Aircraft
Noise
Abatement
Office

San Francisco International Airport

Technical Report

Aircraft Overflight and Noise Analysis

at

Terrace Ave
Bolinas, California

August 2000

Prepared by:

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January 3, 2001

This preface clarifies the calculation procedures used by Harris Miller Miller & Hanson Inc. (HMMH) when determining aircraft-only Community Noise Equivalent Level (CNEL) and community-only CNEL such that their sum is the total daily CNEL, as measured.

HMMH generally reports CNEL values in whole numbers due to the inability to know the values to any higher degree of certainty. When conducting noise measurements, the noise monitors used by HMMH record the noise levels and calculate the total daily CNEL value to the nearest tenth (one decimal place). During analysis this measured degree of accuracy is maintained for our calculations until we report the final values.

When adding CNEL values logarithmically, HMMH uses the values to the nearest tenth, calculates the sum, and then rounds to the nearest whole number using standard rounding procedures for the final reported CNEL values. This may cause some confusion when looking at a table and trying to add the rounded numbers to give the resultant sum. For example, logarithmically adding rounded numbers 37 and 52 results in a sum of 52. However, the CNEL table of values may show the sum to be 53. This is the result of logarithmically adding the numbers before rounding (36.9 and 52.4) resulting in a sum of 52.5 which rounds to 53. Therefore, in cases where a value before rounding is near the rounding point (.5), there may be a difference (1 dB) in the sum using rounded numbers versus the numbers to the nearest tenth.

INTRODUCTION

Harris Miller Miller & Hanson Inc., in cooperation with San Francisco International Airport's (SFO) Aircraft Noise Abatement Office, performed a noise monitoring survey on Terrace Avenue, Bolinas, CA from 15 June 2000 through 23 June 2000. On-site observations were conducted in the afternoon on Thursday, 15 June 2000. Figure 1 shows the general location of the monitoring site in relation to SFO.

1. SUMMARY

During the survey, a daily average of approximately 144 aircraft flew within a 2-mile hemispherical radius of the monitoring site as evidenced by actual radar data accumulated at SFO. The majority of these flights were arrivals to SFO on Runways 28L and 28R and arrivals to San Jose International Airport (SJC) on Runways 30L and 30R. Our analysis correlated the aircraft flights to the noise events collected by the noise monitors. The calculated aircraft Community Noise Equivalent Levels (CNEL) ranged from 32 dB to 38 dB which were 8 dB to 17 dB below the corresponding community CNEL. These results are consistent with aircraft noise levels at locations far removed from the airport environs; i.e., aircraft noise events are noticeable and detectable, but are not contributing to the total CNEL.

2. BACKGROUND

3.1 Aircraft Noise Terminology/Metrics

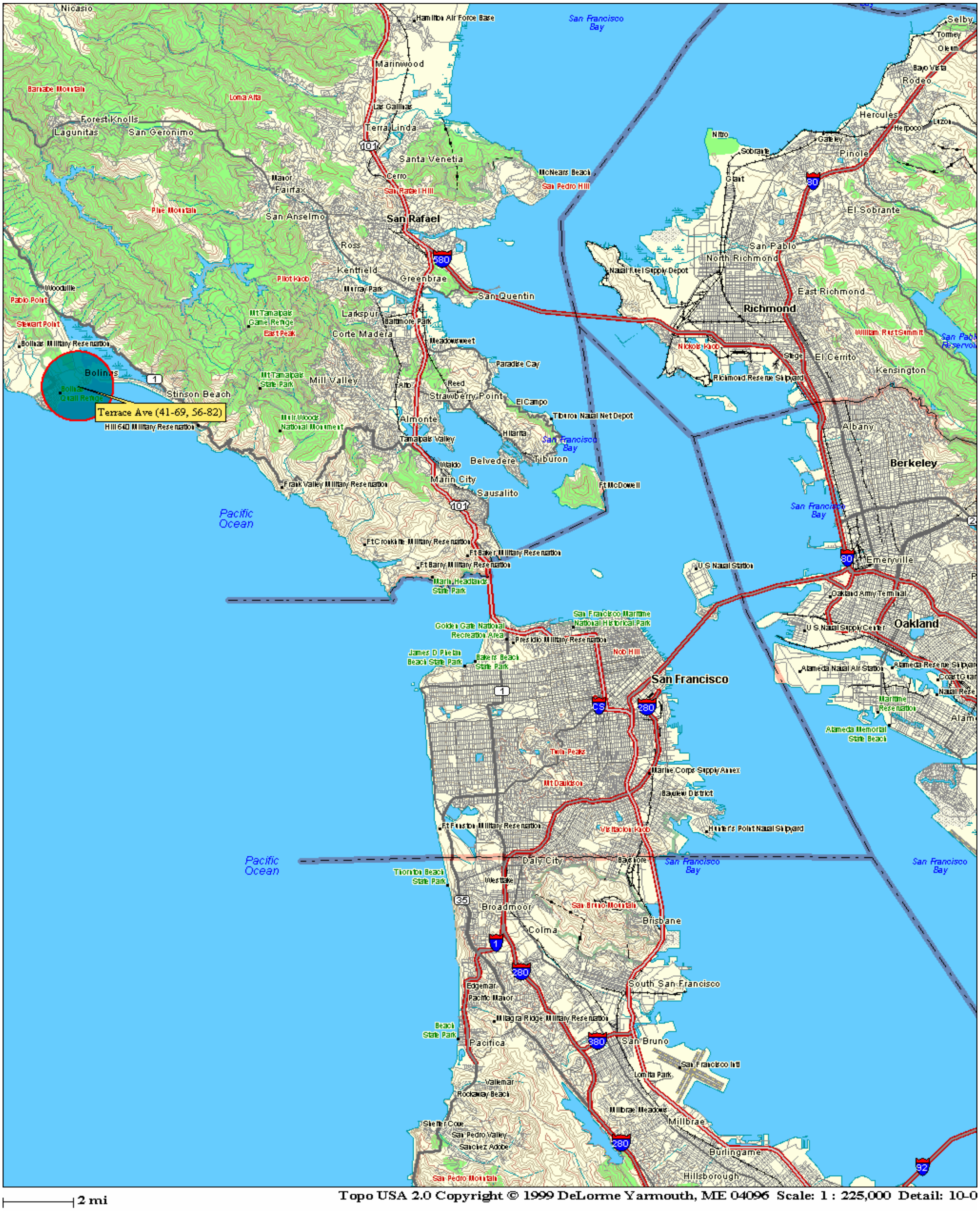
Appendix A defines the aircraft noise terminology used in this report.

