

Hypothesis 2: Main rotor impulsive noise controls the annoyance of helicopter noise (and hence requires an impulsive noise "correction" to A-weighted measurements).

A strong correlation between the prevalence of high annoyance and (A-weighted) DNL values was observed in only one of the three surveys in the interviewing area. Neither C-weighted measurements nor helicopter-adjusted LFSL measurements were any better at predicting annoyance prevalence rates due to dose. In Las Vegas and Washington, D.C., annoyance was not related to dose as measured by the A-weighted, C-weighted, or the helicopter-adjusted LFSL. In Washington, D.C., a public concern over relocated fixed-wing flight tracks might have made it difficult to discern any dosage-response relationship.

It is also likely that the low range of doses of helicopter noise precluded observation of a strong relationship with annoyance. It would have been advantageous to have surveyed a community with a helicopter noise exposure greater than $L_{dn} = 60$ dB. To do that, a survey would have had to have been conducted around a military facility. The research panel restricted the surveys to civil helicopter routes, thus limiting the noise dose to DNL below 60 dB.

Measurements of A- and C-weighted impulsive noise levels and non-impulsive A- and C-weighted levels differed only by a constant. However, the rotor disks of the civil helicopters that created the noise exposure measured in this study lack the heavy loading, larger diameter, and high tip speeds of military helicopters. The levels of impulsive noise to which respondents were exposed in this study were considerably lower than those produced by maneuvering, heavier helicopters. This hypothesis would be better tested at sites with heavy military helicopter operations so that the impulsive noises were more pronounced. No clear conclusion could be drawn from the present findings about this hypothesis.

Hypothesis 3: Secondary emissions (rattle) induced by helicopter noise strongly influences its annoyance.

The prevalence of high annoyance was regressed on reported in-home vibration/rattling as well as on BVI (thumping or slapping), buzzing, and whining noise. No statistically significant relationship was observed between annoyance due to in-home vibration and rattling and annoyance due to noise level alone.

The dosage-response relationship between helicopter noise exposure and annoyance due to buzzing differed significantly from chance, and was unlikely to have arisen by chance alone in Long Beach, but not in Las Vegas or Washington, D.C. The regression of reported buzzing noises on helicopter noise exposure was the only one that was unlikely to have arisen by chance alone, but it accounted for very little variance in the relationship between annoyance and exposure. In the apparent absence of any strong association between helicopter noise exposure and annoyance at the low exposure levels that were available for this study, it is likely that nonacoustic factors had a greater effect than exposure levels on community response to helicopter noise.

Hypothesis 4: The annoyance of helicopter noise is strongly influenced by nonacoustic factors.

No acoustic factors can account for observed differences in the annoyance of exposure to helicopter noise at the interviewing sites. Given the observed differences in response at the Long Beach and Las Vegas interviewing sites, it is likely that nonacoustic factors were more salient than noise exposure in determining community response. Respondents in Las Vegas were exposed to about 10 times the number of flights (albeit at a greater altitude), but a much smaller percentage of the respondents in Las Vegas than in Long Beach reported high annoyance. The higher altitude effect on DNL (about a 3 to 4 dB reduction) was much smaller than the 10 dB effect of a greater number of operations on DNL.

Aircraft fleet mix cannot account for the difference in annoyance prevalence rates either. In Washington D.C., the concern over the change in fixed-wing flight tracks obscured the dosage-response effect for both fixed-wing and helicopter noise.

Hypothesis 5: Annoyance is better predicted by time-integrated proximity to flight tracks than by acoustic measures.

Regression analyses showed that proximity to the flight path was as good a predictor of self-reported high annoyance with helicopter noise as helicopter noise levels. This is not a surprising finding, since proximity and sound level are highly correlated. It remains unclear, however, whether exposure to the noise of direct overflights was found to be more annoying than exposure to noise of overflights that pass to the sides of residents' homes.

Additional hypotheses examined: Complaints lodged about helicopter noise are more reliable predictors of the prevalence of annoyance than measures of exposure to helicopter noise or proximity to helicopter flight paths.

An analysis of variance revealed no statistically significant difference in noise exposure for respondents who reported complaining than for those who did not. Very few respondents indicated that they had ever registered complaints about helicopter noise, however. Nonetheless, a statistically significant relationship was observed between the likelihood of complaint and reporting some degree of annoyance. Among the respondents who reported no annoyance from helicopter noise, 1.3% complained; of the respondents who reported at least slight annoyance from helicopter noise, 9.4% registered complaints. The likelihood of complaining about helicopter noise is thus at least partially dependent upon some degree of annoyance.

Additional observations: Noise exposure and annoyance, dosage-response relationship

No compelling evidence was found other than at the Long Beach interviewing site of a dosage-related increase in the prevalence of high annoyance. That is, all data points were observed to lie on some non-zero asymptotic value. With the Long Beach data, the rightmost three data points in the dosage-response plot were assumed to be dependent on dose. The remainder were assumed to be independent of dose and lie at some asymptotic value. Similarly, for the distance relationship, the data points at 28 dB and higher were assumed to be dependent on reciprocal distance, and the rest independent.

For Washington, D.C., there is no evidence of annoyance growth with increasing dose or reciprocal distance as shown in Figures 5-19, 5-21, 5-23 and 5-35. For fixed-wing aircraft the asymptotic value of annoyance is about 15%. The range of respondent DNLs is also the same (a 10 dB range from 50–60 dB). However, comparing asymptotic annoyance percentages between fixed- and rotary-wing aircraft, the numbers are 15%, 16%, and 4.75%, respectively—a 10.41 dB difference.

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Wright, S., and Damongeot, A. (1977). *Psychoacoustic Studies of Impulsive Noise*. Paper #55, Third European Rotorcraft Powered Lift Aircraft Forum, Aeronautical and Astronautic Association of France, September 1977.

APPENDIX A

Technical Discussion of Helicopter Noise

This Appendix discusses two distinct matters: the nature of helicopter noise emissions (Section A.1) and the relationship among various measures of helicopter noise levels (Section A.2). The former discussion provides insight into some of the constraints on site selection for subsequent field studies. The latter discussion, which presents the results of an analysis of the relationships among various helicopter noise measurements, can help with the design of field measurements.

A.1 Characteristics of Helicopter Noise in Various Flight Regimes

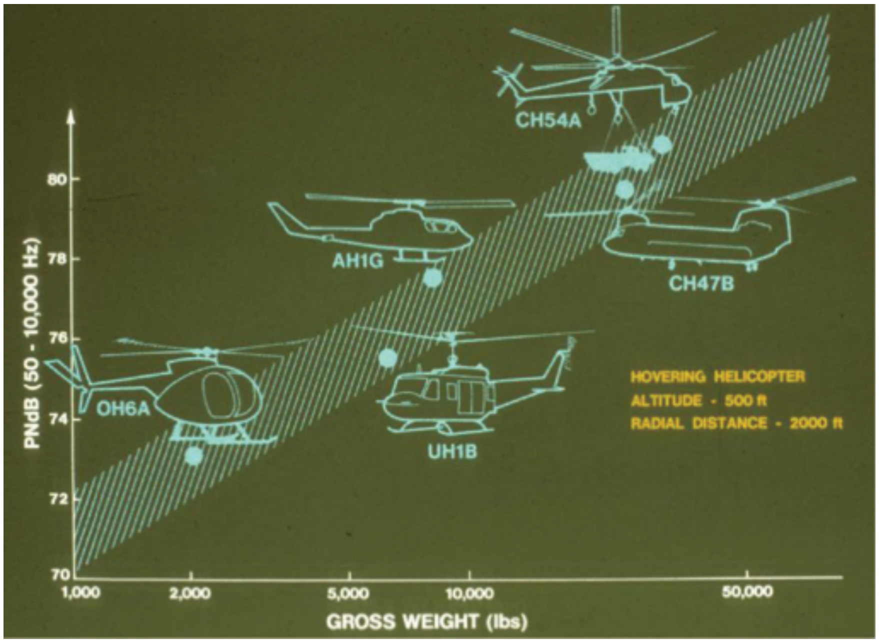
Helicopter noise is an unavoidable by-product of creating the lift necessary to make helicopters and other vertical lift machines fly. When rotating and translating through the air, rotor blades displace the air due to their finite thickness. When these spatial disturbances of the fluid are added at a far-field observer location (keeping track of retarded time), they create harmonic "thickness noise." The rotating and translating rotor also accelerates air to cause net forces (lift and drag) on the blades. This acceleration of the air, caused by the lift and drag forces, causes small compressible waves that, when added together at the correct retarded time, radiate harmonic noise to an observer far from the noise source. Heavier vehicles produce more noise, as shown in Figure A-1 for a series of older military helicopters. While there is some deviation about the trend line due to design characteristics unique to each model, the trend is readily apparent. Other unsteady aerodynamic sources dependent on design details of particular vehicles can add to the noise. The basic physics of these phenomena has been known for more than six decades—and even longer for propellers.

A.1.1 Major Helicopter Noise Sources

Before addressing the origins and mechanisms of helicopter external noise, it is useful to identify the most noticeable, even if not necessarily the most annoying, sources. The order of importance for producing an acceptably quiet helicopter is shown in Figure A-2 for a generic single rotor helicopter of the light to medium weight class—up to 10,000 lbs.

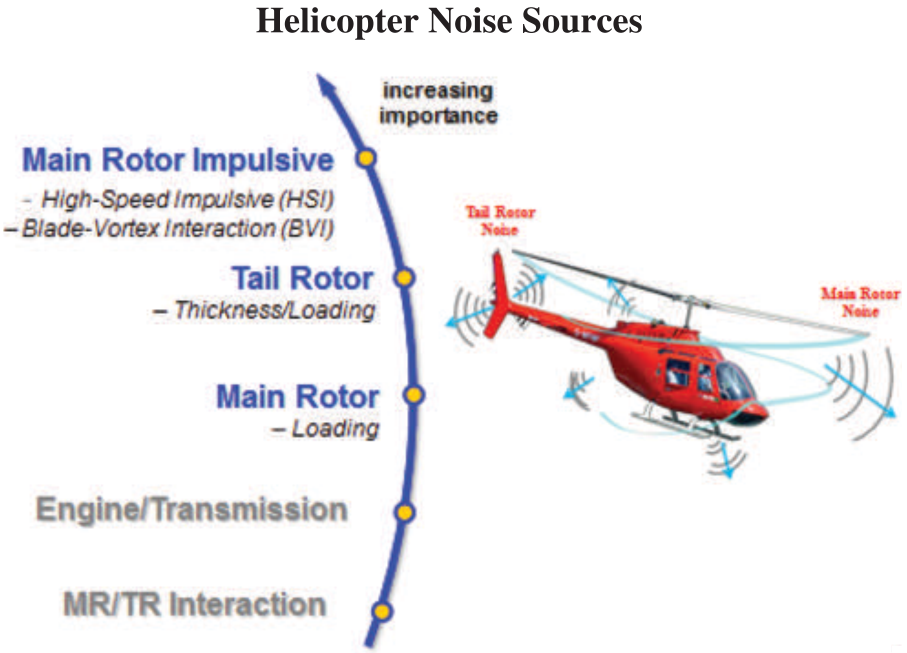
Impulsive harmonic noise sources generally dominate helicopter detectability, and are often thought to be the main source of annoyance, for both the main rotor and tail rotor. The tip region on the advancing side of the rotor near the 90-degree azimuth angle of the rotor disk produces most of the radiated harmonic noise. The thickness and loading noise sources on each blade element are amplified by the high advancing Mach numbers in this region.

At high advancing-tip Mach numbers, thickness noise often becomes more dominant as Mach number increases. At very high advancing-tip Mach numbers, High-Speed Impulsive (HSI) noise



(Source: Old Army Report—Circa 1974)

Figure A-1. Relationship between helicopter weight and perceived noise level.



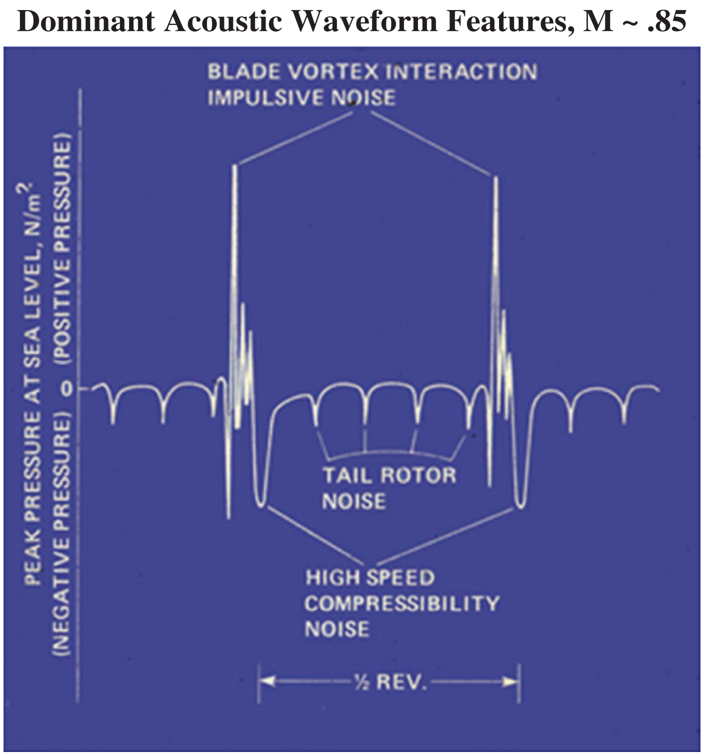
(Source: Schmitz—Sketch from student's University of Maryland PhD thesis.)

Figure A-2. Prioritized contributions of helicopter noise sources to overall emissions.

develops. The local transonic flow around the rotor blade often couples with this radiating acoustic field causing acoustic "delocalization" that radiates local shock waves to an observer in the far-field. When this occurs, the noise produced is nearly always highly annoying, and dominates the acoustic signature of the helicopter. This type of noise tended to dominate the main rotor noise of the "Huey" helicopter of the Vietnam War era. When it occurs, HSI noise clearly dominates the acoustic radiation near the plane of the rotor. Most modern helicopters are designed so that "delocalization" does not occur in normal cruising operations. However, thickness noise remains a main contributor to in-plane noise levels in cruising flight even for modern helicopters. It is also interesting to note that main rotor HSI noise cannot be heard in the helicopter cabin because the radiating waves originate near the tip of the rotor and radiate in the direction of forward flight.

Most helicopters also produce a second impulsive noise caused by sudden, rapid pressure changes occurring on the lifting rotor blades. These pressure changes occur when the rotors pass in close proximity to their previously shed or trailed tip vortices. They normally occur when the helicopter is operating in descending, turning, or decelerating flight, at times when the rotor blades are passing through or near their own wake system. A typical one-revolution period for this type of noise signature radiated from a single main rotor helicopter is shown in Figure A-3. This "wop-wop" sounding impulse stream, called Blade-Vortex-Interaction, BVI, is often the characteristic sound that distinguishes helicopter operational noise from other transportation noise sources in terminal operating areas.

The noise produced by the anti-torque device of a single rotor helicopter can also be a major noise source. When tail rotors are used as the anti-torque device, the dominant sources are


Dominant Acoustic Waveform Features, M ~ .85

(Source: Schmitz, F. H.; Boxwell, D. A.; and Vause,C. R.:High-Speed Helicopter Impulsive Noise. *J. American Helicopter Soc.,* vol. 22, no. 4, Oct. 1977, pp.28-36.)

Figure A-3. A typical one-revolution period for "wop-wop" of noise signature radiated from a single main 2-bladed rotor helicopter.

fundamentally the same as the main rotor. However, the higher operating RPMs of the tail rotor make the lower and mid-frequency tail rotor harmonic noise more noticeable and objectionable to a far-field observer. Because the tail rotor is often unloaded in forward flight, tail rotor thickness noise can often be the first sound heard by a far-field observer.

On some helicopters, the main rotor wake can pass in close proximity to the tail rotor disk in some operating conditions and increase noise emission level. The problem is aggravated by helicopters that operate with "top forward rotating" tail rotors. The problem has been minimized by more careful design and operation.

Aérospatiale introduced a lifting fan for directional control on many of their single rotor helicopters to mitigate tail rotor noise and reduce tail rotor drag in forward flight. The many-bladed fan (the "Fenestron") creates somewhat lower levels of harmonic noise, but at higher frequencies, and can be quite annoying. However, noise at these frequencies is reduced with distance from the source due to atmospheric absorption effects. Fenestron noise therefore contributes little to helicopter noise at long ranges.

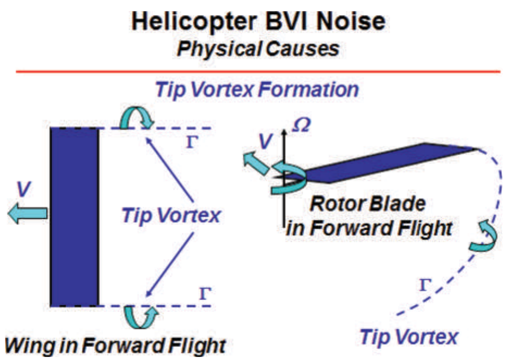
Lower frequency harmonic loading of the helicopter is next in order of acoustic importance. This sound is a direct result of the lift and drag (torque) produced by helicopters. It tends to be most important for civil helicopter operations directly underneath the helicopter. Although it is low frequency in character, it has substantial energy and is partially responsible for the excitation of "rattle" in many instances. For military helicopters, however, the low- to mid-frequency radiated noise near the plane of the rotor is of prime concern, because it often sets the aural and electronically aided detection range of helicopters. This noise is determined by the in-plane drag time history of the rotor and by the thickness of the blades, as noted above.

Engine noise can also be an important noise source. It is controlled by engine choice and on-board installed acoustic treatment. Transmission noise is important in close proximity to the helicopter or internally, but unless excessive, is not usually an external noise problem.

Last on the list of noise sources is "Broadband" noise. It is caused by changes in localized blade pressures caused by aperiodic and/or unsteady disturbances. It is normally of lower level on light- to medium-weight helicopters with normal operational tip speeds, but becomes more important on heavy helicopters as design tip speeds are lowered and the numbers of rotor blades are increased. It is also influenced to a great extent by the local inflow through the rotor system. Higher positive or negative inflow tends to reduce the noise by carrying the disturbed unsteady flow away from the rotor, thus avoiding additional unsteady blade loading and hence additional noise.

Because of their ability to carry large loads and more easily handle the center of gravity issues associated with these large loads, tandem rotor helicopters have also become a workhorse helicopter for the military. The lack of conventional tail rotors on these machines reduces the noise to a degree, but their large overlapped rotor systems often create unsteady inflow to the rotors, making large harmonic noise levels commonplace for such vehicles. Because of their high-tip Mach numbers, tandem rotors also produce large amounts of thickness noise. For a variety of reasons, most tandem rotor helicopters do not operate in commercial airspace in or around noise sensitive areas.

The tiltrotor is another type of dual rotor rotorcraft that was developed by the military. It is being proposed for civilian operations in a scaled down version for executive travel (Agusta 609) to combine a vertical lift capability with conventional turboprop airspeeds. In helicopter mode, the net inflow through the rotor can be controlled, thus controlling BVI noise in the terminal area. Thickness noise at cruise speeds is minimized by converting to aircraft mode at reduced rotor RPM. The reduced RPM in cruise decreases the noise level. Lower frequency noise is still



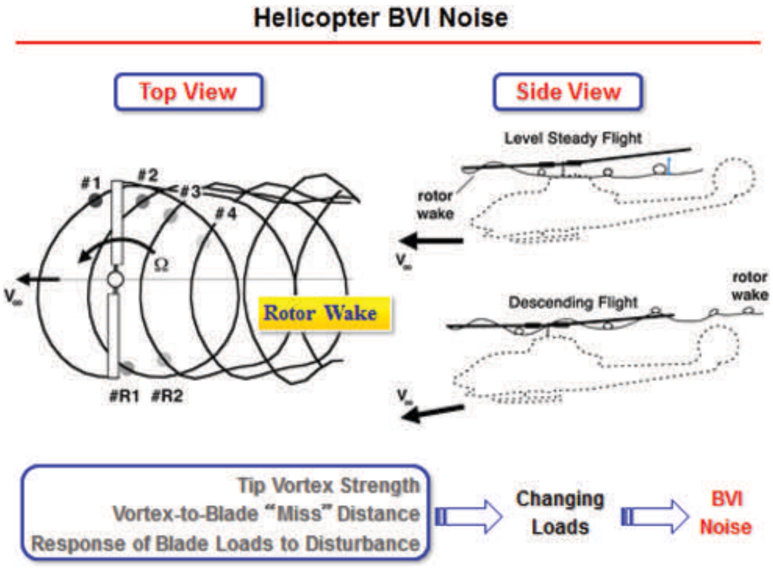
(Source: Boxwell, D. A.; and Schmitz, F. H.: Full-Scale Measurements of Blade-Vortex Interaction Noise. *J. American Helicopter Soc.*, vol. 27, no. 4, Oct. 1982, pp. 11–27.)

Figure A-4. Physical causes of helicopter blade-vortex interaction noise.

present because the disturbance field of the wings induces periodic loading on the blades, creating far-field noise.

A.1.2 Controlling BVI Noise in the Terminal Area

As discussed above, BVI impulsive noise occurs when the rotor operates near its own shed wake. Figure A-4 shows that a vortex is shed from the tip of each rotor blade just as it does for a fixed-wing aircraft. The tip vortex trailed behind each blade interacts with the following blades to create sharp changes in local blade pressure (and thus lift.) The pressure changes push on the fluid and radiate BVI noise. Figure A-5 shows a sketch of the geometry of the BVI interaction process. The top view shows the geometry of the interaction process, while the side view illustrates the closeness of the shed tip vortices to the top tip-path-plane.



(Source: Schmitz, F. H. and Sim. B., Sketch from HAI briefing, Los Angeles, CA 2005.)

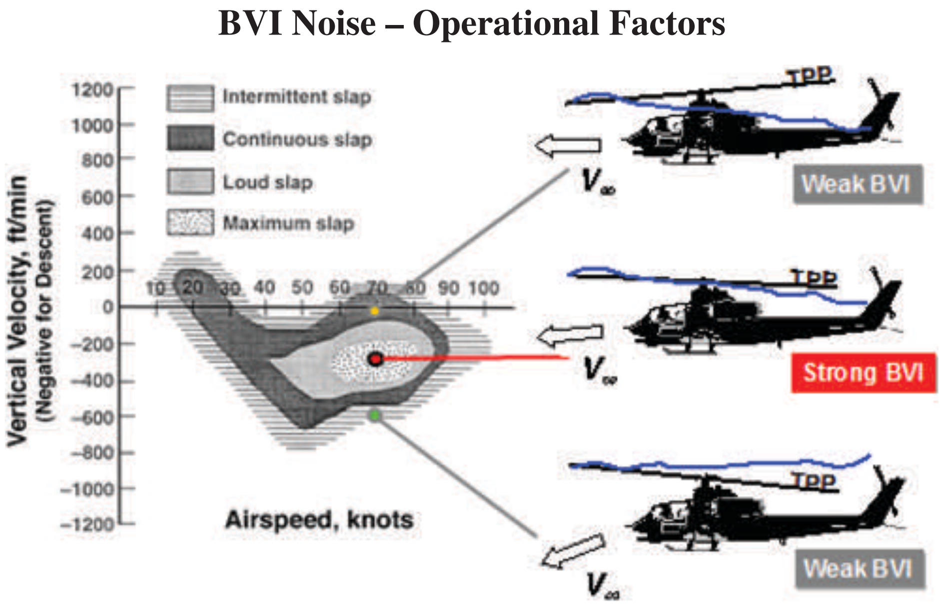
Figure A-5. Geometry of the BVI interaction process.

Figure A-6 shows that this closeness can be controlled to some degree by the choice of the helicopter operating condition. In level flight, the helicopter's shed tip vortices pass under the rotor's tip-path plane and radiate small to moderate amounts of BVI noise. However, as the helicopter descends, the rotor's wake is forced to remain near the rotor's tip-path plane, causing the rotor to closely interact with the shed tip vortices of preceding blades. These strong changes in lift cause large levels of BVI noise radiation. Increasing the descent rates further causes most of the shed tip vortices to pass above the rotor's tip-path plane, which reduces BVI noise levels. Vehicle acceleration/deceleration and turning in flight can also influence the location of the tip vortices with respect to the rotor tip-path plane and hence dramatically change the radiated BVI noise.

Figure A-7 shows in-flight measurements of BVI noise, taken on a microphone about 30 degrees below the plane of the rotor. A rapid series of positive pressure pulses is seen to occur that reach a peak and then decrease with increasing rates of descent at approach airspeeds. Because these pressure pulses are very narrow, they radiate most, but not all, of their energy in the mid- to high-frequency range and can easily annoy and disturb a far-field observer. A narrow band FFT of the pulse time histories illustrates the moderate to high frequency nature of the resulting BVI noise (Figure A-8).

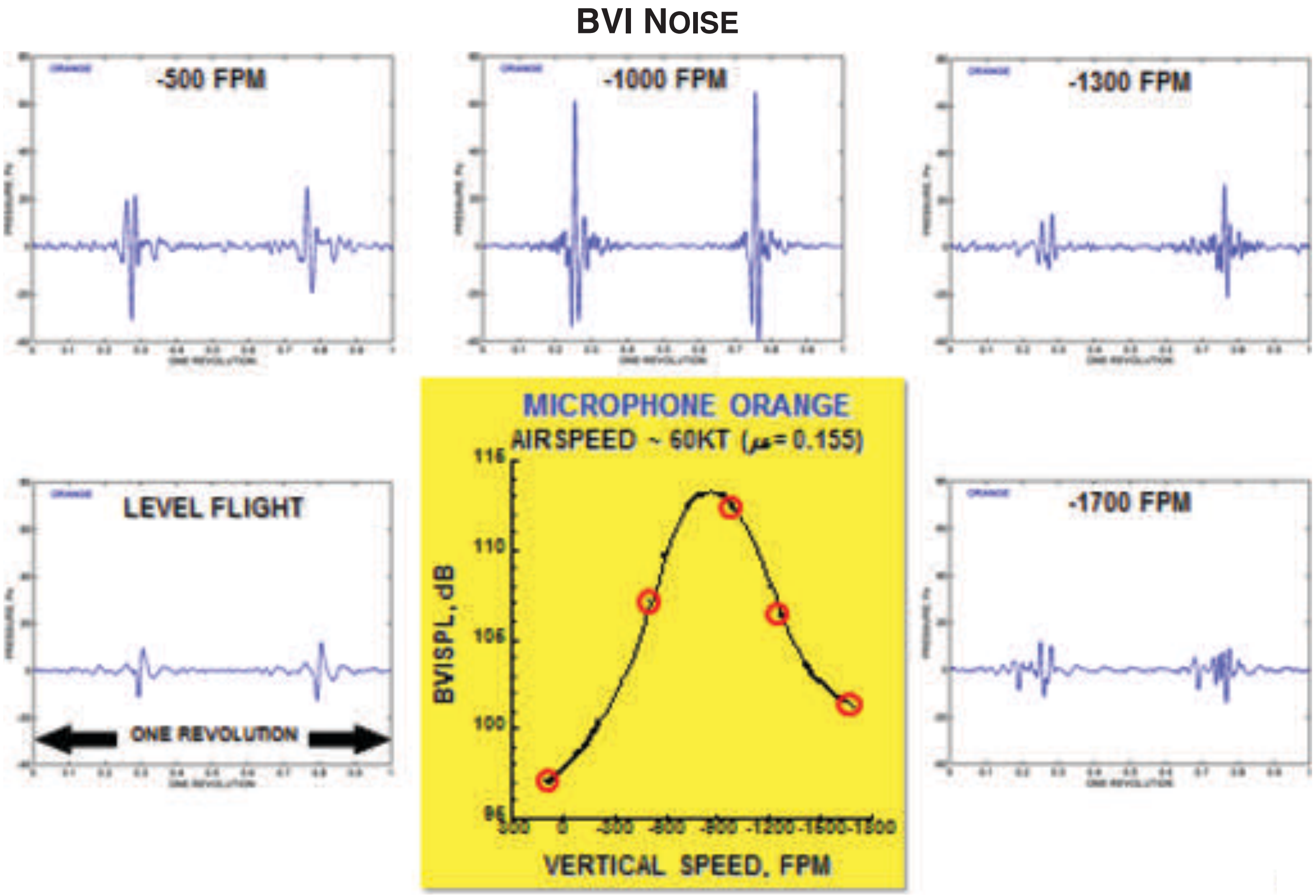
The fact that the radiated BVI noise levels can be controlled by changing the helicopter flight path has not gone unnoticed by the rotorcraft operational community. The Helicopter International Association (HAI) has developed a "Fly Neighborly Program" to make pilots aware that helicopters can be flown quietly near high-density and/or sensitive population zones. Research has also shown that "X-Force" control (acceleration/deceleration and drag/thrust control) can also be effective at minimizing BVI noise. In fact, a 0.1g deceleration is equivalent to a 5.7-degree change in descent angle. A sketch of the use of such techniques is shown in Figure A-9.

Use of operational parameters to minimize noise exposure is well documented. One such example is shown in Figure A-10, in which a Sikorsky S-76 helicopter was flown to minimize ground noise exposure. High rates of descent and deceleration were both used to substantially reduce radiated BVI noise levels.



(Source: Schmitz, F. H. and Sim. B., -Sketch from HAI briefing, Los Angeles, CA 2005.)

Figure A-6. Effect of operating condition on blade slap.



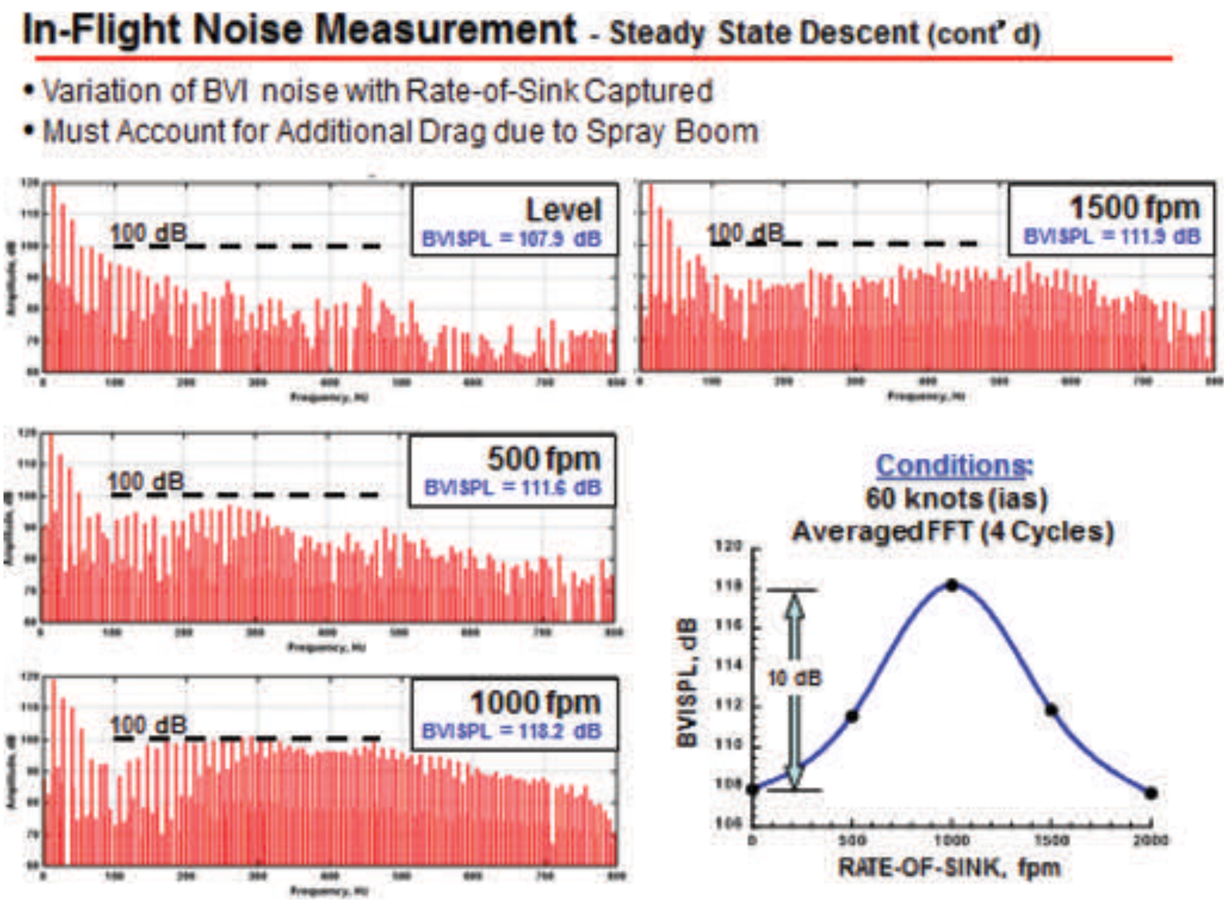
(Source: Schmitz, F. H. and Sim. B., Sketch from HAI briefing, Los Angeles, CA 2005.)

Figure A-7. BVI noise as a function of descent rate and level flight.

Source noise reductions depicted in Figures A-9 and A-10 are not always achievable in normal operations. Weather, winds, other flight traffic, and maneuvering flight can substantially change BVI noise levels. In addition, the BVI noise may become intermittent—occurring for a few seconds (seemingly disappearing) and then reappearing randomly. This often happens in near level flight operations in "bumpy" air—creating intermittent BVI.

A.2 Correlational Analysis of Helicopter Noise Metrics

Version 7.0d[19] of FAA's Integrated Noise Model (INM) permits users to predict helicopter noise exposure in a range of units (noise metrics). INM's databases contain information for a variety of helicopter types that include physical descriptions of aircraft, noise-power-distance (NPD) curves, standard arrival, departure, and level flight profiles, and for some helicopters, hover-in-ground-effect profiles, directivity profiles for each operating mode, and spectral class data for some helicopters. The NPD curves include A-weighted metrics maximum noise level (L_{max} or LA_{max}) and sound exposure level (SEL), and for some aircraft, tone-corrected perceived noise level [PNL(T)] and effective perceived noise level (EPNL). INM uses spectral class data to compute C-weighted metrics: C-weighted maximum noise level (LC_{max}) and C-weighted SEL (CEXP) and time above C-weighted threshold.

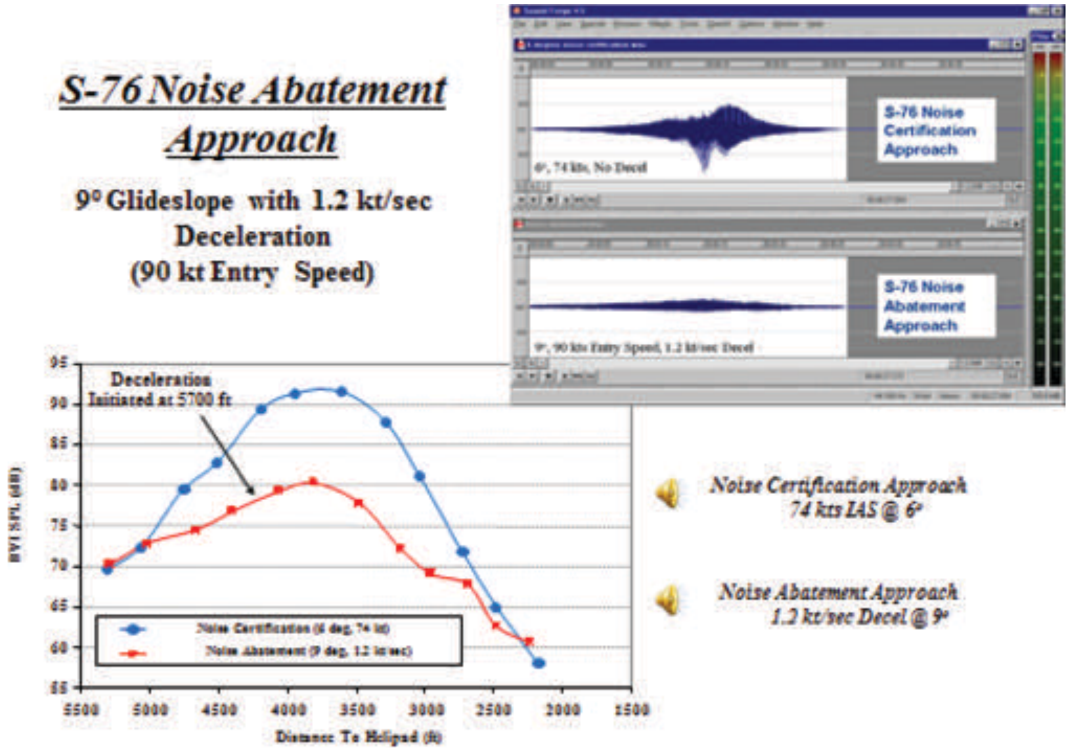


In-Flight Noise Measurement - Steady State Descent (cont' d)

- Variation of BVI noise with Rate-of-Sink Captured
- Must Account for Additional Drag due to Spray Boom

(Source: Schmitz, F. H. and Gapolan, G. – Sketch from HAI briefing, Las Vegas, NV 2004.)

Figure A-8. Sound frequency as function of climb rate and level flight.



S-76 Noise Abatement Approach

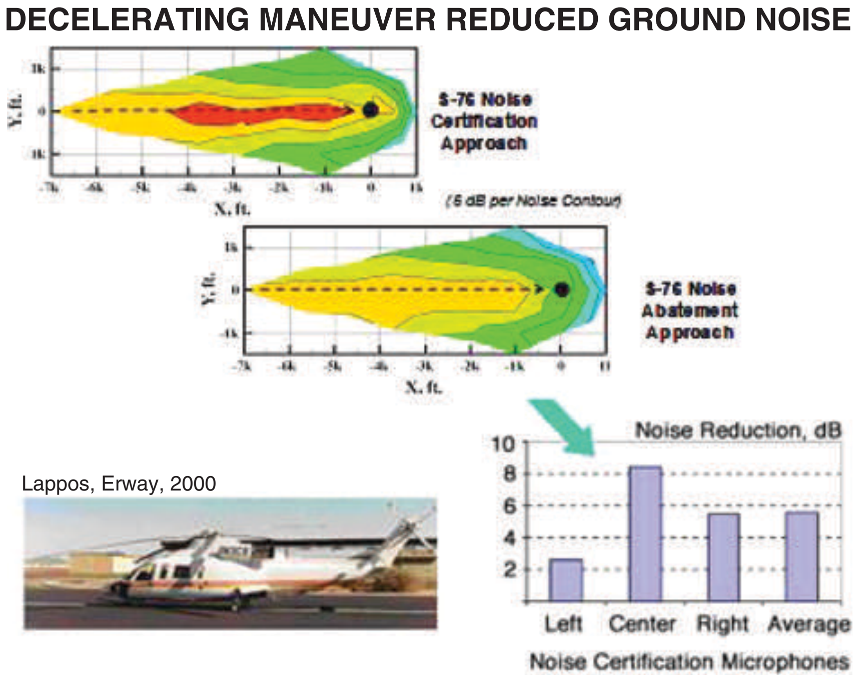
9° Glideslope with 1.2 kt/sec Deceleration (90 kt Entry Speed)

Noise Certification Approach 74 kts IAS @ 6°

Noise Abatement Approach 1.2 kt/sec Decel @ 9°

(Source: Schmitz, F. H., *et. al.,* Measurement and Characterization of Helicopter Noise in Steady-State and Maneuvering Flight, presented at the AHS Annual Forum, 2007.)

Figure A-9. S-76 noise abatement approach.



(Source: Schmitz, F. H. and Gapolan, G. Sketch from HAI briefing, Las Vegas, NV 2004.)

Figure A-10. Reduced ground noise with modified approach procedure.

Table A-1 lists the helicopters that are currently included in the INM database. Note that FAA has published a long list of substitutions for helicopters not included in the database and a recommended helicopter from the database to use as a surrogate for that helicopter.

A.2.1 Helicopter Spectral Classes

INM helicopter spectral classes are representations of average spectra for groups of helicopters with common characteristics. Figure A-11 and Figure A-12 show two of INM's spectral class charts for the B212, BO150, and S70 helicopters (Figure A-11) and the SA335, S65, and H500D helicopters (Figure A-12). Note that the spectral class data are unavailable for frequencies lower than the one-third octave band centered at 50 Hz. The database structure allows for lower frequency information, but none is currently available.

A.2.2 Correlations Among Helicopter Noise Metrics

A hypothetical helicopter exposure case was constructed to examine the relationships among the noise metrics that INM computes. The purpose of the exercise was to inform the selection of noise metrics for the field measurements of this research project. The numbers and types of measurements required for the social survey and subsequent analyses can directly affect the cost and design of the research.

The hypothetical case modeled noise exposure for a generic heliport with a large number of operations. The first case studied featured simple straight-in and straight-out departure flight paths, using the standard profiles built into INM for the nine helicopters that have both A-weighted and PNL based NPD data. One hundred arrivals and one hundred departures were evaluated using an equal distribution of the following helicopter types: B206B3, B407, B427, B429, B430, EC130, R22, R44, and SC300C.

(Contour values 75 DNL to 55 DNL, Grid point spacing 0.1 nm.)

