Aircraft Noise Measurement Report

Old Camp Meade Rd.

Severn, MD 21144

Prepared by Harris Miller Miller & Hanson, Inc.

May 2018

1. INTRODUCTION

This memorandum presents the measured aircraft noise levels for the period of April 18 to May 2, 2018 at Old Camp Meade Rd. Severn, MD 21144. This residence is located approximately 2.8miles southwest of the southeastern end of Runway 15R/33L of Baltimore/Washington International Thurgood Marshall (BWI Marshall) Airport. Figure 1 shows the location of the measurement site (marked as BW274) relative to BWI Marshall. Measurement data were collected and analyzed on behalf of the Maryland Department of Transportation Maryland Aviation Administration (MDOT MAA) by Harris Miller Miller & Hanson Inc. (HMMH) and Straughan Environmental (SE). The equipment was regularly checked for function and calibrated during the measurements. With the exception of brief periods during calibration, noise levels were monitored continuously throughout the measurement period.

At the conclusion of the measurement period, data were uploaded to the MDOT MAA's Noise and Operations Monitoring System (NOMS). The NOMS compared the times of noise events to its database of aircraft radar flight paths. For the analyses presented in this report, a noise event occurs when the sound level exceeds a baseline threshold for five seconds. The baseline threshold is set at the start of the measurement period to be approximately ten decibels above the background sound levels. Noise events which occurred while aircraft were passing within the vicinity were identified as aircraft noise. This matching of noise events to individual aircraft flights makes possible the calculation of the total aircraft noise exposure over a particular hour or day as well as the full measurement period. Additionally, the relative contribution of different aircraft types (e.g. jet aircraft, propeller aircraft, helicopters) or operations (e.g. arrivals, departures) to the total noise exposure can be computed.

Section 2 of this memorandum describes the measurement location. Section 3 presents information about the aircraft operations during the measurement period. Section 4 summarizes the measured noise levels. Section 5 provides conclusions. The appendix titled "How Do We Describe Aircraft Noise" provides background information on acoustical terms used in this memorandum.

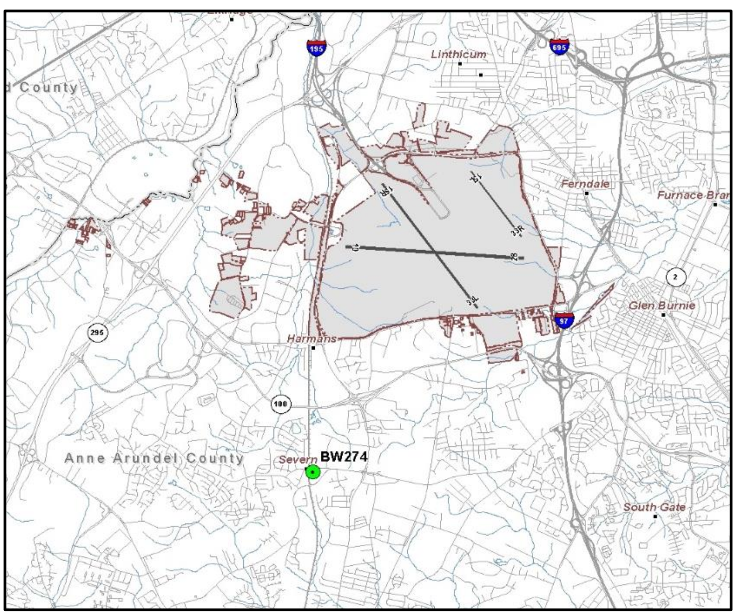

Figure 1. Noise Monitoring Location Map

2. MEASUREMENT SITE

Aircraft noise levels were measured from the afternoon of April 18 through the afternoon of May 2, 2018 at Old Camp Meade Rd. in Severn. The noise monitor was placed in the backyard of the residence. Figure 2 shows the placement of the noise monitoring equipment.

The noise monitor is a Type I sound level meter and is regularly calibrated. Additionally, the system was calibrated every two to three days during the measurements during equipment checks. The equipment experienced no malfunctions and the meter was only stopped briefly for the periodic calibration checks.

During setup, a baseline threshold was established for the sound level meter. Once the sound level exceeded the baseline threshold for five seconds, a noise event was recorded. The sound level meter recorded the following information about each noise event: date; time, duration, and noise levels. Notable noise sources at this site include aircraft overflights, primarily departures from BWI Marshall, a train line approximately two hundred feet from the residence, as well as typical suburban sounds including landscaping equipment, neighborhood animals, and local vehicle traffic.

Once the temporary noise monitoring period was complete, the noise event data was uploaded into MDOT MAA's NOMS to compare the times of noise events to its database of aircraft radar flight paths. The NOMS conservatively attributes any noise event that occurs when an aircraft is within 10,000 ft. of a measurement site to that aircraft. Noise events which occurred while aircraft were passing within the vicinity were associated with an actual aircraft flight and therefore assigned as aircraft noise events. Using this methodology, noise events that are correlated with aircraft overflights may include other community noise, such as a nearby passing train, which may or may not exceed the noise level from the aircraft overflight.

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Figure 2. Noise Measurement Microphone

3. AIRCRAFT OPERATIONS

The measurement site is located to the southwest of BWI Marshall and the primary aircraft noise events for this site are due to departures on BWI Marshall Runway 15R. Other less common noise events are due to departures on BWI Marshall Runway 28 and other overflights not associated with BWI Marshall.

During the measurement period, BWI Marshall operated in two configurations:

- departures on Runway 28 and departures on Runway 15R (west flow) and
- departures on Runway 15R and arrivals on Runway 10 (east flow).

The most common configuration on an annual basis at BWI Marshall, departures on Runway 28 and departures on Runway 15R, was active for eight days during the measurement period. On one day, the configuration was departures on Runway 15R and arrivals on Runway 10. On six days, BWI Marshall operated in combinations of the two configurations above during different portions of the day. Table 2 in the Measured Noise Levels section includes a description of the primary arrival and departure runways for each day.

Figure 3 displays all BWI Marshall flight tracks for a typical day during the measurement period in west flow, which primarily utilizes Runway 28 for departures and Runway 33L for arrivals. The red flight tracks are arrivals and the blue flight tracks are departures. The location of the measurement site is marked with its unique identifier in the NOMS, “BW274”. Figure 4 displays the same west flow flight tracks at a closer scale. Again, the text “BW274” shows the location of the measurement site. In west flow, the primary BWI Marshall overflights were departures on Runway 28. These departures were generally 2,400 to 6,600 ft. above ground level at their point of closest approach to the measurement site, with the most common altitude being 5,200 ft.

