Appendix F

Noise Technical Report

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Appendix F

F1 – Fundamentals of Noise

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Fundamentals of Noise

This appendix presents the basic tools for describing and understanding sound: how it originates, moves through a medium – most frequently the atmosphere – and how it is experienced by a receiver. Understanding these fundamentals at a basic level is critical to subsequently understanding how characteristics of sound influence human perception of *noise*, which is commonly referred to as "unwanted sound." Information presented in this document relies upon a reader's understanding of the characteristics of sound, the effects noise has on persons and communities, and the metrics or descriptors most commonly used to quantify noise. This appendix presents these fundamentals to facilitate an understanding of the noise exposure setting against which land-compatibility is assessed and recommendations are made.

Fundamentals of Acoustics

Sound is a physical phenomenon consisting of minute vibrations (waveforms) that travel through a medium such as air or water. Audible sounds are those vibrations that can be sensed by the human ear. At the ear, sound waves vibrate the ear drum, which transmits the vibration via a network of bones to the cochlea. The cochlea then converts the vibration into neurological impulses that are interpreted by the brain as sound. One's experience and perception of sound depends on both the pattern of vibrations from the sound source and the way our hearing mechanism interprets these vibrations.

A sound *source* induces vibrations in the air, which spread outward from the sound source as alternating bands of dense (compression) and sparse (expansion) air particles. This results in a variation of pressure above and below the baseline atmospheric pressure. The distance between successive compressions or successive expansions is the wavelength of the sound, and the number of compressions or expansions passing a fixed location per unit of time is the frequency of the sound. Frequency is normally expressed in cycles per second or Hertz (Hz); a sound having a 1,000 Hz frequency indicates that the alternating compression and expansion occurs 1,000 times per second. A high frequency sound is shorter in wavelength and lower frequency sound is correspondingly longer in wavelength. In contrast to frequency, which describes the cycling of impulses, the overall magnitude of such impulses that is the average amplitude of the variations of the pressure above and below atmospheric pressure is called the sound pressure.

Sound travels through air at about 1,100 feet per second; however, its speed is different speeds in other media (e.g., water). Therefore, to more fully characterize sound, its three defining characteristics are typically identified: (1) magnitude, (2) frequency spectrum, and (3) the variations of these two over a time interval.

Magnitude

Telephone engineers were among the first to extensively study the ear's response to sound pressure, finding that the ear responds to a broad range of sound pressures. A healthy human ear can detect a sound tone having a frequency a 1,000 Hz at sound pressures (amplitudes) as low as 20 micropascals. (This is expressed as 20 μPa and equals to 20 x 10^{-6} Pascals (Pa). For reference, standard atmospheric pressure at sea level is 101,325 Pascals. At the other end of an amplitude scale, the threshold of pain was found to occur around a sound pressure of 200 Pascals, or ten million times as large as the barely audible 20 μPa magnitude. Whether barely audible (20 μPa) or pain-inducing (200 Pa), these pressures are comparatively small variations around atmospheric pressure (101,235 Pa).

Since a human ear is able to respond to such a large range of sound pressures, early telephone engineers had a measurement problem. At the threshold of hearing, where the ear could detect a sound pressure of 20 μPa, an increase of 40 μPa was a noticeable change; yet at 10 Pa, that same increase of 40 μPa (or 0.00004 Pascals) was undetectable. Thus, a shorthand method for expressing the magnitude of a sound was necessary. Their solution was to develop a logarithmic scale based on the ratio of the sound pressure to a reference sound pressure.

A logarithm (base 10 "common" logarithm) is simply a power of 10. For example, 100 equals 10 times 10, which equates to 10^2. The logarithm of 100 is then 2 (log 100 = 2). Similarly, 10^3 equals 10 times 10 times 10, which equates to 1,000. Consequently, the log of 1,000 is 3.

When units were standardized, the Bel, in honor of Alexander Graham Bell, was defined as the log of the square of the ratio of two sound pressures, with the decibel one tenth of that. The Bel itself proved to be too coarse of a unit, so the term decibels (dB) remained in common use. Values on the decibel scale are referred to as levels. The following equation shows the relationship of sound pressure level, L, in decibels to sound pressure where p is the pressure of the sound that is being compared and p_0 is the reference pressure against which p is compared.

$$L = 10 \log 10 \left(\frac{p^2}{p_0^2}\right)$$

The level (in decibels) equals 10 times the log of the square of the quantity of measured sound pressure divided by 20 μPa (this squared quantity is proportional to the sound power). Recall that the sound pressure that is barely detectable by the human ear is 20 μPa. By using this as a reference, the telephone engineers "zeroed" the logarithmic scale for sound at the threshold of hearing.

Sensitivity to Changes in Loudness

Under laboratory conditions, people can detect single-decibel changes in sound level. But, when comparing sounds in our everyday experience, we are less sensitive to differences in sound intensities. From a practical standpoint, a 5-dB difference is the smallest change generally noticeable to the average listener. A change in sound level of about 10 dB is usually perceived by the average person as a doubling (or halving) of the sound's loudness. This relation holds true for loud sounds and for quieter sounds across the speech frequencies.

Adding Decibels

Because of the logarithmic nature of the decibel and the fact that sound pressure is a measure of the variation in air pressure, neither sound pressure level in decibels nor sound pressures in μPa can be added directly. However, the quantity inside the parentheses in the above equation, which is proportional to the sound energy, can be added. Note that if the sound pressure levels being added are quite different in magnitude, adding the lesser value to the greater value yields relatively little change to the higher value when expressed as dB and that adding sounds with equal sound pressure levels results in a three-decibel increase.

Frequency

As noted, frequency is the rate of vibrations for a sound and is measured in Hz where one Hz indicates one vibration (or cycle) per second. As with the ability to hear events of widely ranging pressure amplitudes described above, the human ear also hears sounds having widely ranging frequencies (e.g., from about 20 Hz to about 20,000 Hz). However, not all sounds in this wide range of frequencies are heard equally well by the human ear. The ear is most sensitive to sounds having frequencies in the range of 1,000 Hz to 4,000 Hz.

Some simple sound sources, such as a tuning fork, produce sounds with a single frequency (i.e., a pure tone). Most sounds however are more complicated and their signals consist of multiple many frequencies. A sound spectrum is a representation of a sound showing the magnitude of the various frequencies present in the sound. Knowledge of the frequency spectrum of a signal is important for the following reasons:

- People and animals have different hearing sensitivity and react differently to various frequencies. For instance, most people are familiar with a "dog whistle" which produces a signal that dogs can hear but humans cannot. This occurs because dog whistles produce a tone having a frequency above the range at which humans can hear but within the range of the dog's hearing. At the other end of the frequency scale, elephants communicate at frequencies below the range of human hearing.

- Structures respond to much lower frequencies (e.g., 1−30 Hz) than humans. Therefore, low-frequency sounds that people cannot hear can still create problems by inducing vibration in buildings.

- Different sound sources produce signals consisting of different frequency characteristics. Engineering solutions for reducing or controlling sound are therefore frequency-dependent.

High-quality measuring devices (e.g., sound level meters) are equally sensitive to sounds across the full range of human hearing. Therefore, to approximate the human perception of common environmental sounds, the acoustical community designed a range of frequency-based adjustments to be applied to measured sound levels. Today, two of these weighting systems remain in common usage, the A-weighting and C-weighting.

These weightings are based on the response of human ears to moderate- (A-weighting) or high-level (C-weighting) sounds. For most industrial and transportation applications, A-weighting is used. For loud sounds with significant low frequency content, C-weighting is used. A-weighting applies progressively higher reductions to lower frequencies, mimicking the reduced sensitivity of human ears to low frequency sounds. However, in order to more accurately capture the low frequency energy and higher levels present, C-weighting, with its much slower roll-off at lower frequencies, is more appropriate for noise sources such as explosions and sonic booms.

In addition to representing human hearing sensitivity, A-weighted sound levels have been found to correlate better than other weighting networks with human perception of “noisiness.” One of the primary reasons for the improved correlation is the A-weighting network emphasizes the frequency range where human speech occurs, and noise in this frequency range interferes with speech communication. Another reason is the increased hearing sensitivity makes noise more annoying in this frequency range. For all of the above reasons, A-weighted sound levels are used worldwide in noise standards and regulations to address the effects and impact of noise on human activity.

Variation of Sound with Time

The third characteristic used to describe sound (after magnitude and frequency) is its relative stability over time. Sound can be classified into three categories that define its basic time pattern: steady state, intermittent, and impulsive.

Steady-state sound is a sound of consistent level and spectral content. Typical examples of steady-state sound are the sounds produced by ventilation or mechanical systems that operate more or less continuously.

Intermittent sounds are those that are produced for short periods. The sound temporarily rises above the background and then fades back into it. Intermittent sounds are typically associated with moving sound sources such as an aircraft overflight or a single-vehicle drive-by. Intermittent sound is typically a few minutes or less in duration.

Impulsive sound is of short duration (typically less than one second), low frequency, and high intensity. It has abrupt onset, rapid decay, and often a rapidly changing spectral composition. Impulsive sound is characteristically associated with such sources as large-caliber weapons, demolition activities, sonic booms, and many industrial processes (e.g., jackhammers, pile drivers). However, certain aspects of helicopter noise events are also impulsive.

Propagation of Sound

As sound travels from the source to the receiver, several factors influence the level and spectrum of the sound heard by a receiver. These factors generally result in a reduction, or *attenuation*, of the sound level:

- Spherical spreading
- Ground effects
- Attenuation through vegetation
- Attenuation due to barriers (including terrain)
- Atmospheric effects

Note that, for other than spherical spreading, all factors tend to have more effect on higher frequencies with low frequencies able to propagate over long distances with little attenuation. Hence, the “rumble” of jet departures or highway traffic can often be heard at large distances, while the higher frequency characteristics of the signal are lost.

Spherical Spreading and Noise Directivity

The sound from the point source, such as a generator, spreads in all directions like an expanding sphere. A rule of thumb in acoustics is that a spherically spreading sound decreases by 6 dB for every doubling of distance. Thus, with a reference distance of, say, 50 feet, increasing the distance from 200 feet to 300 feet does not provide as much reduction as increasing the distance from 100 to 200 feet. In practice, high-frequency sound is attenuated faster than 6 dB per doubling of the distance because some energy is lost in the medium (air) due to atmospheric effects at this frequency range. This loss, called excess attenuation, is dependent upon air temperature and humidity as well as the signal's sound frequency and is due to a process called vibrational relaxation in oxygen and nitrogen molecules.

Aircraft do not emit sound in all directions equally, i.e., omni-directionally. The sound pattern produced by an aircraft depends on many factors including the engine type (jet or propeller), the number of engines and how they are installed on the aircraft, e.g., over/under wing or rear mounted, the jet bypass ratio (engine design), wing flap configuration and mode of flight, e.g., takeoff/departure or arrival. The shape of the sound pattern around the aircraft is called its directivity. The directivity of aircraft with jet engines is typically a cardioid shape with the larger lobes of the cardioid emanating approximately 45 degrees from the tail of the aircraft relative to the aircraft's longitudinal axis. Counter-intuitively, there is less sound directly behind a jet aircraft than off to its side.

