Bellingham International Airport Noise Study

HMMH Report No. 303270
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Prepared for:

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1 Study Description

This report presents the findings of a noise study conducted by Harris Miller Miller & Hanson Inc. (HMMH) for the Port of Bellingham (the Port) of existing conditions at Bellingham International Airport (BLI or the Airport). BLI is a single runway airport in Bellingham, WA approximately 14 miles south of the Canadian border and 80 miles north of Seattle. General aviation activity comprised the majority of the operations at BLI with more than half of the estimated 69,000 operations in 2008.

This study of existing conditions aircraft noise at BLI consists of two parts: a noise measurement program conducted on the dates of February 2-6, 2009 and computer modeling of existing (calendar year 2008) noise due to aircraft operations at BLI. This report begins with an introduction to aircraft noise terminology.

2 Introduction to Noise Evaluation

Noise is a very complex physical quantity. The properties, measurement, and presentation of noise involve specialized terminology that is often difficult to understand. This document will use graphics and everyday comparisons to communicate information on noise measurements and calculations of existing noise levels.

To provide a basic reference on these technical issues, this chapter provides an introduction to fundamentals of acoustics and noise terminology (Section 2.1), the effects of noise on human activity (2.2), community annoyance (2.3), and currently accepted noise-land use compatibility guidelines (2.4).

2.1 Introduction to Acoustics and Noise Terminology

Airport noise studies typically rely largely on a measure of cumulative noise exposure over an entire calendar year, in terms of a metric called the Day-Night Average Sound Level (DNL). However, DNL does not provide an adequate description of noise for many purposes. A variety of other measures are available to address essentially any issue of concern.

This chapter introduces the following acoustic metrics, which are all related to DNL, but provide bases for evaluating a broad range of noise situations.

- Decibel, dB;
- A-Weighted Decibel, dBA;
- Maximum A-Weighted Noise Level, L_{max}
- 2.1.5 Equivalent Sound Level, L_{eq};
- Sound Exposure Level, SEL; and
- Day-Night Average Sound Level, DNL.

2.1.1 The Decibel, dB

All sounds come from a sound source – a musical instrument, a voice speaking, or an airplane that passes overhead. It takes energy to produce sound. The sound energy produced by any sound source is transmitted through the air in sound waves – tiny, quick oscillations of pressure just above and just below atmospheric pressure. These oscillations, or sound pressures, impinge on the ear, creating the sound we hear.

Our ears are sensitive to a wide range of sound pressures. The loudest sounds that we hear without pain have about one million times more energy than the quietest sounds we hear. But our ears are incapable of detecting small differences in these pressures. Thus, to better match how we hear this sound energy, we compress the total range of sound pressures to a more meaningful range by introducing the concept of sound pressure level (SPL). Sound pressure level is a measure of the sound pressure of a given noise source relative to a standard reference value (typically the quietest sound that a young person with good hearing can detect). Sound pressure levels are measured in decibels (abbreviated dB). Decibels are logarithmic quantities – logarithms of the squared ratio of two pressures, the numerator being the pressure of the sound source of interest, and the denominator being the reference pressure (the quietest sound we can hear).

The logarithmic conversion of sound pressure to sound pressure level means that the quietest sound we can hear (the reference pressure) has a sound pressure level of about zero decibels, while the loudest sounds we hear without pain have sound pressure levels of about 120 dB. Most sounds in our day-to-day environment have sound pressure levels from 30 to 100 dB.

Because decibels are logarithmic quantities, they do not behave like regular numbers with which we are more familiar. For example, if two sound sources each produce 100 dB and they are operated together, they produce only 103 dB – not 200 dB as we might expect. Four equal sources operating simultaneously result in a total sound pressure level of 106 dB. In fact, for every doubling of the number of equal sources, the sound pressure level goes up another three decibels. A tenfold increase in the number of sources makes the sound pressure level go up 10 dB. A hundredfold increase makes the level go up 20 dB, and it takes a thousand equal sources to increase the level 30 dB!

If one source is much louder than another, the two sources together will produce the same sound pressure level (and sound to our ears) as if the louder source were operating alone. For example, a 100 dB source plus an 80 dB source produce 100 dB when operating together. The louder source “masks” the quieter one, but if the quieter source gets louder, it will have an increasing effect on the total sound pressure level. When the two sources are equal, as described above, they produce a level three decibels above the sound of either one by itself.

From these basic concepts, note that one hundred 80 dB sources will produce a combined level of 100 dB; if a single 100 dB source is added, the group will produce a total sound pressure level of 103 dB. Clearly, the loudest source has the greatest effect on the total

2.1.2 A-Weighted Decibel, dBA

Another important characteristic of sound is its frequency, or "pitch". This is the rate of repetition of the sound pressure oscillations as they reach our ear. Formerly expressed in cycles per second, frequency is now expressed in units known as Hertz (Hz).

Most people hear from about 20 Hz to about 10,000 to 15,000 Hz. People respond to sound most readily when the predominant frequency is in the range of normal conversation, around 1,000 to 2,000 Hz. Acousticians have developed "filters" to match our ears' sensitivity and help us to judge the relative loudness of sounds made up of different frequencies. The so-called "A" filter does the best job of matching the sensitivity of our ears to most environmental noises. Sound pressure levels measured through this filter are referred to as A-weighted levels (dBA). A-weighting significantly de-emphasizes noise at low and high frequencies (below about 500 Hz and above about 10,000 Hz) where we do not hear as well. Because this filter generally matches our ears' sensitivity, sounds having higher A-weighted sound levels are usually judged to be louder than those with lower A-weighted sound levels, a relationship which does not always hold true for unweighted levels. It is for these reasons that A-weighted sound levels are normally used to evaluate environmental noise.

Other weighting networks include the B, C, and D filters. They correspond to four different level ranges of the ear. The rarely used B-weighting attenuates low frequencies (those less than 500 Hz), but to a lesser degree than A-weighting. C weighting is nearly flat throughout the audible frequency range, hardly de-emphasizing low frequency noise. C-weighted levels can be preferable in evaluating sounds whose low-frequency components are responsible for secondary effects such as the shaking of a building, window rattle, or perceptible vibrations. Uses include the evaluation of blasting noise, artillery fire, and in some cases, aircraft noise inside buildings.

The D-weighting network, also used only rarely, is similar to the B-weighting at low frequencies, but includes a significant amplification of the sound (up to about 10 dB) in the 2,000 to 8,000 Hz range.

Figure 1 compares these various weighting networks.

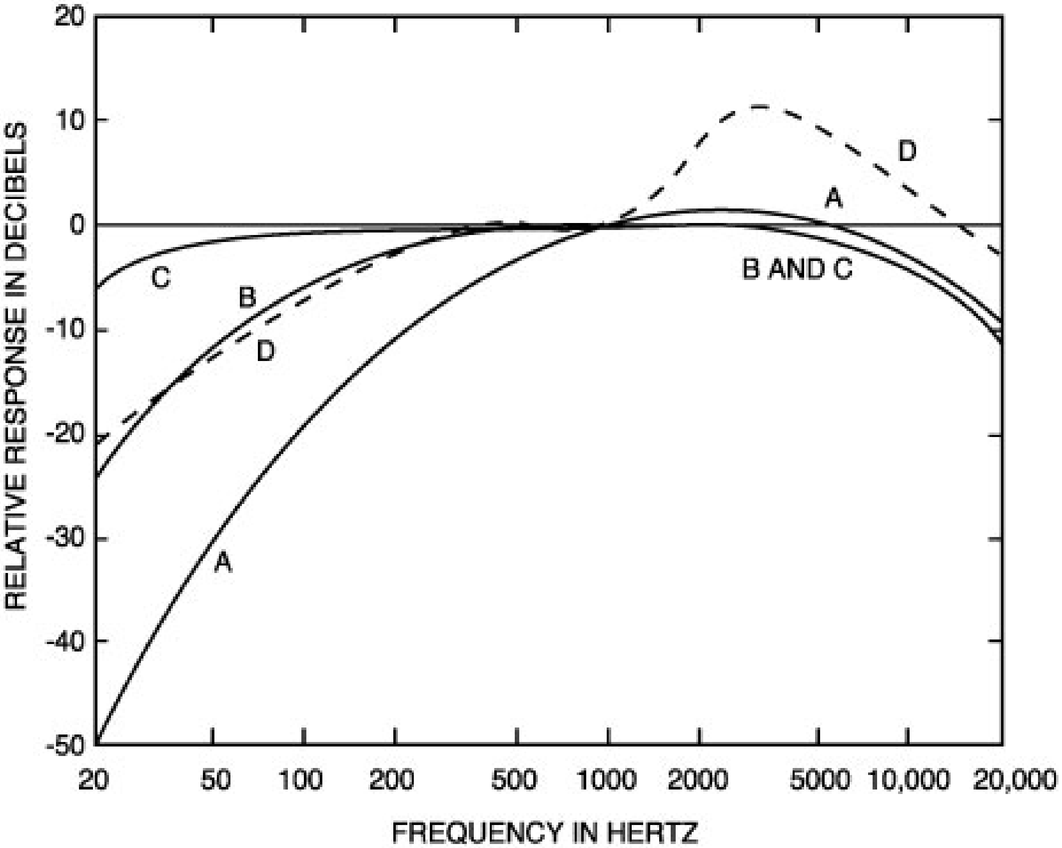


Figure 1 Frequency-Response Characteristics of Various Weighting Networks

Source: Harris, Cyril M., editor; Handbook of Acoustical Measurements and Noise Control, (Chapter 5, "Acoustical Measurement Instruments"; Johnson, Daniel L.; Marsh, Alan H.; and Harris, Cyril M.); New York; McGraw-Hill, Inc.; 1991; p. 5.13

Because of the correlation with our hearing, the A-weighted level has been adopted as the basic measure of environmental noise by the U.S. Environmental Protection Agency (EPA) and by nearly every other federal and state agency concerned with community noise. Figure 2 presents typical A-weighted sound levels of several common environmental sources.

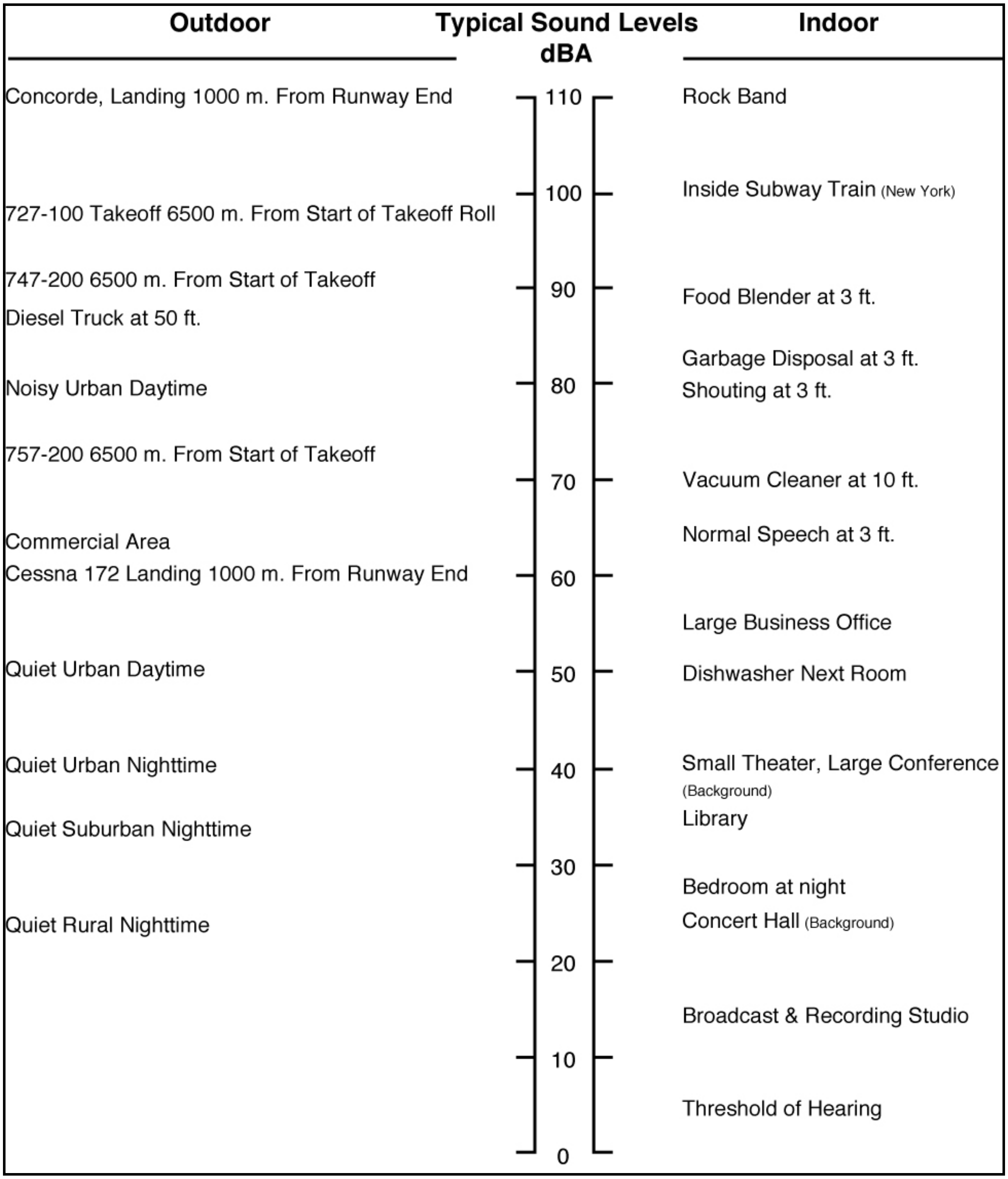


Figure 2 Common Environmental Sound Levels, in dBA

Source: HMMH (Aircraft noise levels from FAA Advisory Circular 36-3G)

An additional dimension to environmental noise is that A-weighted levels vary with time. For example, the sound level increases as an aircraft approaches, then falls and blends into the background as the aircraft recedes into the distance (though even the background varies as birds chirp or the wind blows or a vehicle passes by). Figure 3 illustrates this concept.

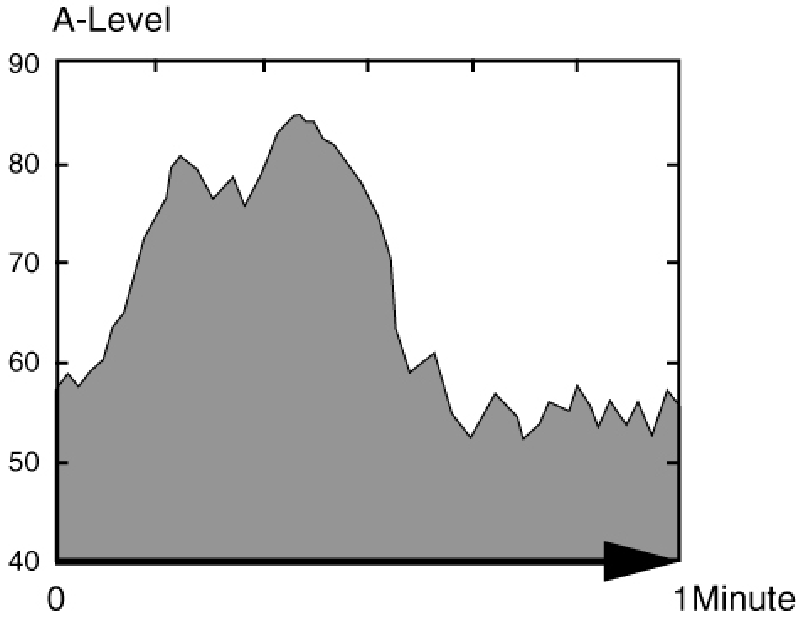


Figure 3 Variations in the A-Weighted Sound Level Over Time

Source: HMMH

2.1.3 Maximum A-Weighted Noise Level, L_{max}

The variation in noise level over time often makes it convenient to describe a particular noise "event" by its maximum sound level, abbreviated as $L_{max.}$ In the figure above, it is approximately 85 dBA.