3.2 Instrumentation Set-up

A Larson-Davis Type 820 Noise Monitor measured the noise environment. A GRAS microphone and Larson-Davis microphone pre-amp were placed on a 5-foot tripod and were connected to the monitor with the use of a microphone cable. The monitor was locked in "run-mode" and secured in a locked box. The monitor was powered by external AC power through a power cord connected to the residence. The data were downloaded at various intervals. For each recorded event, the data collected by the Larson-Davis 820 consisted of event time, duration, Lmax, and calculated SEL.

3.3 Measurement Site Description

This site was approximately 27 miles from SFO and was located in a residential backyard on a hill overlooking Bolinas Bay and the Pacific Ocean. The community noise levels at this site were influenced by several factors including occasional street traffic, neighborhood maintenance and construction activities, and the sounds of the wind and ocean surf. Prior to taking measurements the monitor was calibrated and, through observation, an ambient or background noise level of 38 dB - 42 dB was determined; therefore, the exceedance or threshold level on the noise monitor was set to 47 dB. The minimum noise duration was set at five seconds. That is, for a noise event to be recorded, it had to exceed the established threshold of 47 dB for at least 5 seconds. The monitor stored the total CNEL value for each 24-hour day (midnight to midnight) during the monitoring period from 15 June 2000 through 23 June 2000.


Terrace Ave (41-69, 56-82)
Bolinas
Stinson Beach
Mill Valley
San Rafael
Richmond
Berkeley
Oakland
San Francisco
Sausalito
Daly City
South San Francisco
San Bruno
Millbrae
Burlingame
Pacific Ocean
San Francisco Bay
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Topo USA 2.0 Copyright © 1999 DeLorme Yarmouth, ME 04096 Scale: 1 : 225,000 Detail: 10-0

Figure 1. Location of Monitoring Site

3.4 Aircraft Flight Information

An average of 144 aircraft per day flew in the vicinity of this site during the measurements. Figure 2 shows the various aircraft tracks for 22 June 2000. A number of flights (non-SFO arrivals) were on different flight paths, i.e., arrivals to SJC and overflights by aircraft with unknown destinations or origins. Most of the aircraft that passed within the vicinity of this site *and* had an effect on the daily sound exposure levels were arrivals to SFO on Runways 28L and 28R and arrivals to SJC on Runway 30L and 30R. The altitude for the flights overflying the monitoring site ranged from approximately 9,000 feet MSL to 20,000 feet MSL with an average altitude of 12,500 feet MSL. The arrivals to SFO were generally at 11,000 feet MSL and the arrivals to SJC were generally at altitudes of 17,000 and 18,000 feet MSL.