Figure 5 displays all BWI Marshall flight tracks for a typical day during the measurement period in east flow, which primarily utilizes Runway 15R for departures and Runway 10 for arrivals. Figure 6 displays the same flight tracks at a closer scale. In east flow, the primary BWI Marshall overflights were departures on Runway 15R. These departures were generally 2,000 to 4,000 ft. above ground level at their point of closest approach to the measurement site, with the most common altitude being 2,500 ft.

Figure 7 displays flight tracks of all overflights not associated with BWI Marshall for a typical day during the measurement period. Figure 8 displays the same flight tracks at a closer scale. There were low and high altitude overflights not associated with BWI Marshall near the measurement site. Low altitude overflights were generally 600 to 1,900 ft. above ground level at their point of closest approach to the measurement site, with the most common altitude being 700 ft. High altitude overflights were generally 9,500 to 9,900 ft. above ground level at their point of closest approach to the measurement site, with the most common altitude being 9,900 ft. The majority of the low altitude overflights not associated with BWI Marshall are local helicopter operations, while the majority of high altitude overflights not associated with BWI Marshall are jet aircraft arrivals to the Washington, D.C. airports.

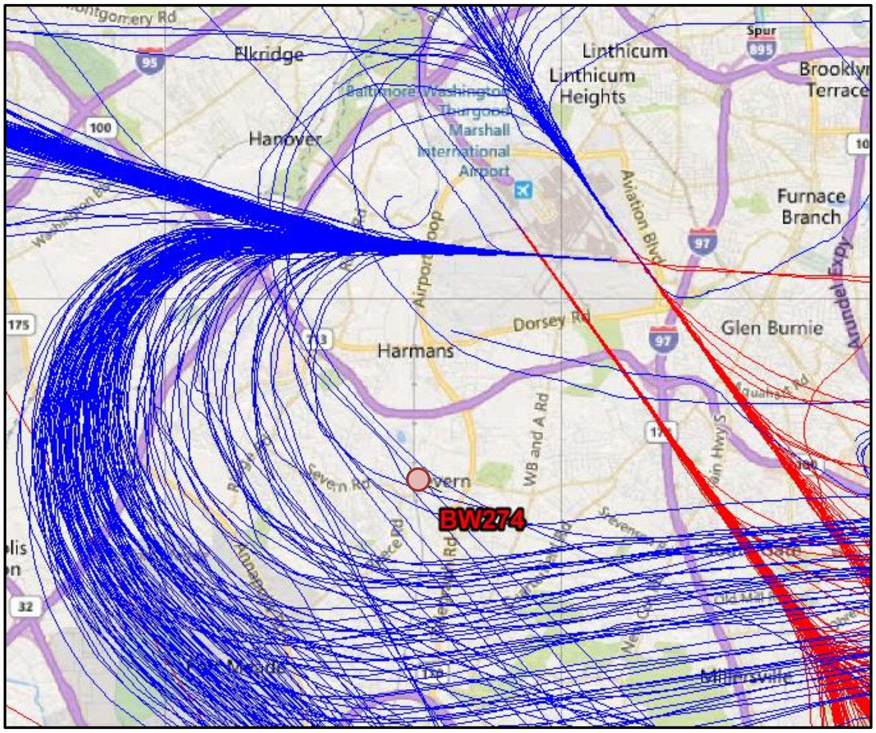

Figure 3. All Flight Tracks for a West Flow Day – April 30, 2018
(red = arrivals, blue = departures)

