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September 28, 2020

Michele Rodriguez
San Francisco International Airport Community Roundtable Coordinator
County of San Mateo
P: 415.309.1608
MRodriguez2@smcgov.org

Subject: Proposal to Provide a Ground Based Noise (GBN) Modeling Study
Reference: HMMH Proposal Number 20-0152

Dear Ms. Rodriguez:

HMMH is pleased to present this proposal to provide a Ground Based Noise (GBN) modeling study.

Scope of Work:

HMMH proposes to conduct GBN noise modeling of San Francisco International Airport (SFO) utilizing a software program called SoundPLAN[1]. In order to conduct the initial GBN noise modeling, we will need the following GIS data:

- Current Airport Layout Plan (ALP)
    - Should include runway end and taxiway coordinates and elevations, threshold crossing heights and taxiway positions, and displaced thresholds and glideslope for each runway end
    - Should include on airfield surface type identification (i.e. concrete, grass, rubber, etc.)
- On and Off Airport Building Footprints and Heights
- Surrounding Roadway Centerlines

HMMH proposes to conduct the following modeling scenarios. The two (2) aircraft types shall be determined by the SFO Aircraft Noise Abatement Office (ANAO) and should be based on the most frequent and loudest aircraft departing Runway 1L/1R. HMMH will then determine if we have measured and modeled spectral and directivity information for those aircraft. The location, types, heights and thickness of the vegetation will be provided to us by the client.

Scenario 1 – 2 Aircraft Types Departing Runway 1L at Start of Takeoff Roll – Without and With Vegetation

Scenario 2 – 2 Aircraft Types Departing Runway 1R at Start of Takeoff Roll – Without and With Vegetation

Scenario 3 – 2 Aircraft Types Departing Runway 1L at Secondary Takeoff Point – With and Without Vegetation

Scenario 4 – 2 Aircraft Types Departing Runway 1R at Secondary Takeoff Point– With and Without Vegetation

Scenario 5 – 2 Aircraft Types Departing at the Same Time but Staggered on Runway 1L and 1R – With and Without Vegetation

Scenario 6 – 2 Aircraft Types Departing Runway 28L or Runway 28R at Secondary Takeoff Point – With and Without Vegetation

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[1] https://www.soundplan.eu/english/

The model will output the following information:

- Maximum noise Level (Lmax) noise contours
- Unweighted spectral noise values at up to 12 receiver points

Utilizing the noise modeling outputs, HMMH will create Lmax noise contour figures overlaid over a basemap and receiver point tables to be incorporated into the technical memorandum.

HMMH proposes to create a technical memorandum that provides a statement of purpose and details of the noise modeling results. The technical memorandum will general GBN information based on the literature review already prepared for and presented to the GBN subcommittee. Finally, the technical memorandum will make a recommendation to the GBN subcommittee on next steps.

Cost Estimate and Delivery:

HMMH can perform the scope of work described above on a time and materials basis utilizing our previously agreed upon contractual hourly rates and for a Not-To-Exceed (NTE) amount of $50,000.

It is estimate that HMMH can complete the noise modeling and technical memorandum within a period of 30-45 business days provided we receive all of the GIS data requested and final determination by the GBN subcommittee of things such as the location, types, heights, and thickness of vegetation.

We will not exceed this amount without your prior written consent. Please note that this proposal is valid for a period of 60 days from the date of this letter.

If this proposal and our Standard Terms & Conditions are acceptable to you, you may accept it by signing below, and then HMMH will return a countersigned copy to you to serve as our contractual agreement. We are prepared to begin work on this project within two (2) weeks of receipt of a signed agreement, or an alternative contracting mechanism.

Thank you for the opportunity to submit a proposal for the subject project. We very much look forward to the opportunity to assist you with this interesting project. Please feel free to contact me if you have any questions or concerns about this proposal.

Sincerely yours,

Harris Miller Miller & Hanson Inc. d/b/a/ HMMH

Justin W. Cook

Justin W. Cook - INCE, LEED GA
Principal Consultant

Note: Once we come to agreement on the terms for these services, Mary Ellen Eagan, President and CEO, will need to sign the contract and/or task order(s) to bind HMMH.

cc: Gene Reindel

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TECHNICAL MEMORANDUM

To:	James A. Castaneda, AICP San Mateo County 455 County Center, 2nd Floor Redwood City, CA 94063
From:	Heather A. Bruce Justin W. Cook - INCE, LEED GA
Date:	January 3, 2020
Subject:	Ground Based Noise (GBN) - Vegetation and Noise Effects
Reference:	HMMH Project Number 309090.000

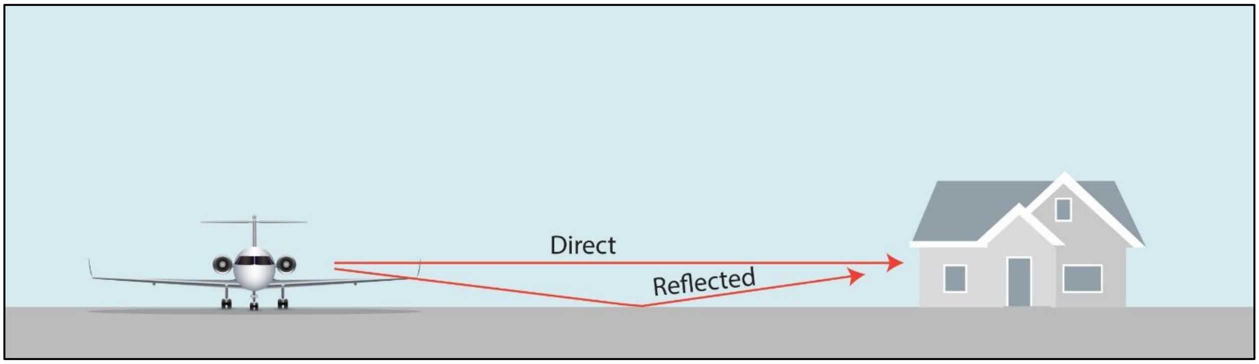
1. Introduction

On the behalf of the San Francisco International Airport/Community Roundtable, Harris Miller Miller & Hanson Inc. (HMMH), conducted a literature search regarding the acoustical attenuation provided by vegetation.

2. 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, 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 source 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. Figure 1 depicts ground effect.

Figure 1. Ground Effect



Source: HMMH Inc.