The maximum level describes only one dimension of an event; it provides no information on the cumulative noise exposure. In fact, two events with identical maxima may produce very different total exposures. One may be of very short duration, while the other may continue for an extended period and be judged much more annoying. The next measure corrects for this deficiency.

2.1.4 Sound Exposure Level, SEL

The most frequently used measure of noise exposure for an individual aircraft noise event (and the measure that Part 150 specifies for this purpose) is the Sound Exposure Level, or SEL. SEL is a measure of the total noise energy produced during an event, from the time when the A-weighted sound level first exceeds a threshold level (normally just above the background or ambient noise) to the time that the sound level drops back down below the threshold. To allow comparison of noise events with very different durations, SEL “normalizes” the duration in every case to one second; that is, it is expressed as the steady noise level with just a one-second duration that includes the same amount of noise energy as the actual longer duration, time-varying noise. In lay terms, SEL “squeezes” the entire noise event into one second.

Figure 4 depicts this transformation. The shaded area represents the energy included in an SEL measurement for the noise event, where the threshold is set to 60 dBA. The darkly shaded vertical bar, which is 90 dBA high and just one second long (wide), contains exactly the same sound energy as the full event.

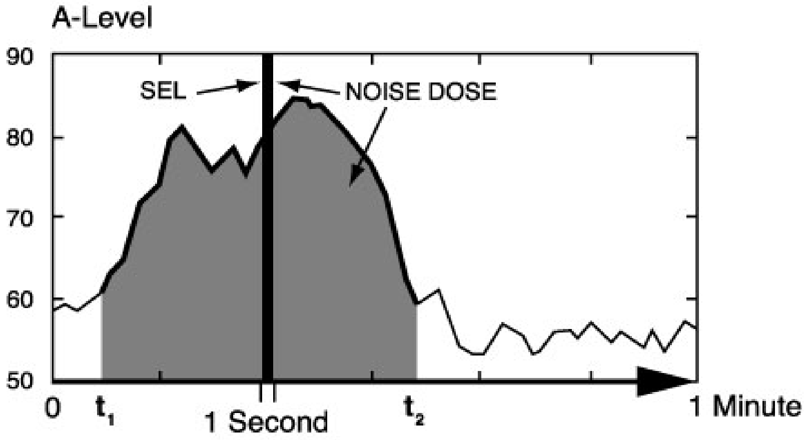


Figure 4 Sound Exposure Level

Source: HMMH

Because the SEL is normalized to one second, it will always be larger than the L_{max} for an event longer than one second. In this case, the SEL is 90 dB; the L_{max} is approximately 85 dBA. For most aircraft overflights, the SEL is normally on the order of 7 to 12 dB higher than L_{max}. Because SEL takes duration into account, longer exposure to relatively slow, quiet aircraft, such as propeller models, can have the same or higher SEL than shorter exposure to faster, louder planes, such as corporate jets.

Aircraft noise models use SEL as the basis for computing exposure from multiple events. The original Part 150 study used SEL contours as a basis for analyzing the single event benefits of noise abatement measures. This study will also study SEL contours in this manner.

2.1.5 Equivalent Sound Level, L_{eq}

The L_{max} and SEL quantify the noise associated with individual events. The remaining metrics in this section describe longer-term cumulative noise exposure that can include many events.

The Equivalent Sound Level (L_{eq}) is a measure of exposure resulting from the accumulation of A-weighted sound levels over a particular period of interest; for example, an hour, an eight hour school day, nighttime, or a full 24-hour day. Because the length of the period can differ, the applicable period should always be identified or clearly understood when discussing the metric. Such durations are often identified through a subscript, for example $L_{eq(8)}$ or $L_{eq(24)}$.

L_{eq} is equivalent to the constant sound level over the period of interest that contains as much sound energy as the actual time-varying level. This is illustrated in Figure 5. Both the solid and striped shaded areas have a one-minute L_{eq} value of 76 dB. It is important to recognize, however, that the two signals (the constant one and the time-varying one) would sound very different in real life. Also, be aware that the "average" sound level suggested by L_{eq} is not an arithmetic value, but a logarithmic, or "energy-averaged" sound level. Thus, loud events dominate L_{eq} measurements.

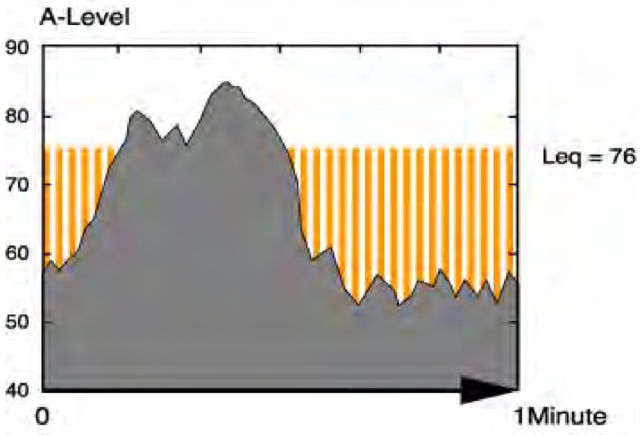


Figure 5 Example of a One Minute Equivalent Sound Level

Source: HMMH

In airport noise studies, L_{eq} is often presented for consecutive one-hour periods to illustrate how the exposure rises and falls throughout a 24-hour period, and how individual hours are affected by unusual activity, such as rush hour traffic or a few loud aircraft.

2.1.6 Day-Night Average Sound Level, DNL

The Day-Night Average Sound Level, DNL, is a slightly more complicated measure of noise exposure which describes cumulative noise exposure during an average annual day. The U.S. Environmental Protection Agency identified DNL as the most appropriate means of evaluating airport noise based on the following considerations (from "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," U. S. EPA Report No. 550/9-74-004, September 1974):

1. The measure should be applicable to the evaluation of pervasive long-term noise in various defined areas and under various conditions over long periods of time.
2. The measure should correlate well with known effects of the noise environment and on individuals and the public.
3. The measure should be simple, practical and accurate. In principal, it should be useful for planning as well as for enforcement or monitoring purposes.
4. The required measurement equipment, with standard characteristics, should be commercially available.
5. The measure should be closely related to existing methods currently in use.
6. The single measure of noise at a given location should be predictable, within an acceptable tolerance, from knowledge of the physical events producing the noise.
7. The measure should lend itself to small, simple monitors, which can be left unattended in public areas for long periods of time.

Most federal agencies dealing with noise have formally adopted DNL. The Federal Interagency Committee on Noise (FICON) reaffirmed the appropriateness of DNL in 1992. The FICON summary report stated; "There are no new descriptors or metrics of sufficient scientific standing to substitute for the present DNL cumulative noise exposure metric."

In simple terms, DNL is the average noise level over a 24-hour period except that noises occurring at night (defined as 10:00 p.m. through 7:00 a.m.) are artificially increased by 10 dB. This weighting reflects the added intrusiveness of nighttime noise events attributable to the fact that community background noise levels decrease at night.

DNL can be measured or estimated. Measurements are practical only for obtaining DNL values for relatively limited numbers of points, and, in the absence of a permanently installed monitoring system, only for relatively short time periods. Most airport noise studies are based on computer-generated DNL estimates, depicted in terms of equal-exposure noise contours (much as topographic maps have contours of equal elevation).

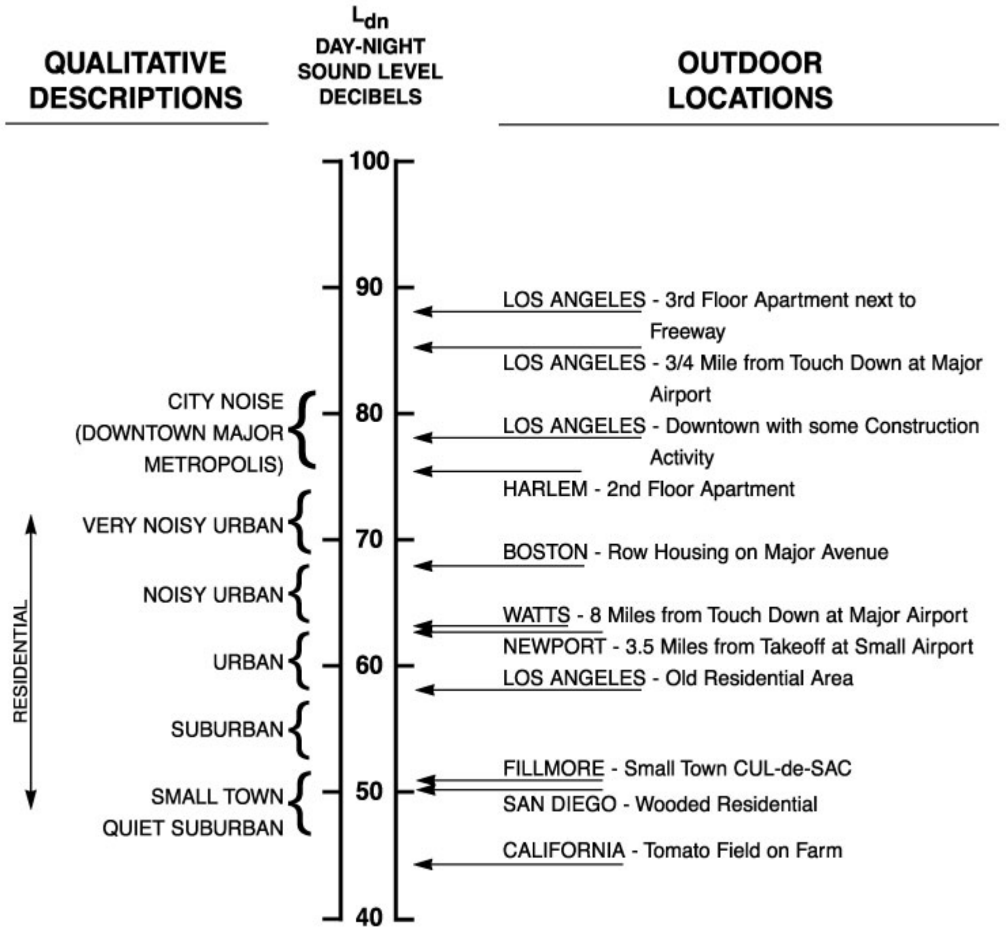


Figure 6 Examples of Day-Night Average Sound Levels, DNL

Source: United States Environmental Protection Agency, Information on Levels Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, March 1974, p. 14.

2.2 The Effects of Aircraft Noise on People

To residents around airports, aircraft noise can be an annoyance and a nuisance. It can interfere with conversation and listening to television, it can disrupt classroom activities in schools, and it can disrupt sleep. Relating these effects to specific noise metrics helps in the understanding of how and why people react to their environment.

2.2.1 Speech Interference

A primary effect of aircraft noise is its tendency to drown out or "mask" speech, making it difficult to carry on a normal conversation. The sound level of speech decreases as the distance between a talker and listener increases. As the background sound level increases, it becomes harder to hear speech. Figure 1 presents typical distances between talker and listener for satisfactory outdoor conversations, in the presence of different steady A-weighted background noise levels for raised, normal, and relaxed voice effort. As the background level increases, the talker must raise his/her voice, or the individuals must get closer together to continue talking.

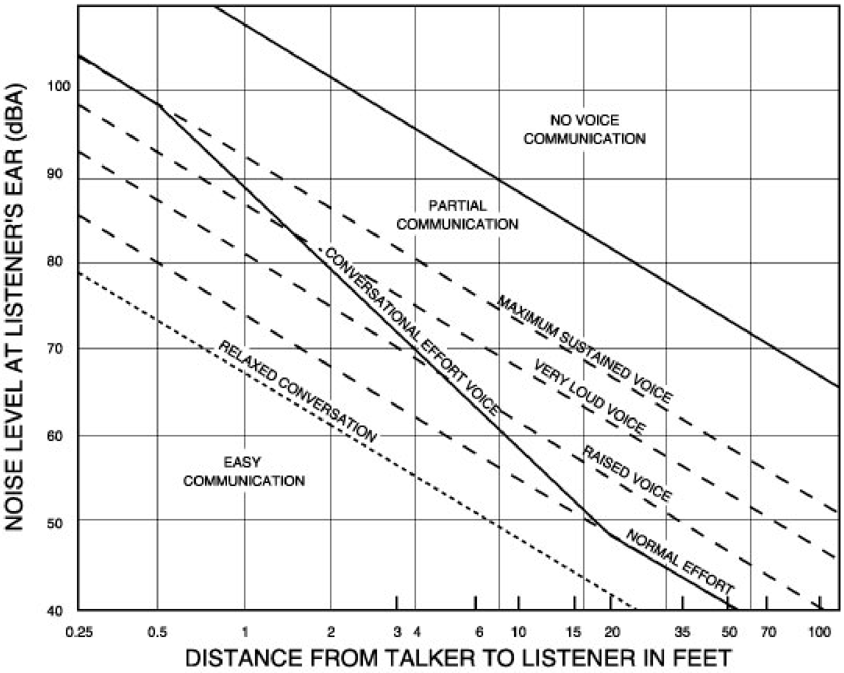


Figure 7 Outdoor Speech Intelligibility

Source: United States Environmental Protection Agency, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, March 1974, p. D-5.

As indicated in the figure, "satisfactory conversation" does not always require hearing every word; 95% intelligibility is acceptable for many conversations. Listeners can infer a few unheard words when they occur in a familiar context. However, in relaxed conversation, we have higher expectations of hearing speech and require generally require closer to 100% intelligibility. Any combination of talker-listener distances and background noise that falls below the bottom line in Figure 1.7 (thus assuring 100% intelligibility) represents an ideal environment for outdoor speech communication and is considered necessary for acceptable indoor conversation as well.

One implication of the relationships in Figure 7 is that for typical communication distances of 3 or 4 feet (1 to 1.5 meters), acceptable outdoor conversations can be carried on in a normal voice as long as the background noise outdoors is less than about 65 dBA. If the noise exceeds this level, as might occur when an aircraft passes overhead, intelligibility would be lost unless vocal effort were increased or communication distance were decreased.