Ground Effect

When sound propagates along the surface of the earth from a source to a receiver, it follows two paths. The first is a direct path from the source to the receiver and the second is a path that starts at the source, reflects off the ground, and then travels to the receiver. If the ground is hard, such as pavement or water (lakes, oceans, etc.), the sound reflects off the surface and adds to the sound from the direct path resulting in higher levels than the direct path alone. When sound reflects off of soft ground, such freshly-plowed earth, grass, or loose snow, some frequencies of the reflected sound experience a phase reversal, where the areas of high and low pressure become reversed. Adding this phase-reversed sound with the sound from the direct pathway results in a reduction in the total sound at the receiver. Thus, sound levels are generally higher when the sound propagates over hard ground as compared to soft ground. Another way of thinking of the way so-called ground-effect attenuation works is to think of the sound waves traveling above the ground on their way from the source to the receiver. If the ground under the traveling sound wave is hard, then none of sound is absorbed by the ground along the way. However, if the ground is porous and softer, then the soft ground will absorb some of the sound along the way, reducing the overall sound level at the receiver. Generally, the longer the sound propagation path and the softer the ground, the greater the degree of additional attenuation over soft ground will be.

Attenuation from Vegetation

Wide areas of dense foliage provide some attenuation for higher frequency sound when they are located between a source and receiver. The vegetation must be dense enough to block the line of sight over even short distances and must extend well above the line of sight. The attenuation is negligible for low-frequency sound sources such as explosions, but increases with frequency. At 250 Hz, approximately 400 feet of dense foliage would be required to produce a noticeable 5 dB of attenuation for a sound source such as an aircraft run-up. At 1,500 Hz, approximately 250 feet of dense foliage would be required to produce 5 dB of attenuation for a sound source such as roadway traffic.

Attenuation Due to Barriers (Including Natural Terrain)

Barriers, berms, and natural terrain can attenuate sound when they are located in the line of sight between the source and the receiver. This attenuation, which acousticians call insertion loss, increases with height, width, and proximity to either the source or the receiver. If there are gaps in a barrier, the potential benefits of acoustical shielding will be substantially reduced.

Atmospheric Effects

Weather (or atmospheric) conditions that influence the propagation of sound include humidity, precipitation, temperature, wind, and turbulence (or gustiness). The effect of wind—turbulence in particular—is generally more important than the effects from other factors. Under calm wind conditions, the importance of temperature can increase, in particular, temperature changes occurring with altitude known as temperature gradients. This can sometimes influence propagation quite significantly. Humidity generally has little significance compared to the other effects.

The effects on propagation described below interact with each other and in some cases are additive. Specific/complex combinations of conditions influence propagation, and in order to predict how sound would propagate, it is important to understand these varied effects. This document is meant to introduce the reader to these topics.

Influence of Humidity and Precipitation

Humidity and precipitation rarely affect sound propagation in a significant manner. Humidity can reduce propagation of high-frequency noise under calm wind conditions. In very cold conditions, listeners often observe that noise sources such as aircraft sound “tinny,” because the dry air increases the propagation of high-frequency sound. Rain, snow, and fog also have little, if any, noticeable effect on sound propagation. A substantial body of empirical data supports these conclusions.

Influence of Temperature

Air temperature affects the velocity of sound in the atmosphere. As a result, if the temperature varies at different heights above the ground, sound will travel in curved paths rather than straight lines. This bending of the sound path is called refraction. During the day, temperature normally decreases with increasing height. Under such “temperature lapse” conditions, when the air temperature decreases with height, the atmosphere refracts (“bends”) sound waves upwards, and an acoustical shadow zone may exist at some distance from the noise source.

Under some weather conditions, an upper level of warmer air may trap a lower layer of cool air. Such an inversion of normal conditions (i.e., temperature gradients typically lapse with altitude) is most common in the evening, at night, and early in the morning when heat absorbed by the ground during the day radiates into the atmosphere. The effect of an inversion is just the opposite of lapse conditions: it causes sound propagating through the atmosphere to refract downward.

The downward refraction caused by temperature inversions often allows sound rays with originally upward-sloping paths to bypass obstructions and ground effects, increasing noise levels at greater distances. This type of effect is most noticeable at night, when temperature inversions are most common and when ambient sound levels are low enough that they do not otherwise mask distant noise sources.

Influence of Wind

Sound traveling in the direction of the wind (downwind) has a higher speed than sound traveling through calm air. Likewise, sound traveling against the direction of the wind (upwind) has a lower speed than sound traveling through calm air. Wind speed typically increases with the height above the ground. This gradient in wind speeds, and sound speeds, causes the sound to refract. Sound refracts downward in the downwind direction and upward in the upwind direction. In general, receivers that are downwind of a source will experience higher sound levels, and those that are upwind will experience lower sound levels. As with a temperature inversion, the downward curving paths reduce or eliminate the insertion loss of barriers in the downwind direction. Wind perpendicular to the sound path has no significant effect.

Wind turbulence (or gustiness) can also affect sound propagation. Sound levels heard at remote receiver locations will fluctuate with gustiness. In addition, gustiness can cause considerable attenuation of sound due to the effects of eddies traveling with the wind. Attenuation due to eddies is essentially the same in all directions, with or against the flow of the wind, and can mask the refractive effects discussed above.

Effects on Propagation

The foregoing effects on propagation described above interact with each other and in some cases are additive. Specific combinations of conditions influence propagation and in order to predict how sound would propagate it is important to understand these varied effects. While the basics are described in this document, for complex permutations entailing interaction of several variables, consultation with an acoustical professional for modeling support and analysis may be required.

Noise Descriptors

Noise levels are measured using a variety of scientific metrics. As a result of extensive research into the characteristics of noise and human response to that noise, standard noise descriptors have been developed for noise exposure analyses. The following provides an overview of various noise descriptors.

A-Weighted Sound Pressure Level (dBA): The decibel (dB) is a unit used to describe sound pressure level. When expressed in dBA, the sound has been filtered to reduce the effect of very low and very high frequency sounds, much as the human ear filters sound frequencies. Without this filtering, calculated and measured sound levels would include events that the human ear cannot hear (e.g., dog whistles and low frequency sounds, such as the groaning sounds emanating from large buildings with changes in temperature and wind). With A-weighting, calculations and sound monitoring equipment approximate the sensitivity of the human ear to sounds of different frequencies.

Some common sounds on the dBA scale are listed in **Table 1**. As shown in Table 1, the relative perceived loudness of a sound doubles for each increase of 10 dBA, and a 10-dBA change in the sound level corresponds to a factor of 10 increase or decrease in relative sound energy.

Table 1: Common Sounds on the A-Weighted Decibel Scale

Sound	Sound level (dBA)	Relative loudness (approximate)	Relative sound energy
Rock music, with amplifier	120	64	1,000,000
Thunder, snowmobile (operator)	110	32	100,000
Boiler shop, power mower	100	16	10,000
Orchestral crescendo at 25 feet, noisy kitchen	90	8	1,000
Busy street	80	4	100
Interior of department store	70	2	10
Ordinary conversation, 3 feet away	60	1	1
Quiet automobiles at low speed	50	½	.1
Average office	40	¼	.01
City residence	30	1/8	.001
Quiet country residence	20	1/16	.0001
Rustle of leaves	10	1/32	.00001
Threshold of hearing	0	1/64	.000001

Source: U.S. Department of Housing and Urban Development. Aircraft Noise Impact--Planning Guidelines for Local Agencies. Figure 2-2. 1972.

In general, humans find a change in sound level of 3 dB is just noticeable, a change of 5 dB is clearly noticeable, and a change of 10 dB is perceived as a doubling or halving of sound level. Because of the logarithmic scale of the decibel unit, sound levels generally cannot be added or subtracted arithmetically. Two sounds of equal physical intensity will result in the sound level increasing by 3 dB, regardless of the initial sound level. For example, 60 dB plus 60 dB equals 63 dB, 80 dB plus 80 dB equals 83 dB. However, where ambient noise levels are high in comparison to a new noise source, there will be a small change in noise levels. For example, when 70 dB ambient noise levels are combined with a 60-dB noise source the resulting noise level equals 70.4 dB.

Maximum Noise Level (Lmax): L_{max} is the maximum or peak sound level during a noise event. The metric accounts only for the instantaneous peak intensity of the sound, and not for the duration of the event. As a vehicle or aircraft passes by an observer, the sound level increases to a maximum level and then decreases. Some sound level meters measure and record the maximum or L_{max} level.

Single Event Metrics

Single Event Noise Exposure Level (SENEL) and Sound Exposure Level (SEL): Another metric that is reported for aircraft flyovers is SENEL. This metric is essentially equivalent to SEL. SEL, expressed in dBA, is a time integrated measure, expressed in decibels, of the sound energy of a single noise event at a reference duration of one second. The sound level is integrated over the period that the level exceeds a threshold. Therefore, SEL accounts for both the maximum sound level and the duration of the sound. The standardization of discrete noise events into a one-second duration allows calculation of the cumulative noise exposure of a series of noise events that occur over a period of time. Because of this compression of sound energy, the SEL of an aircraft noise event is typically 7 to 12 dBA greater than the L_{max} of the event. SELs for aircraft noise events depend on the location of the aircraft relative to the noise receptor, the type of operation (landing, takeoff, or overflight), and the type of aircraft.

Speech and sleep interference research can be assessed relative to SENEL. This metric is also useful in that airport noise models contain aircraft noise curve data based upon the SENEL metric.

Cumulative Noise Metrics

Cumulative noise metrics assess community response to noise by including the loudness of the noise, the duration of the noise, the total number of noise events and the time of day these events occur in one single number rating scale.

Equivalent Continuous Noise Level (Leq): L_{eq} is the sound level, expressed in dBA, of a steady sound that has the same A-weighted sound energy as the time-varying sound over the averaging period. Unlike SEL, L_{eq} is the average sound level for a specified time period (e.g., 24 hours, 8 hours, 1 hour, etc.). L_{eq} is calculated by integrating the sound energy from all noise events over a given time period and applying a factor for the number of events. L_{eq} can be expressed for any time interval; for example, the L_{eq} representing an averaged level over an 8-hour period would be expressed as $L_{eq(8)}$. Leq for one hour is used to develop Community Noise Equivalent Level (CNEL) values.

Day-Night Average Sound Level (DNL): DNL, formerly referred to as Ldn, is expressed in dBA and represents the noise level over a 24-hour period. Because environmental noise fluctuates over time, DNL was devised to relate noise exposure over time to human response. DNL is a 24-hour average of the hourly L_{eq}, but with penalties to account for the increased sensitivity to noise events that occur during the more sensitive nighttime periods. Specifically, DNL penalizes noise 10 dB during the nighttime time period (10:00 p.m. to 7:00 a.m.), but it does not include an evening penalty (7:00 p.m. to 10:00 p.m.). Typically, DNL is about 1 dB lower than CNEL, although the difference may be greater if there is an abnormal concentration of noise events in the 7:00 p.m. to 10:00 p.m. time period.

The U.S. Environmental Protection Agency (USEPA) introduced the metric in 1976 as a single number measurement of community noise exposure. The Federal Aviation Administration (FAA) adopted DNL as the noise metric for measuring cumulative aircraft noise under Federal Aviation Regulations (FAR) Part 150, Airport Noise Compatibility Planning. The Department of Housing and Urban Development, the Veterans Administration, the Department of Defense, the United States Coast Guard, and the Federal Transit Administration have also adopted DNL for measuring cumulative noise exposure.