Table A-1. Helicopters included in INM v7.0d database.

HELICOPTER INM NAME	DESCRIPTION
A109	Agusta A-109
B206L	Bell 206L Long Ranger
B212	Bell 212 Huey (UH-1N) (CH-135)
B222	Bell 222
B206B3	Bell 206B-3
B407	Bell 407
B427	Bell 427
B429	Bell 429
B430	Bell 430
BO105	Bölkow BO-105
CH47D	Boeing Vertol 234 (CH-47D)
EC130	Eurocopter EC-130 w/Arriel 2B1
H500D	Hughes 500D
MD600N	McDonnell Douglas MD-600N w/ RR 250-C47M
R22	Robinson R22B w/Lycoming 0320
S61	Sikorsky S-61 (CH-3A)
S65	Sikorsky S-65 (CH-53)
S70	Sikorsky S-70 Blackhawk (UH-60A)
S76	Sikorsky S-76 Spirit
SA330J	Aérospatiale SA-330J Puma
SA341G	Aérospatiale SA-341G/342 Gazelle
SA350D	Aérospatiale SA-350D AStar (AS-350)
SA355F	Aérospatiale SA-355F Twin Star (AS-355)
R44	Robinson R44 Raven / Lycoming O-540-F1B5
SC300C	Schweizer 300C / Lycoming HIO-360-D1A
SA365N	Aérospatiale SA-365N Dauphin (AS-365N)

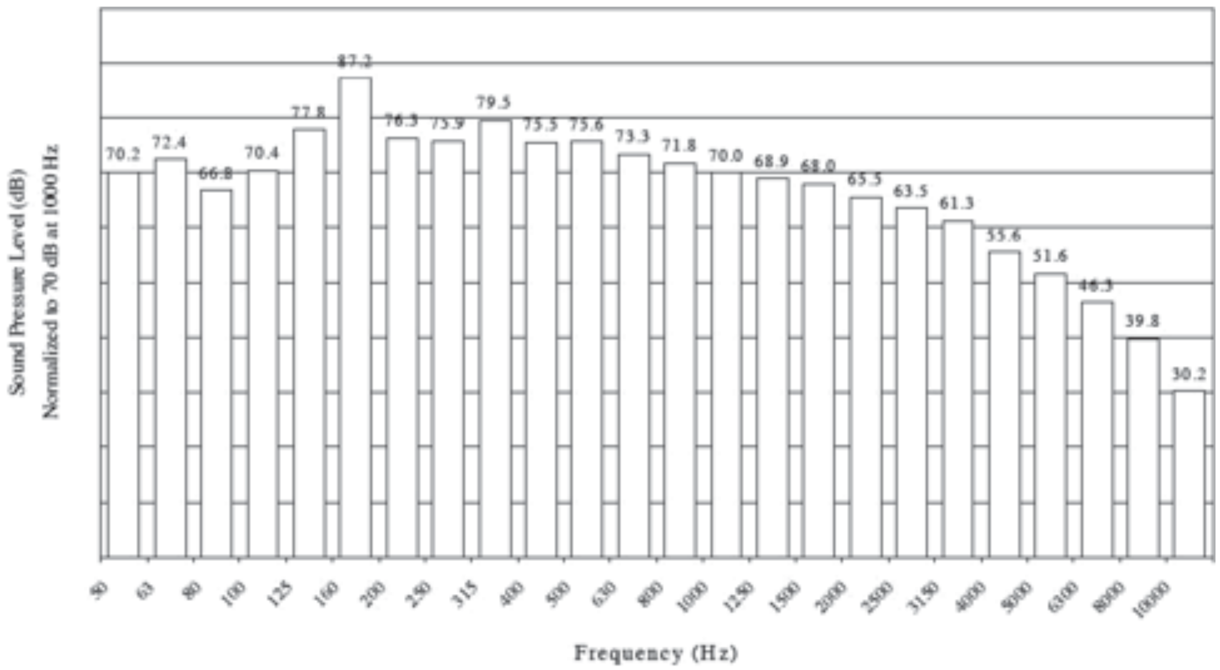


FIGURE 14. DEPARTURE SPECTRAL CLASS 114

INM Aircraft Descriptions:	Helicopter
INM Aircraft ID:	B212 BO150 S70

Figure A-11. Spectral class example 1.

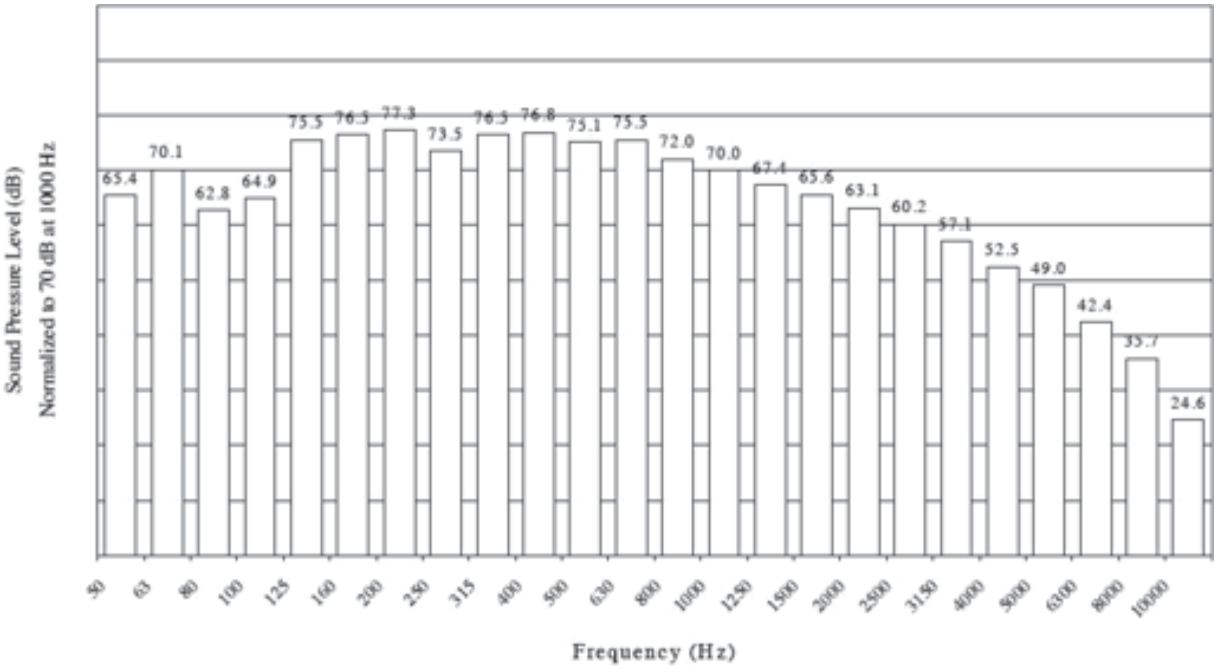


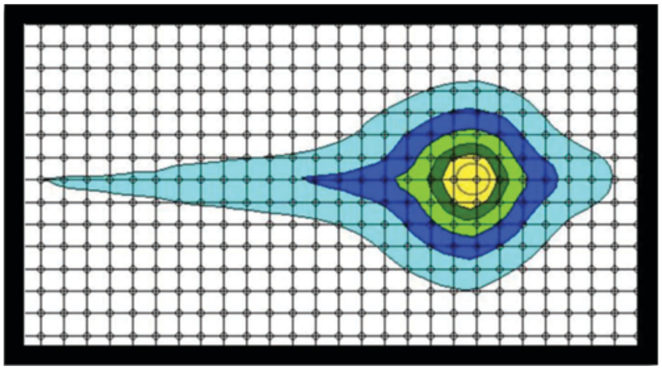
FIGURE 16. DEPARTURE SPECTRAL CLASS 116

INM Aircraft Descriptions:	Helicopter
INM Aircraft ID:	SA355 S65 H500D

Figure A-12. Spectral class example 2.

Figure A-13 shows the 55 through 75 DNL contours for this generic helicopter test case. The grid points shown are 0.1 nautical miles apart (approximately 608 feet). The resulting DNL contours are relatively small, even with 200 daily helicopter operations.

Figure A-14 and Figure A-15 compare the noise metrics that INM can compute relative to the DNL value at each of the grid points within a 4 nautical mile square grid with 0.1 nautical mile spacing. Figure A-14 shows the traditional level based metrics, while Figure A-15 shows the Time Above metrics.



(Contour values 75 DNL to 55 DNL, Grid point spacing 0.1 nm.)

Figure A-13. DNL contours for test case operations.

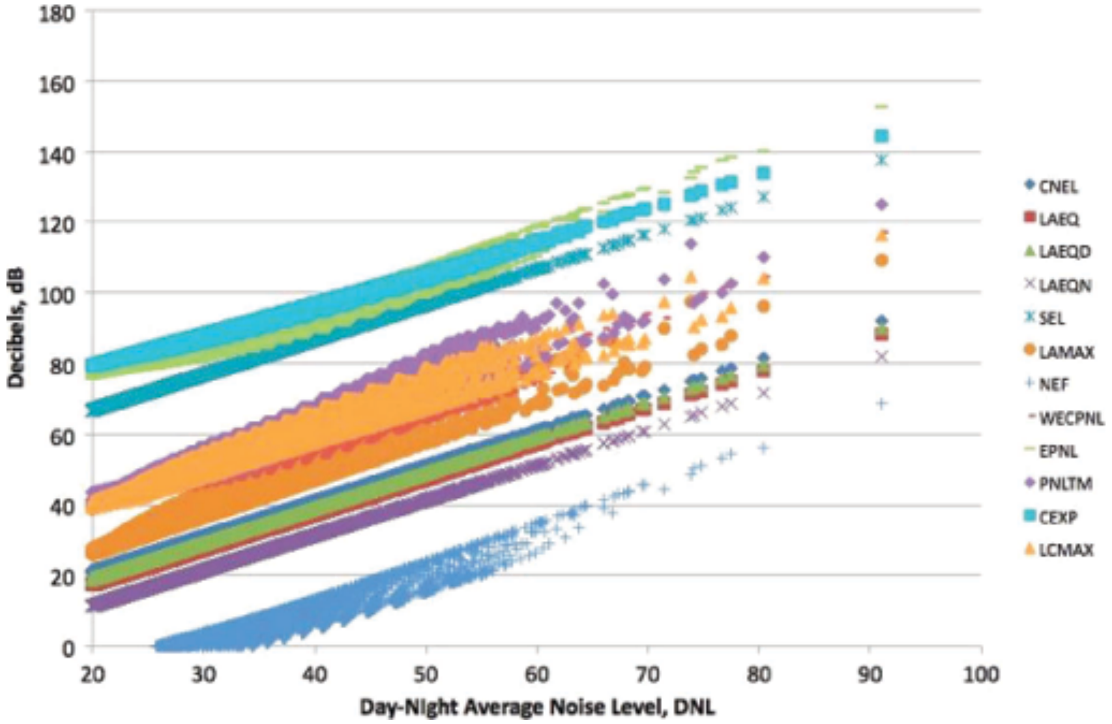


Figure A-14. ***Relationship of traditional level based noise metrics to DNL for an example heliport.***

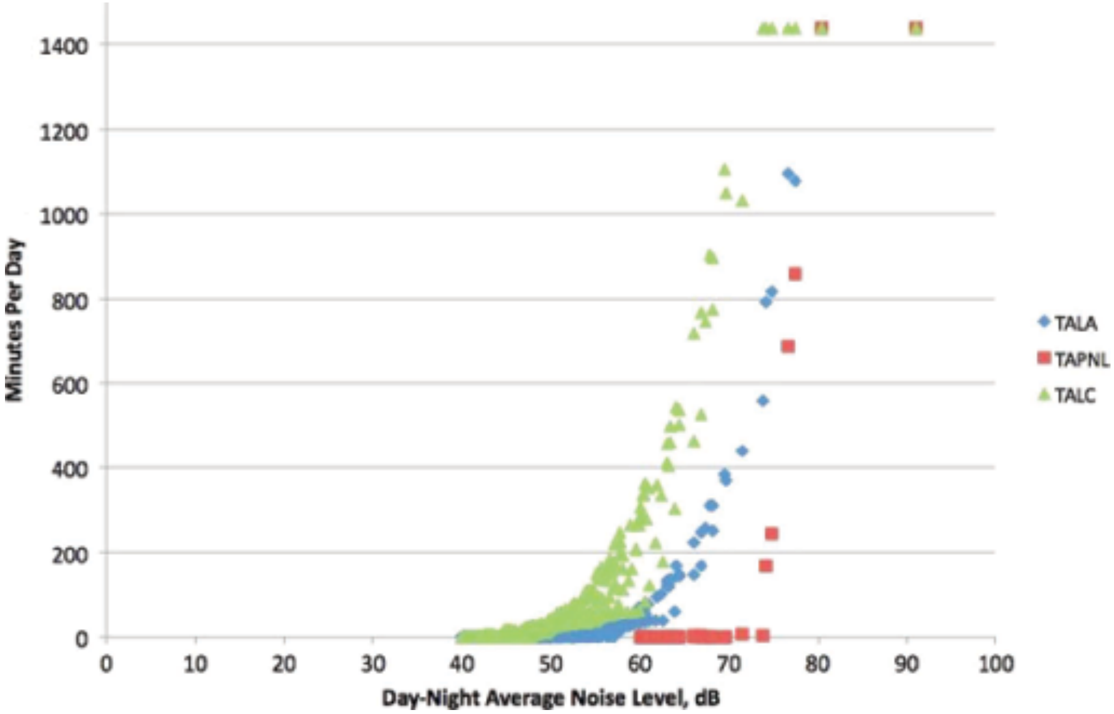


Figure A-15. ***Correlation of Time Above Metrics to DNL for an example heliport (threshold 65 dB for TALA and TALC and 95 dB TAPNL) (TALA – time above A-weighted SEL, TAPNL = time above PNL-weighted SEL, TALC = time above C-weighted SEL.)***

Table A-2. Coefficients of determination (R^2) of noise metrics with DNL.

NOISE METRIC	R^2 RELATIVE TO DNL
CNEL	0.99997
LAEQ	1
LAEQD	0.99997
LAEQN	0.99997
SEL	0.99998
LAMAX	0.95152
NEF	0.92129
WECPNL	0.92128
EPNL	0.92126
PNLTM	0.92887
CEXP	0.99538
LCMAX	0.95927
TALA	0.86722
TALC	0.86848
TAPNL	0.6641

Table A-2 shows the variance accounted for (coefficients of determination) for each of the noise metrics with DNL. All of the metrics other than the Time Above metrics are highly correlated with DNL. For all practical purposes, if one of the equivalent energy metrics is known, all of the other equal energy metrics are also known (except for constants and scale factors.) These results are similar to the results for fixed-wing aircraft (Mestre et al. 2011).

The R2 values between DNL and individual metrics displayed in Table A-2 demonstrate that essentially all of the metrics modeled by INM are highly correlated with DNL. Note that in each case in Table A-2 the correlation of determination was based on a linear fit except for the Time Above metrics. For the Time Above metrics, a 2nd order polynomial fit was used. The choice of linear or 2nd order fit of DNL to the individual metrics was based on the shape of the data plot and the method that provided the best correlation. TAPNL is the metric most independent from DNL, albeit in a not particularly useful manner. Figure A-15 shows that the TAPNL data have a very narrow dynamic range, with a nearly vertical slope between DNL 75 and DNL 80. Time Above 95 PNL goes from nearly 0 to 1400 minutes within a range of only $L_{dn} = 5$ dB.

Note that none of the metrics, the traditional level based metrics nor Time Above, include any corrections or adjustments for impulse type noise that occurs as part of some helicopter operating modes. Note also that the spectral data used by INM to compute C-weighted and PNL metrics do not contain any information below the one-third octave band centered at 50 Hz.

APPENDIX B

Annotated Bibliography

The entries in the following bibliography are not intended to be comprehensive but rather to summarize interpretations of findings of some of the better-known studies of the annoyance of helicopter noise. They exclude studies intended mostly to measure helicopter noise emissions, and some laboratory studies of rotor noise whose findings have little direct bearing on the design of social surveys of the annoyance of helicopter noise. Although preference was given to annotating peer-reviewed studies, a number of technical reports are annotated as well.

Atkins, C., Brooker, P. and Critchley, J. (1983) *1982 Helicopter Disturbance Study: Main Report*. Civil Aviation Authority/Department of Transport/British Airports Authority.

The authors report the results of a large-scale field study intended to evaluate attitudinal differences to fixed- and rotary-wing aircraft. Six interviewing areas were chosen with differing proportions of the two aircraft types, from none to exclusive. Areas near military installations were avoided in the belief that attitudes near such installations might differ from those of the general population. Each potential site received considerable pre-study qualification, including site visits to some and consultations with air traffic control and airport personnel. Exclusive helicopter exposure was found in areas where aircraft served North Sea oil platforms and helicopter passenger service.

Interviews were conducted in person. Interview areas were sized to encompass cumulative exposure ranges no greater than 5 dB. (All respondents within such areas were assumed to receive the same dose.) Questionnaire completion rates across interviewing areas ranged from 61 to 82 percent. Continuous sound level measurements were conducted for 10 or more days in each area. The measurements were largely unattended except in areas where varying source contributions or complex flight procedures were anticipated.

The survey instrument was quite lengthy, as it sought information about a large number of variables that might relate to respondent attitudes. The main questionnaire item about bother or annoyance used a four-point category scale. This question was asked only of those respondents who in an earlier question responded positively that they heard aircraft noise. An average of 30 percent of respondents expressed fear that an overhead aircraft might crash. The attitudinal response of bother or annoyance to aircraft noise was found to be positively correlated with crash fear: “On the whole, residents who feared a crash were more annoyed by aircraft noise than those who did not.”

The authors noted that the scatter of dosage-response points about their trend line exhibited greater scatter than expected by chance alone. This scatter was somewhat reduced when respondent socio-economic group was factored into the analysis. Some neighborhoods differed markedly in the age of the population, however no age effect was found in the dosage-response analysis.

Edwards, B. (2002) ***Psychoacoustic Testing of Modulated Blade Spacing for Main Rotors.*** **NASA Contractor Report 2002-211651.**

Edwards reports the results of laboratory studies of the annoyance of noise created by a simulated 5-bladed main rotor with unevenly spaced rotors. Forty subjects assigned numeric ratings to the annoyance of various simulated blade configurations, and forty provided paired-comparison ratings. Edwards concludes that "No strong subjective differences among the predicted helicopter test sounds were found in either test. . . ." and that A-weighted measures of helicopter rotor noise are ". . . not strongly indicative of subjective response."

Federal Aviation Administration (2004) ***Report to Congress: Nonmilitary Helicopter Urban Noise Study*****. Report of the Federal Aviation Administration to the United States Congress Pursuant to Section 747 of the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR-21), Washington, D.C.**

FAA's review of the technical literature on the annoyance of helicopter noise in its Report to Congress cites eight (mostly laboratory) studies supporting the imposition of a blade slap "penalty" on A-weighted measurements of helicopter noise, and seven suggesting that such a penalty is not justified. The FAA report also cites two studies of "heightened reaction" to helicopter noise—presumably not associated with blade slap—by Schomer (1983) and by Atkins et al. (1983). Despite the inconsistency and ambiguity of these findings, the report repeats the common assertion that "helicopter noise may be more noticeable because of its periodic impulsive characteristic." The report also cites "the possible phenomena (sic) of 'virtual noise'" [see annotation for Leverton (2014) below], which it suggests may be due to attitudes and beliefs about the necessity of helicopter operations and fear of crashes.

The FAA report also includes brief discussions in Sections 3.5.5 through 3.5.8 of contentions that "helicopter noise is more annoying than fixed-wing aircraft noise"; that "helicopter sounds may be more readily noticeable than other sounds"; that attitudes such as fear of danger, beliefs about the importance of the noise source, and invasions of privacy may influence the annoyance of helicopter noise; and that rotary-wing flight capabilities such as prolonged hovering and proximity to residences may also heighten the annoyance of helicopter noise.

The primary conclusion of FAA's Report to Congress is that "models for characterizing the human response to helicopter noise should be pursued." The report also includes a wide range of recommendations, including some that are reflected in the current effort. For example, FAA recommends study of "nonacoustical effects," among which includes vibration and rattle, and "virtual noise," as described informally by Leverton (see below) and systematically by Fidell et al. (2011). The report also suggests that unique characteristics of helicopter noise emissions (notably including blade slap) may heighten community annoyance with helicopters; that evaluation of noise metrics other than DNL should be undertaken; and that "operational alternatives that mitigate noise should be examined." The latter specifically includes higher altitude flight and route planning to avoid noise sensitive areas.

Fidell, S., and Horonjeff, R. (1981) ***Detectability and Annoyance of Repetitive Impulse Sounds,*** **Proceedings of the 37th Annual Forum, American Helicopter Society, New Orleans, LA, pp. 515–521.**

The audibility of low-frequency rotor noise is of concern not only in residential settings, but also in military applications (where the element of surprise can be mission-critical) and airspace subject to special federal aviation regulations intended to protect natural quiet. In such applications, the main concern is prediction of the audibility of wavetrains of repetitive acoustic impulses, rather than of individual impulses. Fidell and Horonjeff (1981) demonstrated that over a range of observation intervals (0.25 to 2.00 seconds) and repetition rates (5 Hz to 40 Hz, corresponding to the range of fundamental and harmonics of blade passage rates of present interest) the audibility of impulse wavetrains is very closely predictable from the audibility of a single impulse. Under highly controlled listening conditions, participants determined when impulse wave trains of varying repetition rate and observation interval duration were just audible in white noise. The impulse was a 1000 Hz sinusoid. Test participants also listened for a single impulse randomly placed within a 500 msec observation interval.

Equation 1 shows a derived relationship between the energy ratio of a wave train divided by single impulse (left side of equation) and the repetition rate and observation interval (right side).

$$10 \log_{10}(E_{ri}/N_0) - 10 \log_{10}(E_{si}/N_0) = 5 \log_{10}(RR) + 8 \log_{10}(D) + 1.5 \qquad \text{Eq. 1}$$

where:

E_{ri}/N_0 = signal energy to noise power density ratio of impulse wave train
E_{si}/N_0 = signal energy to noise power density ratio of a single impulse
RR = impulse repetition rate (Hz)
D = observation interval (seconds)

Figure B-1 shows the resulting clustering of data points (each an average over all test subjects) when the energy ratio is plotted against repetition rate and the energy ratios have been adjusted for the duration term, 8 Log10(D) in Equation 1.

The tight fit of the data points to the line (plus or minus 0.3 dB) suggests a strong predictive relationship between repetition rate and observation interval (all for the same waveform) and the energy ratio of the wavetrain and single impulse. The positive slope of about 1.5 dB per

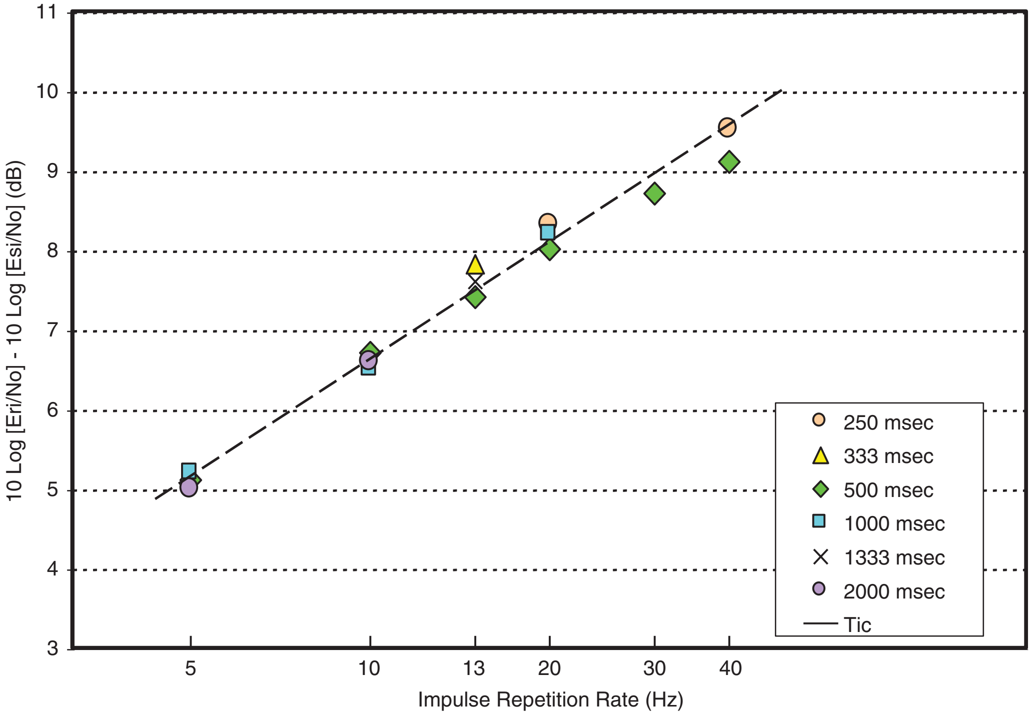


Figure B-1. Observed relative signal-to-noise ratios (10 log10[En/N0] – 10 log10 [Esi/N0]) of equally detectable impulse wavetrains as a function of impulse repetition rate collapsed over observation interval duration by 8 log10[D].

doubling of repetition rate (or 5 dB/decade) indicates that greater signal energy is needed at increasing repetition rates to maintain constant detection performance, and that these slopes are effectively independent of observation interval duration over the investigated range.

Fields, J., and Powell, A. (1987) Community Reactions to Helicopter Noise: Results from an Experimental Study. *J. Acoust. Soc. Am.*, 82(2), 479–492.

Noting the characteristically small numbers of helicopter overflights in many residential exposure settings, Fields and Powell focus on "the applicability of the equivalent energy assumptions about the relative importance of noise level and number of noise events." They devised a controlled-listening field study in which the same 330 respondents were paid $40 to complete repeated interviews on the evenings of 22 days about their annoyance with late morning and early afternoon weekday helicopter noise.

The study area, in close proximity to an army helicopter training base, was a strip 500 meters long, containing 861 dwellings, in a "quiet, well-maintained, middle-class suburban area" with high military employment. The residents were thoroughly habituated to helicopter overflight noise. Large percentages of respondents considered helicopters "very important" (64%), believed that "pilots or other authorities" could not do anything to reduce helicopter noise (62%), and were not afraid that a helicopter might crash nearby (67%).

The daily interview lasted only about four minutes and was confined to determining the times at which respondents were at home during the day, what noise sources they heard, and how annoyed they were by them. Noise measurements were limited to those made at one fixed site at the end of the exposure area, and two roving mobile sites.

Fields and Powell found that respondents' annoyance ratings of helicopter noise increased with both number and level of noise exposure. The average annoyance scores were almost all below 4 on a ten-point scale, indicating that few, if any, respondents were highly annoyed by helicopter noise in the target population. They also found only minor differences in annoyance scores for long-term exposure to more or less impulsive noise: "annoyance, in general, was slightly higher" for exposure to more impulsive noise (UH-1H). Correlations between noise exposure levels and annoyance scores accounted for less than 10% of the variance in the relationship.

Leverton, J. Helicopter Noise: What is the Problem? *Vertiflite*, Vol. 60, No. 2, March/April 2014, pp. 12–15. (See also Leverton and Pike, 2007 and 2009)

The standard measure of adverse public reaction to transportation noise exposure is the prevalence of a consequential degree of noise-induced annoyance (FICON 1992; ISO 2016). Leverton (2014) asserts that vigorous adverse community reaction to helicopter noise "is a little difficult to understand because most helicopters generate less noise than the noise certification standards [for fixed-wing aircraft]. . . ."[20] He infers from this observation that "there appears to be something different about the way in which helicopters are perceived."

Leverton expands the concept of "something different" about the perception of helicopter noise into the concept of "virtual noise." He offers somewhat contradictory definitions of virtual noise, however. On the one hand, Leverton states that virtual noise is nonacoustic in nature. This is a plausible belief, since the annoyance of an unwanted noise intrusion is, after all, a property of an unwilling listener, not of a noise source per se. A sound level meter measures sound pressures, not annoyance. Absent a reliable dosage-response relationship, useful inferences cannot be drawn from noise levels alone about the prevalence of annoyance with transportation noise in noise-exposed communities.

On the other hand, Leverton believes that even though virtual noise is not directly related "either to the absolute level or to the character of the noise generated by helicopters," it is nonetheless "triggered by the direct acoustic signal." As Leverton puts it, "Virtual noise is dependent on a wide range of inputs but is triggered initially by any distinctive feature of the acoustic signature and, to a far lesser extent, the absolute noise level." In other words, adverse community reaction to helicopter noise is conditioned on two sets of factors other than the conventionally measured, A-weighted acoustic energy of helicopter noise emissions. The first component of virtual noise is the noticeability of distinctive features of helicopter noise emissions, such as HSI, tail rotor (TR) noise, main rotor/tail rotor interaction (TRI) noise, and BVI. In Leverton's view, the second component of "virtual noise" is entirely nonacoustic.

Leverton's concept of virtual noise has several limitations. First, it does not consider the possibility that certain characteristics of helicopter noise could be highly annoying at levels that do not control a helicopter's total A-weighted noise emissions. Second, it does not clearly distinguish between the influences of acoustic and nonacoustic factors on the annoyance of helicopter noise, nor offer any quantitative guidance about the relationships between them. Third, it does not provide any operational definition or methods of quantifying the nonacoustic aspects of virtual noise.

The major contribution of this publication is that it reinforces the notion that factors other than those that can be measured with a sound level meter may somehow affect the annoyance of helicopters.

Magliozzi, B., Metzger, F., Bausch, W., and King, R. (1975) *A comprehensive review of helicopter noise literature.* FAA-RD-75-79.

The "comprehensive review" of Magliozzi et al. (1975) is more of a summary of early field measurements of helicopter noise than a critical review. It focuses more on noise emissions and noise control concerns than on the subjective effects of helicopter noise on individuals or communities. Some of the reasoning is specious, as for example, when the authors conclude "Spectrum analyses of helicopter noise show that the main rotor, tail rotor, and engine sources contribute significantly to annoyance." Merely because rotating noise sources contribute conspicuously to a spectrogram does not mean that they are "significant" sources of annoyance.

Likewise, Magliozzi et al. (1975) repeat the views that a need for "a new noise unit" for measuring helicopter noise is required, and assert that a "modification of the Day-Night Noise Level (sic) . . . shows promise" for assessing community acceptance of helicopter noise.

Molino, J. A., (1982) Should Helicopter Noise Be Measured Differently From Other Aircraft Noise?—A Review of the Psychoacoustic Literature, NASA Contractor Report 3609.

Molino's review describes the many differences between fixed- and rotary-wing aircraft noise but pays most attention to the impulsive nature of helicopter BVI noise ("blade slap"). He reviewed 34 studies of the noisiness of helicopter blade slap, many of which were non-peer-reviewed conference papers or technical reports, which yielded conflicting if not contradictory findings. His conclusion that "there is apparently no need to measure helicopter noise any differently from other aircraft noise" is based largely on the lack of consistent empirical findings about the "excessive" (with respect to the annoyance of fixed-wing aircraft noise) annoyance of impulsiveness per se.

The zeitgeist of the early 1980s, particularly ISO's attempts to recommend noise metrics appropriate for certification of helicopter noise, appears to have influenced Molino's analyses. Several national helicopter industries had proposed methods for assessing the annoyance of helicopter noise. Each disproportionately penalized the noise emissions of competitors' products. Aérospatiale, for example, proposed a "correction" to helicopter noise that heavily penalized even slight short-term temporal variation in noise levels. "Corrections" proposed by British sources, on the other hand, heavily penalized tonal components of helicopter noise, such as those produced by Sud Aviation's (subsequently Aérospatiale, Eurocopter, and now Airbus Helicopters) high-speed, ducted fan ("Fenestron") tail rotor.

Molino's report goes into considerable detail about the acoustic characteristics of helicopter noise emissions and into variability in noise emissions associated with various helicopter types and operating conditions. He notes that relationships between operating mode, engine power, and airspeed in helicopters are not as straightforward as they are for fixed-wing aircraft. For example, Molino observes that unlike fixed-wing aircraft, "helicopters generally produce a minimum sound level at some intermediate airspeed, with higher sound levels at lower and higher airspeeds." He also observes that "for the same airspeed, helicopters often exhibit different sound spectra for approach versus level flight."

The psychoacoustic research reviewed by Molino consists mostly of 1970s-era studies, with a smattering of earlier and later studies. A major part of Molino's review addresses the methodological advantages and disadvantages of varying forms of signal presentation, listening contexts, and annoyance-rating scales for controlled-listening tests. He ultimately speculates that 1) "the source of . . . [discrepancies among empirical findings] . . . may lie in the methodologies and approaches selected by the experimenters," rather than in bona fide differences in the annoyance of helicopter noise and 2) that inadequate experimental treatment of the complexity of helicopter noise may obscure the annoyance of helicopter noise. For example, Molino notes "The presence of blade slap, in and of itself recognized as contributing to increased annoyance, produces changes in other acoustic parameters that can compensate for or account for the increased annoyance caused by the presence of blade slap."

Molino concludes from the contradictory and inconclusive nature of the findings of laboratory studies about the annoyance of helicopter noise that "there is apparently no need to measure helicopter noise any differently from other aircraft noise." The logic and universality of Molino's conclusion are open to question given the limited nature of comparisons that Molino describes among the findings of different forms of laboratory studies of the annoyance of helicopter noise.

Another major limitation of Molino's review is that he confines his review to the direct annoyance of airborne acoustic energy produced by helicopters, and does not take into account the potential contributions to annoyance of secondary emissions (audible rattle and sensible vibration) produced by helicopter flight operations inside residences. To the extent that any excess annoyance of helicopter noise is related to the annoyance of secondary emissions, Molino's conclusion about the sufficiency of A-weighted measurements is premature.

More, S. R., (2011) *Aircraft Noise Characteristics and Metrics*. Purdue University Doctoral Thesis and Report No. PARTNER-COE-2011-004.

More's thesis reports the findings of laboratory studies of second-order effects, such as "sharpness" (spectral balance of low and high frequency energy), tonality (presence of prominent tones), slow fluctuations in loudness (fluctuation "strength"), and "roughness" (rapid fluctuations in loudness) on absolute judgments of the annoyance of single-event, fixed-wing aircraft noise presentations. (The reported work does not address the effects of rattle and vibration, or the annoyance of cumulative noise exposure.) Although More's interests did not specifically extend to the annoyance of helicopter noise, some of the factors that he studied are more characteristic of complex rotary-wing noise emissions than those of simpler, broadband fixed-wing aircraft.

The laboratory judgments did not demonstrate any clear contributions of sharpness, roughness, and fluctuation strength to judgments of the annoyance of aircraft noise. Loudness remained the major determinant of judged annoyance, with a clear contribution of tonality.

Munch, C. and King, R. (1974), *Community acceptance of helicopter noise: criteria and application.*National Aeronautics and Space Administration, NASA-CR-132430.

Because assumptions made by the authors have not withstood the passage of time, the reasoning in this 40-year old study—dating from the era prior to FICON's recognition of the prevalence of a consequential degree of annoyance as a preferred measure of adverse impact of transportation noise—is largely irrelevant to modern analyses of the effects of helicopter noise exposure on communities.

For example, the authors loosely define "community noise acceptance criteria" in terms of "a noise exposure acceptable to the average member of the community." Further, they interpret EPA's recommendation of a DNL of 60 dB as a level consistent with "requirements for human compatibility in the areas of annoyance, speech interference, and hearing damage risk" as a basis for regulating aircraft noise. They also assume that A-weighted noise levels 2 dB lower than ambient levels are completely acceptable, and that ambient noise levels in inhabited places will decrease "over the years due to stricter controls on noise sources other than aircraft." Neither assumption is correct. The audibility of aircraft noise cannot be reliably predicted from A-weighted noise levels, and Schomer et al. (2011) has shown that the slope of the relationship between population density and cumulative noise exposure has remained unchanged for about 40 years.

The authors also report an informal study of the noticeability of blade slap, from which they estimate that notice of blade slap occurs at a crest factor of 13 dB. This figure is little greater than the crest factor of many urban ambient noise environments. Although the authors repeatedly emphasize that understanding of the annoyance of blade slap is "sketchy," "inadequate," "very limited," "inconsistent," etc., they nonetheless conclude that a "penalty" is required to account for the annoyance of repetitive impulsive aircraft noise. The magnitude of the recommended penalty in units of perceived noise level is 4 to 6 dB, or 8 to 13 dB in A-weighted units.

Namba, S., Kuwano, S., and Koyasu, M. (1993) The Measurement of Temporal Stream by Hearing by Continuous Judgments—In the Case of the Evaluation of Helicopter Noise, *J. Acoust. Soc. Jpn.*, 14, 5.

Namba et al. (1993) suggest that the practice of calculating equivalent energy metrics for time-varying environmental noises (such as those produced in the course of helicopter flight operations) can misestimate their annoyance because they do not take into consideration the temporal context of noise intrusions.[21] They propose instead a method of continuous judgment, such that the annoyance of helicopter and other ". . . fluctuating sounds [can be measured] by pressing a key on a response box . . .", in real time. The authors found marked differences in the momentary annoyance of helicopter takeoffs, overflights, and landings.

Ollerhead, J. B. (1982) *Laboratory Studies of Scales for Measuring Helicopter Noise.* NASA Contractor Report 3610.

Ollerhead solicited absolute judgments from scores of test subjects of the annoyance of tape recorded helicopter sounds presented both over headphones and via loudspeaker in a series of laboratory studies. A set of preliminary investigations was conducted to pilot-test the annoyance-rating and signal presentation methods. A set of "main" tests followed, in which six undergraduates at a time rated the annoyance of the sounds of 89 helicopters (mostly level flyovers) and 30 fixed-wing aircraft heard through headphones. The headphone presentation results were generally replicated in subsequent free-field testing at NASA Langley Research Center.

Ollerhead concludes that tone-corrected effective (that is, duration-adjusted) Perceived Noise Level predicts the annoyance of helicopter noise better than does A-weighted sound pressure level, and that any putative effects of impulsiveness per se may be equally attributed to increases in helicopter noise level and duration.

Ollerhead, J. B., (1985) *Rotorcraft Noise*. Loughborough University of Technology, Leicestershire, England.

Ollerhead's review addresses "subjective impact" (individual and community response to exposure to helicopter noise), mechanisms of helicopter noise generation, and potential helicopter noise control measures, with greater emphasis accorded to the latter two topics.[22] Like most other review articles, Ollerhead's article deals at length with differences between rotary- and fixed-wing noise emissions. Among other salient differences, Ollerhead notes that unlike fixed-wing aircraft, "helicopters are usually confined to low altitudes," and that "many helicopters radiate maximum noise in a forward direction," so that "an approaching helicopter can often be heard for as long as five minutes."

Ollerhead's review of subjective impacts of helicopter noise deals with statements attributed to Molino (1982). Like Molino, Ollerhead draws attention to contradictory findings and to apparent discrepancies between the findings of field studies and laboratory studies. Ollerhead notes, for example, that his own 1971 finding "that the very long attention-arresting sound of an approaching helicopter did not affect annoyance responses in the laboratory experiments" conflicts with "hearsay evidence of complainants near heliports that [duration of audibility] may be a particular source of aggravation to people at home."

Patterson, J., Mozo, B., Schomer, P., and Camp, R. (1977) *Subjective Ratings of Annoyance Produced by Rotary-Wing Aircraft Noise*. Bioacoustics Division, US Army Aeromedical Research Laboratory, Fort Rucker, Alabama, USAARL Report No. 77-12, May 1977.

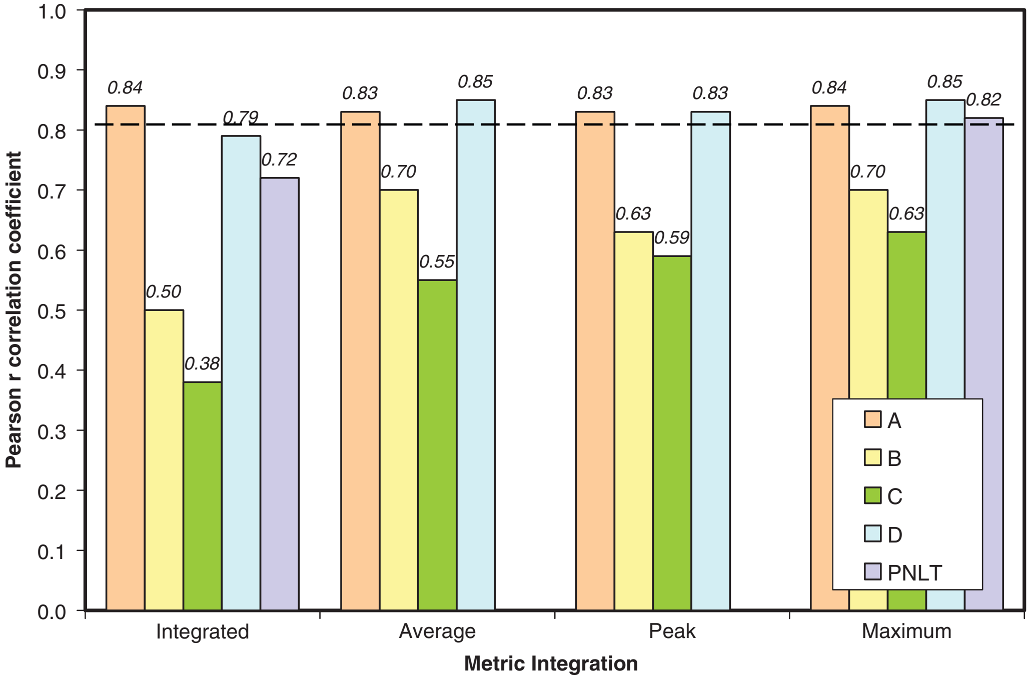
Patterson et al. (1977) describe an outdoor noisiness magnitude estimation test in which a panel of 25 audiometrically screened participants rated the sounds of actual rotary-wing aircraft passbys relative to that of a fixed-wing C-47 propeller-driven aircraft. The goals of the study were fourfold with regard to determining a metric that would best predict subjective annoyance: (1) which spectral weighting function(s) are most appropriate? (2) what type of temporal integration should be used? (3) is an impulsive blade slap correction factor necessary? and (4) do present fixed-wing annoyance predictors underestimate annoyance from rotary-wing aircraft?

