**Oakland**International Airport

A division of the Port of Oakland

# Runway 29 ILS Noise Study
# Hayward, California

Prepared by

**Noise/Environmental Management Office**
**Port of Oakland**

**July 19, 2005**

# INTRODUCTION AND BACKGROUND

## Community Location and Concerns

A resident on Bal Harbor Lane in Hayward, California has made numerous complaints about turbojet aircraft frequently flying low and loud directly over the home as these aircraft are on final approach to Runway 29 at Oakland International Airport (OAK). These concerns were initially expressed during the summer and fall of 2003. At the request of the South Field Research Group, on behalf of the Airport-Community Noise Management Forum, the Noise/Environmental Management Office performed an aircraft noise monitoring survey from 20 August 2004 through 7 September 2004 to evaluate aircraft noise impacts on this neighborhood. Figure 1 shows the location of the residence and noise monitoring site in relation to the airport.

The Hayward residence is located approximately seven miles southeast of the Runway 29 approach threshold at Oakland International Airport and lies directly below the final approach course or ILS for Runway 29. The Runway 29 ILS has been used since the runway opened in 1962. Figure 2 shows the location of the residence and a sample of the Runway 29 ILS flight tracks.

## Aircraft Flight Information

The Federal Aviation Administration (FAA) standard or "common" precision instrument approach utilized for the ***instrument flight rules*** (IFR) environment throughout the country is known as an ***instrument landing system*** or ILS. This system has been used for many years and is the primary approach procedure for Runway 29 at OAK. Since Runway 29 is the primary commercial aircraft runway, mostly large turbojet aircraft are flown on the final approach flight path or ILS. The volume of aircraft arrivals has generally increased throughout the years as the demand for air transportation has increased with the exception of the economic downturn resulting from September 11th.

Runway 29 is used for aircraft arrivals and departures when the Bay Area is being operated in the West Plan air traffic pattern. Air traffic patterns are a function of the wind conditions and the prevailing winds are blowing from the west and northwest in the Bay Area the majority of the time. The West Plan air traffic pattern is maintained by FAA Air Traffic Control about 90% of the time throughout the year; otherwise the Southeast Plan is in effect. When the Southeast Plan is in effect, Runway 11 is used and aircraft arrive from the north and northeast and depart to the south and southeast. Approximately 240 turbojet aircraft land on Runway 29 daily and about 85% of these aircraft fly in the vicinity (within one mile) of Bal Harbor Lane.

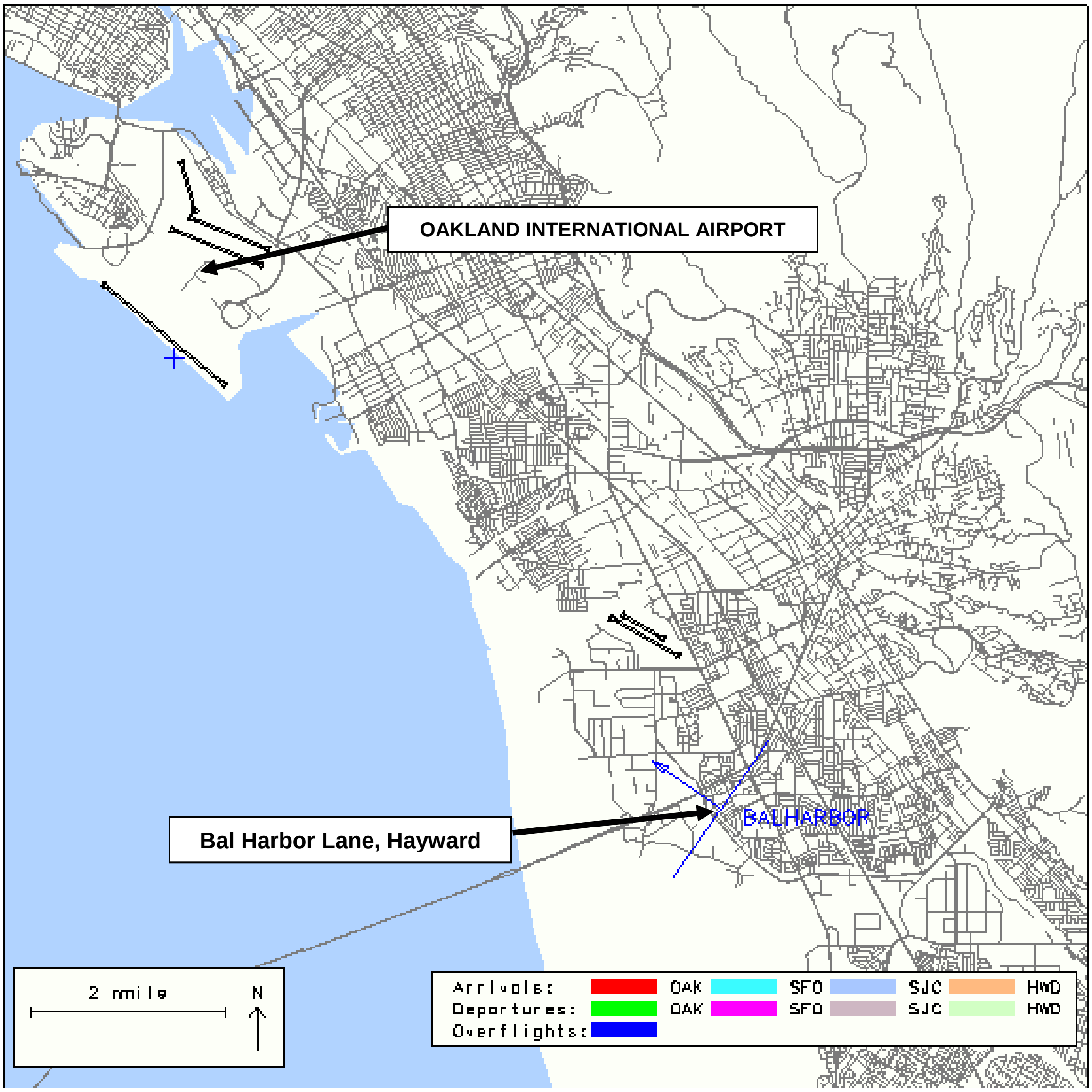

Figure 1. Site Location Map

## Aircraft Noise Terminology/Metrics

The FAA has adopted the Day-Night Average Sound Level (DNL) as the noise metric to assess community aircraft noise exposure. The FAA also recommends the use of the annual average DNL for determining compatible land use near airports and the 65 DNL as the criterion for incompatible residential land use. As a result, airports generally report their community noise exposure in terms of annual DNL contours overlaid on a map to show areas of compatible and incompatible land use. In California, the FAA, in accordance with California State Regulations Title 21, has allowed the use of the Community Noise Equivalent Level (CNEL) in place of the DNL. Appendix A describes these noise metrics and other noise information in detail.

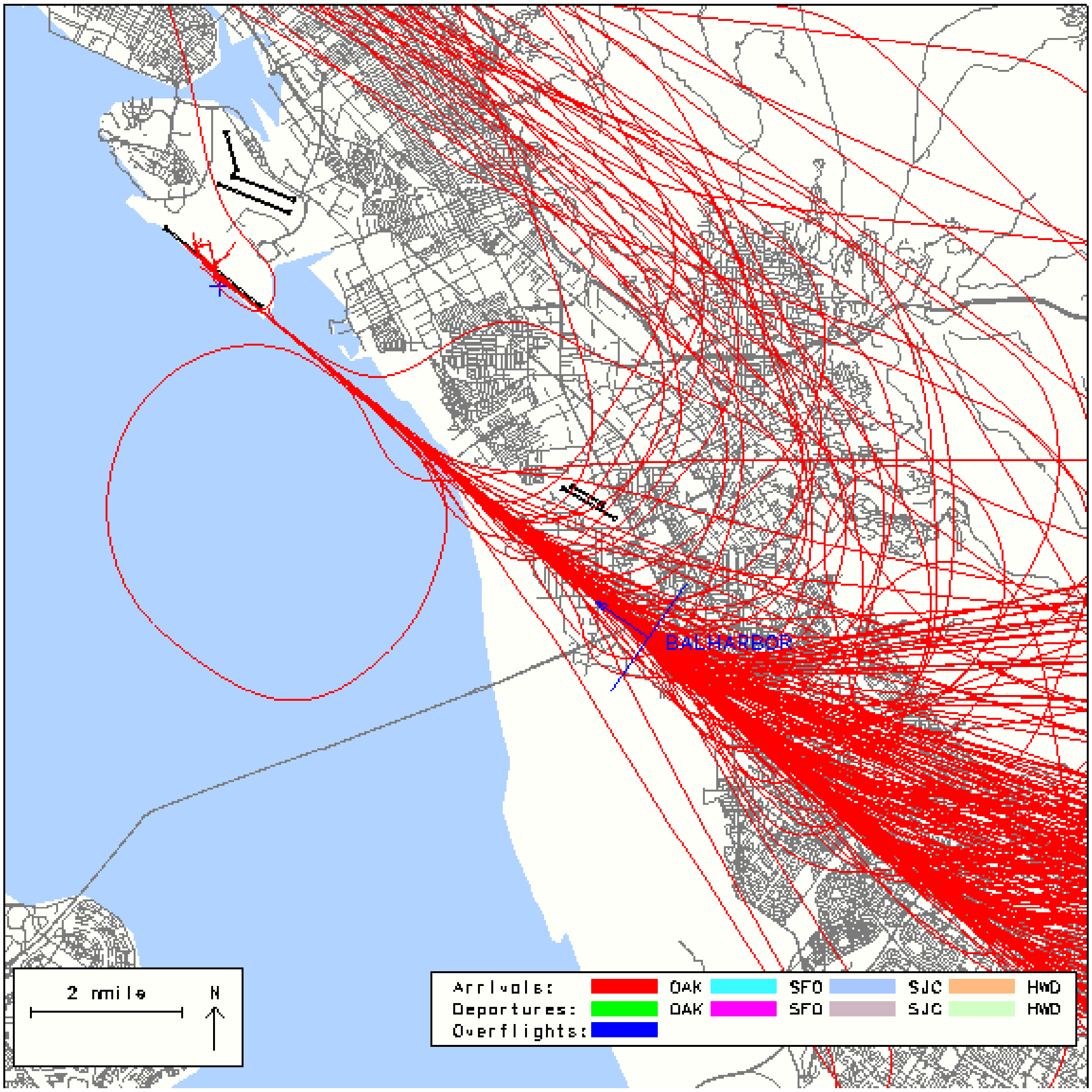

Figure 2. Site Location Map with Flight Tracks

Since the aircraft CNEL measured at Bal Harbor Lane were less than 65 dB, single-event noise metrics were also evaluated to determine the cause of annoyance from aircraft over-flights occurring in Hayward. Two single event metrics were analyzed: (1) the Single Event Noise Exposure Level (SEL) and (2) the maximum sound level (Lmax).