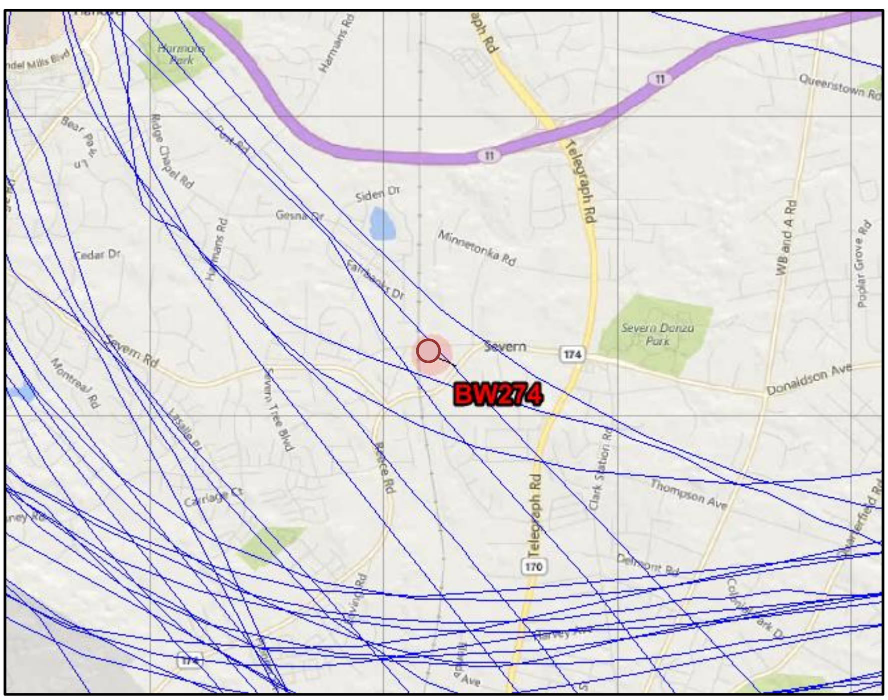

Figure 4. All Flight Tracks for a West Flow Day – April 30, 2018
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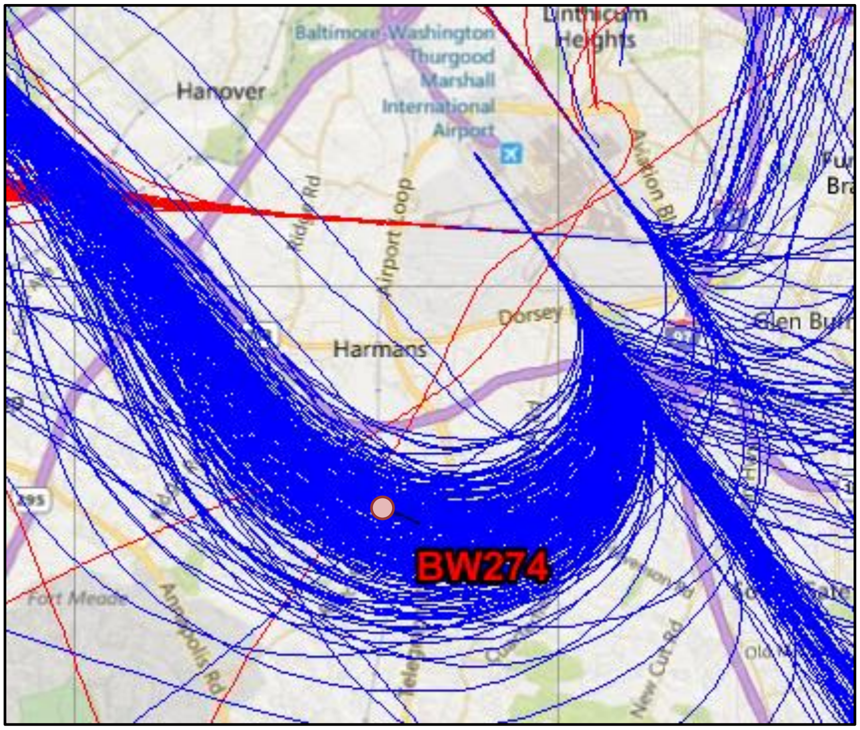

Figure 5. All Flight Tracks for an East Flow Day – April 24, 2018 (red = arrivals, blue = departures)

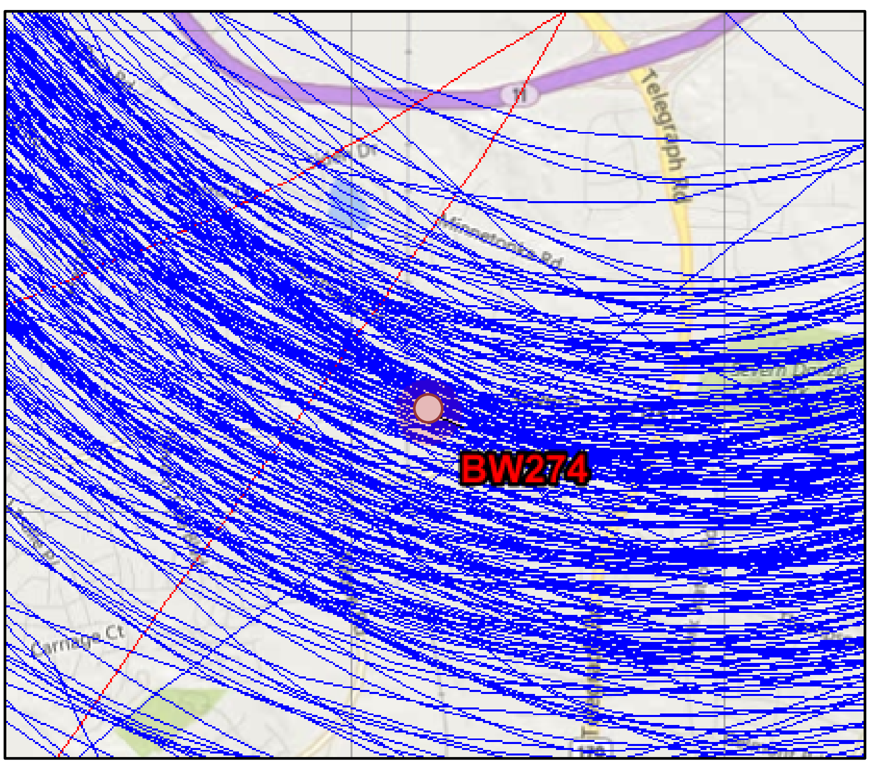

Figure 6. All Flight Tracks for an East Flow Day – April 24, 2018 (red = arrivals, blue = departures)

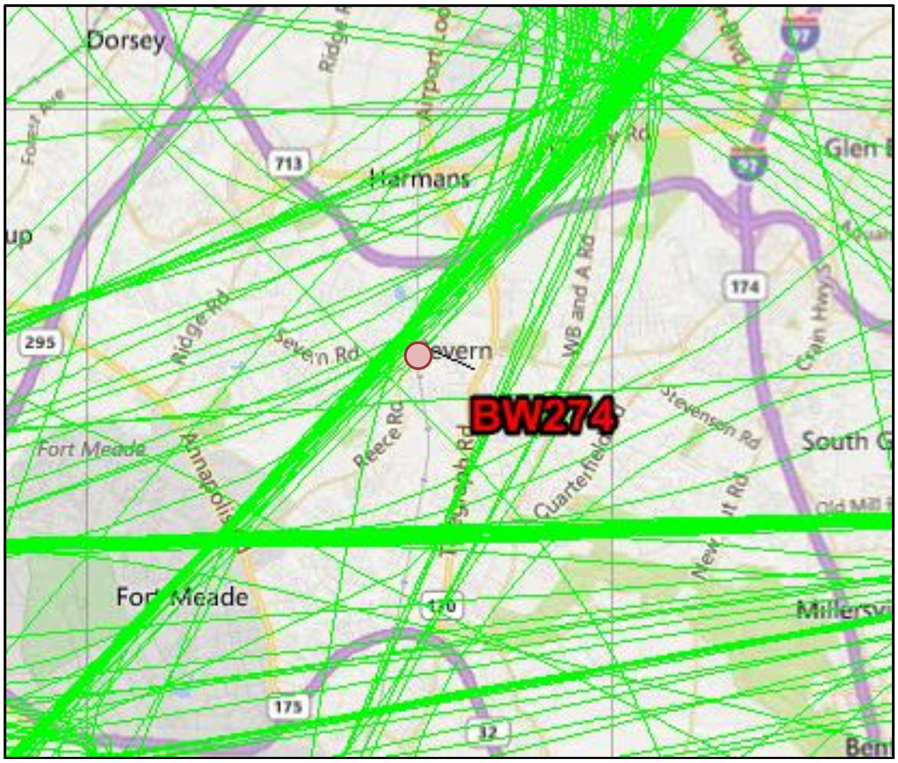

Figure 7. All Overflights not associated with BWI Marshall – April 24, 2018
(green = overflights)