To evoke differing spectral and temporal characteristics, the listening test involved nine different rotary-wing aircraft each flying six different flight maneuvers: (1) level flyover, (2) nap-of-the-earth, (3) ascent, (4) decent, (5) left turn, and (6) right turn. During each passby the sound pressure level signature was FM-recorded on magnetic tape for subsequent analysis into one-third octave bands. Observers recorded their noisiness rating relative to the C-47 at the end of each passby.

In the subsequent analysis five broadband frequency-weighted metrics were considered: A-weighted sound level, B-weighted sound level, C-weighted sound level, D-weighted sound level, and tone-corrected perceived noise level (per Federal Aviation Regulation Part 36). For each, four different temporal treatments were examined: the maximum sound level, the peak sound level, the average sound level over the passby, and the time-integrated level over the passby. The Pearson product moment correlations (r), relating noisiness to all frequency weightings and temporal considerations are shown in Powell, C. A. (1981) *Subjective Field Study of Response To Impulsive Helicopter Noise*, NASA Technical Paper 1833.

Figure B-2 plots the correlations in four groups of differing temporal considerations. Within each group the four different frequency weightings are shown.

The figure reveals that the A-weighted and D-weighted sound levels and the tone-corrected perceived noise level all performed equally well as noisiness predictors regardless of the time integration method employed. The dashed horizontal line plots the average value of all the



Powell, C.A. (1981) *Subjective Field Study of Response To Impulsive Helicopter Noise*, NASA Technical Paper 1833.

Figure B-2. Subjective noisiness correlations with four frequency weighting functions and four temporal integration measures.

coefficients for these metrics (0.81). In addition, the figure shows that B-weighted and C-weighted sound levels performed demonstrably more poorly. However, the maximum level was a better predictor of annoyance for both the C-weighted sound level and tone-corrected perceived noise level than was a temporal integration of these measures. These correlations notwithstanding, the authors found that on average the rotary-wing aircraft were rated an equivalent of 2 decibels more annoying than the fixed-wing C-47. This difference represents only about one-third of the scatter in sound level observed for any given relative annoyance rating but this difference is probably significantly different from zero (not determined by the authors).

The authors note that the similar performance of the A, D, and tone-corrected metrics was largely due to the high correlation between the metrics themselves. The correlations (r) were largely independent of temporal consideration and ranged from 0.91 to 0.98. The authors thus concluded "The high correlation among these predictors of annoyance makes any attempt to show the superiority of one over another unlikely to succeed."

The authors also explored two measures of impulsivity to determine whether either improved the correlation. These were (1) the crest factor (peak minus root mean square) and (2) a novel adjunct to crest factor that measured the root mean square level between blade slaps and subtracted this value from the peak level. No improvement was found using crest factor. However, some modest improvement was found using the second method, but the authors concluded the method was too cumbersome to be used in practice.

Powell, C. A. (1981) *Subjective Field Study of Response to Impulsive Helicopter Noise*. NASA Technical Paper 1833.

Powell conducted two controlled-listening studies in which 91 test participants located both indoors and outdoors judged the noisiness of 72 helicopter and propeller-driven, fixed-wing aircraft flybys. After noting the "very diverse" character of helicopter noise, Powell comments on the inconclusiveness of studies intended to ascertain whether an impulsiveness correction is useful for predicting the noisiness of helicopter noise. One purpose of the current investigation was to determine whether highly impulsive helicopter overflights are judged to be noisier than less impulsive helicopter overflights at constant EPNL values. The other purpose was to determine the utility of ISO's then recent suggestion of an impulsiveness correction to EPNL.

Powell's findings were counter-intuitive and in direct contrast to the common assumption (cf. Sternfeld and Doyle, 1978) that the impulsiveness of helicopter noise accounts for much of its annoyance. Powell found that "at equal effective perceived noise levels (EPNL), the more impulsive helicopter was judged less noisy than the less impulsive helicopter." Powell also found that ISO's proposed impulsiveness correction, based on measurements of A-weighted crest factors, failed to improve the ability of EPNL to predict helicopter noisiness judgments. Powell concluded that ". . . some characteristic [of helicopter noise] related to impulsiveness is perceivable by subjects but is not accounted for by either EPNL or [ISO's] proposed impulsiveness correction."

Schomer, P. D., Hoover, B. D., and Wagner, L. R. (1991) *Human Response to Helicopter Noise: A Test of A-weighting.* U.S. Army Corps of Engineers, USACERL Technical Report N-91/13.

Schomer, P. D., and Neathammer, R. D. (1987) The role of helicopter noise-induced vibration and rattle in human response. *J. Acoust. Soc. Am.*, 81(4), pp. 966–976.

Schomer et al. (1991) describe this study as a continuation of a field study ("jury test") conducted by Schomer and Neathammer (1987). The former study solicited individual paired-comparison judgments of the annoyance of helicopter flybys with respect to a single broadband noise from groups of paid test participants seated in a house, a tent, and a mobile home. Schomer and Neathammer (1987) concluded that A-weighted measurements of helicopter flyby noise did not adequately predict differences in annoyance between the flyby noise and the control signal, and that the level of secondary emissions (helicopter-induced rattle) in the listening environment influenced the annoyance judgments. The annoyance judgments were solicited in a field setting rather than in a laboratory because "the very low-frequency sounds, the rattles, and the vibrations characteristic of helicopter noise would be too hard to simulate realistically in a laboratory. . . ."

Neither A-weighted nor C-weighted measurements of helicopter noise were able to predict offsets between objective measurements of sound levels produced by helicopter flybys and the comparison sounds when heard at subjectively equally annoying levels. The differences between A-weighted and C-weighted levels of helicopters and equally annoying broadband noise varied from 10 dB (for helicopters with two bladed main rotors) to 8 dB for helicopters with greater numbers of rotor blades.

In other words, Schomer et al. (1987, 1991) found that exposure to helicopter noise depended in part on its impulsive characteristics (blade passage frequency and/or repetition rate) and the rattle induced by repetitive impulsive signals in residences. This finding directly contradicts Molino's interpretation a decade earlier of the (largely laboratory-based) research findings that "there is apparently no need to measure helicopter noise any differently from other aircraft noise."

Note, however, that the Schomer et al. (1987, 1991) studies included no direct comparisons of the annoyance of exposure to rotary- and fixed-wing aircraft sounds. Because these studies included no direct empirical comparisons of helicopter noise with fixed-wing aircraft noise, they do not clarify whether the observed "excess" (that is, greater than A-weighted) annoyance of helicopter noise also holds with respect to fixed-wing aircraft noise.[23]

Schomer, P., and Wagner, L. (1996) On The Contribution Of Noticeability of Environmental Sounds to Noise Annoyance. ***Noise Control Eng. J.,*** **44 (6), 294–305.**

Schomer and Wagner provided modest numbers of paid volunteers at three locations with portable (palm-top) computers to self-report prompt annoyance judgments for naturally occurring outdoor noises that they noticed while at home. The computers administered a brief questionnaire that asked respondents to identify the source of the annoying sound (e.g., rotary- or fixed-wing aircraft) and their degree of annoyance with it. Unattended outdoor noise measurements were made at locations near the test participants' homes.

The authors analyzed both the per event annoyance ratings and the rate of notice of noise events. They found only minor differences in the per event annoyance ratings of fixed- and rotary-wing aircraft noise of comparable A-weighted SELs. In fact, for some of the test participants, the annoyance ratings varied little with SELs. Mere detection of noise events seemed to suffice to annoy these participants.

However, the authors also found that the rate of notice of helicopter noise was three times as great as the rate of notice of fixed-wing aircraft noise. They speculate that the greater rate of notice of helicopter noise was due to the "distinct sound character" of rotary—wing aircraft. Since the participants were exposed to notably fewer helicopter than fixed-wing overflights, it is also possible that they were less habituated to helicopter noise than to fixed-wing aircraft noise.

Sternfeld, H., and Doyle, L. B. (1978) ***Evaluation of the Annoyance Due to Helicopter Rotor Noise.*** **NASA Contractor Report 3001, NASA Langley Research Center Contract NAS1-14192.**

Sternfeld and Doyle conducted controlled (laboratory environment) listening tests in which 25 volunteer listeners adjusted the annoyance of three degrees of rotor impulsiveness, heard at four blade passage (repetition) rates, to the annoyance of a single broadband noise. Like virtually all other publications in this research area, Sternfeld and Doyle characterize helicopter noise as "unusually complex." They assert, however, without further elaboration, "It is the more impulsive types of rotor noise which are responsible for most of the noise complaints against helicopters." Sternfeld and Doyle did not match the annoyance of broadband noise with that of fixed-wing aircraft noise.

The experimentation conducted by Sternfeld and Doyle was premised on the assumption that main rotor impulsiveness controls the annoyance of helicopter noise. The authors therefore did not study the potential contributions of other sources of helicopter noise to annoyance judgments. Sounds presented to test participants for annoyance judgments were reproduced by headphones, rather than in free-field settings and consisted entirely of synthesized signals. On the continuum of compromise between face validity and precision of control, the work of Sternfeld and Doyle sacrifices nearly all claims to face validity to a desire for very high precision of control of signal presentation.

The authors concluded that their findings permit designers of helicopter rotor systems "to trade off rotor design parameters" to minimize their annoyance, but note certain limitations of the generalizability and practicality of their findings. They were also puzzled (1) by an "apparent inconsistence that when different rotor sounds were adjusted to be equally annoying as a broadband reference sound, subsequent subjective ratings of the rotor sounds were not equal to each other, or to the broadband reference sound," and about (2) "the apparent relative insensitivity to the rotor blade passage period." They conjecture that headphone presentation of signals for annoyance judgments deprived test participants of the sensations of high-level, near-infrasonic harmonics on body surfaces.

Sternfeld, H., Spencer, R., and Ziegenbein, P. (1995) ***Evaluation of The Impact of Noise Metrics On Tiltrotor Aircraft Design*****. NASA Contractor Report 198240.**

Sternfeld et al. (1995) introduce their indoor, controlled-listening study of the judged annoyance of simulated rotor noise by re-capping the inappropriateness of the A-weighting network as applied to rotary-wing aircraft noise, which characteristically includes large amounts of low-frequency, if not infrasonic, acoustic energy associated with the fundamental blade passage frequency of a main rotor and its harmonics. Although the work is motivated by concerns about noise produced by a hovering tiltrotor, the arguments apply generally to other rotary-wing aircraft.

Forty test subjects rated the annoyance of 145 outdoor and 145 indoor simulated rotor noise sounds. The sounds varied in A-weighted and overall sound pressure level from 72 to 96 dB, and in fundamental blade passage rates from 15 to 35 Hz. The spectra and presentation levels of the test sounds were arranged such that the overall sound pressure levels of the test sounds always exceeded A-weighted levels by 6 dB. Sounds intended to represent indoor listening conditions were accompanied by a projection of an indoor scene, while sounds intended to represent outdoor listening conditions were accompanied by a projection of an outdoor scene.

Sternfeld et al. (1995) concluded that A-weighted measurements of the sounds rated by the test subjects were inferior predictors of the annoyance ratings because they were insufficiently sensitive to low-frequency rotor harmonics. They also concluded:

1. That a combination of A-weighted and overall sound pressure level measurements provided improved prediction of the annoyance ratings;
2. That annoyance predictions based on a combination of the two metrics were at least as good as, if not superior to, predictions made from Stevens Mark VII method of predicting perceived sound levels; and
3. That including blade passage frequency as a predictor of annoyance judgments improves matters yet further.

The differences in correlations between predicted and observed ratings for the various prediction schemes were quite small in some cases. For example, adding blade passage frequency to perceived level increased the variance accounted for in outdoor judgments by only 2%, from $R^2 = 0.87$ to $R^2 = 0.89$. Considering the marginal size of many of the observed differences, and that the ISO standard for low-frequency equal loudness curves has changed since the conduct of the Sternfeld et al. analyses, the authors' conclusions are best regarded as suggestive rather than definitive.

Sutherland, L., and Burke, R. (1979) ***Annoyance, Loudness, and Measurement of Repetitive Type Noise Sources*****. EPA 550/8-79-103.**

This report evaluated "subjective and objective aspects of moderate levels of noise from impulsive sources," such as truck-mounted garbage compactors, drop hammers, two-stroke motorcycle engines, and rock drills. The report specifically excludes consideration of high-energy impulses (sonic booms, weapons fire, and quarry blasting), and treats helicopter blade slap as a special case. Sutherland and Burke's summary of early findings about the annoyance of blade slap may be paraphrased as follows:

- The mean observed blade slap correction or penalty factor was 3.3 ±2.7 dB for 11 (laboratory) studies that measured this quantity directly. However, three of these 11 studies found essentially a zero or negative correction. The maximum correction for moderate blade slap (i.e., crest level of 10 to 15 dB) was about 6 dB. The maximum correction for severe blade slap *(i.e.*, crest level about 20 dB) was 13 dB, comparable to the values measured for a variety of non-helicopter sounds.

- The methods proposed [by ICAO in the late 1970s] to objectively compute a blade slap correction factor do not appear to agree consistently with the correction factors measured subjectively to account for annoyance of blade slap.
- Improved results are obtained if [ICAO's proposed methods] are modified to account for variations in the frequency of the blade slap. Adjustments of 2 dB (for a blade slap repetition rate of 10 Hz) to 7 dB (for a blade slap rate of 30 Hz] might be appropriate. (These findings are discussed above in the annotation for Fidell and Horonjeff.) The dependency on repetition rates in this frequency range suggests that a blade slap "correction factor" may arise from inherent errors in perceived noise level computations for signals with significant energy below 50 Hz. The latter inference is not fully consistent with the observations of Fidell and Horonjeff (see above.)
- ICAO's proposed methods for predicting a subjective correction factor depend on some means of measuring the relative impulsiveness. These methods vary from a simple measurement of the crest level of A-weighted noise levels to more complex procedures involving sampling the detected signal (e.g., instantaneous A-weighted level) at a high rate (~5000 Hz) and computing a measure of mean square fluctuation level from these samples.

APPENDIX C

Systematic Analysis of Nonacoustic Influences on Annoyance

A long-standing approach to the problem of accounting for variability in judgments of the annoyance of fixed-wing aircraft noise has been to develop new noise metrics. This approach has produced a veritable alphabet soup of noise metrics, but no appreciable improvement in understanding or predictability of annoyance caused by fixed-wing aircraft noise. Nonetheless, it remains plausible that some improvement in predicting the annoyance of helicopter noise can be achieved via more complex noise metrics alone. After all, helicopter noise can be far more complex than the noise of fixed-wing aircraft.

For practical purposes, a technically defensible answer to the question "Are people more annoyed by helicopter than by fixed-wing aircraft noise?" requires answers to several further questions. Assuming for purposes of discussion that all other things being equal, helicopter noise *is* more annoying than aircraft noise, the first of these additional questions is whether any observed differences in annoyance prevalence rates are due to acoustic or nonacoustic factors.

Given the extent to which communities differ in their opinions about the annoyance of exposure to fixed-wing aircraft noise, it is likely that they also differ widely in their opinions about the annoyance of exposure to rotary-wing aircraft noise. Figure C-1 shows the scatter in prior measurements of the relationship between aircraft noise exposure and the prevalence of a consequential degree of annoyance in communities. Each data point shows the percentage of survey respondents who described themselves as "highly" annoyed (usually, "very" or "extremely" annoyed) by aircraft noise.

The range in noise exposure levels that give rise to the same prevalence of annoyance is on the order of 60 dB. The range in annoyance prevalence rates for the same exposure level across all transportation modes extends from none to about 90%. Figure C-2 shows that the correlation is particularly poor in the range of greatest regulatory interest, from 55 to 75 dB.

C.1 Definition of Community Tolerance Level

Fidell et al. (2011) have shown that a nonacoustic measure known as the CTL, in conjunction with cumulative noise exposure *per se*, accounts for half again as much of the variance in aircraft noise-induced annoyance prevalence rates from one community to the next as noise exposure alone. CTL is formally defined in a Final Draft International Standard 1996-1, shortly to be adopted as an ISO standard. A CTL value is a level of DNL at which half of a community is highly annoyed by noise exposure, and half is not. Since field studies of the prevalence of noise-induced annoyance in communities do not often directly measure DNL values at which half of a community is highly annoyed, it is necessary to estimate CTL values in another way.

CTL-based predictions of annoyance prevalence rates are based on the observation that the annoyance of transportation noise exposure grows at a rate very similar to the rate of growth of

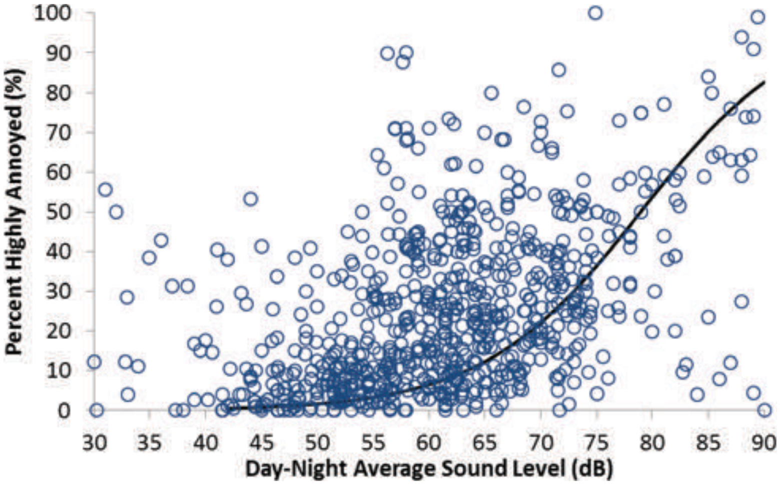


Figure C-1. Relationship between FICON curve and field measurements of DNL and the prevalence of high annoyance for all modes of transportation noise.

duration-adjusted ("effective") loudness with sound level. Fidell et al. (2011) and Schomer et al. (2012) show that the fits of social survey data sets to effective loudness predictions can be found by first converting DNL values for interviewing sites in the same community into a noise dose, m, calculated as $m = (10^{(\mathrm{DNL}/10)})^{0.3}$.

Annoyance prevalence rates for the calculated dose are then predicted as $p(\mathrm{HA}) = e^{-(A/m)}$, where A is a nonacoustic decision criterion originally defined by Fidell, Schultz, and Green (1988). The dose parameter, m, controls the rate of growth of annoyance on the ordinate of a dosage-response relationship, while the decision criterion parameter, A, translates the growth function along the abscissa. The value of A for a given community is estimated by minimizing

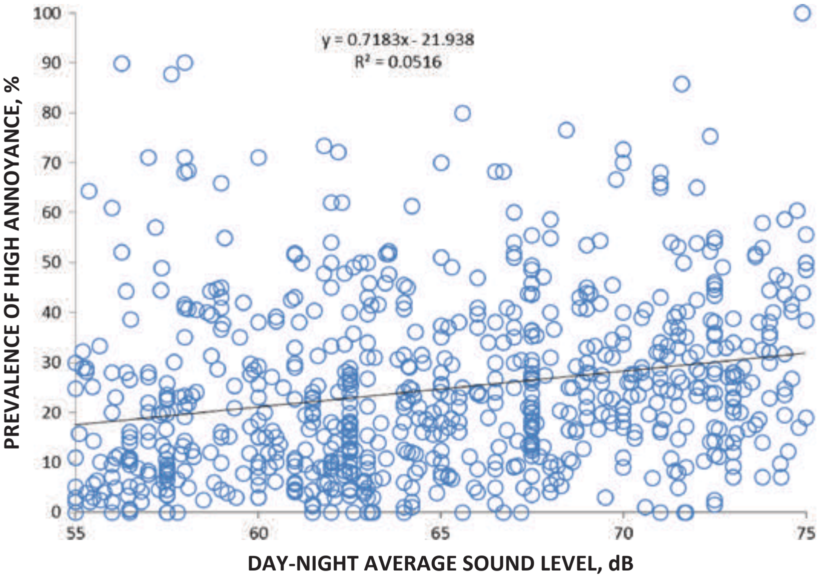


Figure C-2. Poor correlation between exposure and response in exposure range of greatest pragmatic concern.

the root-mean-square error between observed and predicted percentages of highly annoyed survey respondents (Green and Fidell, 1991; Fidell et al., 2011).

C.2 Communities Form Unique Attitudes About Noise

Communities exposed to similar aircraft noise show a wide variance in attitudes about that noise. It is from this observation that the conclusion is made that the focus of understanding annoyance is better done on the community level rather than the individual level. The panels of Figure C-3 (Fidell, 2011) display the fit of the findings of several social surveys to the effective loudness function. Each data point shown in these panels represents a paired observation of the prevalence of high annoyance among respondents at an interviewing site with the site's aircraft noise exposure level. The solid portion of the effective loudness function in each panel of Figure C-3 is the range of primary interest for policy and regulatory purposes. The dashed extensions show the behavior of the function outside the range of primary interest. Not all of the data sets fit the effective loudness function as well as the examples shown in Figure C-3 panels a–f. On average, however, the effective loudness function built into the CTL calculation

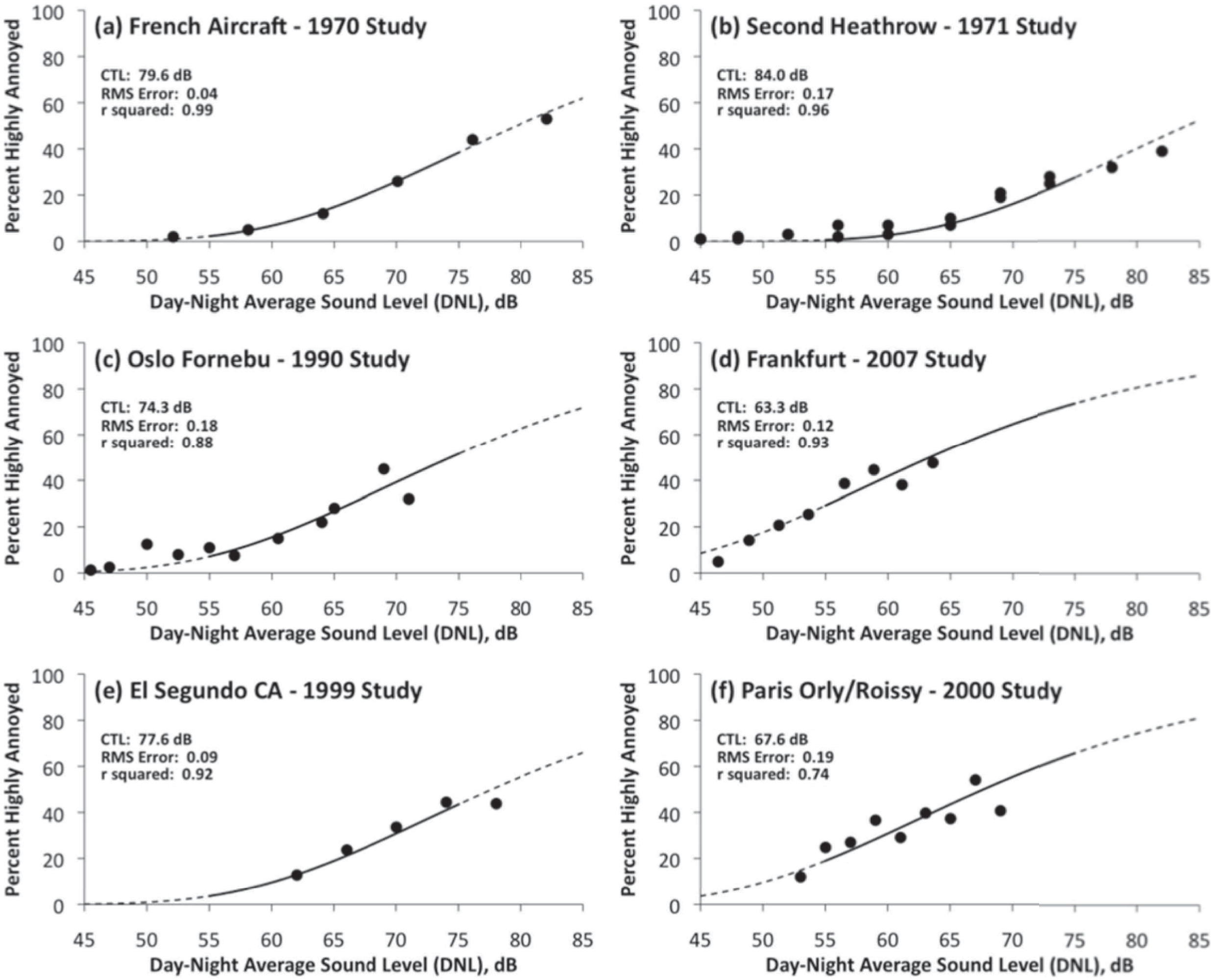


Figure C-3. A comparison of CTL values for six airports showing that at similar noise exposure levels the rate of annoyance varies over a wide range.

accounts for two-thirds of the variance in the association of observed and predicted annoyance prevalence rates.

C.3 Application of CTL Analysis to Annoyance of Exposure to Helicopter Noise

CTL values directly comparable to those calculated for the Fidell et al. (2011) surveys can also be calculated for interviewing sites that are exposed to a range of helicopter noise exposure conditions. Calculating CTL values for the proposed sites would make it possible to make consistent comparisons of the annoyance of rotary- with fixed-wing aircraft noise. These comparisons could be made both with respect to new social survey findings, and with respect to the Fidell et al. (2011) database for aircraft and the Schomer et al. (2012) database for road and rail noise.[24]

APPENDIX D

Noise Measurement Protocol

The noise monitoring for this study was performed using four identical systems of two sound level meters (SLMs). Each system consisted of one Larson Davis (LD) 831 Sound Level Meter and one LD 824 Sound Level Meter connected to a Zoom H4 recorder. Table D-1 presents a list of the SLM used along with the microphone and preamplifier used with each SLM and their serial numbers.

The LD 831 SLMs were set to record the overall A-weighted and C-Weighted L_{eq} and maximum noise levels as well as 1/3 octave band L_{eq} noise levels every second. The LD824 SLMs were set to record the overall A-weighted and C-weighted L_{eq} noise levels and maximum level every second. The audio output of the LD824 SLM was connected to the input of the Zoom H2 digital recorders which were set to record uncompressed WAV audio files at a sampling rate of 44.1 kHz and a bit rate of 16 bits/sample.

Prior to the commencement of monitoring, the performance of each SLM, preamplifier, and microphone combination was verified using a Brüel and Kjær (B&K) 4231 calibrator producing a 1 kHz test tone at 93.8 dB (Serial Number 2528535) and a B&K 4420 pistonphone producing a 250 Hz test tone at 124.0 dB (Serial Number 147402). Certificates of Performance showing the measured calibration levels for each of the SLM systems prior to each measurement period are attached. The calibrator and pistonphone were calibrated by Odin Metrology using standards with values traceable to the National Institute of Standards and Technology. Calibration certificates for these units are attached.

At the commencement of each measurement period, one system, consisting of two SLMs and a Zoom audio recorder, were set up at each measurement location. The SLMs and audio recorder were located in weather resistant cases with access ports for microphone cables and power. The microphones were placed on tripods to mount them at a height of approximately five feet AGL. The microphone tripods were located near the center of the yards at least 10 feet away from any building or wall.

Each SLM was calibrated using the B&K 4231 calibrator in the field prior to starting each measurement period and calibration levels recorded. Data capture on the SLMs was started along with the Zoom audio recording. A calibration tone was recorded to the Zoom recorder and an audible time stamp was recorded. The systems were locked within their cases, and left unattended.

Data storage limitations on the LD 824 SLM and Zoom H4 recorders required downloading of data from the units every other day. Data from the LD 831 SLM were generally downloaded every fourth day. Upon approaching the meters, an audible time stamp was recorded to the Zoom audio file. Data capture on the LD 824 and audio recording on the Zoom were paused and their data was transferred to a portable hard drive. This process was generally repeated for the LD831 SLM on every other visit. After the data was downloaded from the SLMs, the calibration

Table D-1. Sound level monitoring equipment.

	COMPONENT	MANUFACTURER	MODEL	SERIAL #
System A - Monitor 1				
	SLM	Larson Davis	831	2564
	Preamplifier	Larson Davis	PRM831	12422
	Microphone	GRAS	40AQ	83680
System A - Monitor 2				
	SLM	Larson Davis	831	A1460
	Pre-Amp.	Larson Davis	PRM902	1983
	Mic.	Larson Davis	2551	178
System B - Monitor 1				
	SLM	Larson Davis	831	2562
	Preamplifier	Larson Davis	PRM831	15267
	Microphone	GRAS	40AQ	101907
System B - Monitor 2				
	SLM	Larson Davis	831	A1459
	Preamplifier	Larson Davis	PRM902	1987
	Microphone	Brüel & Kjær	4176	2316550
System C - Monitor 1				
	SLM	Larson Davis	831	2565
	Preamplifier	Larson Davis	PRM831	15268
	Microphone	GRAS	40AQ	101963
System C - Monitor 2				
	SLM	Larson Davis	831	A1458
	Preamplifier	Larson Davis	PRM902	1976
	Microphone	Brüel & Kjær	2551	2316551
System D - Monitor 1				
	SLM	Larson Davis	831	2566
	Pre-Amp.	Larson Davis	PRM831	15270
	Mic.	GRAS	40AQ	101912
System D - Monitor 2				
	SLM	Larson Davis	831	A1457
	Pre-Amp.	Larson Davis	PRM902	1989
	Mic.	Larson Davis	2551	177

was checked and recorded using the B&K 4231 calibrator. The SLMs were recalibrated if the measured level differed from the calibration level by more than 0.4 dB. After this process was completed, data capture on the SLMs and recording on the Zoom were restarted. A calibration tone and audible time stamp were recorded on the audio file. The time the technician approached and departed each measurement site was recorded along with file names, measurement start and stop times, and calibration levels.

At the end of each measurement period an audible time stamp was recorded to the Zoom audio file as the meters were initially approached. Audio file recording and SLM data capture were paused and transferred to a portable hard drive. Calibration levels were checked using the Brüel and Kjaer calibrator and recorded.

The calibration checks for the SLMs are attached.

Endnotes

1. Fidell (2003) presents a broader tutorial on the findings, interpretations, and practical implications of community noise research.
2. Note that these nonacoustic influences are more productively addressed at the community, rather than individual, level. As described in the paper on Community Tolerance Level, CTL, (Fidell et al. 2011) communities form unique attitudes about noise. Decades of efforts (e.g., Job 1988; Fields 1993) to quantify individual differences in sensitivity to aircraft noise have produced little information useful for prediction of annoyance prevalence rates, or for regulation of aviation noise.
3. The lowermost curve is FICON's dosage-response relationship for the prevalence of annoyance for all forms of transportation noise. The Miedema and Vos (1998) curve is that of the European Noise Directive.
4. "Final Rule," The New York North Shore Helicopter Route, 77 Fed. Reg., pp. 39,911–39,913.
5. FAA's endorsement of A-weighted noise measurements for assessment of community noise impacts is in large part based on limitations of field-portable, analog-era sound level meters. Lacking the capacity for combining one-third octave band sound level measurements and identifying tonal signal components, it was not possible decades ago to directly measure PNL(T) values in the field.
6. Readers interested in additional detail about these frequency-weighting networks and noise metrics are referred to Mestre et al. (2011).
7. Idealized conditions include a stable and still atmosphere, close adherence to published flight paths and procedures, and ideal pilot technique. Because relatively few helicopter operations are likely to occur under all of these conditions, and because of the great sensitivity of helicopter noise emissions to minor changes in operating conditions, actual noise emissions in the vicinity of helipads may diverge considerably from predicted noise emissions.
8. Truncating the range of a predictor variable such as noise exposure level reduces the magnitude of any observable correlation with a predicted variable such as the prevalence of annoyance.
9. This is particularly true in areas orthogonal to runway centerlines, where the sideline noise exposure gradients for fixed-wing aircraft can be as steep as 10 dB per thousand feet. At airports with midfield helipads, this means that fixed-wing aircraft noise exposure levels are likely to decrease far more rapidly with distance from the runway than rotary-wing aircraft noise exposure levels.
10. Fidell et al. (2011) have suggested one potential solution to this problem—reliance on an assumed shape for the dosage-response relationship.
11. ISO Technical Specification 15666 ("Assessment of noise annoyance by means of social and socio-acoustic surveys") does not recommend screening questions, but also notes that ". . . specific requirements and protocols of some social and socio-acoustic studies may not permit the use of some or all of the present specifications. This Technical Specification in no way lessens the merit, value or validity of such research studies."
12. Proprietary databases, constructed from multiple (e.g., credit bureau, census, telephone, etc.) sources, may nonetheless be useful for present purposes if they permit geocoding and sampling based on areas enclosed by vertices of polygons that can be defined by noise exposure modeling.
13. More recent methods of interviewing (e.g., smartphone- and Internet-based) are not as likely to yield population-representative samples of opinions, since they either permit respondents to self-select for participation in the survey and/or attract primarily respondents with prior interests in the subject matter of the interview.
14. Note that the width of the confidence interval varies not only with sample size, but also with the absolute value of the proportion estimated. The values shown in Figure 3.12 are based on a normal approximation to a binomial distribution, and should not be extrapolated beyond the plotted range.
15. INM 7.0d was released prior to AEDT 2b, but produces identical noise exposure predictions for identical inputs. Note that AEDT 2c was published after the technical work was completed for this study.

16. In broad stokes, landline and wireless sampling frames are developed using a combination of public records and self-reported information. The starting point for compilation for the landline sampling frame is telephone white page directories. These directories are scanned, manually entered, and compared for accuracy. Public record sources, such as birth and mortgage records, are used to enrich this data wherever available. Enhanced-Wireless™ is based upon a self-reported sampling database of approximately 125,000,000 wireless phones. Using Enhanced-Wireless™, samples can be targeted to specific demographic groups, including age, income, gender, presence of children, and ethnic groups—just to name a few. Enhanced-Wireless™ was developed by STS using a proprietary set of databases that includes product purchase data, warranty card information, survey data, and many similar sources of information. Enhanced-Wireless™ is not a panel. Its consumers are not opt-in, instead, it is very much like a landline listings sample—except for covering the wireless universe.
17. Site 4 is a special case. Noise levels measured at Sites 1, 2, and 3 were dominated by a police helicopter that circled and crisscrossed the area above those sites many times at low altitude at 1 AM. Site 4 (north of Sites 1, 2, and 3) was shielded from this operation by a converted garage about 15 feet from the microphone location. Site 4 recorded appreciably lower noise levels for this series of events than did the other sites.
18. The concern over revised flight tracks, known as the "Metroplex Project" was not anticipated at the time of site selection. While the project was known, the concern that it would generate was not known. The FAA had determined that no significant impact would take place. In hindsight, it is clear that Metroplex projects around the U.S. generated more concern than was anticipated. It is still unclear if the concern was in fact a noise issue or whether the mere announcement of the changes or some other nonacoustic effect generated the adverse response. In any event, Washington, D.C., was the only place where we had overlapping fixed-wing and helicopter operations in significant numbers.
19. The current version of INM, version 7.0d (FAA 2007), will be replaced by the Airport Environmental Design Tool (AEDT) Version 2b by the end of the current calendar year. Prior to INM Version 6, helicopter noise was modeled with the Helicopter Noise Model, HNM (Volpe 1994). The helicopter noise computation model from HNM was incorporated into INM beginning with INM Version 6.
20. This assertion assumes that compliance with ICAO standards for fixed-wing aircraft noise certification precludes vigorous adverse reaction in aircraft noise-exposed communities near airports. ICAO's recommendations are consensus standards for noise levels that may not be exceeded by aircraft offered for sale in those member states who chose to adopt ICAO's recommendations. ICAO's noise certification standards are not intended to, and do not, in fact, preclude adverse community reaction to aircraft noise exposure. Indeed, it is commonplace for communities near airports served by large fleets of ICAO-compliant aircraft to oppose continued, unmitigated airport operation and expansion.
21. The influence of meaning on annoyance judgments was also demonstrated by Fidell et al. (2002b), who solicited annoyance judgments under highly controlled listening conditions to sounds with identical duration and power spectra, but differing phase spectra. Large differences were documented between meaningful sounds and the same sounds with scrambled phase spectra.
22. For example, Ollerhead's conclusions include no mention of the subjective impact of helicopter noise.
23. It is possible, for example, that rattle and vibration produced by fixed-wing aircraft at the relatively short ranges of the controlled helicopter flybys would also have created "excess" annoyance.
24. Descriptive statistical tools such as regression may also be used in some cases to estimate values of DNL that highly annoy half of the population at a given interview site. Such estimates do not offer all of the advantages of CTL analysis, however. The slopes of regression-derived estimates of DNL values that highly annoy half of survey respondents are not directly comparable in multiple communities, and levels of annoyance that annoy half of a sample of respondents often do not reach 50% at common levels of helicopter noise exposure.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAST	Fixing America's Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TDC	Transit Development Corporation
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

Plan 4. Air Installations Compatibility Use Zones (AICUZ)

DoD Instruction 4165.57 (Air Installations Compatible Use Zones (AICUZ)) is a program designed to educate airport, heliport, and seaport personnel. The AICUZ Program is designed to promote the health, safety, and welfare of persons in the vicinity of and on air installations by minimizing aircraft noise and safety impacts without degrading flight safety and mission requirements; and promotes long-term compatible land use on and in the vicinity of air installations.

AIR INSTALLATION
COMPATIBLE USE ZONE STUDY

ANDREWS AIR FORCE BASE, MARYLAND

DECEMBER 2007

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ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
AFI	Air Force Instruction
AGL	above ground level
AICUZ	Air Installation Compatible Use Zone
ALM	A-weighted sound level or maximum sound level
APZ	Accident Potential Zone
cps	cycles per second
CZ	Clear Zone
dB	decibel
dBA	A-weighted sound level measured in decibels
DNL	Day-Night Average A-Weighted Sound Level
DoD	Department of Defense
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
HUD	Housing and Urban Development
Hz	Hertz
INM	Integrated Noise Model
LZ	landing zone
MSA	Metropolitan Statistical Area
MSL	mean sea level
NLR	Noise Level Reduction
SEL	sound exposure level
SLUCM	Standard Land Use Coding Manual
the Base	Andrews Air Force Base
UCLA	University of California at Los Angeles
UFC	Unified Facilities Criteria
U.S.	United States
USEPA	United States Environmental Protection Agency

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SECTION 1
PURPOSE AND NEED

1.1 INTRODUCTION

This study is an update of the 1998 Andrews Air Force Base (AFB), Maryland Air Installation Compatible Use Zone (AICUZ) Study. The update presents and documents changes to the AICUZ amendment for the period 1998-2007 and is based on the May 2007 aircraft operations condition. This AICUZ Study reaffirms Air Force policy of assisting local, regional, state, and federal officials in the areas neighboring Andrews AFB by promoting compatible development within the AICUZ area of influence; and protecting Air Force operational capability from the effects of land use that are incompatible with aircraft operations. Specifically, the report documents changes in aircraft operations since the last study and provides noise contours and compatible use guidelines for land areas neighboring the installation based on the May 2007 operations. This information is provided to assist local communities and to serve as a tool for future planning and zoning activities. Changes that occurred since the 1998 Andrews AFB AICUZ Study include:

- Addition, elimination, and modification of aircraft flight tracks to correspond to flying operations changes;
- Addition, elimination, and modification of the number of operations associated with the various aircraft types; and
- Technical improvements to the NOISEMAP Version 7.296 computer modeling program.

1.2 PURPOSE AND NEED

The purpose of the long-standing AICUZ program is to promote compatible land development in areas subject to aircraft noise and accident potential. The Air Force provides the AICUZ Study to all local communities to assist them in preparing local land use plans. As Prince George’s County prepares and modifies land use development plans, recommendations from this updated AICUZ Study should be included in the planning process to prevent incompatible land use that could compromise the ability of Andrews AFB to fulfill its mission. Accident potential and aircraft noise should be major considerations in the planning process.