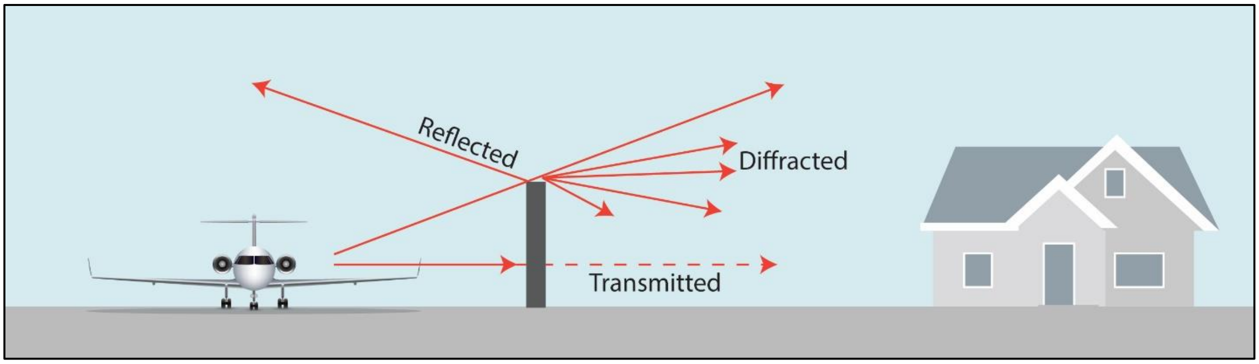
3. Noise Barriers

Noise can be reduced by implementing noise barriers. A noise barrier can be constructed with the specific intent of shielding the community beyond from source noise, or it can be a result of strategically placing buildings (i.e., hangars) or other structures (i.e., retaining walls) blocking the line of sight from the community to the sound source. Objects that are noise barriers include those that are relatively opaque to sound and block the line-of-sight from sound source to receiver, resulting in a sound shadow.

3.1 Barrier Basics

Noise barriers are only effective at reducing noise levels when the barrier blocks the line of sight between the source and receiver and the resulting sound path over the receiver differs significantly from the original sound path. The higher the barrier, the more the line-of-sight is blocked, the greater the path differences (i.e., the difference in distance that the unshielded path and the shielded path of sound has to travel), the greater the sound attenuation (reduction). Aircraft noise can be reflected off, transmitted through, and diffracted from noise barriers. Figure 2 illustrates the sound paths over and through a noise barrier.

Figure 2. Propagation of Noise with Barrier



Source: HMMH

Noise barriers will only perform adequately if they have a minimum surface density of four pounds per square foot, or a Sound Transmission Class (STC) rating of 25 dB or higher. Other than the material used to construct the noise barrier, gaps in noise walls need to be eliminated to the extent possible for a given barrier to be effective. For an adequately constructed noise barrier, the sound transmitted though the barrier is negligible. Masonry and concrete barriers are very common with post and precast panels often being most cost effective. These types of barriers also withstand wide varieties of weather and require little maintenance. Absorptive materials, such as those with metal paneling and incorporating absorptive materials, such as acoustic mineral wool, can be implemented to reduce the amount of sound reflected off a barrier.

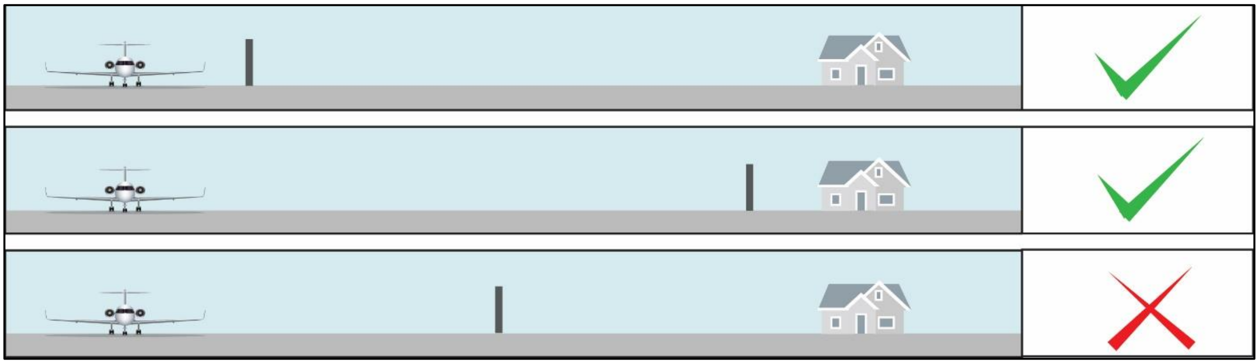
The maintenance free life cycle of a noise barrier as well as the maintenance dependent life-cycle of a noise barrier maintenance depends on several factors, predominantly what the barrier is constructed of and the environmental conditions where it is situated. For example, wooden noise barriers may perform as well initially as a post and panel concrete wall, but are more susceptible to weather damage in certain settings reducing their maintenance free life-cycle.

Over the maintenance dependent life-cycle, access to the noise barrier, availability of replacement parts, landscaping, graffiti, moisture deterioration, snow storage and snow drift are all factors to consider. Providing adequate space for maintenance is important to allow for maintenance crews access, typically 10-15 feet is sufficient. If a noise barrier is a custom-made feature, the availability of replacement parts will be sparse; therefore, it is generally best practice to construct noise barriers of standard materials so that maintenance may be performed. Moisture can result in wall deterioration, such as rust and decomposition of metal and wooden walls, reducing their life and making maintenance more frequent and costly, depending on barrier material. Native vegetation that is relatively maintenance free is often implemented near noise barriers to reduce the amount of time crews will need to keep areas landscaped. Snow being plowed into barriers may cause damage and should be considered in barrier design, both from the snow impacting the barrier during plowing and the resulting pressure of snow pressed up against the barrier. Similarly, snowdrifts may occur with snow accumulating at barriers that may inhibit airfield functions and require crews to remove the snow.

The amount of reduction that a noise barrier provides can be important when it comes to obtaining federal funding for implementation as noise mitigation. For example, FAA Order 5100.38D requires that a noise barrier reduce noise levels by 5 dB at incompatible land uses (e.g., residences within the 65dB DNL contours) in order to be eligible for AIP funding. Note that sound insulated residences are considered a compatible land use.

Careful placement of barriers is critical to their effectiveness. Figure 3 shows locations of noise barriers in relation to the source and receiver, with the green check marks being examples of where barriers can effectively shield noise and an example of where a noise barrier would not provide much shielding due to being far from the source and receiver. In practice, placing the barrier close to the noise source is most effective because it reduces sound levels for many receiver locations. Additionally, the barrier location would generally be on airport property.

