B. Appendix B, Aircraft Noise Technical Report

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Aircraft Noise Technical Report
Beverly Regional Airport
2021 Airport Master Plan

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This technical report describes the noise exposure and methodology used to develop the existing and future aircraft noise contours for the Beverly Regional Airport (BVY), located in Beverly, Massachusetts.

1.1. Noise Fundamentals

1.1.1. General Characteristics of Sound

Sound, traveling in the form of waves from a source, exerts a sound pressure level (referred to as sound level), which is measured in decibels (dB). On this scale, zero dB corresponds roughly to the threshold of human hearing and 140 dB corresponds to the threshold of pain. Pressure waves traveling through air exert a force registered by the human ear as sound. Noise is commonly defined as unwanted sound.

Sound pressure fluctuations can be measured in units of hertz (Hz), which correspond to the frequency of a particular sound. Typically, sound does not consist of a single frequency, but rather a broad band of frequencies varying in levels of magnitude (sound power). The typical human ear is not equally sensitive to all frequencies. Therefore, when assessing potential noise impacts on humans, sound is measured using an electronic filter that de-emphasizes the frequencies below 1,000 Hz and above 5,000 Hz in a manner corresponding to the human ear's decreased sensitivity to extremely low and extremely high frequencies. This method of frequency weighting is referred to as A-weighting and is expressed in units of A-weighted decibels (dBA). A-weighting follows an international standard methodology of frequency weighting and is typically applied to community noise measurements.

Outdoor sound levels decrease as a function of distance from the source because of wave divergence, atmospheric absorption, and ground attenuation. If sound is radiated from a source in an undisturbed manner, the sound travels as spherical waves. As the sound wave travels away from the source, the sound energy is distributed over a greater area, dispersing the sound power of the wave. Spherical spreading of the sound wave reduces the noise level, for most sound sources, at a rate of 6 dB per doubling of the distance.

Atmospheric absorption also influences the sound levels that are received by the observer. The greater the distance sound travels, the greater the influence of atmospheric effects. Atmospheric absorption becomes important at distances of greater than 1,000 feet. The degree of absorption is a function of the sound frequency, as well as the humidity and temperature of the air. For example, atmospheric absorption is lowest at high humidity and higher temperatures. Absorption effects in the atmosphere vary with frequency. The higher frequencies are more readily absorbed than the lower frequencies. Over large distances the lower frequencies become the dominant sound.

1.1.2. Aircraft Noise Metrics

The description, analysis, and reporting of aircraft noise levels is made difficult by the complexity of human response to sound and the myriad of sound-rating scales and metrics that have been developed for describing acoustic effects. Various rating scales have been devised to approximate the human response to the "loudness" or "noisiness" of a sound. Noise metrics have been developed to account for additional parameters, such as duration and cumulative effect of multiple events.

Noise metrics can be categorized as single-event metrics and cumulative metrics. Single-event metrics describe the noise from individual events, such as an aircraft flyover. Cumulative metrics describe the noise in terms of the total noise exposure over a period of time. The primary noise descriptors/metrics that are used in this study are described below.

A-Weighted Sound Pressure Level (dBA) -the decibel 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). The relative perceived loudness of a sound doubles for each increase of 10 dBA. Generally, single-event sound levels with differences of 2 dBA or less are not perceived to be noticeably different by most listeners. Common sound levels expressed in dBA are included in **Table 1-1**.

Table 1-1: 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	90	8	1,000
Busy street	80	4	100
Ordinary conversation, 3 feet away	60	1	1
Quiet automobiles at low speed	50	1/2	.1
Average office	40	1/4	.01
City residence	30	1/8	.001
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, 1972.

Maximum A-Weighted Sound Level (Lmax) **-** is the maximum, or peak, sound level during a noise event. The metric only accounts for the highest A-weighted sound level measured during a noise event, not for the duration of the event. For example, as an aircraft approaches, the sound of the aircraft begins to rise above ambient levels. The closer the aircraft gets, the louder the sound until the aircraft is at its closest point. As the aircraft passes, the sound level decreases until the sound returns to ambient levels. This is graphically presented on **Figure 1-1**.

Equivalent Noise Level (Leq) – is the sound level corresponding to a steady state, A-weighted sound level containing the same total energy as a time-varying signal over a given sample period. Leq is the "energy" average noise level during the time period of the sample. It is based on the observation that the potential for a noise to impact people is dependent on the total acoustical energy content of the noise. It is the energy sum of all the sound that occurs during that time period. This is graphically illustrated on **Figure 1-2**. Leq can be measured for any time period, but is typically measured for 15 minutes, 1 hour, or 24 hours.