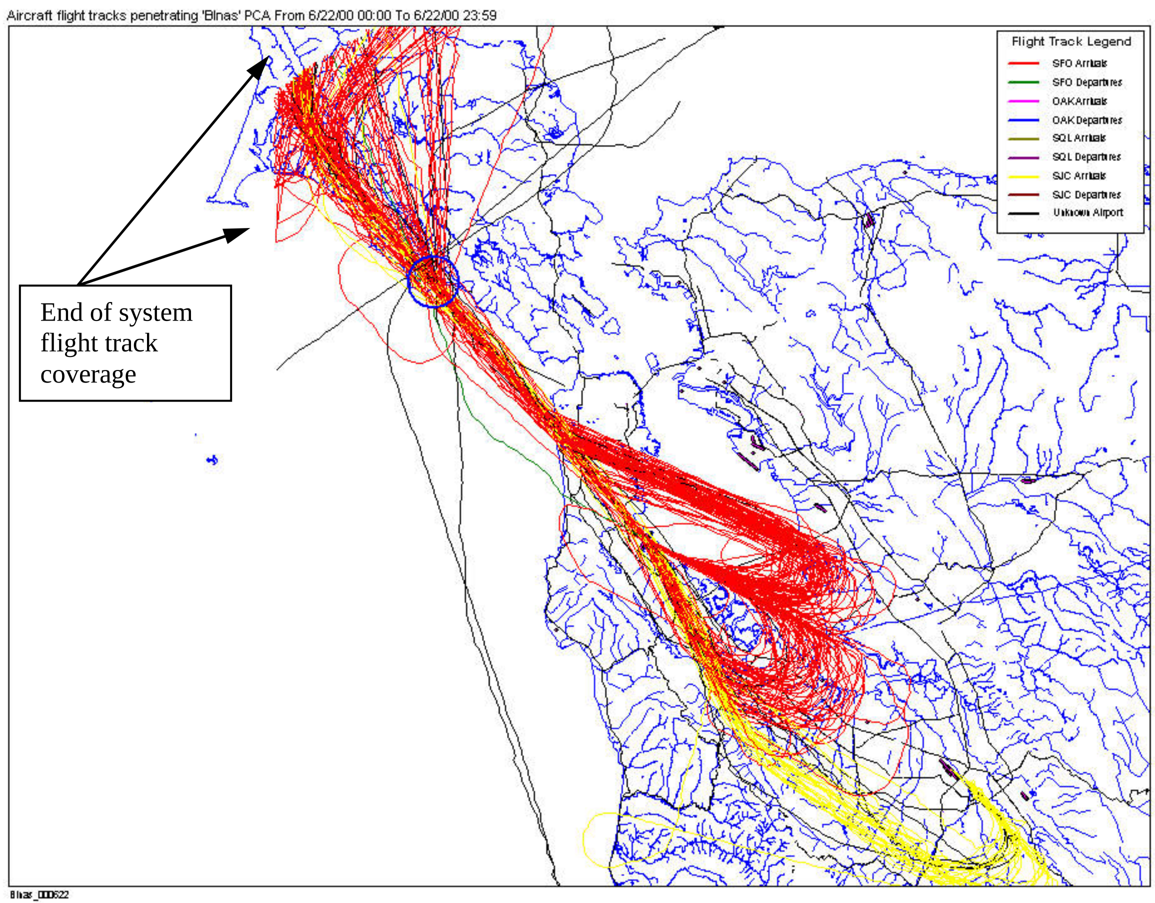


Figure 2. Flight Tracks in Vicinity of Site (22 June 2000)

3. MEASUREMENTS

Data were collected on-site from 15 June 2000 through 23 June 2000. On the afternoon of 15 June, on-site observations were conducted to observe the air traffic patterns and gain an insight into the sounds of the community environment. Unfortunately, the broken to overcast cloud cover impacted the ability to observe the traffic patterns. An analysis of recorded events and associated radar flight data was conducted for the period of 16 June 2000 through 22 June 2000. The analysis used the time of each event and the aircraft radar data to correlate the events to aircraft type, air carrier, aircraft altitude at the point of closest approach (where, in the flight path, the aircraft is closest to the ground site), destination or origin airport, runway used, and direction of traffic flow. Table 1 summarizes the data analyzed.