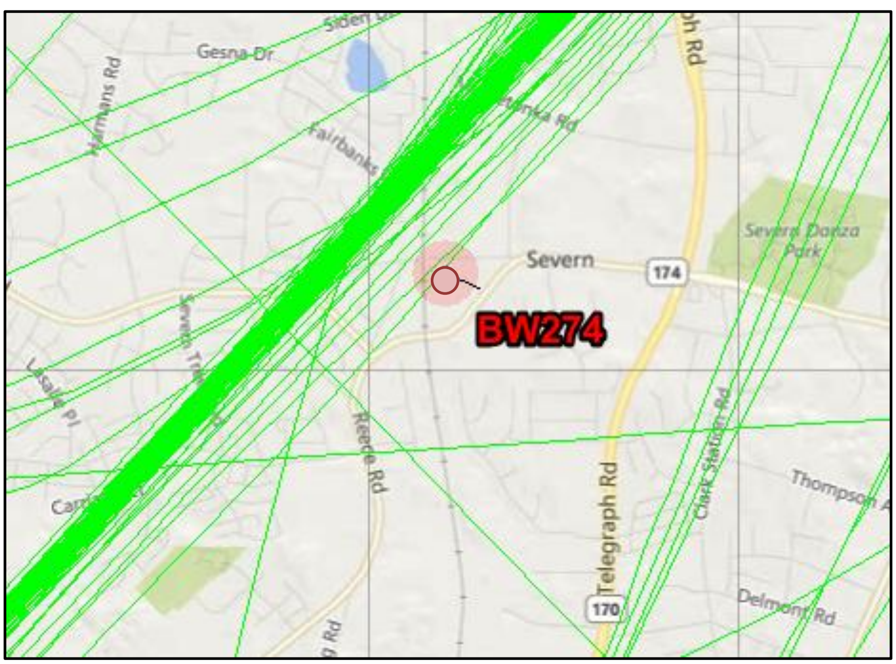

Figure 8. All Overflights not associated with BWI Marshall – April 24, 2018
(green = overflights)

4. MEASURED NOISE LEVELS

This section provides an introduction to noise terminology, discusses the noise levels from individual aircraft noise events, and summarizes the cumulative noise exposure over the measurement period.

4.1 Aircraft Noise Terminology

There are several key metrics which are used to describe aircraft noise on a single-event and cumulative basis. The appendix titled "How Do We Describe Aircraft Noise" provides a more detailed overview of the metrics which are discussed in this section.

In brief, noise can be described by A-Weighted Sound Level[1] and is expressed in decibels (noted as dB or dBA). This noise level rises and falls from second to second as noise becomes louder or quieter. The average noise level over some time period, such as an hour, is called the Equivalent Sound Level (Leq). For a particular noise event, such as an aircraft overflight, the loudest level at any instant during the event is the Maximum A-Weighted Sound Level (Lmax). The Lmax tends to correlate poorly to people's perception of the total "noisiness" of an event because it neglects the duration. The Sound Exposure Level (SEL) accounts for both the level and duration of the noise and is the best measure of the "noisiness" of a single event. Finally, the noise exposure over a complete day is represented by the Day-Night Average Sound Level (DNL). This metric sums all of the noise exposure over the day with a ten decibel weighting for any noise which occurs during the nighttime (10 pm to 7 am) to account for the intrusive nature of these noise events.

4.2 Single Event Noise Levels

Figure 9 presents a count of noise events due to departures on Runway 15R at various Lmax values for the complete measurement period. For example, the tallest blue bar in the figure shows that 111 departures on Runway 15R had an Lmax of 75 dB. For typical conversational speech at a distance of approximately three feet, speech is interrupted by noise levels at or above 65 dB. Any noise events shown in this figure with a maximum level at or above 65 dB would, briefly for quieter events and longer for louder events, interrupt typical conversations outdoors. Figure 10 shows counts of noise events at various Lmax values due to departures on Runway 28 and other overflights not associated with BWI Marshall. Note that there were far fewer noise events due to these aircraft operations as compared to departures on Runway 15R and therefore the vertical scale of this figure is quite different from the scale in Figure 9.

Figure 11 and Figure 12 tell a similar story using the SEL metric which corresponds better to people's judgment of the noisiness of an event. Departures on Runway 15R produced the largest number of noise events. Noise events due to departures on Runway 28 and other overflights not associated with BWI Marshall were less common than noise events due to departures on Runway 15R.

Note that the noise events measured and presented in this report are those which can be clearly detected by the noise measurement equipment. Aircraft noise events with maximum levels at, near, or below the ambient noise levels from community noise sources are difficult, and sometimes impossible, to quantify and in most cases contribute little to the total noise exposure.

[1] A-Weighting simply refers to a method of computing the noise level which accounts for the particular response of the human ear. It is the standard for the vast majority of environmental noise analyses.

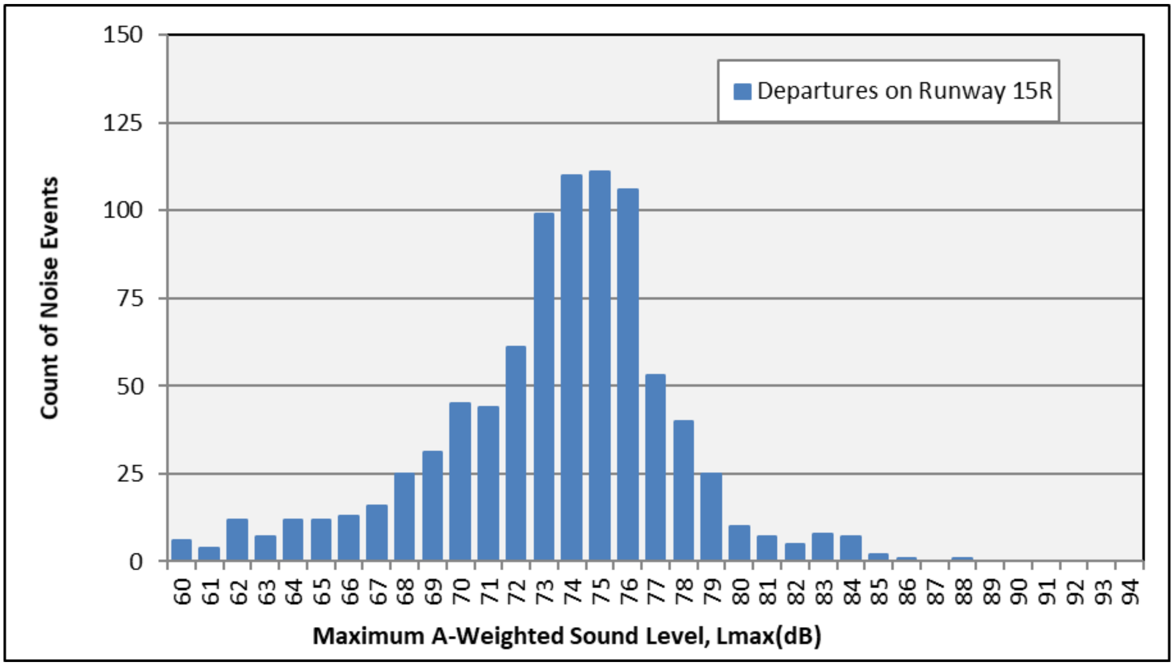

Figure 9. Counts of Maximum Noise Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 15R