Figure 1-1: Lmax Sound Level

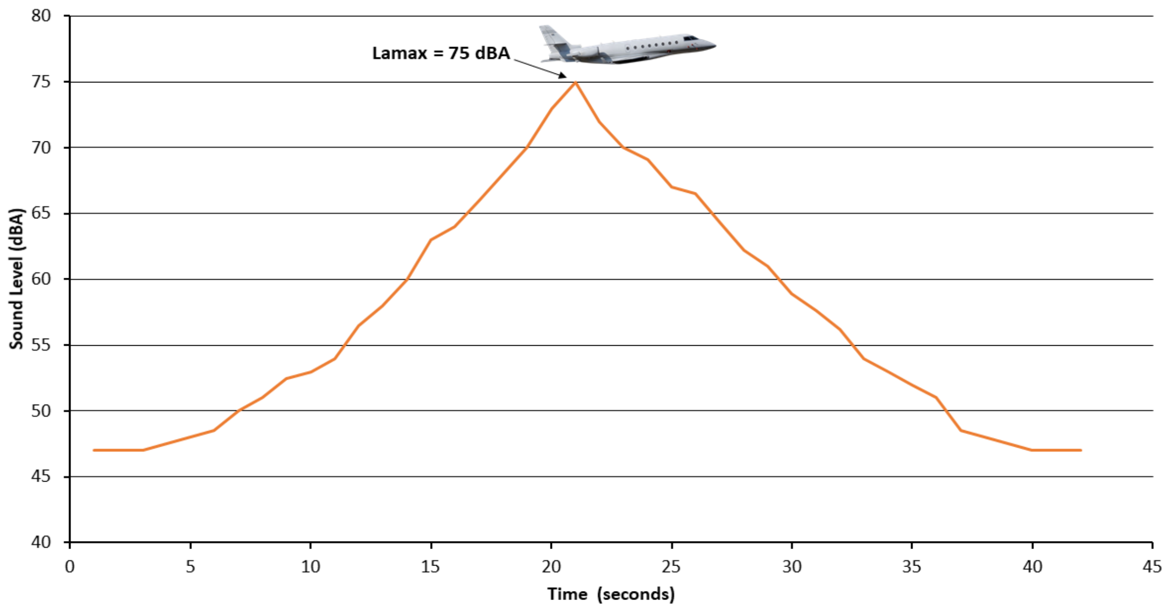
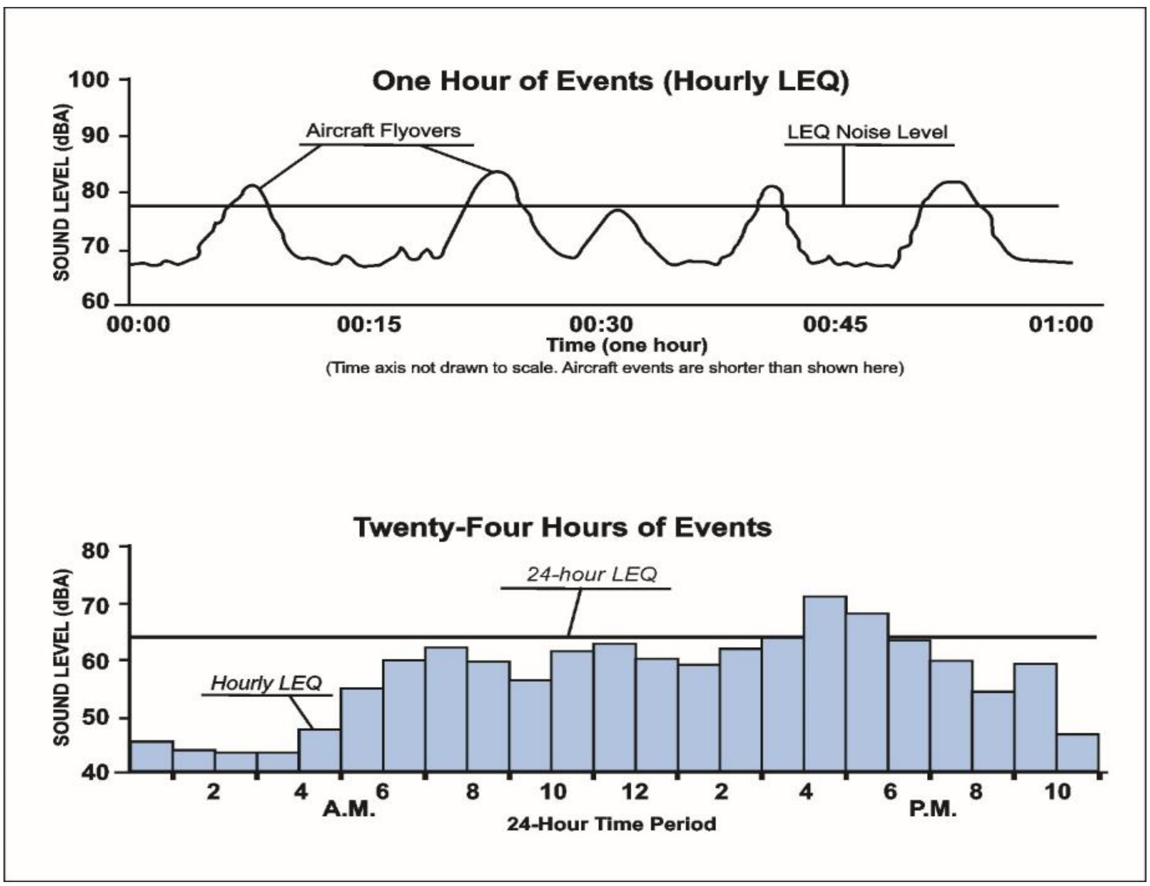