DNL is used to describe existing and predicted noise exposure in communities in airport environs based on the average daily operations during the year and the average annual operational conditions at an airport. Therefore, at a specific location near an airport, the noise exposure on a particular day is likely to be higher or lower than the annual average noise exposure, depending on the specific operations at an airport on that day. DNL is widely accepted as the best available method to describe aircraft noise exposure and is the noise descriptor required for aircraft noise exposure analyses and land use compatibility planning under FAR Part 150 and for environmental assessments for airport improvement projects (FAA Order 10501.F). The FAA guidelines allow for the use of CNEL as a substitute to DNL, as further discussed below.

Community Noise Equivalent Level (CNEL): CNEL, expressed in dBA, is the standard metric used in California to represent cumulative noise exposure. The metric provides a single-number description of the sound energy to which a person or community is exposed over a period of 24 hours similar to DNL. CNEL includes penalties applied to noise events occurring after 7:00 p.m. and before 7:00 a.m., when noise is considered more intrusive; it also accounts for the typically lower ambient noise levels during these hours. The penalized time period is further subdivided into evening (7:00 p.m. through 9:59 p.m.) and nighttime (10:00 p.m. to 6:59 a.m.). When a noise event occurs in the evening, a penalty of 5 dBA is added to the nominal sound level (equivalent to a three-fold increase in aircraft operations). A 10-dBA penalty is added to nighttime noise events (equivalent to a ten-fold increase in aircraft operations). Examples of typical outdoor noise levels measured in terms of CNEL decibel levels include wilderness areas at approximately 35 CNEL, rural residential areas at approximately 40 to 50 CNEL, suburban areas at approximately 60 CNEL, high-density development in downtown areas at approximately 70 CNEL, and development adjacent to a major freeway at approximately 85 CNEL.[1]

The CNEL metric used for this aircraft noise analysis is based on an Average Annual Day (AAD) of aircraft operations, generally derived from data for a calendar year. An AAD activity profile is computed by adding all aircraft operations occurring during the course of a year and dividing the result by 365. As such, AAD does not reflect activities on any one specific day, but represents average conditions as they occur during the course of the year.

The evening weighting is the only difference between CNEL and DNL. For purposes of aircraft noise analysis in the State of California, the FAA recognizes the use of CNEL. CNEL is also specified for use in the California Airport Noise Regulations and is used by local planning agencies in their General Plan Noise Element for land use compatibility planning.

Time Above (TA): TA measures the amount of time (in minutes) a source emits a noise that exceeds a designated threshold level. For instance, the threshold could be outdoor speech interference. TA is therefore both a single event and a cumulative metric.

[1] Extrapolated from U.S. Environmental Protection Agency, *Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure, EPA Report NTID 73.4*, 1973. Available: https://nepis.epa.gov/Exe/ZyNET.exe/9101DPQN.txt?ZyActionD=ZyDocument&Client=EPA&Index=Prior%20to%201976&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C70THRU75%5CTXT%5C00000021%5C9101DPQN.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&slide.

Appendix F

F2 – Aircraft Noise Analysis Technical Memorandum

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TECHNICAL MEMORANDUM

To:	Anthony Skidmore CDM Smith 46 Discovery, Suite 250 Irvine, CA 92617
From:	Scott A. McIntosh Vincent Ma Justin W. Cook
Date:	May 19, 2021
Subject:	San Diego International Airport – Airfield Improvements and Terminal 1 Replacement Project Environmental Assessment (EA) – Aircraft Noise Modeling Approach and Input Assumptions
Reference:	HMMH Project Number 310560.000

1. BACKGROUND

HMMH is assisting CDM Smith and the San Diego County Regional Airport Authority in the preparation of aircraft noise analyses for the Environmental Assessment (EA) for the San Diego International Airport (SAN) Airfield Improvements and Terminal 1 Replacement Project.

This technical memorandum describes the aircraft noise modeling approach and input assumptions to be used for the SAN Airfield Improvements and Terminal 1 Replacement Project's EA aircraft noise analyses.

The aircraft noise analyses for the SAN Airfield Improvements and Terminal 1 Replacement Project EA will include one (1) existing conditions year and two (2) forecast years. Therefore, the resulting contours and analyses will represent years 2018, 2026, and 2031. Two planning scenarios – No Build (No Action) and Proposed Project – will be evaluated.

The subsequent sections address the FAA's Aviation Environmental Design Tool (AEDT)[1], Version 2d, inputs developed under the following categories:

- Physical description of the airport layout
- Aircraft operations
- Aircraft noise and performance characteristics
- Runway utilization
- Flight track geometry and use
- Meteorological conditions
- Terrain data

2. PHYSICAL DESCRIPTION OF THE AIRPORT LAYOUT

SAN is located within San Diego County and the City of San Diego approximately 1.5 miles south of the intersection of interstate highways 5 and 8. SAN has one runway: 09/27. Figure 1 shows the Airport Diagram and Table 1 provides the runway specifications required for aircraft noise modeling.

Each end of the runway is designated by a number that, with the addition of a trailing "0", reflects the magnetic heading of the runway to the nearest 10 degrees, as seen by the pilot. The runway is oriented on approximate magnetic headings of 90º and 270º and is 9,400 feet long by 200 feet wide.

[1] https://aedt.faa.gov/

Figure 1. Existing Airport Diagram

Source: FAA, Effective, 23 May 2019 to 20 June 2019

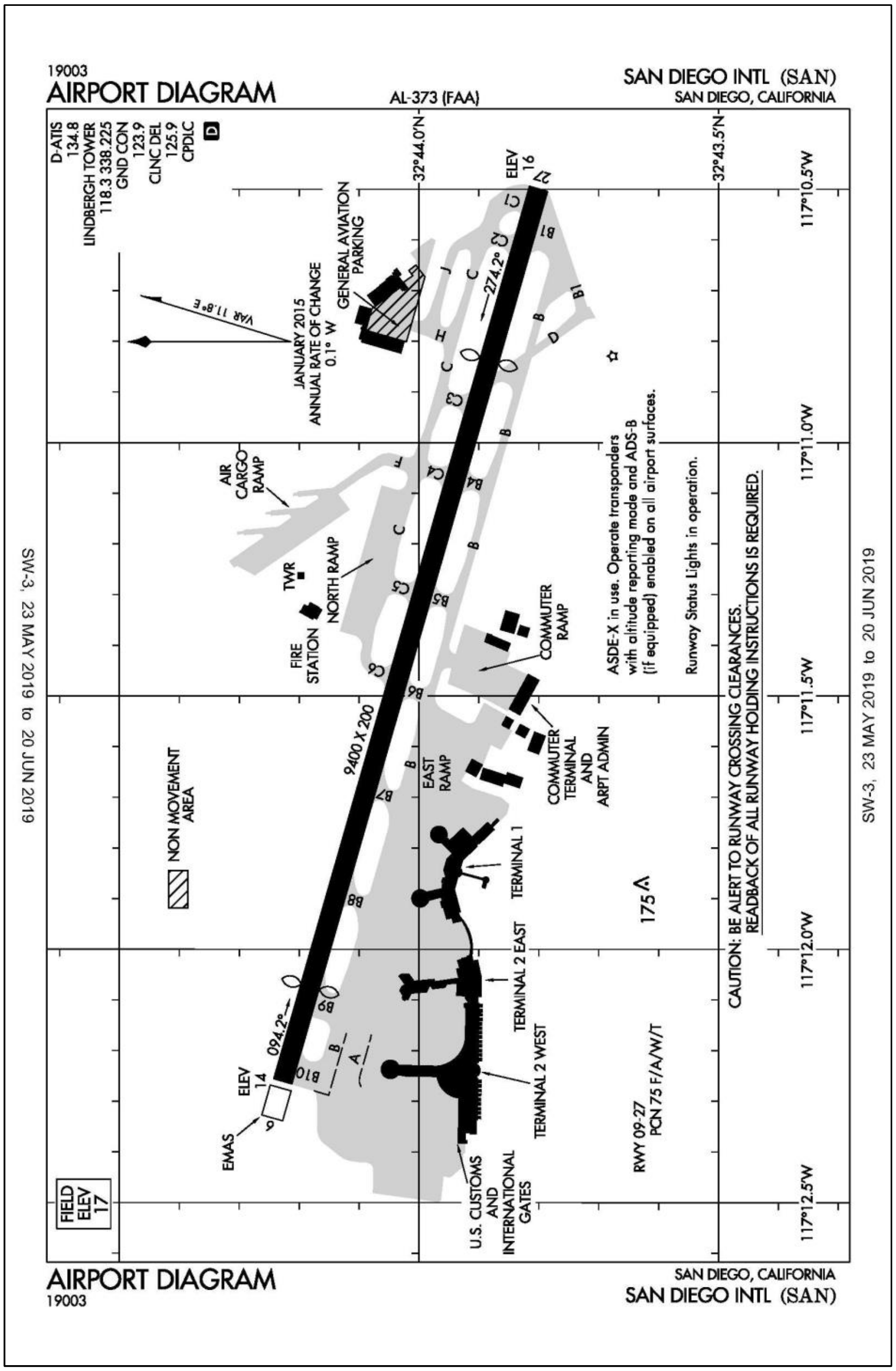

Table 1. Runway Data

Runway/ Helipad	Latitude	Longitude	Elevation (ft. MSL)	Length (ft.)	Approach Angle (degrees)	Displaced Arrival Thresholds (ft)
09	32.737123	-117.204357	13.7	9,400	3.0	1,000
27	32.730002	-117.174973	16.4	9,400	3.5	1,810
H1	32.732789	-117.182452	14.0	N/A		
Source: AEDT Version 2d						

3. AIRCRAFT OPERATIONS

Title 14 of the Code of Federal Regulations Part 150 (14 CFR Part 150) and its table of noise/land use compatibility guidelines require the calculation of "yearly Day-Night Average Sound Level (DNL)" values. In California, the Community Noise Equivalent Level, or CNEL, is the recognized noise metric and is allowed by the FAA to replace DNL for the purposes of airport planning. The daily noise exposure (in CNEL) is averaged over a year and is typically a calendar year. AEDT produces these values of exposure utilizing an "average annual day" (AAD) of airport operations.

HMMH analyzed 2018 aircraft operations and fleet mix data prepared by Leigh Fisher that was based on 2018 SAN Aircraft Noise and Operations Management System (ANOMS) data to develop the average annual day's operations. HMMH also analyzed 2026 and 2031 aircraft operations and fleet mix data prepared by KB Environmental Sciences, Inc. (KBE) that was based on Leigh Fisher AAD data to develop the AAD's operations for all modeling scenarios. Table 2 shows the forecasted SAN aircraft operations for all analysis years.

It is important to note that run-up operations will be omitted from the aircraft noise analyses due to negligible contributions.

Table 2. Forecast of Aircraft Operations – 2018, 2026, and 2031 Scenarios

Scenario	Aircraft Category	2018 Operations	2026 Operations	2031 Operations
No Action	Commercial/Cargo	212,430	247,105	261,340
	Air Taxi/Charter	365	730	730
	General Aviation	11,680	9,855	9,125
	Military	730	730	730
	Helicopter	365	365	365
Total		**225,570**	**258,785**	**272,290**
Proposed Project	Commercial/Cargo	-	247,105	261,340
	Air Taxi/Charter	-	730	730
	General Aviation	-	9,855	9,125
	Military	-	730	730
	Helicopter	-	365	365
Total		**-**	**258,785**	**272,290**
Source: 2018 Aircraft Operations and Fleet Mix Data Prepared by Leigh Fisher Based on 2018 SAN ANOMS Data, 2026, and 2031 Aircraft Operations and Fleet Mix Data Prepared by KBE Based on Leigh Fisher AAD Data.				