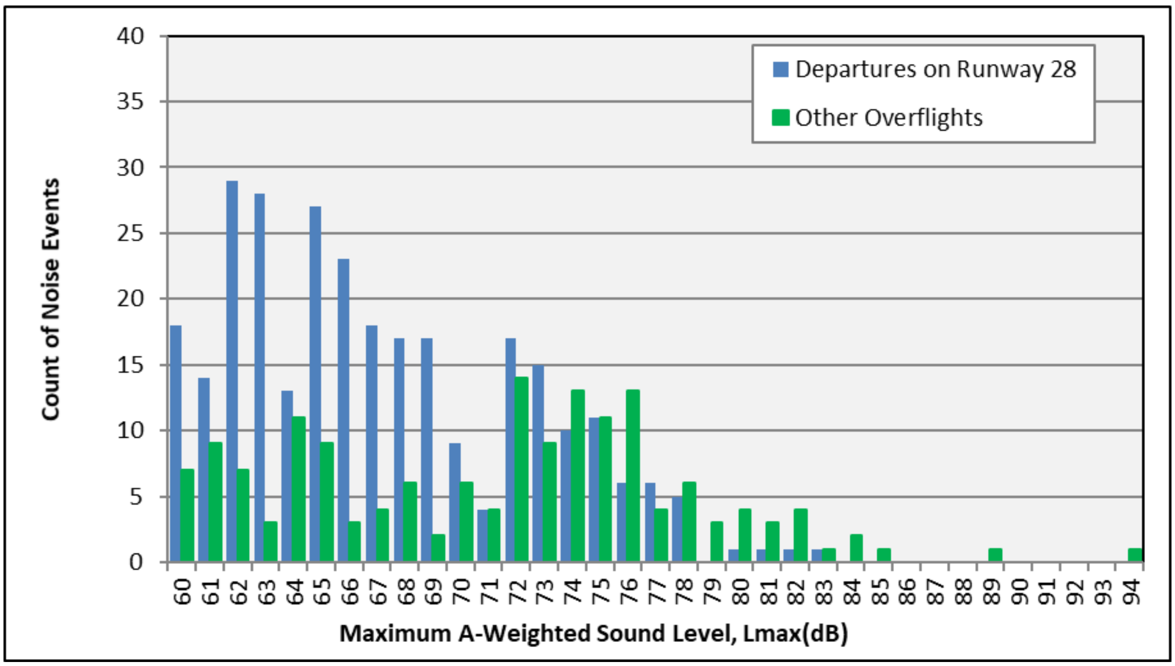

Figure 10. Counts of Maximum Noise Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 28 and Other Overflights not associated with BWI Marshall

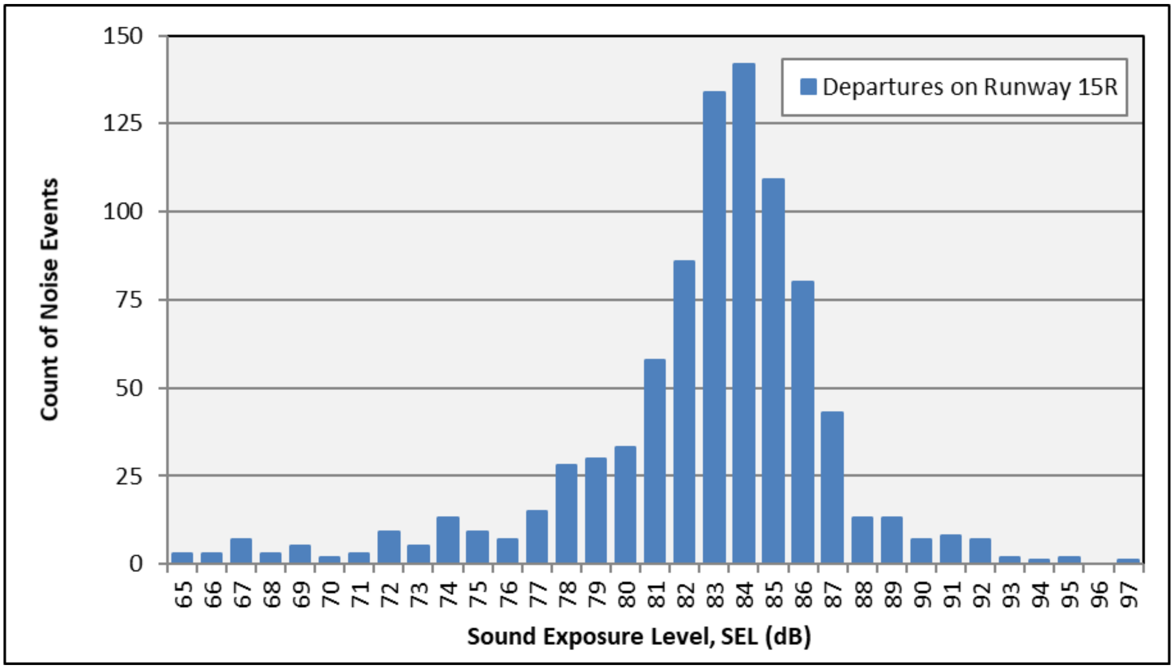

Figure 11. Counts of Sound Exposure Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 15R