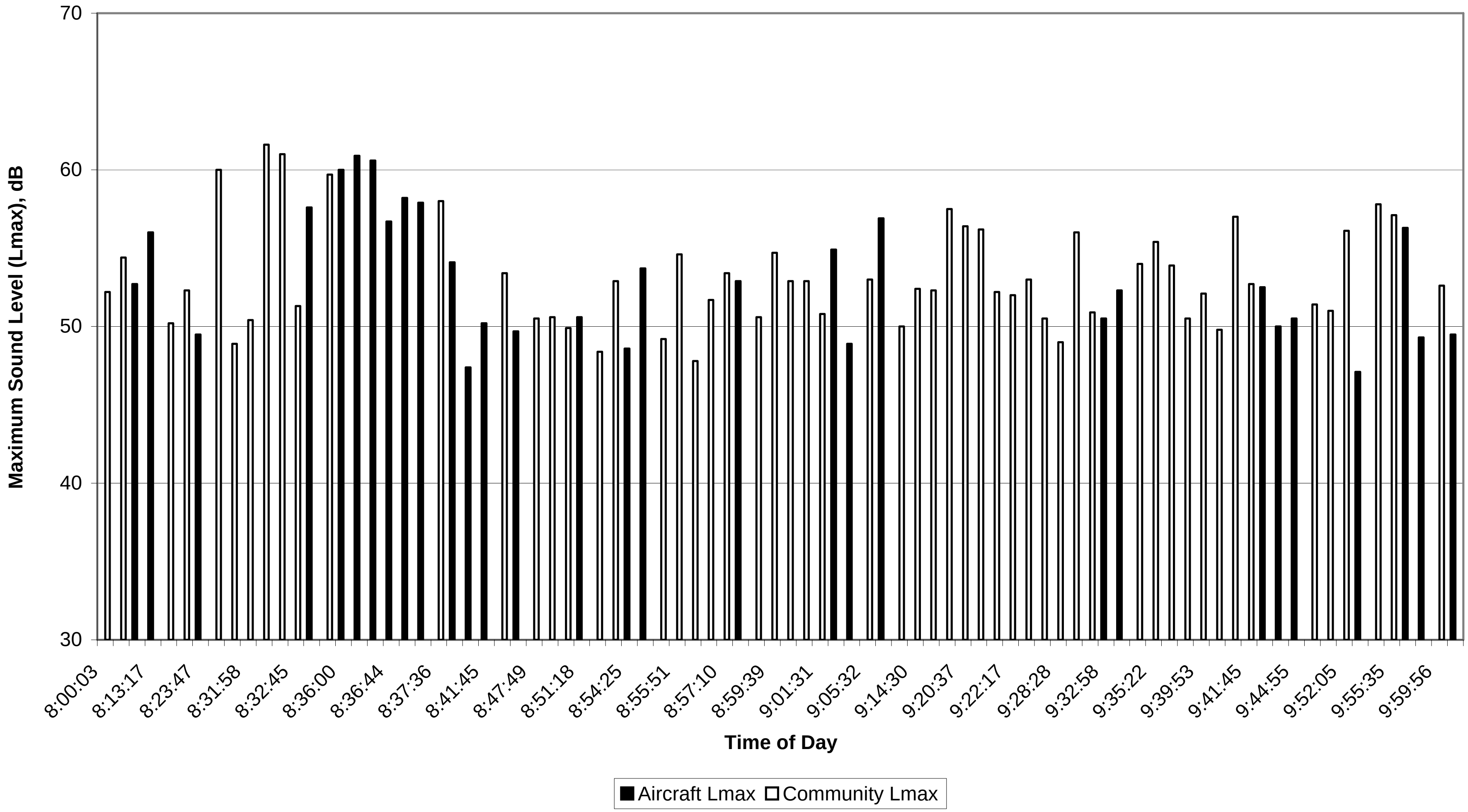
Table 1. Daily Aircraft Noise Measurements

Date	Number of Aircraft Overflights	Total Number of Noise Events	Correlated Aircraft Noise Events	Aircraft CNEL (dB)	Range (dB)	
					L_{max}	SEL
06/16/00	139	720	141	36	47 - 70	53 - 76
06/17/00	131	659	72	32	47 - 56	53 - 70
06/18/00	156	450	128	35	47 - 69	53 - 72
06/19/00	142	466	114	36	47 - 67	54 - 85
06/20/00	126	489	120	35	47 - 61	53 - 70
06/21/00	147	511	145	36	47 - 71	53 - 77
06/22/00	166	610	171	38	47 - 65	53 - 75

The number of correlated aircraft noise events exceeded the number of overflights on two occasions as sometimes one aircraft would create more than one noise event due to the variation in sound level.

Figure 3 shows a sample two-hour period of recorded Lmax values for aircraft and community noise events. As shown, the majority of the noise events are between 47 dB and 62 dB Lmax. The aircraft Lmax values varied between 47 dB to 61 dB and the community-only Lmax values varied from 47 dB to 62 dB. These levels are fairly typical of the rest of the data analyzed.

Figure 3. Sample of Aircraft and Community Event Lmax Values - 22 June 2000



The measured SELs correlated to actual aircraft operations were used to compute the CNEL from aircraft operations at the site. Table 2 and Figure 4 show the aircraft CNEL varied between 32 dB to 38 dB throughout the measurement period with the median level being 36 dB. The total measured CNEL for the time period is also shown in Table 2 and Figure 5 and ranged from 45 dB to 50 dB with a median of 47 dB. We determined the community-only CNEL by removing the daily-calculated aircraft CNEL contribution from the measured total daily CNEL. Table 2 shows the community 24-hour noise exposure, without aircraft noise, ranged from 45 dB to 50 dB with the median level being 46 dB. This range corresponds to expected noise levels in quiet suburban living areas (Ref: "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety", U.S. Environmental Protection Agency, March 1974). The results indicate the aircraft increased the total daily CNEL by 0 to 1 dB.

Table 2. Daily CNEL Measurements

Date	Total-Daily CNEL (dB)	Aircraft-Only CNEL (dB)			Community-Only CNEL (dB)
		Total	SFO	SJC	
06/16/00	50	36	34	32	49
06/17/00	49	32	32	19	49
06/18/00	45	35	34	21	45
06/19/00	50	36	35	26	50
06/20/00	46	35	34	27	46
06/21/00	46	36	35	25	45
06/22/00	47	38	37	29	46

A review of the daily contributions to the aircraft CNEL at this site by specific airport revealed that SFO arrivals to Runways 28L and 28R dominate with SJC arrivals to Runways 30L and 30R also contributing. An energy average of the aircraft CNEL for the time period of measurement was 36 dB. SFO average aircraft CNEL contribution was 35 dB and that of SJC was 27 dB.