Figure 1-2: Equivalent Noise Level

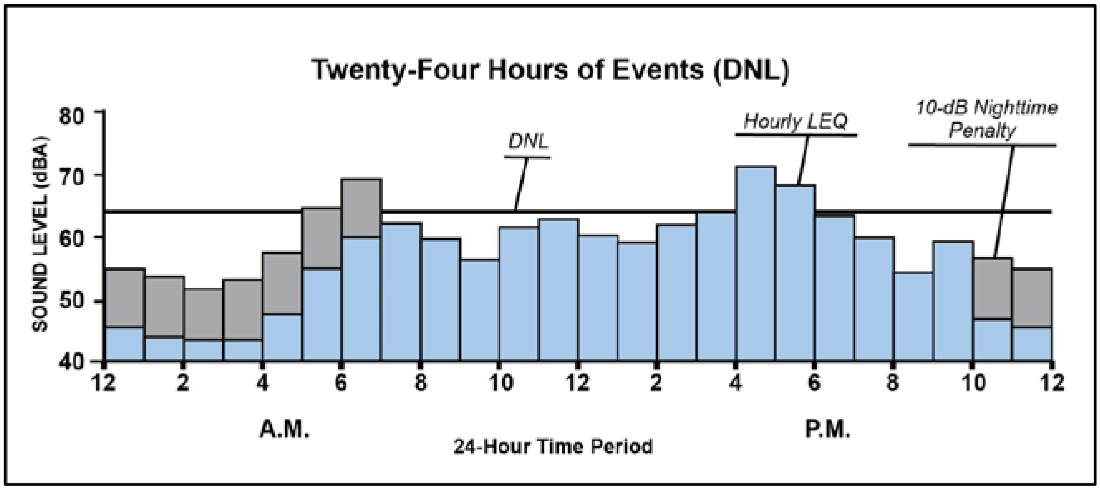


Source: CMT, Inc.

1.1.3. Day-Night Average Sound Level (DNL)

Day-Night Average Sound Level (DNL) is expressed in dBA and represents the sound level over a 24-hour period. DNL includes the cumulative effects of several sound events rather than a single event. It also accounts for increased sensitivity to noise during relaxation and sleeping hours. In the calculation of DNL, for each hour during the nighttime period (10:00 p.m. to 6:59 a.m.), the sound levels are increased by a 10 decibel-weighting penalty (equivalent to a 10-fold increase in aircraft operations) before the 24-hour value is computed. The weighting penalty accounts for the more intrusive nature of noise during the nighttime hours. The weighting penalty is illustrated on **Figure 1-2**.

Figure 1-2: Day-Night Average Sound Level



Source: CMT, Inc.

DNL is expressed as an average noise level based on annual aircraft operations for a calendar year. To calculate the DNL at a specific location, the SELs at that location associated with each individual aircraft operation (landing or takeoff) are determined. Using the SEL for each noise event and applying the 10-dB penalty for nighttime operations as appropriate, a partial DNL is then calculated for each aircraft operation. The partial DNLs for each aircraft operation are added logarithmically to determine the total DNL.

DNL is used to describe existing and predicted noise exposure in communities in airport environs based on the average daily operations over the year and the average annual operational conditions at the 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 the 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 14 CFR Part 150 and for federal environmental reviews of airport improvement projects.

The Federal Aviation Administration's (FAA) guidelines regarding the compatibility of land uses within various DNL contour intervals are specified in *Appendix A of 14 CFR Part 150*. As shown in **Table 1-2**, the FAA guidelines show that the all the land uses listed in the table are normally compatible with aircraft noise exposure below the 65 DNL contour. When evaluating noise exposure and land use compatibility, attention is therefore focused on uses within the 65 DNL contour.

Table 1-2: FAA Land Use Compatibility With Yearly Day-Night Average Sound Levels

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

Table Notes: SLUCM=Standard Land Use Coding Manual. Y (Yes) = Land Use and related structures compatible without restrictions. N (No) = Land Use and related structures are not compatible and should be prohibited. NLR = Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.

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

(1) Where the community determines that residential or school uses must be allowed, measures to achieve outdoor to indoor Noise Level Reduction (NLR) of at least 25 dB and 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide a NLR of 20 dB, thus, the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year-round. However, the use of NLR criteria will not eliminate outdoor noise problems. (2) Measures to achieve NLR 25 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low. (3) Measures to achieve NLR of 30 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low. (4) Measures to achieve NLR 35 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal level is low. (5) Land use compatible provided special sound reinforcement systems are installed. (6) Residential buildings require an NLR of 25. (7) Residential buildings require an NLR of 30. (8) Residential buildings not permitted.