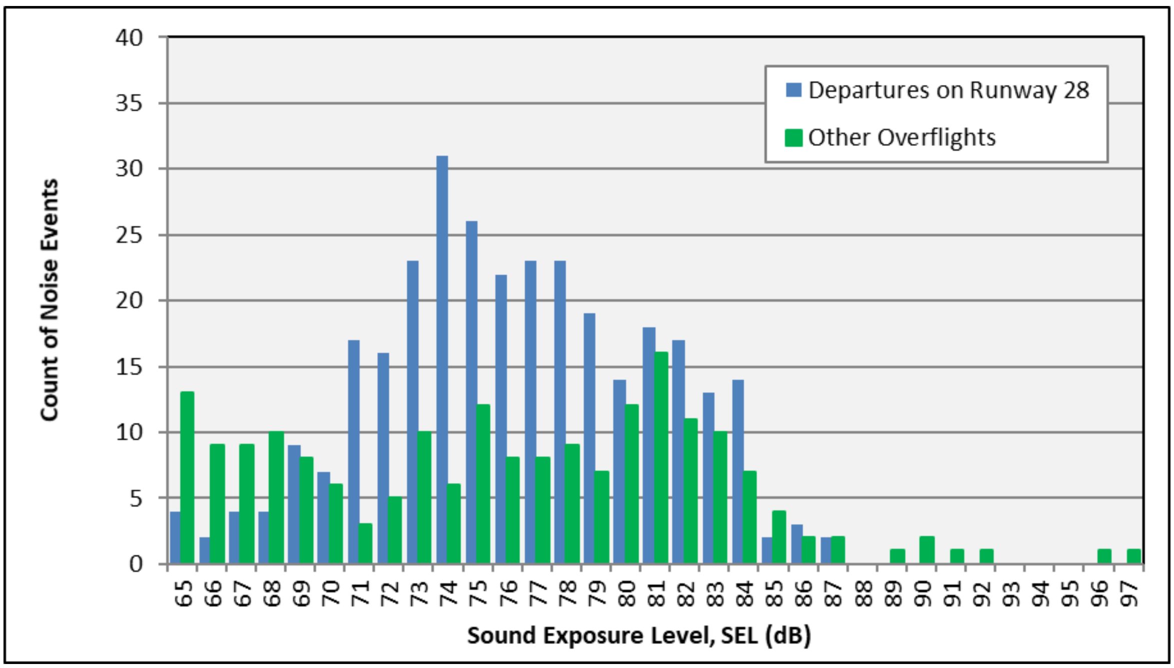

Figure 12. Counts of Sound Exposure Levels from Aircraft Overflights over the Full Measurement Period – Departures on Runway 28 and Other Overflights not associated with BWI Marshall

Departures on Runway 15R were the most common aircraft operation associated with noise events during the measurement period. The table below shows the distribution of Lmax values for departures on Runway 15R for all aircraft types over the full measurement period.

Table 1 Noise Events Associated with Departures on Runway 15R

Maximum A-Weighted Sound Level, Lmax (dB)	Total Number of Noise Events	Average Daily Number of Noise Events	Percent
60-64	41	2.9	5%
65-69	97	6.9	11%
70-74	359	25.6	41%
75-79	335	23.9	38%
80-84	37	2.6	4%
85+	4	0.3	0%
Total	**873**	**62.4**	**100%**

As discussed above in Section 2 , the noise events that are correlated with aircraft overflights may also include other community noise (e.g. train noise, landscaping equipment, neighborhood animals, local vehicle traffic, etc.) within the measurement. Such community noise may or may or may not exceed the noise level from the correlated aircraft overflight, but may contribute to higher single event noise levels.

4.3 Cumulative Noise Levels

Figure 13 provides a way to visualize the changes in aircraft noise levels over the measurement period. The average aircraft noise level (Leq) is presented on an hourly basis. Hours with louder or more aircraft events will show higher Leq values. Regions where the bars are absent simply indicate periods where no aircraft noise events occurred. Note that the cumulative noise level for each day incorporates these hourly noise levels with an additional ten decibel weighting for nighttime noise levels. This cumulative daily noise level, called DNL, is discussed next.