Figure 4. Aircraft CNEL

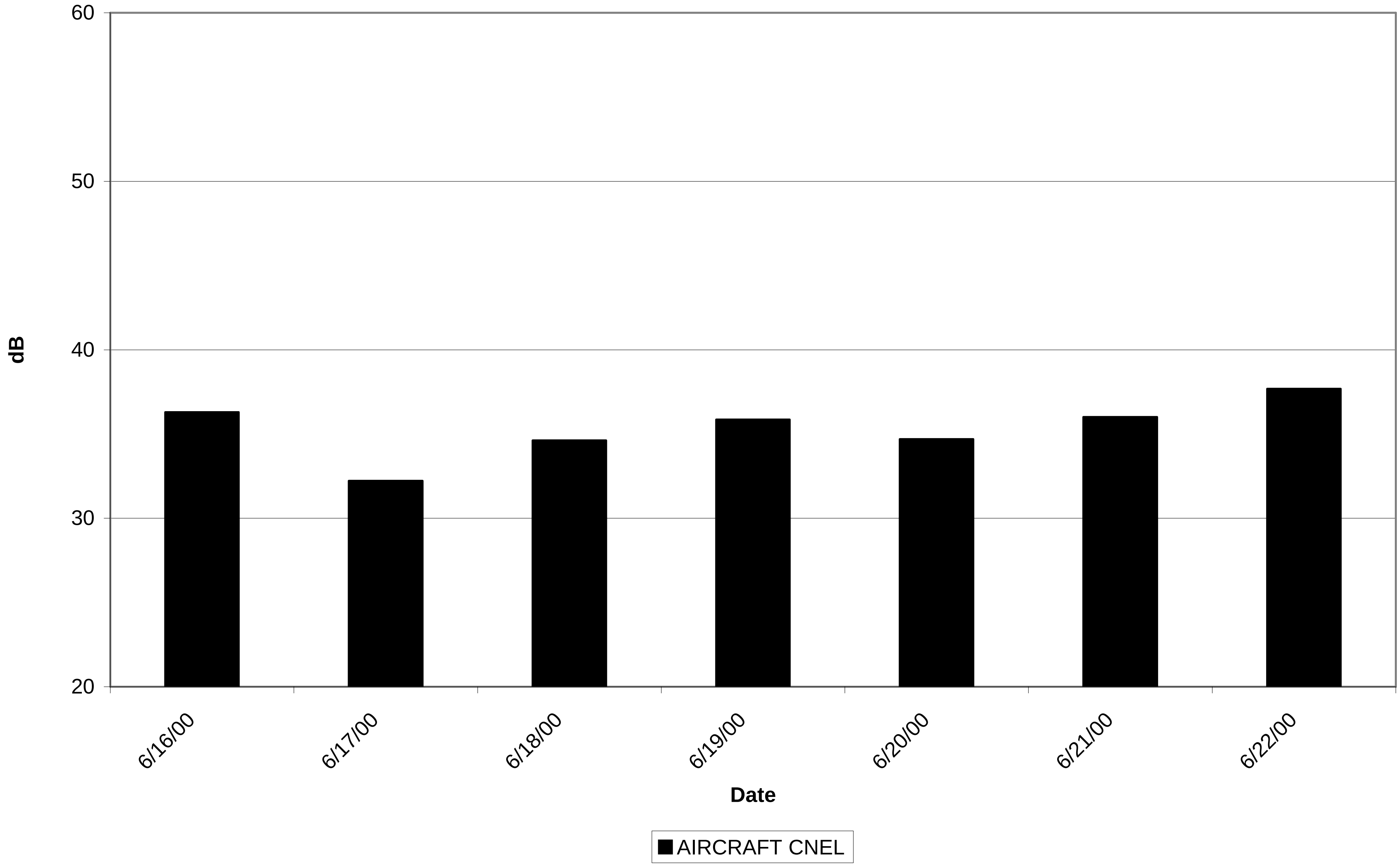
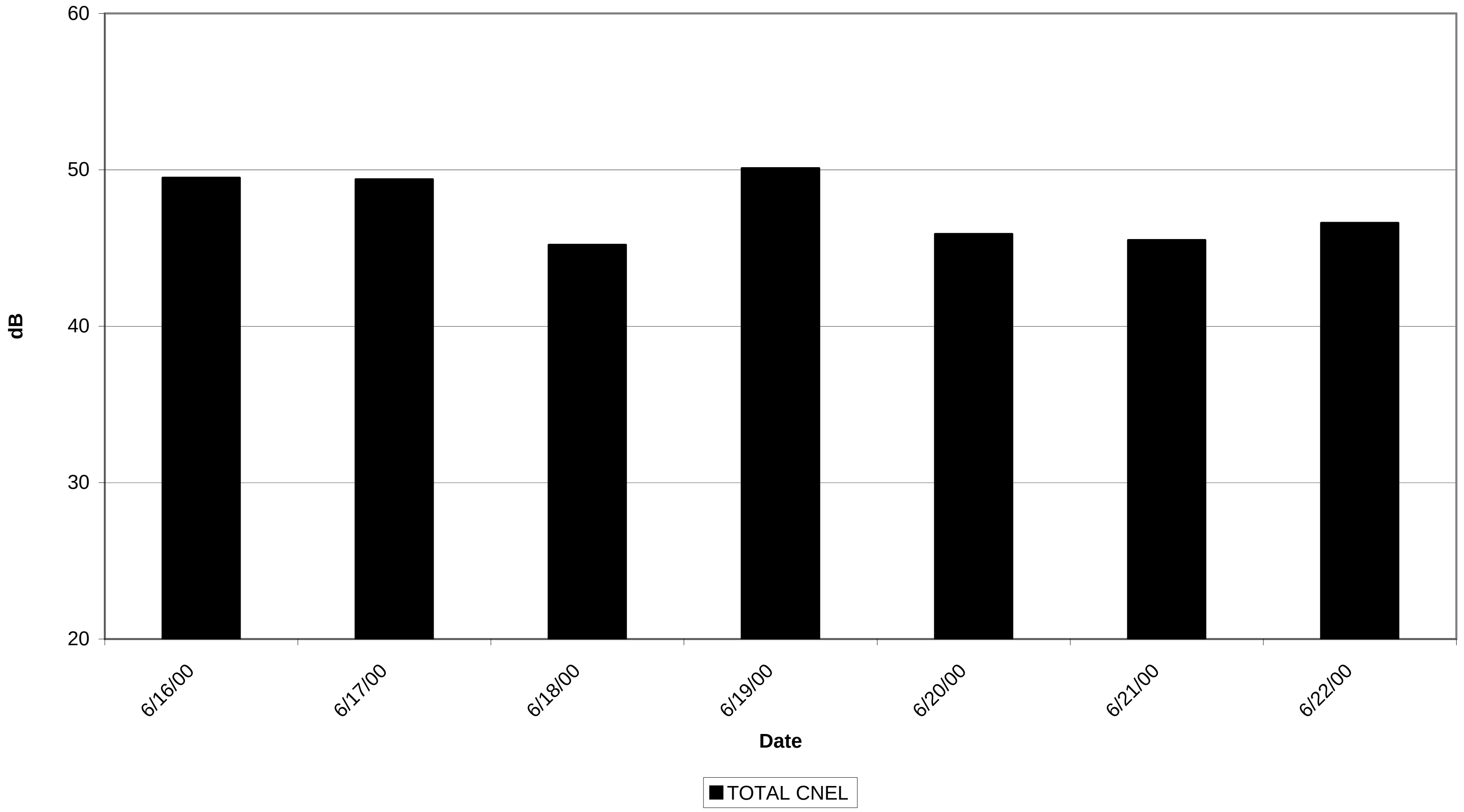