## SUMMARY

Table 1 below provides a summary of the relevant information and data collected during the aircraft noise monitoring period conducted between 20 August 2004 and 7 September 2004. On an average day, there were 156 aircraft noise events associated with Runway

29 turbojet arrivals over the 10 days monitored. On average, there were 197 aircraft that passed over the Hayward neighborhood daily during this period, which means that about 78% of these aircraft generated measurable noise events.

The average aircraft generated Lmax was 70 dBA (decibels, A-weighted), the average SEL was 79 dBA, and the average aircraft noise event duration was 17 seconds. The computed levels for the average **aircraft CNEL** was 58 DBA, the average **community CNEL** was 59 dBA, and the average **total CNEL** was 62 dBA. For comparison purposes, the cumulative aircraft noise level at permanent microphone RMT# 1, which is located approximately two miles closer to the airport, is CNEL 65 dBA.

| Hayward Study Summary | |
|---|---|
| Average Daily Runway 29 Arrivals | 231 |
| Average Daily Arrivals In Gate | 197 |
| Average Daily Aircraft Noise Events | 151 |
| Average Aircraft Lmax | 70 dBA |
| Average Aircraft SEL | 79 dBA |
| Average Noise Event Duration | 17 seconds |
| Average Daily Aircraft CNEL | CNEL 58 dBA |
| Average Daily Community CNEL | CNEL 59 dBA |
| Average Daily Total CNEL | CNEL 62 dBA |

**Table 1: Aircraft Over-flight and Noise Summary**

## DATA ACQUISITION

A Larson-Davis Type 870 portable noise monitor measured the noise environment at the Hayward residence for about three weeks. Based upon observations, a minimum threshold level for the neighborhood was established at 65 dBA with a minimum duration set at 5 seconds. That is, for a noise event to be recorded, it had to exceed the established threshold of 65 dBA for at least 5 seconds.

For each recorded event, the data collected by the Larson-Davis 870 consisted of event time, duration, Lmax, and calculated SEL. The monitor also stored the total CNEL value for each 24-hour day (midnight to midnight) during the monitoring period.

All the noise event data collected by the portable noise monitor were later stored in the Airport Noise and Operations Monitoring System (ANOMS) and correlated with aircraft flight tracks in order to identify aircraft noise events from community noise events. CNEL values for aircraft and community measurements were also calculated using ANOMS.

ANOMS is a sophisticated computer system that integrates aircraft identification, aircraft flight track data and noise data, which is utilized to evaluate aircraft noise impacts on local communities. Data gathered by ANOMS was used to evaluate not only aircraft noise but also aircraft performance and operations statistics for this report.

An aircraft penetration or analysis gate (identified as BalHarbor) was established in ANOMS and centered over Bal Harbor Lane. The gate analysis function in the ANOMS software program allows the user to evaluate any aircraft that penetrates the gate as the aircraft passes through this imaginary "window in the sky". The two-mile wide gate, centered over this residence, is extended one mile from the gate's center in both directions, to the northeast and to the southwest. (See Figure 3) Every turbojet aircraft that passed through the gate and landed on Runway 29 was evaluated for noise and altitude.

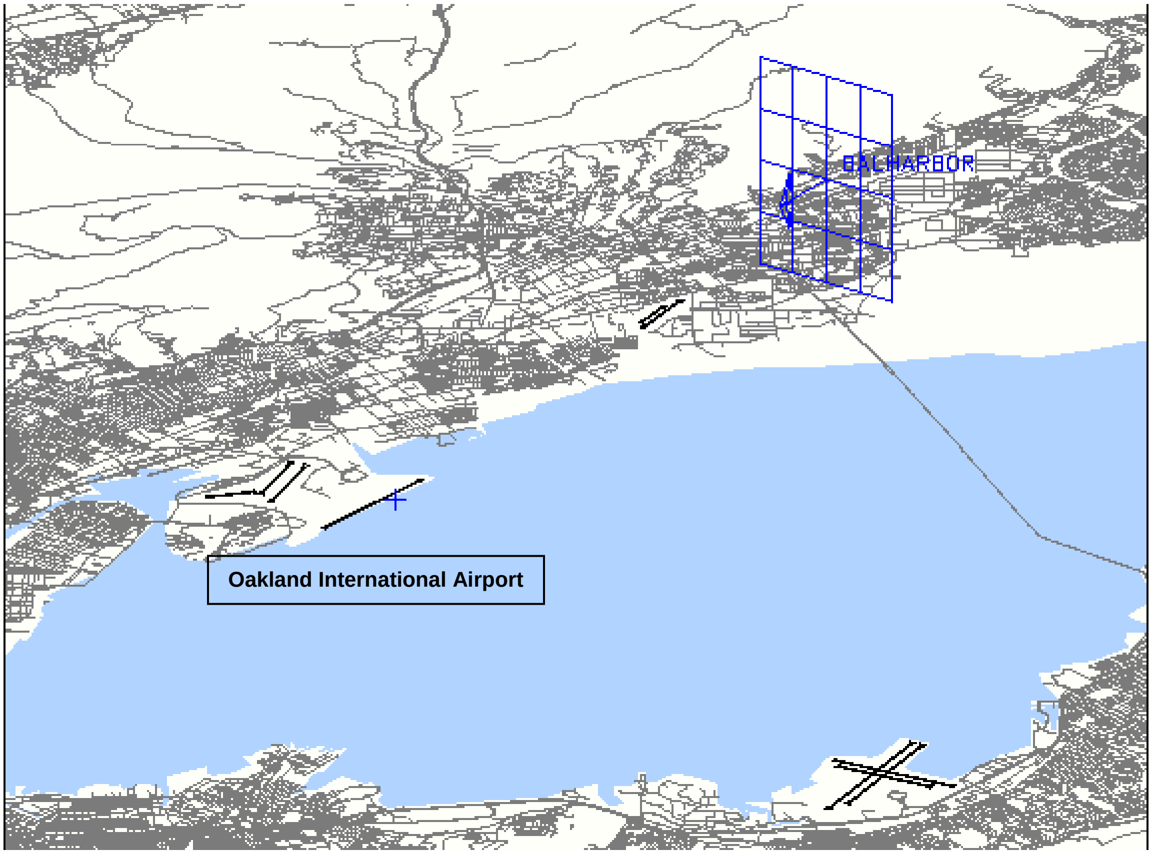

**Figure 3. BalHarbor Gate "Window-in-the-Sky"**

## AIRCRAFT NOISE ANALYSIS

### Frequency of Aircraft Arrivals

First, the frequency of aircraft arrivals was evaluated for Runway 29. This information is important since the perceived changes in frequency, or the amount of flights, can be a factor in the level of annoyance that people experience. Table 2 below provides a summary of the daily aircraft arrival rates and the cumulative noise measurements for each day of the noise measurement study in the Hayward neighborhood.

During the 10-day study period, there were a total of 2,310 Runway 29 arrivals, of which 1,968 aircraft passed within one mile of the residence and 1,507 aircraft triggered a noise event. (See graphic example of aircraft penetration through the BalHarbor Gate in Figure 4 below.) On average, there are approximately 231 aircraft arrivals per day and 197 pass within one mile of the monitored site. Of the 197 aircraft arrivals, 151 noise events are created on an average day. In summary, the data indicate that approximately 85% of all Runway 29 aircraft arrivals passed through the analysis gate and within one-mile of the Hayward residence and approximately 77% of all aircraft that passed through the BalHarbor Analysis Gate created a noise event. Table 2 provides a daily summary of aircraft over-flight and aircraft noise data.