Source: 14 CFR Part 150

2.1. Existing (2019) Noise Exposure

The methodology for assessing noise exposure included preparing DNL contours using the FAA's Aviation Environmental Design Tool (AEDT) Version 3c. This section includes the existing baseline 2019 DNL contours, the data used to develop the contours, and any noise sensitive land uses located within the limits of the 65 DNL.

2.1.1. AEDT Input Data

In the development of DNL contours, the AEDT uses both default and airport-specific factors. The default factors include engine noise levels, thrust settings, aircraft arrival and departure flight profiles and aircraft speed. The airport-specific factors include the number of aircraft operations, the types of aircraft, runway use, and the operational time (day/night). The following describe these airport-specific data.

2.1.2. Annual Operations and Aircraft Fleet Mix

The 2019 itinerant and local operations[1] were developed using data in the BVY 2021 Airport Master Plan. The 2019 annual aircraft operations by category are provided in **Table 2-1.** As shown, the 2019 annual operations totaled 66,949 (an average of approximately 183 operations per day).

Table 2-1: 2019 Annual Aircraft Operations

Year	Single Engine	Multi-Engine	Turboprop	Jet	Helicopter	Total
2019	51,552	4,017	3,347	4,686	3,347	66,949
Note: Single engine includes experimental and light-sport aircraft.						

Source: 2021 BVY Airport Master Plan, Chapter 3 – Forecast of Aviation Activity.

For the purposes of preparing DNL contours, operational data were segregated by aircraft type. The FAA's Traffic Flow Management System Count (TFMSC) data for calendar year 2019 was used to develop the 2019 AEDT aircraft fleet mix. TFMSC data provides information on traffic counts by airport and includes the aircraft types operating at that airport. The TFMSC data for BVY was reviewed and each aircraft type was assigned the corresponding AEDT aircraft type. The 2019 itinerant and local operations by aircraft type are provided in **Tables 2-2** and **2-3**.

[1] An itinerant operation is defined as an aircraft departure where the aircraft leaves the airport vicinity and lands at another airport, or an aircraft landing where the aircraft arrives from another airport. Local operations are aircraft touch-and-go training operations or remain within the local airspace. A touch-and-go operation occurs when an aircraft departs an airport, lands on a runway, and then departs again without stopping.

Table 2-2 - 2019 Annual Aircraft Operations and Fleet Mix - Itinerant

Category	AEDT ID	Aircraft Type(s)	AEDT ANP ID	Operatio
Single Engine Piston	1882	Piper Cherokee, Aero Commander, Cessna 152, Light Sport	GASEPF	9,953
	1261	Cessna 172/177	CNA172	2,426
	3819	Cirrus SR22/22T	COMSEP	2,177
	1898	Beech Bonanza, Piper Malibu Meridian, Turbo Mooney	GASEPV	1,119
Multi Engine Piston	1196	Baron 55/58, Piper Seneca, Cessna 401/402	BEC58P	4,017
Turboprop	2106	Pilatus PC-12, Cessna 208, Socata TBM7	CNA208	2,486
	1497	Raytheon King Air 90, Super King Air 300/350	DHC6	592
	1278	Cessna 441 Conquest, Socata TBM-850	CNA441	148
GA Jet	1237	Challenger 300/600/601	CL600	843
	3047	Cessna Citation Sovereign/ Latitude	CNA680	770
	2028	Learjet 31/35/45/55/60/75, Hawker 800	LEAR35	500
	3162	Cessna Citation Mustang, Phenom 100/300	CNA510	451
	1292	Citation II/Bravo, Beechjet 400	CNA55B	401
	4640	Cessna 560 Citation XLS	CNA560XL	363
	4034	Dassault Falcon 50/900, Falcon F7X	FAL900EX	301
	1291	Cessna Citation CJ1/CJ2/CJ3	CNA500	264
	1773	Bombardier BD-700 Global Express	BD-700-1A10	228
	1307	Cessna 750 Citation X, Dassault Falcon 2000	CNA750	183
	1298	Cessna 560 Citation V/Ultra	CNA560U	162
	1974	Gulfstream 150/200/280	IA1125	71
	1920	Gulfstream GIV/G400	GIV	60
	1923	Gulfstream GV / 500	GV	56
	2573	Bombardier BD-700 Global 5000	BD-700-1A11	33
Helicopter	3161	Robinson R-44	R44	837
	4091	Bell 206/407	B206L	2,510
Military	20	Sikorsky SH-60 Sea Hawk	S70	73
	3039	EDAS CASA CN-235	SF340	36
	1875	HU-25 Guardian (Dassault Falcon 20)	FAL20	12
			Total	**31,073**

Source: FAA Traffic Flow Management System Count (TFMSC) data - calendar year 2019; CMT, Inc.

Table 2-3 - 2019 Annual Aircraft Operations and Fleet Mix - Local

Category	AEDT ID	Aircraft Type(s)	AEDT ANP	Operations
Single Engine Piston	1882	Piper Cherokee, Aero Commander, Cessna 152, Light Sport	GASEPF	22,781
	1261	Cessna 172/177	CNA172	5,551
	3819	Cirrus SR22/22T	COMSEP	4,982
	1898	Beech Bonanza, Piper Malibu Meridian, Turbo Mooney	GASEPV	2,562
			Total	**35,876**

Source: FAA Traffic Flow Management System Count (TFMSC) data - calendar year 2019; CMT, Inc.