Figure 5. Total Daily CNEL



4. CONCLUSIONS

Based on observations and collected data, we conclude the following:

1. Aircraft noise exposure measured 32 dB to 38 dB CNEL.
2. Aircraft noise was primarily due to arrivals at SFO and SJC at altitudes above 10,000 feet MSL.
3. Aircraft arrivals to SFO dominated the aircraft contribution to the noise exposure level.
4. Aircraft increased the total daily CNEL by 0 to 1 dB.
5. Community, or non-aircraft, noise exposure of 45 dB - 50 dB exceeds aircraft noise exposure.

APPENDIX A

Aircraft Noise Terminology/Metrics

To assist in understanding the noise measurements and noise metrics used in evaluating airport noise, we provide a brief introduction to noise terminology used in this report. Specifically, the noise metrics discussed are the decibel (dB), the A-weighted sound level, the Maximum Noise Level (L_{max}), the Single Event Noise Exposure Level (SENEL), the Sound Exposure Level (SEL), and the Community Noise Equivalent Level (CNEL).

The <u>decibel or dB</u> is the unit of measure used to represent the change in sound pressure which is detected by the human ear. Since the range between the slightest and greatest sounds that we hear is extremely large, the decibel uses the logarithmic scale to compress this range to a more meaningful scale with 0 dB representing the slightest sound we can hear. Most sounds we experience in our day-to-day lives vary somewhere between 30 dB and 100 dB. Figure A-1 presents typical sound levels of several common environmental sources.

Aircraft sound measurements generally use the metric known as A-weighted sound level. This is the sound level that has been filtered or weighted to reduce the influence of high and low frequency extremes. This closely replicates the sensitivity of the human ear in the frequency range of 500 – 10,000 Hz and correlates well with perceptions of the loudness of sounds. Thus, an aircraft noise event with a higher A-weighted sound level is perceived to be louder than an aircraft noise event with a lower A-weighted sound level. This correlation with human's perception of loudness is the primary reason that A-weighted sound levels are used to evaluate environmental noise sources. Although A-weighted sound levels are normally written with units dBA, all sound levels in this report are A-weighted and the unit dB indicates A-weighted sound levels.

<u>L_{max}</u>, or the maximum noise level, is a measurement of the maximum sound level for a single event. L_{max} can be directly measured in dB with a wide variety of sound measurement instruments. However, L_{max}, by itself, provides no information on the cumulative noise exposure from a single source. The duration of a noise event also impacts our perception of annoyance. Therefore, a term or metric is needed that accounts for both intensity and duration and provides a uniform assessment of noise events with differing intensities and durations. This metric is SENEL or SEL.