| | **Total Runway 29 Arrivals** | **Total Flights Through Gate** | **Percentage of Arrivals Through Gate** | **Total Number of Aircraft Noise Events** | **Percentage of Gate Flights w/Noise Events** | **CNEL dBA Aircraft** | **CNEL dBA Com-munity** | **CNEL dBA Total** | **Average Lmax Noise Level** | **Average SEL Noise Level** |
|---|---|---|---|---|---|---|---|---|---|---|
| **8/20/2004** | 264 | 224 | 85% | 128 | 57% | 59 | 58 | 62 | 70 dBA | 78 dBA |
| **8/21/2004** | 223 | 178 | 80% | 120 | 67% | 56 | 57 | 59 | 69 dBA | 77 dBA |
| **8/22/2004** | 213 | 186 | 87% | 138 | 74% | 55 | 56 | 59 | 68 dBA | 77 dBA |
| **8/23/2004** | 242 | 220 | 91% | 142 | 65% | 53 | 57 | 59 | 68 dBA | 77 dBA |
| **9/2/2004** | 259 | 222 | 86% | 210 | 95% | 63 | 59 | 65 | 71 dBA | 81 dBA |
| **9/3/2004** | 256 | 240 | 94% | 212 | 88% | 63 | 61 | 65 | 71 dBA | 80 dBA |
| **9/4/2004** | 213 | 175 | 82% | 148 | 85% | 59 | 61 | 63 | 70 dBA | 80 dBA |
| **9/5/2004** | 191 | 140 | 73% | 121 | 86% | 57 | 60 | 62 | 70 dBA | 79 dBA |
| **9/6/2004** | 213 | 183 | 86% | 137 | 75% | 58 | 60 | 62 | 70 dBA | 79 dBA |
| **9/7/2004** | 236 | 200 | 85% | 151 | 76% | 60 | 64 | 66 | 70 dBA | 79 dBA |
| **Totals** | 2,310 | 1,968 | - | 1,507 | - | - | - | - | - | - |
| **Averages** | **231** | **197** | **85%** | **151** | **77%** | **58** | **59** | **62** | **70 dBA** | **79 dBA** |

**Table 2: Daily Aircraft Over-flight and Noise Summary**

The majority of aircraft that penetrated the BalHarbor Gate flew almost directly over the residence and within 1,000 feet either side of the center point of the analysis gate (Hayward residence). Table 3 below provides data showing the distance (in feet) aircraft deviated (east or west) from passing directly over the residence.

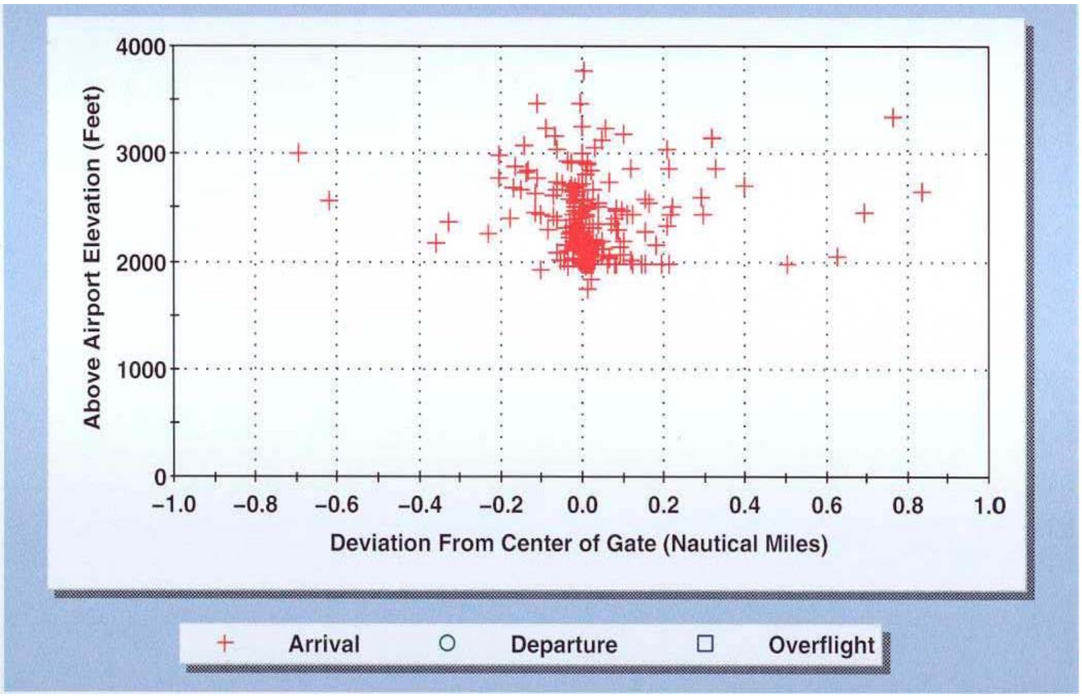

Figure 4.  24 Hours of Flight Tracks Penetrating BalHarbor Analysis Gate

| Deviation From Gate Center | Aircraft Over-Flights | Percentage of Total |
|---|---|---|
| Up to 500 feet | 957 | 49% |
| 500 to 1,000 feet | 748 | 38% |
| 1,000 to 1,500 feet | 114 | 6% |
| 1,500 to 2,000 feet | 70 | 4% |
| 2,000 to 3,000 feet | 28 | 1% |
| Greater than 3,000 feet | 51 | 3% |

Table 3:  Deviation from the Center of the BalHarbor Analysis Gate

## Cumulative Noise Exposure

During the ten days monitored, the average daily Community CNEL was 59 decibels, the average daily Aircraft CNEL was 58 decibels, and the average daily Total CNEL was 62 decibels. Although Community noise contributions are greater than the Aircraft contribution to the total noise environment, aircraft noise is nearly the same level and contributes approximately three decibels to the overall total CNEL level.

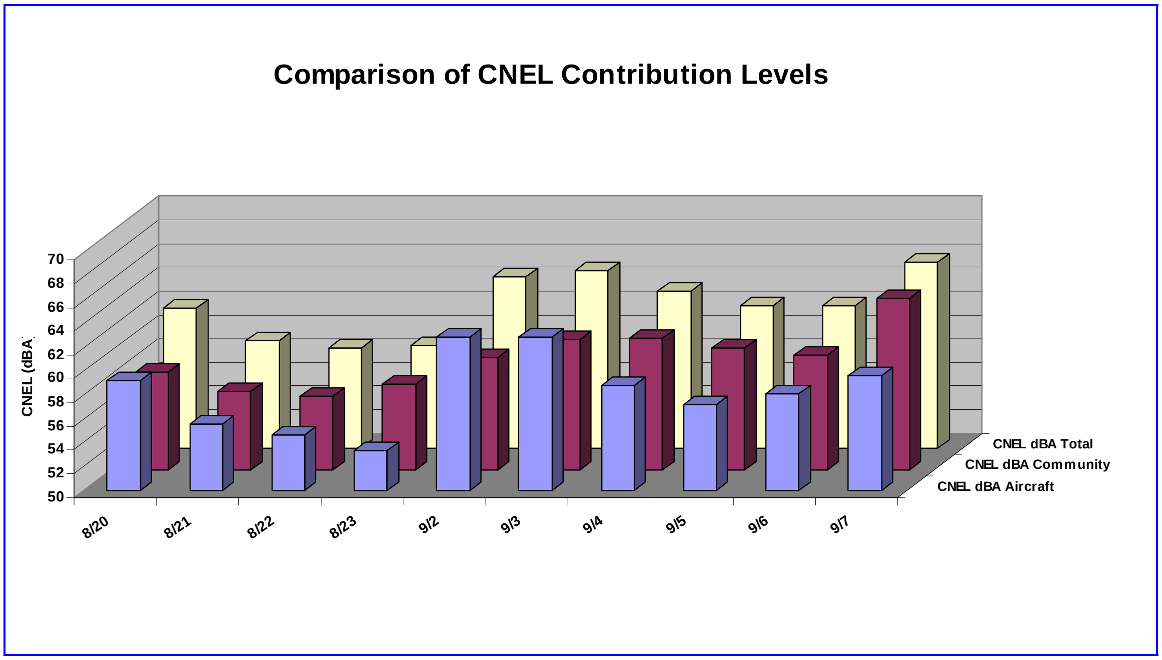

**Figure 5. Daily Cumulative Noise Contribution Comparisons**

## Single Event Noise Data

During the ten days monitored, the average peak or Lmax noise level for aircraft noise events was 70 decibels; the average sound exposure level or SEL for aircraft noise was 79 decibels, and the average duration for each aircraft noise event was 17 seconds. Figures 6 and 7 below provide a graphic representation of the range of single event noise levels and the association between these levels and the hour of the day.