2.1.3. Time of Day

Aircraft operations modeled in AEDT are assigned as occurring during daytime (7:00 A.M. to 9:59 P.M.) or nighttime (10:00 P.M. to 6:59 A.M.). The calculation of DNL includes an additional weight of 10 decibels for those aircraft events occurring at night. Based on discussions with BVY Air Traffic Control Tower (ATCT) and airport personnel, for modeling purposes, it was estimated that in 2019 95% of the itinerant operations and 98% of the local operations occurred during the daytime hours.

2.1.4. Runway Layout and Use

BVY has two runways - Runway 16/34 which is 5,001 feet long and Runway 9/27 which is 4,755 feet long. Based on discussions with BVY ATCT personnel, for modeling purposes, it was estimated that operations were about equally split among the four runway ends. The 2019 AEDT modeled runway use included 25% of the aircraft operations occurring on each of the four runway ends (9, 27, 16, and 34).

2.1.5. Modeled Aircraft Flight Tracks

The AEDT uses airport-specific ground tracks and vertical flight profiles to compute three-dimensional flight paths for each modeled aircraft operation. The "default" AEDT vertical profiles, which consist of altitude, speed, and thrust settings, are compiled from data provided by aircraft manufacturers. Flight tracks utilized by itinerant (arrivals and departures) were modeled straight-in/straight-out in the immediate vicinity of the runway ends. The local touch-and-go operations were modeled following a standard left-traffic pattern.

2.1.6. 2019 DNL Contours

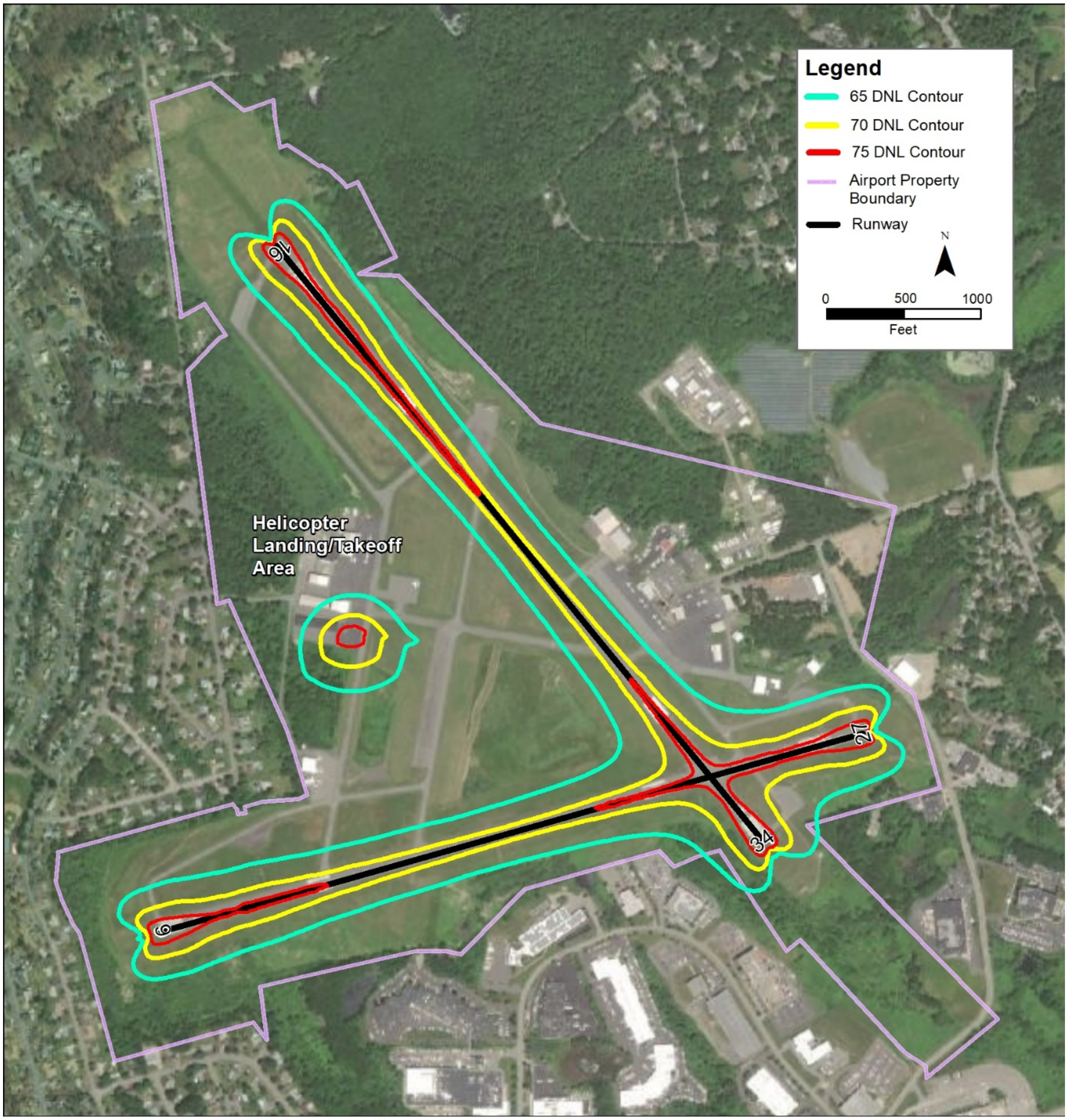
The 2019 65-75 DNL contours are provided on **Figure 2-1**. **Table 2-4** identifies the areas within the DNL contour ranges. As shown in the table, the total area within 65 DNL contour is approximately 119 acres and the 65 DNL contour primarily remains within the limits of the airport property boundary. Notably, there are no incompatible land uses or other noise sensitive sites within the 2019 65 DNL contour.