Air Force AICUZ guidelines reflect land use recommendations for the Clear Zones (CZ), Accident Potential Zones (APZ) I and II, and four noise zones exposed to noise levels at or above 65 decibels (dB) Day-Night Average A-Weighted Sound Level (DNL). These guidelines were established on the basis of studies prepared and sponsored by several federal agencies, including the United States Department of Housing and Urban Development, United States Environmental Protection Agency (USEPA), United States Air Force, and state and local agencies. The guidelines recommend land uses that are compatible with airfield operations while allowing maximum beneficial use of adjacent properties. The Air Force has no desire to recommend land use regulations that render property economically useless. It does, however, have an obligation to the inhabitants of the Andrews AFB area of influence and the citizens of the United States to point out ways to protect the public investment in the installation and the people living in areas adjacent to the installation. The AICUZ area of influence includes the area within the DNL 65 dB and greater noise exposure area and the area within the CZs and APZs.

1.3 PROCESS, PROCEDURE, AND NOISE METRICS

Preparation and presentation of this update to Andrews AFB's AICUZ Study is part of the continuing Air Force participation in the local planning process. Guidance for the Air Force AICUZ program is contained in Air Force Instruction (AFI) 32-7063, *Air Installation Compatible Use Zone Program*, which implements Department of Defense (DoD) Instruction 4165.57, *Air Installations Compatible Use Zones*. This AICUZ Study is accompanied by a Citizen's Brochure, which is a separate document that summarizes the Study.

As local communities prepare land use plans and zoning ordinances, the Air Force recognizes it has the responsibility to provide input on its activities relating to the community. This study is presented in the spirit of mutual cooperation and assistance by Andrews AFB to aid in the land use planning process around the Base.

The AICUZ program uses the latest technology to define noise levels in areas near Air Force installations with a flying mission. Aircraft operational data used in this study were collected at Andrews AFB during the period March 2006-May 2007. The Air Force reviewed and validated the data through a communicative process that was finalized in May 2007. Aircraft flight data were obtained to derive average daily operations by runway and type of aircraft. Analysis of Andrews AFB's flying operations included the types of aircraft, flight patterns utilized, variations in altitude, power settings, number of operations, and hours of operations. These data were supplemented by flight track information (where we fly), flight profile information (how we fly), and ground runup information. After verification for accuracy, the data were input into the NOISEMAP Version 7.296 computer program to produce DNL noise contours. The noise contours for Andrews AFB were plotted on an area map and overlaid with the CZ and APZ areas for the airfield.

The noise contours reflecting the 2007 aircraft operations condition and land use data calculations in this AICUZ Study were prepared by Parsons (Parsons 2007). The basic data for the background maps were obtained from the Maryland-National Capital Park and Planning Commission. The land use and zoning figures presented in Section 5 were developed using additional sources including the Maryland State Highway Administration and the Maryland Department of Planning.

1.4 COMPUTERIZED NOISE EXPOSURE MODELS

The Air Force adopted the NOISEMAP computer program to describe noise impacts created by aircraft operations. NOISEMAP is one of two USEPA-approved computer programs; the other is the Integrated Noise Model (INM) used by the Federal Aviation Administration (FAA) for noise analysis at civil airports. The NOISEMAP and INM programs are similar; however, INM is specifically designed to model aircraft flight operations at civil airports.

NOISEMAP is a suite of computer programs and components developed by the Air Force to predict noise exposure in the vicinity of an airfield due to aircraft flight, maintenance, and ground run-up operations. The components of NOISEMAP are:

- BASEOPS is the input module for NOISEMAP and is used to enter detailed aircraft flight track and profile and ground maintenance operational data.
- NOISEFILE is a comprehensive database of measured military and civil aircraft noise data. Aircraft operational information is matched with the noise measurements in the NOISEFILE after the detailed aircraft flight and ground maintenance operational data has been entered into BASEOPS.
- NMAP is the computational module in NOISEMAP. NMAP takes BASEOPS input and uses the NOISEFILE database to calculate the noise levels caused by aircraft events at specified grid points in the airbase vicinity. The output of NMAP is a series of georeferenced data points, specific grid point locations, and corresponding noise levels.
- NMPLOT is the program for viewing and editing the sets of georeferenced data points. NMPLOT plots the NMAP output in a noise contour grid that can be exported as files that can be used in mapping programs for analyzing the noise impacts.

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SECTION 2
INSTALLATION DESCRIPTION

2.1 DESCRIPTION OF ANDREWS AIR FORCE BASE

Andrews AFB is located in the Maryland portion of the Washington D.C. Metropolitan Area. The Base is situated in northwestern Prince George's County, approximately 5 miles southeast of the Washington D.C. boundary line. The Capital Beltway (I-495) passes just west of installation, and the surrounding lands are heavily developed as part of the Washington D.C. suburban core. The Base encompasses 4,346 acres of fee-owned federal land. Andrews AFB has two parallel runways, respectively designated as Runways 01Left/19Right (01L/19R), and 01R/19L. Figure 2.1 shows the location of Andrews AFB.

Andrews AFB is responsible for two outlying communication sites: Brandywine and Davidsonville. The Brandywine site covers 1,635 acres and is located 10 miles south of the Base. The Davidsonville site, which covers over 900 acres, is approximately 20 miles northeast of the Base. The Davidsonville and Brandywine sites each have landing zones and support helicopter training operations.

2.2 MISSION

The 316th Wing -- the Base's host wing -- is responsible for maintaining emergency reaction rotary-wing airlift and other National Capital Region contingency response capabilities critical to national security and for organizing, training, equipping, and deploying combat-ready forces for Air and Space Expeditionary Forces. The Wing also provides installation security, services and airfield management to support the President, Vice President, other U.S. senior leaders and more than 50 tenant organizations and federal agencies. Flying operations are accomplished by units from the Department of Defense (Air Force, Air National Guard, Army, Navy, Marine Corps, and Defense Intelligence Agency), Department of Energy, and Maryland State Police.

2.3 ECONOMIC IMPACT

Andrews AFB is within the Washington Metropolitan Statistical Area (MSA). This MSA is extremely large and diverse, covering all of Washington D.C. and nearby parts of Virginia, Maryland, and West Virginia. The unit is formally known as the Washington-Arlington-Alexandria-DC-VA-MD-WVA MSA and is home to over five million people. The majority of this population lives in the dense suburban zones that ring the nation's capital. These suburban areas stretch south along the I-95 corridor as far as Fredericksburg, Virginia. Dense suburban development also extends west to Manassas, Virginia and northwest to Charlestown, West Virginia, and Frederick, Maryland. The northeastern suburban areas of Washington, D.C. meld with the Baltimore suburbs into a single area of medium density development. Areas to the east and southeast of Washington D.C. are somewhat less extensively developed.

These localities are characterized by a mix of older towns and suburbs, rural fringe, and recent residential development.

2.3.1 Local Economic Characteristics

Local economic characteristics within the Washington D.C. MSA are varied. Suburban areas such as Fairfax County in Virginia and Montgomery County in Maryland rank as some of the wealthiest localities in the nation in terms of household income. By contrast, some neighborhoods in Washington D.C. (the District) remain blighted with high poverty and unemployment rates. In general, the Washington D.C. MSA enjoys a robust economy and the area has experienced sustained growth over many years. The region has traditionally lacked a heavy industrial/manufacturing base; the economy has been driven by government, defense, and other service industry sectors. In recent decades, the area has attracted a large number of technology firms and these high growth industries contribute heavily to the economy of the National Capital Region.

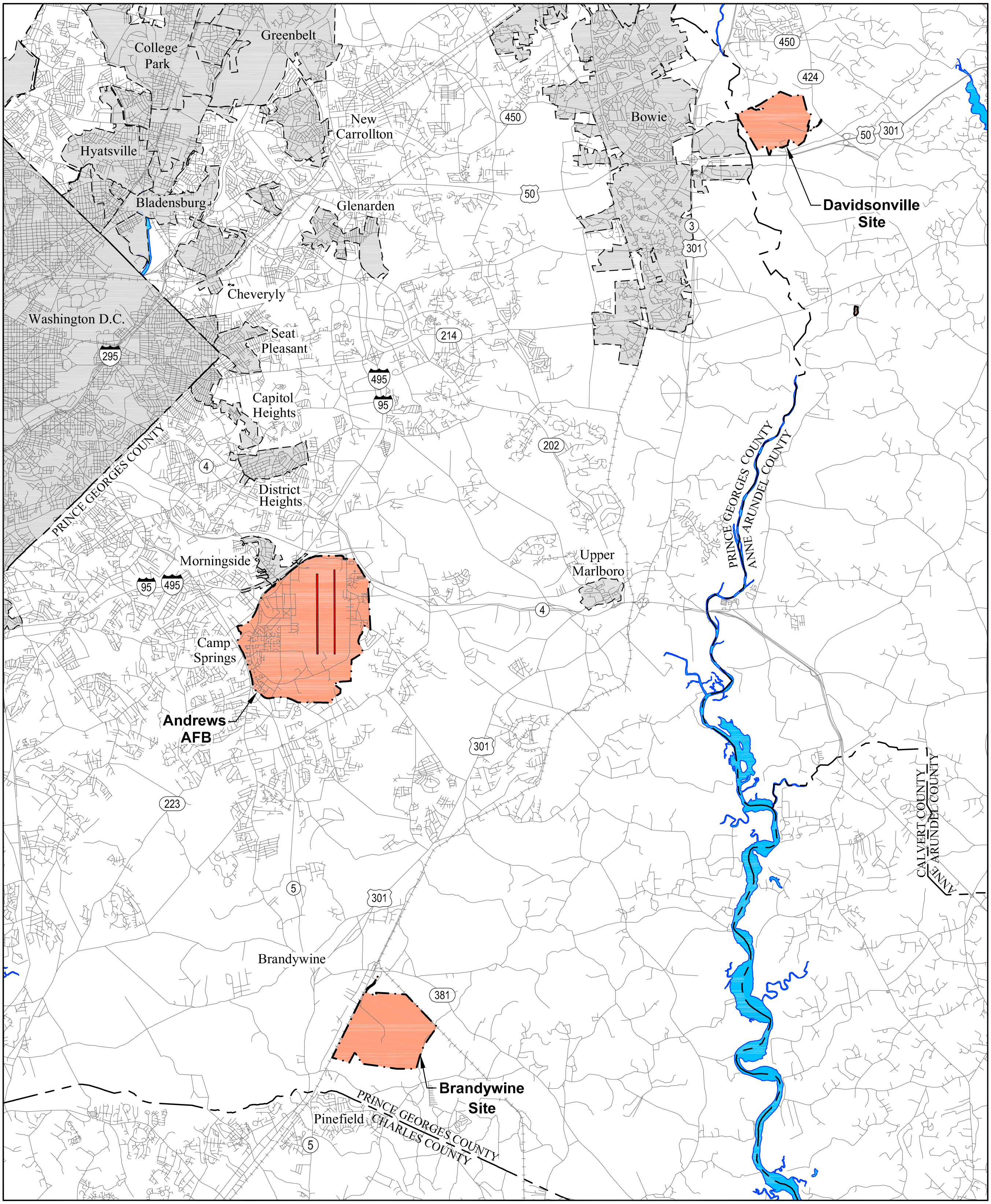
As shown in Table 2.1, the estimated 2005 population of the Washington D.C. MSA stands at over 5.4 million. The region's population increased by 14.2 percent between 1990 and 2000, and is expected to reach 5.9 million by 2010. Population growth in Prince George's County is also robust, with a 9.1 percent increase between 1990 and 2000. By contrast, population of the District decreased during the same time, and this trend is expected to continue through 2010.

Table 2.1 Historic and Projected Population

Area	1990	2000	2005	2010 projection
Prince George's County	729,268	801,515	846,123	943,100
Washington DC	606,900	572,059	550,521	529,700
Washington DC MSA	4,222,830	4,923,153	5,408,028	5,908,000

Source: U.S. Census Bureau 2000

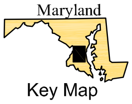
Despite being located within a major, fast growing metropolitan area, Andrews AFB has a significant overall impact on the economy of Prince George's County and surrounding areas. The median income in Prince George's County in 2003 was $53,659, just slightly below the Maryland medium household income of $54,302. The Prince George's County poverty rate in 2003 was 9.4 percent, above the Maryland mean of 8.8 percent. By contrast, the 2003 median household income for nearby Montgomery County was $76,546, with just 6.4 percent of the county population living below the poverty line. Table 2.2 lists the major civilian employment sectors in Prince George's County for 2003, the latest year in which county level economic statistics are available.



Andrews Air Force Base 2007 AICUZ

LEGEND

▨	Andrews AFB Property
—	Roadway
- - - -	City Limits
━	Runway



Key Map

Location Map

Figure 2.1

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Table 2.2 Prince George's Employment Estimates by Industry Group

Industry	Employees	Establishments
Forestry and Fishing	20-99	4
Mining	100-249	9
Utilities	500-999	7
Construction	31,734	1,536
Manufacturing	10,535	366
Wholesale Trade	20,455	699
Retail Trade	38,802	2,302
Transportation and Warehousing	8,040	353
Information	9,796	297
Real Estate Rental & Leasing	6,048	638
Professional, Scientific& Technical Services	20,546	1,058
Management of Companies and Enterprises	4,807	84
Admin Support, Waste Mgt and Remediation Enterprises	19,569	808
Educational Services	3,633	170
Accommodation & Food Services	20,546	1,058
Other Services (except administration)	15,378	1,688
Unclassified Establishments	20-99	41

Source: U.S. Economic Census

2.3.2 Base Impact

Andrews AFB directly employs 9,803 personnel. As shown in Table 2.3, the Base has a total population of 16,225 when accounting for military dependents. The annual payroll of the installation is over $508 million (Table 2.4). As a result of payroll expenditures and the estimated value of indirect jobs in the local area, Andrews AFB has an estimated total economic impact of nearly $1.0 billion on the local economy. The majority of this economic impact is due to payroll and contracts provided by the installation.

Table 2.3 Personnel by Classification

Classification	Total
Active Duty Military	5,568
Reserve and Guard	1,623
Total Military	**7,191**
Appropriated Fund Civilian Employees	937
Other Civilian Employees	1,675
Military Dependents	6,422
Total Civilian	**9,034**
Grand Total	**16,225**

Source: Andrews AFB Economic Impact Report FY06

Table 2.4 Annual Economic Impact

Category	**($)**
Payroll	
Military	331,967,786
Appropriated Fund Civilian Employees	82,203,798
Other Civilian	94,246,434
Total	**508,418,018**
Expenditures	
Base Operations and Maintenance Spending	72,906,723
Base Non-Operations and Maintenance Spending	11,257,046
Other	136,260,068
Total	**220,423,837**
Estimated Value of Indirect Jobs	**232,638,176**
Grand Total	**961,480,031**

Source: Andrews AFB Economic Impact Report FY06

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SECTION 3
AIRCRAFT OPERATIONS

3.1 INTRODUCTION

To describe the relationship between aircraft operations and land use at and around the airfield, it is necessary to fully evaluate the exact nature of flying activities. The May 2007 inventory of Andrews AFB aircraft operations included where aircraft fly, how high they fly, how many times they fly over a given area, and the time of day they operate.

Subsection 3.2 discusses aircraft operations at Andrews AFB. Subsection 3.3 discusses runway and flight track utilization for all operations by aircraft type. Subsection 3.4 describes aircraft maintenance activity, Subsection 3.5 discusses aircraft flight profiles, and Subsection 3.6 presents climatological data.

3.2 AIRCRAFT OPERATIONS

Over 141,000 annual aircraft operations occurred at Andrews AFB for the period May 2006-April 2007 based on aircraft operations data validated in May 2007. An aircraft operation is defined as one takeoff/departure, one approach/landing, or half a closed pattern. A closed pattern consists of two portions, a takeoff/departure and an approach/landing, *i.e.,* two operations. A sortie is a single military aircraft flight from the initial takeoff through the termination landing. The minimum number of aircraft operations for one sortie is two operations, one takeoff (departure) and one landing (approach).

Table 3.1 summarizes the projected average busy-day aircraft operations for the Andrews AFB airfield based on information provided by Base staff, flying organization, and air traffic control personnel. The 20 Air Force, Air National Guard, Army, Navy, Marine Corps, Defense Intelligence Agency, Department of Energy, and Maryland State Police flying units at Andrews AFB operate 16 different aircraft types such as executive transport, cargo, fighter, and helicopter. In addition to the Andrews AFB based aircraft, 54 types of transient military and civil aircraft conduct operations at the Base. The table reflects a total of about 314 average busy-day aircraft operations based on collected operations data. Approximately 8 percent of the operations occur at night (10:00 p.m.-7:00 a.m.). Helicopters from Andrews AFB's 1st Helicopter Squadron also accomplish operations at the Brandywine and Davidsonville sites. Appendix D contains information on the Brandywine and Davidsonville operations.

Although the number of military and civil aircraft operations at an installation usually varies from day to day, NOISEMAP requires input of the specific numbers of daily flight and aircraft maintenance engine runup operations. The Air Force does not follow the FAA's use of the "average annual day" in which annual operations are averaged over an entire 365-day year. Neither does the Air Force use the "worst-case day" since it typically does not represent the typical noise exposure. Instead, the Air Force uses the "average busy-day" concept in which annual operations for an aircraft type are averaged over the number of flying days per year by that aircraft type. Non-flying days (*e.g.*, weekends or holidays) are not used in computing the "average busy-day" operations. Flying by Andrews AFB flying units ranges from 104 to 260 days per year. Transient aircraft operations are based on 365 days per year.

Table 3.1 Average Busy-Day Aircraft Operations for 2007

Aircraft Type	Daily Arrival/ Departure Operations	Daily Closed Pattern Operations	Total Daily Operations
Andrews AFB Aircraft			
16 types	122.67	144.29	266.96
Transient Aircraft			
54 types	47.45	0.00	47.45
Total	**170.12**	**144.29**	**314.41**
Note: An operation is one takeoff/departure or one arrival/landing. A closed pattern consists of two operations, one takeoff and one landing.			

3.3 RUNWAY AND FLIGHT TRACK UTILIZATION

Runways 01L/19R and 01R/19L are oriented 011°–191°magnetic. Runway 01L/19R is 9,300 feet long and 200 feet wide. Runway 01R/19L is 150 feet wide and 9,755 feet long. The overruns at the ends of each runway are approximately 1,000 feet long. The airfield elevation is 280 feet above mean sea level (MSL).

Aircraft operating at Andrews AFB use the following flight patterns:

- Straight-out departure;
- Straight-in arrival;
- Overhead closed patterns both east and west of the airfield;
- Radar closed patterns to the east of the airfield; and,
- Re-entry patterns.

To reduce the affect of noise, Andrews AFB limits transient aircraft to one approach to a full stop landing. Additionally, the Base controls and schedules missions to keep noise levels low, especially at night.

Flight patterns specific to Andrews AFB result from several considerations, including:

- Takeoff patterns routed to avoid noise-sensitive areas as much as possible;
- Arrivals and departures routed to avoid restricted airspace;
- Criteria governing the speed, rate of climb, and turning radius for each type of aircraft;
- Efforts to control and schedule missions to keep noise levels low, especially at night; and

- Coordination with the FAA to minimize conflict with civil aircraft operations.

Planning for the areas surrounding an airfield considers three primary aircraft operational/land-use determinants: (1) aircraft accident potential to land users; (2) aircraft noise; and (3) hazards to operations from land uses (*e.g.*, height of structures). Each of these concerns is addressed in conjunction with mission requirements and safe aircraft operations to determine the optimum flight track for each aircraft type.

The flight tracks depicted in Figures 3.1 through 3.3 are the result of such planning and depict the representative flight tracks used for noise modeling. The flight track locations represent the various types of arrivals, departures, and closed patterns accomplished at Andrews AFB. A closed pattern includes successive takeoffs and landings or low approaches where the aircraft does not exit the tower- or radar-controlled traffic pattern. Closed patterns allow pilots to accomplish numerous landings in a short period of time to meet training and certification requirements.

The location for each track is representative for the specific track and may vary due to air traffic control, weather, and other reasons (*e.g.*, one pilot may fly the track on one side of the depicted track, while another pilot may fly the track slightly to the other side). Runway use is: Runway 01L—35 percent; Runway 19R—19 percent; Runway 01R—28 percent; and Runway 19L- 18 percent.

3.4 AIRCRAFT MAINTENANCE RUNUP OPERATIONS

To the maximum extent possible, aircraft maintenance engine runup locations have been established in areas to minimize noise for people in the surrounding communities, as well as for those on base. Aircraft maintenance engine runup operations are accomplished by based flying units and their associated maintenance functions. When possible, engine ground runups are accomplished in a hush house.

Average busy-day aircraft maintenance runup operations were calculated similarly to flight operations described in Subsection 3.1. Weekly, monthly, or annual estimates of runups provided by Andrews AFB aircraft maintenance personnel were divided by the typical number of days runups were performed over the respective period. Approximately 0.2 percent of the total aircraft maintenance runup time at Andrews AFB occurs during nighttime (10:00 p.m. to 7:00 a.m.).

3.5 AIRCRAFT FLIGHT PROFILES

For purposes of this AICUZ Study, aircraft “flight profiles” denote the aircraft power settings, altitudes above runway level, and airspeeds along each flight track. Aircraft flight profiles for based aircraft were obtained from Andrews AFB personnel. Generic flight profiles from the BASEOPS database were used to model operations for the other military and civilian aircraft types.

3.6 CLIMATOLOGICAL DATA

Weather conditions, measured by temperature and relative humidity, are an important factor in the propagation of noise. Temperature and relative humidity affect sound absorption. The average temperature and humidity for each month of the year are input into BASEOPS, which then calculates the sound absorption coefficient for each month. Ranking the twelve monthly sound absorption coefficients from smallest to largest, BASEOPS chooses the sixth smallest sound absorption coefficient to represent the typical weather conditions at the installation. The month with the sixth smallest sound absorption coefficient for Andrews AFB is the month with the average monthly temperature of 65 degrees Fahrenheit and 68 percent relative humidity.

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SECTION 4
EFFECTS OF AIRCRAFT OPERATIONS

4.1 INTRODUCTION

This section has two purposes. The first is to describe the imaginary surfaces associated with obstructions to air navigation, noise exposure, CZs, and APZs. The second purpose is to present applicable land-use compatibility guidelines and the Air Force's participation in the land-use planning process.

4.2 RUNWAY AIRSPACE IMAGINARY SURFACES

Obstructions to air navigation are considered to be:

- Natural objects or man-made structures that protrude above the planes or imaginary surfaces, and/or;
- Man-made objects that extend more than 500 feet above ground level (AGL) at the site of the structure.

4.2.1 Explanation of Terms

The following elevation, runway length, and dimensional criteria apply:

- Controlling Elevation—Whenever surfaces or planes within the obstruction criteria overlap, the controlling (or governing) elevation becomes that of the lowest surface or plane.
- Runway Length—Andrews AFB has two runways. Runways 01L/19R and 01R/19L are 9,300 and 9,755 feet long, respectively. Both runways are Class B runways that are designed and built for sustained aircraft landings and take-offs:
- Established Airfield Elevation—The established elevation for the Andrews AFB airfield is 280 feet above MSL.
- Dimensions—All dimensions are measured horizontally unless otherwise noted.

4.2.2 Runway Airspace Imaginary Surfaces

Runway airspace imaginary surfaces, in graphical form, are the result of the application of obstruction height criteria to Andrews AFB. Imaginary surfaces are surfaces in space around airfields in relation to runways. The surfaces are designed to define the obstacle-free airspace at and around the airfield. Refer to Unified Facilities Criteria (UFC) 3-260-01, *Airfield and Heliport Planning and Design,* for a more complete description of runway airspace imaginary surfaces for Class B runways. Air Force obstruction criteria in UFC 3-260-01 are based on those contained in Federal Aviation Regulation (FAR) Part 77, *Objects Affecting Navigable Airspace*, Subpart C. FAR Part 77 provides guidance on submittal of FAA Form 7460-1, *Notice of Proposed Construction or Alteration*. The form is used to notify the FAA of construction or alteration of structures proximate to imaginary surfaces around airfields.

Figure 4.1 depicts the runway airspace imaginary surfaces for the Andrews AFB Class B runways. The following paragraphs contain definitions of the runway airspace imaginary surfaces for Air Force class B runways:

- Primary Surface—An imaginary surface symmetrically centered on the runway, extending 200 feet beyond each runway end that defines the limits of the obstruction clearance requirements in the vicinity of the landing area. The width of the primary surface is 2,000 feet, or 1,000 feet on each side of the runway centerline.

- Clear Zone Surface—An obstruction-free surface (except for features essential for aircraft operations) on the ground symmetrically centered on the extended runway centerline beginning at the end of the runway and extending outward 3,000 feet. The CZ width is 3,000 feet (1,500 feet to either side of runway centerline).

- Accident Potential Zone Surfaces—APZ I begins at the outer end of the CZ and is 5,000 feet long and 3,000 feet wide. APZ II begins at the outer end of APZ I and is 7,000 feet long and 3,000 feet wide.

- Approach-Departure Clearance Surface—This imaginary surface is symmetrically centered on the extended runway centerline, beginning as an inclined plane (glide angle) 200 feet beyond each end of the primary surface, and extending for 50,000 feet. The slope of the approach-departure clearance surface is 50:1 until it reaches an elevation of 500 feet above the established airfield elevation. It then continues horizontally at this elevation to a point 50,000 feet from the starting point. The width of this surface at the runway end is 2,000 feet, flaring uniformly to a width of 16,000 feet at the end point.

- Inner Horizontal Surface—This imaginary surface is an oval plane at a height of 150 feet above the established airfield elevation. The inner boundary intersects with the approach-departure clearance surface and the transitional surface. The outer boundary is formed by scribing arcs with a radius 7,500 feet from the centerline of each runway end and interconnecting these arcs with tangents.

- Conical Surface—This is an inclined imaginary surface extending outward and upward from the outer periphery of the inner horizontal surface for a horizontal distance of 7,000 feet to a height of 500 feet above the established airfield elevation. The slope of the conical surface is 20:1. The conical surface connects the inner and outer horizontal surfaces.

- Outer Horizontal Surface—This imaginary surface is located 500 feet above the established airfield elevation and extends outward from the outer periphery of the conical surface for a horizontal distance of 30,000 feet.

- Transitional Surface—This imaginary surface extends outward and upward at right angles to the runway centerline and extended runway centerline at a slope of 7:1. The transitional surface connects the primary and the approach-departure clearance surfaces to the inner horizontal, the conical, and the outer horizontal surfaces.

4.3 RESTRICTED AND/OR PROHIBITED LAND USES

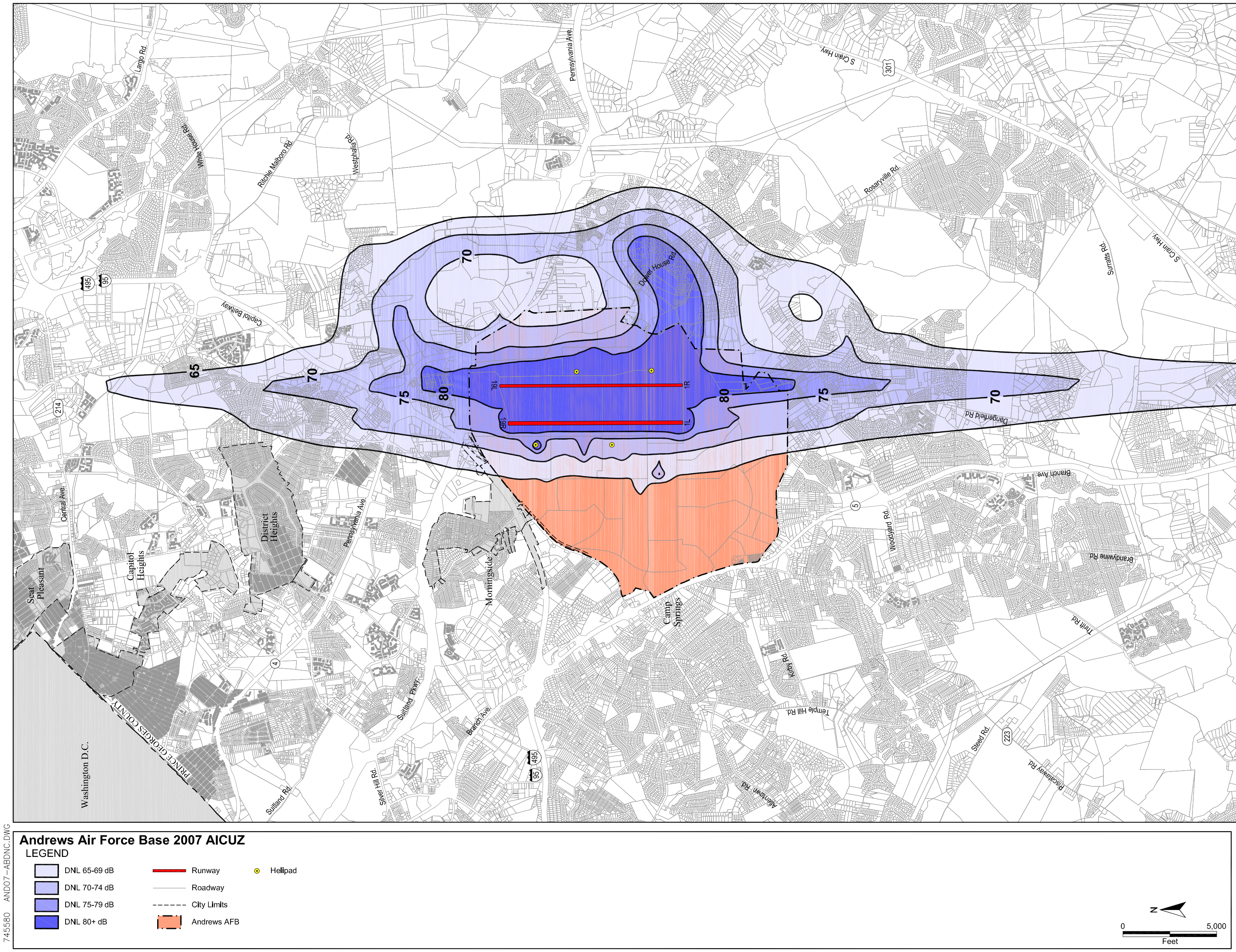
The land areas outlined by these criteria should be regulated to prevent uses that might otherwise be hazardous to aircraft operations. The following uses should be restricted and/or prohibited:

- Releases into the air of any substance that would impair visibility or otherwise interfere with the operation of aircraft (*e.g.,* steam, dust, or smoke);
- Light emissions, either direct or indirect (reflective), that would interfere with pilot vision;
- Electrical emissions that would interfere with aircraft communications systems or navigational equipment;
- Uses that would attract birds or waterfowl, including but not limited to, operation of sanitary landfills, waste transfer facilities, maintenance of feeding stations, sand and gravel dredging operations, storm water retention ponds, created wetland areas, or the growing of certain vegetation; and
- Structures within 10 feet of aircraft approach-departure and/or transitional surfaces.

4.4 NOISE EXPOSURE

NOISEMAP Version 7.296 was used to calculate and plot the DNL noise contours based on the average busy-day aircraft operations data collected in 2007 and described in Subsections 3.1 through 3.6. Figure 4.2 shows the DNL noise contours plotted in 5 dB increments, ranging from DNL 65 dB to DNL at or above 80 dB.

Different sounds have different frequency content. When describing sound and its effect on a human population, A-weighted (dB) sound levels are typically used to account for the response of the human ear. The term “A-weighted” refers to a filtering of the sound signal to emphasize frequencies in the middle of the audible spectrum and to de-emphasize low and high frequencies in a manner corresponding to the way the human ear perceives sound. This filtering network has been established by the American National Standards Institute. The A-weighted noise level has been found to correlate well with people’s judgments of the noisiness of different sounds and has been in use for many years as a measure of community noise. The noise levels presented in this AICUZ Study are A-weighted.



Average Busy-Day Noise Contours for 2007

Figure 4.2

Table 4.1 shows the off-installation noise exposure within the DNL 65 dB and greater noise exposure area for aircraft operations at Andrews AFB in terms of acreage and estimated population. DNL is the measure of the total noise environment. DNL averages the sum of all aircraft noise producing events over a 24-hour period, with a 10 dBA upward adjustment added to the nighttime events (between 10:00 p.m. and 7:00 a.m.). The population data used in preparing this estimate was obtained from the United States Census Bureau 2000 census. To estimate affected population, it was assumed that population was equally distributed within a census tract area. Using this assumption, the total acreage and population in each census tract surrounding Andrews AFB was collected and assessed. Using the noise contour information, the number of acres of land in each noise zone (*i.e.*, DNL 65-69 dB, 70-74 dB, 75-79 dB, and 80 dB and greater) was divided by the number of acres of land in each census tract to determine what portion of the census tract was contained within each noise zone. The population total in each block-group was then multiplied by this ratio to estimate population exposed to aircraft noise at and above DNL 65 dB.

Table 4.1 Area and Population within DNL 65 dB and Greater Noise Exposure Area (Off-Installation)

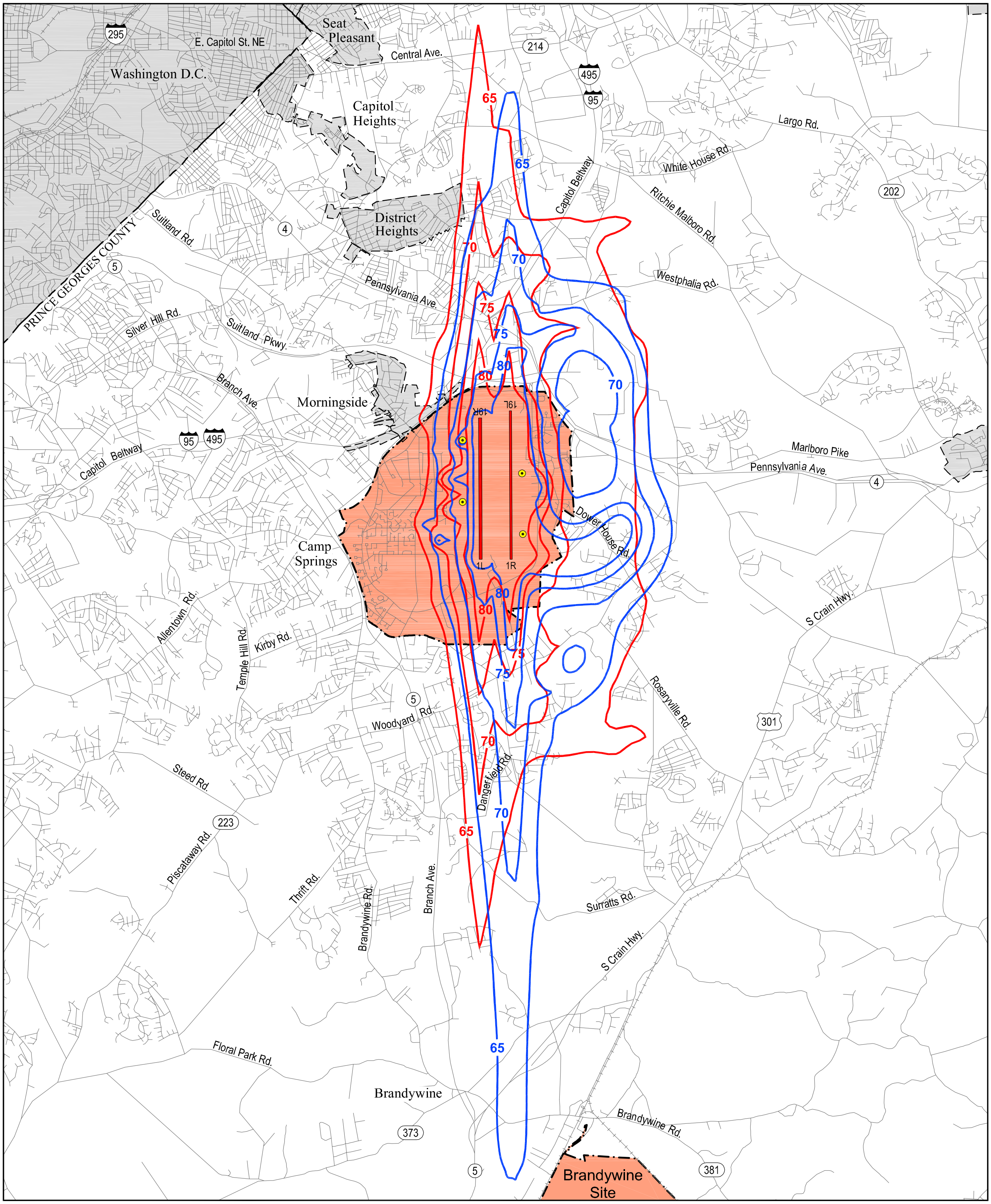
DNL Noise Zone	Acres	Population
65–69	5,008	7,462
70–74	2,187	2,431
75–79	701	789
80+	394	401
Total	**8,290**	**11,083**

From Table 4.1, a total of 8,290 acres and 11,083 persons are expected to be in the off-installation area within the DNL 65 dB and greater noise exposure area. The largest affected population is within the DNL 65–69 dB noise zone. This area is estimated to contain 5,008 acres in off-installation land area (60 percent of the total) and an estimated population of 7,462 persons (67 percent of the total) based on the calculated population densities for the area.

As mentioned in Subsection 3.2, helicopters from the 1st Helicopter Squadron accomplish operations at the Brandywine and Davidsonville sites. Appendix D contains the noise contours resulting from operations at the two locations.

4.5 COMPARISON WITH 1998 AICUZ STUDY

Noise contours presented in this study are similar in both shape and extent of coverage when compared to the noise contours in the 1998 AICUZ Study. Figure 4.3 depicts the 1998 AICUZ Study contours and Figure 4.4 compares the 2007 and 1998 contours. The off-installation exposure for this AICUZ Study is about 7 acres less than the 1998 AICUZ Study. Table 4.2 lists the total noise exposure for the four noise zones in each study. Although there are fewer off-installation acres within the DNL 65-69 dB noise zone in the 2007 AICUZ Study when compared to the 1998 Study, the number of acres within each of the



Andrews Air Force Base 2007 AICUZ

LEGEND

🟥	1998 Noise Contour	🟥	Runway
🟦	2007 Noise Contour	—	Roadway
▨	Andrews AFB	– – – – – –	City Limits
⊙	Helipad		

N

0 9,000 Feet

Comparison of 2007 and 1998 AICUZ Study Noise Contours

Figure 4.4

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other three zones is greater in the 2007 Study. Differences in the contours occur to the south where the 2007 contour extends farther and to the northeast and southeast where the 1998 contour covers more land. Additional differences occur to the northeast, east, and southeast of the installation where area that was exposed to DNL 65-69 dB in the 1998 study is exposed to DNL 70-80+ dB in the 2007 Study. The changes in the contours result from a greater number of operations being accomplished on Runway 19L/01R for 2007 when comparing the aircraft operations conditions for the 2007 and 1998 studies. The increase in operations on Runway 19L/01R causes the slight eastward "shift" of the contours when comparing 2007 and 1998. Additionally, there is a greater number of closed pattern flight tracks on the east side of the airfield under the 2007 Study, and the operations on these tracks contribute to the increased noise exposure to the northeast, east, and southeast of the installation.

Table 4.2 Total Acres within the 2007 and 1998 AICUZ Study Noise Zones (Off-Installation)

	Acres	
DNL Noise Zone	**2007 Study**	**1998 Study**
65–69	5,008	6,172
70–74	2,187	1,574
75–79	701	491
80+	394	60
Total	**8,290**	**8,297**

4.6 CLEAR ZONES AND ACCIDENT POTENTIAL ZONES

The purpose of this section is to describe the basis for CZs and APZs and apply the zones to the Andrews AFB runways.

4.6.1 Basis for Clear Zones and Accident Potential Zones

Areas around airports are exposed to the possibility of aircraft accidents even with well-maintained aircraft and highly trained aircrews. Despite stringent maintenance requirements and countless hours of training, past history makes it clear that accidents may occur.

The risk of people on the ground being killed or injured by aircraft accidents is miniscule. However, an aircraft accident is a high-consequence event and, when a crash does occur, the result is often catastrophic. Because of this, the Air Force does not attempt to base its safety standards on accident probabilities. Instead it approaches this safety issue from a land use-planning perspective. Designation of safety zones around the airfield and restriction of incompatible land uses can reduce the public's exposure to safety hazards.

The AICUZ program includes three safety zones: the CZ, APZ I, and APZ II. These zones were developed from analysis of over 800 major Air Force accidents that occurred within 10 miles of an Air Force installation between 1968 and 1995. Figure B-3 in Appendix B summarizes the location of these accidents.

The CZ has the highest accident potential of the three zones, as 27 percent of accidents studied occurred in this area. Due to the relatively high accident potential, the Air Force adopted a policy of acquiring real estate interests in the CZ through purchase or easement when feasible.

APZ I is an area that possesses somewhat less accident potential than the CZ, with 10 percent of the accidents studied occurring in this zone. APZ II has less accident potential than APZ I, with 6 percent of the accidents studied occurring in this zone. While the potential for aircraft accidents in APZs I and II does not warrant land acquisition by the Air Force, land-use planning and controls are strongly encouraged in these areas for the protection of the public.

4.6.2 Clear Zones and Accident Potential Zones

Figure 4.5 depicts the CZs and APZs for Runways 01L/19R and 01R/19L at Andrews AFB. Each end of the runways has a 3,000 foot by 3,000 foot CZ and two APZs. Accident potential on or adjacent to the runway or within the CZ is so high that the necessary land use restrictions would prohibit reasonable economic use of land. It is Air Force policy to request that Congress authorize and appropriate funds to purchase the real property interests in this area to prevent incompatible land uses.