Indoors, typical distances, voice levels, and intelligibility expectations generally require a background level less than 45 dBA. With windows partly open, housing generally provides about 12 dBA of interior-to-exterior noise level reduction. Thus, if the outdoor sound level is 60 dBA or less, there a reasonable chance that the resulting indoor sound level will afford acceptable conversation inside. With windows closed, 24 dB of attenuation is typical.

2.2.2 Sleep Interference

Research on sleep disruption from noise has led to widely varying observations. In part, this is because (1) sleep can be disturbed without awakening, (2) the deeper the sleep the more noise it takes to cause arousal, (3) the tendency to awaken increases with age, and other factors.

Figure 8 shows a recent summary of findings on the topic.

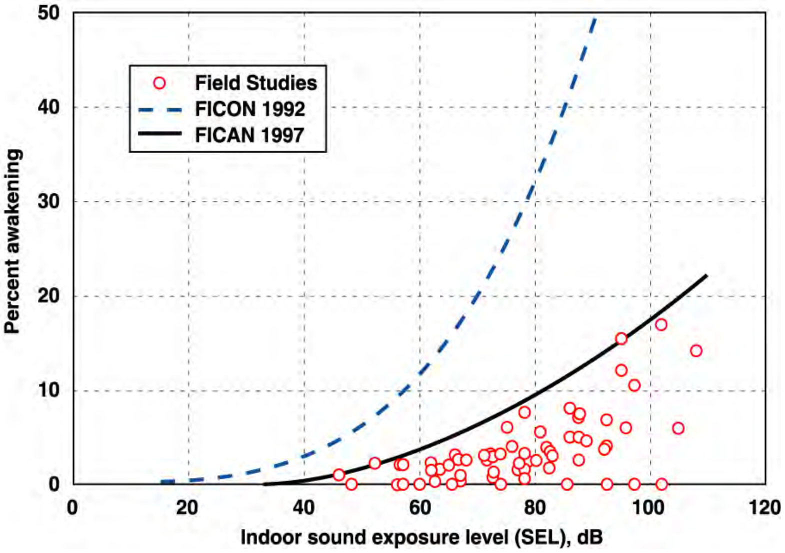


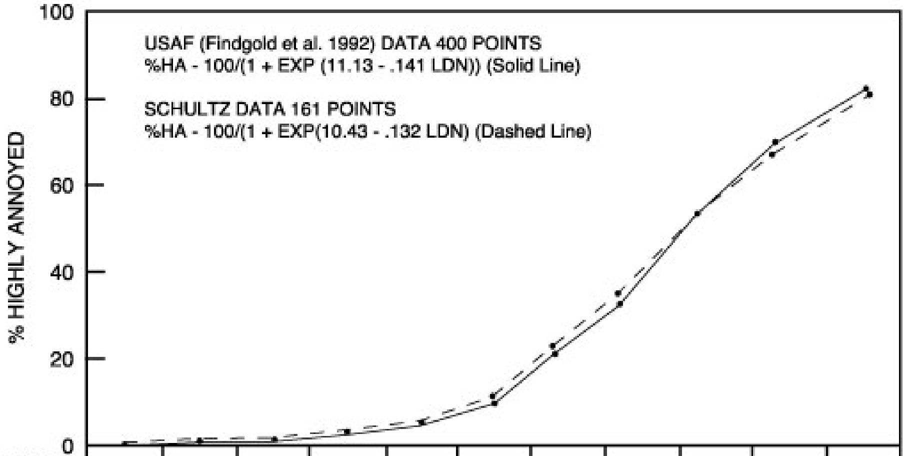
Figure 8 Sleep Interference

Source: Federal Interagency Committee on Aviation Noise (FICAN), "Effects of Aviation Noise on Awakenings from Sleep", June 1997, page 6.

Figure 8 uses indoor SEL as the measure of noise exposure; recent work supports the use of this metric in assessing sleep disruption. An indoor SEL of 80 dB results in a maximum of 10% awakening. Assuming the typical windows-open interior-to-exterior noise level reduction of approximately 12 dB, and a typical L_{max} value for an aircraft flyover 12 dB lower than the SEL value, an interior SEL of 80 dB roughly translates into an exterior L_{max} of the same value.

2.3 Community Annoyance

Social survey data make it clear that individual reactions to noise vary widely for a given noise level. Nevertheless, as a group, people's aggregate response is predictable and relates well to measures of cumulative noise exposure such as DNL. Figure 9 shows the most widely recognized relationship between environmental noise and annoyance.



Day - Night Average Sound Level in dB		40	45	50	55	60	65	70	75	80	85	100
Calculated %HA Points	USAF	0.41	0.831	1.66	3.31	6.48	12.29	22.1	36.47	53.74	70.16	82.64
	SCHULTZ	0.576	1.11	2.12	4.03	7.52	13.59	23.32	37.05	53.25	68.78	81

Figure 9 Percentage of People Highly Annoyed

Source: Federal Interagency Committee on Noise. "Federal Agency Review of Selected Airport Noise Analysis Issues". August 1992. (From data provided by USAF Armstrong Laboratory). pp. 3-6.

Based on data from 18 surveys conducted worldwide, the curve indicates that at levels as low as DNL 55, approximately five percent of the people will still be highly annoyed, with the percentage increasing more rapidly as exposure increases above DNL 65.

Separate work by the EPA has shown that overall community reaction to a noise environment is also dependent on DNL. This relationship is shown in Figure 10. Levels have been normalized to the same set of exposure conditions to permit valid comparisons between ambient noise environments. Data summarized in that figure suggest that little reaction would be expected for intrusive noise levels five decibels below the ambient, while widespread complaints can be expected as intruding noise exceeds background levels by about five decibels. Vigorous action is likely when the background is exceeded by 20 dB.

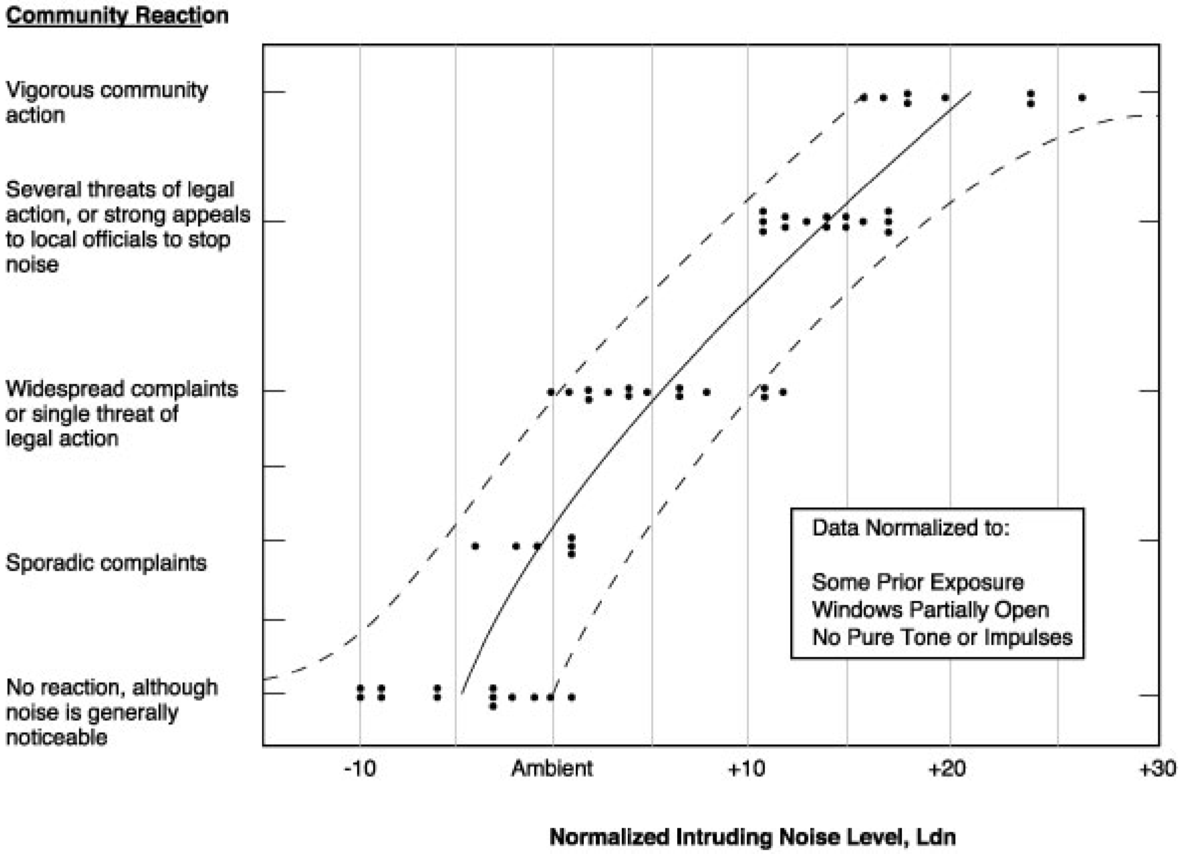


Figure 10 Community Reaction as a Function of Outdoor DNL

Source: Wyle Laboratories, Community Noise, prepared for the U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Washington, D.C. 20406, December 1971, page 63.

2.4 Noise / Land Use Compatibility Guidelines

FAR Part 150 specifies noise/land use compatibility guidelines which are used in many noise studies. Part 150 specifically notes that responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities.

These guidelines represent a compilation of the results of extensive scientific research into noise-related activity interference and attitudinal response. However, reviewers should recognize the highly subjective nature of response to noise, and that special circumstances can affect individuals' tolerance. For example, a high non-aircraft background noise level can reduce the significance of aircraft noise, such as in areas constantly exposed to relatively high levels of traffic noise. Alternatively, residents of areas with unusually low background levels may find relatively low levels of aircraft noise annoying.

Response may also be affected by expectation and experience. People may get used to a level of exposure that guidelines indicate may be unacceptable, and changes in exposure may generate response that is far greater than that which the guidelines might suggest.

The cumulative nature of DNL means that the same level of noise exposure can be achieved in an essentially infinite number of ways. For example, a reduction in a small number of relatively noisy operations may be counterbalanced by a much greater increase in relatively quiet flights, with no net change in DNL. Residents of the area may be highly annoyed by the increased frequency of operations, despite the seeming maintenance of the noise status quo.

With these cautions in mind, the Part 150 guidelines can be applied to the DNL contours to identify the potential types, degrees and locations of incompatibility. Measurement of the land areas and populations within each noise contour can provide a quantitative measure of impact.

Part 150 guidelines indicate that all uses normally are compatible with aircraft noise at exposure levels below 65 DNL. This limit is supported in a formal way by standards adopted by the U. S. Department of Housing and Urban Development (HUD). The HUD standards address whether sites are eligible for Federal funding support. These standards, set forth in Part 51 of the Code of Federal Regulations, define areas with DNL exposure not exceeding 65 dB as acceptable for funding. Areas exposed to noise levels between DNL 65 and 75 are "normally unacceptable," and require special abatement measures and review. Those at 75 and above are "unacceptable" except under very limited circumstances.

Part 150 permits airports and local land use control jurisdictions to adopt land use compatibility criteria that differ from the guidelines reproduced in Table 1.

Table 1 FAR Part 150 Noise / Land Use Compatibility Guidelines

Source: FAR Part 150, Appendix A, Table 1

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

Key to Table 1:

SLCUM: Standard Land Use Coding Manual.

Y (Yes): Land use and related structures compatible without restrictions.

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

NLR: Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.

25, 30, or 35: Land use and related structures generally compatible; measures to achieve NLR of 25, 30, or 35 dB must be incorporated into design and construction of structure.

Notes for Table 1
The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable or unacceptable under Federal, State, or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

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

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

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

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

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

(6) Residential buildings require an NLR of 25.

(7) Residential buildings require an NLR of 30

(8) Residential buildings not permitted.

3 Noise Measurement Program

In February of 2009, HMMH collected noise measurements at three sites in the BLI environment. The program began on February 2 and ended on February 6. The program included both attended and un-attended monitoring with measurements of hourly, daily, and single event noise levels.

3.1.1 Noise Measurement Site Selection

Table 2 lists the measurement locations, the dates and times of measurements, and the number of hours of monitoring. A total of over 160 hours of measurements were conducted at the 3 locations. Figure 11 displays the noise measurement sites.

Table 2 Summary of Noise Measurement Sites

Site #	Address	Start		End		Hours Monitored
		Date	Time	Date	Time	
1	3935 Cliffside Dr, Bellingham, WA 98225	2/2/2009	2:00 PM	2/6/2009	2:20 PM	70[1]
2	2767 Lummi Shore Dr Bellingham, WA 98226	2/2/2009	3:20 PM	2/3/2009	3:24 PM	24
3	1033 Sunset Ave Bellingham, WA 98226	2/3/2009	5:20 PM	2/6/2009	1:39 PM	68

3.1.2 Noise measurement equipment, staffing, and procedure

All noise measurements were conducted with HMMH-owned Larson-Davis Model 870 ("LD 870") noise monitors. These instruments are portable devices capable of long-term unattended operation, and meet American National Standards Institute (ANSI) S1.4-1983 standards for Type I "precision" sound level meters, that meet or exceed accuracy requirements outlined in FAR Part 150 paragraph A150.5. HMMH staff calibrated the equipment in the field before and after each of the measurements. These calibrations are traceable to the United States National Institute of Standards and Technology ("NIST", formerly the National Bureau of Standards).

The LD870 was programmed to record integrated levels, such as L_{eq} and DNL, and maximum single event levels, L_{max}. Section 2.1introduces these metrics. All measurements were A-weighted, as discussed in Section 2.1.2.

The units operated on a 24-hour basis during the five-day measurement session, with breaks for relocation, battery changes, calibrations, and other basic maintenance requirements. One HMMH staff member conducted the measurements. To the extent feasible during daylight hours, the staff spent time at the portable monitoring locations, on a rotating basis, to observe and log aircraft and non-aircraft noise-producing events, weather data, and other relevant information.

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[1] The monitor at site 1 experienced power failures for two periods on February 3rd and 4th which resulted in the loss data for a total of 17 hours (not included in the 70 hours).

Figure 11 Noise Measurement Sites

3.2 Day-Night Average Sound Level Results

Table 3 summarizes the DNL measurement results for the three noise measurement locations during the period from February 2nd through February 6th.

Table 3 Summary of Day-Night Average Sound Level, DNL, Measurements

Site #	Daily DNL (dBA)					Avg. DNL (dBA)
	Mon. 2/2	Tue. 2/3	Wed. 2/4	Thu. 2/5	Fri. 2/6	
1	55	55	64	56	53	61
2	64	66	-	-	-	66
3	-	63	70	66	64	68

3.3 Site-by-site results

This section provides site-by-site discussion of the portable monitoring results. For Sites 1 through 3, measurement results include single event results, in terms of L_{max}, and cumulative exposure, in terms of hourly L_{eq} and DNL. The summaries present the L_{max} and hourly L_{eq} in graphical form, as described below.