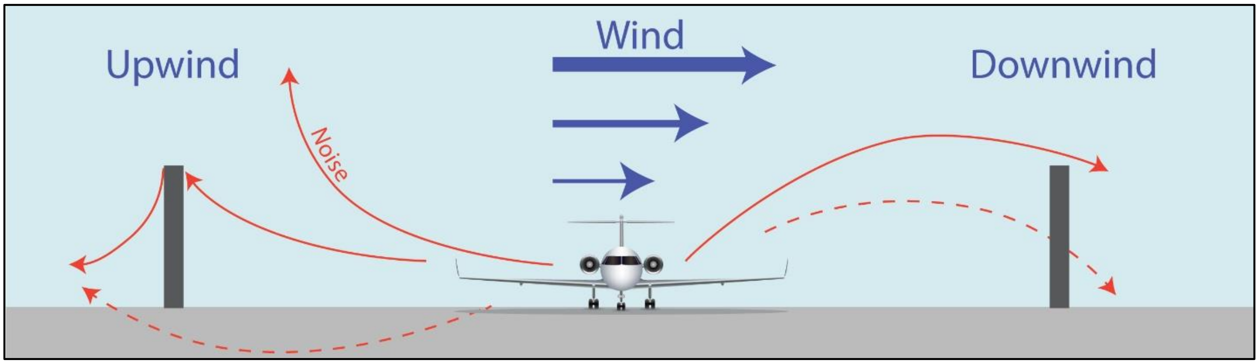
Figure 3. Noise Barrier Placement



Source: HMMH

As discussed in earlier, atmospheric effects of wind and temperature effect sound propagation, especially at distances of about 300 feet or greater from the source. For receptors within about 200 feet of a sound source, temperature and wind effects are less pronounced on barrier performance and the atmospheric conditions can be treated as homogeneous. Figure 4 depicts how wind can increase the effectiveness of barriers in the upwind direction and decrease their effectiveness in the downwind direction. The barrier can remain effective in the downwind direction if it is sufficiently close to the sound source.

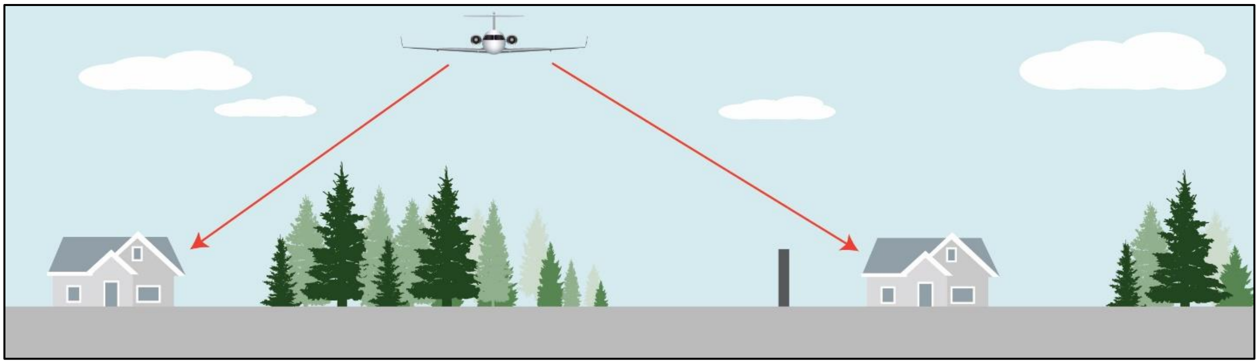
Figure 4. Wind Effects on Noise Barrier Effectiveness



Source: HMMH

Residents near airports commonly inquire about reducing all kinds of airport-related noise using barriers. However, elevated sources of noise, such as aircraft in flight, cannot be mitigated via sound barriers since the line of sight cannot be impeded. Figure 5 provides an illustration of this concept.

Figure 5. Elevated Sound Source

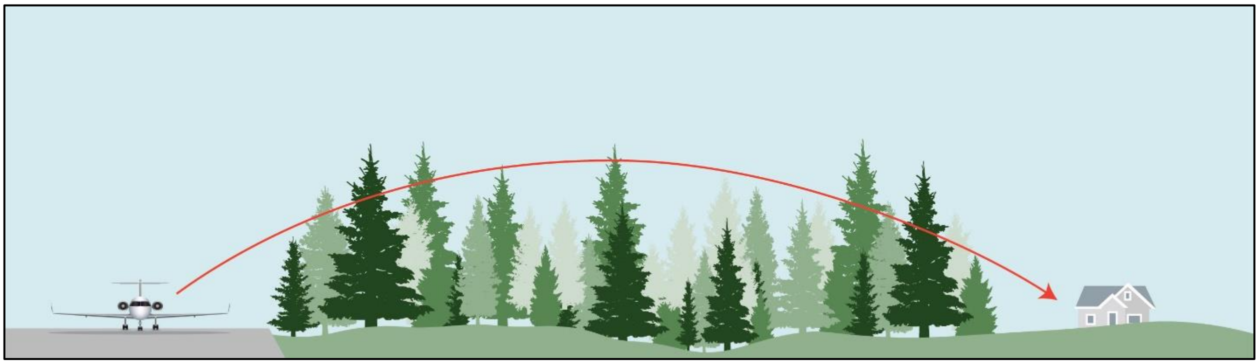


Source: HMMH

3.2 Vegetation as Noise Barrier

Vegetation does not generally meet the qualifications for an adequate sound barrier as outlined above. It may hide the source visually, but not reduce sound levels significantly. The general rule of thumb is that vegetated areas need to be sufficiently dense and cover a significant area (width between the source and receiver) to reduce noise levels. Specifically, it has been found that about 200 feet of continuous densely spaced vegetation is necessary to achieve 5 to 10 dB reductions. For this reason, it is uncommon that implementation of vegetation is feasible for noise reduction purposes. Figure 6 provides an illustration of noise from a taxiing aircraft propagating through a vegetated area. Note that much of the sound path may pass over the vegetation due to downward refraction.