Accident potential in zone I is less critical than the CZ, but still possesses a significant risk factor. This 3,000 foot by 5,000 foot area has land use compatibility guidelines that are sufficiently flexible to allow reasonable economic use of the land, such as industrial/manufacturing, transportation, communication/utilities, wholesale trade, open space, recreation, and agriculture. However, uses that concentrate people in small areas are not acceptable.

Accident potential zone II is less critical than APZ I, but still possesses potential for accidents. Accident potential zone II, also 3,000 feet wide, is 7,000 feet long extending to 15,000 feet from the runway threshold. Acceptable uses include those of APZ I, as well as low density single family residential and those personal and business services and commercial/retail trade uses of low intensity or scale of operation. High density functions such as multi-story buildings, places of assembly (*e.g.*, theaters, churches, schools, restaurants, *etc.*), and high density office uses are not considered appropriate.

High people densities should be limited to the maximum extent possible in APZ II. The optimum density recommended for residential usage (where it does not conflict with noise criteria) in APZ II is one dwelling per acre. For most nonresidential usage, buildings should be limited to one story and the lot coverage should not exceed 20 percent.

4.6.3 Land Use Compatibility Guidelines

Subsection 4.6.3.1 introduces the AICUZ concept and Subsection 4.6.3.2 presents the land-use compatibility guidelines applicable to Andrews AFB.

4.6.3.1 Introduction

The DoD developed the AICUZ program for military airfields. Using this program at its installations, the DoD works to protect aircraft operational capabilities and to assist local government officials in protecting and promoting the public's health, safety, and quality of life. The goal is to promote compatible land-use development around military airfields by providing information on aircraft noise exposure and accident potential.

AICUZ reports describe three basic types of constraints that affect, or result from, flight operations. The first constraint involves areas that the FAA and the DoD identified for height limitations (see Subsection 4.2).

The second constraint involves noise zones based on the DNL metric and the DoD NOISEMAP method. Using the NOISEMAP program, which is similar to FAA's INM, the Air Force produces noise contours showing the noise levels generated by aircraft operations. The AICUZ report contains noise contours plotted in 5 dB increments, ranging from DNL 65 dB to 80+ dB.

The third constraint involves CZs and APZs based on statistical analysis of past DoD aircraft accidents. DoD analysis has determined that areas immediately beyond the ends of runways and along the approach and departure flight paths have greater potential for aircraft accidents (see Figure 4.5).

4.6.3.2 Land-Use Compatibility Guidelines

Each AICUZ Study contains land-use guidelines. Table 4.3 identifies land uses and possible noise exposure and accident potential combinations for Andrews AFB. These noise guidelines are essentially the same as those published by the Federal Interagency Committee on Urban Noise in the June 1980 publication, *Guidelines for Considering Noise in Land-Use Planning and Control.* The U.S. Department of Transportation publication, *Standard Land Use Coding Manual (SLUCM),* has been used to identify and code land-use activities. The designations are a combination of criteria listed in the Legend and Notes at the end of the table. For example, Y^1 means land use and related structures are compatible without restriction at a suggested maximum density of 1-2 dwelling units per acre, possibly increased under a Planned Unit Development where lot coverage is less than 20 percent.

4.7 PARTICIPATION IN THE PLANNING PROCESS

The Air Force provides the AICUZ Study to local communities to assist them in preparing their local land use plans. This section discusses how the base participates in the community planning process. Subsection 6.3 addresses the role played by the local community in enhancing compatible land use.

Airspace obstructions, construction in the APZs, residential development, and the construction of other noise-sensitive uses near the base are of great concern to Andrews AFB. The Air Force is very interested in minimizing increases in incompatible usage and in encouraging voluntary conversion of non-compatible usage to compatible usage. Applying the categories for compatible land use described in Table 4.3, the Base evaluates the impact aircraft operations have on surrounding properties and the effect new development or changes in land use might have on Andrews AFB operational capabilities.

In addition to working with local governing entities and planning professionals, the Andrews AFB Base Public Affairs Office works to address complaints and concerns expressed by off-airfield neighbors.

Andrews AFB conducts active outreach to the community by meeting with various community groups and speaking with individuals as needed. The Andrews AFB Base Civil Engineer and Public Affairs Offices work together providing public meetings and informational workshops to disseminate information about base operations, forecasts, plans, and mitigation strategies.

Table 4.3 Land Use Compatibility Guidelines

Land Use		Accident Potential Zones			Noise Zones in DNL dB			
SLUCM No.	Name	Clear Zone	APZ I	APZ II	65-69	70-74	75-79	80+
10	**Residential**							
11	Household units							
11.11	Single units; detached	N	N	Y[1]	A[11]	B[11]	N	N
11.12	Single units; semidetached	N	N	N	A[11]	B[11]	N	N
11.13	Single units; attached row	N	N	N	A[11]	B[11]	N	N
11.21	Two units; side-by-side	N	N	N	A[11]	B[11]	N	N
11.22	Two units; one above the other	N	N	N	A[11]	B[11]	N	N
11.31	Apartments; walk up	N	N	N	A[11]	B[11]	N	N
11.32	Apartments; elevator	N	N	N	A[11]	B[11]	N	N
12	Group quarters	N	N	N	A[11]	B[11]	N	N
13	Residential hotels	N	N	N	A[11]	B[11]	N	N
14	Mobile home parks or courts	N	N	N	N	N	N	N
15	Transient lodgings	N	N	N	A[11]	B[11]	C[11]	N
16	Other residential	N	N	N[1]	A[11]	B[11]	N	N
20	**Manufacturing**							
21	Food & kindred products; manufacturing	N	N[2]	Y	Y	Y[12]	Y[13]	Y[14]
22	Textile mill products; manufacturing	N	N[2]	Y	Y	Y[12]	Y[13]	Y[14]
23	Apparel and other finished products made from fabrics, leather, and similar materials; manufacturing	N	N	N[2]	Y	Y[12]	Y[13]	Y[14]
24	Lumber and wood products (except furniture); manufacturing	N	Y[2]	Y	Y	Y[12]	Y[13]	Y[14]

Table 4.3 Land Use Compatibility Guidelines *(continued)*

Land Use		Accident Potential Zones			Noise Zones			
SLUCM No.	**Name**	**Clear Zone**	**APZ I**	**APZ II**	**65-69**	**70-74**	**75-79**	**80+**
25	Furniture and fixtures; manufacturing	N	Y[2]	Y	Y	Y[12]	Y[13]	Y[14]
26	Paper & allied products; manufacturing	N	Y[2]	Y	Y	Y[12]	Y[13]	Y[14]
27	Printing, publishing, and allied industries	N	Y[2]	Y	Y	Y[12]	Y[13]	Y[14]
28	Chemicals and allied products; manufacturing	N	N	N[2]	Y	Y[12]	Y[13]	Y[14]
29	Petroleum refining and related industries	N	N	Y	Y	Y[12]	Y[13]	Y[14]
30	**Manufacturing**							
31	Rubber and misc. plastic products, manufacturing	N	N[2]	N[2]	Y	Y[12]	Y[13]	Y[14]
32	Stone, clay and glass products manufacturing	N	N[2]	Y	Y	Y[12]	Y[13]	Y[14]
33	Primary metal industries	N	N[2]	Y	Y	Y[12]	Y[13]	Y[14]
34	Fabricated metal products; manufacturing	N	N[2]	Y	Y	Y[12]	Y[13]	Y[14]
35	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks manufacturing	N	N	N[2]	Y	A	B	N
39	Miscellaneous manufacturing	N	Y[2]	Y[2]	Y	Y[12]	Y[13]	Y[14]
40	**Transportation, Communications and Utilities**							
41	Railroad, rapid rail transit and street railroad transportation	N[3]	Y[4]	Y	Y	Y[12]	Y[13]	Y[14]
42	Motor vehicle transportation	N[3]	Y	Y	Y	Y[12]	Y[13]	Y[14]
43	Aircraft transportation	N[3]	Y[4]	Y	Y	Y[12]	Y[13]	Y[14]
44	Marine craft transportation	N[3]	Y[4]	Y	Y	Y[12]	Y[13]	Y[14]
45	Highway & street right-of-way	N[3]	Y	Y	Y	Y[12]	Y[13]	Y[14]
46	Automobile parking	N[3]	Y[4]	Y	Y	Y[12]	Y[13]	Y[14]
47	Communications	N[3]	Y[4]	Y	Y	A[15]	B[15]	N
48	Utilities	N[3]	Y[4]	Y	Y	Y	Y[12]	Y[13]
49	Other transportation communications and utilities	N[3]	Y[4]	Y	Y	A[15]	B[15]	N

Table 4.3 Land Use Compatibility Guidelines *(continued)*

Land Use		Accident Potential Zones			Noise Zones			
SLUCM No.	**Name**	**Clear Zone**	**APZ I**	**APZ II**	**65-69**	**70-74**	**75-79**	**80+**
50	**Trade**							
51	Wholesale trade	N	Y[2]	Y	Y	Y[12]	Y[13]	Y[14]
52	Retail trade-building materials, hardware and farm equipment	N	Y[2]	Y	Y	Y[12]	Y[13]	Y[14]
53	Retail trade-general merchandise	N	N[2]	Y[2]	Y	A	B	N
54	Retail trade-food	N	N[2]	Y[2]	Y	A	B	N
55	Retail trade-automotive, marine craft, aircraft and accessories	N	Y[2]	Y[2]	Y	A	B	N
56	Retail trade-apparel and accessories	N	N[2]	Y[2]	Y	A	B	N
57	Retail trade-furniture, home furnishings and equipment	N	N[2]	Y[2]	Y	A	B	N
58	Retail trade-eating and drinking establishments	N	N	N[2]	Y	A	B	N
59	Other retail trade	N	N[2]	Y[2]	Y	A	B	N
60	**Services**							
61	Finance, insurance and real estate services	N	N	Y[6]	Y	A	B	N
62	Personal services	N	N	Y[6]	Y	A	B	N
62.4	Cemeteries	N	Y[7]	Y[7]	Y	Y[12]	Y[13]	Y[14,21]
63	Business services	N	Y[8]	Y[8]	Y	A	B	N
64	Repair services	N	Y[2]	Y	Y	Y[12]	Y[13]	Y[14]
65	Professional services	N	N	Y[6]	Y	A	B	N
65.1	Hospitals, nursing homes	N	N	N	A*	B*	N	N
65.1	Other medical facilities	N	N	N	Y	A	B	N
66	Contract construction services	N	Y[6]	Y	Y	A	B	N
67	Governmental services	N	N	Y[6]	Y*	A*	B*	N
68	Educational services	N	N	N	A*	B*	N	N
69	Miscellaneous services	N	N[2]	Y[2]	Y	A	B	N

Table 4.3 Land Use Compatibility Guidelines *(continued)*

Land Use		Accident Potential Zones			Noise Zones			
SLUCM No.	**Name**	**Clear Zone**	**APZ I**	**APZ II**	**65-69**	**70-74**	**75-79**	**80+**
70	**Cultural, Entertainment and Recreational**							
71	Cultural activities (including churches)	N	N	N[2]	A*	B*	N	N
71.2	Nature exhibits	N	Y[2]	Y	Y*	N	N	N
72	Public assembly	N	N	N	Y	N	N	N
72.1	Auditoriums, concert halls	N	N	N	A	B	N	N
72.11	Outdoor music shell, amphitheaters	N	N	N	N	N	N	N
72.2	Outdoor sports arenas, spectator sports	N	N	N	Y[17]	Y[17]	N	N
73	Amusements	N	N	Y[8]	Y	Y	N	N
74	Recreational activities (including golf courses, riding stables, water recreation)	N	Y[8,9,10]	Y	Y*	A*	B*	N
75	Resorts and group camps	N	N	N	Y*	Y*	N	N
76	Parks	N	Y[8]	Y[8]	Y*	Y*	N	N
79	Other cultural, entertainment and recreation	N	Y[9]	Y[9]	Y*	Y*	N	N
80	**Resources Production and Extraction**							
81	Agriculture (except livestock)	Y[16]	Y	Y	Y[18]	Y[19]	Y[20]	Y[20,21]
81.5 to 81.7	Livestock farming and animal breeding	N	Y	Y	Y[18]	Y[19]	Y[20]	Y[20,21]
82	Agricultural related activities	N	Y[5]	Y	Y[18]	Y[19]	N	N
83	Forestry activities and related services	N[5]	Y	Y	Y[18]	Y[19]	Y[20]	Y[20,21]
84	Fishing activities and related services	N[5]	Y[5]	Y	Y	Y	Y	Y
85	Mining activities and related services	N	Y[5]	Y	Y	Y	Y	Y
89	Other resources production and extraction	N	Y[5]	Y	Y	Y	Y	Y

LEGEND

SLUCM - Standard Land Use Coding Manual, U.S. Department of Transportation.

Y - (Yes) - Land use and related structures are compatible without restriction.

N - (No) - Land use and related structures are not compatible and should be prohibited.

Y^x - (yes with restrictions) - Land use and related structures generally compatible; see notes 1-21.

N^x - (no with exceptions) - See notes 1-21.

NLR - (Noise Level Reduction) - NLR (outdoor to indoor) to be achieved through incorporation of noise attenuation measures into the design and construction of the structures (see Appendix C, section c.4).

A, B, or C - Land use and related structures generally compatible; measures to achieve NLR of A (DNL 25 dB), B (DNL 30 dB), or C (DNL 35 dB) need to be incorporated into the design and construction of structures.

A^*, B^*, and C^* - Land use generally compatible with NLR. However, measures to achieve an overall noise level reduction do not necessarily solve noise difficulties and additional evaluation is warranted. See appropriate footnotes.

***** - The designation of these uses as "compatible" in this zone reflects individual federal agency and program consideration of general cost and feasibility factors, as well as past community experiences and program objectives.

Localities, when evaluating the application of these guidelines to specific situations, may have different concerns or goals to consider.

NOTES

1. Suggested maximum density of 1-2 dwelling units per acre possibly increased under a Planned Unit Development where maximum lot coverage is less than 20 percent.
2. Within each land use category, uses exist where further definition may be needed due to the variation of densities in people and structures. Shopping malls and shopping centers are considered incompatible in any accident potential zone (CZ, APZ I, or APZ II).
3. The placing of structures, buildings, or aboveground utility lines in the clear zone is subject to severe restrictions. In a majority of the clear zones, these items are prohibited. See AFI 32-7063 and UFC 3-260-01 for specific guidance.
4. No passenger terminals and no major aboveground transmission lines in APZ I.
5. Factors to be considered: labor intensity, structural coverage, explosive characteristics, and air pollution.
6. Low-intensity office uses only. Meeting places, auditoriums, etc., are not recommended.
7. Excludes chapels.
8. Facilities must be low intensity.
9. Clubhouse not recommended.
10. Areas for gatherings of people are not recommended.

11A. Although local conditions may require residential use, it is discouraged in DNL 65-69 dB and strongly discouraged in DNL 70-74 dB. An evaluation should be conducted prior to approvals, indicating a demonstrated community need for residential use would not be met if development were prohibited in these zones, and there are no viable alternative locations.

11B. Where the community determines the residential uses must be allowed, measures to achieve outdoor to indoor NLR for DNL 65-69 dB and DNL 70-74 dB should be incorporated into building codes and considered in individual approvals.

11C. NLR criteria will not eliminate outdoor noise problems. However, building location and site planning, and design and use of berms and barriers can help mitigate outdoor exposure, particularly from near ground level sources. Measures that reduce outdoor noise should be used whenever practical in preference to measures which only protect interior spaces.

12. Measures to achieve the same NLR as required for facilities in the DNL 65-69 dB range 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.
13. Measures to achieve the same NLR as required for facilities in the DNL 70-74 dB range 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.
14. Measures to achieve the same NLR as required for facilities in the DNL 75-79 dB range 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.
15. If noise sensitive, use indicated NLR; if not, the use is compatible.
16. No buildings.
17. Land use is compatible provided special sound reinforcement systems are installed.
18. Residential buildings require the same NLR required for facilities in the DNL 65-69 dB range.
19. Residential buildings require the same NLR required for facilities in the DNL 70-74 dB range.
20. Residential buildings are not permitted.
21. Land use is not recommended. If the community decides the use is necessary, personnel should wear hearing protection devices.

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SECTION 5
LAND USE ANALYSIS

5.1 INTRODUCTION

Land use planning and control is a dynamic, rather than a static process. The specific characteristics of land use determinants will always reflect, to some degree, the changing conditions of the economic, social, and physical environment of a community, as well as changing public concern. The planning process accommodates this fluidity in which decisions are normally not based on boundary lines, but rather on more generalized area designations.

Andrews AFB was originally established in the relatively undeveloped, rural fringe of Washington D.C. Beginning in the 1960s, these areas of Prince George's County experienced significant amounts of growth and today the west side of the installation fronts the densely developed Capital Beltway corridor.

Computer technology enables Andrews AFB to more precisely display its flight tracks and noise contours for land use planning purposes. The computer technology reveals the extent of the Andrews AFB region of impact into the counties and surrounding nearby cities and towns.

For the purpose of this Study, existing and future land uses on the figures in this section are generalized into one of the following six categories:

<u>Residential</u>: This category includes all types of residential activity, such as single and multi-family residences and mobile homes, at a density greater than one dwelling unit per acre.

<u>Commercial</u>: This category includes offices, retail, restaurants, and other types of commercial establishments.

<u>Industrial</u>: This category includes manufacturing, warehousing, and other similar uses.

<u>Public/Quasi-Public</u>: This category includes publicly owned lands and/or land to which the public has access, including military reservations and training grounds, public buildings, schools, churches, cemeteries, and hospitals.

<u>Recreational</u>: This category includes land areas designated for recreational activity including parks, wilderness areas and reservations, conservation areas, and areas designated for trails, hikes, camping, etc.

<u>Open/Agricultural/Low Density</u>: This category includes undeveloped land areas, agricultural areas, grazing lands, and areas with residential activity at densities less than or equal to one dwelling unit per acre.

5.2 EXISTING LAND USE

The areas immediately surrounding Andrews AFB are all part of Prince George's County, Maryland. The local communities that fall within the AICUZ footprint are unincorporated and under county governance. In general, land use in the vicinity of Andrews AFB is characterized by a mix of commercial and residential suburban development. Areas immediately west of the installation fronting the Capital Beltway are the most heavily developed and contain several established commercial corridors. Areas immediately east of the installation typically remain semi-rural, or have only recently experienced low and medium density suburban development.

Virtually all of Prince George's County was rural when Andrews AFB was first established in 1941. Areas south and east of the installation remained fully rural until the 1960s. During the 1960s and 1970s, the Washington D.C. area experienced rapid growth. However, development in the area of Andrews AFB was limited to the adjacent Capital Beltway corridor west of the installation. Growth in the following decades increased dramatically, spreading east and south from the Capital Beltway. However, suburban growth in Prince George's County has not reached the intensity or geographic extent seen in the northern Virginia portions of the Washington D.C. area. As a result, some areas east and south of Andrews AFB retain vestiges of their former rural character. In recent years, residential development has taken hold in eastern and southern Prince George's County. This growth has been centered along Maryland Route 4, Maryland Route 5, and U.S. Route 301 corridors. Farther north, a significant amount of development has occurred along Route 50 linking the Capital Beltway with Annapolis. Development along the Route 50 corridor extends as far as the Chesapeake Bay Bridge. Areas of Eastern Shore on the far side of the Chesapeake Bay remain rural and agricultural. While most towns near Andrews AFB have been in existence since at least the turn of the 20th century, many of these older localities have been encroached upon or physically overtaken by recent suburban development. The east side of the Base is bordered by Allentown Road and Marlboro Pike, two major local commercial corridors. Named communities adjacent to the Base are Morningside and Woodyard to the north and east, and Clinton and Camp Springs to the south and west.

The Capital Beltway skirts the northwestern edge of Andrews AFB. Land use in this area is a mix of moderate density residential development and commercial establishments. The immediate northern end of the installation is bounded by Suitland Parkway and associated green space. Farther north, land use is characterized by a mix of commercial and light industrial development and individual residential communities. Much of the commercial development is oriented along Capital Beltway. Moving clockwise, land use along a broad swath northeast and east of Andrews AFB is typified by open space and agricultural land interspersed by recent, single home residential developments. Some agricultural fields are present, but large tracts of undeveloped land remain wooded. Residential land use increases south of Maryland Route 4, and the area just east-southeast of the installation is the location of established residential communities. Most of this development is in the form of single family houses. Areas fronting the southeast corners of the installation are undeveloped. Residential development borders the southern end of the Base, while a mix of medium density residential and established commercial land uses define the Branch Avenue (Maryland Route 5) corridor, which extends along the southwest and west sides of Andrews AFB.

Figure 5.1 presents the existing land uses for the area that surrounds Andrews AFB and within the DNL 65 dB and greater noise exposure area for the installation. Table 5.1 summarizes the acreage by land use category exposed to noise levels of DNL 65 dB and greater.

Table 5.1 Generalized Existing Land Use Within DNL 65 dB and Greater Noise Exposure Area (Off Installation)

Category	Acreage Within Noise Zones, Not Included in CZs and APZs				Total
	65-69	70-74	75-79	80+	
Residential	558	143	92	70	**863**
Commercial	62	21	13	0	**96**
Industrial	59	59	25	51	**194**
Public/Quasi-public	29	1	0	0	**30**
Recreation/Open/ Agricultural/Low Density	3,195	974	228	172	**4,569**
Total	**3,903**	**1,198**	**358**	**298**	

The analysis also includes land use within the Andrews AFB CZs and APZs. Inclusion of the CZs and APZs in the evaluation shows 951 acres of residential land within the Andrews AFB CZs and APZs. Table 5.2 reflects the land use (off-installation areas only) within the Andrews AFB CZs and APZs.

Table 5.2 Generalized Existing Land Use within the Andrews AFB Clear Zones and Accident Potential Zones (Off-Installation)

Category	Acreage Within CZs and APZs			Total
	CLEAR ZONE	APZ I	APZ II	
Residential	0	133	818	**951**
Commercial	9	73	32	**114**
Industrial	16	219	89	**324**
Public/Quasi-public	0	8	29	**37**
Recreation/Open/ Agricultural/Low Density	109	435	627	**1,171**
Total	**134**	**868**	**1,595**	**2,597**

5.3 CURRENT ZONING

Figure 5.2 overlays the 2007 noise contours and APZs on a map displaying the current generalized zoning in the vicinity of Andrews AFB. Prince George's County has adopted standard zoning ordinances and zoning maps to guide and control development. Local governments and planning agencies have developed a strong working relationship with

Andrews AFB in matters of development planning. The zoning classifications identified on Figure 5.2 have been generalized for AICUZ planning purposes.

Prince George's County zoning in the area of Andrews AFB generally follows existing land use patterns. An exception to this is in the area just to the northeast of the installation, which is the future site of the Westphalia planned community described in the succeeding Subsection 5.4. To accommodate this project, a 6,000-acre tract northeast of the Base has been rezoned to include mixed use, low urban, high suburban, and retail commercial categories. The project also reserves significant open space and preservation areas.

Areas immediately fronting the north end of the installation are zoned industrial. The industrial zoning continues north along the east side of the Capital Beltway up to the Maryland Route 214 Central Avenue interchange. Areas to the east of the industrial corridor are zoned in a mix of residential and open/agricultural/low density with the exception of the Westphalia tract. Areas immediately to the east and southeast of the installation are zoned industrial. Zoning farther east is mostly residential with increasing amounts of open/agricultural/low density areas at a distance from the installation. Areas south of Andrews AFB are mostly residential. Residential and commercial zoning is dominant directly west of the Base. Some industrial zoning occurs along the Capital Beltway while much of the Branch Avenue corridor is commercial.

Analysis of current zoning in the noise exposure area was performed to determine the acreage of each zoning designation within the DNL 65dB and greater noise contours. From this analysis, as with the land use analysis, the zoning designations were categorized into residential, commercial, industrial, public/quasi-public, and recreational/open/agricultural/low density. Figure 5.2 shows the results of the compilation, and Table 5.3 provides a breakdown of the generalized zoning (areas outside Andrews AFB only, outside CZs and APZs) within the DNL 65 dB and greater noise area.

Table 5.3 Generalized Zoning within DNL 65 dB and Greater Noise Exposure Area (Off-Installation outside CZs and APZs)

Category	Acreage Within Noise Zones, Not Included in CZs and APZs				Total
	65-69	**70-74**	**75-79**	**80+**	
Residential	1,935	607	169	100	**2,811**
Commercial	477	209	29	172	**887**
Industrial	488	248	129	0	**865**
Public/Quasi-public	0	0	0	0	**0**
Recreation/Open/ Agricultural/Low Density	779	86	0	0	**865**
Total	**3,697**	**1,150**	**327**	**272**	**5,428**

A similar analysis was performed to determine the acreage of each generalized zoning category within the Andrews AFB CZs and APZs and is shown on Table 5.4.

Table 5.4 Generalized Zoning within the Andrews AFB Clear Zones and Accident Potential Zones (Off-Installation)

Category	Acreage Within CZs and APZs			Total
	CLEAR ZONE	APZ I	APZ II	
Residential	0	132	1,112	**1,244**
Commercial	0	24	29	**53**
Industrial	52	559	199	**810**
Public/Quasi-public	0	0	0	**0**
Recreation/Open/ Agricultural/Low Density	0	31	57	**88**
Total	**52**	**746**	**1,397**	**2,195**

5.4 FUTURE LAND USE AND FUTURE DEVELOPMENT PROJECTS

Figure 5.3 shows long-range generalized future land use predicted for the Andrews AFB environs based on local zoning maps, comprehensive plans, and local development proposals. The following paragraphs discuss these anticipated future land use patterns.

In general, development along the southeastern quadrant of the Capital Beltway loop lags behind the other parts of the Washington D.C. metropolitan area. Medium and high density development near Andrews AFB has been limited to the area adjacent to the Capital Beltway. Areas to the west, or inside the Beltway, are characterized by older suburbs and urban fringe. Areas east and south of the installation retain some of their rural fringe character. This situation is changing and much of Prince George's County in the area of Andrews AFB is poised for growth. This growth will be spurred in part by several high profile projects. Real estate interests are also drawn to the western Prince George's County as the area contains some of the last major tracts of developable land in proximity to the Capital Beltway.

Future land use in the area of Andrews AFB is guided in the broadest sense by the Prince George's County General Plan (2002). The Plan divides the county into three basic zones. These are: 1) the Developed Tier; 2) the Developing Tier; and 3) the Rural Tier. The General Plan also defines transportation corridors and planned Metropolitan Centers, Regional Centers, and Community Centers. The Developed Tier includes all county areas inside the Capital Beltway. The Developed Tier in the area of Andrews AFB extends across the Beltway up to the installation's western limits. The Beltway delineates the Developed Tier's eastern limits north of Andrews AFB. The Developing Tier encompasses middle sections of the county while the Rural Tier occupies the eastern end of Prince George's County. Residential density in the Rural Tier outside established communities is heavily restricted by zoning in order to maintain a rural character. Zoning in the Developing Tier is variable but is structured to promote logical and sustainable development.

More specific future land use guidance is provided in the Prince George's Comprehensive Plan (Maryland-National Capital Park and Planning Commission 1994). Most of the AICUZ footprint falls within the Melwood Westphalia unit of the Plan. The Comprehensive Plan's Melwood Westphalia unit was approved in 1994 but is currently in the process of being updated. The Plan depicts future industrial categories to the north, east, and southeast of the installation. The Comprehensive Plan also calls for the significant residential land use east of the installation, including both low density and high density residential development.

Areas south of Andrews AFB can expect some increases in residential development in the coming years. This will consist mostly of infill type development between established residential communities. The areas west of the installation are fairly well built out. At present, Prince George's County has targeted the established commercial and residential districts along Branch Avenue as an area suitable for revitalization as urban fringe.

Several major development projects are planned in the vicinity of Andrews AFB and these will have a major bearing on future land use in the vicinity of the installation. The largest of these projects is Westphalia, which will front the northeast corner of Andrews AFB. This undertaking is in the final planning stages. In February 2007, the Maryland National Capital Park and Planning Commission approved the Preliminary Sector Plan and Proposed Sectional Map Amendment for the project area. The Westphalia project includes construction of up to 14,000 residential units, up to 710,000 square feet of retail space, and over four million square feet of other commercial space. The development will include a high density town center, several outlying village center nodes, and ample open space. The 6,000-acre Westphalia tract is bounded on the south by Maryland Route 4, Pennsylvania Avenue, to the east by the Capital Beltway, and to the north and east by Ritchie Marlboro Road.

Other major development projects will have some effect on development and future land use in the area of Andrews AFB. These include construction of a new U.S. Census Bureau headquarters in Suitland that will consolidate approximately 6,000 staff positions in a single location. The ongoing National Harbor project in Oxon Hill will provide nearly four million square feet of hotel, office, retail, entertainment, and residential space. Although not located immediately adjacent to Andrews AFB, the National Harbor project will likely be a catalyst for additional high density development along the southeast quadrant of the Capital Beltway from the Maryland Potomac River shore north and east toward Andrews AFB.

5.5 INCOMPATIBLE LAND USES

Table 5.4 shows land use compatibility as it applies to existing land use within the APZs and noise contours DNL 65dB and greater for Andrews AFB. For a land use area to be considered compatible, it must meet both noise and accident potential criteria shown in Table 4.3. The compatibility guidelines shown in Table 4.3 were combined with the existing land use plan shown in Figure 5.1 to determine land use incompatibility associated with aircraft operations at Andrews AFB. Results of this analysis are depicted numerically in Table 5.5 and illustrated in Figure 5.4.

Table 5.5 Incompatible Land Use for Runways 19Left/01Right and 19Right/01Left at Andrews AFB

Category	Acreage Within CZs and APZs			Acreage Within Noise Zones, Not Included in CZs and APZs				Total
	CLEAR ZONE	APZ I	APZ II	65-69	70-74	75-79	80+	
Residential	•	128	•	565	140	97	71	**1,001**
Commercial	9	78	•	•	•	•	•	**87**
Industrial	16	•	•	•	•	•	•	**16**
Public/Quasi-public	•	8	30	•	1	•	•	**39**
Recreation/Open/ Agricultural/Low Density	•	•	•	•	•	•	•	**0**
Total	**25**	**214**	**30**	**565**	**141**	**97**	**71**	**1,143**

** Represents compatible land use*

As mentioned in Subsection 3.2, helicopters from the 1st Helicopter Squadron accomplish operations at the Brandywine and Davidsonville sites. Appendix D discusses land use incompatibility at the two locations.

5.5.1 Runways 19L and 19R Clear Zones and Accident Potential Zones

5.5.1.1 Runways 19L and 19R Clear Zone (North of the Airfield)

Any land uses other than vacant are incompatible with the safety criteria established for a CZ. The majority of the Runway 19 CZ is located within the Andrews AFB boundary. The Runway 19 CZ contains rights-of-way for Interstate 95 and Suitland Parkway. The actual roadways represent an incompatible land use. The northern portion of the CZ contains incompatible industrial development and a small portion of commercial land use exists in the extreme northeast corner of the CZ. A commercial parking lot is also incompatibly located in the west end of the Runway 19 CZ, just north of the base boundary.

5.5.1.2 Runways 19L and 19R Accident Potential Zone I (North of the Airfield)

In general, industrial, recreational, vacant, and agricultural/open land uses are compatible with the safety criteria established for APZ I. Compatibility of commercial uses within APZ I is dependent on densities and intensity of uses. Incompatible uses located in the Runway 19 APZ I are primarily located in the northwest corner of APZ I and include residential, commercial, and a public/quasi-public parcel.

5.5.1.3 Runways 19L and 19R Accident Potential Zone II (North of the Airfield)

Most categories of land use are compatible with the safety criteria established for APZ II with the exception of public/quasi-public and some densities of residential. These land uses generally would be incompatible if residential densities are greater than two dwelling units per acre. Significant areas of residential development that exceed the density recommendations exist within the Runway 19 APZ II. Additionally, several incompatible public/quasi-public activities exist within APZ II including churches, pre-schools, and the North Forestville Elementary School.

5.5.2 Runways 01R and 01L Clear Zones and Accident Potential Zones

5.5.2.1 Runways 01R and 01L Clear Zone (South of the Airfield)

All land within the CZ is located within the Andrews AFB boundary.

5.5.2.2 Runways 01R and 01L Accident Potential Zone I (South of the Airfield)

In general, industrial, recreational, vacant, and agricultural/open land uses are compatible with the safety criteria established for APZ I. Compatibility of commercial uses within APZ I is dependent on densities and intensity of uses. A small amount of incompatible residential development exists within APZ I. A restaurant and convenience store, incompatible commercial uses, are located at the intersection of Alexandria Ferry and Woodyard Roads. An incompatible public/quasi-public activity, the Tanglewood Regional Center, is located at the southern end of APZ I.

5.5.2.3 Runways 01R and 01L Accident Potential Zone II (South of the Airfield)

Most categories of land use are compatible with the safety criteria established for APZ II with the exception of public/quasi-public and some densities of residential. The predominant incompatible land use within APZ II are residential areas that have densities greater than two dwelling units per acre.

5.6 NOISE ZONES

At noise levels between DNL 65-69 dB, the only incompatible land use type is residential without noise level reduction (NLR) materials. Residential uses within the DNL 65-69 dB noise zone would be conditionally compatible upon incorporation of the appropriate amount of NLR. Based on the land use compatibility guidelines detailed in Table 4.3, residential use within the DNL 65-74 dB zone is discouraged unless there is a demonstrated community need and no viable alternate locations. The majority of the residential areas surrounding Andrews AFB appears to have been built prior to the implementation of sound attenuation and energy insulation requirements. Significant areas of incompatible residential areas exist within the DNL 65-74 dB to the north and south of the Base, with smaller areas of incompatibility to the east. A few residences along Colonial Lane, directly south of the Base, are located within the DNL 80+ dB zone. A small amount of public/quasi-public activities are located to the south of the airfield within the DNL 70-74 dB zone. Commercial activities are incompatibly located within the DNL 80+ dB zone, adjacent to Old Marlboro Pike Road, directly north of the airfield.

5.7 AIR INSTALLATION COMPATIBLE USE ZONE STUDY UPDATES

AICUZ noise contours describe the noise characteristics of a specific operational environment, and as such, will change if a significant operational change is made. An AICUZ Study should be evaluated for an update if the noise exposure map changes by DNL 2 dB or more in noise sensitive areas when compared to the noise contour map in the last publicly released AICUZ Study. With this in mind, this AICUZ Study updates the 1998 AICUZ Study and provides flight track, accident potential zone and noise zone information in this report, which reflects the most accurate picture of the installation's aircraft activities as of May 2007.

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SECTION 6
IMPLEMENTATION

6.1 INTRODUCTION

Implementation of the AICUZ Study must be a joint effort between the Air Force and adjacent communities. The role of the Air Force is to minimize impact on the local communities by Andrews AFB aircraft operations. The role of the communities is to ensure that development in the surrounding area is compatible with accepted planning and development principles and practices.

6.2 AIR FORCE RESPONSIBILITIES

In general, the Air Force perceives its AICUZ responsibilities as encompassing the areas of flying safety, noise abatement, and participation in the land use planning process.

Well-maintained aircraft and well-trained aircrews do a great deal to ensure that aircraft accidents are avoided. Despite the best aircrew training and aircraft maintenance intentions, however, history clearly shows that accidents do occur. It is imperative flights be routed over sparsely populated areas as regularly as possible to reduce the exposure of lives and property to a potential accident.

Commanders are required by Air Force policy to periodically review existing traffic patterns, instrument approaches, weather minima, and operating practices, and evaluate these factors in relationship to populated areas and other local situations. This requirement is a direct result and expression of Air Force policy that all AICUZ plans must include an analysis of flying and flying-related activities designed to reduce and control the effects of such operations on surrounding land areas. Noise is generated from aircraft both in the air and on the ground. In an effort to reduce the noise effects of Andrews AFB operations on surrounding communities, the installation routes flight tracks to avoid populated areas.

Preparation and presentation of this Andrews AFB AICUZ Study is one phase of continuing Air Force participation in the local planning process. It is recognized that as the local community updates its land use plans, the Air Force must be ready to provide additional input when needed.

It is also recognized that the AICUZ program is an ongoing activity even after compatible development plans are adopted and implemented. Andrews AFB personnel are prepared to participate in the continuing discussion of zoning and other land use matters as they may affect, or may be affected by the Base. Base personnel also are available to provide information, criteria, and guidelines to state, regional, and local planning bodies, civic associations, and similar groups.

Participation in land-use planning can take many forms. The simplest of these forms is straightforward, consistent two-way discussion and information sharing with both professionals and neighbors. Copies of the AICUZ Study, including maps, will be provided to regional planning departments and zoning administrators. Through this communication process, the Base reviews applications for development or changed use of properties within the noise impact and safety areas, as well as other nearby parcels. The Base coordinates closely with surrounding communities and counties on zoning and land-use issues.

6.3 LOCAL COMMUNITY RESPONSIBILITIES

Residents in the area neighboring Andrews AFB and Base personnel have a long history of working together for mutual benefit of the area around the airfield. Local jurisdictions have taken a proactive approach in incorporating land use regulations into local plans and ordinances, which consider the Andrews AFB flying operations when considering development proposals. Adoption of the following recommendations will strengthen this relationship, increase the health and safety of the public, and help protect the integrity of the installation's flying mission:

- Incorporate AICUZ policies and guidelines into the comprehensive plans of Prince George's County. Use overlay maps of the AICUZ noise contours and Air Force Land Use Compatibility Guidelines to evaluate existing and future land use proposals.
- Modify existing zoning ordinances and subdivision regulations to support the compatible land uses outlined in this study through implementation of a zoning overlay district based on noise contours and accident potential zones.
- Real Estate disclosure of noise impact to all prospective property buyers of properties exposed to noise levels greater than DNL 65 dB.
- Implement height and obstruction ordinances to reflect current Air Force and FAR Part 77 requirements.
- Modify building codes to ensure new construction within the AICUZ area of influence has the recommended noise level reductions incorporated into design and construction codes.
- Consider use of the transfer of development rights program. This program allows the owner of AICUZ impacted property to transfer the development rights to another organization or agency in exchange for compensation such as real estate, or the right to develop other property that does not have AICUZ compatibility issues.
- Support the Joint Land Use Study Program for the Andrews AFB area to protect the area from encroachment.

Continue to inform Andrews AFB of planning and zoning actions that have the potential of affecting base operations. Develop a working group representing city planners, county planners, and base planners to meet at least quarterly to discuss AICUZ concerns and major development proposals that could affect airfield operations.

SECTION 7
REFERENCES

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Annex B. The 811 Operations Group Noise Abatement

The 811 Operations Group (OG) Standard Operating Procedure supplements Air Force and FAA flying regulations to accommodate local flying area requirements. These documents provide 811 OG aircrews the guidance to fly neighborly within the NCR. This includes proactive measures to mitigate the impact of flight operations along with the ability to react to noise sensitive issues highlighted to the unit.

BULLET BACKGROUND PAPER

ON

811 OPERATIONS GROUP NOISE ABATEMENT

PURPOSE

Overview of the Air Force Instructions, unit Operating Instructions, unit policies, and procedures in place for the 811 Operations Group to "fly neighborly" within the National Capital Region.