3.3.1 Presentation of L_{max} Measurements

L_{max} measurements provide a basis for comparing noise produced by aircraft and non-aircraft sources at a site, and for comparing single event levels among sites. For each measurement location, there is a figure that presents L_{max} data in a “box and whisker” form. The ranges of L_{max} values for observed aircraft operations are displayed with “whiskers” showing the highest and lowest values and the “box” representing the mean value. These figures provide a visual basis for comparing levels caused by different aircraft types and different types of aircraft operations, and for comparing sound levels at different sites. The figures group the aircraft data by type of operations (i.e., arrival, departure, and overflight) and by major aircraft type categories. The aircraft type categories include:

- “Prop” – Piston powered aircraft.
- “Turbo Prop” – Turbine powered aircraft.
- “Commercial Jet” – Large air carrier type jets used in scheduled passenger service.
- “GA Jet” – Smaller (general aviation) jets.
- “Helicopter” – Helicopter flight operations.

3.3.2 Presentation of Hourly L_{eq} Results

Each site discussion also includes figures that graphically present hourly Leq results and states the DNL for each calendar day during which measurements were performed at the site. For any days with less than 24 hours of data, the DNL estimate is based on the proper weighting of the available day and night hours. The hours indicated on the figures represent the starting time of the measurement interval; e.g., hour 10 is the hour starting at 10 am. The figures use a 24-hour clock (“military time”), where the hour starting at midnight is hour 0, 2 pm is 14, through the hour starting at 11 pm which is hour 23.

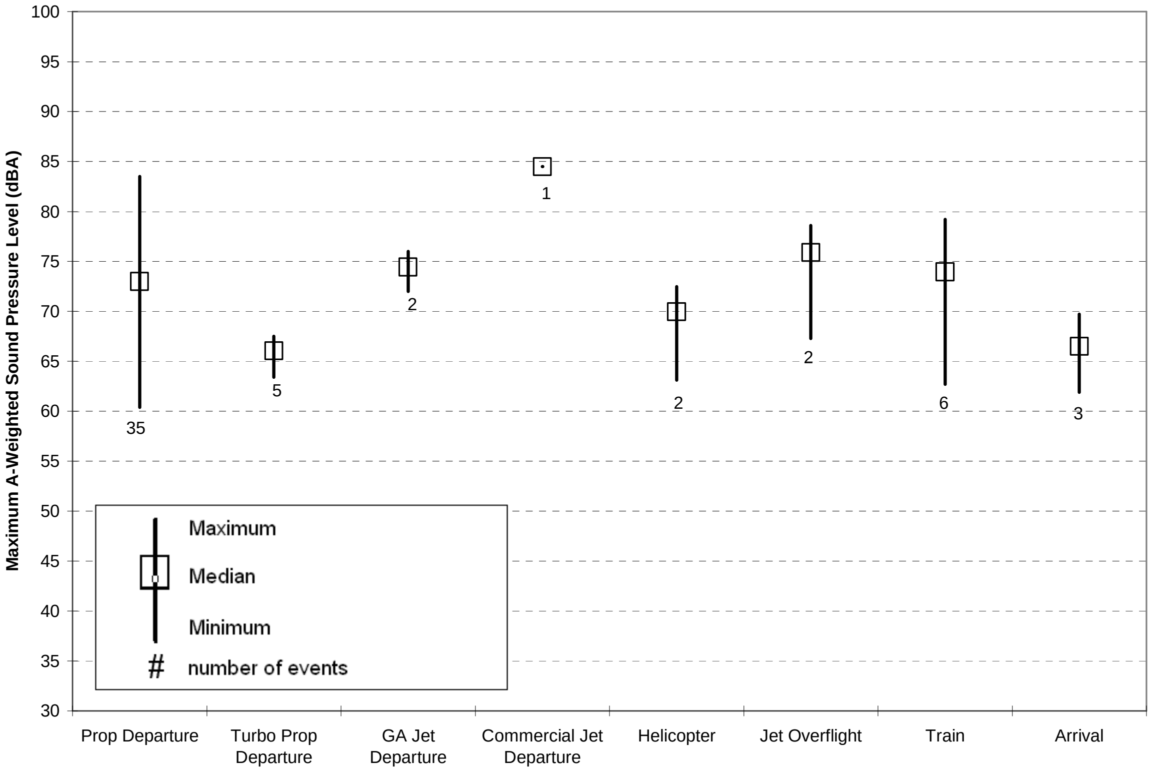
3.3.3 Site 1: 3935 Cliffside Dr, Bellingham, WA 98225

This measurement site is located approximately 2,400 feet southwest of the south end of Runway 16/34 and roughly 1,500 feet west of the extended centerline of Runway 16/34. The principal aircraft operations affecting the site during the measurements were departures from Runway 16

As shown in Figure 12, jet departures generally produced the highest noise levels for aircraft events. Passing trains generated the highest noise levels for non-aircraft noise events.

Figure 13 presents the hourly noise levels at Site 1. The hourly L_{eq} ranged from 37 to 74 dBA.[2] The lowest levels were recorded during the late night and early morning hours. The measured DNL for Site 1 was 61 dBA.[3]

Figure 12 Site 1 Maximum A-Weighted Levels
Source: HMMH February 2009



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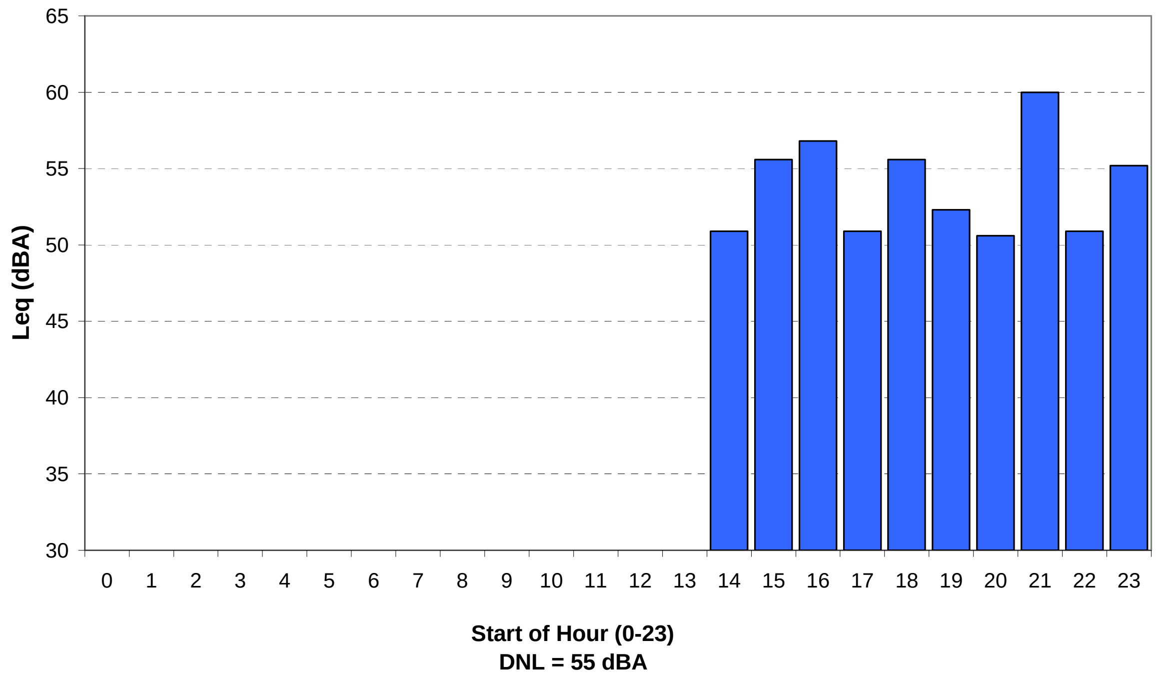
[2] The 10:00 PM hour of 2/4/2009 had a L_{eq} of 74 dBA due to an exceptionally loud and long noise event. The next highest hourly L_{eq} was 60.5 dBA.

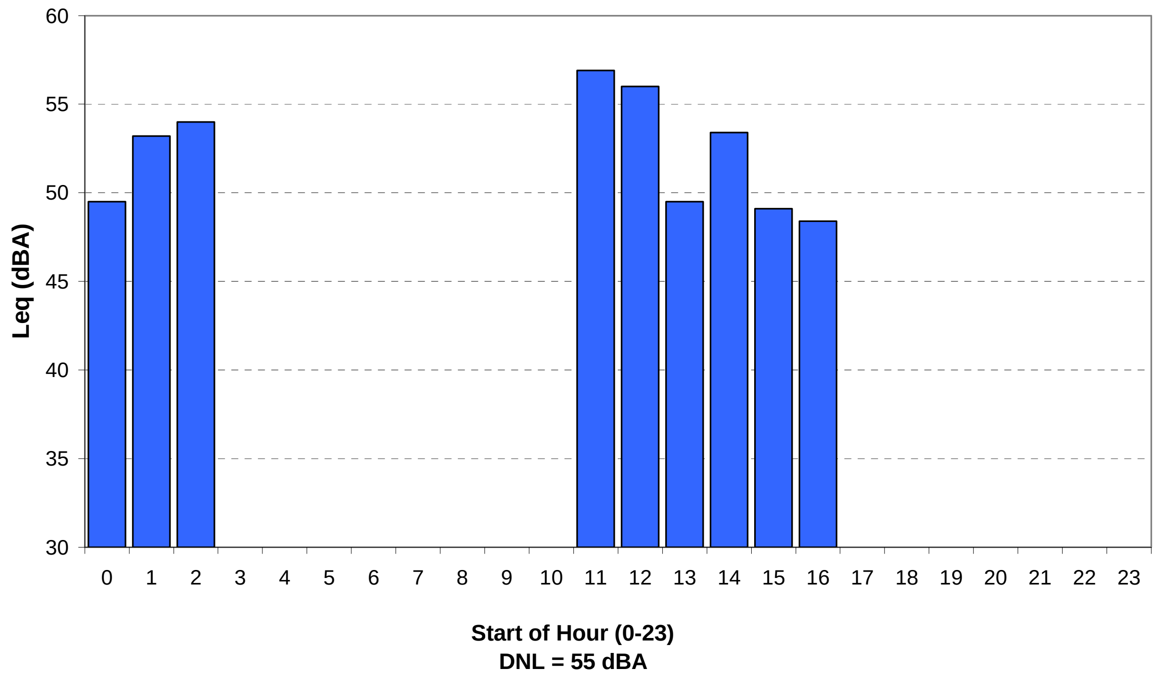
[3] The measured DNL at Site 1 for the entire measurement period, excluding the exceptional noise event during the 10:00 PM hour of 2/4/2009, was 55 dBA.

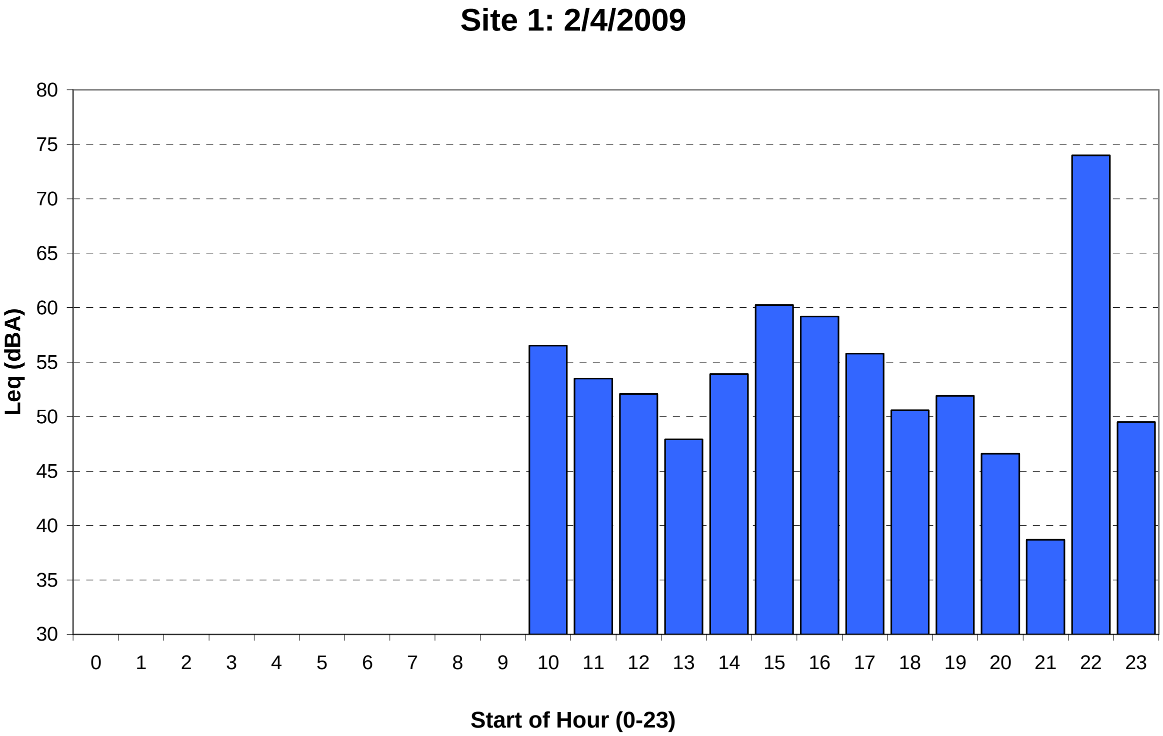
Figure 13 Site 1 Measured Hourly Noise Levels (L_{eq})
Source: HMMH February 2009