Figure 6. Propagation of Noise through Vegetation



Source: HMMH

4. Applicable Standards

The sections below discuss literature regarding the acoustical attenuation provided by dense vegetation and the methods for computing this attenuation. HMMH looked into three documents, the International Standard ISO 9613-2, the General Prediction Method (GPM) and Leo Baranek’s Noise and Vibration Control, Principles and Applications. HMMH judged the ISO Standard predictions of forest reduction to be more consistent with those of other highly-respected sound models such as Nord-2000 and the FHWA’s Traffic Noise Model, which derived its calculations from the ISO Standard.

4.1 The International Standard ISO 9613-2

The International Standard ISO 9613-2[1], originally developed for industrial noise sources, ISO 9613-2 is well-suited for the evaluation of ground-based aircraft noise sources under favorable meteorological conditions for sound propagation. ISO 9613-2's methodology for calculating sound propagation includes geometric dispersion from acoustical point sources, atmospheric absorption, the effects of areas of hard and soft ground, screening due to barriers, and reflections. The attenuation provided by dense foliage varies by octave band and by distance as shown in Table 1. For propagation through less than 10 m of dense foliage, no attenuation is assumed. For propagation through 10 m to 20 m of dense foliage, the total attenuation is shown in the first row of Table 1. For distances between 20 m and 200 m, the total attenuation is computed by multiplying the distance of propagation through dense foliage by the db/m values shown in the second row of Table 1.

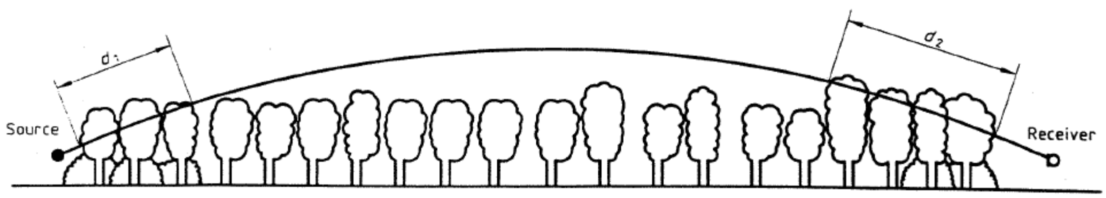
Table 1 Dense Foliage Noise Attenuation

Propagation Distance	Nominal Midband Frequency (Hz)							
	63	125	250	500	1,000	2,000	4,000	8,000
10 m to 20 m (dB/m Attenuation)	0	0	1	1	1	1	2	3
20 m to 200 m (dB/m Attenuation)	0.02	0.03	0.04	0.05	0.06	0.08	0.09	0.12

Source: ISO 9613-2, Table A.1

ISO 9613-2 assumes a moderate downwind condition. The equations in the ISO Standard also hold, equivalently, for average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear, calm nights. In either case, the sound is refracted downward. The radius of this curved path is assumed to be 5 km. With this curved sound path, only portions of the sound path may travel through the dense foliage, as illustrated by Figure 7. Thus, the relative locations of the source and receiver, the dimensions of the volume of dense foliage, and the contours of the intervening terrain are essential to the estimation of the noise attenuation.

Figure 7 Downward Refracting Sound Path (source: ISO 9613-2)



As illustrated in Figure 7, the foliage only provides attenuation if the sound path passes through the foliage. Additionally, either the noise source or receiver must be near the foliage for it to have an effect. As shown in Figure 8, for aircraft in the air, the sound will pass through little, if any foliage.

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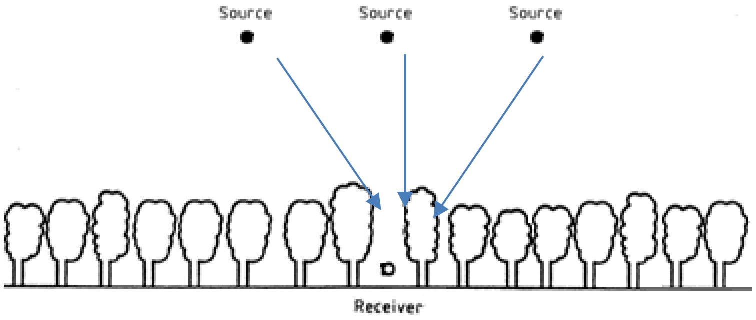
[1] International Organization for Standardization, Acoustics – Attenuation of sound during propagation outdoors – Part 2: General Method of calculation, International Standard ISO9613-2, Geneva, Switzerland (15 December 1996).

Figure 8 Air to Ground Sound Propagation through Vegetation



Source: HMMH; adapted from ISO-9613-2

4.2 The General Prediction Method (GPM)

The General Prediction Method (GPM)[2] assumes moderate downwind conditions and a neutral temperature gradient, and also would hold for calm wind with a temperature inversion. Although use of either Standard provides a conservatively high estimate of community sound levels caused by ground-based airport sources, GPM provides an overly conservative estimate of noise reduction provided by a path through a forest, particularly in the presence of a long propagation path over acoustically soft ground.

4.3 Leo Baranek's Noise and Vibration Control, Principles and Applications

Another method found in the literature was a formula referenced in Leo Baranek's Noise and Vibration Control, Principles and Applications[3]. This predicts that the attenuation of heavy woods (must block sight and protrude by more than five meters above the line of sight) is frequency dependent and can have a maximum value of 10 dB. Another method, by C-F Fang, was derived from measurement in thirty-five uniform plantations[4]. The formula predicts attenuation based on visibility through the vegetation. Where visibility is as low as five meters, twenty meters of vegetation may provide 6 dB or more of attenuation. Note that shrubbery which was taller than the source provided the best attenuation. Both of these formulas required calibration to the particular forest and the literature search did not indicate that either had found wide usage.

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[2] ÖAL-Richtline nr 28 Schallabstrahlung und Schallausbreitung. Österreichischer Arbeitstring für Lärmbekämpfung, 1987 (Austrian Acoustical Society Report No. 28, "Sound Radiation and Sound Propagation").

[3] Verein Deutscher Ingenieure, "Schallausbreitung im Freien," (Outdoor Sound Propagation), Repret No. VDI 2714, VDI-Verlag GmbH, Dusseldorf, 1988.

[4] C.-F. Fang, D.-L. Ling, Investigation of the noise reduction provided by tree belts, Landscape and Urban Planning 63 (2003) 187–195.