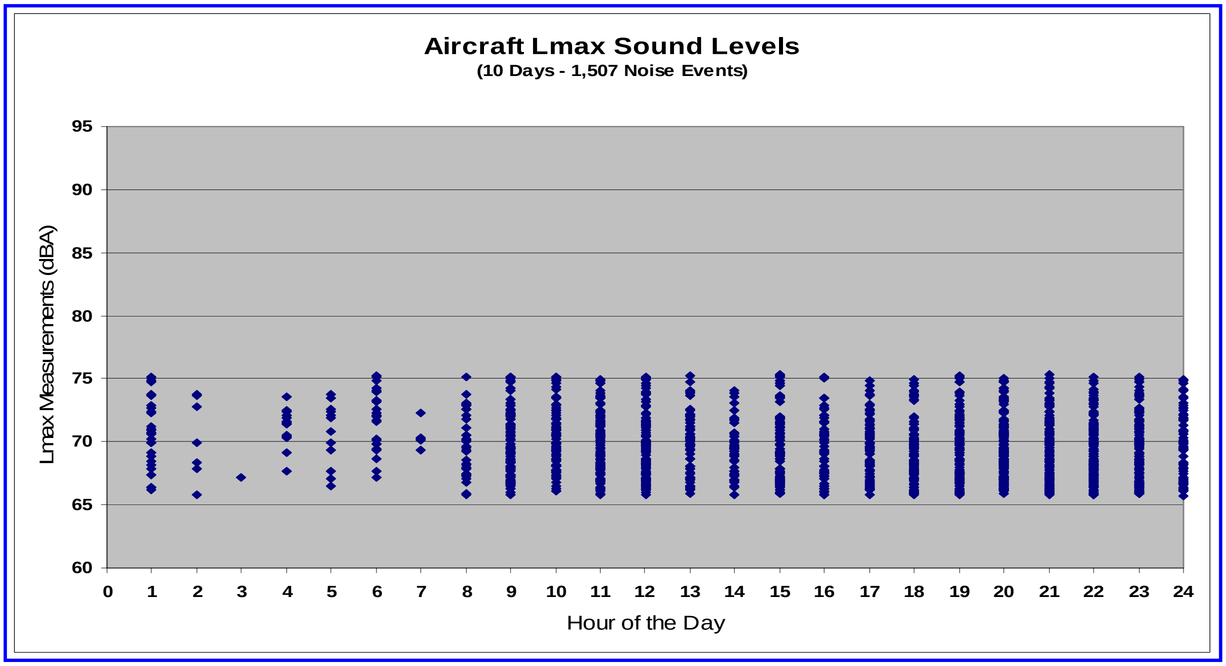

Figure 6. Aircraft Lmax Levels by Hour-of-the-Day

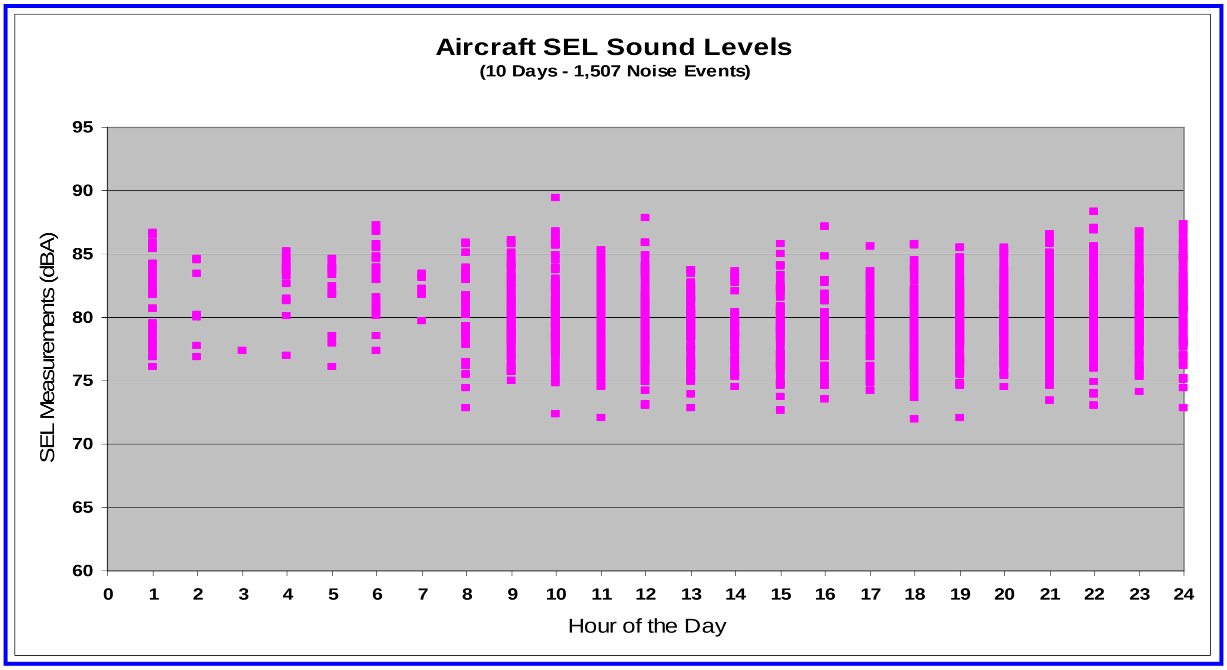

Figure 7. Aircraft SEL Levels by Hour-of-the-Day

## AIRCRAFT OVER-FLIGHT NOISE REDUCTION ANALYSIS

The homeowner on Bal Harbor Lane in Hayward expressed his concern about the frequency and proximity of commercial jet aircraft that pass over his residence as these aircraft are on final approach to OAK Runway 29. The homeowner presented his concerns and suggestions to the Airport-Community Noise Management Forum, which requested the South Field Research Group to examine the possibility of applying potential aircraft noise reduction techniques on Runway 29 ILS arrivals.

**Sound Propagation Theory**

As sound propagates further from a source, the sound energy is spread over a greater and greater area, and the intensity (loudness) is less and less. In an ideal homogeneous atmosphere, the sound level from a point source, such as a faraway airplane, reduces by six decibels every time the distance between the source and receiver is doubled.[1]

Aircraft noise may potentially be reduced by moving aircraft further from the noise receiver's location. There are two means by which to increase distance between the source and the receiver of the aircraft noise events in situations where a residence lies below an ILS runway approach. Either aircraft would need to fly higher or the aircraft flight path would need to be relocated horizontally from a normal approach path.

In Table 4, sound propagation theory is applied to the data acquired in this study to approximate the amount of aircraft noise reduction that might be achieved by moving aircraft further from the residence in Hayward.

| Estimated Noise Level Reductions | | | | |
|---|---|---|---|---|
| **Average Aircraft Altitude** | **Aircraft Relocation Distance** | **Adjusted Aircraft Slant Range** | **Original Less Adjusted Distance** | **Potential Noise Level Reduction** |
| **2,262 ft.** | **1,000 ft.** | **2,473 ft.** | **211 ft.** | **<1 dBA** |
| **2,262 ft.** | **2,500 ft.** | **3,371 ft.** | **1,119 ft.** | **3 dBA** |
| **2,262 ft.** | **5,000 ft.** | **5,488 ft.** | **3,244 ft.** | **6 dBA** |

**Table 4: Estimated Noise Level Reduction**

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[1] Harris Miller Miller & Hanson, Noise Office Management Training Course Notes

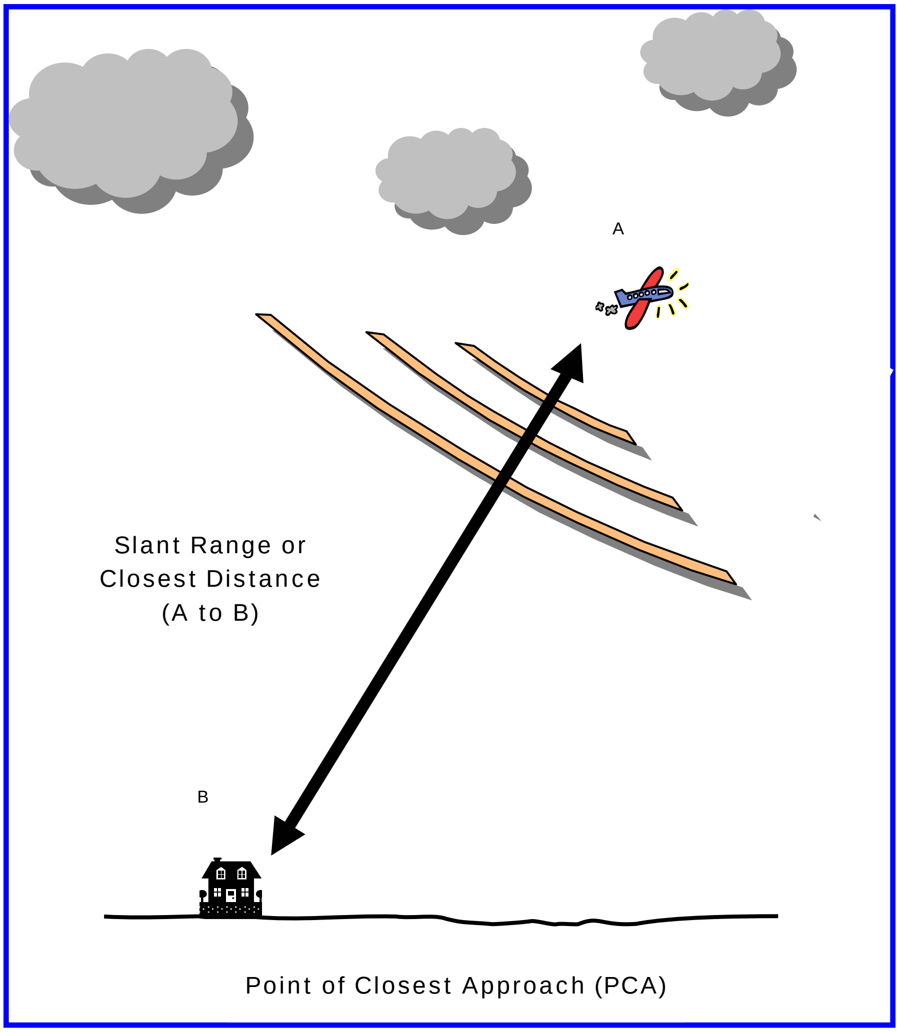


**Figure 8. Slant Range Distance and PCA**

## Understanding Noise Level Reduction

Since aircraft are not flown on exact routes in the sky as automobiles are driven on freeways at ground level, aircraft will be at varying distances to the receiver, or a neighborhood as they fly over communities when approaching or departing an airport. The distance between an aircraft in the sky and an individual or residence on the ground at the point of closest approach is commonly referred to as "slant range distance." The graphic in Figure 8 provides a depiction of the slant range distance between Point A (aircraft) and Point B (residence). For aircraft noise analysis purposes, the slant range distance is the closest distance between the aircraft (source) and the residence (receiver).

In the Hayward study, aircraft on final approach to Runway 29 fly directly over the residence nearly all the time. (The average aircraft altitude of 2,262 feet was very close to the average slant range distance, 2,445 feet.) Since the location of the Hayward residence is approximately seven miles from Runway 29's threshold, the average aircraft is at the altitude expected for a standard three degree airport glide slope. (On a three degree glide slope, aircraft altitude is approximately 300 feet higher per mile in distance from the airport.)