The aircraft operations format for entering data into AEDT includes day, evening, and night arrivals, departures, and pattern/touch-and-go operations (as appropriate) expressed in terms of an AAD. The AAD day operations are determined by dividing the annual operations by 365 days. Table 3 through Table 5 list the AAD operations by aircraft type, operation mode, and time of day for the existing (2018) conditions, 2026, and 2031 scenarios, respectively.

Table 3. Modeled Average Daily Aircraft Operations for 2018

Aircraft Type	Arrivals			Departures			Total
	Day	Evening	Night	Day	Evening	Night	
717200	0.9992	0.4565	0.7320	1.4557	0.7265	0.0000	**4.3699**
737300	0.0167	0.0028	0.0028	0.0195	0.0056	0.0000	**0.0473**
737400	0.0501	0.0306	0.0000	0.0223	0.0612	0.0028	**0.1670**
737500	0.0028	0.0000	0.0000	0.0028	0.0000	0.0000	**0.0056**
737700	58.9495	14.0116	8.6925	65.9080	14.3234	1.2108	**163.0958**
737800	49.4665	17.7859	14.2148	61.5771	14.0812	5.5278	**162.6533**
747400	0.3841	0.0167	0.0000	0.0000	0.3841	0.0195	**0.8044**
757300	0.7766	0.1169	0.0362	0.5817	0.1447	0.1921	**1.8482**
767300	1.7396	0.2310	1.8231	1.2024	2.1989	0.3925	**7.5875**
777200	0.0334	0.0000	0.0000	0.0000	0.0306	0.0028	**0.0668**
777300	0.0000	0.0000	0.0000	0.0028	0.0000	0.0000	**0.0028**
1900D	0.0056	0.0028	0.0000	0.0056	0.0028	0.0000	**0.0167**
7378MAX	0.7654	0.2171	0.1169	0.9324	0.1475	0.0139	**2.1933**
757PW	3.0339	0.7766	1.3499	3.9079	1.0271	0.2199	**10.3153**
767CF6	0.6096	0.0000	0.1113	0.6652	0.0529	0.0000	**1.4390**
7773ER	0.4509	0.1225	0.0000	0.0056	0.5483	0.0195	**1.1468**
7878R	1.0104	0.0000	0.0028	1.0159	0.0000	0.0000	**2.0291**
A109	0.0251	0.0000	0.0028	0.0167	0.0111	0.0000	**0.0557**
A310-304	0.0000	0.0000	0.0000	0.0056	0.0000	0.0000	**0.0056**
A319-131	4.9878	0.5817	1.0577	5.5640	1.0521	0.0056	**13.2490**
A320-211	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0000**
A320-232	13.0486	5.1604	1.8259	14.9357	4.1389	0.8740	**39.9835**
A321-232	19.7788	6.0511	4.0610	22.0055	5.5501	2.3102	**59.7567**
A330-301	0.0084	0.1503	0.8656	1.0159	0.0028	0.0000	**2.0430**
A330-343	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0000**
A340-211	0.6569	0.0167	0.0000	0.5539	0.1030	0.0167	**1.3472**
B206L	0.0084	0.0000	0.0000	0.0139	0.0000	0.0000	**0.0223**
BD-700-1A10	0.3201	0.0724	0.0557	0.3758	0.0696	0.0084	**0.9018**
BD-700-1A11	0.1392	0.0167	0.0084	0.1531	0.0084	0.0000	**0.3257**
BEC58P	0.2589	0.0028	0.0028	0.2366	0.0167	0.0000	**0.5177**
CIT3	0.1336	0.0084	0.0000	0.1280	0.0139	0.0000	**0.2839**
CL600	3.4653	0.5177	0.0668	3.7632	0.3117	0.0139	**8.1386**
CL601	0.8016	0.0974	0.0306	0.8656	0.0557	0.0139	**1.8649**
CNA172	0.2032	0.0334	0.0056	0.2255	0.0445	0.0000	**0.5121**

Aircraft Type	Arrivals			Departures			Total
	Day	Evening	Night	Day	Evening	Night	
CNA182	0.1058	0.0139	0.0000	0.1197	0.0139	0.0000	**0.2533**
CNA206	0.0668	0.0000	0.0000	0.0696	0.0000	0.0000	**0.1364**
CNA208	2.7222	0.0251	0.0278	2.3826	0.4259	0.0000	**5.5835**
CNA20T	0.0445	0.0028	0.0000	0.0473	0.0000	0.0000	**0.0946**
CNA441	0.0473	0.0000	0.0000	0.0418	0.0000	0.0000	**0.0891**
CNA500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0000**
CNA510	0.7014	0.0891	0.0362	0.7237	0.1030	0.0028	**1.6561**
CNA525C	0.9241	0.0585	0.0473	0.9380	0.0946	0.0084	**2.0708**
CNA55B	1.2330	0.1364	0.0445	1.3444	0.0807	0.0028	**2.8418**
CNA560U	0.3563	0.0167	0.0306	0.3563	0.0501	0.0056	**0.8155**
CNA560XL	1.5420	0.1447	0.0334	1.6366	0.0807	0.0056	**3.4431**
CNA680	1.0187	0.0612	0.0223	1.0382	0.0724	0.0139	**2.2267**
CNA750	2.8224	0.3368	0.1141	3.0172	0.2310	0.0557	**6.5772**
COMSEP	0.3284	0.0585	0.0056	0.3674	0.0306	0.0000	**0.7905**
CRJ9-ER	4.7346	1.2136	1.5531	6.3155	1.1579	0.0167	**14.9914**
DC1030	0.2895	0.0139	0.0028	0.0111	0.2589	0.0390	**0.6151**
DC3	0.0000	0.0000	0.0000	0.0028	0.0000	0.0000	**0.0028**
DC870	0.0084	0.0028	0.0056	0.0139	0.0028	0.0000	**0.0334**
DHC6	2.2991	0.1086	0.0195	2.2657	0.3507	0.0028	**5.0463**
DHC8	0.0028	0.0000	0.0000	0.0028	0.0000	0.0000	**0.0056**
DHC830	0.9491	0.0418	0.0000	0.6096	0.3841	0.0028	**1.9873**
DO328	0.0056	0.0000	0.0000	0.0056	0.0000	0.0000	**0.0111**
ECLIPSE500	0.0473	0.0056	0.0000	0.0529	0.0028	0.0000	**0.1086**
EMB145	0.0668	0.0084	0.0056	0.0640	0.0111	0.0028	**0.1587**
EMB175	25.3400	5.5111	3.2761	29.2423	4.7763	0.0919	**68.2377**
EMB190	0.0334	0.0056	0.0000	0.0334	0.0056	0.0000	**0.0779**
GASEPF	0.0362	0.0028	0.0028	0.0779	0.0028	0.0000	**0.1225**
GASEPV	0.4620	0.0557	0.0167	0.4843	0.0696	0.0028	**1.0911**
GIIB	0.0056	0.0000	0.0028	0.0056	0.0028	0.0000	**0.0167**
GIV	1.0020	0.1364	0.0585	1.0772	0.1141	0.0056	**2.3937**
GV	0.7599	0.1113	0.0334	0.7738	0.1113	0.0278	**1.8176**
H500D	0.0084	0.0000	0.0000	0.0223	0.0000	0.0000	**0.0306**
IA1125	0.3340	0.0251	0.0139	0.3451	0.0278	0.0056	**0.7515**
LEAR25	0.0084	0.0000	0.0000	0.0056	0.0056	0.0000	**0.0195**
LEAR35	2.0959	0.1837	0.1169	2.2044	0.2115	0.0111	**4.8236**
MD11PW	0.0111	0.0028	0.0028	0.0028	0.0111	0.0028	**0.0334**
MD83	0.0418	0.0000	0.0000	0.0418	0.0000	0.0000	**0.0835**
MD9025	0.3563	0.0111	0.0000	0.3368	0.0306	0.0028	**0.7376**
MU3001	0.5288	0.0390	0.0167	0.5455	0.0445	0.0000	**1.1746**

Aircraft Type	Arrivals			Departures			Total
	Day	Evening	Night	Day	Evening	Night	
PA28	0.0612	0.0000	0.0000	0.0390	0.0056	0.0000	**0.1058**
R44	0.0278	0.0056	0.0000	0.0418	0.0000	0.0000	**0.0752**
S76	0.0000	0.0000	0.0000	0.0028	0.0000	0.0000	**0.0028**
SA341G	0.0028	0.0028	0.0000	0.0000	0.0028	0.0000	**0.0084**
SA350D	0.0111	0.0028	0.0056	0.0306	0.0056	0.0000	**0.0557**
SA355F	0.0000	0.0000	0.0000	0.0056	0.0000	0.0000	**0.0056**
T41	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0000**
Total	**213.5727**	**54.9136**	**40.5596**	**243.9089**	**53.8921**	**11.1531**	**618.0000**

Table 4. Modeled Average Daily Aircraft Operations for 2026

Aircraft Type	Arrivals			Departures			Total
	Day	Evening	Night	Day	Evening	Night	
CL600	3.6923	0.0000	0.0000	3.6923	0.0000	0.0000	**7.3846**
CNA500	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	**2.0000**
CNA510	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0000**
CNA560XL	1.2308	0.0000	0.0000	1.2308	0.0000	0.0000	**2.4615**
CNA750	2.0000	0.0000	0.0000	2.0000	0.0000	0.0000	**4.0000**
DHC6	4.0000	0.0000	1.0000	4.0000	1.0000	1.0000	**11.0000**
GIV	1.8462	0.0000	0.0000	1.8462	0.0000	0.0000	**3.6923**
GV	2.2308	0.0000	0.0000	2.2308	0.0000	0.0000	**4.4615**
LEAR35	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	**2.0000**
717200	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	**2.0000**
737300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0000**
737700	124.7922	35.6634	34.6040	67.0000	17.0000	15.0000	**294.0596**
737800	1.2078	0.3366	0.3960	70.0000	12.0000	16.0000	**99.9404**
767300	1.0000	0.0000	4.0000	0.0000	2.0000	3.0000	**10.0000**
777300	0.0198	0.0000	0.0000	1.0000	0.0000	0.0000	**1.0198**
7378MAX	1.0000	0.0000	1.0000	2.0000	0.0000	0.0000	**4.0000**
757PW	2.0000	2.0000	1.0000	2.0000	1.0000	2.0000	**10.0000**
7773ER	0.9802	0.0000	0.0000	0.0000	0.0000	0.0000	**0.9802**
7878R	3.0000	0.0000	0.0000	2.0000	1.0000	0.0000	**6.0000**
A319-131	4.0000	0.0000	1.0000	4.0000	0.0000	1.0000	**10.0000**
A320-211	3.0000	3.0000	0.0000	3.0000	3.0000	0.0000	**12.0000**
A320-232	23.0000	8.0000	3.0000	24.0000	4.0000	6.0000	**68.0000**
A321-232	35.0000	8.0000	9.0000	39.0000	4.0000	9.0000	**104.0000**
A330-343	0.0000	0.0000	1.0000	1.0000	0.0000	0.0000	**2.0000**
A340-211	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	**2.0000**
EMB175	13.0000	6.0000	1.0000	16.0000	3.0000	1.0000	**40.0000**
EMB190	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0000**
CRJ9-ER	2.0000	0.0000	0.0000	1.0000	0.0000	0.0000	**3.0000**
CNA208	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	**2.0000**
CNA172	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0000**
T41	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0000**
R44	0.5000	0.0000	0.0000	0.5000	0.0000	0.0000	**1.0000**
Total	**234.5000**	**63.0000**	**57.0000**	**252.5000**	**48.0000**	**54.0000**	**709.0000**