<u>SENEL</u> expressed in dB represents the cumulative sound energy detected above an established threshold for a single event considering both intensity and duration of the sound. For measurements, the threshold is 30 dB below an upper SENEL limit which depends on the aircraft type and distance from either the start of the take-off roll or the landing threshold. <u>SEL</u> is functionally equivalent to SENEL with the difference being that the threshold for SEL is referenced to the background noise level. The SEL is <u>calculated</u> by normalizing or standardizing the accumulated sound energy to a one-second duration. Thus, for example, two events with the same intensity but different durations can be differentiated with the longer duration event having higher SEL. This normalization will usually result in the SEL for most aircraft overflights being on the order of 7 dB to 12 dB higher than the corresponding L_{max}. Thus, SEL gives us a common basis for comparing noise events that matches our instinctive impression – the higher the SEL, the more annoying it is likely to be.

APPENDIX A

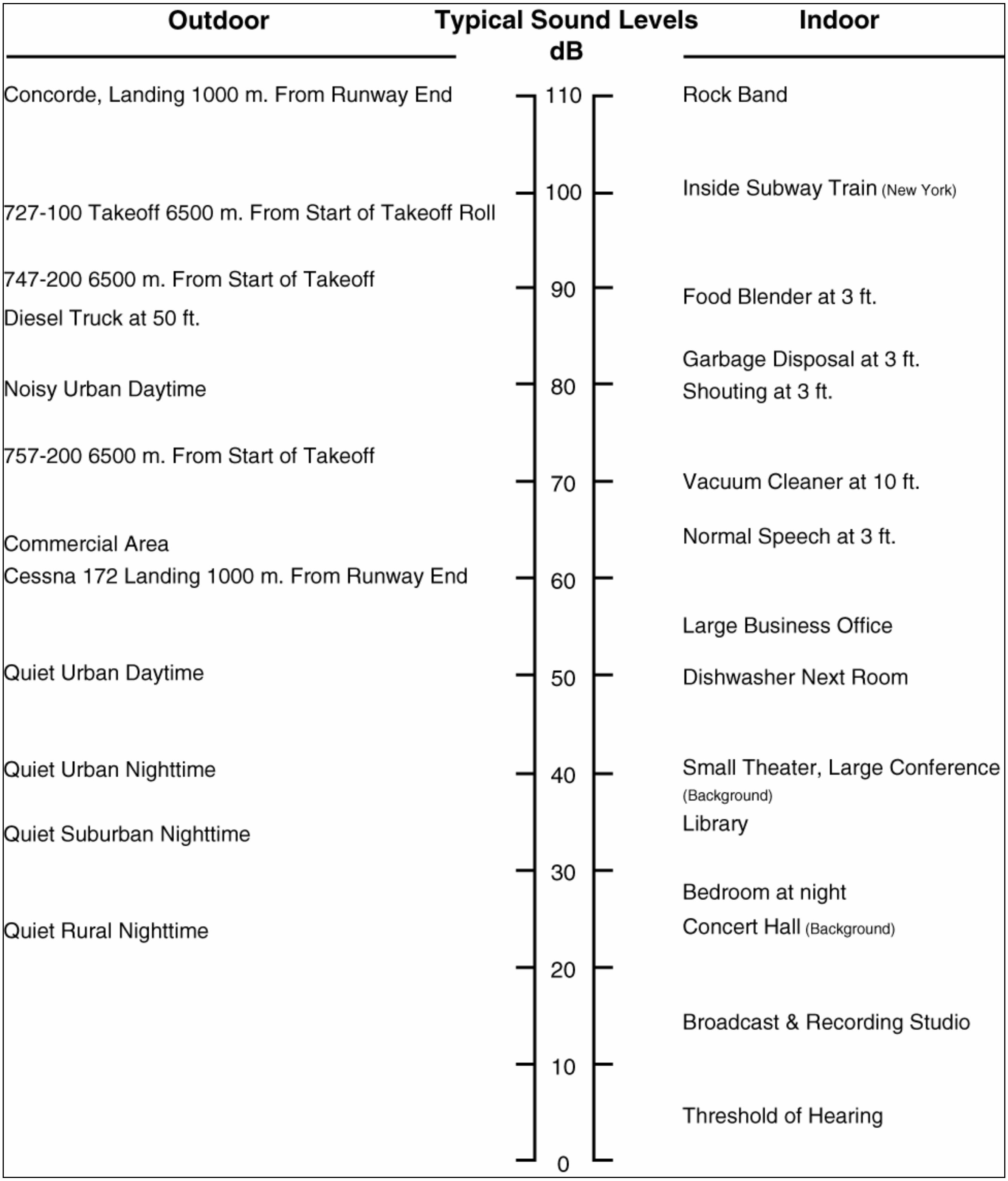


Figure A-1. Common Environmental Sound Levels in dB

APPENDIX A

The previous two metrics dealt with measuring noise on an event by event basis. To determine the cumulative effect of noise exposure on a community and to correlate that level of noise exposure to a community annoyance response, the CNEL was developed.