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TECHNICAL MEMORANDUM

To:	James A. Castaneda, AICP San Mateo County 455 County Center, 2nd Floor Redwood City, CA 94063
From:	Heather A. Bruce Justin W. Cook - INCE, LEED GA
Date:	December 7, 2019
Subject:	Ground Based Noise (GBN) - Spectral Data Noise Analysis
Reference:	HMMH Project Number 309090.000

The purpose of this technical memorandum is to provide a summary of HMMH's analysis of spectral noise data provided by San Francisco International Airport's (SFO's) Aircraft Noise Abatement Office (ANAO). The spectral noise data was obtained from SFO's Aircraft Noise & Operations Monitoring System (ANOMS) for Noise Monitoring Terminals (NMT's) 8, 9, 10 and 11.

The goal of our analysis was to analyze three time periods of data: prior to, during and after the runway safety area construction. Prior to construction meant data from the month of April 2013, during construction meant data from the month of April 2014 and after construction meant data from the month of September 2014.

The spectral data contained frequency ranges from 16 Hertz (Hz) to 16 kHz (16,000 Hz) and was unweighted. The typical frequency range of hearing for most people extends from a low of about 20 Hz to a high of about 10,000 to 15,000 Hz. Most people respond to sound most readily when the predominant frequency is in the range of normal conversation – typically around 1,000 to 2,000 Hz.

The spectral noise data received from SFO was converted from centibels to decibels (dB). The data was then broken down by NMT and runway. HMMH looked at the noise level differences by frequency between time periods to determine if there were any trends in the data.

Table 1 provides spectral noise level averages across NMTs 8, 9, 10 and 11 in dB for prior to construction, during construction and after construction of the runway safety area. When comparing the spectral noise level averages from prior to and during the construction, the low and high frequency averages increased. When comparing the spectral noise level averages from prior to after construction, low frequency averages decreased, and the high frequency averages increased. Figure 1 provides a graphical representation of the data within Table 1.

Table 2 provides spectral noise level averages for NMT 8 in dB. When comparing the spectral noise level averages from prior to during the construction, the high frequency averages increased. When comparing the spectral noise level averages from prior to after construction, the low frequency averages decreased, and the high frequency averages increased. Figure 2 provides a graphical representation of the data within Table 2.

Table 3 provides spectral noise level averages for NMT 9 in dB. When comparing the spectral noise level averages from prior to during the construction, the high frequency averages increased. When comparing the spectral noise level averages from prior to after construction, the low frequency averages decreased, and the high frequency averages increased. Figure 3 provides a graphical representation of the data within Table 3.

Table 4 provides spectral noise level averages for NMT 10 in dB. When comparing the spectral noise level averages from prior to during the construction, the low frequency averages. When comparing the spectral noise level averages from prior to after construction, the low frequency averages decreased. Figure 4 provides a graphical representation of the data within Table 4.

Table 5 provides spectral noise level averages for NMT 11 in dB. When comparing the spectral noise level averages from prior to during the construction, the high frequency averages increased. When comparing the spectral noise level averages from prior to after construction, the high frequency averages decreased. Figure 5 provides a graphical representation of the data within Table 5.

Table 6 provides spectral noise averages across NMTs 8, 9, 10 and 11 in dB for Runway 01L. When comparing the spectral noise level averages from prior to during the construction, the low and high frequency averages increased. When comparing the spectral noise level averages from prior to after construction, the low frequency averages decreased, and the high frequency averages increased. Figure 6 provides a graphical representation of the data within Table 6.

Table 7 provides spectral noise averages across NMTs 8, 9, 10 and 11 in dB for Runway 01R. When comparing the spectral noise level averages from prior to during the construction, the low frequency averages increased. When comparing the spectral noise level averages from prior to after construction, the low frequency averages decreased, and the high frequency averages increased. Figure 7 provides a graphical representation of the data within Table 7.

Table 1. NMT's 8, 9, 10 and 11 – Unweighted Spectral Noise Level Averages (dB)

Frequency	Prior to Runway Safety Area Construction	During Runway Safety Area Construction	After Runway Safety Area Construction	Change During to Prior	Change After from Prior	Change After from During
16 HZ	74.6	77.0	71.7	2.4	-2.9	-5.3
20 HZ	73.5	75.9	70.6	2.3	-3.0	-5.3
25 HZ	73.0	75.2	70.5	2.2	-2.5	-4.7
31 HZ	71.8	74.0	69.5	2.2	-2.3	-4.5
40 HZ	68.8	71.3	66.0	2.6	-2.8	-5.3
50 HZ	69.5	70.3	66.3	0.8	-3.2	-4.0
63 HZ	70.7	70.3	68.0	-0.4	-2.7	-2.3
80 HZ	71.5	70.2	69.7	-1.3	-1.8	-0.5
100 HZ	70.6	69.1	69.0	-1.5	-1.6	-0.1
125 HZ	69.1	68.1	68.0	-0.9	-1.0	-0.1
160 HZ	68.2	66.9	66.9	-1.3	-1.3	0.0
200 HZ	66.3	65.5	65.8	-0.7	-0.5	0.3
250 HZ	65.1	64.0	64.5	-1.1	-0.6	0.5
315 HZ	65.2	63.9	64.3	-1.3	-0.9	0.4
400 HZ	66.2	64.1	66.3	-2.1	0.1	2.2
500 HZ	65.9	64.9	65.3	-1.0	-0.6	0.4
630 HZ	65.0	65.2	65.4	0.1	0.4	0.3
800 HZ	64.5	63.7	63.9	-0.8	-0.6	0.2
1 KHZ	63.3	62.8	62.6	-0.4	-0.6	-0.2
1.2 KHZ	60.6	61.1	61.8	0.4	1.1	0.7
1.6 KHZ	58.2	59.0	59.4	0.8	1.2	0.4
2 KHZ	55.5	56.4	57.1	0.9	1.6	0.7
2.5 KHZ	53.2	54.5	56.0	1.3	2.8	1.5
3.1 KHZ	50.0	52.0	53.3	2.0	3.3	1.3
4 KHZ	47.8	52.4	50.8	4.6	3.1	-1.6
5 KHZ	46.4	51.5	48.5	5.1	2.1	-3.0
6.3 KHZ	44.9	54.2	48.1	9.3	3.3	-6.1
8 KHZ	44.1	54.5	48.5	10.4	4.4	-6.0
10 KHZ	42.8	52.1	49.1	9.2	6.3	-3.0
12 KHZ	40.6	49.1	50.1	8.5	9.5	1.0
16 KHZ	37.2	44.9	47.5	7.7	10.3	2.6