Table 5. Modeled Average Daily Aircraft Operations for 2031

Aircraft Type	Arrivals			Departures			Total
	Day	Evening	Night	Day	Evening	Night	
737700	48.0000	18.0000	7.0000	50.0000	14.0000	9.0000	**146.0000**
737800	90.0000	25.0000	24.0000	102.0000	15.0000	23.0000	**279.0000**
7378MAX	9.0000	2.0000	7.0000	11.0000	2.0000	5.0000	**36.0000**
757PW	2.0000	1.0000	0.0000	1.0000	1.0000	1.0000	**6.0000**
767300	1.0000	0.0000	5.0000	0.0000	2.0000	4.0000	**12.0000**
777300	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	**2.0000**
7878R	4.0000	0.0000	0.0000	2.0000	2.0000	0.0000	**8.0000**
A320-211	3.0000	3.0000	0.0000	3.0000	3.0000	0.0000	**12.0000**
A320-232	14.0000	6.0000	2.0000	14.0000	4.0000	4.0000	**44.0000**
A321-232	47.0000	12.0000	12.0000	53.0000	5.0000	12.0000	**141.0000**
A330-343	0.0000	0.0000	1.0000	1.0000	0.0000	0.0000	**2.0000**
A340-211	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	**2.0000**
CL600	3.6923	0.0000	0.0000	3.6923	0.0000	0.0000	**7.3846**
CNA500	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	**2.0000**
CNA560XL	1.2308	0.0000	0.0000	1.2308	0.0000	0.0000	**2.4615**
CNA750	2.0000	0.0000	0.0000	2.0000	0.0000	0.0000	**4.0000**
CRJ9-ER	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	**2.0000**
DHC6	5.0000	0.0000	1.0000	5.0000	1.0000	1.0000	**13.0000**
EMB175	4.0000	2.0000	1.0000	6.0000	1.0000	0.0000	**14.0000**
GIV	1.8462	0.0000	0.0000	1.8462	0.0000	0.0000	**3.6923**
GV	2.2308	0.0000	0.0000	2.2308	0.0000	0.0000	**4.4615**
LEAR35	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	**2.0000**
R44	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**1.0000**
Total	**244.0000**	**69.0000**	**60.0000**	**264.0000**	**50.0000**	**59.0000**	**746.0000**

4. AIRCRAFT NOISE AND PERFORMANCE CHARACTERISTICS

Specific noise and performance data must be entered into AEDT for each aircraft type operating at SAN. Noise data are included in the form of Sound Exposure Level (SEL) 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 include thrust, speed, and altitude profiles for takeoff and landing operations. The AEDT database contains standard noise and performance data for over 300 different fixed-wing aircraft types, most of which are civilian aircraft. AEDT automatically accesses the noise and performance data for takeoff and landing operations by those aircraft.

Within the AEDT database, aircraft takeoff or departure profiles are usually defined by a range of trip distances identified as "stage lengths." A longer trip distance or higher stagelength is associated with a heavier aircraft due to the increase in fuel requirements for the flight. Stagelength determinations were obtained from gated schedules derived from data analyzed by Leigh Fisher and KBE. Table 6 provides the stagelength definitions based on distance between origin and destination airports. Stagelength "M" is the maximum range of an aircraft with maximum fuel and no additional cargo other than what is already in the AEDT's payload assumptions. Table 7 through Table 9 provide the stagelength use percentages for both takeoffs and landings by aircraft for each modeling scenario.

Besides identifying the aircraft type in the database, AEDT has standard and International Civil Aviation Organization (ICAO) aircraft flight profiles for takeoffs, landings, and flight patterns or touch-and-go operations. HMMH will use these standard profiles for all aircraft types for landings to Runway 09 and takeoffs from Runways 09 and 27. For landings to Runway 27, and as recommended by the FAA, HMMH created custom profiles for every aircraft type to more accurately account for the 3.5 degree approach to Runway 27.

Table 6. Stagelength Definitions

Stagelength	Distance (nmi)
1	0 – 500
2	501 – 1,000
3	1,001 – 1,500
4	1,501 – 2,500
5	2,501 – 3,500
6	3,501 – 4,500
7	4,501 – 5,500
8	5,501 – 6,500
9	6,501 – 7,500
10	7,501 – 8,500
11	>8,500
M	Maximum range at Maximum Takeoff Weight

Table 7. Stagelength Usage by Aircraft Type for 2018

Aircraft Type	Day*									Evening*									Night*				Total
	1	2	3	4	5	6	7	8	M**	1	2	3	4	5	6	7	8	M**	1	2	3	5	
717200	24%	32%	0%	0%	0%	0%	0%	0%	0%	11%	0%	0%	0%	0%	16%	0%	0%	0%	17%	0%	0%	0%	100%
737300	59%	6%	6%	6%	0%	0%	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%	100%
737400	38%	3%	2%	0%	0%	0%	0%	0%	0%	53%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	2%	0%	100%
737500	50%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
737700	59%	7%	6%	2%	0%	3%	0%	0%	0%	12%	1%	0%	0%	0%	4%	0%	0%	0%	6%	0%	0%	0%	100%
737800	38%	9%	11%	9%	0%	2%	0%	0%	0%	13%	1%	0%	0%	0%	5%	0%	0%	0%	9%	1%	2%	0%	100%
747400	48%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	19%	28%	0%	0%	0%	0%	2%	0%	1%	100%
757300	42%	0%	0%	32%	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%	8%	0%	0%	0%	2%	0%	10%	0%	100%
767300	23%	0%	8%	8%	0%	0%	0%	0%	0%	3%	4%	11%	8%	0%	0%	6%	0%	0%	24%	1%	4%	0%	100%
777200	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	13%	33%	0%	0%	0%	0%	0%	0%	4%	100%
777300	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
1900D	67%	0%	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
7378MAX	46%	4%	14%	9%	0%	0%	0%	0%	4%	11%	1%	0%	0%	0%	2%	0%	0%	2%	6%	1%	0%	0%	100%
757PW	39%	2%	1%	22%	0%	0%	4%	0%	0%	11%	0%	2%	0%	0%	0%	4%	0%	0%	13%	0%	2%	0%	100%
767CF6	85%	0%	0%	1%	0%	0%	3%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	100%
7773ER	39%	0%	0%	0%	0%	0%	0%	0%	0%	11%	0%	0%	0%	27%	21%	0%	0%	0%	0%	1%	0%	1%	100%
7878R	50%	0%	0%	0%	0%	25%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
A109	75%	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	100%
A310-304	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
A319-131	53%	10%	11%	5%	1%	0%	0%	0%	0%	7%	0%	0%	0%	5%	0%	0%	0%	0%	8%	0%	0%	0%	100%
A320-232	48%	10%	8%	2%	2%	0%	0%	0%	0%	16%	0%	2%	2%	3%	0%	0%	0%	0%	5%	1%	1%	0%	100%
A321-232	35%	2%	14%	18%	1%	0%	0%	0%	0%	11%	0%	2%	1%	5%	0%	0%	0%	0%	7%	1%	3%	0%	100%
A330-301	0%	0%	0%	50%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	42%	0%	0%	0%	100%
A340-211	49%	0%	0%	0%	0%	26%	15%	0%	0%	1%	0%	0%	0%	5%	3%	0%	0%	0%	0%	0%	0%	1%	100%
B206L	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%

Notes: * = Only the stagelengths (i.e., columns) with non-zero values are shown for Day, Evening, and Night operations.
** = Stagelength "M" is representative of the maximum available range for the given aircraft.

Aircraft Type	Day*									Evening*									Night*				Total
	1	2	3	4	5	6	7	8	M**	1	2	3	4	5	6	7	8	M**	1	2	3	5	
BD-700-1A10	59%	3%	7%	6%	0%	1%	0%	2%	0%	10%	1%	1%	0%	1%	1%	0%	2%	0%	6%	0%	0%	0%	100%
BD-700-1A11	69%	2%	5%	9%	1%	0%	3%	0%	0%	7%	0%	0%	0%	0%	1%	0%	0%	0%	3%	0%	0%	0%	100%
BEC58P	96%	0%	0%	0%	0%	0%	0%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
CIT3	92%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
CL600	89%	0%	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	100%
CL601	90%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	100%
CNA172	84%	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	100%
CNA182	89%	0%	0%	0%	0%	0%	0%	0%	0%	11%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
CNA206	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
CNA208	91%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	100%
CNA20T	97%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
CNA441	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
CNA510	86%	0%	0%	0%	0%	0%	0%	0%	0%	12%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	100%
CNA525C	90%	0%	0%	0%	0%	0%	0%	0%	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	100%
CNA55B	91%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	100%
CNA560U	87%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	100%
CNA560XL	92%	0%	0%	0%	0%	0%	0%	0%	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	100%
CNA680	92%	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	100%
CNA750	89%	0%	0%	0%	0%	0%	0%	0%	0%	9%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	100%
COMSEP	88%	0%	0%	0%	0%	0%	0%	0%	0%	11%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	100%
CRJ9-ER	55%	0%	16%	0%	3%	0%	0%	0%	0%	13%	0%	0%	0%	3%	0%	0%	0%	0%	10%	0%	0%	0%	100%
DC1030	47%	0%	2%	0%	0%	0%	0%	0%	0%	3%	8%	31%	0%	0%	0%	2%	0%	0%	1%	6%	0%	0%	100%
DC3	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
DC870	58%	9%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	8%	0%	0%	17%	0%	0%	0%	100%
DHC6	91%	0%	0%	0%	0%	0%	0%	0%	0%	9%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%

Notes: * = Only the stagelengths (i.e., columns) with non-zero values are shown for Day, Evening, and Night operations.
** = Stagelength "M" is representative of the maximum available range for the given aircraft.

Aircraft Type	Day*									Evening*									Night*				Total
	1	2	3	4	5	6	7	8	M**	1	2	3	4	5	6	7	8	M**	1	2	3	5	
DHC8	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
DHC830	79%	0%	0%	0%	0%	0%	0%	0%	0%	21%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
DO328	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
ECLIPSE500	82%	8%	3%	0%	0%	0%	0%	0%	0%	5%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
EMB145	63%	9%	3%	7%	0%	0%	0%	0%	0%	7%	0%	2%	4%	0%	0%	0%	0%	0%	5%	0%	0%	0%	100%
EMB175	61%	8%	11%	0%	0%	0%	0%	0%	0%	10%	0%	5%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	100%
EMB190	86%	0%	0%	0%	0%	0%	0%	0%	0%	11%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
GASEPF	93%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	100%
GASEPV	87%	0%	0%	0%	0%	0%	0%	0%	0%	11%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	100%
GIIB	66%	0%	0%	0%	0%	0%	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%	0%	0%	17%	0%	0%	0%	100%
GIV	87%	0%	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	100%
GV	85%	0%	0%	0%	0%	0%	0%	0%	0%	12%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	100%
H500D	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
IA1125	90%	0%	0%	0%	0%	0%	0%	0%	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	100%
LEAR25	71%	0%	0%	0%	0%	0%	0%	0%	0%	29%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
LEAR35	89%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	100%
MD11PW	42%	0%	0%	0%	0%	0%	0%	0%	0%	9%	0%	33%	0%	0%	0%	0%	0%	0%	8%	8%	0%	0%	100%
MD83	50%	44%	3%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
MD9025	48%	45%	1%	0%	0%	0%	0%	0%	0%	2%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
MU3001	92%	0%	0%	0%	0%	0%	0%	0%	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	100%
PA28	95%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
R44	93%	0%	0%	0%	0%	0%	0%	0%	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
S76	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
SA341G	33%	0%	0%	0%	0%	0%	0%	0%	0%	67%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
SA350D	75%	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	100%
SA355F	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%

Notes: * = Only the stagelengths (i.e., columns) with non-zero values are shown for Day, Evening, and Night operations.
** = Stagelength “M” is representative of the maximum available range for the given aircraft.