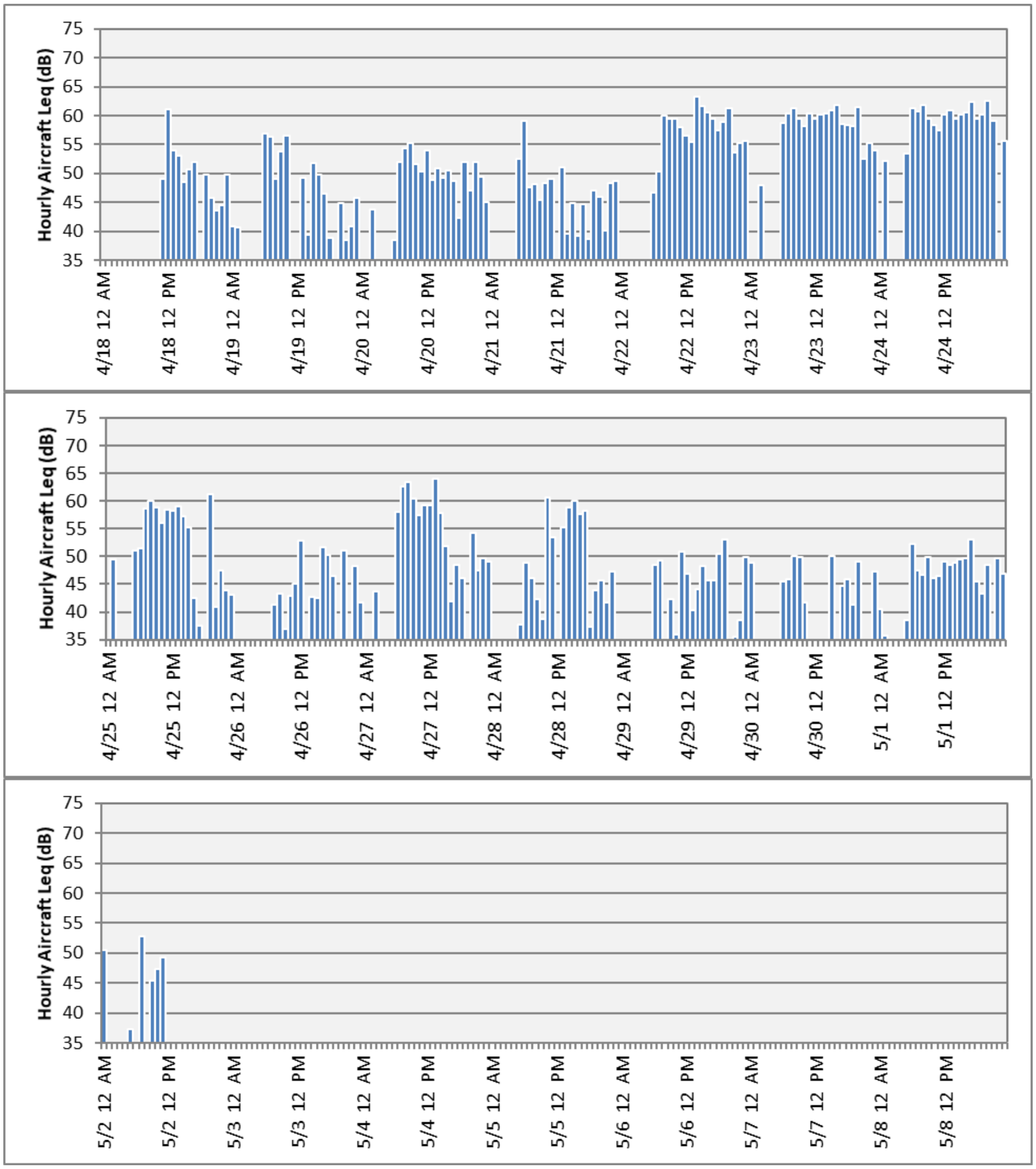

Figure 13. Average Hourly Aircraft Noise Levels

Table 2 summarizes the cumulative noise exposure over each of the fifteen days of recorded data within the measurement period using the DNL metric. DNL sums the noise from every aircraft noise event over the day. The formula for DNL gives an extra ten decibel weighting to nighttime noise events to account for the intrusive nature of these events. The DNL for the thirteen complete days, as shown in Table 2, ranged from 48 dB to 62 dB.

Table 2. Measured Daily Aircraft Noise Levels

Date	Day-Night Average Sound Level, DNL (dB)	Hours Measured	Primary Aircraft Operations
4/18/2018	55*	12	28 Dep/33L Arr
4/19/2018	55	24	15R Dep/10 Arr until 7 am, then 28 Dep/33L Arr
4/20/2018	52	24	28 Dep/33L Arr
4/21/2018	57	24	15R Dep/10 Arr until 7 am, then 28 Dep/33L Arr
4/22/2018	59	24	15R Dep/10 Arr until 4 am, then 28 Dep/33L Arr until 7 am, then 15R Dep/10 Arr
4/23/2018	61	23	28 Dep/33L Arr until 7 am, then 15R Dep/10 Arr
4/24/2018	62	24	15R Dep/10 Arr
4/25/2018	57	24	15R Dep/10 Arr until 3 pm, then 28 Dep/33L Arr
4/26/2018	48	24	28 Dep/33L Arr
4/27/2018	59	24	28 Dep/33L Arr until 6 am, then 15R Dep/10 Arr until 2 pm, then 28 Dep/33L Arr
4/28/2018	54	24	28 Dep/33L Arr until 1 pm, then 15R Dep/10 Arr until 6 pm, then 28 Dep/33L Arr
4/29/2018	50	24	28 Dep/33L Arr
4/30/2018	50	24	28 Dep/33L Arr
5/1/2018	53	24	28 Dep/33L Arr
5/2/2018	51*	11	28 Dep/33L Arr
Total	**57**	**334**	-

Notes:
* Measurements for a partial day may not represent the average noise level for the complete day.

As shown in the single event figures, Figure 9 through Figure 12, most of the loudest noise events at this site are from departures on Runway 15R. Less common noise events are due to departures on Runway 28 and other overflights not associated with BWI Marshall. Departures on Runway 15R accounted for about seventy-eight percent of the DNL. Departures on Runway 28 accounted for about twelve percent of the DNL. Other overflights not associated with BWI Marshall accounted for about seven percent of the DNL. The small remainder of the DNL was due to arrivals and departures on other BWI Marshall runways.

5. CONCLUSION

The composite aircraft DNL over the full measurement period was 57 dB. The precise DNL over a full year will depend on the type and number of aircraft utilizing BWI Marshall and the percentage of time the airport spends in various operational configurations. Approximately seventy-two percent of operations during the measurement period were in west flow and twenty-eight percent were in east flow, which is similar to the typical annual average of seventy percent west flow operations. Noise levels at this site are higher in east flow. Based only on the measurements and a seventy percent annual west flow assumption, the annual DNL at the measurement site is likely similar to the 57 dB that was measured for this period. Note however, that all things are generally not equal when comparing a small time period to a full year of data. Aircraft profiles and flight paths can vary due to weather and the types of aircraft and times of flights can change due to shifts in airline flight schedules.

In Appendix A of 14 CFR Part 150, the Federal Aviation Administration provides guidelines for the compatibility of land uses with various annual DNL values. These guidelines consider residential land use to be incompatible when the DNL is 75 dB or greater. For noise levels between 65 dB and 75 dB DNL, residential land use is considered incompatible, but where the community determines that this land use must be allowed, measures to achieve greater than typical outdoor to indoor noise level reduction should be incorporated into building codes. The guidelines designate all land uses, including residential, as compatible for DNL values below 65 dB.

How do we Describe Aircraft Noise?

We use a number of terms to describe aircraft noise. These metrics form the basis for the majority of noise analyses conducted at most airports in the U.S.

The Decibel, dB

All sounds come from a source – a musical instrument, a voice speaking, an airplane. The energy that produces these sounds is transmitted through the air in waves, or sound pressures, which impinge on the ear, creating the sound we hear.

The decibel is a ratio that compares the sound pressure of the sound source of interest (e.g., the aircraft over flight) to a reference pressure (the quietest sound we can hear). Because the range of sound pressures is very large, we use logarithms to simplify the expression to a smaller range, and express the resulting value in decibels (dB). Two useful rules of thumb to remember when comparing individual noise sources are: (1) most of us perceive a six to ten dB increase to be about a doubling of loudness, and (2) changes of less than about three dB are not easily detected outside of a laboratory.

The A-Weighted Decibel, dB(A)

Frequency, or "pitch", is an important characteristic of sound. When analyzing noise, we are interested in how much is low-, middle-, and high-frequency noise. This breakdown is important for two reasons. First, our ears are better equipped to hear mid- and high-frequencies; thus, we find mid- and high-frequency noise more annoying. Second, engineering solutions to noise problems are different for different frequency ranges. The "A" filter approximates the sensitivity of our ear and helps us to assess the relative loudness of various sounds.