AIR FORCE INSTRUCTIONS

- AFI 11-202V3 AFDW SUP (23 Dec 15) *General Flight Rules*

-- 6.2.3.2. Non-congested Areas
-- Operate at an altitude of 500 ft. AGL
-- Helicopter Specific: Helicopters in FAA airspace may operate at lower altitudes
-- Exceptions: Over open water, Special Use Airspace (SUA), sparsely populated areas
-- Ref: Attachment 1, pages 47

-- 6.2.3.3. Congested Areas
-- Operate at an altitude at least 1,000 ft. above the highest obstacle within a 2,000-ft radius
-- Examples: groups of people, cities, towns, settlements
-- Helicopter Specific: Helicopters in FAA airspace may operate at lower altitudes
-- Ref: Attachment 1, page 48

-- 6.2.3.4. Flight over National Recreation Areas and Wildlife Refuges
-- Operate no less than 2,000 ft. AGL (mission permitting)
-- Examples: NPS monuments, seashores, lake shores, recreation and scenic riverways, USFWS refuges, USFS wilderness and primitive areas
-- Exceptions: SUA, Low-altitude tactical navigation areas (LATN), Military Training Routes (MTR)
-- Ref: Attachment 1, 48

- AFI 11-2UH-1NV3 (19 Apr 12) *UH-1N Helicopter Operations Procedures*

-- 2.22. General
-- Operate at or above 300 feet AGL unless otherwise required
-- Exceptions: Takeoff, departure, arrival, landing, operational missions, training flights in approved areas, approved exercise missions, or when directed by FAA/NACO Helicopter Route Chart
-- Ref: Attachment 2, 18

Maj Nep/811 OG/OGV/612-5808/jsn/10 Jul 17

-- 2.23. Low-level
  -- Flight below 300 feet AGL, no lower than 50 feet AHO
  -- 1 HS OI 11-03 restricts low-level flight to no lower than 100 feet AHO within the LATN
  -- 811 OG does not conduct Night Vision Goggle (NVG) low-level operations within the AFDW LATN
  -- Exceptions: Lower altitudes when required by the Baltimore-Washington Helicopter Route Chart
  -- Ref: Attachment 2, page 18; Attachment 6, 4.25.2

-- 6.5.1. Units maintain a master chart depicting the low-level flight area
  -- Chart displays: man-made obstacles over 50 feet AGL, low-level routes, no-fly areas, exotic animal farms, other hazards
  -- Updated immediately for local no-fly areas when directed by unit leadership
  --Ref: Attachment 2, page 36

- AFI 11-2UH-1NV3 AFDW SUP (IC 17 Feb 15) *UH-1N Helicopter Operations Procedures*

-- 6.4.1.1. (Added) AFDW LATN area has defined boundaries
  -- Ref: Attachment 3, page 10

-- 6.5.1.2 (Added) LATN Procedures/Restrictions
  -- Overflight frequency restricted within LATN
  -- Low-level within Washington DC Flight Restricted Zone (FRZ) prohibited
  -- Exceptions: Baltimore-Washington Helicopter Route Chart
  -- Ref: Attachment 3, page 10

- AFI 13-217 AFDW SUP (18 Apr 14) *Drop Zone and Landing Operations*

-- 3.15. Helicopter Landing Zone (HLZ) surveys required for all training and exercises
  -- Primary purpose is safety
  -- Ref: Attachment 4, page 55

-- 3.18. (AFDW) Helicopter Landing Zone Survey Requirements
  -- Approved AF Form 4303 (Helicopter Landing Zone Survey) required for all helicopter landing zones used for training
  -- Ref: Attachment 4, page 56

-- 3.18.1. HLZ Survey requires a physical inspection of the HLZ, an AF 4303 Helicopter Landing Zone Survey, a safety-of-flight review, and final approval
  -- Ref: Attachment 4, page 56

-- 3.18.1.2. Listing of required elements of the HLZ
  -- Required elements: prohibited areas, noise sensitive areas, special use airspace, route of flight to avoid such areas, preferred routing, NOTAM requirements, etc.
  -- Example: Attachment 5
  -- Ref: Attachment 4, page 57; Attachment 5

-- 3.18.1.2. (AFDW) Portable Flight Planning Software (PFPS)
  -- PFPS authorized for AFDW units
  -- Printed or displayed on the iPad Electronic Flight Bag (EFB) for in-flight use
  -- Ref: Attachment 4, page 57

-- 3.19.1. (AFDW) Initial surveys conducted by an instructor pilot or instructor flight engineer
  -- Ref: Attachment 4, page 58

-- 3.20. Helicopter Landing Zone Survey Updates
  -- HLZ surveys updated every six months
    -- Requires a qualified rotary wing aircrew member
    -- AFDW requires a Contingency (local mission) certified aircrew member
  -- Outside of six months, HLZ closed until resurveyed
    -- Requires a qualified rotary wing aircrew member
    -- AFDW requires Contingency (local mission) certified aircrew member
  -- Outside of 12 months, HLZ is expired and requires a new AF Form 4303
    -- AFDW requires an instructor pilot or instructor flight engineer
  -- Ref: Attachment 4, page 58-59

LOCAL INSTRUCTIONS

- (FOUO) 1 HS OI 11-03 (1 Feb 16) *Aircrew Procedures*

-- 4.22. Fly Neighborly
  -- Establishes the noise abatement policies with respect to the local low-level areas (AFDW LATN) and the routes and zones
    -- LATN: Climb to 300 feet AGL for excessively populated areas
    -- Washington DC Helicopter Chart: Fly at or close to the highest allowable altitude
    -- Do not circle around landing zones
    -- Directs aircrew to reference noise sensitive area maps in the unit Flight Planning Area
  -- Ref: Attachment 6, 4.22

-- 4.25.2. Low-Level Flying Procedures
  -- Restricts unit to low-level flight to no lower than 100 feet AHO within the LATN
  -- Ref: Attachment 6, 4.25.2

IMMEDIATE INSTRUCTIONS

- 811 OG Semi-Annual Flight Crew Bulletin (FCB) (28 Feb 17)

  -- 4.2. Noise Abatement Procedures
    -- Acknowledges the impact of rotary wing operations within the NCR
    -- Updated on a semi-annual basis from unit Operations Notes
    -- Information awaiting incorporation into unit Operating Instructions and Supplements
    -- Directs specific restrictions for the following areas:
      -- Airspace between Dulles and Manassas airports
      -- Housing in the vicinity of Davidsonville remote site (near Davidsonville, MD)
      -- Paris, Virginia
      -- College Park Airport (KCGS)
      -- Construction areas near Brandywine Landing Zone (near Brandywine, MD)
    -- Ref: Attachment 7, page 6-7

  -- Flight Crew Information File (FCIF): Operations Notes
    -- Immediate, published guidance from unit or organizational leadership
      -- May originate from Squadron or Group
    -- Aircrew must initial receipt of guidance
    -- Utilized to direct noise abatement procedures for 811 OG
      -- e.g. Immediate creation of local no-fly area
    -- Ref: Attachment 8-10
    OG-17-01C Noise Abatement and Pattern Ops at KDAA (21 Jun 17), Ops Note 17-12 Noise Abatement for KDAA and KCGS (30 Mar 17), Ops Note 17-18 KCGS Noise Abatement Ops (9 May 17)

FLIGHT PLANNING

- Portable Flight Planning Software (PFPS)
  -- Computer program utilized to plan flight routes
  -- Displays local no-fly areas within the AFDW LATN
  -- Generates charts (paper and electronic) utilized during flight operations

- 1 HS Flight Planning SharePoint Site Links/Posted Information
  -- Wolftrap Concerts
  -- Washington Nationals' Baseball Team Schedule

CONCLUSION

The regulations, instructions, policy, and procedures outlined above provide 811 OG aircrew the guidance to fly neighborly within the NCR. This includes proactive measures to mitigate the impact of flight operations along with the ability to react to noise sensitive issues highlighted to the unit. While not a perfect process to ensure complete noise abatement, these measures provide a comprehensive methodology to conduct flight operations within the NCR.

Chapter 6

ENROUTE

6.1. Airspace Clearance Authority.

6.1.1. **Uncontrolled Airspace.** The PIC is the clearance authority for IFR or VFR flight in uncontrolled airspace (T-0).

6.1.2. **Controlled Airspace.**

6.1.2.1. **VFR.** The PIC is the clearance authority for VFR flight (if allowed) in controlled airspace (T-0). If cancelling an IFR clearance, VFR flight following is not required if already in contact with the destination's control tower.

6.1.2.2. **IFR.** Pilots shall obtain ATC clearance before an IFR departure (or as soon as practicable after departure while maintaining VMC) or before entering controlled airspace (T-0).

6.2. Minimum Aircraft Altitude.

6.2.1. **VFR.** In the NAS, fly appropriate VFR hemispheric altitudes when higher than 3,000 ft. above ground level (AGL), unless authorized by ATC (T-0). Do not apply these altitudes when turning or holding in a holding pattern of 2 minutes or less. Outside the NAS, fly altitudes or flight levels as specified in FLIP (T-0).

6.2.2. **IFR.** Except when necessary for takeoff, landing, or when being vectored by ATC, do not fly lower than:

6.2.2.1. On Airways, no lower than any published minimum for the airway (T-0).

6.2.2.2. Off Airways, no lower than:

6.2.2.2.1. The Off Route Obstacle Clearance Altitude (OROCA) (T-0);

6.2.2.2.2. The Off Route Terrain Clearance Altitude (ORTCA) (T-0); or,

6.2.2.2.3. An altitude that provides at least 1,000 ft. of clearance above all obstacles within 4 NMs of the course to be flown in non-mountainous terrain, or 2,000 ft. in mountainous terrain (T-0).

6.2.3. **Other Minimum Altitudes.** Except for MAJCOM-approved aerial demonstrations/events or during takeoff or landing, do not operate aircraft below an altitude that, should an emergency landing become necessary, creates undue hazard to persons or property.

6.2.3.1. **Military Routes and Special Use Airspace.** Adhere to minimum altitudes published in FLIP AP for all military routes and special use airspace (e.g., military operations area (MOAs), slow speed training routes (SR), IFR military training routes (IR), VFR military training routes (VR), controlled firing areas, restricted airspace) (T-0).

6.2.3.2. **Non-congested Areas.** Operate over non-congested areas at an altitude at or above 500 ft. AGL except over open water, in special use airspace (SUA), or in sparsely populated areas (T-0). Under such exceptions, do not operate aircraft closer than 500 ft. to any person, vessel, vehicle, or structure (T-0). Helicopters in FAA airspace or operating IAW host-nation agreements may operate at lower altitudes and in closer proximity if they do not create a hazard to persons or property on the surface.

6.2.3.3. **Congested Areas.** Operate over congested areas (e.g., cities, towns, settlements) or groups of people at an altitude which ensures at least 1,000 ft. above the highest obstacle within a 2,000-ft. radius (T-0). Helicopters in FAA airspace or operating IAW host-nation agreements may operate at lower altitudes and in closer proximity if they do not create a hazard to persons or property on the surface.

6.2.3.4. **Flight over National Recreation Areas and Wildlife Refuges.** Operate no less than 2,000 ft. AGL (mission permitting) over: National Park Service monuments, seashores, lake shores, recreation and scenic riverways; US Fish and Wildlife Service refuges; and US Forest Service wilderness and primitive areas (T-0). This paragraph is not applicable to SUA, low-altitude tactical navigation areas and MTRs. Specific areas may require higher altitudes (see FLIP and sectional aeronautical charts).

6.2.3.5. **Disaster Areas.** Do not operate within a designated disaster area unless the aircraft is: assisting efforts, specifically cleared by ATC, or flying to or from an airport in the area without hampering or endangering relief activities (T-0). Check NOTAMs for disaster areas.

6.3. Aircraft Speed.

6.3.1. **Supersonic Flight.** Do not operate aircraft at or above Mach 1 except as specified in AFI 13-201. See same guidance if inadvertent flight occurs above Mach 1.

6.3.2. **In the NAS**:

6.3.2.1. Do not exceed 200 knots indicated airspeed (KIAS) at or below 2,500 ft. AGL within 4 NM of the primary airport in Class C or Class D airspace unless authorized by ATC or required to maintain the minimum operating airspeed specified in the aircraft T.O. (T-0).

6.3.2.2. Do not exceed 200 KIAS in the airspace underlying Class B airspace or in a VFR corridor designated through Class B airspace unless required to maintain the minimum operating airspeed specified in the aircraft T.O. (T-0).

6.3.2.3. Do not exceed 250 KIAS below 10,000 ft. MSL (T-0). MAJCOMs may approve operations exceeding 250 KIAS below 10,000 ft. MSL:

6.3.2.3.1. Within restricted areas or MOAs.

6.3.2.3.2. Within DoD/FAA mutually developed instrument routes or DoD developed visual routes. (Do not exceed 250 KIAS on slow speed training routes (SR)).

6.3.2.3.3. Within unpublished DoD- and FAA-designated areas or routes. This provision is intended to accommodate speed requirements, as necessary to accomplish the national defense mission, on an interim basis until the area/route can be published.

6.3.2.3.4. During large-scale exercises or short-term special missions with appropriate coordination to ensure awareness of the nonparticipating flying public.

the helicopter's airworthiness or encounters hazardous weather conditions, they should execute a precautionary landing, provided the landing conditions are not more hazardous than the in-flight problem. Aircraft security and accessibility for maintenance are secondary considerations to aircrew safety. Report all precautionary landings through appropriate channels as soon as communications are established.

2.21.1. Forced or Precautionary Landings due to In-flight Malfunction.

2.21.1.1. Aircraft malfunctions must be investigated, corrected, and inspected by qualified maintenance personnel. Coordinate maintenance support via radio, telephone, or any other means available. The group commander or designated representative (cannot be delegated below unit Director of Operations [DO]) approval is required prior to further flight when the precautionary landing occurs at a location where qualified maintenance is not available.

2.21.1.2. In the event a forced or precautionary landing occurs at a location where communications are not available, and the AC determines the aircraft is safe for flight the AC may authorize further flight. The decision to resume flight under these circumstances must be based on a thorough evaluation of all the hazards and risks involved.

2.21.2. Precautionary Landings Due to Weather.

2.21.2.1. If deteriorating weather is encountered during VFR operations, consider a precautionary landing a viable option in addition to course reversal, course deviation, or continuing under IFR.

2.21.2.2. The AC may authorize further flight after a precautionary landing for weather. Make a reasonable effort to notify appropriate agencies of the precautionary landing and to determine additional weather information.

Section 2I—Altitude Restrictions

2.22. General. Conduct all operations at or above 300 feet AGL except when lower altitudes are required for takeoff, departure, arrival, landing, operational missions, training flights in approved areas, approved exercise missions, or when directed lower by a FAA/NACO Helicopter Route Chart.

2.22.1. Minimum en route altitude for unaided night is 500 feet Above Highest Obstacle (AHO) within 5 NM of the flight path unless directed lower by a FAA/NACO Helicopter Route Chart.

2.23. Low-level. Flight below 300 feet AGL is considered low-level.

2.23.1. Daytime, low-level flights may be conducted no lower than 50 feet AHO along the route of flight.

2.23.2. NVG enroute operations in a surveyed low-level area, or on a FAA/NACO Helicopter Route Chart, may be conducted no lower than 50 feet AHO when 20 percent Effective Moon Illumination (EMI) or greater exists. Operations are limited to 150 feet AHO when less than 20 percent EMI exists. To increase situational awareness, an operable GPS receiver should be available for NVG flight below 300 feet AGL.

and operational areas may be designated as low-level flight areas. The area/route will have defined boundaries and meet the following requirements prior to any low-level flight:

6.4.1. Established low-level surveyed routes or Low Altitude Tactical Navigation (LATN) areas. MAJCOMs will establish guidance IAW AFI 13-201, *Air Force Airspace Management*. ***NOTE:*** Missile Wing missile complexes are not considered LATNs; however, low-level flight is authorized in order to accomplish assigned missions/training.

6.4.2. Helicopter low-level flight areas will be surveyed annually. Verify all man-made obstacles above 50 feet AGL (or commensurate with the lowest altitude flown within the area) and document all new man-made obstacles on the master chart and flight charts. Annotate the survey date on the master chart.

6.4.3. If low-level helicopter flight operations have not been conducted in a designated area for greater than six months, a resurvey will be accomplished before any low-level flights are conducted in the area.

6.5. Charts:

6.5.1. A master chart depicting the low-level flight areas will be maintained for flight planning purposes. Annotate all man-made obstacles over 50 feet AGL (or commensurate with the lowest altitude flown). Additionally, annotate any published low-level routes, no-fly areas, exotic animal farms, or other hazards within the boundaries. Master charts will be updated monthly using the Chart Update Manual (CHUM) supplement. The date of the CHUM update will be annotated on the master chart. Crewmembers should continuously scan for uncharted obstacles. When uncharted obstacles are found, temporarily suspend training and record appropriate information on to the aircrew chart (location and approximate height AGL). ACs will ensure this information is immediately passed to appropriate supervisors upon landing.

6.5.2. Charts used for flying will reflect the same information as the master chart. Crewmembers will ensure the chart is updated and annotated using the latest CHUM. ACs will ensure a copy of the planned route is available at the unit.

6.6. Route Planning. Aircrews will review and deconflict low altitude charts for IFR, VFR, and slow speed low altitude (IR, VR, and SR) training routes and annotate potential conflict areas along the proposed routes during pre-mission planning.

6.7. Evasive Maneuvering. Evasive Maneuver Training. Maintain 100 feet obstacle clearance during evasive maneuvers. If a break call is made below 100 feet, the pilot flying must climb above 100 feet before initiating any evasive turns. Pilots will make crew advisory calls prior to turns and will clear their flight path throughout maneuvering. If hovering, this does not preclude turning the tail of the helicopter to mitigate the threat or minor heading changes during takeoff.

Section 6C—Formation Procedures

6.8. Formation Types/Maneuvers. A description of formation types and maneuvers is listed in AFTTP 3-3.H-1.

6.8.1. Safety Considerations:

and operational areas may be designated as low-level flight areas. The area/route will have defined boundaries and meet the following requirements prior to any low-level flight:

6.4.1. Established low-level surveyed routes or Low Altitude Tactical Navigation (LATN) areas. MAJCOMs will establish guidance IAW AFI 13-201, *Air Force Airspace Management*. ***NOTE:*** Missile Wing missile complexes are not considered LATNs; however, low-level flight is authorized in order to accomplish assigned missions/training.

6.4.2. Helicopter low-level flight areas will be surveyed annually. Verify all man-made obstacles above 50 feet AGL (or commensurate with the lowest altitude flown within the area) and document all new man-made obstacles on the master chart and flight charts. Annotate the survey date on the master chart.

6.4.3. If low-level helicopter flight operations have not been conducted in a designated area for greater than six months, a resurvey will be accomplished before any low-level flights are conducted in the area.

6.5. Charts:

6.5.1. A master chart depicting the low-level flight areas will be maintained for flight planning purposes. Annotate all man-made obstacles over 50 feet AGL (or commensurate with the lowest altitude flown). Additionally, annotate any published low-level routes, no-fly areas, exotic animal farms, or other hazards within the boundaries. Master charts will be updated monthly using the Chart Update Manual (CHUM) supplement. The date of the CHUM update will be annotated on the master chart. Crewmembers should continuously scan for uncharted obstacles. When uncharted obstacles are found, temporarily suspend training and record appropriate information on to the aircrew chart (location and approximate height AGL). ACs will ensure this information is immediately passed to appropriate supervisors upon landing.

6.5.2. Charts used for flying will reflect the same information as the master chart. Crewmembers will ensure the chart is updated and annotated using the latest CHUM. ACs will ensure a copy of the planned route is available at the unit.

6.6. Route Planning. Aircrews will review and deconflict low altitude charts for IFR, VFR, and slow speed low altitude (IR, VR, and SR) training routes and annotate potential conflict areas along the proposed routes during pre-mission planning.

6.7. Evasive Maneuvering. Evasive Maneuver Training. Maintain 100 feet obstacle clearance during evasive maneuvers. If a break call is made below 100 feet, the pilot flying must climb above 100 feet before initiating any evasive turns. Pilots will make crew advisory calls prior to turns and will clear their flight path throughout maneuvering. If hovering, this does not preclude turning the tail of the helicopter to mitigate the threat or minor heading changes during takeoff.

Section 6C—Formation Procedures

6.8. Formation Types/Maneuvers. A description of formation types and maneuvers is listed in AFTTP 3-3.H-1.

6.8.1. Safety Considerations:

5.4.1.4. Practice emergency procedures may be accomplished while an FAA examiner is onboard and conducting an examination of rated aircrew personnel for civil certificates or ratings.

6.4.1.1. **(Added)** The AFDW LATN is defined by: Northern Boundary is the 40° latitude line from 80° longitude to the western edge of the Susquehanna River. Southern Boundary is the 38° latitude line from 80° longitude to point south of PT Lookout on the Chesapeake Bay. Western Boundary is the 80° longitude line from the 40° latitude to 38° latitude. Eastern Boundary is the intersection of the Susquehanna river and the 40° latitude along the western shore of the Susquehanna River and then on the western shore of the Chesapeake Bay running south until the point directly south of PT Look out on the 38° latitude line.

6.4.1.2. **(Added)** Flight activities in the AFDW LATN will comply with all applicable Federal Aviation Regulations (FARs). Routes and waypoints will be overflown a maximum of one time during a 24 hour period by any aircraft. The 811 OG will develop procedures to ensure no part of the LATN is overflown more than once a day. Low-level flight within the Washington DC Flight Restricted Zone (FRZ), other than operations on routes depicted on published Federal Aviation Administration (FAA)/National Charting Office (NACO) Helicopter Route Charts, is not authorized. The 11 WG will maintain a full description of the LATN and any further restriction in the 1 HS current operations office.

RONALD B. BALDINGER, Colonel, USAF
Director, Operations, Plans and Requirements,
& Assessments

EDWARD J. LENGEL, Colonel, USAF
Director, Operations, Plans and Readiness

meet AFSC 1C2X1, combat control, CFETP training requirements. Training will be validated in a memorandum signed by the 720 STG/CC and tracked at the 720 OSS.

3.14.2. Following completion of the ground survey by combat control personnel or qualified civilians, the AF IMT 3822 is forwarded to the appropriate chief, wing/group tactics, or as designated by the OG/CC, for a safety-of-flight review. The MAJCOM/A3 or ACC or their designated representative is final approval authority.

3.14.2.1. Safety-of-Flight Review. A safety-of-flight review is completed by the nearest Air Force wing/group tactics office on all LZ surveys. The purpose of a safety-of-flight review is to ensure an aircraft can safely ingress, egress and operate in the vicinity of the LZ. A safety-of-flight review includes an in-depth chart study of the terrain features, obstructions to flight, and airspace restrictions along the route of flight to and from an LZ. For a complete list of regional group/wing tactics offices see: **https://afkm.wpafb.af.mil/ASPs/CoP/OpenCoP.asp?Filter=OO-OP-AM-40**. A 1:50,000-scale chart and satellite imagery (if available) should be used when available for the objective area and at least a 1:250,000-scale chart for the ingress, egress and traffic pattern. If approved by the MAJCOM, Portable Flight Planning Software (PFPS) may be used instead of paper charts. The safety-of flight review lists all obstructions such as terrain, towers, or power lines that may affect the aircraft's ability to achieve ingress, egress, traffic pattern altitudes and airspeeds. The safety-of-flight review will also review any prohibited areas, restricted operating zones (ROZs), noise sensitive areas, special use airspace, route of flight to avoid such areas, preferred routing, NOTAM requirements, population areas etc. Evaluate terrain/obstructions within a radius of 5nm (minimum) and 10nm (desired) from the LZ centerpoint. High altitude penetrations to the LZ may require evaluation of terrain/obstructions out to a 20nm radius. Evaluate likely avenues of ingress/egress along runway centerline and others as mission planning requirements dictate arrival/departure paths. Evaluation of terrain/obstructions should include service ceiling and climb performance for the particular aircraft involved, the ability of the aircraft to take-off/fly over the LZ at low speeds and escape from the LZ using 3-engine climb out rates. If these criteria cannot be met, the ingress/egress routing must be modified, altitude raised, take-off/landing directions restricted to one-way operations, or the safety-of-flight review denied.

3.14.3. The AF IMT 3822 is not valid for use until it has been reviewed and recommended for use by the appropriate MAJCOM/A3 or the ACC. The AF IMT 3822 is then forwarded for inclusion in the landing zone database.

3.14.4. The AF IMT 3822 documents the conditions that existed at the time the survey was accomplished and may not account for changes to the LZ seasonal topography. The condition of the LZ should be confirmed prior to commencing operations.

Section 3B—Helicopter Landing Zone Operations

3.15. General. Helicopters require their own landing zone procedures to safely operate in areas unsuitable for fixed-wing aircraft. HLZ surveys are required for all training and exercises and highly recommended as part of the normal mission planning for contingencies. HLZ surveys are not required if another survey is available (ie. fixed wing LZ survey or FARP survey). The paragraphs below define the procedures.

3.15.1. **(Added-AFDW)** Approved operational sites are not considered HLZs and are not governed by this publication. Follow AFI11-2UH-1NV3 guidance for operational sites.

3.16. Helicopter Landing Zone Selection. Helicopter landing zones (HLZ) are dependent on the aircraft type and size, and whether the HLZ will be used for takeoffs/landings or alternate insertion/extraction (AIE). Selecting the HLZ location is the joint responsibility of the ACC and the supported force commander. JFSOCC forces determine their suitable locations from JSOACC recommendations.

3.16. (AFDW)Helicopter Landing Zone Selection. Selecting an HLZ for training purposes is the responsibility of the unit commander. Selection of HLZs for contingency response is the responsibility of the supported customer and unit commander.

3.16.1. Weight Bearing Capacity. HLZs are dependent on the aircraft type or size. Weight bearing capacity is not required for helicopter operations, but care must be exercised to ensure the HLZ is cleared to prevent possible engine damage or personnel injury from flying debris due to hover operations.

3.17. Helicopter Landing Zone Markings. MAJCOMs may supplement this instruction with their unique requirements. There are no USAF requirements to mark HLZs for day or NVG use. HLZs flown to unaided at night must be clearly marked with a minimum of two overt lights that either outline or target obstruction free areas compatible with the aircraft being used. Additionally, overt spot or landing lights must be available and used by the aircraft during the approach.

3.18. Helicopter Landing Zone Survey Requirements. The HLZ survey program is a group tactics function or an office with an equivalent level of expertise. Group tactics must ensure surveys are conducted IAW the procedures below.

3.18. (AFDW)Helicopter Landing Zone Survey Requirements. All references and responsibilities assigned to group tactics will be conducted by the 811 OG/CC's designee. The 811 OG/CC's designee will ensure an approved AF Form 4303 is completed on all helicopter landing zones used for training purposes.

3.18.1. Completing the HLZ survey process involves a physical inspection of the HLZ, documenting the information on the AF Form 4303, **Helicopter Landing Zone Survey**, a safety-of-flight review, and final approval. MAJCOMs will determine their own requirement for HLZ surveys for AIE training. Surveys may be accomplished by the using units whose equipment or personnel are being landed or for an AIE. For exercises and joint training operations, users must ensure the survey is completed and meets the appropriate criteria for operational and safety standards. The user must conduct a physical inspection of the HLZ prior to use to identify and evaluate potential hazards to personnel/equipment, man-made or natural structures, and ground personnel. If the survey was conducted using any other method than GPS-derived coordinates, provide the reviewer with the raw coordinate data and the method of conversion.

3.18.1. **(AFDW)** The 1 HS/CC or 1 HS/DO will determine which contingency response site requires an HLZ survey and ensure an approved AF Form 4303 is completed. The intent is to complete an AF Form 4303 on contingency sites that the alert crew(s) is/are expected to utilize. The AF Form 4303 for any given LZ will be classified at the appropriate level and stored accordingly.

3.18.1.1. Host Nation (HN) HLZ Surveys. When conducting operations on or over a HN surveyed HLZ, a review of the HN survey will be accomplished before operations to the HLZ begin. Users remain responsible for ground operational and safety criteria.

3.18.1.2. A 1:50,000 scale chart or less should be used when available for the objective area for the ingress and egress (Portable Flight Planning Software (PFPS) may be used instead of paper charts if approved by the MAJCOM). The review lists all obstructions such as terrain, towers, or power lines that may affect the helicopter's route of flight. Also listed on the review are any prohibited areas, noise sensitive areas, special use airspace, route of flight to avoid such areas, preferred routing, NOTAM requirements, etc. Evaluation of terrain/obstructions should consider the particular helicopter involved, and the ability to fly over and/or land on the HLZ unless OGE hover power plus 5-percent is available. If these criteria cannot be met, the ingress must be modified, or the review denied.

3.18.1.2. **(AFDW)** Portable Flight Planning Software (PFPS) generated maps are authorized for AFDW units. PFPS maps can be printed or viewed via an authorized portable electronic devise (Example: iPad).

3.18.2. When conducting operations on a HLZ that was previously surveyed by another unit, the commander of the using unit is responsible for ensuring the HLZ meets the criteria for that operation. In all cases, the using unit must accept responsibility for all personnel injuries, parachute or load damage, and property damage.

3.18.3. Tactical HLZ Surveys. During exercises and contingencies, when time or situations do not permit completion of a full HLZ survey, a tactical HLZ survey may be required to meet the appropriate commander's objective(s).

3.18.3.1. Though preferable, the use of an AF Form 4303 is not required for a tactical survey. Requests and surveys may be passed electronically. As much information as practical should be obtained and forwarded for review.

3.18.3.2. Requests for tactical surveys will be forwarded to the designated exercise/contingency ACC for final review.

3.18.3.3. When using a tactical HLZ, the rotary-wing unit assumes responsibility for helicopter safety-of-flight.

3.19. Helicopter Landing Zone Review Process. The following paragraphs outline the HLZ review process from performing the initial groundwork to the final coordination. All completed surveys will be forwarded to the group tactics office, or an office with an equivalent level of expertise. Surveys will be reaccomplished when the user and/or provider determine changes in the ground or air aspects of the HLZ data require a new survey.

3.19.1. The HLZ surveys will be conducted during daylight by a qualified combat controller; survey qualified rotary wing aircrew member, Chief Group Weapons and Tactics, or a qualified civilian. Qualified civilians will meet the training and documentation requirements listed in para **3.14.1**. AFSPC will establish requirements in their supplement for surveying Missile Alert Facilities (MAF) and Launch Facilities. The surveyor (AF Form 4303, item 4A) performs the actual ground portion of the HLZ survey (i.e., measurements, coordinates, calculating size, obtaining maps and creating diagrams) and annotates results on the AF Form

4303. The surveyor may be a member of the unit that intends to use the HLZ, or a member of another unit may perform the ground portion of a survey if requested and time permits. To facilitate future use of surveyed HLZs, initial surveys will encompass the largest area available and will not be limited by specific mission requirements. The surveyor will forward the completed survey to the group tactics office, or the OG/CC designated office, for review. Include recommended use, any deviations from HLZ standards contained in service or MAJCOM directives, and other pertinent remarks.

3.19.1. **(AFDW)** To conduct initial HLZ surveys, an aircrew member must be a qualified instructor pilot or instructor flight engineer.

3.19.2. The reviewer, in order of preference, is the Chief, Group Tactics, Squadron Commander, or Squadron Operations Officer (AFSPC/A3 may designate the helicpter squadron commander and operations officer as reviewing officials). The reviewer (AF Form 4303, item 4B) ensures the HLZ can be safely used from a flight perspective. Throughout the review process, HLZ survey packages will include all applicable maps, photos, charts and diagrams necessary to determine the safety and utility of the HLZ.

3.19.3. Approval Authority (AF Form 4303, item 4C). Prior to use, surveys will be approved for air operations by the OG/CC or appropriate ACC. This approval assures the review has been accomplished and the HLZ is considered safe for air operations.

3.19.4. Once item 4C of AF Form 4303 is completed, the survey is ready for use. Respective group tactics offices are the local area repositories for HLZ surveys. AFSPC/A3 will designate an office to serve as a repository for LZ surveys.

3.19.4. **(AFDW)** The 1 HS/DO will determine where HLZ surveys are maintained. Surveys will be accessible to aircrews for use in pre-mission planning.

3.19.5. HLZ surveys document the conditions that existed at the time the survey was accomplished, and may not account for changes to seasonal topography. Recommended uses may be based on minimum requirements and should not be misconstrued to be all-inclusive (i.e., a HLZ recommended for two MH-53s may not be suitable for a CV-22). It is the responsibility of the flying and ground units involved to ensure that any HLZ being considered for use meets the requirements for their specific operation.

3.20. Helicopter Landing Zone Survey Updates. HLZ surveys will be updated every six months. HLZs that are not updated in the six months time period will be closed until resurveyed using the above criteria (does not require a new AF Form 4303). AFSPC will establish requirements in their supplement for updating MAF and Launch Facilities. The absolute minimum to update a HLZ survey requires a qualified combat controller, qualified rotary wing aircrew member, or Chief Group Weapons and Tactics to resurvey the HLZ during daylight. This member must evaluate items 6 through 10 of AF Form 4303. Annotate date of update and surveyor's initials in remarks section. A HLZ survey that has not been updated for 12 months is expired and a new AF Form 4303 will be accomplished.

3.20.1. **(Added-AFDW)** Any contingency certified aircrew member can accomplish the HLZ survey update.

3.20.2. **(Added-AFDW)** The date of update and surveyor's initials in remarks section of AF Form 4303 may be in an electronic format.

3.20.3. **(Added-AFDW)** If an HLZ survey has not been updated for 12 months, the HLZ survey is expired and must be re-accomplished by a qualified instructor pilot or instructor flight engineer.

HELICOPTER LANDING ZONE SURVEY	1A. HLZ NAME Davidsonville	1B. ZAR INDEX NO. R-008	2A. COUNTRY USA	2B. STATE Maryland
	3. MAP SERIES/SHEET NUMBER/EDITION/DATE OF MAP VFR Terminal Area Chart Baltimore-Washington, 75th Edition, 30 August 2007			

4. SURVEY APPROVAL/DISAPPROVAL DATA

A. DATE SURVEYED 20080108	TYPED NAME AND GRADE OF SURVEYOR WILLIAM D. DUNOW, TSgt, USAF	PHONE NUMBER *(DSN)* 858-5131	LOCATION Andrews AFB MD 20762
B. DATE REVIEWED 20080211	TYPED NAME AND GRADE OF REVIEWER DONALD A. SNYDER, Lt Col, US	PHONE NUMBER *(DSN)* 858-4829	SIGNATURE //SIGNED//
	UNIT AND LOCATION 1st Helicopter Squadron, Andrews AFB MD 20762		
C. DATE 20080213	TYPED NAME AND GRADE OF APPROVING AUTHORITY KENNETH V. VOLMERT, Col, USAF	PHONE NUMBER *(DSN)* 858-3319	SIGNATURE //SIGNED//
APPROVED DISAPPROVED ☑ ☐	UNIT AND LOCATION 316th Operations Group, Andrews AFB MD 20762		

5. COORDINATING ACTIVITIES

A. HLZ CONTROLLING AGENCY OR UNIT Davidsonville	PHONE NUMBER *(DSN)* 858-5843
B. RANGE CONTROL N/A	PHONE NUMBER *(DSN)*

6. HLZ AXIS DATA (APPROACH/DEPARTURE)

A. MAGNETIC 020 / 200	B. GRID *(MGRS)* N/A	C. TRUE 009 / 189	D. SOURCE/DATE OF VARIATION DATA 20050101

7. HLZ COORDINATES

A. SPHEROID/DATUM WGS-84	B. GPS DERIVED ☑ YES ☐ NO	C. GRID ZONE *(52 S PQ)* N/A	D. EASTING N/A	E. NORTHING N/A
F. HLZ CENTER - POINT	MGRS COORDINATES N/A	WGS84 LATITUDE *(D-M.MM)* N 038 57.79	WGS84 LONGITUDE *(D-M.MM)* W 076 41.28	

8. HLZ SURFACE DATA

A. LENGTH *(FEET)* 300	B.WIDTH *(FEET)* 200	C.ELEVATION 150	D. QTY/TYPE *(2/H-53: 2/H-60)* 4 UH-1
E. QUADRANT *(OBSTRUCTED/UNOBSTRUCTED)* See Below		F. SLOPE variable, 5 degrees	

9. REMARKS

Type: Remote Site, Single Pilot NVG Approved
PPR Required: No
Communications: Potomac Approach 128.35
Heading/Distance from ADW: 053 / 12.5
Navigation Aids: 193 / 12.7 from (BAL 115.1, CH 98)
Recommended Flight Paths: 020/200 , 110/290 Make patterns to the west (some towers are unlit), using river max extent possible
Surface: Unprepared grass site
Lighting: None
Windsock type/location: Flagpole south of main building / large tower
Fire Support: No
Obstacles/Hazards: Site surrounded by antennas and trees
250' AGL red & white tower 1/2 mile northeast; 100' antenna southside of HLZ
5ft diameter hole x 3ft deep approx 75ft S of lone 50' tree in LZ,
50' tower farms NW and NE sides of LZ
Possible fire hazard due to tall grass. Pilots should extinguish landing light during ground operations
Use caution for general aviation aircraft transitioning along HWY 50

Restrictions: Avoid Freeway Airport (approx 4 miles southwest)
Avoid overflight of houses, Noise Sensitive Area northwest and southeast of Landing Zone
Unaided training is NOT authorized, Single Pilot NVG approved
Training Power Requirements: Hover
Requires DO approval: No

LAST REVIEW: 16 NOV 2016 MIT

HLZ NAME

10. HLZ DIAGRAM

11. PHOTOGRAPHY AVAILABLE

☑ YES ☐ NO

LOW LEVEL ROUTES

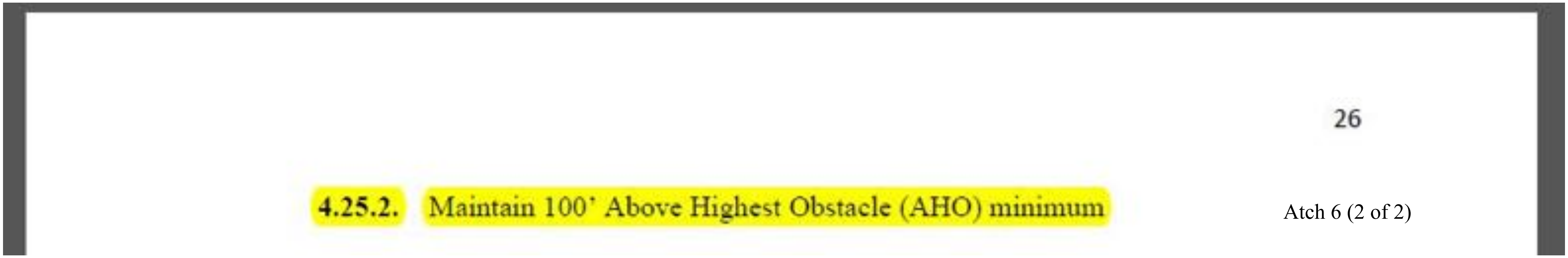
☐ NONE AVAILABLE

☐ ROUTE NAME/DESIGNATOR

AF IMT 4303, 20021001, V3 ***(REVERSE)***

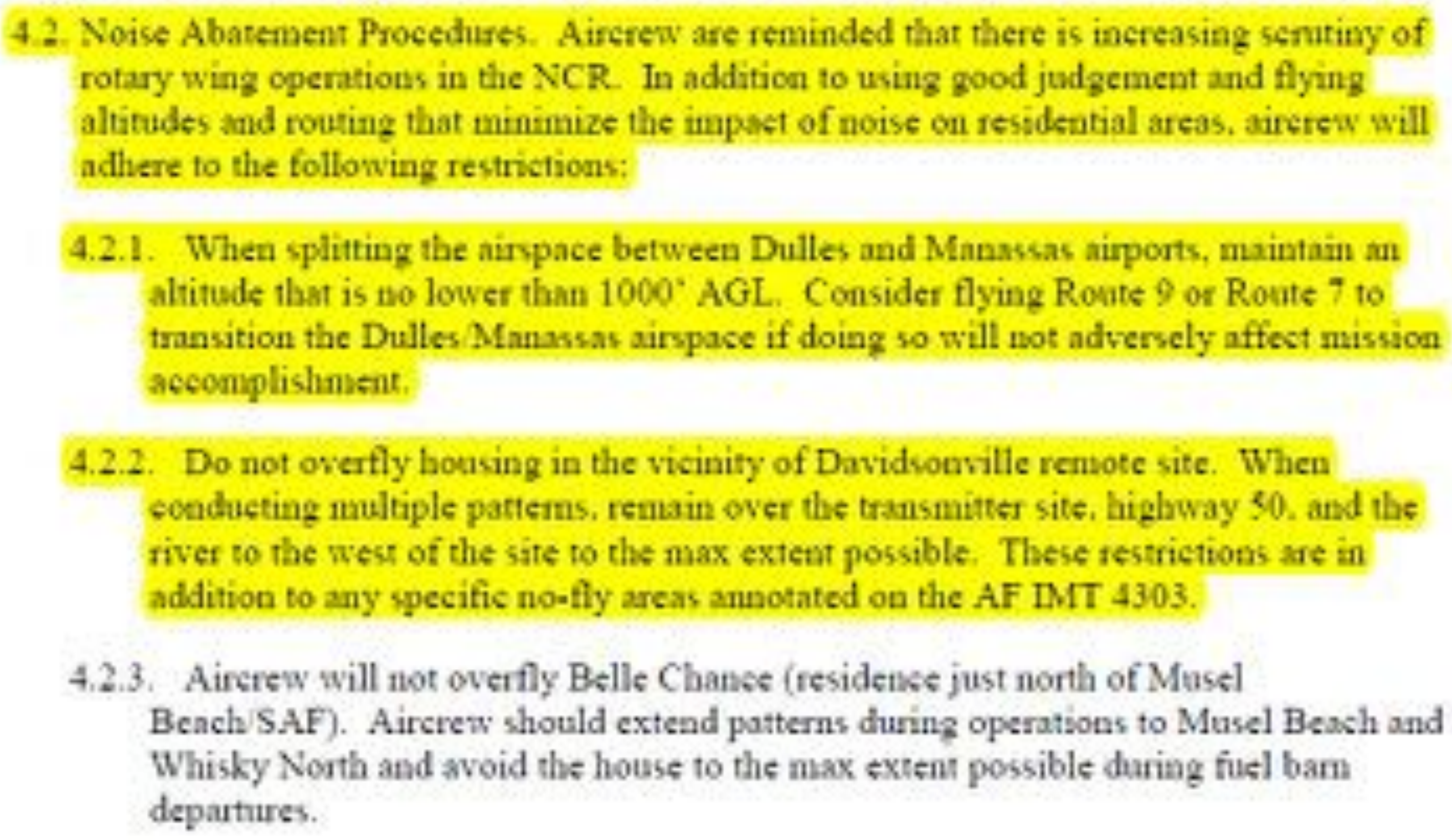

Davidsonville
N
Flag Pole for Winds
30' tree
Small Tower Farm
Small Tower Farm
Wire
Tower w/ guy wires

4.22. Fly Neighborly. Crews are expected to minimize their noise footprint in populated areas as much as possible. If low level areas are excessively populated, climb to 300' AGL or above until clear. In the routes and zones structure, fly at or close to the highest allowable altitude. Do not circle over mission LZs. Reference noise sensitive area maps located in the flight planning area.