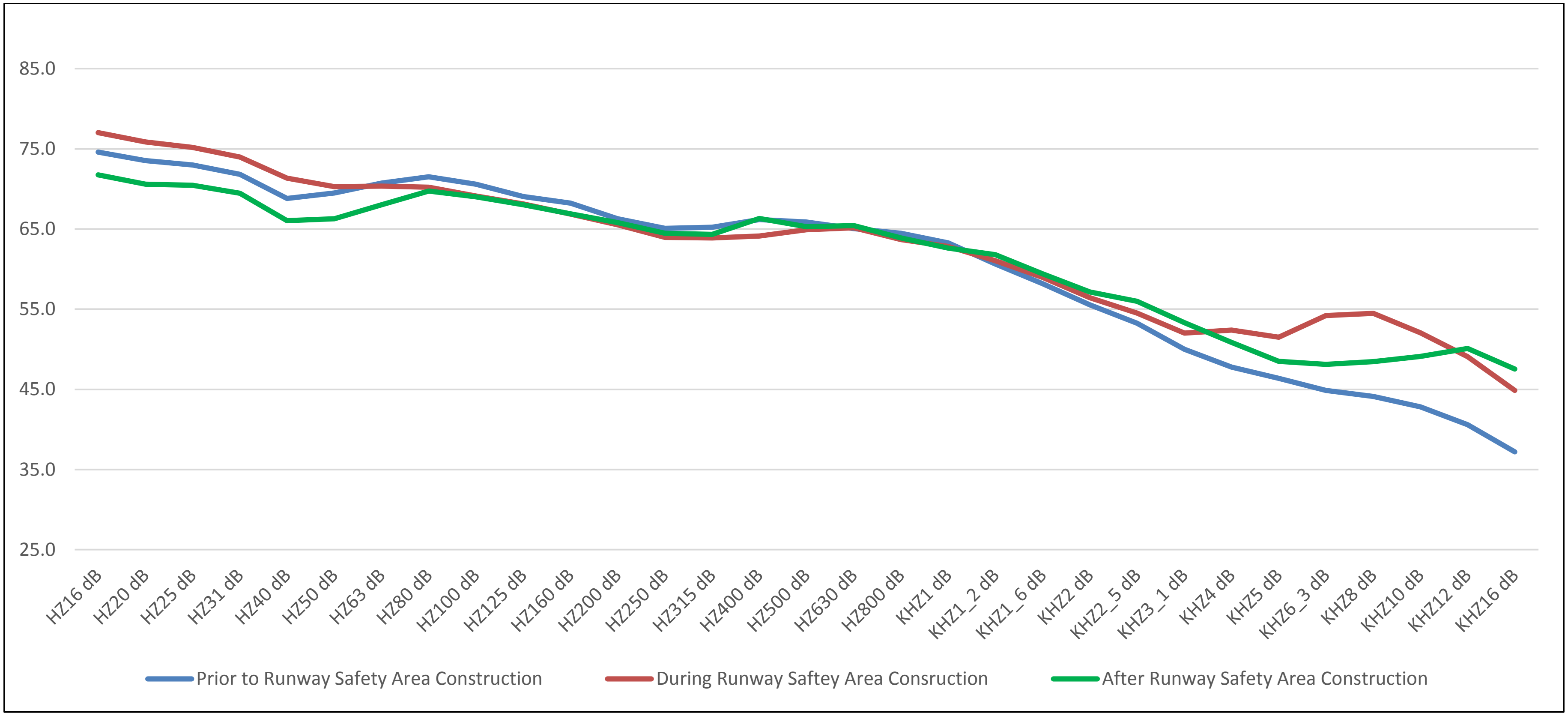

Figure 1. NMT's 8, 9, 10 and 11 – Unweighted Spectral Noise Level Averages (dB)

Table 2. NMT 8 – Unweighted Spectral Noise Level Averages (dB)

Frequency	Prior to Runway Safety Area Construction	During Runway Safety Area Construction	After Runway Safety Area Construction	Change During to Prior	Change After from Prior	Change After from During
16 HZ	74.2	74.6	72.6	0.4	-1.6	-2.0
20 HZ	73.2	73.6	71.4	0.4	-1.8	-2.2
25 HZ	72.8	73.3	71.4	0.5	-1.5	-1.9
31 HZ	71.6	72.3	70.4	0.7	-1.2	-1.9
40 HZ	67.6	68.5	65.8	0.9	-1.8	-2.6
50 HZ	67.6	67.8	65.4	0.1	-2.3	-2.4
63 HZ	69.2	68.8	67.1	-0.4	-2.1	-1.7
80 HZ	69.5	68.7	68.0	-0.7	-1.4	-0.7
100 HZ	68.3	67.8	66.7	-0.5	-1.6	-1.1
125 HZ	68.3	67.7	67.2	-0.6	-1.0	-0.5
160 HZ	67.5	66.5	66.3	-1.0	-1.2	-0.2
200 HZ	65.2	65.1	64.6	-0.1	-0.6	-0.5
250 HZ	64.7	64.0	64.1	-0.8	-0.6	0.1
315 HZ	64.9	64.0	63.9	-0.8	-1.0	-0.1
400 HZ	64.0	63.1	63.1	-0.8	-0.9	0.0
500 HZ	63.8	63.9	63.6	0.1	-0.2	-0.3
630 HZ	64.8	65.3	65.1	0.5	0.3	-0.2
800 HZ	63.6	63.3	62.9	-0.4	-0.7	-0.4
1 KHZ	62.7	62.7	62.4	0.0	-0.3	-0.2
1.2 KHZ	60.1	60.9	61.0	0.8	0.9	0.1
1.6 KHZ	57.8	58.8	59.3	1.0	1.5	0.5
2 KHZ	55.4	56.1	57.3	0.7	1.9	1.2
2.5 KHZ	53.1	54.1	56.4	1.0	3.3	2.3
3.1 KHZ	49.4	50.8	53.6	1.4	4.2	2.8
4 KHZ	46.7	48.5	51.1	1.7	4.4	2.6
5 KHZ	44.1	46.4	48.8	2.3	4.7	2.4
6.3 KHZ	42.3	45.9	48.7	3.6	6.4	2.8
8 KHZ	41.8	45.0	49.2	3.2	7.4	4.2
10 KHZ	42.0	45.5	50.0	3.4	7.9	4.5
12 KHZ	40.7	44.2	51.2	3.5	10.5	7.0
16 KHZ	37.2	41.1	48.6	3.9	11.4	7.5