Table 2-4: 2019 DNL Contour Areas

DNL Range	Area (Acres)
65 to <70	74
70 to <75	34
75 and greater	11
Total	**119**

Source: CMT, Inc.

Figure 2-1: 2019 DNL Contour



Source: CMT, Inc.

3.1. Future Noise Exposure

This section includes the future 2029 and 2039 DNL contours, the data used to develop the contours, and any incompatible land uses or noise sensitive sites located within the limits of the 65 DNL.

3.1.1. 2029 and 2039 Noise Exposure

The future DNL contours were modeled using aircraft operations data included in the BVY Master Plan Chapter 3 – Forecast of Aviation Activity. According to the forecast, annual operations are expected to total 74,800 in 2029 (an average of approximately 205 operations per day) and 83,571 in 2039 (an average of approximately 229 per day). The 2029 and 2039 annual aircraft operations are provided in **Table 3-1.**

Table 3-1: 2029 and 2039 Annual Aircraft Operations

Year	Single Engine	Multi-Engine	Turboprop	Jet	Helicopter	Total
2029	55,352	4,488	3,740	6,732	4,488	74,800
2039	58,500	5,014	5,014	9,193	5,850	83,571
Note: Single engine includes experimental and light-sport aircraft.						

Source: 2021 BVY Airport Master Plan, Chapter 3 – Forecast of Aviation Activity.

The 2029 and 2039 aircraft fleet mix was determined by multiplying the percentages by aircraft type that occurred in 2019 by the operations forecast to occur in 2029 and 2039. The 2029 and 2039 itinerant and local operations by aircraft type are provided in **Tables 3-2** and **3-3** respectively.

Table 3-2 – 2029 and 2039 Annual Aircraft Operations and Fleet Mix - Itinerant

Category	AEDT ID	Aircraft Type(s)	AEDT ANP ID	2029	2039
Single Engine Piston	1882	Piper Cherokee, Aero Commander, Cessna 152, Light Sport	GASEPF	9,695	8,710
	1261	Cessna 172/177	CNA172	2,363	2,123
	3819	Cirrus SR22/22T	COMSEP	2,120	1,905
	1898	Beech Bonanza, Piper Malibu Meridian, Turbo Mooney	GASEPV	1,090	980
Multi Engine Piston	1196	Baron 55/58, Piper Seneca, Cessna 401/402	BEC58P	4,488	5,014
Turboprop	2106	Pilatus PC-12, Cessna 208, Socata TBM7	CNA208	2,778	3,747
	1497	Raytheon King Air 90, Super King Air 300/350	DHC6	662	893
	1278	Cessna 441 Conquest, Socata TBM-850	CNA441	165	223
GA Jet	1237	Challenger 300/600/601	CL600	1,211	1,654
	3047	Cessna Citation Sovereign/ Latitude	CNA680	1,107	1,511
	2028	Learjet 31/35/45/55/60/75, Hawker 800	LEAR35	719	982
	3162	Cessna Citation Mustang, Phenom 100/300	CNA510	647	884
	1292	Citation II/Bravo, Beechjet 400	CNA55B	576	786
	4640	Cessna 560 Citation XLS	CNA560XL	522	713
	4034	Dassault Falcon 50/900, Falcon F7X	FAL900EX	432	591
	1291	Cessna Citation CJ1/CJ2/CJ3	CNA500	379	517
	1773	Bombardier BD-700 Global Express	BD-700-1A10	328	448

Category	AEDT ID	Aircraft Type(s)	AEDT ANP ID	2029	2039
	1307	Cessna 750 Citation X, Dassault Falcon 2000	CNA750	262	358
	1298	Cessna 560 Citation V/Ultra	CNA560U	233	318
	1974	Gulfstream 150/200/280	IA1125	101	138
	1920	Gulfstream GIV/G400	GIV	86	118
	1923	Gulfstream GV / 500	GV	81	110
	2573	Bombardier BD-700 Global 5000	BD-700-1A11	48	65
Helicopter	3161	Robinson R-44	R44	1,122	1,463
	4091	Bell 206/407	B206L	3,366	4,388
Military	20	Sikorsky SH-60 Sea Hawk	S70	81	91
	3039	EDAS CASA CN-235	SF340	41	45
	1875	HU-25 Guardian (Dassault Falcon 20)	FAL20	14	15
			Total	**34,717**	**38,788**

Source: 2021 BVY Airport Master Plan, Chapter 3 – Forecast of Aviation Activity; CMT, Inc.