Site 1: 2/2/2009

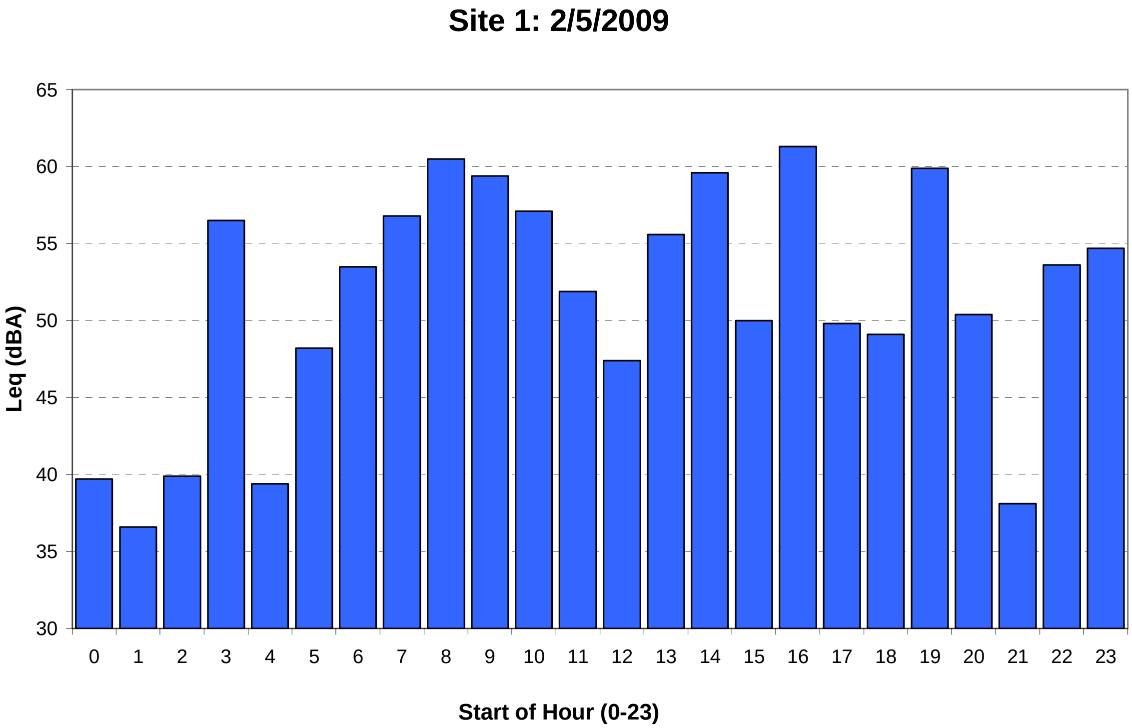


Site 1: 2/3/2009

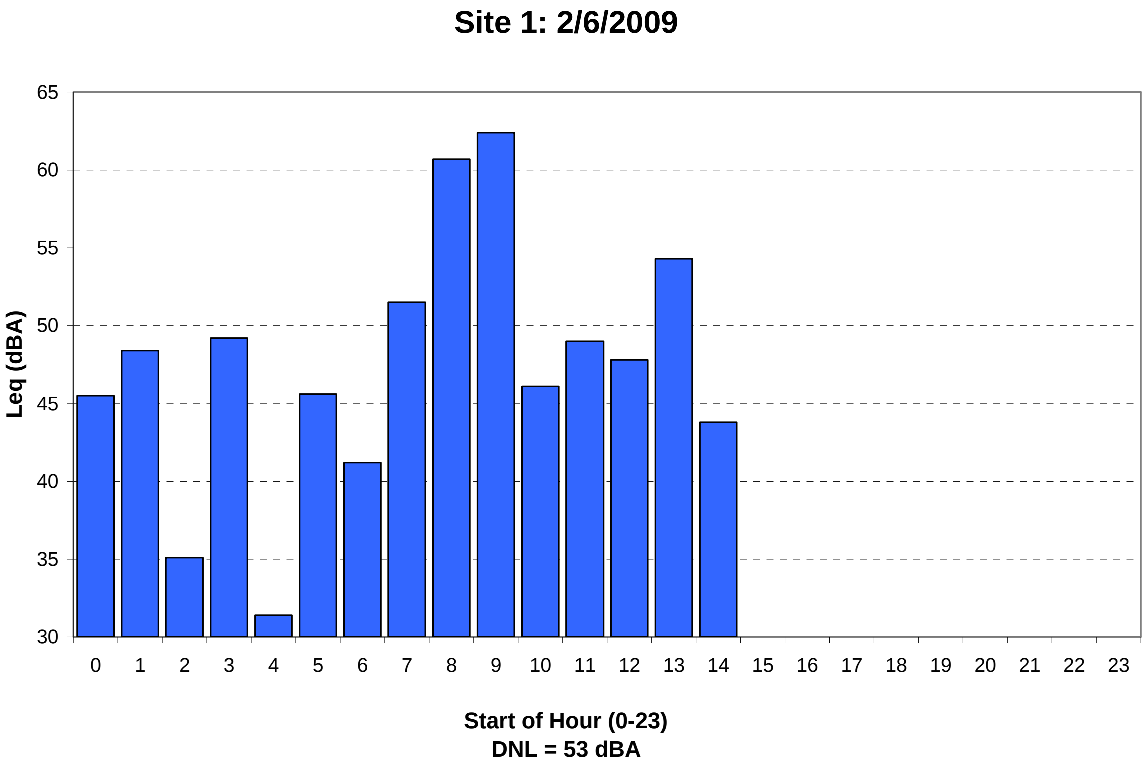




DNL =64 dBA



DNL = 56 dBA


Site 1: 2/6/2009
Leq (dBA)
65
60
55
50
45
40
35
30
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Start of Hour (0-23)
DNL = 53 dBA

3.3.4 Site 2: 2767 Lummi Shore Dr. Bellingham, WA 98226

This measurement site is located approximately five and one half miles southwest of the center of the airport and roughly four and one quarter miles west of the extended centerline of Runway 16/34.

The principal aircraft operations affecting the site during the measurements were arrivals to Runway 16 approaching from the south. As shown in Figure 14, a jet overflight produced the highest noise level of the observed aircraft events. Motor traffic accounts for the highest number of noise events. During the attended measurements, noise from vehicle traffic was pervasive with background levels continuously in the high 50's to high 60's. Only the louder events are noted in the figure below.

Figure 15 displays the hourly noise levels measured at Site 2. The hourly L_{eq} ranged from 59 to 72 dBA. The lowest levels were recorded during the late night and early morning hours.

The measured DNL for Site 2 was 66 dBA. Note that this reflects all noise sources including vehicle traffic. The minimum level during the measurement period was approximately 52 dBA.

Figure 14 Site 2 Maximum A-Weighted Levels

Source: HMMH February 2009

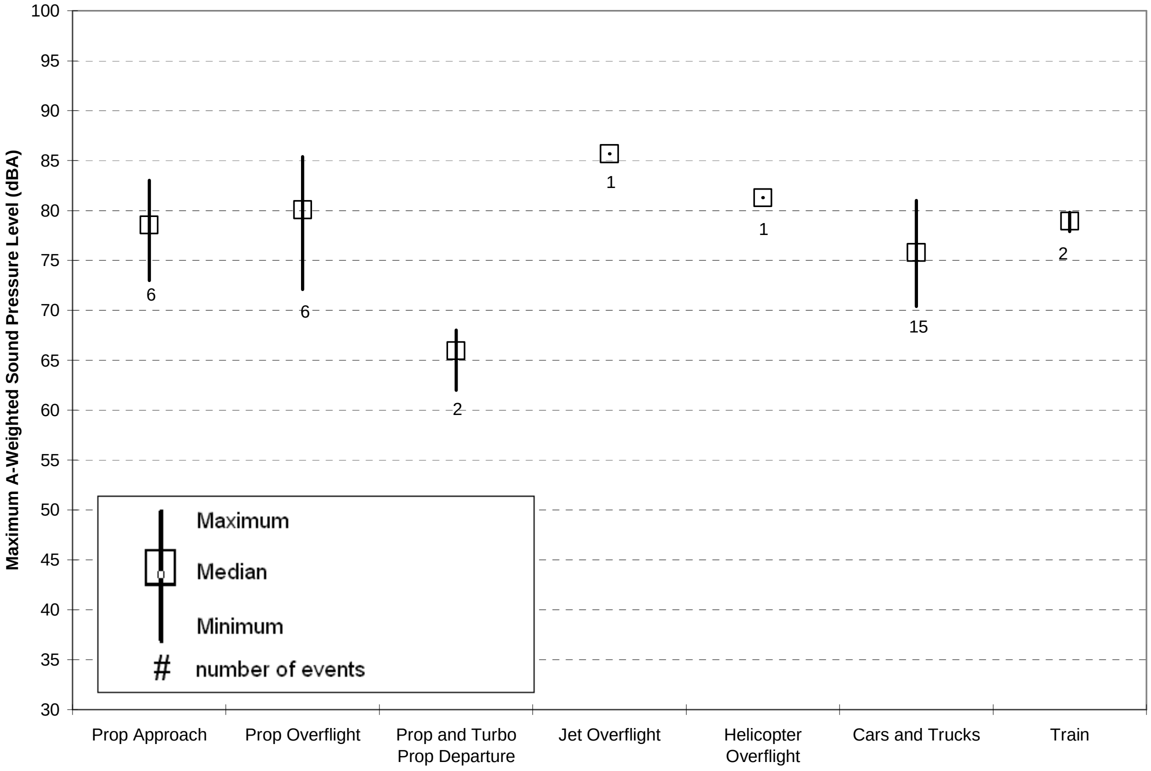
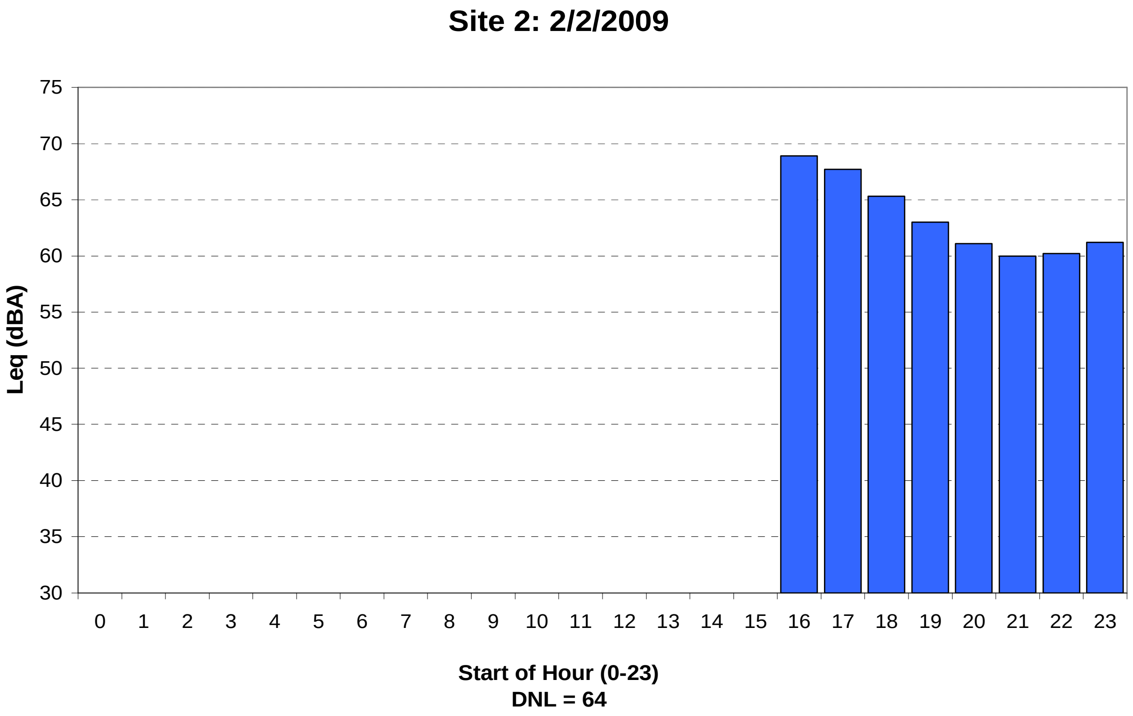
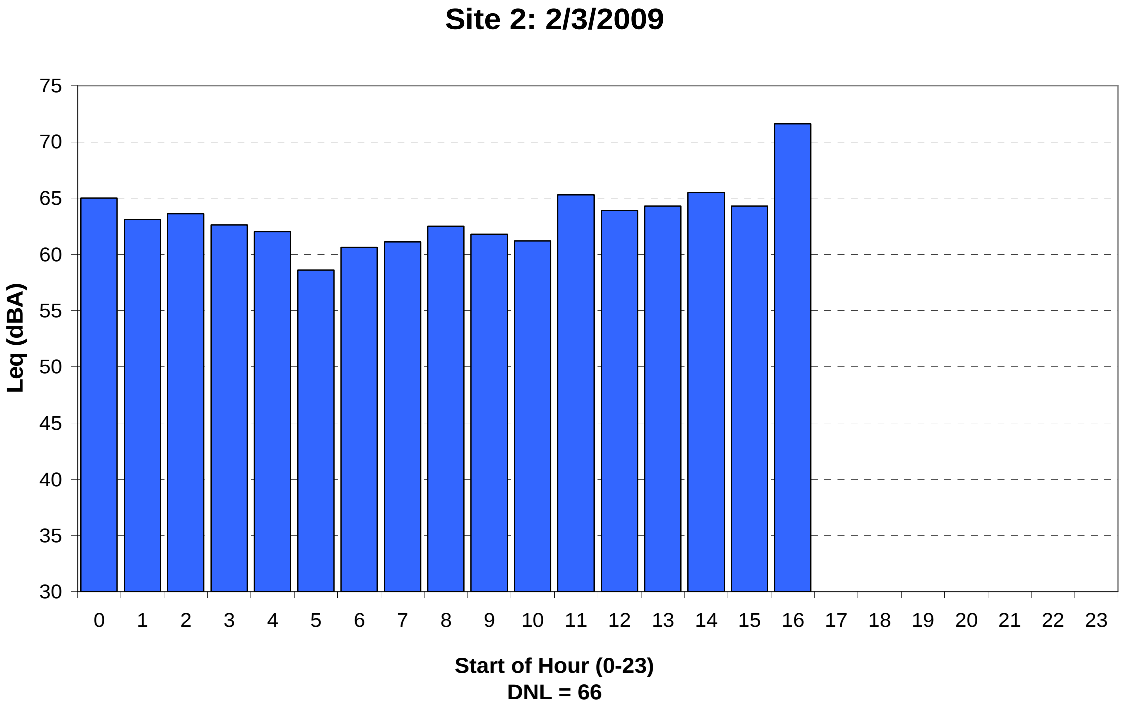


Figure 15 Site 2 Measured Hourly Noise Levels (L_{eq})
Source: HMMH February 2009





3.3.5 Site 3: 1033 Sunset Ave, Bellingham, WA 98226

This measurement site is located approximately 7,400 feet north of the north end of Runway 16/34 and roughly 380 feet west of the extended centerline of Runway 16/34.

The principal aircraft operations affecting the site during the measurements were approaches to Runway 16. As shown in Figure 16, a commercial jet arrival produced the highest noise level for the observed aircraft events. Background levels at this site include noise from vehicle traffic on I-5. Ambient levels during observed periods routinely reached the mid-60’s with minimum levels in many hours in the high 50’s to low 60’s. Only louder individual vehicle events are included in the chart below.

Figure 17 displays the measured hourly noise levels for Site 3. The hourly L_{eq} ranged from 55 to 75 dBA.[4] The lowest levels were recorded during the late night and early morning hours.

The measured DNL for Site 3 was 68 dBA.[5] Note that this is for all noise sources including the contribution of the persistent noise from I-5.

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[4] The 10:00 PM hour of 2/4/2009 had a L_{eq} of 75 dBA due to an exceptionally loud and long noise event. The next highest hourly L_{eq} was 71 dBA.

[5] The measured DNL at Site 3 for the entire measurement program, excluding the exceptional noise event during the 10:00 PM hour of 2/4/2009, was 66 dBA.