Therefore, the best means for increasing the distance between an aircraft and a residence this close to an airport is to move aircraft horizontally away from the residence. Figure 9 provides a graphic comparison of two possible distances (1,000 feet vs. 5,000 feet) for moving aircraft horizontally away from a residence when average aircraft altitudes do not vary. Essentially the distance between the aircraft and residence would need to be moved between one-half to one mile in order to achieve a 3-6 decibel aircraft noise level reduction.

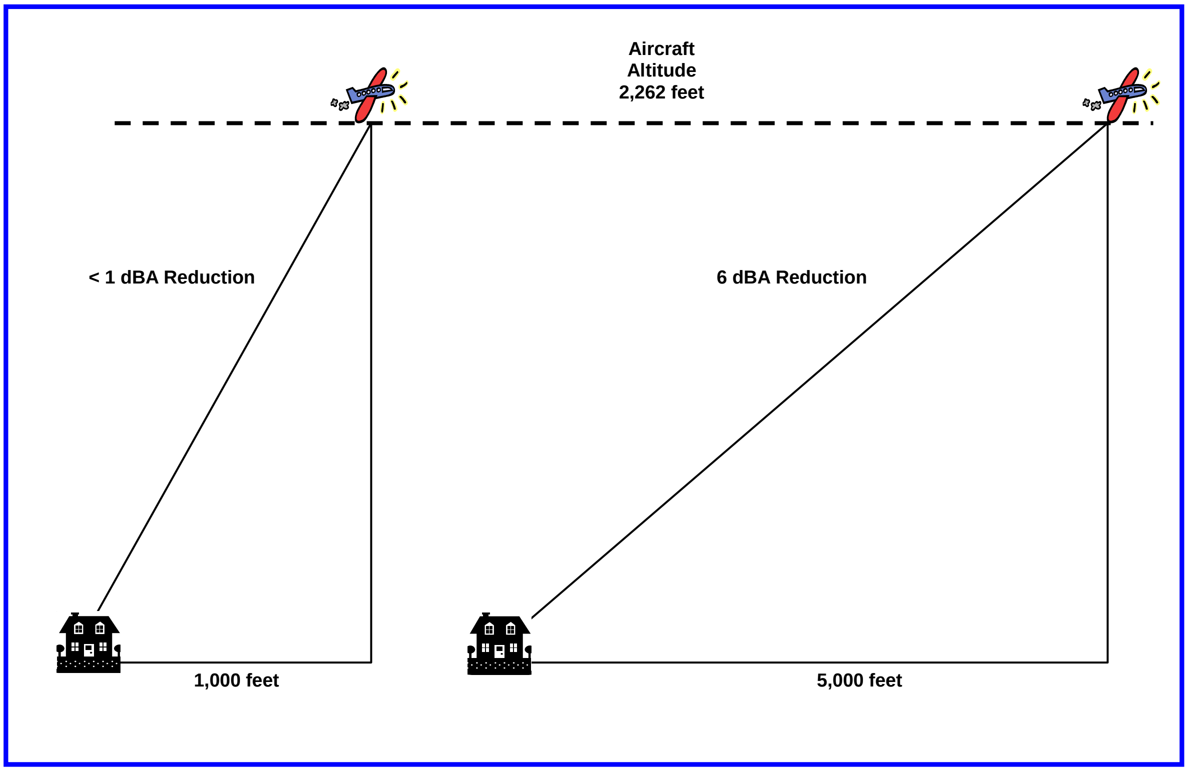


**Figure 9. Comparison of Different Slant Range Distances and Noise Reduction**

In Figure 10 below, data points from the Hayward study have been plotted to compare aircraft sound exposure level (SEL) values with aircraft slant range distance or point of closest approach values. The scatter graph displays the effect that distance has on the propagation of aircraft noise; the greater the distance between the source and the receiver the lower the levels of aircraft sound exposure.

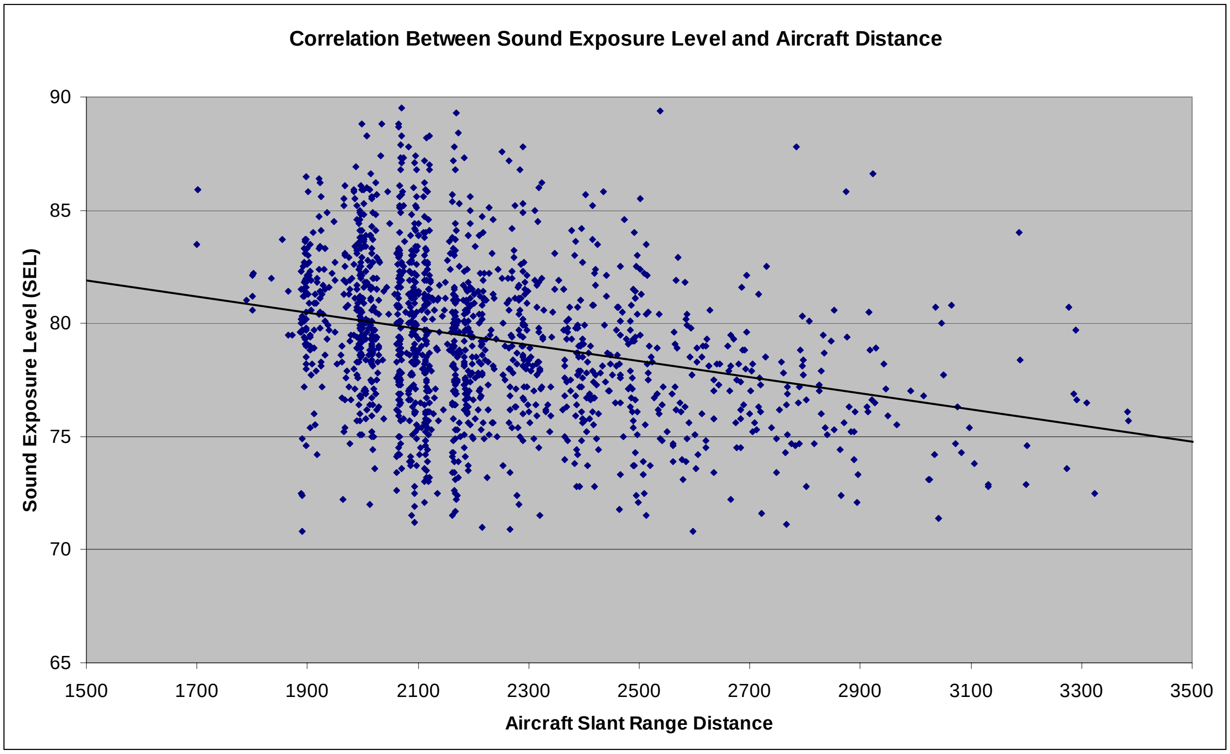


**Figure 10. Correlation Between Sound Exposure Level and Distance**

## Review of Possible Alternative Approach Procedures for Runway 29

For the Hayward study, the South Field Research Group evaluated alternative approach procedures to determine the possibility of moving flight paths further from the neighborhood. A graphic representation of the alternatives is depicted in Figure 11. The South Field Research Group has recommended that the Forum pursue implementation of the Chartered Visual Approach (CVA) procedure (Alternative Procedure 3) as soon as possible. In summary the evaluation included:

**Alternative 1:** Utilization of existing VOR/DME Runway 29 approach path during certain late nighttime periods.

**Impacts:** Likely operational restrictions with Air Traffic resulting in limited use. Over-flight/noise impacts on new neighborhoods.

**Discussion:** Increased use of the published **VOR/DME for Runway 29** approaches could be proposed as a noise relief measure. When weather conditions permit, flight crews could be asked to accept this offset approach to reduce noise impacts near the ILS flight track. The fact that this approach is a “non-precision” approach and anticipated air traffic concerns could make this alternative less marketable.