Table 3-3 – 2029 and 2039 Annual Aircraft Operations and Fleet Mix - Local

Category	AEDT ID	Aircraft Type(s)	AEDT ANP ID	2029	2039
Single Engine Piston	1882	Piper Cherokee, Aero Commander, Cessna 152, Light Sport	GASEPF	25,452	28,436
	1261	Cessna 172/177	CNA172	6,202	6,930
	3819	Cirrus SR22/22T	COMSEP	5,566	6,219
	1898	Beech Bonanza, Piper Malibu Meridian, Turbo Mooney	GASEPV	2,863	3,198
			Total	**40,083**	**44,783**

Source: 2021 BVY Airport Master Plan, Chapter 3 – Forecast of Aviation Activity; CMT, Inc.

3.1.2. Runway Use, Flight Tracks and Time of day

The runway use, flight tracks and time of day modeled for the 2029 and 2039 condition were the same as the 2019 condition.

3.1.3. 2029 and 2039 DNL Contours

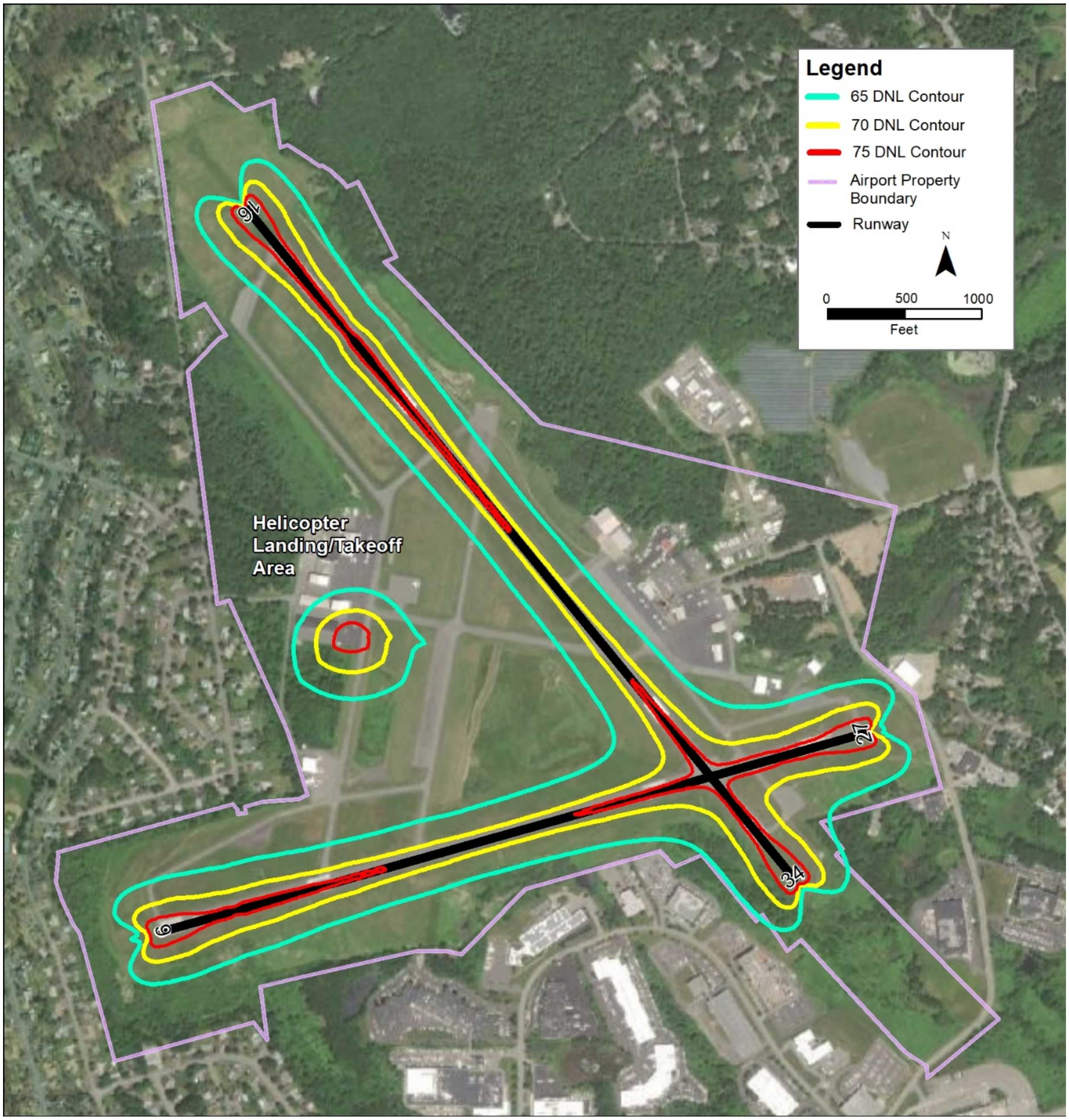
The 2029 and 2039 65-75 DNL contours are provided on **Figures 3-1** and **3-2** respectively. **Table 3-4** identifies the areas within the DNL contour ranges. As shown in the table, the total area within the 2029 65 DNL contour is approximately 142 acres and in 2039 is 161 acres. For both years, the 65 DNL contour primarily remains within the limits of the airport property boundary and there are no incompatible land uses or other noise sensitive sites within the 65 DNL contour.