Figure 16 Site 3 Maximum A-Weighted Levels

Sources: HMMH February 2009

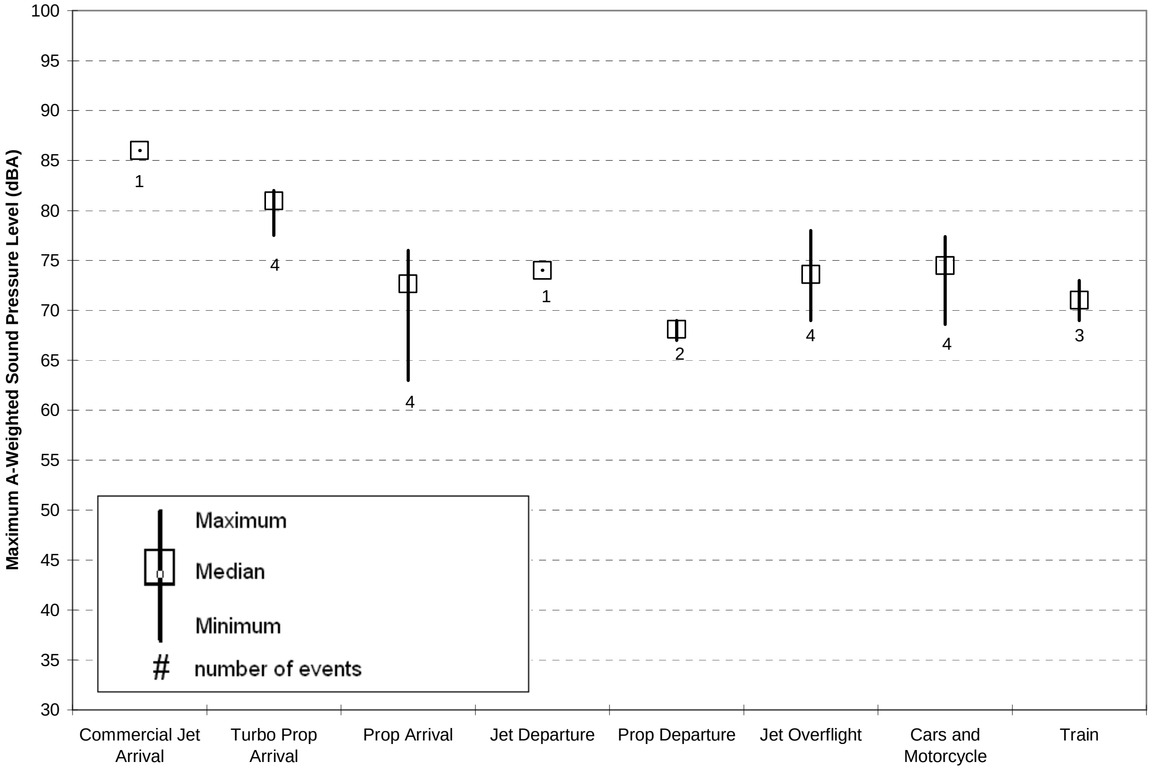
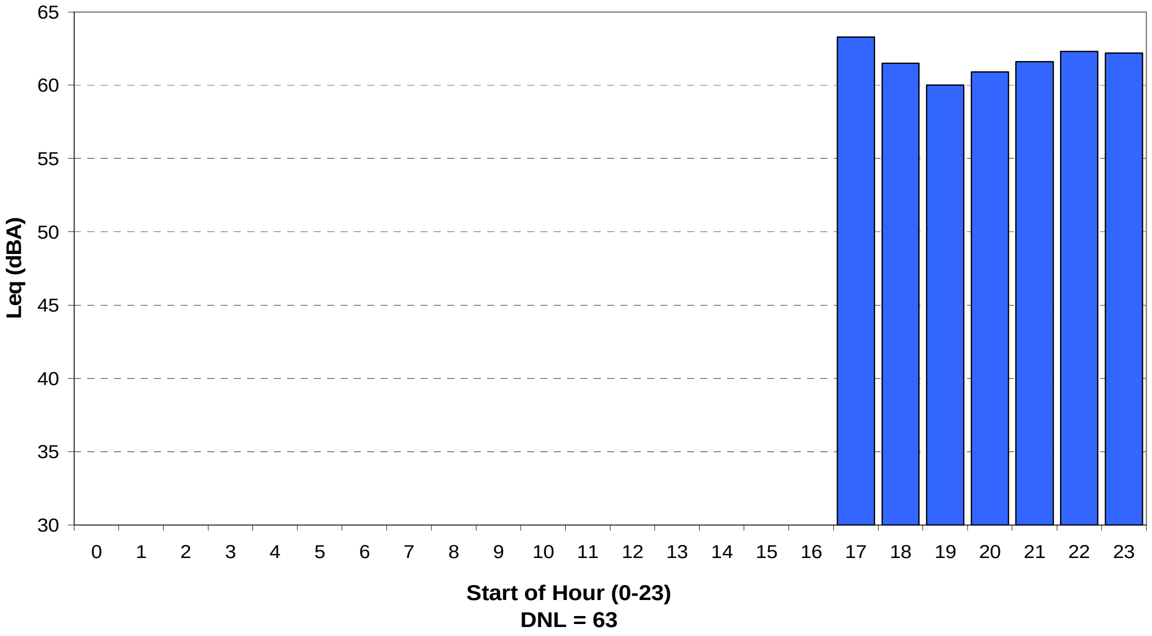


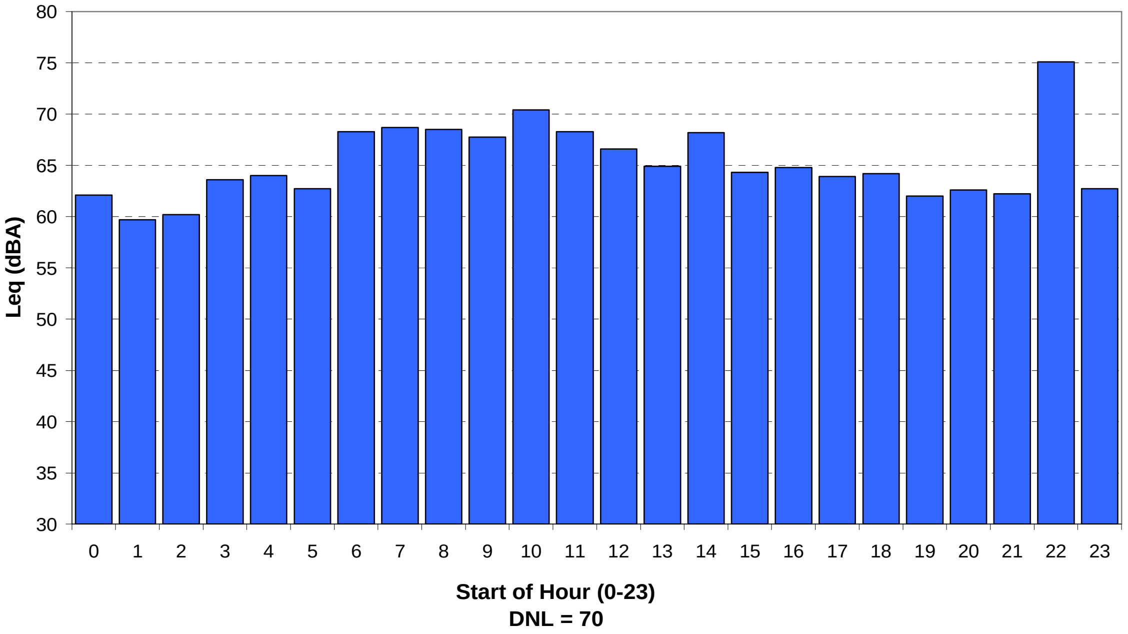
Figure 17 Site 3 Measured Hourly Noise Levels (L_{eq})

Source: HMMH February 2009

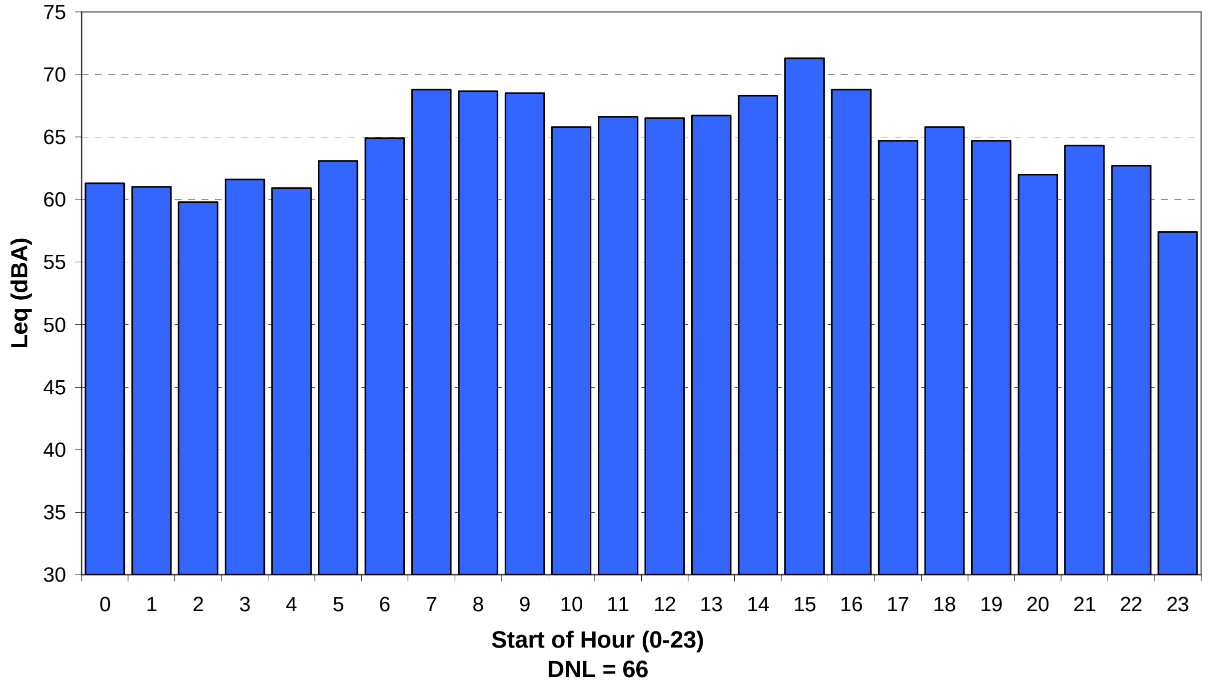
Site 3: 2/3/2009



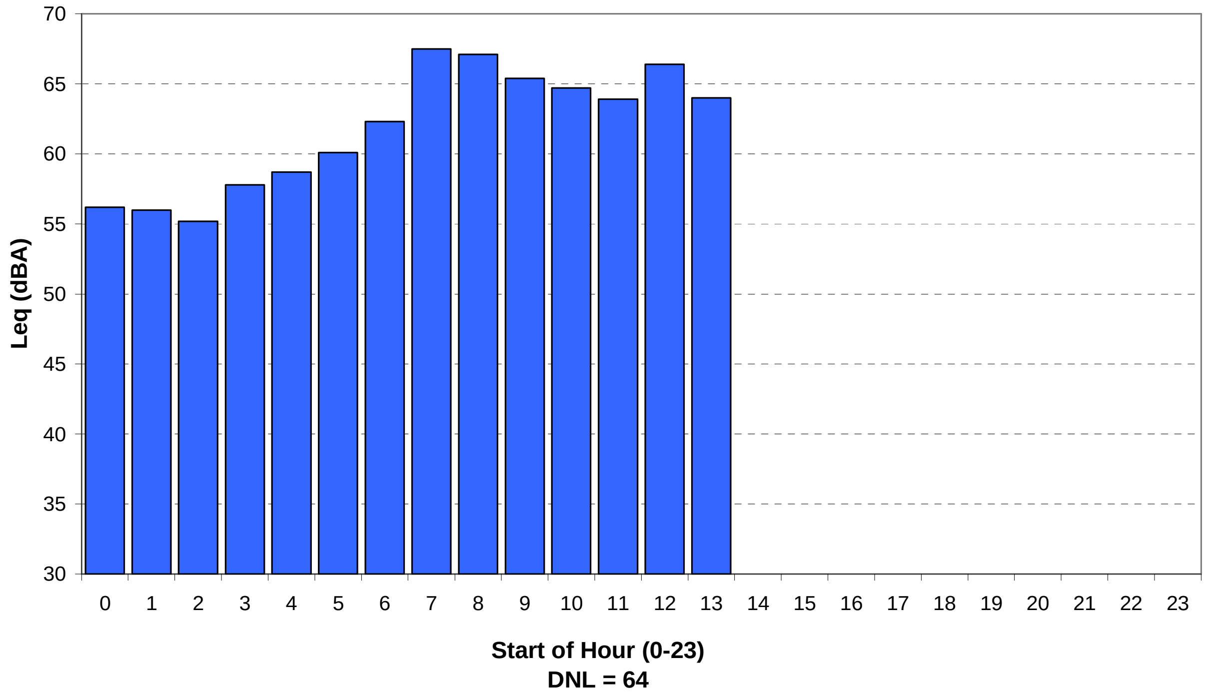
Site: 3: 2/4/2009



Site 3: 2/5/2009



Site 3: 2/6/2009



4 Noise Modeling

Section 4.1 describes the development of the noise modeling input for the existing conditions 2008 DNL contours. Section 4.2 presents the results of the noise modeling and compares these results to contours developed in a previous study for the year 2000.

4.1 Development of Noise Contours

The DNL contours for this study were prepared using the most recent release of the FAA's Integrated Noise Model (INM) that was available at the time the contours were prepared, Version 7.0a. The model was used without any unauthorized "calibration" or "adjustment".

The INM requires inputs in the following categories:

- Physical description of the airport layout
- Number and mix of aircraft operations
- Day-night split of operations (by aircraft type)
- Runway utilization rates
- Prototypical flight track descriptions and accompanying utilization rates.

Sections 4.1.1 through 4.1.5 present this information in order, for the 2008 existing conditions noise contours presented in Section 4.2.

4.1.1 Airport Physical Parameters

HMMH obtained the runway geometry though FAA's form 5010 data service. BLI has a single 6701-foot runway, Runway 16/34, with no displaced thresholds.

4.1.2 Aircraft Operations

The number of operations by aircraft category was determined by HMMH using FAA traffic count data for 2008 and an adjustment to account for the period during which BLI's tower is not attended. This adjustment was determined for each aircraft group using data from the FAA's Enhanced Traffic Management System Counts (ETMSC) which provide detailed listings of operations for aircraft which file flight plans and are handled en route. The ETMSC provide the aircraft type, origin, destination, and arrival and departure hours. The percentage of operations occurring during the unattended period in the ETMSC for each group was applied to the tower counts to produce the final modeled operations. The ETMSC showed that approximately 12% of the air carrier, 10% of the air taxi, 5% of the general aviation, and 7% of the military operations in 2008 occurred during the unattended hours. The resulting operations by each aircraft group are presented in Table 4.

Table 4 2008 Existing Conditions Average Daily Aircraft Operations by Aircraft Group
Sources: FAA ETMSC and FAA ATADS

Aircraft Group	Daytime	Nighttime	Total
Air Carrier	16.4	2.4	18.8
Air Taxi	39.6	5.3	44.9
General Aviation	117.2	6.9	124.1
Military	1.7	0.1	1.8
Total	**174.9**	**14.7**	**189.6**

In addition, the ETMSC were utilized to determine the day-night split of operations and the percentages of each aircraft type. To best represent all operations at BLI including aircraft not present in the ETMSC, the aircraft operations were reviewed and adjusted by FAA tower personnel. The two adjustments were that all EA6 operations occurred in the daytime and that the maximum nighttime percentage for an particular general aviation aircraft was set at 15 %. The capping of the nighttime percentage affected five aircraft, the A109, CNA20T, CNA750, GV, and H500D, which together comprise approximately 1.3 average daily operations. Table 5 presents the modeled 2008 existing conditions aircraft operations. One operation is a single arrival or departure.