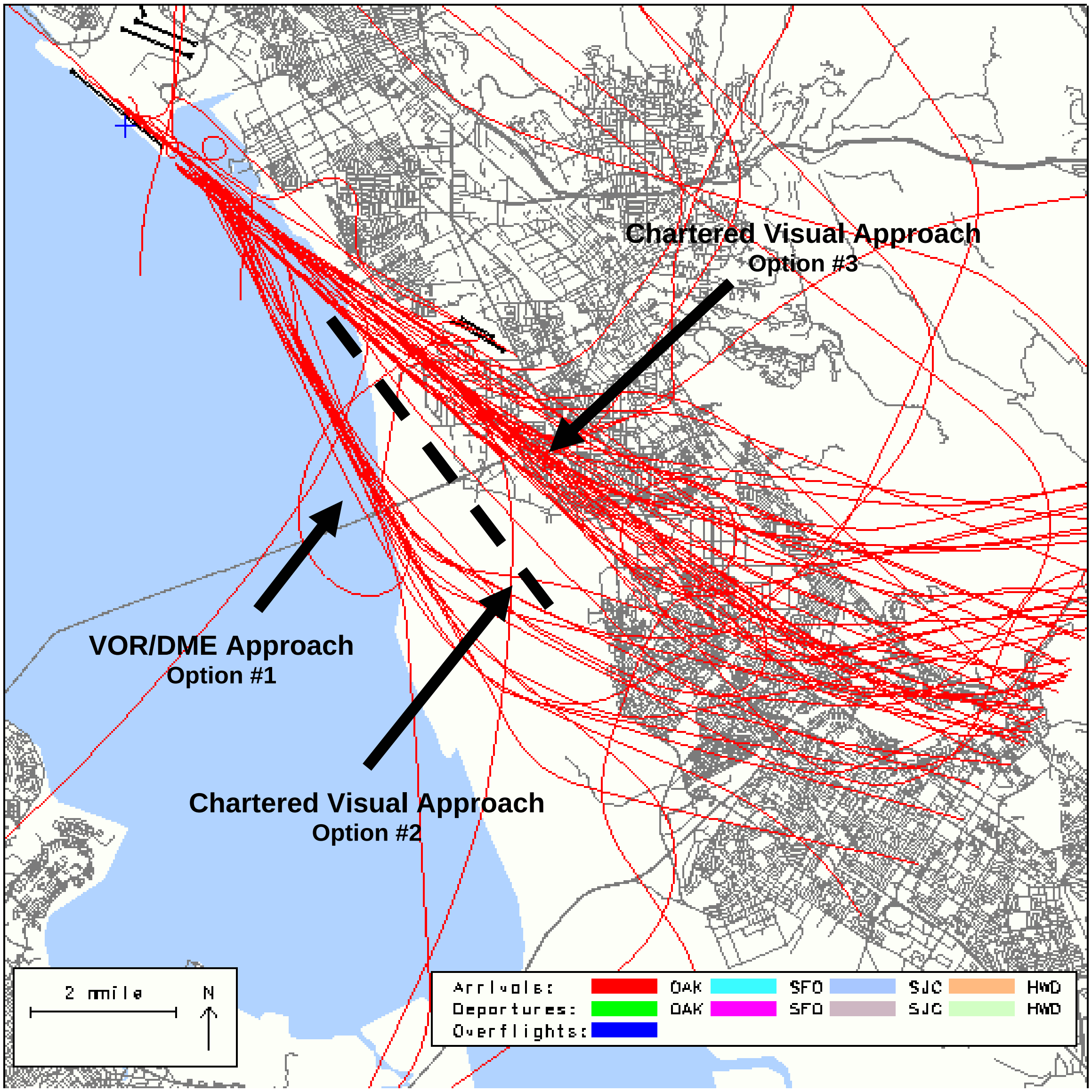


**Figure 11. Alternative Approach Procedures**

**Alternative 2:** Development of a Charted Visual Approach (CVA) utilizing an approach path between ILS localizer path and VOR/DME path.

**Impacts –** Likely operational restrictions with Air Traffic resulting in limited use. Over-flight/noise impacts on new neighborhoods.

**Discussion:** Propose a **Charted Visual Approach** utilizing a course (flight track) that is south of the existing ILS course but not as far south as the VOR/DME course. Using a published visual approach procedure to enhance noise reduction is an established practice throughout the country and should be easily established with existing navigational aids and geographical landmarks. As discussed earlier any “offset” course will have to be aligned with the runway at some distance which may lessen the desired effect of this type approach. Testing of alternative #2 could be achieved with the use of the VOR/DME approach as currently published. If this approach was utilized for a “test period” noise impacts and citizen/flight crew/air traffic acceptance could be studied.

**Alternative 3:** Development of a Charted Visual Approach utilizing existing ILS Runway 29 approach path with proposed higher altitudes approaching Hayward area to mimic a Continuous Descent Approach (CDA). See Figure 12 for a graphic representation of the flight tracks that may be affected by this alternative. The aircraft that pass through the triangle grid area are examples of those that may be moved higher as the result of the implementation of a CVA.

**Impacts –** Little to none with benefits to ATC operations (i.e. reduced phraseology). No new neighborhoods affected.

**Discussion:** Propose a **Charted Visual Approach** utilizing the current flight track, i.e. ILS Localizer for course guidance, but suggest a slight increase in altitudes as the aircraft approach from the east. In addition, a suggested lowering of the current 6 DME air traffic altitude restriction might be proposed to gain acceptance of higher altitudes further out and avoid the altitude “leveling off” that may contribute to over all noise. Although alternatives 1 and 2 may appear on the surface to be the most desirable, aircraft would fly over other communities and likely produce new noise impacts. Alternative #3 appears to be the best alternative for operational acceptance from both the air traffic and flight crews.

As with any evaluation of this nature, a number of factors required consideration. FAA operational approval and an environmental review could be required in the event that a procedural alternative was determined feasible for noise reduction. Air traffic operational impacts could likely result if the final approach course was moved south of the present course, i.e. closer to the Bay. Operational considerations could involve Hayward traffic, SFO traffic and other air traffic that transits the bay near the San Mateo Bridge to/from the peninsula. Increased Traffic Alert and Avoidance System (TCAS) alarms for flight crews could result from any flight track shift and may have a significant impact for aircraft operations. Also, any shift of flight tracks from current practice would likely result in noise level increases for those communities newly impacted.

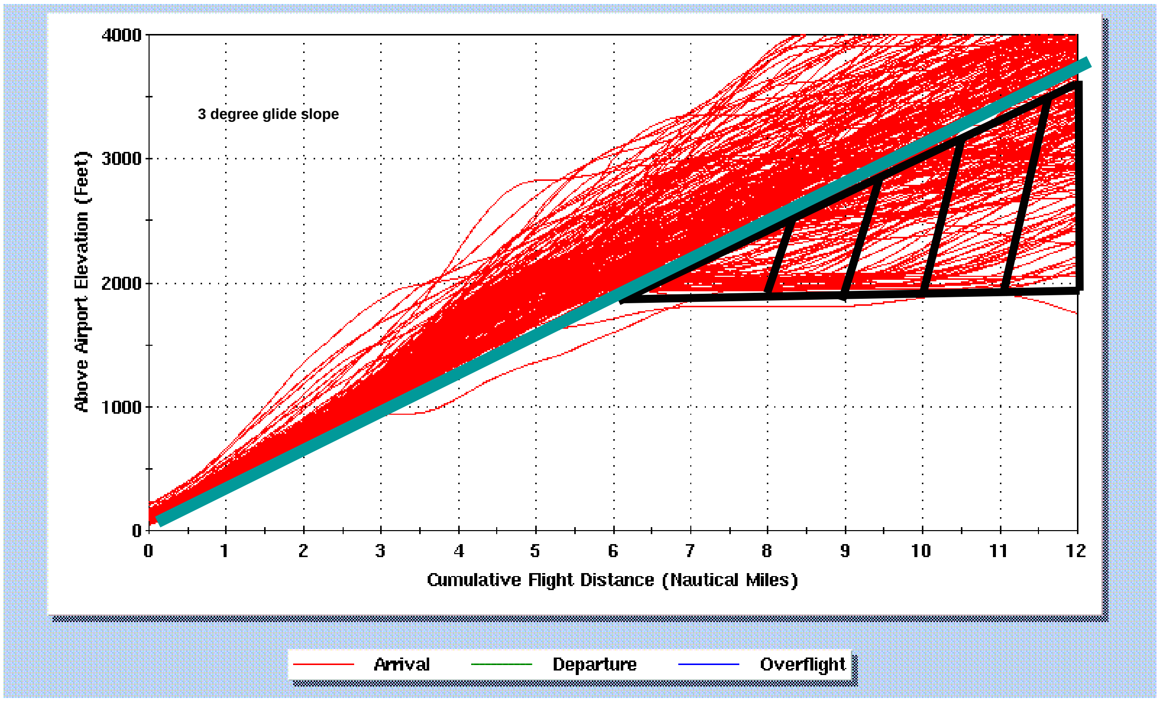


**Figure 12. Runway 29 ILS Aircraft Flight Track Profiles**

### Background on Air Traffic Approach Procedures - Runway 29

As a matter of standard procedure all air carrier, passenger and/or cargo flight crews are required by their companies to fly under Instrument Flight Rules (IFR). The information listed below applies to IFR flights and procedures.

In addition to the ILS approach for Runway 29, two other approach procedures are also available; a VOR/DME approach which is routed south of the ILS path and the RNAV (GPS) approach which utilizes the exact lateral course of the ILS path. The VOR/DME approach, which is an offset approach, over-fly's the bay shoreline and is a *non-precision* approach procedure requiring higher weather criteria. This approach typically will not be accepted by air carrier pilots unless no precision approach is available. The VOR/DME is not aligned with the runway and has no electronic course guidance. An additional IFR procedure that is available during good weather conditions is a "visual" approach procedure that can be published as a "charted visual approach procedure" or flown by each individual flight crew as they choose. Almost all flight crews will continue to rely on electronic lateral and vertical guidance, i.e. "ILS signals" if they are available for the landing runway.

It is important to note that all aircraft need to be "stabilized" (lined up on the runway and at an appropriate glide angle) at some point on final approach. That point will vary depending on the type of aircraft, size, operation (passenger/cargo), and company policy. Safety of the aircraft is dependent upon this stabilized point procedure.