CNEL looks at a 24-hour period and the associated noise events with corresponding SEL values and derives an average SEL or equivalent sound level for an entire day. To account for the perceived greater sensitivity to evening and nighttime noise, CNEL applies a weighting to aircraft events occurring during those time periods. For evening (7:00 PM – 9:59 PM) and nighttime (10:00 PM – 6:59 AM) aircraft noise events, CNEL logarithmically multiplies each operation by 3 and 10, respectively. This effectively adds 4.8 dB to evening event SELs and 10 dB to nighttime event SELs. The aircraft CNEL is then derived using the SELs from all aircraft generated events for the period. A total CNEL will include the aircraft generated events as well as other noise events generated in the community during the corresponding time period. Typically, total CNEL in our environment ranges from a low of 40-45 dB in very quiet locations to 80-85 dB immediately adjacent to an active noise source – busy traffic route or active airport. Figure A-2 shows representative values of CNEL in typically different environments. Aircraft CNEL is also used to depict noise contours of equal exposure levels around an airport to reflect long-term operations, usually one year.

APPENDIX A

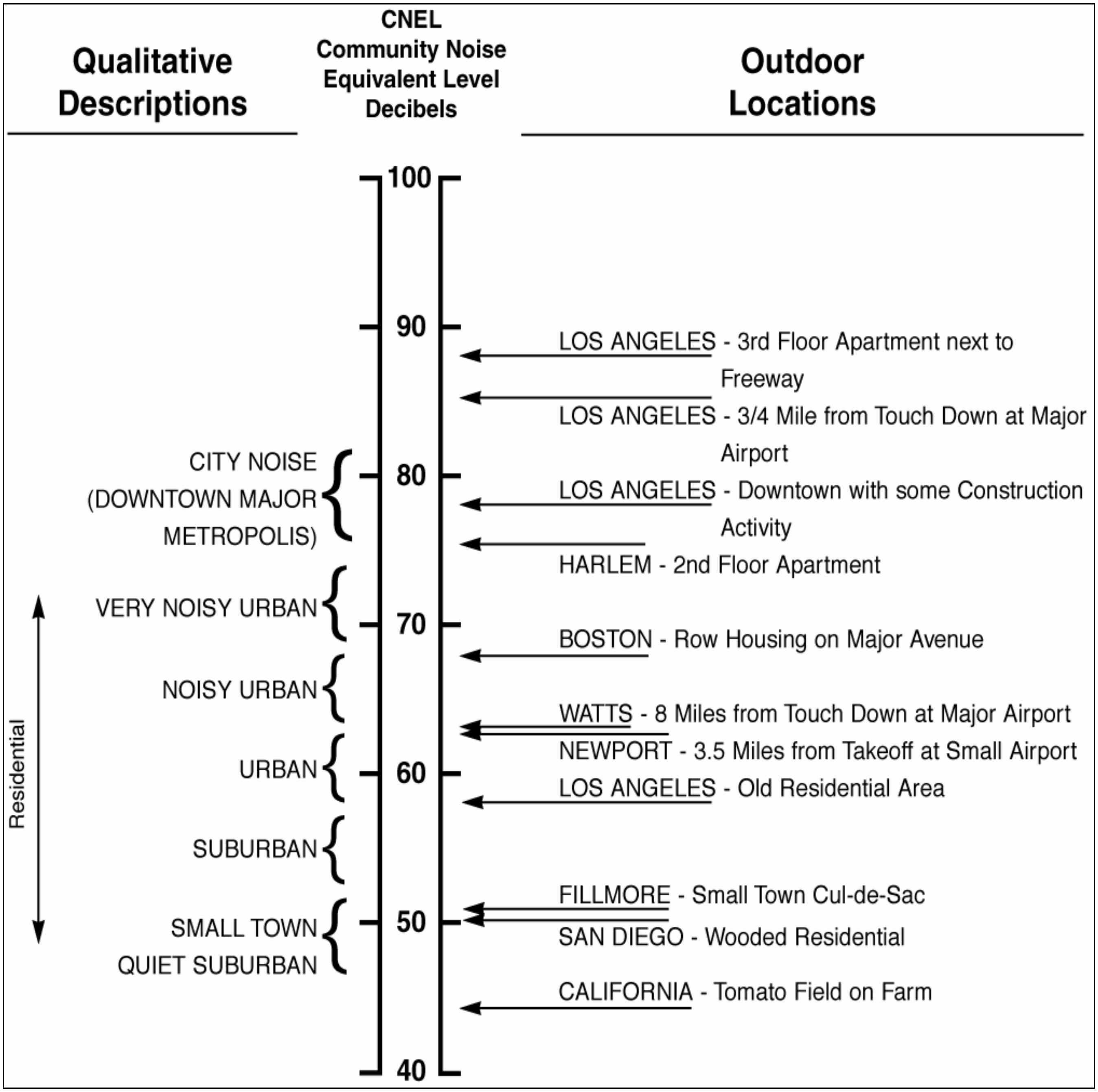


Figure A-2. Representative Cumulative Sound Levels