Table 5 2008 Existing Conditions Modeled Average Daily Aircraft Operations

Sources: FAA ETMSC and FAA ATADS

Aircraft Group	INM Type	Daytime	Nighttime	Total
Air Carrier	737400	0.16	0.00	0.16
	737800	0.16	0.00	0.16
	A319-131	0.03	0.00	0.03
	DHC830	9.74	1.92	11.65
	MD81	0.05	0.00	0.05
	MD83	6.32	0.48	6.79
Air Carrier Subtotal		**16.45**	**2.39**	**18.84**
Air Taxi	1900D	6.55	1.50	8.05
	BEC58P	2.23	0.00	2.23
	CL600	0.66	0.02	0.67
	CL601	0.37	3.66	4.03
	CNA206	0.27	0.00	0.27
	CNA441	0.29	0.00	0.29
	CNA500	0.09	0.00	0.09
	CNA750	0.34	0.00	0.34
	CVR580	0.09	0.00	0.09
	DHC6	5.58	0.00	5.58
	DHC8	0.07	0.00	0.07
	GASEPF	14.80	0.02	14.82
	GASEPV	0.06	0.02	0.09
	GII	0.07	0.00	0.07
	GV	0.37	0.00	0.37
	IA1125	0.62	0.00	0.62
	LEAR35	0.60	0.03	0.64
	MU3001	1.39	0.03	1.43
	PA31	3.88	0.00	3.88
	S70	0.05	0.00	0.05
	SD330	1.19	0.02	1.21
Air Taxi Subtotal		**39.56**	**5.30**	**44.86**
Table continues on next page.				

Table 5 2008 Existing Conditions Modeled Average Daily Aircraft Operations (Continued)

General Aviation	737800	0.21	0.00	0.21
	A109	0.26	0.02	0.29
	BEC58P	19.68	2.43	22.11
	CIT3	0.34	0.00	0.34
	CL600	3.15	0.05	3.20
	CNA172	9.58	0.64	10.22
	CNA206	11.88	0.55	12.43
	CNA20T	0.15	0.01	0.16
	CNA441	6.17	0.50	6.67
	CNA500	11.05	0.86	11.91
	CNA55B	5.16	0.13	5.29
	CNA750	0.31	0.05	0.36
	DHC6	7.98	0.10	8.08
	EC130	0.03	0.00	0.03
	FAL20	0.26	0.00	0.26
	FAL900	0.29	0.00	0.29
	GASEPF	3.94	0.05	3.99
	GASEPV	12.28	0.31	12.59
	GIV	1.09	0.08	1.17
	GV	0.33	0.03	0.36
	H500D	0.06	0.01	0.08
	IA1125	2.03	0.05	2.09
	LEAR25	0.78	0.00	0.78
	LEAR35	6.96	0.60	7.56
	MU3001	3.57	0.05	3.63
	PA28	2.24	0.03	2.27
	PA30	0.24	0.00	0.24
	PA31	0.39	0.00	0.39
	R22	0.10	0.00	0.10
	S70	0.08	0.00	0.08
	SD330	6.65	0.34	6.99
General Aviation Subtotal		**117.23**	**6.92**	**124.15**
Military	737700	0.04	0.00	0.04
	A109	0.19	0.07	0.26
	BEC58P	0.02	0.00	0.02
	C130	0.04	0.00	0.04
	CH47D	0.04	0.00	0.04
	CNA172	0.02	0.00	0.02
	CNA206	0.12	0.00	0.12
	CNA55B	0.02	0.00	0.02
	DC95HW	0.04	0.00	0.04
	DHC6	0.30	0.02	0.32
	EA6B	0.20	0.00	0.20
	F15E29	0.02	0.00	0.02
	F16GE	0.04	0.00	0.04
	F-18	0.02	0.00	0.02
	HS748A	0.01	0.01	0.02
	L188	0.10	0.00	0.10
	S70	0.08	0.00	0.08
	SA365N	0.10	0.00	0.10
	SD330	0.30	0.00	0.30
Military Subtotal		**1.69**	**0.10**	**1.80**
Total		**174.93**	**14.72**	**189.65**

4.1.3 Aircraft Noise and Performance Characteristics

Specific noise and performance data must be entered for each aircraft type operating at the airport. Noise data is included in the form of sound exposure level (SEL – see Section 2.1.4) at a range of distances (from 200 feet to 25,000 feet) from a particular aircraft with engines at a specific thrust level. Performance data includes thrust, speed and altitude profiles for takeoff and landing operations. The INM database contains standard noise and performance data for over one hundred different fixed wing aircraft types, most of which are civilian aircraft. The program automatically accesses the applicable noise and performance data for departure and approach operations by those aircraft.

One aircraft within the modeled operations at BLI is not included in the INM's standard database. The Falcon 50/900, was modeled as a Lear 35 with 1.8 dBA added to its noise curves. This is the FAA's recommended substitution for this aircraft.

4.1.4 Runway Utilization

The FAA Air Traffic Control Tower (ATCT) Manager provided input on the runway utilization of each aircraft group for particular seasons of the year. HMMH applied these rates to the FAA's monthly tower counts for 2008 to yield the annualized arrival, departure, and touch-and-go rates displayed in Table 6, Table 7, and Table 8, respectively.

Table 6 2008 Existing Conditions Arrival Runway Utilization

Aircraft Group	Daytime			Nighttime		
	Runway 16	Runway 34	Total	Runway 16	Runway 34	Total
Air Carrier	77%	23%	100%	77%	23%	100%
Air Taxi	78%	22%	100%	78%	22%	100%
General Aviation	81%	19%	100%	81%	19%	100%
Air Taxi	78%	22%	100%	78%	22%	100%
Military	75%	25%	100%	75%	25%	100%

Table 7 2008 Existing Conditions Departure Runway Utilization

Aircraft Group	Daytime			Nighttime		
	Runway 16	Runway 34	Total	Runway 16	Runway 34	Total
Air Carrier	77%	23%	100%	77%	23%	100%
Air Taxi	78%	22%	100%	78%	22%	100%
General Aviation	92%	8%	100%	92%	8%	100%
Air Taxi	78%	22%	100%	78%	22%	100%
Military	91%	9%	100%	91%	9%	100%

Table 8 2008 Existing Conditions Touch-And-Go Runway Utilization

Aircraft Group	Daytime			Nighttime		
	Runway 16	Runway 34	Total	Runway 16	Runway 34	Total
General Aviation	87%	14%	100%	87%	14%	100%
Military	83%	17%	100%	83%	17%	100%

4.1.5 Flight Track Geometry and Utilization

BLI staff provided HMMH with model flight track input from a URS Corporation study of noise for year 2000 conditions at BLI. HMMH presented these tracks to FAA tower staff for approval, modification, and specification of utilization rates. The resulting departure, arrival, and touch-and-go flight tracks are presented in Figure 18, Figure 19, and Figure 20, respectively. The INM models flight corridors using "backbone" or centerline flight tracks which are flanked by dispersed "sub-tracks". The operations assigned to each track are spread across the backbone and sub-tracks using a normal distribution.

The resulting utilization rates for arrival, departure, and touch-and-go flight tracks are displayed in Table 9, Table 10, and Table 11, respectively. Flight track utilization for a given aircraft group and operation type is expressed as the percentage of operations on a particular runway which are assigned to a specific flight track. For example, air carrier arrivals to Runway 34 are split between two tracks with 99% on AR34S and 1% on AR34N1 Note that due to rounding for presentation in the table, the percentages may add up to 99% or 101%.

Table 9 2008 Existing Conditions Arrival Flight Track Utilization

Aircraft Group	Runway	Track	Daytime	Nighttime
Air Carrier	16	AR16SE1	45%	45%
		AR16SE2	45%	45%
		AR16S2	5%	5%
		AR16S3	5%	5%
	34	AR34S	99%	99%
		AR34N1	1%	1%
Air Taxi	16	AR16W3	85%	85%
		AR16W5	8%	8%
		AR16W6	8%	8%
	34	AR34W3	85%	85%
		AR34SW	15%	15%
General Aviation	16	AR16W3	85%	85%
		AR16W7	14%	14%
		AR16NE	1%	1%
	34	AR34W3	85%	85%
		AR34NW1	5%	5%
		AR34SW	10%	10%
Helicopter	H1	ARH1SE1	100%	100%
Military Jets	16	AR16SE1	45%	45%
		AR16SE2	45%	45%
		AR16S2	5%	5%
		AR16S3	5%	5%
	34	AR34S	99%	99%
		AR34N1	1%	1%
Military Props	16	AR16NE	100%	100%
	34	AR34NE2	100%	100%

Table 10 2008 Existing Conditions Departure Flight Track Utilization

Aircraft Group	Runway	Track	Daytime	Nighttime
Air Carrier	16	DP16SW	99%	99%
		DP16NE	1%	1%
		DP16N1	1%	1%
	34	DP34W5	99%	99%
		DP34N2	1%	1%
Air Taxi	16	DP16W4	85%	85%
		DP16SE3	15%	15%
	34	DP34W4	85%	85%
		DP34W3	15%	15%
General Aviation	16	DP16W	43%	43%
		DP16W2	43%	43%
		DP16SE3	8%	8%
		DP16SE5	8%	8%
	34	DP34W4	43%	43%
		DP34W3	43%	43%
		DP34NW	3%	3%
		DP34NE	1%	1%
		DP34N	11%	11%
Helicopter	H1	DPH1SE1	100%	100%
Military Jets	16	DP16SW	99%	99%
		DP16NE	1%	1%
		DP16N1	1%	1%
	34	DP34W5	99%	99%
		DP34N2	1%	1%
Military Props	16	DP16NE3	100%	100%
	34	DP34NE	100%	100%

Table 11 2008 Existing Conditions Touch-And-Go Flight Track Utilization

Aircraft Group	Runway	Track	Daytime	Nighttime
General Aviation	16	TGO16L	8%	8%
		TGO16R	92%	92%
	34	TGO34L	90%	90%
		TGO34R	10%	10%
Military Jets	16	TGO16L	8%	8%
		TGO16R	92%	92%
	34	TGO34L	90%	90%
		TGO34R	10%	10%
Military Props	16	TGO16L	8%	8%
		TGO16R	92%	92%
	34	TGO34L	90%	90%
		TGO34R	10%	10%