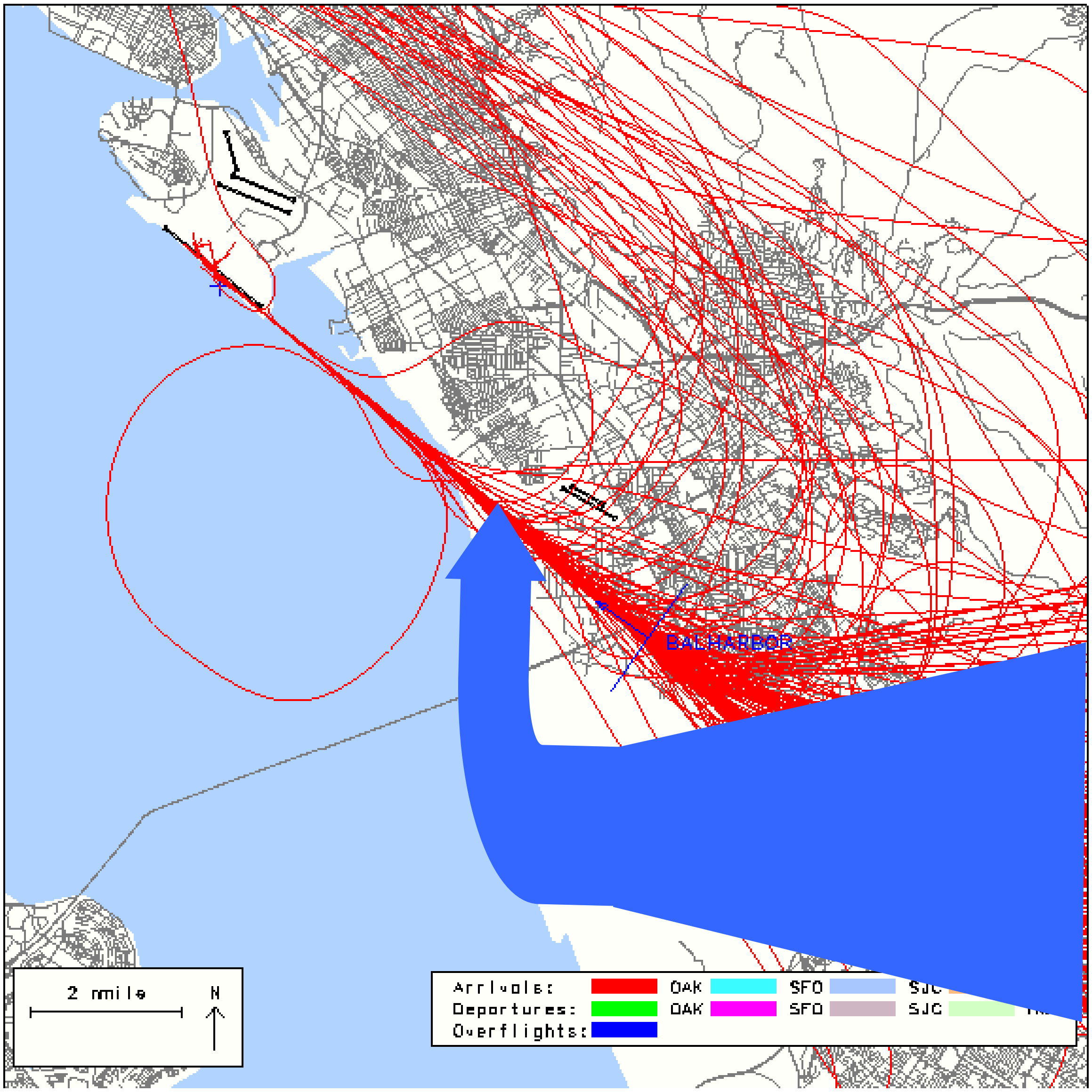


**Figure 13. Probable Flight Track Changes for Alternatives 1 and 2**

**ILS Systems:** This precision landing system is dependent upon exact alignment of the electronic course guidance with the runway center line. Electronic glide path guidance is also provided at an approximate 3 degree glide path equaling an approximate 300 foot per mile descent. As air traffic controllers provide radar vectors (issuance of headings for the aircraft to follow) to the ILS intercept, certain maximum degree intercept and altitude criteria apply. Current technology does not provide for any bending or curving of this straight in electronic signal. Typically, aircraft intercept the ILS approximately 8 to 10 miles from the runway approach threshold below the altitude descent profile (glide slope altitude).

**Visual Approach Procedure:** This visual element of an IFR approach procedure is only conducted when the flight crews can both see the airport from a reasonable distance and see and avoid air traffic they are following and other air traffic in the area. This procedure can be used at Oakland when the ceiling is above 2500 feet and the visibility exceeds three miles. The listed minimum is approximate and will vary on real time weather conditions. Visual approaches can be "charted" with an actual visual depiction provided to the pilots giving suggested course and altitude guidance and left to the flight crews to navigate as they choose. Even under these visual conditions air carrier type aircraft will normally need to be stabilized at an approximate 6 to 7 mile final.

## Pilot and Airline Considerations

Southwest Airlines (SWA) is the major air carrier at OAK and an airline representative participates as a member of the South Field Research Group. SWA provided some important information for the Hayward study evaluation as the airline's pilots are required to have the aircraft "stabilized" prior to 1,000 ft. above ground level (AGL). The aircraft is stabilized when established at a designated speed, on centerline, and with a constant rate of descent. The air traffic control requirement to cross the Oakland 6 DME at 2,000 ft. (Hayward) on Runway 29 arrivals complicates SWA pilot workload to meet the stability criteria. At 2000 ft. and at the 6 OAK DME, the aircraft is about 300 feet above the altitude where the aircraft would normally be on a three degree glide slope for runway 29. There are additional concerns because the VOR is offset and not at the approach end of the runway. A 6 mile VOR distance actually places the aircraft approximately 4.5 miles fro m the runway threshold. Because the pilots are already making an extra effort on these arrivals to be stable, any extra maneuvering at this point in the approach would compromise safety. The SWA representative stated that although joining the final ILS approach in this manner would be contrary to normal pilot instincts, such a turn to a final approach could be safely accomplished further out than 6 miles.

## Conclusions

Aircraft noise levels on Bal Harbor Lane in Hayward are at levels expected in a community that is seven miles away from the airport and that lies directly below the Runway 29 ILS approach course at Oakland International Airport. The average community CNEL was 59 dBA (ten days of measurements) and the aircraft CNEL was 58 CNEL dBA. On average, aircraft noise levels contributed approximately three decibels to the cumulative total noise levels of CNEL 62 dBA.

The State of California airport noise regulations state: "The standard for the acceptable level of **aircraft** noise for persons living in the vicinity of airports is hereby established to be a **community noise equivalent level (CNEL) of 65 decibels**." Although the average aircraft community noise equivalent level measured was nearly half of the amount of cumulative noise in the Hayward neighborhood, this residential area has an acceptable level of aircraft noise as defined by State law. The aircraft CNEL 58 dBA level on Bal Harbor Lane is significantly lower than the CNEL 65 dBA standard. Figure

14 below presents a current airport noise contour map that shows the extent of the aircraft CNEL 65 dBA noise contour at Oakland International Airport.

The number of aircraft arrivals over the Hayward neighborhood has increased incrementally over the past few years. There was a drop in flight levels for several months after September 11, 2001 but air traffic has continued to increase since then and air transport is expected to increase about 3-4% per year in the future as passenger demands increase.

As the result of the evaluation of noise reduction alternatives for the Runway 29 ILS aircraft approach traffic, the South Field Research Group has recommended to the Forum that the Federal Aviation Administration develop a Chartered Visual Approach (CVA) for Runway 29 arrivals. A Runway 29 CVA may provide noise reduction benefits similar to those achieved by a Continuous Descent Approach (CDA) procedure, which has shown positive results in national studies for communities further than seven miles from an airport. Although the residence on Bal Harbor Lane in Hayward is too close to the airport to expect much relief from a CVA procedure, other South Bay communities will benefit from its implementation.

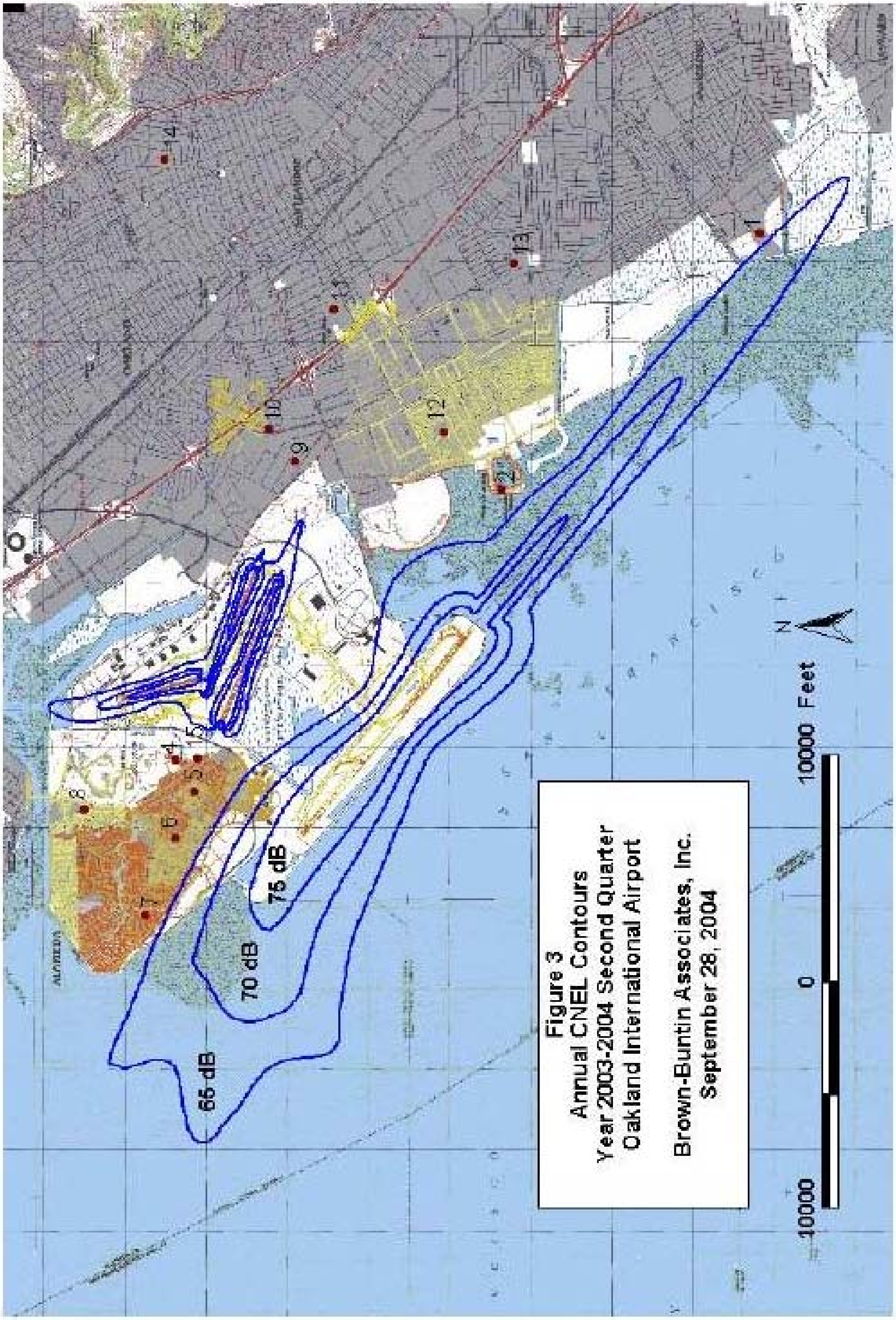


Figure 14. OAK Annual CNEL Noise Contour Map

# Appendix A

## Aircraft Noise Terminology/Metrics

To assist in understanding the noise measurements and noise metrics used in evaluating airport noise, this fact sheet provides 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 (Lmax), the sound exposure level (SEL), and the Community Noise Equivalent Level (CNEL).