Table 8. Stagelength Usage by Aircraft Type for 2026

Aircraft Type	Day*					Evening*						Night*				Total
	1	2	3	4	7	1	2	3	4	7	9	1	2	3	4	
CL600	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
CNA500	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
CNA510	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CNA560XL	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
CNA750	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
DHC6	73%	0%	0%	0%	0%	9%	0%	0%	0%	0%	0%	18%	0%	0%	0%	100%
GIV	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
GV	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
LEAR35	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
717200	50%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
737300	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
737700	55%	4%	3%	2%	0%	17%	1%	0%	0%	0%	0%	15%	1%	1%	1%	100%
737800	17%	16%	18%	20%	0%	6%	2%	3%	1%	0%	0%	1%	2%	4%	10%	100%
767300	10%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	40%	0%	10%	20%	100%
777300	2%	0%	0%	0%	98%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
7378MAX	25%	25%	25%	0%	0%	0%	0%	0%	0%	0%	0%	25%	0%	0%	0%	100%
757PW	20%	0%	0%	20%	0%	20%	0%	0%	10%	0%	0%	10%	0%	0%	20%	100%
7773ER	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
7878R	50%	0%	0%	0%	33%	0%	0%	0%	0%	17%	0%	0%	0%	0%	0%	100%
A319-131	50%	20%	10%	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	100%
A320-211	33%	0%	9%	8%	0%	42%	0%	0%	8%	0%	0%	0%	0%	0%	0%	100%
A320-232	41%	12%	10%	6%	0%	13%	0%	0%	5%	0%	0%	7%	3%	3%	0%	100%
A321-232	38%	1%	15%	16%	0%	10%	0%	0%	2%	0%	0%	10%	1%	3%	4%	100%
A330-343	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	100%
A340-211	50%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
EMB175	52%	7%	13%	0%	0%	20%	0%	3%	0%	0%	0%	5%	0%	0%	0%	100%
EMB190	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CRJ9-ER	67%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
CNA208	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
CNA172	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
T41	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
R44	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%

Note: * = Only the stagelengths (i.e., columns) with non-zero values are shown for Day, Evening, and Night operations.

Table 9. Stagelength Usage by Aircraft Type for 2031

Aircraft Type	Day*					Evening*						Night*			
	1	2	3	4	7	1	2	3	4	7	9	1	2	3	4
737700	58%	26%	10%	6%	0%	79%	14%	7%	0%	0%	0%	44%	22%	22%	11%
737800	25%	23%	26%	26%	0%	53%	13%	27%	7%	0%	0%	13%	9%	26%	52%
767300	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	50%	50%
777300	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7378MAX	55%	18%	18%	9%	0%	100%	0%	0%	0%	0%	0%	80%	0%	0%	20%
757PW	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%
7878R	0%	0%	0%	0%	100%	0%	0%	0%	0%	50%	50%	0%	0%	0%	0%
A320-211	33%	0%	33%	33%	0%	67%	0%	0%	33%	0%	0%	0%	0%	0%	0%
A320-232	29%	29%	29%	14%	0%	50%	0%	0%	50%	0%	0%	25%	50%	25%	0%
A321-232	15%	11%	40%	34%	0%	40%	0%	0%	60%	0%	0%	17%	8%	33%	42%
A330-343	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
A340-211	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CL600	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CNA500	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CNA560XL	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CNA750	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CRJ9-ER	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
DHC6	100%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%	0%	0%
EMB175	50%	17%	33%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
GIV	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
GV	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
LEAR35	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note: * = Only the stagelengths (i.e., columns) with non-zero values are shown for Day, Evening, and Night operations.

5. RUNWAY UTILIZATION

The primary factor affecting runway use at airports is weather, in particular, the wind direction and wind speed. Additional factors that may affect runway use include the position of the facility or ramp relative to the runways or operational proficiency training for military units. There are no anticipated changes to the runway utilization expected between scenarios.

Based on interviews with airport operators and FAA Airport Traffic Control Tower (ATCT) personnel, the overall runway usage for this modeling will remain the same between years, employing 98.02% of operations on Runway 27 and the remaining 1.98% on Runway 09.

6. FLIGHT TRACK GEOMETRY AND USE

Model tracks were developed using a standard method, which entailed analyzing all radar data from SAN's ANOMS and splitting the flight tracks into similar and manageable groups. This was first done by separating tracks by phase of flight (e.g., arrival or departure) and then by runway. Following this, the flights were separated by destination direction, such as north, south, or west. Finally, at this point, radar flight tracks were analyzed and split into groups according to their degree of similar geometry.

Model tracks were developed for each geometrically similar group. For example, Runway 27 Departures with a northerly destination were split into a geometrically similar group, and a 'backbone' track was developed. Each of these backbone tracks were then assigned one or two 'dispersion' sub tracks on either side of the backbone, for a total of three or five tracks (one backbone and two or four dispersion) for each geometrically similar group.

Table 10 through Table 12 present the utilization rates for each group of the developed model tracks for 2018, 2026 and 2031, respectively. Default Integrated Noise Model (INM) dispersion percentages were used to assign utilization of the backbone and subtracks within a given track group.

Table 10. Flight Track Utilization for 2018

	Arrivals				Departures			
Runway	Track Bundle	Day	Evening	Night	Track Bundle	Day	Evening	Night
9	A09JE01	1.27%	2.16%	7.73%	D09JE01	16.38%	13.04%	19.64%
	A09JE02	1.27%	0.00%	3.70%	D09JE02	30.74%	25.00%	51.79%
	A09JE03	57.42%	55.26%	49.73%	D09JS01	2.61%	0.36%	0.00%
	A09JE04	1.62%	1.08%	0.67%	D09JW01	47.41%	61.59%	28.57%
	A09JN01	0.69%	0.54%	0.00%	D09PW01	2.86%	0.00%	0.00%
	A09JS01	1.39%	0.54%	0.34%				
	A09JW01	32.76%	40.43%	37.64%				
	A09PE03	3.56%	0.00%	0.00%				
	A09PW01	0.00%	0.00%	0.20%				
	Total	**100.00%**	**100.00%**	**100.00%**	**Total**	**100.00%**	**100.00%**	**100.00%**
27	A27JE01	28.86%	30.59%	27.74%	D27JE01	0.02%	0.34%	25.74%
	A27JE02	25.93%	25.07%	28.08%	D27JE02	2.39%	1.20%	3.95%
	A27JE03	0.54%	0.14%	0.12%	D27JE03	47.78%	38.08%	29.24%
	A27JN01	0.13%	0.02%	0.01%	D27JE04	0.11%	0.08%	0.92%
	A27JN02	0.00%	0.07%	0.01%	D27JE05	0.00%	0.01%	0.26%
	A27JN03	0.06%	0.01%	0.01%	D27JN01	0.08%	0.06%	0.09%
	A27JS01	1.58%	0.31%	0.03%	D27JS01	1.92%	0.08%	0.05%
	A27JW01	39.32%	43.03%	43.41%	D27JW01	44.06%	56.88%	38.02%
	A27JW02	0.01%	0.10%	0.28%	D27JW02	0.23%	0.10%	1.39%
	A27JW03	0.00%	0.01%	0.13%	D27JW03	0.14%	0.00%	0.10%
	A27PE01	0.34%	0.05%	0.04%	D27JW04	0.40%	0.67%	0.17%
	A27PE02	0.65%	0.12%	0.05%	D27PE01	0.05%	0.00%	0.00%
	A27PE03	0.01%	0.01%	0.00%	D27PE02	0.04%	0.00%	0.00%
	A27PN01	0.21%	0.03%	0.00%	D27PE03	0.36%	0.07%	0.01%
	A27PN02	0.05%	0.02%	0.00%	D27PE04	0.14%	0.00%	0.00%
	A27PN03	0.29%	0.02%	0.00%	D27PE05	0.04%	0.03%	0.00%
	A27PS01	0.02%	0.00%	0.00%	D27PE06	0.09%	0.00%	0.00%
	A27PW01	1.27%	0.22%	0.11%	D27PE07	0.05%	0.03%	0.00%
	A27PW02	0.73%	0.16%	0.00%	D27PN01	0.17%	0.10%	0.01%
					D27PS01	0.03%	0.00%	0.00%
					D27PW02	1.63%	2.03%	0.05%
					D27PW03	0.26%	0.23%	0.01%
	Total	**100.00%**	**100.00%**	**100.00%**	**Total**	**100.00%**	**100.00%**	**100.00%**
H1	AH1HL01	45.16%	81.82%	0.00%	DH1HL01	44.58%	0.00%	0.00%
	AH1HW01	37.90%	13.64%	0.00%	DH1HN01	25.30%	60.00%	0.00%
	AH1HW02	16.94%	4.55%	100.00%	DH1HW01	8.43%	40.00%	0.00%
					DH1HW02	21.69%	0.00%	0.00%
	Total	**100.00%**	**100.00%**	**100.00%**	**Total**	**100.00%**	**100.00%**	**0.00%**