Table 3-4: 2029 and 2039 DNL Contour Areas

DNL Range	Area (Acres)	
	2029	2039
65 to <70	86	93
70 to <75	41	48
75 and greater	15	20
Total	**142**	**161**

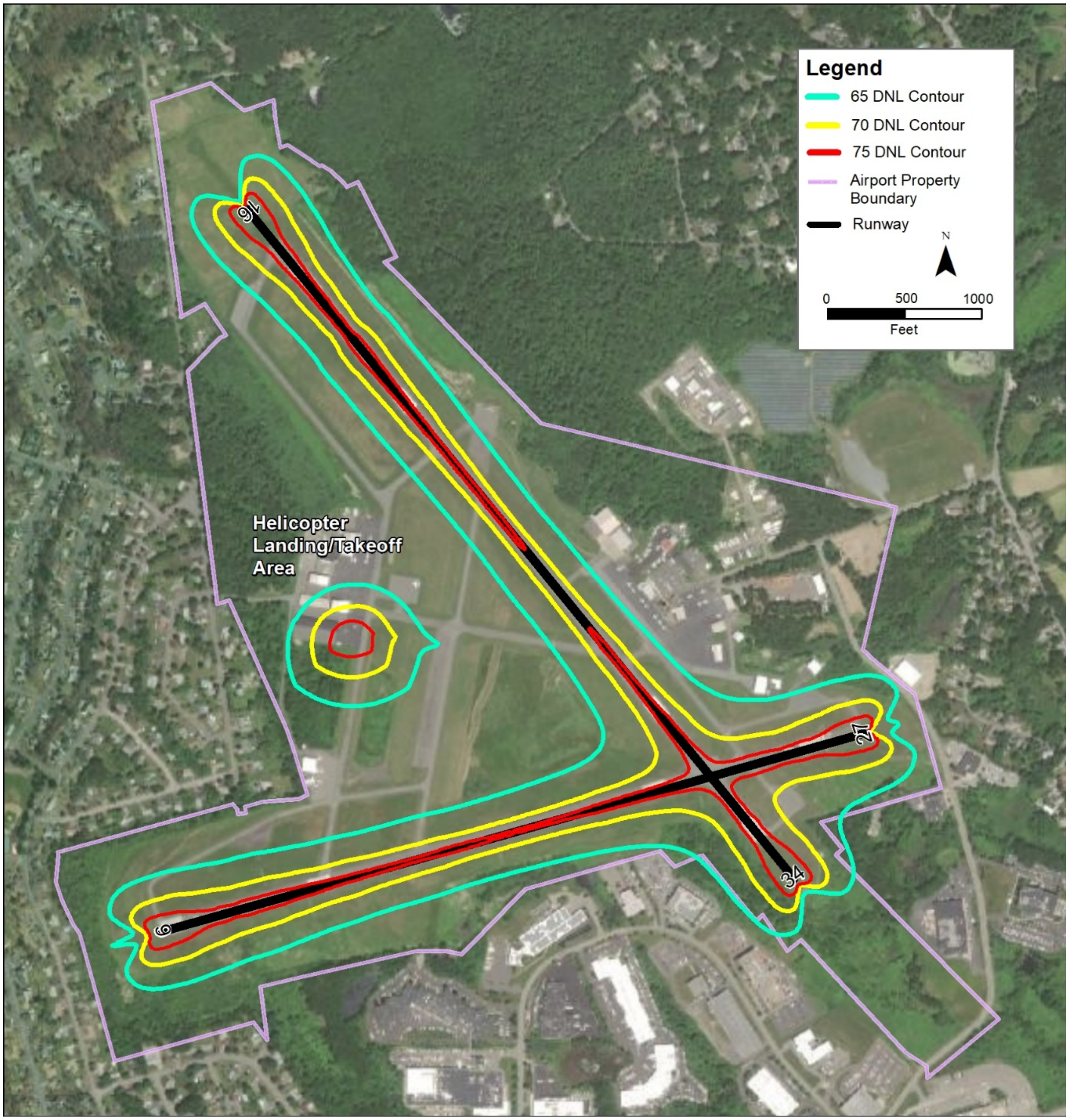
Source: CMT, Inc.

Figure 3-1: 2029 65-75 DNL Contours



Source: CMT, Inc.

Figure 3-2: 2039 65-75 DNL Contours



Source: CMT, Inc.