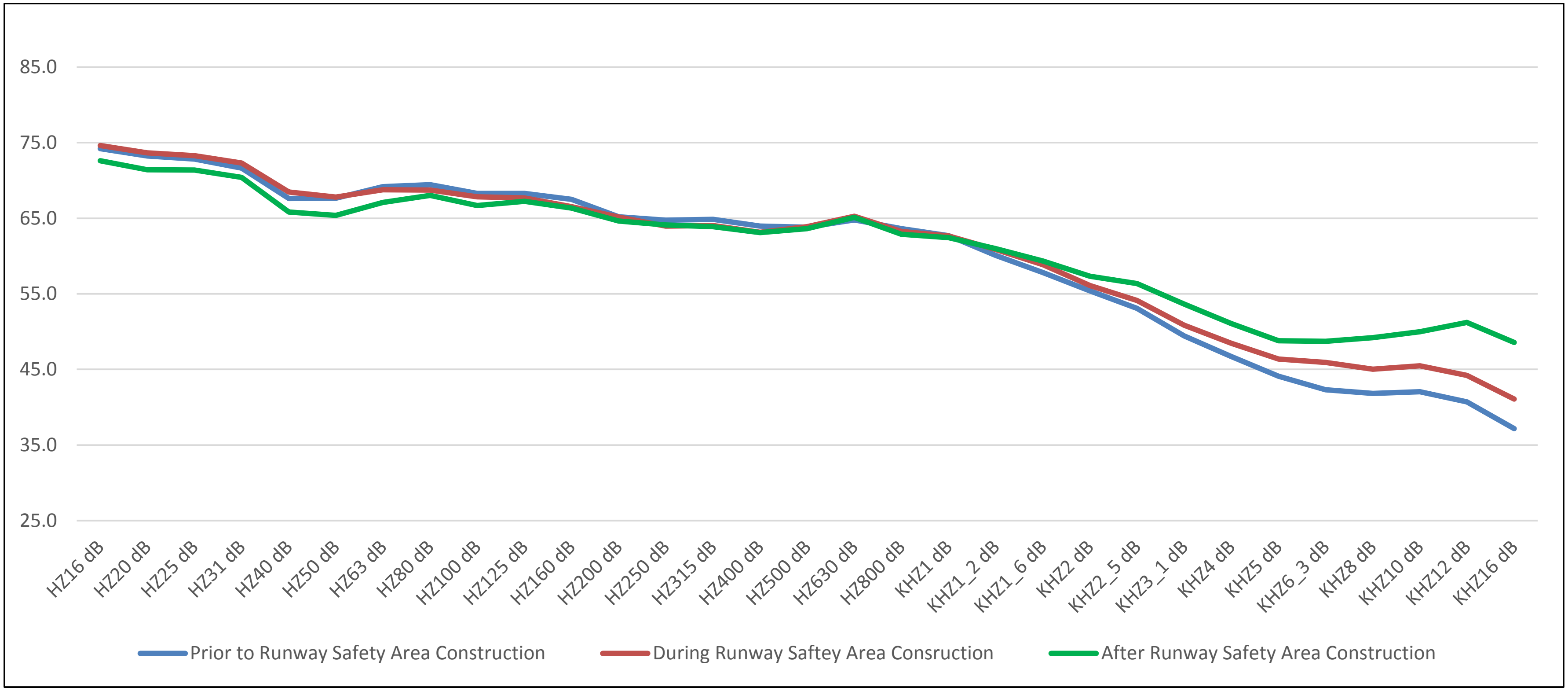

Figure 2. NMT 8 – Unweighted Spectral Noise Level Averages (dB)

Table 3. NMT 9 – Unweighted Spectral Noise Level Averages (dB)

Frequency	Prior to Runway Safety Area Construction	During Runway Safety Area Construction	After Runway Safety Area Construction	Change During to Prior	Change After from Prior	Change After from During
16 HZ	73.4	73.2	66.0	-0.2	-7.3	-7.2
20 HZ	72.0	71.6	65.8	-0.4	-6.2	-5.8
25 HZ	70.7	70.0	65.1	-0.6	-5.6	-5.0
31 HZ	69.9	68.7	64.0	-1.2	-5.9	-4.7
40 HZ	70.1	68.2	66.0	-2.0	-4.1	-2.1
50 HZ	71.8	68.3	67.0	-3.5	-4.8	-1.3
63 HZ	72.0	68.6	68.1	-3.4	-3.9	-0.5
80 HZ	74.2	70.2	70.8	-4.0	-3.4	0.6
100 HZ	73.7	68.9	69.7	-4.8	-3.9	0.9
125 HZ	70.1	67.1	67.6	-3.0	-2.6	0.4
160 HZ	68.5	66.1	66.2	-2.4	-2.3	0.1
200 HZ	67.4	65.0	65.5	-2.4	-1.9	0.5
250 HZ	64.5	62.6	64.1	-1.9	-0.4	1.5
315 HZ	65.9	61.7	65.4	-4.2	-0.5	3.7
400 HZ	71.6	67.6	71.3	-4.0	-0.3	3.7
500 HZ	70.9	69.0	67.9	-1.9	-3.0	-1.1
630 HZ	66.6	65.3	66.7	-1.3	0.0	1.4
800 HZ	68.0	65.6	67.0	-2.4	-1.0	1.4
1 KHZ	65.7	63.5	63.7	-2.2	-2.0	0.2
1.2 KHZ	62.0	60.3	63.3	-1.8	1.3	3.0
1.6 KHZ	58.5	57.6	59.9	-0.9	1.4	2.3
2 KHZ	54.7	54.5	56.1	-0.2	1.4	1.6
2.5 KHZ	51.1	52.1	53.6	1.1	2.5	1.5
3.1 KHZ	48.1	48.9	51.3	0.8	3.2	2.4
4 KHZ	46.2	48.3	48.8	2.1	2.6	0.5
5 KHZ	44.5	47.0	45.5	2.5	1.0	-1.5
6.3 KHZ	40.5	59.3	44.0	18.8	3.5	-15.3
8 KHZ	36.8	57.7	42.5	20.8	5.7	-15.2
10 KHZ	34.5	42.8	43.4	8.3	8.9	0.5
12 KHZ	32.6	40.9	42.9	8.3	10.3	2.0
16 KHZ	29.0	37.5	40.4	8.5	11.4	2.9