Table 11. Flight Track Utilization for 2026

	Arrivals				Departures			
Runway	**Track Bundle**	**Day**	**Evening**	**Night**	**Track Bundle**	**Day**	**Evening**	**Night**
9	A09JE01	1.29%	2.16%	7.61%	D09JE01	16.53%	12.77%	19.28%
	A09JE02	1.29%	0.00%	3.64%	D09JE02	31.01%	24.48%	50.83%
	A09JE03	58.27%	55.26%	48.96%	D09JS01	2.63%	0.35%	0.00%
	A09JE04	1.64%	1.08%	0.66%	D09JW01	47.84%	60.31%	28.04%
	A09JN01	0.70%	0.54%	0.00%	D09PW01	1.98%	2.08%	1.85%
	A09JS01	1.41%	0.54%	0.33%				
	A09JW01	33.25%	40.43%	37.05%				
	A09PE03	2.14%	0.00%	0.00%				
	A09PW01	0.00%	0.00%	1.75%				
	Total	**100.00%**	**100.00%**	**100.00%**	**Total**	**100.00%**	**100.00%**	**100.00%**
27	A27JE01	29.29%	30.79%	27.30%	D27JE01	0.02%	0.34%	25.28%
	A27JE02	26.31%	25.23%	27.64%	D27JE02	2.41%	1.20%	3.88%
	A27JE03	0.55%	0.14%	0.12%	D27JE03	48.21%	38.24%	28.72%
	A27JN01	0.13%	0.02%	0.01%	D27JE04	0.11%	0.08%	0.90%
	A27JN02	0.00%	0.08%	0.01%	D27JE05	0.00%	0.01%	0.25%
	A27JN03	0.06%	0.01%	0.01%	D27JN01	0.08%	0.06%	0.08%
	A27JS01	1.60%	0.32%	0.03%	D27JS01	1.94%	0.08%	0.05%
	A27JW01	39.90%	43.31%	42.73%	D27JW01	44.46%	57.12%	37.34%
	A27JW02	0.02%	0.10%	0.27%	D27JW02	0.23%	0.10%	1.36%
	A27JW03	0.00%	0.01%	0.13%	D27JW03	0.14%	0.00%	0.10%
	A27PE01	0.20%	0.00%	0.32%	D27JW04	0.41%	0.68%	0.17%
	A27PE02	0.39%	0.00%	0.48%	D27PE01	0.03%	0.00%	0.05%
	A27PE03	0.005%	0.00%	0.00%	D27PE02	0.03%	0.00%	0.00%
	A27PN01	0.13%	0.00%	0.00%	D27PE03	0.25%	0.06%	0.14%
	A27PN02	0.03%	0.00%	0.00%	D27PE04	0.09%	0.00%	0.00%
	A27PN03	0.17%	0.00%	0.00%	D27PE05	0.03%	0.03%	0.00%
	A27PS01	0.01%	0.00%	0.00%	D27PE06	0.06%	0.00%	0.00%
	A27PW01	0.76%	0.00%	0.96%	D27PE07	0.04%	0.03%	0.00%
	A27PW02	0.44%	0.00%	0.00%	D27PN01	0.12%	0.08%	0.19%
					D27PS01	0.02%	0.00%	0.00%
					D27PW02	1.13%	1.69%	1.25%
					D27PW03	0.18%	0.19%	0.23%
	Total	**100.00%**	**100.00%**	**100.00%**	**Total**	**100.00%**	**100.00%**	**100.00%**
H1	AH1HL01	45.16%	0.00%	0.00%	DH1HL01	44.58%	0.00%	0.00%
	AH1HW01	37.90%	0.00%	0.00%	DH1HN01	25.30%	0.00%	0.00%
	AH1HW02	16.94%	0.00%	0.00%	DH1HW01	8.43%	0.00%	0.00%
					DH1HW02	21.69%	0.00%	0.00%
	Total	**100.00%**	**0.00%**	**0.00%**	**Total**	**100.00%**	**0.00%**	**0.00%**

Table 12. Flight Track Utilization for 2031

Runway	Arrivals Track ID	Arrivals Percent Use	Departures Track ID	Departures Percent Use
09	A09JE01	2.74%	D09JE01	15.53%
	A09JE02	1.43%	D09JE02	30.10%
	A09JE03	55.35%	D09JS01	1.84%
	A09JE04	1.30%	D09JW01	49.81%
	A09JN01	0.52%	D09PE02	1.26%
	A09JS01	0.98%	D09PW01	1.46%
	A09JW01	35.53%		
	A09PE03	1.69%		
	A09PW01	0.46%		
	Total	**100.00%**	**Total**	**100.00%**
27	A27JE01	29.05%	D27JE01	3.08%
	A27JE02	26.09%	D27JE02	2.41%
	A27JE03	0.42%	D27JE03	44.22%
	A27JN01	0.09%	D27JE04	0.20%
	A27JN02	0.02%	D27JE05	0.03%
	A27JN03	0.04%	D27JH275	0.41%
	A27JS01	1.16%	D27JN01	0.08%
	A27JW01	40.55%	D27JS01	1.45%
	A27JW02	0.06%	D27JW01	44.97%
	A27JW03	0.02%	D27JW02	0.35%
	A27PE01	0.14%	D27JW03	0.12%
	A27PE02	1.33%	D27PE01	0.05%
	A27PE03	0.01%	D27PE02	0.04%
	A27PN01	0.04%	D27PE03	0.26%
	A27PN02	0.01%	D27PE04	0.04%
	A27PN03	0.04%	D27PE05	0.12%
	A27PS01	0.01%	D27PE06	0.63%
	A27PW01	0.81%	D27PE07	0.19%
	A27PW02	0.11%	D27PN01	0.27%
			D27PS01	0.01%
			D27PW01	0.02%
			D27PW02	0.40%
			D27PW03	0.66%
	Total	**100.00%**	**Total**	**100.00%**
H1	AH1HL01	50.34%	DH1HN01	47.06%
	AH1HW01	34.01%	DH1HW01	17.65%
	AH1HW02	15.65%	DH1HW02	35.29%
	Total	**100.00%**	**Total**	**100.00%**

7. METEOROLOGICAL CONDITIONS

AEDT has several settings that affect aircraft performance profiles and sound propagation based on meteorological data. Meteorological settings include average annual temperature, barometric pressure, and relative humidity at the airport. AEDT holds the following values for annual average weather conditions at SAN:

- Temperature: 64° F
- Pressure: 1014.349976 millibars
- Sea-level Pressure: 1015.75 millibars
- Relative Humidity 73.1%
- Dew Point: 53.7200001° F
- Wind Speed: 5.57 Knots

8. TERRAIN DATA

Terrain data describes the elevation of the ground surrounding the airport and on airport property. If the AEDT user selects the use of terrain data, AEDT uses terrain data to adjust the ground level under the flight paths. The terrain data does not affect the aircraft's performance or noise levels but does affect the vertical distance between the aircraft and a "receiver" on the ground. This, in turn, affects noise propagation assumptions about how noise propagates over ground. The terrain data were obtained from the United States Geological Survey (USGS) National Map Viewer and will be used with the terrain feature of the AEDT.

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F3 – Evaluation of Construction Noise Technical Memorandum

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HMMH
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TECHNICAL MEMORANDUM

To:	Anthony Skidmore CDM Smith 46 Discovery, Suite 250 Irvine, CA 92618
Copies:	Justin Cook
From:	Christopher Bajdek, Dillon Tannler, Vincent Ma
Date:	May 19, 2021
Subject:	Evaluation of Construction Noise for the SAN Airfield Improvements and Terminal 1 Replacement Project EA
Reference:	HMMH Project Number 309290.000.003

This memorandum provides an evaluation of construction noise associated with implementation of the San Diego International Airport (SAN) Airfield Improvements and Terminal 1 Replacement Project.

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1. Construction Noise

The Proposed Project will involve both construction on new facilities and demolition of existing facilities (See Appendix A of the Environmental Assessment (EA) for project components and phasing). The noise impact from the construction and demolition activities is included in the noise analysis in Section 4.12 of the EA.

1.1 General Approach and Methodology

The construction noise assessment is based on Federal Aviation Administration (FAA) Order 1050.1F and guidance provided in the Caltrans Traffic Noise Analysis Protocol (TNAP). Consistent with the requirements of FAA Order 1050.1F, the TNAP requires a reasonable method for evaluating construction noise, such as the Federal Highway Administration's (FHWA's) Roadway Construction Noise Model (RCNM). The RCNM describes methodologies of how to assess construction noise.

Construction noise differs from aircraft noise due to differences in the spectral and temporal characteristics of the noise. The degree of noise impact during construction will be a function of the types of equipment used for each activity, the numbers for each type of equipment per activity, and the distances between the construction equipment and noise-sensitive land use. A quantitative assessment of construction noise requires this detailed information, but also includes:

- Noise emission levels for construction equipment types;
- The phasing and duration of specific activities; and
- A detailed schedule that identifies the days and hours at which the activities would occur.

With some relatively minor exceptions (i.e., demolition of a parking lot and subsequent construction of an administrative building on the west side of SAN), most of the construction activity for the Proposed Project would occur to the south and east of Terminal 1. The closest residential land use to these activities is located approximately 2,800 feet eastward of the easternmost activity at residences on West Laurel Street.

Table 1 provides the source noise emission levels for construction equipment that is contained within the RCNM. The noise levels in Table 1 are based on the noise calculations and measurement data compiled for the Central Artery/Tunnel (CA/T) Project in Boston, Massachusetts. One component of the CA/T Project was the development of Construction Noise Control Specification 721.560. Table 1 provides two values of the A-weighted maximum sound pressure levels (L_{max}) at a reference distance of 50 feet – one based on the Specification 721.560 and one based on a sample of measurement data.[1]

At this stage of project development, detailed information about the specific types and numbers of equipment will not be known until later in the project development process.

A generalized model for construction noise was used to estimate average noise levels at various distances from a piece of equipment.[2] The model takes into account the effects of spherical spreading from a point source and atmospheric absorption,[3] and ignores the excess attenuation provided by intervening structures and buildings, and is given by the following equation:

$$L_{eq} \text{ (at distance "D")} = L_{max\ at\ 50\ feet} - 20 \log (D / 50) - 10 \log (UF) - \alpha (D / 1000)$$

Where,

[1] U.S. Department of Transportation, Federal Highway Administration, *FHWA Roadway Construction Noise Model Version 1.0 User's Guide,* DOT-VNTSC-FHWA-05-01/FHWA-HEP-05-054, January 2006. Available: https://www.fhwa.dot.gov/environment/noise/construction_noise/rcnm/.

[2] California Department of Transportation, *Technical Noise Supplement to the Caltrans Traffic Noise Analysis Protocol,* September 2013. Available: http://www.dot.ca.gov/env/noise/docs/tens-sep2013.pdf.

[3] Based on International Organization for Standardization. *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation,* ISO 9613-2:1996(E).

$L_{max\ at\ 50\ feet}$ is the maximum of the two values for a particular piece of equipment in Table 1;
D is the distance of interest as measured in feet;
UF is the acoustical usage factor from Table 1; and
α is the atmospheric absorption in decibels per 1,000 feet.[4]

1.2 Evaluation of Construction Noise

Table 2 provides calculated construction noise levels expressed in terms of the A-weighted L_{eq} for each piece of equipment using the generalized model for construction noise described in Section 1.1. Levels of construction noise in a community are primarily a function of the number and types of equipment used, and the distances between the construction equipment and noise-sensitive land use. Although detailed information about the specific types and numbers of equipment are unknown at this stage of project development, it is possible to draw some broad conclusions about the likelihood of potential construction noise impact in the community.

Based on a conservative assumption that all of the pieces of equipment in Table 1 were operating on the same site at the same time, the total L_{eq} at a distance of 50 feet from the activity would be 96.9 dBA (A-Weighted Sound Pressure Level). Based on a point-source noise (i.e., construction equipment noise) fall-off rate of 6 decibel (dB) per doubling of distance, construction noise would decrease to 86 dB (i.e., the threshold of significance) at a distance of 175 feet from the edge of construction activity. The majority of the Proposed Project site is surrounded by airport uses, such as on-airport roads and parking facilities to the southwest, existing terminals to the west, aircraft taxiways and the runway to the north and northeast, and surface parking to the east. It is only at the southeast portion of the Project site, where the proposed on-airport road would begin off of North Harbor Drive near Laurel Street, are there non-airport uses located nearby, such as those two streets and San Diego Bay farther south. There are no noise-sensitive uses located within 175 feet of construction activity areas associated with the Proposed Project. Additionally, it should be noted that little, if any, construction activity is anticipated to occur from 9 p.m. to 6 a.m., as related to the threshold of significance for construction noise, and equipping internal combustion engines with appropriate mufflers, as provided by the manufacturer, is a standard requirement of construction contracts for projects at SAN.