Maximum A-weighted Sound Level, Lmax

A-weighted sound levels vary with time. For example, the sound increases as an aircraft approaches, then falls and blends into the background as the aircraft recedes into the distance. Figure 1 illustrates this phenomenon. We often describe a particular noise "event" by its maximum sound level (Lmax). Figure 2 shows typical Lmax values for some common noise sources. In fact, two events with identical Lmax may produce very different total exposures. One may be of very short duration, while the other may be much longer.

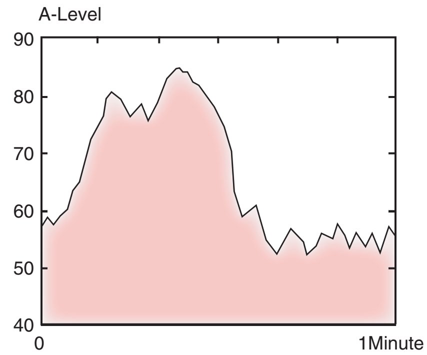

Figure 1. A-weighted Sound Levels Over Time

Sound Exposure Level, SEL

The most common measure of cumulative noise exposure for a single aircraft flyover is the Sound Exposure Level (SEL). Mathematically, it is the sum of the sound energy over the duration of a noise event – one can think of it as an equivalent noise event with a one-second duration. Figure 3 shows that portion of the sound energy included in this event. Because the SEL is normalized to one second, it will almost always be larger in magnitude than the Lmax for the event. In fact, for most aircraft events, the SEL is about 7 to 12 dB higher than the Lmax. Also, the fact that it is cumulative measure means that a higher SEL can result from either a louder or longer event, or some combination.

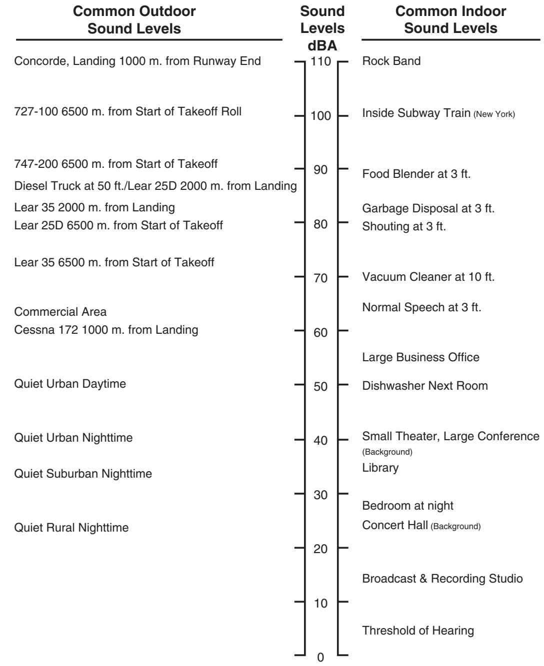

Figure 2. Common Environmental Sound Levels

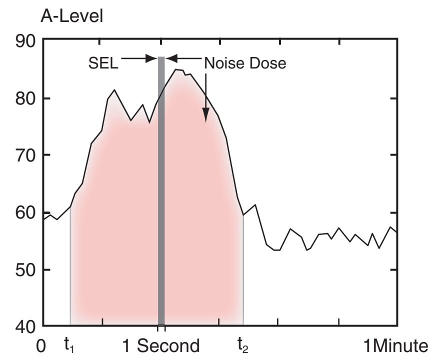

Figure 3. Sound Exposure Level

SEL provides a comprehensive way to describe noise events for use in modeling and comparing noise environments. Computer noise models base their computations on SEL values.

Day-Night Average Sound Level, DNL

The Day-Night Average Sound Level (DNL) represents noise as it occurs over a 24-hour period, with the assumption noise events occurring at night (10 p.m. to 7 a.m.) are 10 dB louder than they really are. This 10 dB penalty is applied to account for greater sensitivity to nighttime noise, and the fact that events at night are often perceived to be more intrusive because nighttime ambient noise is less than daytime ambient noise.

Figure 4 depicts a hypothetical daily noise dose. The top frame repeats the one-minute noise exposure that was shown in Figure 1. The center frame includes this one-minute interval within a full hour; now the shaded area represents the noise during that hour with 16 noise events, each producing an SEL. Finally, the bottom frame includes the one-hour interval within a full 24 hours. Here the shaded area represents the listener's noise dose over a full day.

DNL normally can be measured with standard monitoring equipment or predicted with computer models.

Most aircraft noise studies utilize computer-generated estimates of DNL, determined by accounting for all of the SELs from individual events which comprise the total noise dose at a given location on the ground.

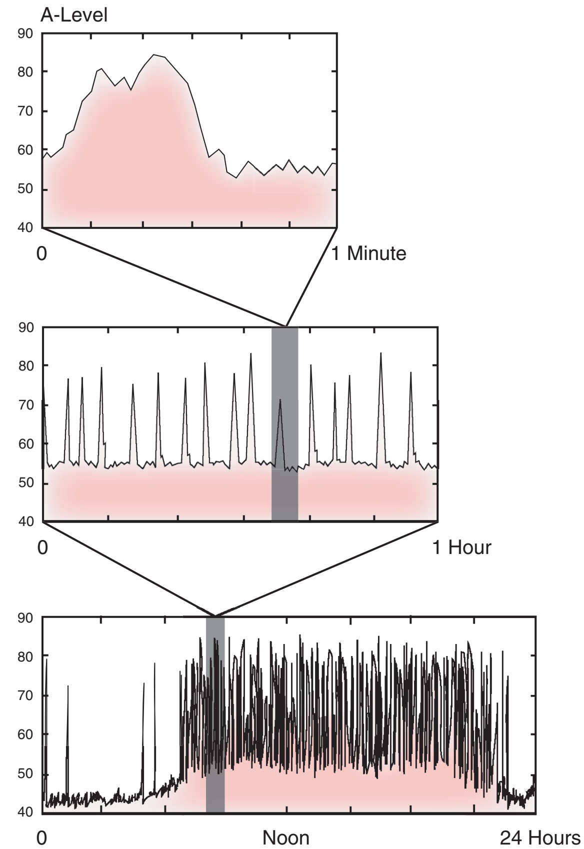

Figure 4. Daily Noise Dose

Computed values of DNL are often depicted as noise contours reflecting lines of equal exposure around an airport (much as topographic maps indicate contours of equal elevation). DNL contours usually reflect annual average operating conditions, taking into account the average number of flights each day, how often each runway is used throughout the year, and where over the surrounding communities the aircraft normally fly.