26

4.25.2. Maintain 100' Above Highest Obstacle (AHO) minimum



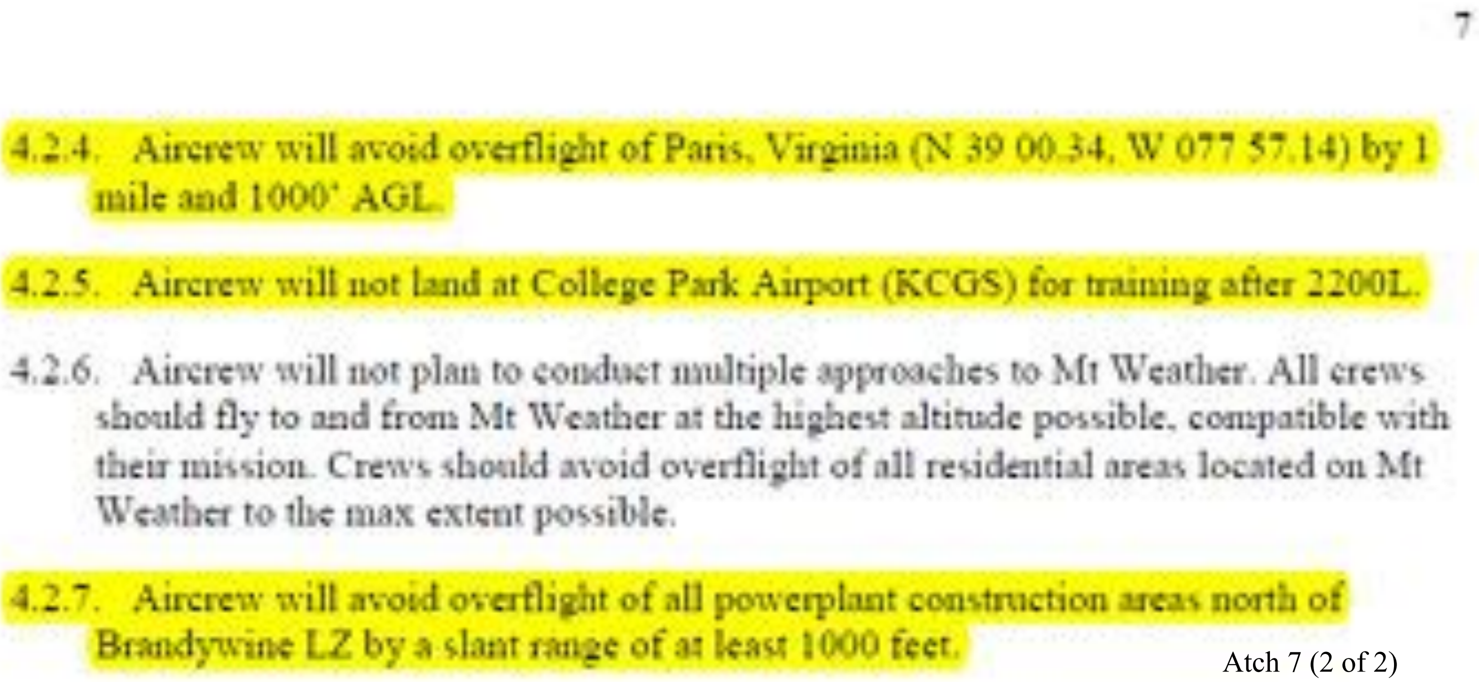
4.2. Noise Abatement Procedures. Aircrew are reminded that there is increasing scrutiny of rotary wing operations in the NCR. In addition to using good judgement and flying altitudes and routing that minimize the impact of noise on residential areas, aircrew will adhere to the following restrictions:

4.2.1. When splitting the airspace between Dulles and Manassas airports, maintain an altitude that is no lower than 1000' AGL. Consider flying Route 9 or Route 7 to transition the Dulles/Manassas airspace if doing so will not adversely affect mission accomplishment.

4.2.2. Do not overfly housing in the vicinity of Davidsonville remote site. When conducting multiple patterns, remain over the transmitter site, highway 50, and the river to the west of the site to the max extent possible. These restrictions are in addition to any specific no-fly areas annotated on the AF IMT 4303.

4.2.3. Aircrew will not overfly Belle Chance (residence just north of Musel Beach/SAF). Aircrew should extend patterns during operations to Musel Beach and Whisky North and avoid the house to the max extent possible during fuel barn departures.

Atch 7 (1 of 2)



4.2.4. Aircrew will avoid overflight of Paris, Virginia (N 39 00.34, W 077 57.14) by 1 mile and 1000' AGL.

4.2.5. Aircrew will not land at College Park Airport (KCGS) for training after 2200L.

4.2.6. Aircrew will not plan to conduct multiple approaches to Mt Weather. All crews should fly to and from Mt Weather at the highest altitude possible, compatible with their mission. Crews should avoid overflight of all residential areas located on Mt Weather to the max extent possible.

4.2.7. Aircrew will avoid overflight of all powerplant construction areas north of Brandywine LZ by a slant range of at least 1000 feet.

Atch 7 (2 of 2)

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 11TH WING (AFDW)
JOINT BASE ANDREWS, MARYLAND 20762

21 June 2017

MEMORANDUM FOR 811 OG Aircrew

FROM: 811 OG/CC

SUBJECT: OPS NOTE OG-17-01C Noise Abatement and Pattern Ops at KDAA

1. Noise complaints in the vicinity of Davison Army Airfield (KDAA) require 811 OG aircrew fly in a professional and friendly manner to ensure noise abatement for the adjacent area of Newington, Virginia, when utilizing the rotary-wing traffic pattern at KDAA.

2. Aircrew should try to minimize multiple pattern operations to KDAA if possible, especially on weekends and holidays.

3. While utilizing KDAA, aircrew will ensure they are at pattern altitude prior to turning downwind for RWY 32 and square the corner of the pattern over I-95 when turning base for RWY 14 (see Attachment).

4. Aircrew will also continue to adhere to the 1 HS IFG, Davison Army Airfield Operations Manual (Dec 2011), and 1 HS Ops Note 17-12.

5. This Ops Note will remain in effect until 30 Sep 17.

6. Direct any questions to 811 OG/OGV.

FRED C. KOEGLER III, Colonel, USAF
Commander

Attachment:
Pattern over Newington

America's Airmen

Pattern over Newington

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 11TH WING (AFDW)
JOINT BASE ANDREWS, MARYLAND 20762

30 March 2017

OPS NOTE 17-12

MEMORANDUM FOR 1 HS AIRCREW

FROM: 1 HS/DO

SUBJECT: Noise Abatement for KDAA and KCGS

1. Effective immediately, all aircrew will extend the upwind legs of their patterns for Runway 32 at Davidson Army Airfield (KDAA) until reaching I-95 for the purposes of noise abatement.

2. Effective immediately, aircrew will not conduct VFR patterns or landings to College Park Airfield (KCGS) after Sunset.

3. Please direct questions to 1HS/CCV.

MARCUS J. JACKSON IV, Lieutenant Colonel, USAF
Director of Operations, 1 HS

Atch 9

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 11TH WING (AFDW)
JOINT BASE ANDREWS, MARYLAND 20762

9 May 17

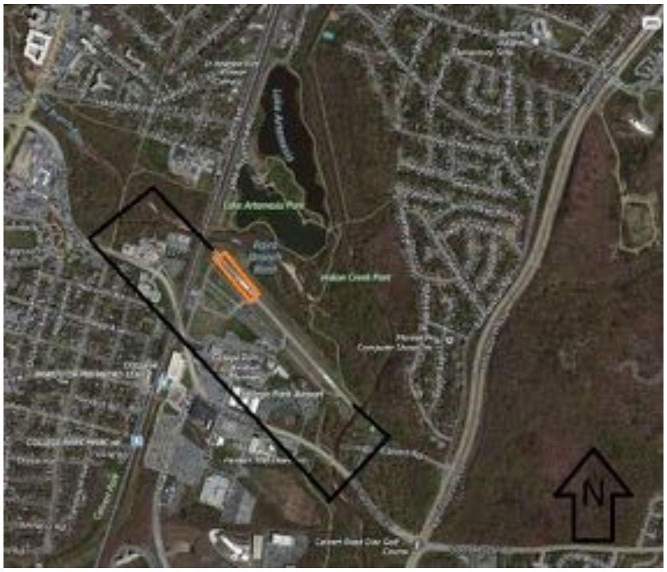
OPS NOTE 17-15

MEMORANDUM FOR 1 HS AIRCREW

FROM: 1 HS/DO

SUBJECT: College Park Airport (KCGS) Noise Abatement Operations

1. Operating hours for KCGS are 0900-2000L. Fly patterns south/southwest at Traffic Pattern Altitude 1000 feet MSL. Make landings to the approach end of runway 15.



2. For questions please contact TSgt Nick Melcher, DSN 858-1588.

CINDY TOPE, Capt, USAF
Stan/Eval Flight Commander, 1HS

Atch 10

Annex C. The United States Army Military District of Washington Helicopter Noise Abatement and Fly Friendly Standard Operating Procedure

This standard operating procedure is intended as a hand-out.

United States Army Military District of Washington (USAMDW) Helicopter Noise Abatement and Fly Friendly Standard Operating Procedure (SOP)

In accordance with Army Regulation 95-1 the USAMDW has established a “Fly Friendly” SOP:

- Installations will develop and publish noise abatement programs that minimize the aircraft noise footprint within the local flying area and establish good public relations programs.
- Aviators will participate in noise abatement and fly neighborly programs to minimize annoyance to persons on the ground when missions and safety are not adversely affected.
- For noise sensitive areas, unless required by the mission, all Army aircraft will maintain a minimum of 2000 feet above the surface of the following: national parks, monuments, recreation areas, and scenic river ways, national wildlife refuges, big game refuges, or wildlife ranges administered by the U.S. Fish and Wildlife Service, and wilderness and primitive areas administered by the U.S. Forest Service.
- Army aviation activities which normally operate in or adjacent to those areas listed in paragraph above may enter into local agreements with the controlling agency to modify procedures required for mission accomplishment.

Goals:

- Minimize aircraft noise impact in the National Capital Region (NCR).
- Establish good public relations programs to educate and inform the public. Commanders will achieve a responsible balance between operational flight requirements and aircraft noise while operating within the NCR.

Commander’s Intent:

- Aircrews will conduct training and operational missions in a manner that minimizes noise impact IAW AR 95-1, Federal Aviation Administration (FAA) regulations and specific airspace limitations.
- Aircrews will fly the highest published altitude practicable based on training requirements, weather and FAA limitations.
- Aircrews will remain on published helicopter routes and fly the highest published route altitudes unless weather, emergencies or FAA direction requires a deviation.
- Aircrews will avoid prolonged flight at low altitudes near noise sensitive areas during airport arrival and departure. The final authority for altitude and routing lies with Air Traffic Control and the FAA.
- All noise concerns will be addressed by the Public Affairs Office and passed to the tenant or visiting unit, as applicable.

Annex D. Maps

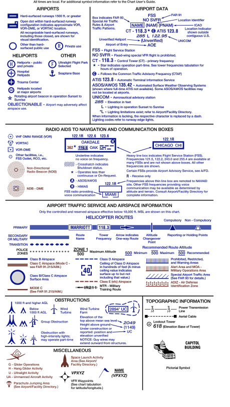
Listing of Maps in this Annex:

Annex D. Map 1. Baltimore-Washington Helicopter Route Charts

HELICOPTER ROUTE CHART
BALTIMORE-WASHINGTON
LEGEND

BALTIMORE · WASHINGTON

Consult Airport/Facility Directory (A/FD) for details involving airport lighting, navigation aids and services. All times are local. For additional symbol information refer to the Chart User's Guide.



BALTIMORE-WASHINGTON HELICOPTER

HELICOPTER ROUTE CHART SCALE 1:125,000

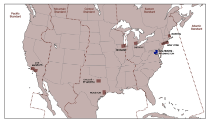
Federal Aviation Administration

10TH EDITION EFFECTIVE 0901Z **23 JUL 2015**

Chart will become OBSOLETE FOR USE IN NAVIGATION upon publication of the next edition. See Dates of Latest Editions

Includes airspace amendments effective **25 JUN 2015**
and all other aeronautical data received by **28 MAY 2015**

Information on this chart will change; consolidated updates of chart changes are available every 56 days in the AIRPORT/FACILITY DIRECTORY Chart Bulletin section (online at http://aeronav.faa.gov). Also consult appropriate NOTICES TO AIRMEN (NOTAMs) and other FLIGHT INFORMATION PUBLICATIONS (FLIPs) for the latest changes.



PUBLISHED IN ACCORDANCE WITH INTERAGENCY AIR CARTOGRAPHIC COMMITTEE SPECIFICATIONS AND AGREEMENTS, APPROVED BY: DEPARTMENT OF DEFENSE * FEDERAL AVIATION ADMINISTRATION

Warning: Refer to current foreign charts and flight information publications for information within foreign airspace.

FAA Product ID: HELDC
NSN 7641014104440
NGA REF. NO. HELOXBALTWASVFR
EFF. DATE 15204

Lambert Conformal Conic Projection Standard Parallels 33° and 45°
Horizontal Datum: North American Datum of 1983 (World Geodetic System 1984)

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Federal Aviation Administration
Aeronautical Information Services
http://faa.gov/go/ais

CONTROL TOWER FREQUENCIES ON WASHINGTON HELICOPTER ROUTE CHART

Airports with control towers are indicated on the face of the chart by the letters CT followed by the primary VHF local control frequency (ies). Information for each tower is listed in the table below. Operational hours are local time. The primary VHF and UHF local control frequencies are listed. An asterisk (*) indicates the part-time tower frequency is remoted to a collocated full-time FSS for use as Airport Advisory Service (AAS) during hours the tower is closed. The primary VHF and UHF ground control frequencies are listed.

Automatic Terminal Information Service (ATIS) frequencies shown on the face of the chart are primary arrival VHF/UHF frequencies. All ATIS frequencies are listed in the table below. ATIS operational hours may differ from tower operational hours.

"MON-FRI" indicates Monday through Friday.

O/T indicates other times.

CONTROL TOWER	OPERATES	TWR FREQ	GND CON	ATIS
DAVISON AAF	0600-2130 MON-FRI EXC HOL	126.3 229.4	121.9 245.2	128.175 230.0
JOINT BASE ANDREWS	CONTINUOUS	118.4 349.0	121.8 275.8	113.1 251.05
MANASSAS RGNL/DAVIS	0630-2230	133.1 360.75	121.8	125.175
PENTAGON AHP	0730-1730 MON-FRI 24 HRS PPR, CLSD HOL	143.1 231.3		
REAGAN WASHINGTON NATIONAL	CONTINUOUS	119.1 257.6 134.35 (HELI)	121.7 257.6	132.65
WASHINGTON DULLES INTL	CONTINUOUS	120.1 317.8 (RWY 01R/19L) 120.25 348.6 (RWY 01C/19C) 134.425 348.6 (RWYS 01L/19R & 12/30)	121.9 317.8 (E) 121.625 348.6 (W)	134.85

CLASS B, CLASS C, TRSA, AND SELECTED APPROACH CONTROL FREQUENCIES

FACILITY	FREQUENCIES			SERVICE AVAILABILITY
WASHINGTON TRI-AREA CLASS B	BALTIMORE	119.0	282.275 (020°-100°)	CONTINUOUS
		124.55	317.425 (101°-130°)	
		119.7	290.475 (131°-180°)	
		128.7	307.9 (181°-019°)	
	DULLES	128.525	306.925 (091°-240°)	
		120.45	306.925 (241°-330°)	
		126.1	338.25 (331°-090°)	
	REAGAN	124.2	269.0 (E)	
	NATIONAL	119.85	319.1 (W)	

SPECIAL USE AIRSPACE ON WASHINGTON HELICOPTER ROUTE CHART

Unless otherwise noted altitudes are MSL and in feet. Time is local.
"TO" an altitude means "To and including."
FL – Flight Level
NO A/G – No air to ground communications.
Contact Flight Service for information.

† Other times by NOTAM.
NOTAM – Use of this term in Restricted Areas indicates FAA and DoD NOTAM systems. Use of this term in all other Special Use areas indicates the DoD NOTAM system.

U.S. P–PROHIBITED, R–RESTRICTED, W–WARNING, A–ALERT, MOA–MILITARY OPERATIONS AREA

NUMBER	ALTITUDE	TIME OF USE	CONTROLLING AGENCY/ CONTACT FACILITY	FREQUENCIES
P-56 A, B	TO 18,000	CONTINUOUS	NO A/G WARNING—AVOID THIS AREA	
P-73	TO BUT NOT INCL 1500	CONTINUOUS	NO A/G	
R-6608 A, B, C	TO 10,000	0500-2400 †24 HRS IN ADVANCE	POTOMAC TRACON	124.65 306.925

MOA NAME	ALTITUDE*	TIME OF USE†	CONTROLLING AGENCY/ CONTACT FACILITY	FREQUENCIES
DEMO 1	500 TO 5000	INTERMITTENT BY NOTAM	POTOMAC TRACON	
DEMO 2	10,000 TO 15,000	INTERMITTENT BY NOTAM	POTOMAC TRACON	
DEMO 3	ABOVE 5000 TO 15,000	INTERMITTENT BY NOTAM	POTOMAC TRACON	

*Altitudes indicate floor of MOA. All MOAs extend to but do not include FL 180 unless otherwise indicated in tabulation or on chart.
†Other times by DoD NOTAM.

WASHINGTON

DESCRIPTION OF ROUTES AND ALTITUDES

ALL ROUTES MAY BE ALTERED AT PILOT'S REQUEST OR AS DIRECTED BY ATC.

ROUTE ALTITUDES ARE MAXIMUM

RT 1: AMERICAN LEGION BRIDGE OVER POTOMAC RIVER, EAST OF ROOSEVELT ISLAND TO THE TIDAL BASIN. OVER WASHINGTON CHANNEL TO ANACOSTIA RIVER. NORTHEAST OVER ANACOSTIA RIVER TO RIVERDALE AND VIA BALTIMORE WASHINGTON PARKWAY TO GREENBELT.
ALTITUDES: AMERICAN LEGION BRIDGE AT OR BELOW 1300 FEET MSL, CHAIN BRIDGE AT OR BELOW 700 FEET MSL, KEY BRIDGE AT OR BELOW 300 FEET MSL, MEMORIAL BRIDGE AT OR BELOW 200 FEET MSL, NOT ABOVE 200 FEET MSL TO THE 11TH STREET BRIDGE, AT OR BELOW 500 FEET MSL TO PENNSYLVANIA AVENUE, AT OR BELOW 700 FEET MSL FROM PENNSYLVANIA AVENUE TO RIVERDALE, AT OR BELOW 1300 FEET MSL TO GREENBELT. (HELICOPTERS CROSSING POTOMAC RIVER TO OR FROM THE PENTAGON SHALL BE AT OR BELOW 200 FEET MSL).

RT. 2: WOODS CORNER VIA BRANCH AVENUE, DIRECT TO MARLOW HEIGHTS, DIRECT TO PENNSYLVANIA AVENUE (PENN) DIRECT TO INTERCEPT RT. 1 AT ANACOSTIA RIVER.
ALTITUDES: WOODS CORNER AT OR BELOW 1000 FEET MSL. AT PENN BEGIN TO DESCEND TO BE AT OR BELOW 500 FEET MSL OVER ANACOSTIA RIVER.

RT. 3: CAPITAL BELTWAY (INTERSTATE 495 AND INTERSTATE 95), EXCEPT FROM THE NORTHWEST ADW WATER TOWER, TO FORESTVILLE MALL, TO WEST SIDE OF THREE GREEN WATER TANKS (UNLIGHTED), TO ADDISON METRO STATION, TO WEST SIDE OF LIGHTED WAREHOUSE, TURN NORTHEAST ALONG RAILROAD TRACKS TO BELTWAY. LEFT TO CONTINUE ROUTE.
ALTITUDES: AT OR BELOW 1300 FEET MSL, EXCEPT BETWEEN GREENBELT AND WOODS CORNER AT OR BELOW 1000 FEET MSL. FROM WOODS CORNER TO WILSON BRIDGE AT OR BELOW 800 FEET MSL. CROSS POTOMAC RIVER AT OR BELOW 300 FEET MSL ON SOUTH SIDE OF WILSON BRIDGE.

RT. 4: FORT WASHINGTON OVER POTOMAC RIVER TO WILSON BRIDGE. THEN VIA EAST BANK OF POTOMAC RIVER TO ANACOSTIA RIVER. INTERCEPT ROUTE 1 AT ANACOSTIA RIVER.
ALTITUDES: AT OR BELOW 1000 FEET MSL AT FORT WASHINGTON, DESCEND TO 600 FEET MSL ABEAM BROAD CREEK INLET, BEGIN DESCENT FROM 600 FEET MSL TO ARRIVE AT 300 FEET MSL OVER WILSON BRIDGE, THEN AT OR BELOW 200 FEET MSL NORTH OF WILSON BRIDGE.

RT. 5: SPRINGFIELD VIA INTERSTATE 395 (SHIRLEY HIGHWAY) TO ABEAM NAVY ANNEX. DIRECT PENTAGON.
ALTITUDES: AT OR BELOW 1300 FEET MSL TO GLEBE ROAD AT OR BELOW 400 FEET MSL ABEAM NAVY ANNEX. DESCEND TO LAND AT THE PENTAGON.

RT. 6: WOODS CORNER DIRECT TO BOLLING REPORTING POINT. DIRECT TO NAVY ANNEX.
ALTITUDES: AT OR BELOW 1000 FEET MSL TO BOLLING. MAINTAIN 1000 FEET MSL UNTIL PAST REAGAN WASHINGTON NATIONAL AIRPORT. DESCEND TO 200 FEET MSL AT NAVY ANNEX.

RT. 7: REAGAN WASHINGTON NATIONAL AIRPORT DIRECT TO GLEBE ROAD AT SHIRLEY HIGHWAY. SHIRLEY HIGHWAY TO VIRGINIA HIGHWAY ROUTE 7. VIRGINIA HIGHWAY ROUTE 7 TO TYSONS CORNER. THEN DIRECT TO WASHINGTON DULLES EAST CONTROL POINT ALONG WASHINGTON DULLES ACCESS ROAD TO RESTON INTERNATIONAL CENTER. THEN DIRECT TO THE WASHINGTON DULLES TANK FARM/ROTATING AIRPORT BEACON. CROSSING BETWEEN THE WASHINGTON DULLES CONTROL TOWERS. REMAIN NORTH RUNWAY 30. THEN SOUTH END OF BEAVERDAM CREEK RESERVOIR. THEN NORTHWEST TO U.S. HIGHWAY ROUTE 15.
ALTITUDES: AT 1000 FEET MSL TO GLEBE ROAD. THEN AT OR BELOW 1300 FEET MSL TO WASHINGTON DULLES TANK FARM/ROTATING BEACON. THEN BETWEEN 1000 TO 1300 FEET MSL FROM WASHINGTON DULLES TANK FARM/ROTATING BEACON AND CROSSING RUNWAY 19R/1L. THEN AT OR BELOW 1300 MSL TO HIGHWAY ROUTE 15.

RT. 8: WALDORF, MD., VIA ROUTE 5, TO BRANDYWINE ROAD TO JUNKYARD TO JENKINS CORNER TO WOODS CORNER.
ALTITUDES: AT OR BELOW 1000 FEET MSL UNLESS OTHERWISE AUTHORIZED BY JOINT BASE ANDREWS TOWER.

RT. 9: VIRGINIA HIGHWAY ROUTE 7 BETWEEN RESTON AND LEESBURG, THEN TO U.S. HIGHWAY ROUTE 15 BETWEEN LEESBURG AND HAYMARKET, TO INTERSTATE 66 BETWEEN HAYMARKET AND OAKTON, TO VIRGINIA HIGHWAY ROUTE 674 BETWEEN OAKTON AND RESTON.
ALTITUDES: AT OR BELOW 1300 FEET MSL, EXCEPT BETWEEN XEROX AND BROAD RUN AT OR BELOW 700 FEET MSL.

CATLETT: CATLETT TO BRISTOW ALONG THE NORFOLK AND SOUTHERN RAILROAD.
ALTITUDES: AT OR BELOW 1300 FEET MSL.

HAYMARKET: HAYMARKET TO GAINESVILLE ALONG THE NORFOLK AND SOUTHERN RAILROAD. GAINESVILLE TO BRISTOW ALONG VIRGINIA HIGHWAY ROUTE 619.
ALTITUDES: AT OR BELOW 1300 FEET MSL.

RT. 10: EAST SIDE OF VIRGINIA HIGHWAY 28 BETWEEN VIRGINIA HIGHWAY ROUTE 7 AND WASHINGTON DULLES TANK FARM/ROTATING AIRPORT BEACON. THEN DIRECT VIRGINIA HIGHWAY 29 AND VIRGINIA HIGHWAY 28 INTERSECTION, REMAINING ON EAST SIDE OF VIRGINIA HIGHWAY 28. VIRGINIA HIGHWAY 28 AND TOWN OF MANASSAS. THE TOWN OF MANASSAS SOUTH OVER VIRGINIA 28 TO INTERSECT THE NORFOLK AND SOUTHERN RAILROAD, THEN WEST TO TRACKS.
ALTITUDES: AT OR BELOW 800 FEET MSL BETWEEN BROAD RUN AND INTERSECTION OF AIR AND SPACE MUSEUM PARKWAY THEN AT OR BELOW 1300 FEET MSL BETWEEN AIR AND SPACE MUSEUM PARKWAY AND MANASSAS.

RT. 11: U.S. HIGHWAY ROUTE 50 BETWEEN INTERSTATE 66 AND CHANTILLY.
ALTITUDES: AT OR BELOW 1300 FEET MSL.

RT. 12: INTERSTATE 95 FROM THE CAPITAL BELTWAY (I-495) NORTHEAST TO THE BALTIMORE BELTWAY (I-695).
ALTITUDES: AT OR BELOW 1000 FEET MSL.
(FOR COMPLETE DESCRIPTION OF ROUTE AND ALTITUDES, SEE REVERSE SIDE OF CHART).

RT. 15: FROM THE CHESAPEAKE BAY BRIDGE (U.S. HIGHWAY ROUTE 50/301) ALONG THE WESTERN SHORE OF THE CHESAPEAKE BAY AND PATAPSCO RIVER, TO THE WEST END OF KEY BRIDGE (I-695).
ALTITUDES: AT OR BELOW 1000 FEET MSL

RT. 16: (BWI ARRIVAL TRAFFIC ONLY) FROM THE CHESAPEAKE BAY BRIDGE (U.S. HIGHWAY ROUTE 50/301) WEST ALONG THE HIGHWAY TO RITCHIE HIGHWAY (MARYLAND HIGHWAY ROUTE 2). THEN VIA ROUTE 2 TO PASADENA. EXPECT FURTHER INSTRUCTIONS FROM ATC.
ALTITUDES: AT OR BELOW 1000 FEET MSL

RT. 17: (BWI ARRIVAL TRAFFIC ONLY) BALTIMORE WASHINGTON PARKWAY FROM THE CAPITAL BELTWAY (I-95/495) TO THE MARYLAND HIGHWAY ROUTE 32 INTERCHANGE. EXPECT FURTHER INSTRUCTIONS FROM ATC.
ALTITUDES: AT OR BELOW 1000 FEET MSL.

RT. 20: RESTON HOSPITAL DIRECT DULLES TOWN CENTER. DULLES TOWN CENTER DIRECT LOUDOUN CENTER.
ALTITUDES: AT OR BELOW 1300 FEET MSL BETWEEN RESTON HOSPITAL AND DULLES TOWN CENTER. AT OR BELOW 700 FEET MSL BETWEEN DULLES TOWN CENTER AND LOUDOUN CENTER.

RT. 21: RESTON INTERNATIONAL CENTER ALONG RESTON PARKWAY (STATE ROUTE 602) TO INTERSECTION VIRGINIA HIGHWAY ROUTE 7 (DRANESVILLE).
ALTITUDES: AT OR BELOW 1300 FEET MSL.

RT. 23: RESTON INTERNATIONAL CENTER ALONG RESTON PARKWAY (STATE ROUTE 602) WHICH BECOMES LAWYERS ROAD TO INTERSECTION WITH WEST OX ROAD (STATE ROAD 608) TO FAIR OAKS MALL.
ALTITUDES: AT OR BELOW 1300 FEET MSL.

SPECIAL FLIGHT RULES AREA (SFRA)
SECTOR BOUNDARY

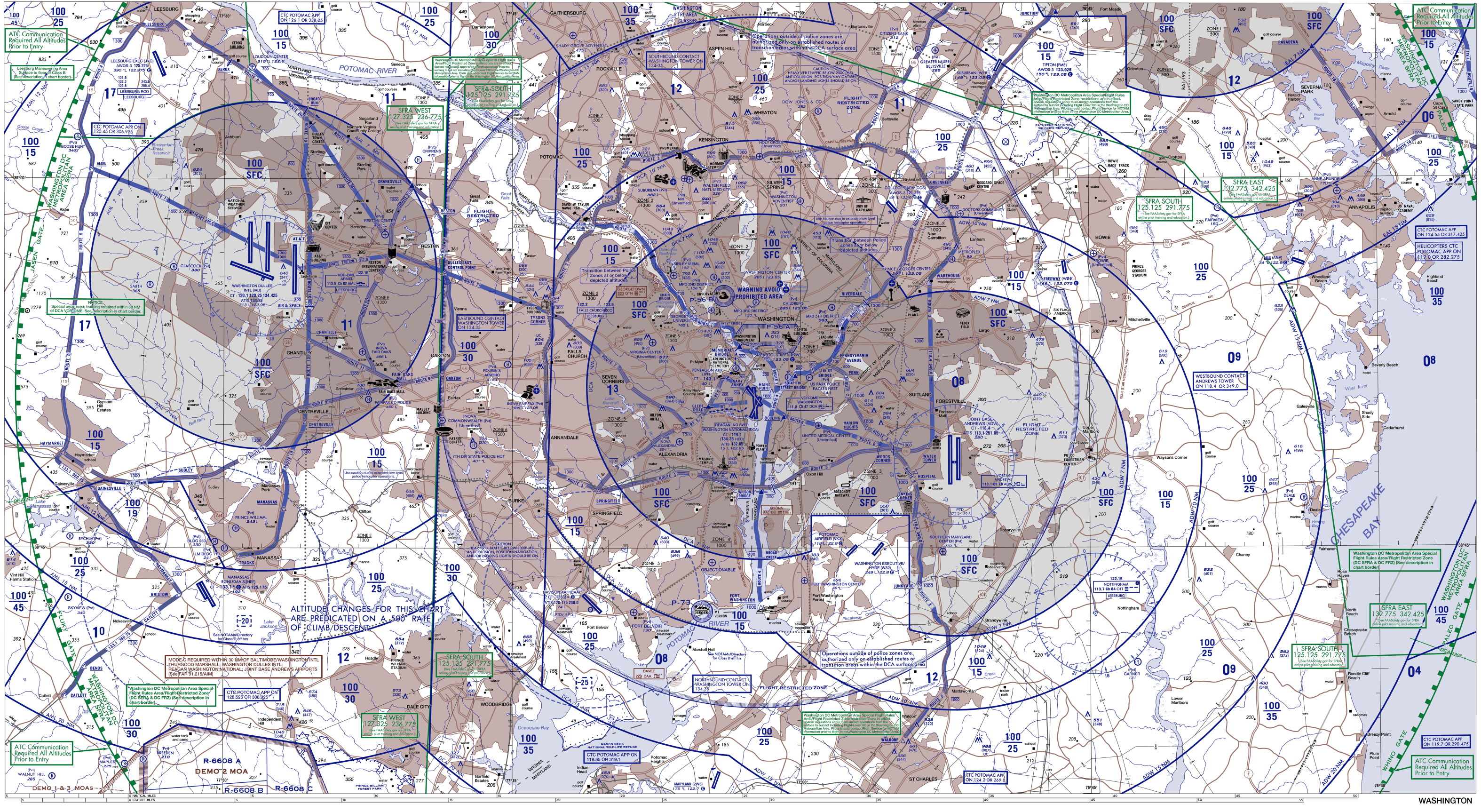
NOTE: EMERGENCY OPERATIONS MAY EXPECT RADAR ASSISTANCE FROM POTOMAC APPROACH CONTROL.

OPERATIONS OUTSIDE OF POLICE ZONES ARE AUTHORIZED ONLY ON ESTABLISHED ROUTES OR TRANSITION AREAS WITHIN THE DCA SURFACE AREA

DOD USERS ARE REQUIRED TO REFER TO AP-1 "WASHINGTON, D.C. METRO AREA."

NOTE: PILOTS ARE EXPECTED TO MAINTAIN THE MAXIMUM ALTITUDE CHARTED WHEN CEILING PERMITS, UNLESS OTHERWISE INSTRUCTED BY ATC.

ATC AUTHORIZATION TO OPERATE ALONG ROUTES, OR WITHIN ZONES, CONSTITUTES CLEARANCE TO ENTER CLASS B AIRSPACE INCIDENTAL TO THE AUTHORIZED OPERATION, AT ALTITUDES STATED IN THE AUTHORIZATION OR AS DEPICTED FOR THE ROUTE SPECIFIED. NOTIFICATION OF DEPARTING CLASS B AIRSPACE IS PROVIDED THROUGH ATC AUTHORIZATION TO OPERATE ALONG ROUTES, OR WITHIN ZONES, AS DEPICTED.



REAGAN WASHINGTON NATIONAL AIRPORT GLEBE TRANSITION ROUTE

ARRIVALS - GLEBE ROAD, EAST OVER SOUTH GLEBE ROAD/FOURMILE RUN TO THE BUS DEPOT THEN DIRECT TO REAGAN WASHINGTON NATIONAL AIRPORT (REMAIN WEST OF ALL RUNWAYS).

ALTITUDES: SOUTH GLEBE ROAD AT OR BELOW 800 FEET MSL. BUS DEPOT DESCEND TO LAND AS INSTRUCTED BY ATC.

DEPARTURES - DEPART FROM THE PAD, PROCEED TO THE BUS DEPOT (REMAIN WEST OF ALL RUNWAYS) THEN WEST VIA SOUTH GLEBE ROAD/FOURMILE RUN TO GLEBE ROAD.

ALTITUDES: AT OR BELOW 800 FEET MSL.

PENTAGON ARMY HELIPORT TRANSITION ROUTE

ARRIVAL/DEPARTURE TRAFFIC FLOW WILL NORMALLY CONFORM TO THE TRAFFIC FLOW IN EFFECT AT REAGAN WASHINGTION NATIONAL AIRPORT (NORTH/OR/SOUTH OPERATIONS) UNLESS OTHERWISE APPROVED BY WASHINGTON TOWER.

DO NOT OVERFLY ARLINGTON NATIONAL CEMETERY, AURORA HILLS, VIRGINIA HIGHLANDS OR APARTMENT BUILDINGS.

DOD USERS CONSULT DOD FLIP FOR PARTICULARS PERTINENT TO OPERATION OF HELICOPTERS TO THE PENTAGON ARMY HELIPORT AND ON THIS SPECIAL HELICOPTER ROUTE CONNECTING WITH THE PENTAGON AHP TRANSITION ROUTE.

ALL AIRCRAFT ARRIVING/DEPARTING OR TRANSITING THE SOUTH ARLINGTON AREA SHALL NOT OVERFLY ARLINGTON NATIONAL CEMETERY, AURORA HILLS, VIRGINIA HIGHLANDS, FAIRLINGTON, SHIRLINGTON, CLAREMONT, OR APARTMENT BUILDINGS.

ALL ROUTES ARE RECOMMENDED ROUTES WHICH PILOTS MAY EXPECT TO RECEIVE WHEN AUTHORIZED TO OPERATE IN THE CLASS B AIRSPACE. UNLESS OTHERWISE INDICATED, ALTITUDES WILL BE ASSIGNED WHEN CONTACTING AIR TRAFFIC CONTROL. HELICOPTER ROUTE AND ALTITUDE ASSIGNMENTS DO NOT RELIEVE PILOTS FROM THEIR DUTY TO COMPLY WITH FAR 91.119 AND 135.203(b). PILOTS ARE EXPECTED TO REQUEST AN ALTERNATE CLEARANCE IF NECESSARY FOR COMPLIANCE.

CAUTION: ROUTES DEPICTED AND ALTITUDES ASSIGNED DO NOT PROVIDE OBSTACLE CLEARANCE PROTECTION. PILOTS ARE RESPONSIBLE FOR SEEING AND AVOIDING TERRAIN AND OBSTACLES. THIS CHART DOES NOT DEPICT COMPLETE OBSTACLE INFORMATION DUE TO THE HIGH CONCENTRATION OF OBJECTS IN THE AREA. OBSTACLES AND OTHER FEATURES SUCH AS POWER TRANSMISSION LINES AND PROMINENT STRUCTURES ARE DEPICTED FOR LANDMARK VALUE ONLY.

ATTENTION

THIS CHART CONTAINS MAXIMUM ELEVATION FIGURES (MEF).
The Maximum Elevation Figures shown in quadrangles bounded by ticked lines of latitude and longitude are represented in THOUSANDS and HUNDREDS of feet above mean sea level. The MEF is based on information available concerning the highest known feature in each quadrangle, including terrain and obstructions (trees, towers, antennas, etc.).

Example: 12,500 feet .... 12^5

NORTH AMERICAN AEROSPACE DEFENSE COMMAND (NORAD) PROCEDURES

All aircraft operating in the U.S. national airspace, if capable, will maintain a listening watch on guard frequencies VHF 121.5 or UHF 243.0. It is incumbent upon all aviators to know and understand their responsibilities if intercepted. Review "AIM" section 5-6-2 for intercept procedures. Additionally, if U.S. military fighter jets intercept an aircraft and flares are dispensed in the area of that aircraft, aviators will pay strict attention, contact air traffic control immediately on the local frequency or on VHF guard 121.5 or UHF 243.0 and follow the interceptor visual ICAO signals. Be advised that non-compliance may result in the use of force.

MILITARY TRAINING ROUTES (MTRs)

All IR and VR MTRs are shown, and may extend from the surface upwards. Only the route centerline, direction of flight along the route and the route designator are depicted - route widths and altitudes are not shown.

Since these routes are subject to change every 56 days, you are cautioned and advised to contact Flight Service for route dimensions and current status for those routes affecting your flight.

Routes with a change in the alignment of the charted route centerline will be indicated in the Aeronautical Chart Bulletin of the Airport/Facility Directory.

DoD users refer to Area Planning AP/1B Military Training Routes North and South America for current routes.

Features normally used as checkpoints for controlling VFR traffic are emphasized on this series of charts so they may be readily identified.

Example: POWER PLANT

The name shown is that used by the controlling personnel and is not necessarily the official name of the feature.

CAUTION: This chart is primarily designed for VFR navigational purposes and does not purport to indicate the presence of all power transmission and telecommunication lines, terrain or obstacles which may be encountered below reasonable and safe altitudes.