[4] Based on ISO 9613, predicted equipment noise levels at distances of 500 feet and beyond include atmospheric absorption at a rate of 1.5 dB per 1,000 feet for impact devices (re: 1,000 Hertz [Hz]) and 0.9 dB per 1,000 feet for non-impact devices (re: 500 Hz). These attenuation rates are based on a temperature of 68°F and 70% relative humidity.

Table 1. Source Noise Emission Levels for Construction Equipment

Equipment Description	Impact Device?	Acoustical Use Factor (%)	Spec 721.560 Lmax @ 50 ft (dBA, slow)	Measured Lmax @ 50 ft (dBA, slow)	No. of Data Samples
All Other Equipment > 5 HP	No	50	85	-- N/A --	0
Auger Drill Rig	No	20	85	84	36
Backhoe	No	40	80	78	372
Bar Bender	No	20	80	-- N/A --	0
Blasting	Yes	-- N/A --	94	-- N/A --	0
Boring Jack Power Unit	No	50	80	83	1
Chain Saw	No	20	85	84	46
Clam Shovel (dropping)	Yes	20	93	87	4
Compactor (ground)	No	20	80	83	57
Compressor (air)	No	40	80	78	18
Concrete Batch Plant	No	15	83	-- N/A --	0
Concrete Mixer Truck	No	40	85	79	40
Concrete Pump Truck	No	20	82	81	30
Concrete Saw	No	20	90	90	55
Crane	No	16	85	81	405
Dozer	No	40	85	82	55
Drill Rig Truck	No	20	84	79	22
Drum Mixer	No	50	80	80	1
Dump Truck	No	40	84	76	31
Excavator	No	40	85	81	170
Flat Bed Truck	No	40	84	74	4
Front End Loader	No	40	80	79	96
Generator	No	50	82	81	19
Generator (<25KVA, VMS signs)	No	50	70	73	74
Gradall	No	40	85	83	70
Grader	No	40	85	-- N/A --	0
Grapple (on backhoe)	No	40	85	87	1
Horizontal Boring Hydr. Jack	No	25	80	82	6
Hydra Break Ram	Yes	10	90	-- N/A --	0
Impact Pile Driver	Yes	20	95	101	11
Jackhammer	Yes	20	85	89	133
Man Lift	No	20	85	75	23
Mounted Impact Hammer (hoe ram)	Yes	20	90	90	212
Pavement Scarafier	No	20	85	90	2
Paver	No	50	85	77	9
Pickup Truck	No	40	55	75	1
Pneumatic Tools	No	50	85	85	90
Pumps	No	50	77	81	17
Refrigerator Unit	No	100	82	73	3
Rivit Buster/chipping gun	Yes	20	85	79	19
Rock Drill	No	20	85	81	3
Roller	No	20	85	80	16
Sand Blasting (Single Nozzle)	No	20	85	96	9
Scraper	No	40	85	84	12
Shears (on backhoe)	No	40	85	96	5
Slurry Plant	No	100	78	78	1
Slurry Trenching Machine	No	50	82	80	75
Soil Mix Drill Rig	No	50	80	-- N/A --	0
Tractor	No	40	84	-- N/A --	0
Vacuum Excavator (Vac-truck)	No	40	85	85	149
Vacuum Street Sweeper	No	10	80	82	19
Ventilation Fan	No	100	85	79	13
Vibrating Hopper	No	50	85	87	1
Vibratory Concrete Mixer	No	20	80	80	1
Vibratory Pile Driver	No	20	95	101	44
Warning Horn	No	5	85	83	12
Welder / Torch	No	40	73	74	5

Source: Based on Table 1 in *FHWA Roadway Construction Noise Model, Version 1.0 User's Guide.*

Table 2. Average A-weighted Noise Levels (L_{eq} in dBA) for Construction Equipment at Various Distances*

Equipment Description	50 ft	500 ft***	1,000 ft***	1,500 ft***	2,000 ft***	2,500 ft***	3,000 ft***	3,500 ft***	4,000 ft***	4,500 ft***
Other Equipment > 5 hp	68.0	47.6	41.1	37.1	34.2	31.8	29.7	28.0	26.3	24.9
Auger Drill Rig	72.0	51.5	45.1	41.1	38.1	35.8	33.7	31.9	30.3	28.9
Backhoe	64.0	43.5	37.1	33.1	30.1	27.8	25.7	23.9	22.3	20.8
Bar Bender	67.0	46.5	40.1	36.1	33.1	30.8	28.7	26.9	25.3	23.9
Blasting**	94.0	73.3	66.5	62.2	59.0	56.3	53.9	51.8	49.9	48.2
Boring Jack Power Unit	66.0	45.6	39.1	35.1	32.2	29.8	27.7	26.0	24.3	22.9
Chain Saw	72.0	51.5	45.1	41.1	38.1	35.8	33.7	31.9	30.3	28.9
Clam Shovel (dropping)	80.0	59.2	52.5	48.2	44.9	42.3	39.9	37.8	35.9	34.2
Compactor (ground)	70.0	49.5	43.1	39.1	36.1	33.8	31.7	29.9	28.3	26.9
Compressor (air)	64.0	43.5	37.1	33.1	30.1	27.8	25.7	23.9	22.3	20.8
Concrete Batch Plant	71.2	50.8	44.3	40.3	37.4	35.0	33.0	31.2	29.6	28.1
Concrete Mixer Truck	69.0	48.5	42.1	38.1	35.1	32.8	30.7	28.9	27.3	25.8
Concrete Pump Truck	69.0	48.5	42.1	38.1	35.1	32.8	30.7	28.9	27.3	25.9
Concrete Saw	77.0	56.5	50.1	46.1	43.1	40.8	38.7	36.9	35.3	33.9
Crane	73.0	52.5	46.0	42.1	39.1	36.7	34.7	32.9	31.3	29.8
Dozer	69.0	48.5	42.1	38.1	35.1	32.8	30.7	28.9	27.3	25.8
Drill Rig Truck	71.0	50.5	44.1	40.1	37.1	34.8	32.7	30.9	29.3	27.9
Drum Mixer	63.0	42.6	36.1	32.1	29.2	26.8	24.7	23.0	21.3	19.9
Dump Truck	68.0	47.5	41.1	37.1	34.1	31.8	29.7	27.9	26.3	24.8
Excavator	69.0	48.5	42.1	38.1	35.1	32.8	30.7	28.9	27.3	25.8
Flat Bed Truck	68.0	47.5	41.1	37.1	34.1	31.8	29.7	27.9	26.3	24.8
Front End Loader	64.0	43.5	37.1	33.1	30.1	27.8	25.7	23.9	22.3	20.8
Generator	65.0	44.6	38.1	34.1	31.2	28.8	26.7	25.0	23.3	21.9
Generator (<25KVA)	56.0	35.6	29.1	25.1	22.2	19.8	17.7	16.0	14.3	12.9
Gradall	69.0	48.5	42.1	38.1	35.1	32.8	30.7	28.9	27.3	25.8
Grader	69.0	48.5	42.1	38.1	35.1	32.8	30.7	28.9	27.3	25.8
Grapple (on backhoe)	71.0	50.5	44.1	40.1	37.1	34.8	32.7	30.9	29.3	27.8
Horizontal Boring	68.0	47.6	41.1	37.1	34.2	31.8	29.8	28.0	26.4	24.9
Hydra Break Ram	80.0	59.3	52.5	48.2	45.0	42.3	39.9	37.8	35.9	34.2
Impact Pile Driver	88.0	67.2	60.5	56.2	52.9	50.3	47.9	45.8	43.9	42.2
Jackhammer	76.0	55.2	48.5	44.2	40.9	38.3	35.9	33.8	31.9	30.2
Man Lift	72.0	51.5	45.1	41.1	38.1	35.8	33.7	31.9	30.3	28.9
Mounted Impact Hammer	77.0	56.2	49.5	45.2	41.9	39.3	36.9	34.8	32.9	31.2
Pavement Scarafier	77.0	56.5	50.1	46.1	43.1	40.8	38.7	36.9	35.3	33.9
Paver	68.0	47.6	41.1	37.1	34.2	31.8	29.7	28.0	26.3	24.9
Pickup Truck	59.0	38.5	32.1	28.1	25.1	22.8	20.7	18.9	17.3	15.8
Pneumatic Tools	68.0	47.6	41.1	37.1	34.2	31.8	29.7	28.0	26.3	24.9
Pumps	64.0	43.6	37.1	33.1	30.2	27.8	25.7	24.0	22.3	20.9
Refrigerator Unit	62.0	41.6	35.1	31.1	28.2	25.8	23.7	21.9	20.3	18.9
Rivit Buster/chipping gun	72.0	51.2	44.5	40.2	36.9	34.3	31.9	29.8	27.9	26.2
Rock Drill	72.0	51.5	45.1	41.1	38.1	35.8	33.7	31.9	30.3	28.9
Roller	72.0	51.5	45.1	41.1	38.1	35.8	33.7	31.9	30.3	28.9
Sand Blasting (one nozzle)	83.0	62.5	56.1	52.1	49.1	46.8	44.7	42.9	41.3	39.9
Scraper	69.0	48.5	42.1	38.1	35.1	32.8	30.7	28.9	27.3	25.8
Shears (on backhoe)	80.0	59.5	53.1	49.1	46.1	43.8	41.7	39.9	38.3	36.8
Slurry Plant	58.0	37.6	31.1	27.1	24.2	21.8	19.7	17.9	16.3	14.9
Slurry Trenching Machine	65.0	44.6	38.1	34.1	31.2	28.8	26.7	25.0	23.3	21.9
Soil Mix Drill Rig	63.0	42.6	36.1	32.1	29.2	26.8	24.7	23.0	21.3	19.9
Tractor	68.0	47.5	41.1	37.1	34.1	31.8	29.7	27.9	26.3	24.8
Vacuum Excavator	69.0	48.5	42.1	38.1	35.1	32.8	30.7	28.9	27.3	25.8
Vacuum Street Sweeper	72.0	51.6	45.1	41.1	38.2	35.8	33.7	31.9	30.3	28.9
Ventilation Fan	65.0	44.6	38.1	34.1	31.2	28.8	26.7	24.9	23.3	21.9
Vibrating Hopper	70.0	49.6	43.1	39.1	36.2	33.8	31.7	30.0	28.3	26.9
Vibratory Concrete Mixer	67.0	46.5	40.1	36.1	33.1	30.8	28.7	26.9	25.3	23.9
Vibratory Pile Driver	88.0	67.5	61.1	57.1	54.1	51.8	49.7	47.9	46.3	44.9
Warning Horn	78.0	57.6	51.1	47.1	44.2	41.8	39.7	38.0	36.3	34.9
Welder / Torch	58.0	37.5	31.1	27.1	24.1	21.8	19.7	17.9	16.3	14.8

Source: HMMH, 2018.

Notes:

* The decibel levels presented in this table are intended only to represent how various equipment sound levels fall off over distance. They are not intended to serve as an impacts analysis specific to noise-receptors near the project site.

** An acoustical usage factor is not available for blasting, so the L_{max} is provided in this table.

*** Predicted equipment noise levels at distances of 500 feet and beyond include atmospheric absorption at a rate of 1.5 dB per 1,000 feet for impact devices (re: 1,000 Hz) and 0.9 dB per 1,000 feet for non-impact devices (re: 500 Hz).