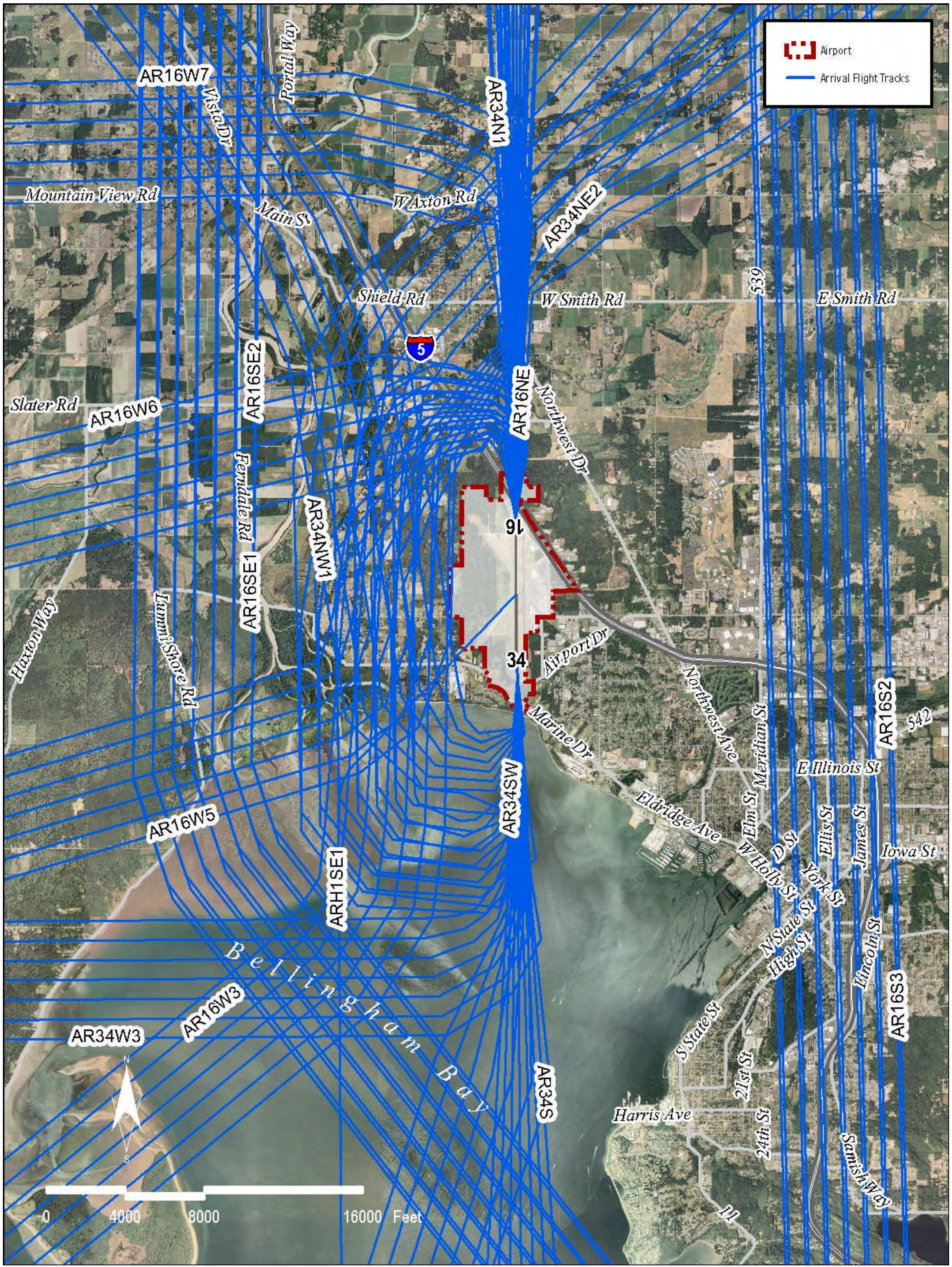


Figure 18 2008 Existing Conditions Modeled Arrival Tracks

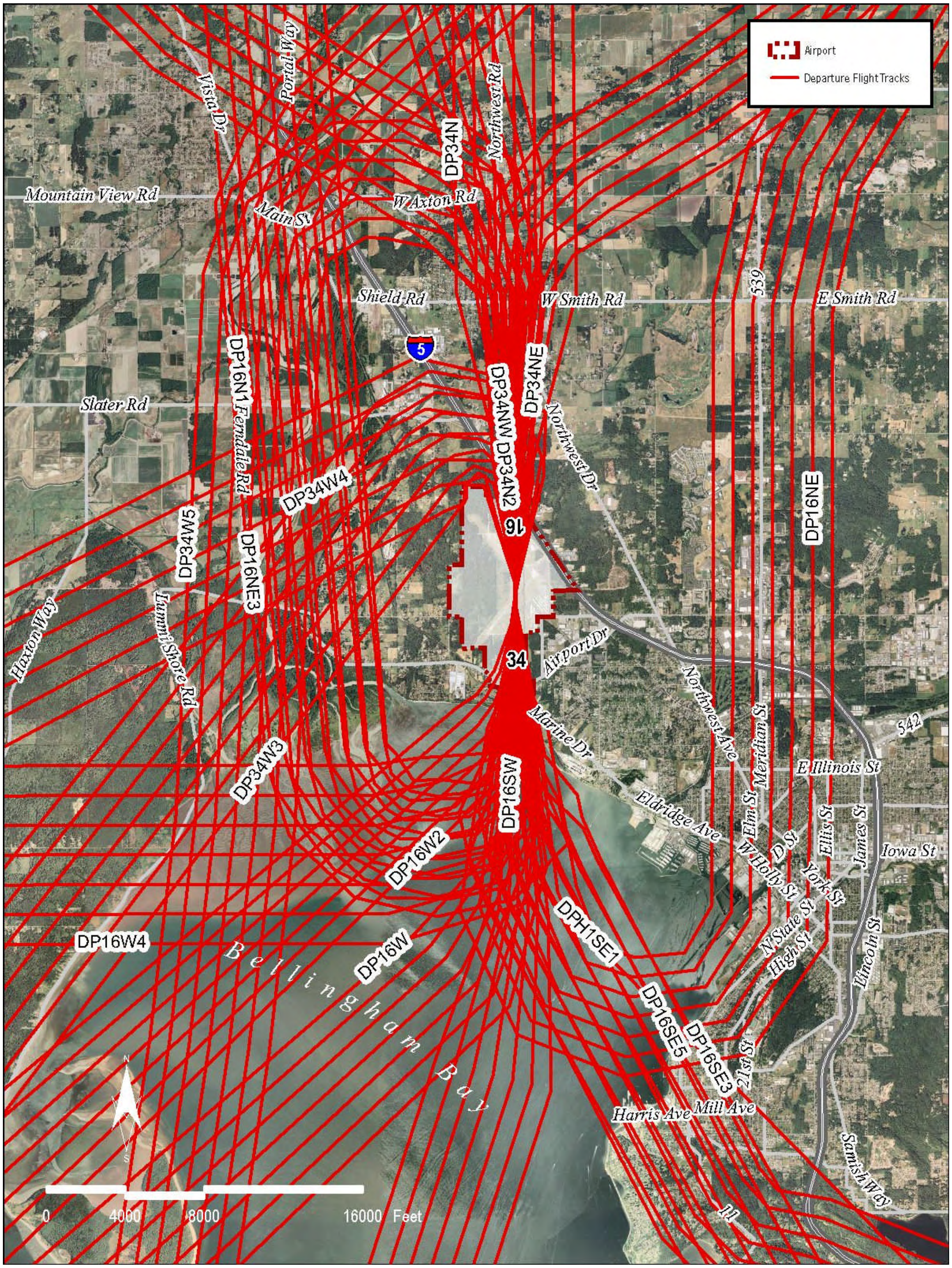


Figure 19 2008 Existing Conditions Modeled Departure Tracks

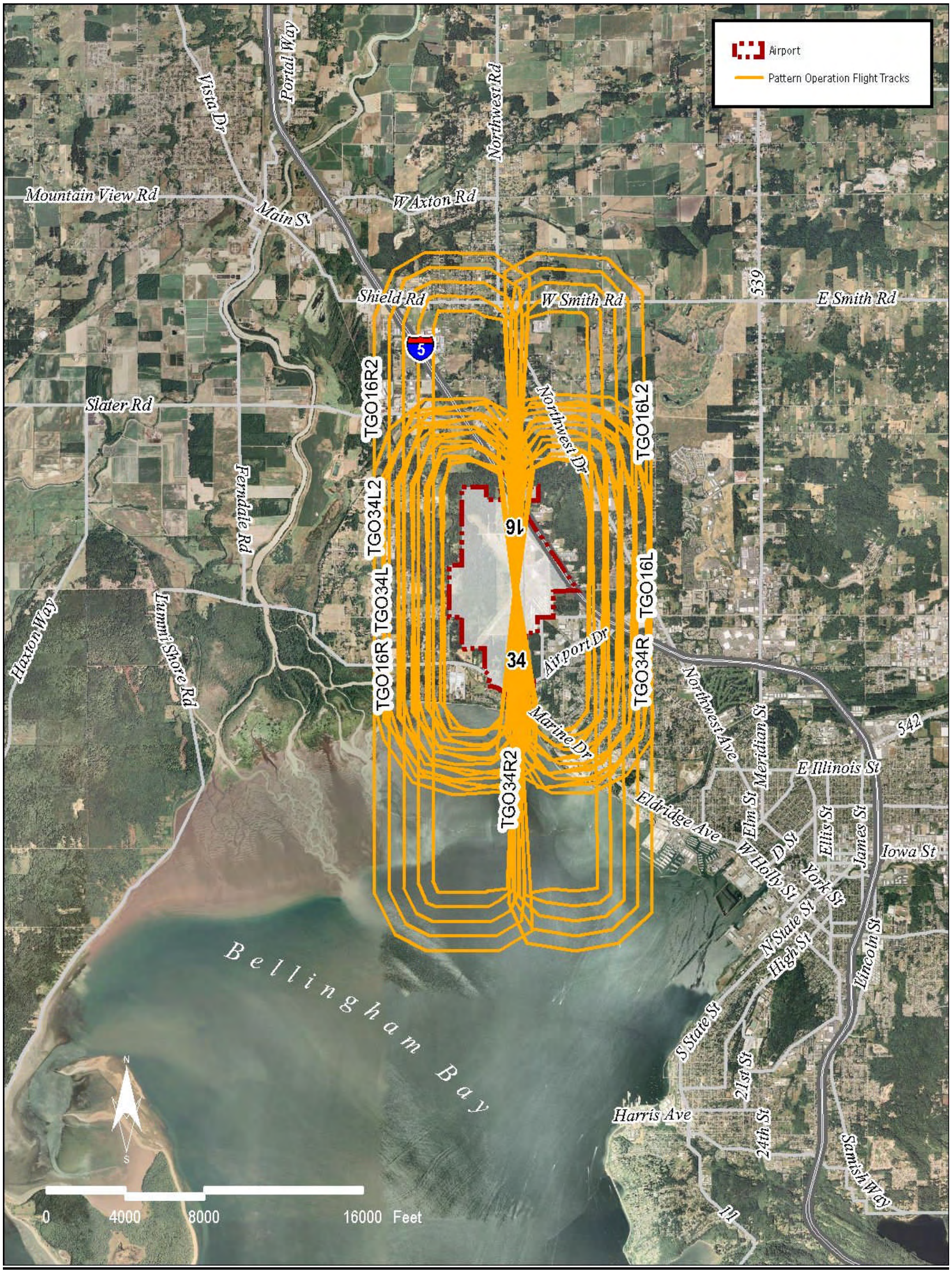


Figure 20 2008 Existing Conditions Modeled Touch and Go Tracks

4.2 Noise Modeling Results

Figure 21 presents the 60 dB through 75 dB DNL contours for the existing conditions (calendar year 2008) at BLI. BLI staff provided HMMH with the INM input from a previous study at BLI. For comparison, HMMH ran the model input for the year 2000 case from that study in INM 7.0a. The contours for these past conditions are shown as dotted yellow lines in the figure. For clarity only the outer 60 dB contour is labeled for the past conditions. In general, the past conditions contours are a little less than 5 dB smaller than the existing conditions contours.

HMMH also estimated the area of the noise contours and the residential population and number of housing units exposed to various noise levels. The population and housing units were estimated using land use provided by BLI staff and block level data from the 2000 U.S. Census. Table 12 presents the results of these analyses for both the 2008 existing conditions and the 2000 past conditions.

Table 12 Area, Population, and Housing Units at Various Noise Levels

DNL (dB)	2008			2000		
	Area (acres)	Population	Housing Units	Area (acres)	Population	Housing Units
60 dB to 65 dB	591	73	39	275	14	7
65 dB to 70 dB	218	11	5	99	0	0
70 dB to 75 dB	75	0	0	57	0	0
> 75 dB	95	0	0	44	0	0

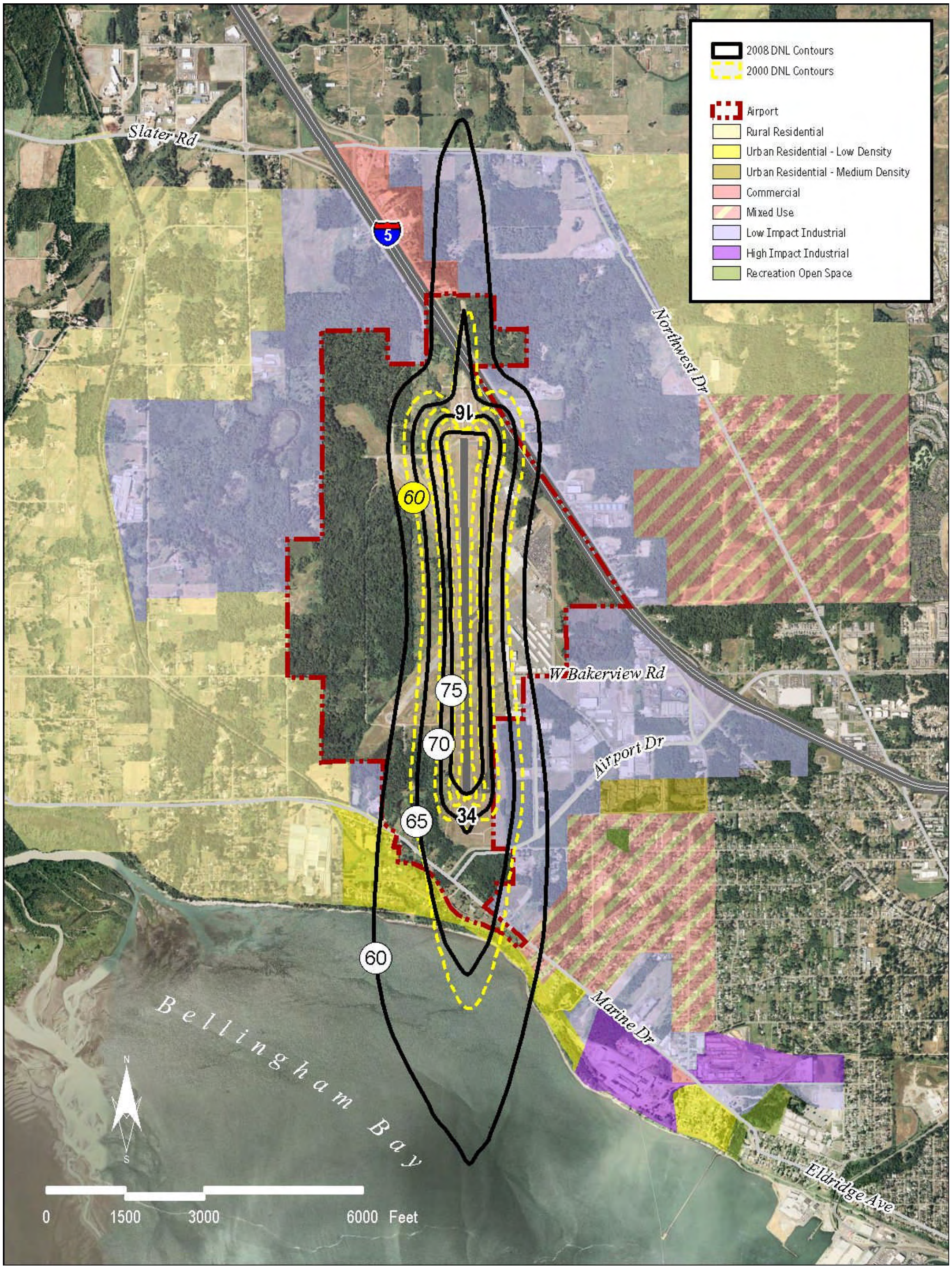


Figure 21 Existing Conditions (2008) and Past Conditions (2000) DNL Contours

Appendix A INM Aircraft

Table 13 provides the FAA's description from the INM 7.0a database for all of the model aircraft utilized in this study.

Table 13 INM Aircraft Descriptions

INM Type	Description
737400	Boeing 737-400/CFM56-3C-1
737700	Boeing 737-700/CFM56-7B24
737800	Boeing 737-800/CFM56-7B26
1900D	Beech 1900D / PT6A67
A109	Agusta A-109
A319-131	Airbus A319-131/V2522-A5
BEC58P	BARON 58P/TS10-520-L
C130	C-130H/T56-A-15
CH47D	Boeing Vertol 234 (CH-47D)
CIT3	CIT 3/TFE731-3-100S
CL600	CL600/ALF502L
CL601	CL601/CF34-3A
CNA172	Cessna 172R / Lycoming IO-360-L2A
CNA206	Cessna 206H / Lycoming IO-540-AC
CNA20T	Cessna T206H / Lycoming TIO-540-AJ1A
CNA441	CONQUEST II/TPE331-8
CNA500	CIT 2/JT15D-4
CNA55B	Cessna 550 Citation Bravo / PW530A
CNA750	Citation X / Rolls Royce Allison AE3007C
CVR580	CV580/ALL 501-D15
DC95HW	DC9-50/JT8D17 w/ ABS Heavyweight hushkit
DHC6	DASH 6/PT6A-27
DHC8	DASH 8-100/PW121
DHC830	DASH 8-300/PW123
EA6B	J52-P-408 NM
EC130	Eurocopter EC-130 w/Arriel 2B1
F15E29	MCDONNELL DOUGLAS EAGLE F100-PW-229 NM
F16GE	GENERAL DYNAMICS FALCON F110-GE-100 NM
F-18	MCDONNELL DOUGLAS HORNET F404-GE-400 NM
FAL20	FALCON 20/CF700-2D-2
FAL900	LEAR35 + 1.8 dB
GASEPF	1985 1-ENG FP PROP
GASEPV	1985 1-ENG VP PROP
GII	Gulfstream GII/SPEY 511-8
GIV	Gulfstream GIV-SP/TAY 611-8
GV	Gulfstream GV/BR 710
H500D	Hughes 500D
HS748A	HS748/DART MK532-2
IA1125	ASTRA 1125/TFE731-3A
L188	L188C/ALL 501-D13
LEAR25	LEAR 25/CJ610-8
LEAR35	LEAR 36/TFE731-2
MD81	MD-81/JT8D-217
MD83	MD-83/JT8D-219
MU3001	MU300-10/JT15D-5
PA28	PIPER WARRIOR PA-28-161 / O-320-D3G
PA30	PIPER TWIN COMANCHE PA-30 / IO-320-B1A
PA31	PIPER NAVAJO CHIEFTAIN PA-31-350 / TIO-5
R22	Robinson R22B w/Lycoming 0320
S70	Sikorsky S-70 Blackhawk (UH-60A)
SA365N	Aerospatiale SA-365N Dauphin (AS-365N)
SD330	SD330/PT6A-45AR