REPORTING POINTS
GEOGRAPHIC COORDINATES

REPORTING POINT	LATITUDE	LONGITUDE
Air & Space	38°54.89'N	77°25.58'W
Aldie	39°00.35'N	77°36.88'W
AT & T	38°57.28'N	77°25.52'W
Bends	38°40.43'N	77°37.17'W
Bolling	38°50.47'N	77°00.70'W
Bristow	38°43.38'N	77°32.20'W
Broad Run	39°02.53'N	77°25.73'W
Cabin John	38°58.08'N	77°10.78'W
Catlett	38°39.03'N	77°38.16'W
Centreville	38°50.32'N	77°25.82'W
Chantilly	38°53.53'N	77°25.63'W
Dorsey	39°11.82'N	76°46.00'W
Dranesville	38°59.67'N	77°20.18'W
Dulles East Control Point	38°56.23'N	77°18.55'W
Fair Oaks Mall	38°51.70'N	77°20.85'W
Fort McHenry Tunnel	39°15.82'N	76°34.33'W
Fort Smallwood	39°09.95'N	76°28.73'W
Fort Washington	38°42.65'N	77°02.10'W
Gainesville	38°47.63'N	77°36.75'W
Glebe Road	38°50.78'N	77°04.77'W
Greenbelt	38°59.48'N	76°53.17'W
Hains Point	38°51.40'N	77°01.35'W
Haymarket	38°49.00'N	77°38.27'W
Hospital	38°48.25'N	76°54.05'W
Jenkins Corner	38°47.18'N	76°53.83'W
Junction	39°06.90'N	76°46.70'W
Junkyard	38°43.70'N	76°53.75'W
Key Bridge	39°13.35'N	76°31.25'W
Laurel	39°07.77'N	76°51.75'W
Leesburg	39°05.97'N	77°33.06'W
Linthicum	39°13.13'N	76°39.52'W
Manassas	38°46.77'N	77°26.87'W
Marlow Heights	38°49.95'N	76°56.26'W
Memorial Bridge	38°53.23'N	77°03.33'W
Navy Annex	38°51.88'N	77°03.83'W
North Avenue	39°18.65'N	76°37.25'W
Oakton	38°52.12'N	77°18.55'W
Pasadena	39°05.28'N	76°33.43'W
Penn	38°52.12'N	76°57.57'W
Relay	39°14.10'N	76°42.62'W
Reston	38°58.53'N	77°19.03'W
Riverdale	38°55.07'N	76°56.55'W
S. Capitol Street Bridge	38°52.10'N	77°00.22'W
Social Security	39°18.35'N	76°44.63'W
Springfield	38°47.45'N	77°10.52'W
Sudley	38°48.07'N	77°31.20'W
Tracks	38°44.90'N	77°29.20'W
Tysons Corner	38°54.62'N	77°13.06'W
Waldorf	38°37.57'N	76°54.65'W
Warehouse	38°55.77'N	76°53.53'W
Water Tower	38°49.33'N	76°53.10'W
Waterloo	39°10.67'N	76°47.38'W
Wilson Bridge	38°47.50'N	77°01.80'W
Woods Corner	38°49.17'N	76°55.17'W
Xerox	39°04.67'N	77°29.72'W

Medical Hospital Helipads and Trauma Centers

Medical Facilities	Latitude	Longitude
Anne Arundel	38°59.44'N	76°32.05'W
Baltimore Washington	39°08.26'N	76°37.40'W
Bowie	*38°56.97'N	76°44.70'W
Childrens	38°55.60'N	77°00.80'W
Doctors Community	*38°58.67'N	76°51.65'W
Fort Belvoir	38°42.40'N	77°08.70'W
Fort Washington Center	38°43.67'N	76°59.53'W
Georgetown University	38°54.70'N	77°04.60'W
Greater Laurel Beltsville	39°05.30'N	76°52.90'W
Harbor-Baltimore	*39°14.99'N	76°36.74'W
Holy Cross	*39°00.80'N	77°01.70'W
Howard County General	39°12.90'N	76°53.20'W
Inova Alexandria	38°49.36'N	77°06.25'W
Inova Commonwealth	*38°50.23'N	77°18.67'W
Inova Fairfax	38°51.42'N	77°13.58'W
Inova Fair Oaks	38°53.06'N	77°22.75'W
Johns Hopkins	39°17.80'N	76°35.60'W
Johns Hopkins Bayview	39°17.48'N	76°32.78'W
Johns Hopkins Critical Care	39°17.75'N	76°35.52'W
Loudoun Center	39°04.70'N	77°28.60'W
Montebello	39°20.17'N	76°35.20'W
Montgomery General	39°09.28'N	77°03.30'W
Mount Vernon (Objectionable)	38°44.40'N	77°04.60'W
National Institutes of Health	*39°00.18'N	77°05.95'W
Prince Georges Center	38°55.82'N	76°55.25'W
Prince William	38°45.95'N	77°29.27'W
Reston Center	38°57.76'N	77°21.82'W
St Agnes	39°16.25'N	76°40.38'W
St Joseph	39°23.30'N	76°36.60'W
Shady Grove Adventist	39°05.90'N	77°11.80'W
Sibley Memorial	38°56.22'N	77°06.63'W
Sinai II	39°21.47'N	76°39.75'W
Southern Maryland Center	38°44.90'N	76°52.60'W
Suburban	38°59.80'N	77°06.60'W
Union Memorial	39°19.76'N	76°36.90'W
United Medical Center	*38°50.06'N	76°59.05'W
University of Maryland	39°17.30'N	76°37.50'W
Virginia Center	*38°53.30'N	77°07.83'W
Walter Reed Natl Med Center	38°59.98'N	77°05.74'W
Washington Adventist	38°59.16'N	77°00.12'W
Washington Center	38°55.70'N	77°01.00'W

*Geographic Coordinates Unverified

NOTE: Pilots needing assistance with hospital locations or other hospital information may contact the Washington Hospital Center "MedSTAR" communication center or the Children's Hospital communications center on 123.05. Children's Hospital can also be reached on 1-800-884-5433. Each hospital center is a back up for the other.

REGULATIONS REGARDING FLIGHTS OVER CHARTED NATIONAL PARK SERVICE AREAS, U.S. FISH AND WILDLIFE SERVICE AREAS, AND U.S. FOREST SERVICE AREAS

The landing of aircraft is prohibited on lands or waters administered by the National Park Service, U.S. Fish and Wildlife Service or U.S. Forest Service without authorization from the respective agency. Exceptions include: 1) when forced to land due to an emergency beyond the control of the operator, 2) at officially designated landing sites, or 3) on approved official business of the Federal Government.

All aircraft are requested to maintain a minimum altitude of 2,000 feet above the surface of the following: National Parks, Monuments, Seashores, Lakeshores, Recreation Areas and Scenic Riverways administered by the National Park Service; National Wildlife Refuges, Big Game Refuges, Game Ranges and Wildlife Ranges administered by the U.S. Fish and Wildlife Service; and Wilderness and Primitive areas administered by the U.S. Forest Service. FAA Advisory Circular (AC) 91-36, "Visual Flight Rules (VFR) Flight Near Noise-Sensitive Areas," defines the surface as: the highest terrain within 2,000 feet laterally of the route of flight, or the upper-most rim of a canyon or valley.

Federal regulations also prohibit airdrops by parachute or other means of persons, cargo, or objects from aircraft on lands administered by the three agencies without authorization from the respective agency. Exceptions include: 1) emergencies involving the safety of human life, or 2) threat of serious property loss.

• • • • • • • • Boundary of National Park Service areas, U.S. Fish and Wildlife Service areas, and U.S. Forest Service Wilderness and Primitive areas.

BALTIMORE

DESCRIPTION OF ROUTES AND ALTITUDES

ALL ROUTES MAY BE ALTERED AT PILOT'S REQUEST OR AS DIRECTED BY ATC.

ROUTE ALTITUDES ARE MAXIMUM

RT. 12: INTERSTATE 95 FROM THE CAPITAL BELTWAY (I-495) NORTHEAST TO THE BALTIMORE BELTWAY (I-695). THEN NORTHEAST THROUGH BALTIMORE CITY VIA THE FORT MC HENRY TUNNEL. THEN NORTHEAST.
ALTITUDES: AT OR BELOW 1000 FEET MSL.

RT. 13: BALTIMORE BELTWAY (I-695) FROM INTERSECTION WITH I-795 SOUTHBOUND AND COUNTERCLOCKWISE TO THE I-95 INTERSECTION NORTHEAST OF BALTIMORE CITY.
ALTITUDES: AT OR BELOW 1400 FEET MSL FROM SOCIAL SECURITY TO WILKENS AVENUE. AT OR BELOW 1000 FEET MSL FROM WILKENS AVENUE TO I-95 NORTHEAST OF BALTIMORE CITY.

RT. 14: JONES FALLS EXPRESSWAY (I-83) FROM THE INTERSECTION WITH I-695 NORTH OF BALTIMORE CITY, SOUTH TO THE EXPRESSWAY TERMINATION, THENCE DIRECT TO INNER HARBOR, DIRECT TO I-95 (HELICOPTER ROUTE 12).
ALTITUDES: AT OR BELOW 1400 FEET MSL FROM I-695 TO NORTH AVENUE. AT OR BELOW 1000 FEET MSL FROM NORTH AVENUE TO I-95.

RT. 15: FROM THE CHESAPEAKE BAY BRIDGE (U.S. HIGHWAY ROUTE 50/301) ALONG THE WESTERN SHORE OF THE CHESAPEAKE BAY AND PATAPSCO RIVER, TO THE WEST END OF KEY BRIDGE (I-695).
ALTITUDES: AT OR BELOW 1000 FEET MSL

RT. 16: (BWI ARRIVAL TRAFFIC ONLY) FROM THE CHESAPEAKE BAY BRIDGE (U.S. HIGHWAY ROUTE 50/301) WEST ALONG THE HIGHWAY TO RITCHIE HIGHWAY (MARYLAND HIGHWAY ROUTE 2). THEN VIA ROUTE 2 TO PASADENA. EXPECT FURTHER INSTRUCTIONS FROM ATC.
ALTITUDES: AT OR BELOW 1000 FEET MSL

RT. 17: (BWI ARRIVAL TRAFFIC ONLY) BALTIMORE WASHINGTON PARKWAY FROM THE CAPITAL BELTWAY (I-95/495) TO THE MARYLAND HIGHWAY ROUTE 32 INTERCHANGE. EXPECT FURTHER INSTRUCTIONS FROM ATC.
ALTITUDES: AT OR BELOW 1000 FEET MSL

RT. 18: (BWI ARRIVAL TRAFFIC ONLY) FROM THE INTERSECTION OF I-95 AND THE BALTIMORE WASHINGTON PARKWAY, VIA THE PARKWAY SOUTH TO THE I-695 INTERSECTION. EXPECT FURTHER INSTRUCTIONS FROM ATC. DO NOT OVERFLY SCHOOL BUILDING 1 MILE NORTH OF BWI.
ALTITUDES: AT OR BELOW 1000 FEET MSL

RT. 1: GREENBELT VIA BALTIMORE WASHINGTON PARKWAY TO RIVERDALE.
ALTITUDES: AT OR BELOW 1000 FEET MSL
(FOR COMPLETE DESCRIPTION OF ROUTE AND ALTITUDES, SEE REVERSE SIDE OF CHART).

RT. 3: CAPITAL BELTWAY (INTERSTATE 495 AND INTERSTATE 95).
ALTITUDES: AT OR BELOW 1300 FEET MSL NORTHWEST OF GREENBELT. AT OR BELOW 1000 FEET MSL SOUTHEAST OF GREENBELT.
(FOR COMPLETE DESCRIPTION OF ROUTE AND ALTITUDES, SEE REVERSE SIDE OF CHART).

ATTENTION

THIS CHART CONTAINS MAXIMUM ELEVATION FIGURES (MEF).
The Maximum Elevation Figures shown in quadrangles bounded by ticked lines of latitude and longitude are represented in THOUSANDS and HUNDREDS of feet above mean sea level. The MEF is based on information available concerning the highest known feature in each quadrangle, including terrain and obstructions (trees, towers, antennas, etc.).

Example: 12,500 feet .... 12^5

NOTE: PILOTS ARE EXPECTED TO MAINTAIN THE MAXIMUM ALTITUDE CHARTED WHEN CEILING PERMITS, UNLESS OTHERWISE INSTRUCTED BY ATC.

EXAMPLES OF CLASS B ALTITUDES

$\frac{70}{30}$

70 --- Ceiling in hundreds of feet MSL
30 --- Floor in hundreds of feet MSL

ALL ROUTES ARE RECOMMENDED ROUTES WHICH PILOTS MAY EXPECT TO RECEIVE WHEN AUTHORIZED TO OPERATE IN THE CLASS B AIRSPACE. UNLESS OTHERWISE INDICATED, ALTITUDES WILL BE ASSIGNED WHEN CONTACTING AIR TRAFFIC CONTROL. HELICOPTER ROUTE AND ALTITUDE ASSIGNMENTS DO NOT RELIEVE PILOTS FROM THEIR DUTY TO COMPLY WITH FAR 91.119 AND 135.203(b). PILOTS ARE EXPECTED TO REQUEST AN ALTERNATE CLEARANCE IF NECESSARY FOR COMPLIANCE.

CONTROL TOWER FREQUENCIES ON BALTIMORE HELICOPTER ROUTE CHART

Airports with control towers are indicated on the face of the chart by the letters CT followed by the primary VHF local control frequency (ies). Information for each tower is listed in the table below. Operational hours are local time. The primary VHF and UHF local control frequencies are listed. An asterisk (*) indicates the part-time tower frequency is remoted to a collocated full-time FSS for use as Airport Advisory Service (AAS) during hours the tower is closed. The primary VHF and UHF ground control frequencies are listed.

Automatic Terminal Information Service (ATIS) frequencies shown on the face of the chart are primary arrival VHF/UHF frequencies. All ATIS frequencies are listed in the table below. ATIS operational hours may differ from tower operational hours.

"MON-FRI" indicates Monday through Friday.

O/T indicates other times.

CONTROL TOWER	OPERATES	TWR FREQ	GND CON	ATIS
BALTIMORE/WASHINGTON INTL THURGOOD MARSHALL	CONTINUOUS	119.4 257.8	121.9	115.1 127.8
MARTIN STATE	0600-2200	121.3 254.425	121.8 253.4	124.925

CLASS B, CLASS C, TRSA, AND SELECTED APPROACH CONTROL FREQUENCIES

FACILITY	FREQUENCIES				SERVICE AVAILABILITY
WASHINGTON TRI-AREA CLASS B	BALTIMORE	119.0	282.275	(020°-100°)	CONTINUOUS
		124.55	317.425	(101°-130°)	
		119.7	290.475	(131°-180°)	
		128.7	307.9	(181°-019°)	
	DULLES	128.525	306.925	(091°-240°)	
		120.45	306.925	(241°-330°)	
		126.1	338.25	(331°-090°)	
	REAGAN	124.2	269.0	(E)	
	NATIONAL	119.85	319.1	(W)	

SPECIAL USE AIRSPACE ON BALTIMORE HELICOPTER ROUTE CHART

Unless otherwise noted altitudes are MSL and in feet. Time is local.
"TO" an altitude means "To and including."
FL – Flight Level
NO A/G – No air to ground communications. Contact Flight Service for information.

† Other times by NOTAM.
NOTAM – Use of this term in Restricted Areas indicates FAA and DoD NOTAM systems. Use of this term in all other Special Use areas indicates the DoD NOTAM system.

U.S. P–PROHIBITED, R–RESTRICTED, W–WARNING, A–ALERT, MOA–MILITARY OPERATIONS AREA

NUMBER	ALTITUDE	TIME OF USE	CONTROLLING AGENCY/ CONTACT FACILITY	FREQUENCIES
R-4001 A	(1) UNLIMITED (2) TO 10,000 HIGHER ALTITUDES BY NOTAM 24 HRS IN ADVANCE	(1) 0700-2400 (2) 0000-0700	WASHINGTON CNTR	134.5 360.7
R-4001 B	TO 10,000 HIGHER ALTITUDES BY NOTAM 24 HRS IN ADVANCE	INTERMITTENT BY NOTAM 24 HRS IN ADVANCE	WASHINGTON CNTR	134.5 360.7
R-4001 C	TO 10,000	CONTINUOUS	POTOMAC TRACON	

CAUTION: ROUTES DEPICTED AND ALTITUDES ASSIGNED/RECOMMENDED DO NOT PROVIDE OBSTACLE CLEARANCE PROTECTION. PILOTS ARE RESPONSIBLE FOR SEEING AND AVOIDING TERRAIN AND OBSTACLES. THIS CHART DOES NOT DEPICT COMPLETE OBSTACLE INFORMATION. OBSTACLES AND OTHER FEATURES SUCH AS POWER TRANSMISSION LINES AND PROMINENT STRUCTURES ARE DEPICTED FOR LANDMARK USE ONLY.

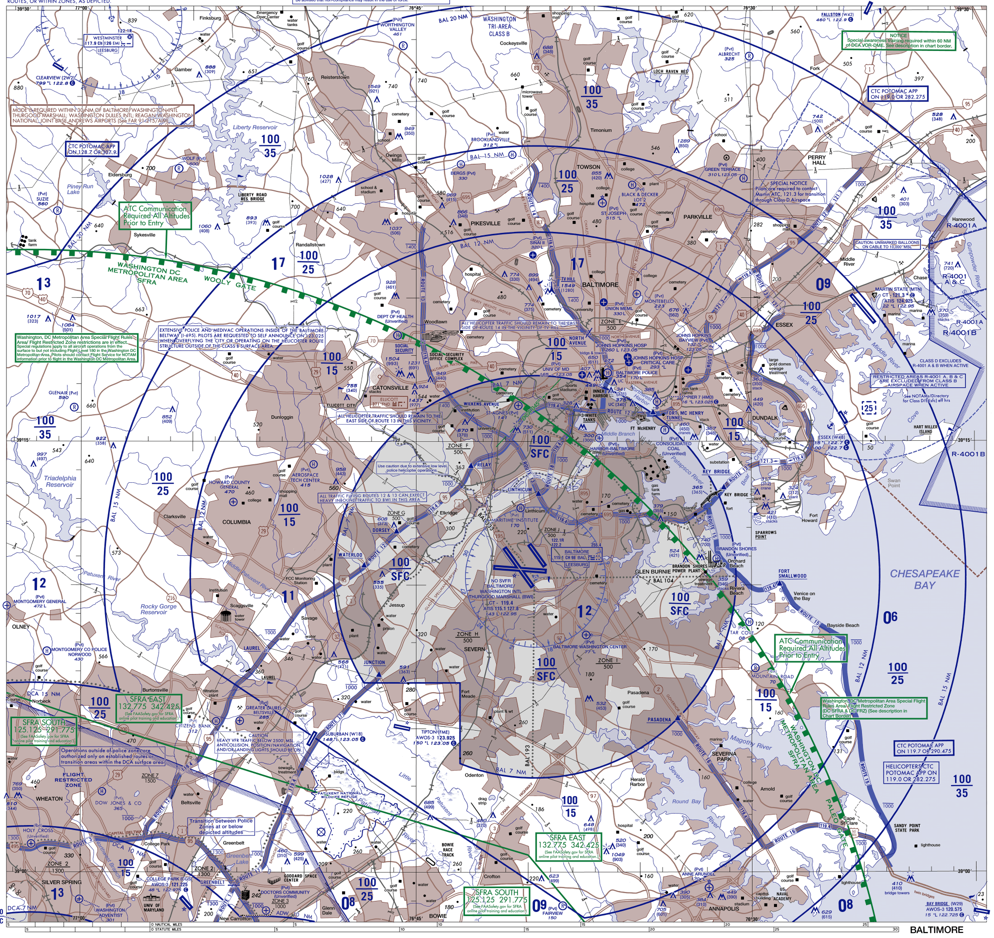
ATC AUTHORIZATION TO OPERATE ALONG ROUTES, OR WITHIN ZONES, CONSTITUTES CLEARANCE TO ENTER CLASS B AIRSPACE INCIDENTAL TO THE AUTHORIZED OPERATION, AT ALTITUDES STATED IN THE AUTHORIZATION OR AS DEPICTED FOR THE ROUTE SPECIFIED. NOTIFICATION OF DEPARTING CLASS B AIRSPACE IS PROVIDED THROUGH ATC AUTHORIZATION TO OPERATE ALONG ROUTES, OR WITHIN ZONES, AS DEPICTED.

NORTH AMERICAN AEROSPACE DEFENSE COMMAND (NORAD) PROCEDURES

All aircraft operating in the U.S. national airspace, if capable, will maintain a listening watch on guard frequencies VHF 121.5 or UHF 243.0. It is incumbent upon all aviators to know and understand their responsibilities if intercepted. Review "AIM" section 5-6-2 for intercept procedures. Additionally, if U.S. military fighter jets intercept an aircraft and flares are dispensed in the area of that aircraft, aviators will pay strict attention, contact air traffic control immediately on the local frequency or on VHF guard 121.5 or UHF 243.0 and follow the interceptor visual ICAO signals. Be advised that non-compliance may result in the use of force.

Class G Airspace within the United States extends up to 14,500 feet MSL. At and above this altitude all airspace is within Class E airspace, excluding the airspace less than 1500 feet above the terrain and certain special use airspace areas.

FOR PROCUREMENT:
Contact an Authorized FAA Chart Sales Agent.
Visit our website https://faa.gov/go/ais and click on "Chart Agent Locator".
For digital products, visit http://faacharts.faa.gov.



Washington DC Metropolitan Area

The DC SFRA is that area of airspace over the surface of the earth where the ready identification, location, and control of aircraft is required in the interests of National Security. Specifically, the DC SFRA is that airspace, from the surface to but not including FL180, within a 30 NM radius of 38°51'34" N, 77°02'11" W or the DCA VOR-DME.

The Washington DC Metropolitan Area Flight Restricted Zone (DC FRZ) is defined as an area bounded by a line beginning at the Washington DCA VOR-DME 311° radial at 15 NM 38°59'31"N, 77°18'30"W, thence clockwise along the DCA 15 NM arc to the DCA 002° radial at 15 NM 39°06'28"N, 077°04'32"W, thence southeast via a line drawn to the DCA 049° radial at 14 NM 39°02'18"N, 76°50'38"W, thence south via a line drawn to the DCA 064° radial at 13 NM 38°59'01"N, 76°48'32"W, thence clockwise along the 13 NM arc to the DCA 276° radial at 13 NM 38°50'53"N, 77°18'48"W, thence north to the point of beginning, excluding the airspace within a 1 NM radius of Freeway Airport (W00) Mitchellville, MD, from the surface up to but not including FL 180. The DC FRZ is within and part of the Washington DC Metropolitan Area SFRA.

The Leesburg Maneuvering Area is the area defined as within the DC SFRA and is the airspace around the Leesburg Executive Airport (JYO) from the surface to the floor of the Class B airspace, bounded by a line beginning at the Washington DCA VOR-DME 299° radial at 30 NM 39°01'39.1"N, 77°38'26.7"W, thence clockwise along the DCA 30 NM arc to the 39°12'42"N, 77°29'30"W or the Armel AML VOR-DME 004° radial at 16.6 NM, thence south via a line drawn to the 39°03'03"N, 77°28'37"W or the AML VOR-DME 004° radial at 7 NM, thence counterclockwise along the AML 7 NM arc to the AML 331° radial at 7 NM 39°01'39.3"N, 77°33'25.5"W, thence west via a line drawn to the point of beginning.

Pursuant to 49 USC 40103(b), the Federal Aviation Administration (FAA) classifies the Washington DC Metropolitan SFRA/FRZ as 'National Defense Airspace'. Pilots who do not adhere to the following procedures may be intercepted, detained and interviewed by law enforcement/security personnel. Any of the following additional actions may also be taken against a pilot who does not comply with the requirements or any special instructions or procedures announced in this NOTAM:

A) The FAA may take administrative action, including imposing civil penalties and the suspension or revocation of airmen certificates; or
B) The United States Government may pursue criminal charges, including charges under Title 49 of the United States Code, Section 46307; or
C) The United States Government may use deadly force against an airborne aircraft, if it is determined that the aircraft poses an imminent security threat.

All VFR aircraft operations within the airspace between the 30 NM radius and 60 NM radius of 38°51'34"N, 77°02'11"W or the Washington DCA VOR-DME, from the surface up to but not including FL 180, are restricted to an indicated airspeed of 230 knots or less, if capable. If unable the pilot must contact the appropriate ATC facility and advise them of the aircraft's operational limitations prior to entering the 60 NM radius of the Washington DCA VOR-DME.

Special Awareness Training for the Washington, DC Metropolitan Area
14 CFR Part 91, Section 91.161 requires any pilot who flies under VFR within a 60 nautical mile radius of DCA VOR-DME to complete the "Washington DC Special Flight Rules Area (SFRA)" training. This training has been developed and provided by the FAA on its www.FAASafety.gov website. See NOTAMs.

▙▙▙▙▙ SPECIAL FLIGHT RULES AREA (SFRA)

——— SECTOR BOUNDARY

REPORTING CHART ERRORS

You are requested to inform us of chart errors and/or additions that come to your attention while using this chart. Frequently asked questions (FAQs) are answered on our website at http://faa.gov/go/ais. See the FAQs prior to contact via toll free number or email. Telephone toll free at 1-800-638-8972, or email us at 9-AMC-Aerochart@faa.gov or mail to: FAA, Aeronautical Information Services, Customer Operations Team, 1305 East-West Highway, SSMC 4, Suite 4400, Silver Spring, MD 20910-3281.

OPERATIONS OUTSIDE OF POLICE ZONES ARE AUTHORIZED ONLY ON ESTABLISHED ROUTES OR TRANSITION AREAS WITHIN THE DCA SURFACE AREA

ALL AIRCRAFT ARRIVING/DEPARTING OR TRANSITING THE SOUTH ARLINGTON AREA SHALL NOT OVERFLY ARLINGTON NATIONAL CEMETERY, AURORA HILLS, VIRGINIA HIGHLANDS, FAIRLINGTON, SHIRLINGTON, CLAREMONT, OR APARTMENT BUILDINGS.

PENTAGON ARMY HELIPORT TRANSITION ROUTE

ARRIVAL/DEPARTURE TRAFFIC FLOW WILL NORMALLY CONFORM TO THE TRAFFIC FLOW IN EFFECT AT REAGAN WASHINGTION NATIONAL AIRPORT (NORTH/OR/SOUTH OPERATIONS) UNLESS OTHERWISE APPROVED BY WASHINGTON TOWER.

DO NOT OVERFLY ARLINGTON NATIONAL CEMETERY, AURORA HILLS, VIRGINIA HIGHLANDS OR APARTMENT BUILDINGS.

DOD USERS CONSULT DOD FLIP FOR PARTICULARS PERTINENT TO OPERATION OF HELICOPTERS TO THE PENTAGON ARMY HELIPORT AND ON THIS SPECIAL HELICOPTER ROUTE CONNECTING WITH THE PENTAGON AHP TRANSITION ROUTE.

DOD USERS ARE REQUIRED TO REFER TO AP-1 "WASHINGTON, D.C. METRO AREA."

REAGAN WASHINGTON NATIONAL AIRPORT GLEBE TRANSITION ROUTE

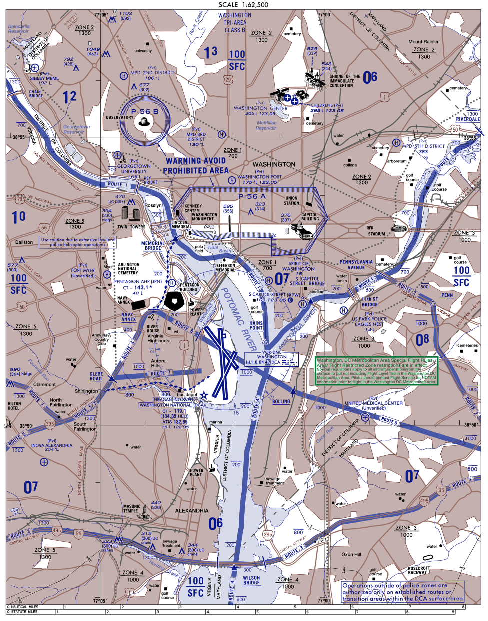
ARRIVALS - GLEBE ROAD, EAST OVER SOUTH GLEBE ROAD/FOURMILE RUN TO THE BUS DEPOT THEN DIRECT TO REAGAN WASHINGTON NATIONAL AIRPORT (REMAIN WEST OF ALL RUNWAYS).

ALTITUDES: SOUTH GLEBE ROAD AT OR BELOW 800 FEET MSL. BUS DEPOT DESCEND TO LAND AS INSTRUCTED BY ATC.

DEPARTURES - DEPART FROM THE PAD, PROCEED TO THE BUS DEPOT (REMAIN WEST OF ALL RUNWAYS) THEN WEST VIA SOUTH GLEBE ROAD/FOURMILE RUN TO GLEBE ROAD.

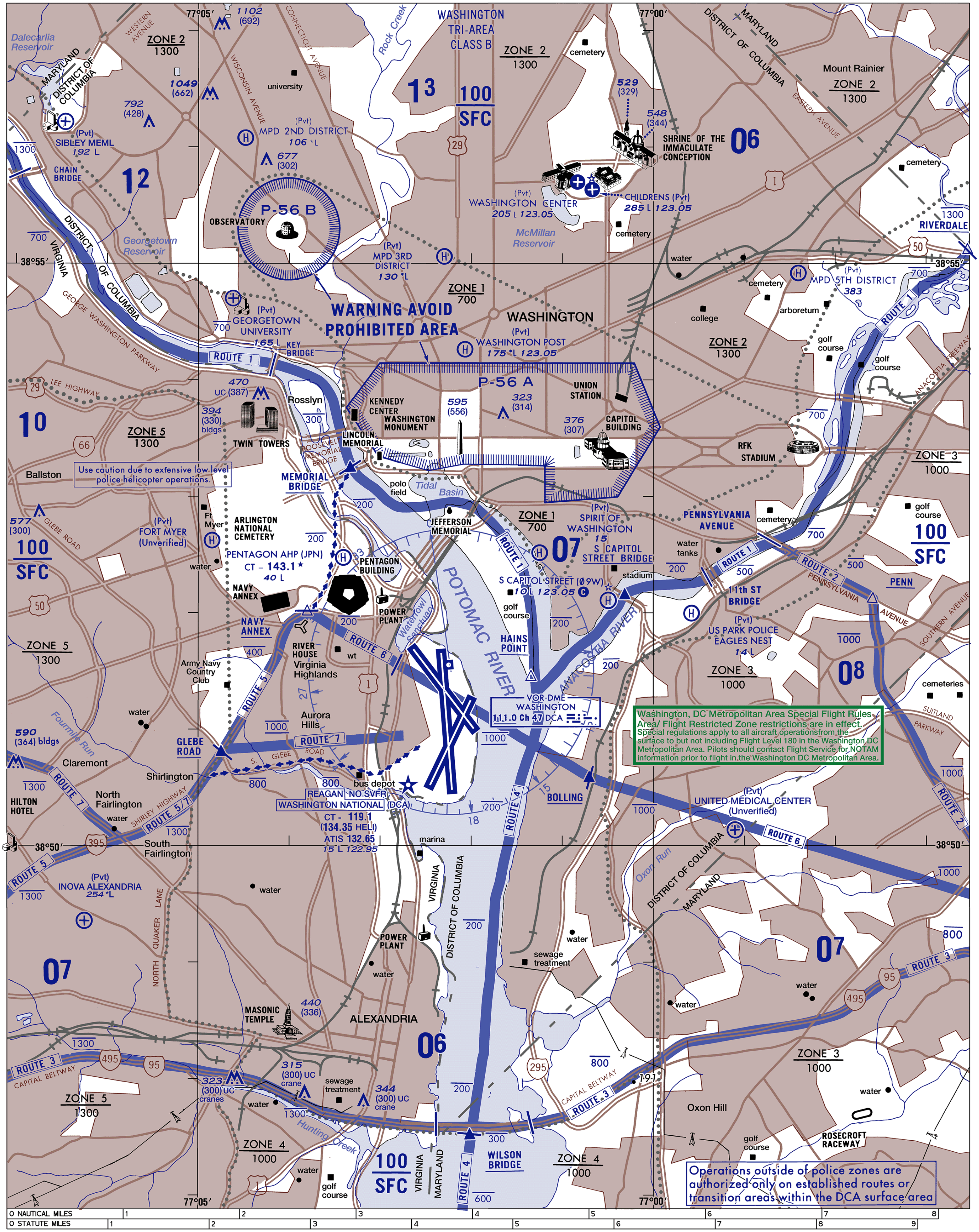
ALTITUDES: AT OR BELOW 800 FEET MSL.

WASHINGTON INSET
SCALE 1:62,500



WASHINGTON INSET

SCALE 1:62,500



Use caution due to extensive low level police helicopter operations.

Washington, DC Metropolitan Area Special Flight Rules Area/ Flight Restricted Zone restrictions are in effect. Special regulations apply to all aircraft operations from the surface to but not including Flight Level 180 in the Washington DC Metropolitan Area. Pilots should contact Flight Service for NOTAM information prior to flight in the Washington DC Metropolitan Area.

Operations outside of police zones are authorized only on established routes or transition areas within the DCA surface area

Annex D. Map 2. Washington Inset/Blow Up of Baltimore-Washington Helicopter Route Chart

- The magnified chart illustrates helicopter routes and zones within a portion of the NCR and the maximum altitudes that can be flown.
- Note the congested airspace in the center of the chart. This is due to Reagan National Airport, two prohibited flight areas and multiple routes.
- Controlled principally by the air traffic control tower at Reagan Washington National Airport, helicopters operating inside of this airspace are subject to extensive monitoring and are very limited in their routing choices.

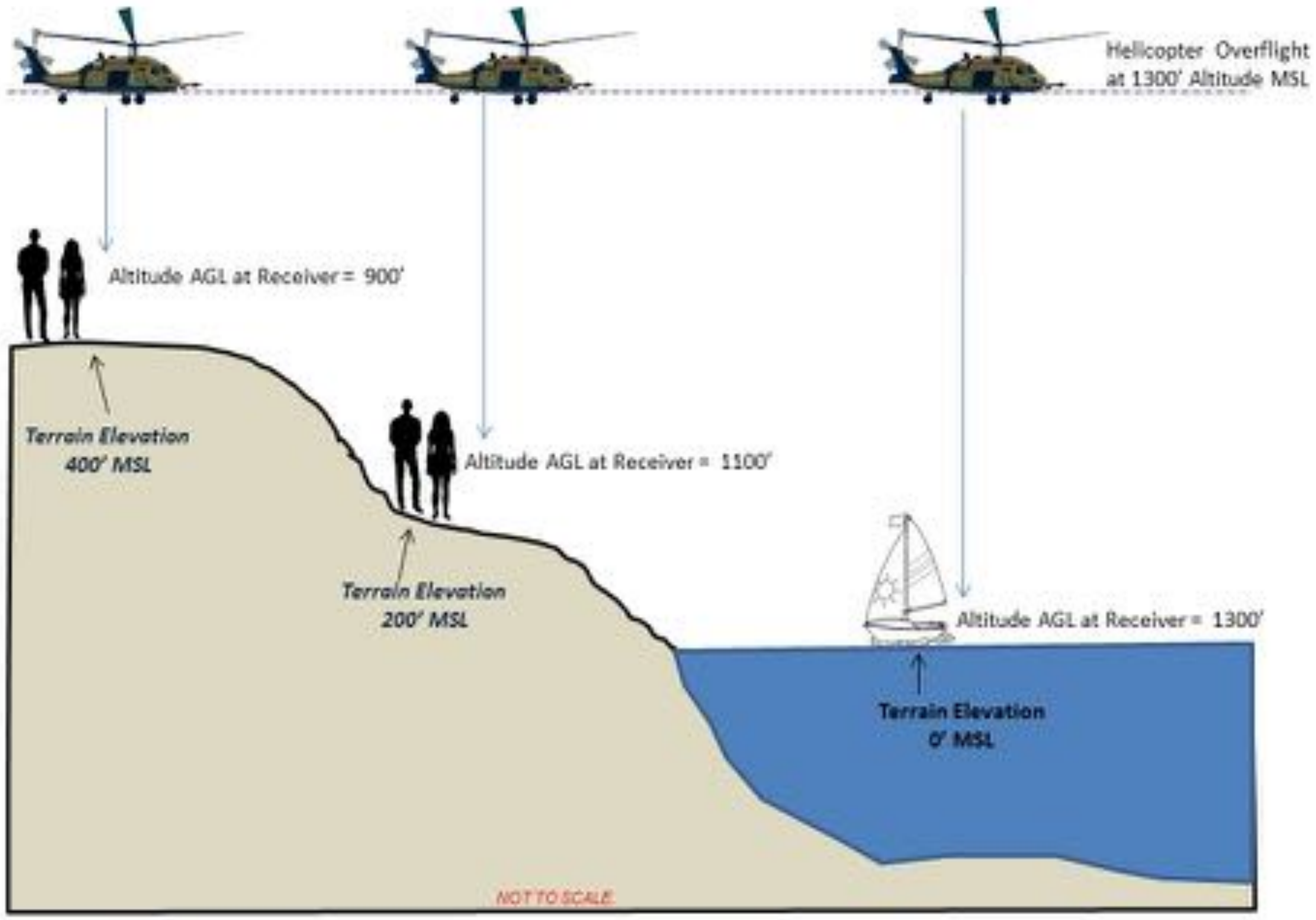
WASHINGTON INSET

SCALE 1:80,500

Annex D. Map 3. Above Ground Level vs. Mean Sea Level

Annex D. Map 3. Altitude Above Ground Level (AGL) vs. Mean Sea Level (MSL)

The pictorial representation describes the difference between AGL and MSL altitudes and how it relates to aircraft overflight.

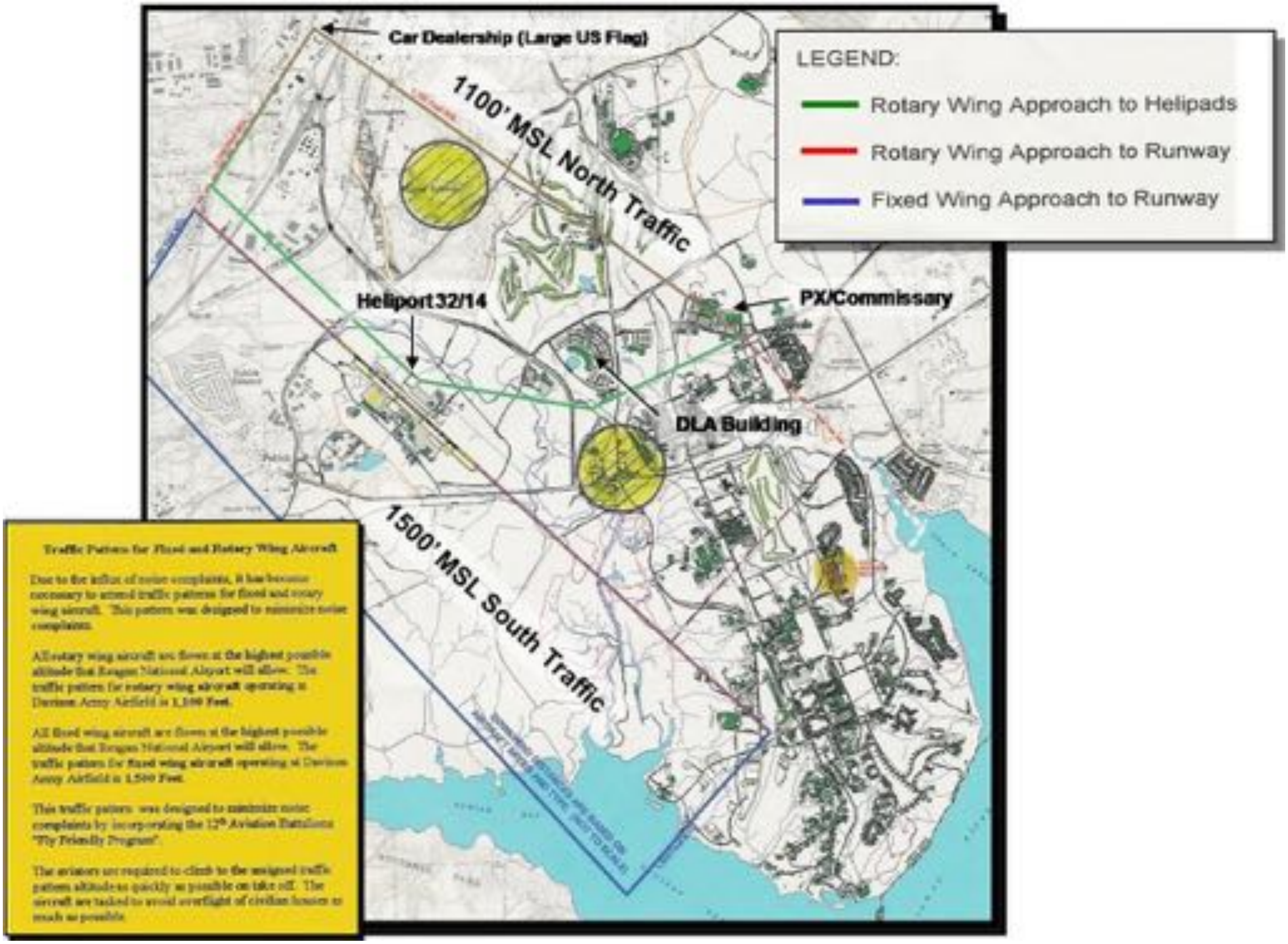


In the Washington DC area, the terrain elevation ranges from 0 – 400 feet Mean Seal Level (MSL).
Altitude Above Ground Level (AGL) is calculated from the Altitude MSL minus physical terrain elevation in MSL

Mean Sea Level (MSL) and Altitude Above Ground Level (AGL) as Related to Aircraft Overflights

Annex D. Map 4. Davison Army Airfield Traffic Pattern with Noise Abatement Procedures

To reduce traffic in the Newington and Fort Belvoir area, Operational Units and Air Traffic Control established a traffic pattern on the southwest side of the Davidson Army Airfield. Helicopter users and air traffic control have been advised to split helicopter traffic between the original northeast pattern and the new southwest pattern to increase the time between overflight of Newington, VA.



Traffic Pattern for *Fixed* and Rotary Wing Aircraft

Due to the influx of noise complaints, it has become necessary to amend traffic patterns for fixed and rotary wing aircraft. This pattern was designed to minimize noise complaints.

All rotary wing aircraft are flown at **the highest** possible altitude that Reagan National Airport will allow. The traffic pattern for **rotary wing aircraft** operating at Davison Army Airfield is **1,100 Feet**.

All fixed wing aircraft are flown at the highest possible altitude that Reagan National Airport will allow. The traffic pattern for **fixed wing aircraft** operating at Davison Army Airfield is **1,500 Feet**.

This traffic pattern was designed to minimize noise complaints by incorporating the 12th Aviation Battalions "Fly Friendly Program".

The aviators are required to climb to the assigned traffic pattern altitude as quickly as possible on take off. The aircraft are tasked to avoid overflight of civilian houses as much as possible.