The decibel or dB 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 2 presents typical sound levels of several common transportation 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.

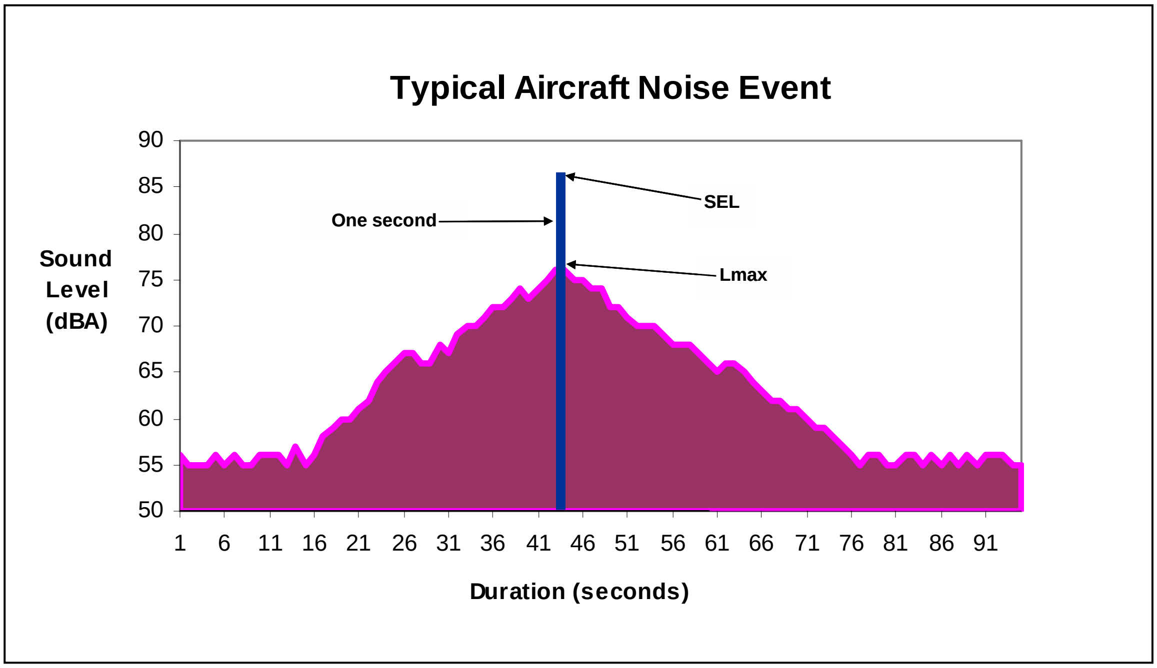
The sound level heard during an arrival or departure of an aircraft varies as a function of the distance from the aircraft to the person hearing the noise (or "receiver"), and as a function of the direction of the aircraft noise source. As the aircraft approaches the receiver, the sound level increases and, as the aircraft moves away from the receiver, the sound level decreases. The effect of noise exposure during such an event can be described in terms of either the maximum sound level (Lmax) or the sound exposure level (SEL) of individual aircraft noise events.

## Noise Event Metrics

The **maximum sound level (Lmax)** metric represents the highest instantaneous noise level heard at a receiver site during a single aircraft event (arrival or departure). However, since this metric describes only the instantaneous maximum noise value, it provides no information on the duration of noise exposure. Human response to noise is not only a function of the maximum level, but also of the duration of the event. 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 the sound exposure level or SEL.

The **sound exposure level (SEL)** represents the cumulative sound energy detected above an established threshold for a single event considering both intensity and duration of the sound. The SEL represents the acoustical energy of the event once it surpasses a specified noise level, but as though it had occurred within one second. Thus, for example, two events with the same intensity but different durations can be differentiated with the longer duration event having a higher SEL. For locations relatively close to an airport, the SEL for most aircraft departures will usually be about 10 decibels higher than the corresponding Lmax. For example, an aircraft departure producing a maximum sound level of 70 dB at a particular location would be expected to produce an SEL value of about 80 dB at the same location. Figure 1 is a graphic representation of a typical aircraft noise event. 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.

Fig. 1: Time History of a Typical Aircraft Noise Event



The **Community Noise Equivalent Level (CNEL)** is a method of predicting, by a single number rating, cumulative aircraft noise that affects communities in airport environs. As defined in the California Airport Noise Standards, CNEL represents the average daytime noise level during a 24-hour day, adjusted to an equivalent level to account for the lower tolerance of people to noise during evening and nighttime periods relative to the daytime period. CNEL applies a weighting to aircraft events occurring during the evening and nighttime 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 3 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.

**Fig. 2: Common Transportation Sound Levels in dB**

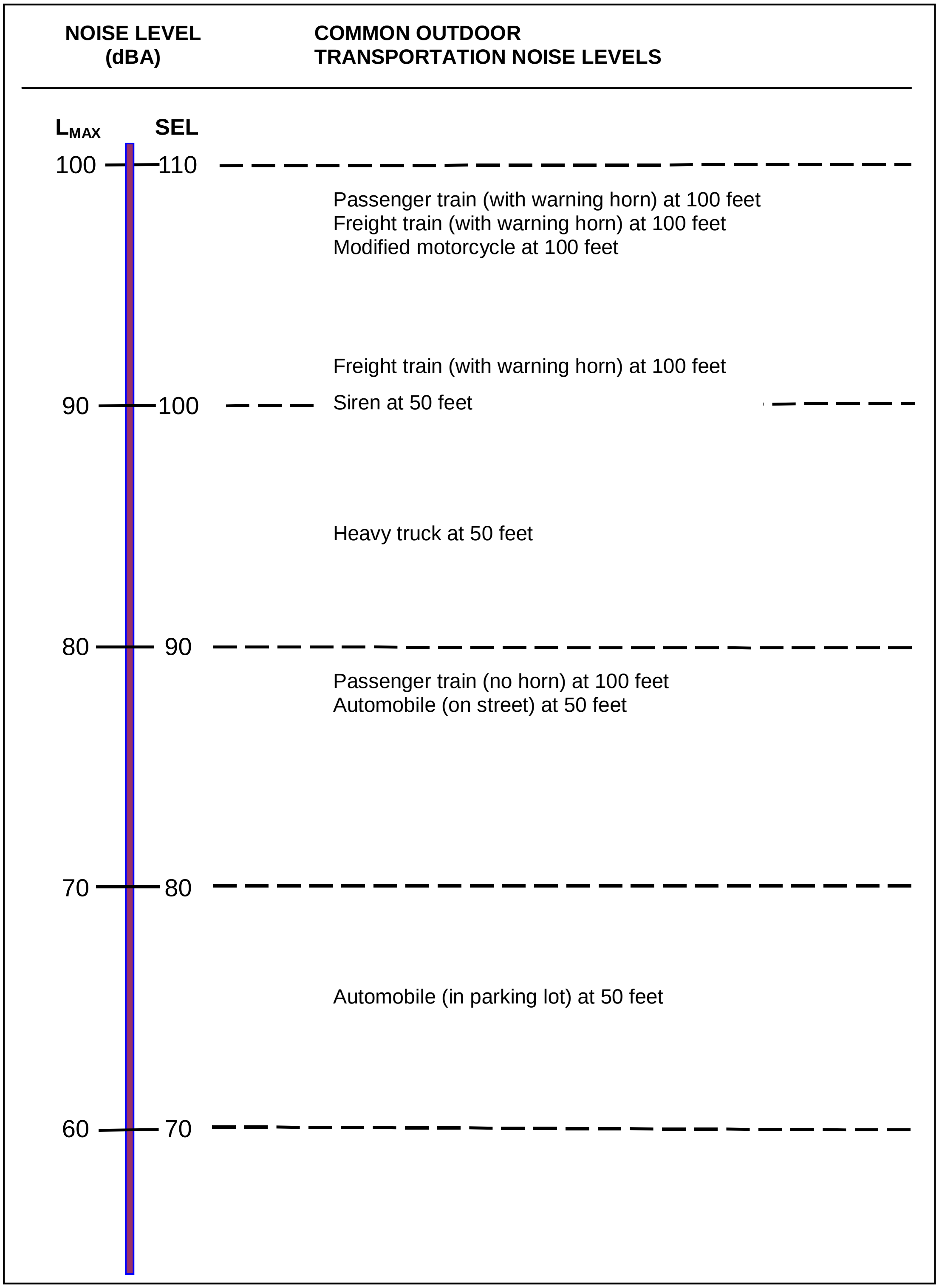


**Figure 3: Representative Cumulative Sound Levels**