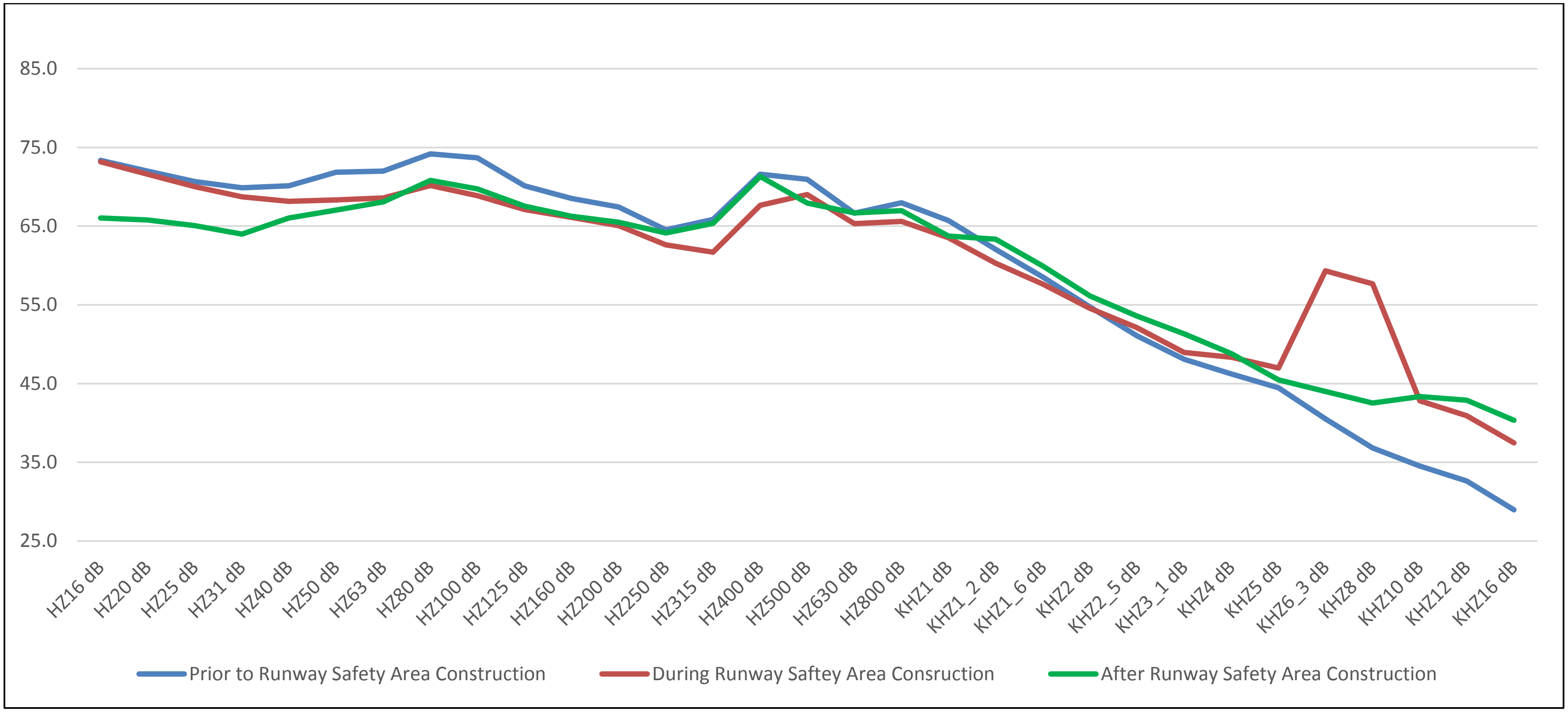

Figure 3. NMT 9 – Unweighted Spectral Noise Level Averages (dB)

Table 4. NMT 10 – Unweighted Spectral Noise Level Averages (dB)

Frequency	Prior to Runway Safety Area Construction	During Runway Safety Area Construction	After Runway Safety Area Construction	Change During to Prior	Change After from Prior	Change After from During
16 HZ	82.5	87.3	73.0	4.8	-9.5	-14.3
20 HZ	81.2	86.1	71.4	4.8	-9.8	-14.7
25 HZ	79.9	85.0	70.1	5.1	-9.8	-15.0
31 HZ	78.2	83.6	69.0	5.4	-9.2	-14.6
40 HZ	76.4	81.9	67.1	5.5	-9.3	-14.7
50 HZ	75.1	80.1	65.7	5.0	-9.4	-14.4
63 HZ	73.9	78.4	64.0	4.4	-9.9	-14.4
80 HZ	72.8	76.5	67.6	3.7	-5.2	-8.9
100 HZ	72.2	74.3	65.4	2.1	-6.8	-8.9
125 HZ	69.9	71.6	64.0	1.7	-5.9	-7.6
160 HZ	71.1	69.0	64.7	-2.1	-6.3	-4.3
200 HZ	69.1	66.9	65.3	-2.2	-3.8	-1.6
250 HZ	66.9	64.3	62.3	-2.6	-4.6	-2.0
315 HZ	67.9	64.1	63.4	-3.8	-4.5	-0.7
400 HZ	67.2	64.1	64.7	-3.1	-2.4	0.6
500 HZ	67.5	63.6	69.1	-4.0	1.6	5.5
630 HZ	67.0	63.5	66.8	-3.4	-0.2	3.3
800 HZ	64.6	62.7	62.4	-1.9	-2.2	-0.4
1 KHZ	65.6	63.0	62.8	-2.5	-2.8	-0.3
1.2 KHZ	65.6	63.4	64.9	-2.3	-0.8	1.5
1.6 KHZ	63.5	61.0	60.1	-2.5	-3.4	-0.9
2 KHZ	60.3	58.5	58.1	-1.7	-2.2	-0.4
2.5 KHZ	58.6	56.1	57.5	-2.5	-1.1	1.4
3.1 KHZ	56.4	53.4	55.1	-3.1	-1.3	1.7
4 KHZ	54.4	51.7	53.1	-2.6	-1.2	1.4
5 KHZ	53.0	51.1	51.2	-1.9	-1.8	0.1
6.3 KHZ	52.1	49.5	49.9	-2.6	-2.2	0.4
8 KHZ	50.7	49.5	50.1	-1.2	-0.6	0.6
10 KHZ	49.1	48.2	49.5	-0.8	0.4	1.2
12 KHZ	47.0	47.7	49.0	0.7	2.0	1.3
16 KHZ	43.5	44.8	47.7	1.3	4.2	2.9

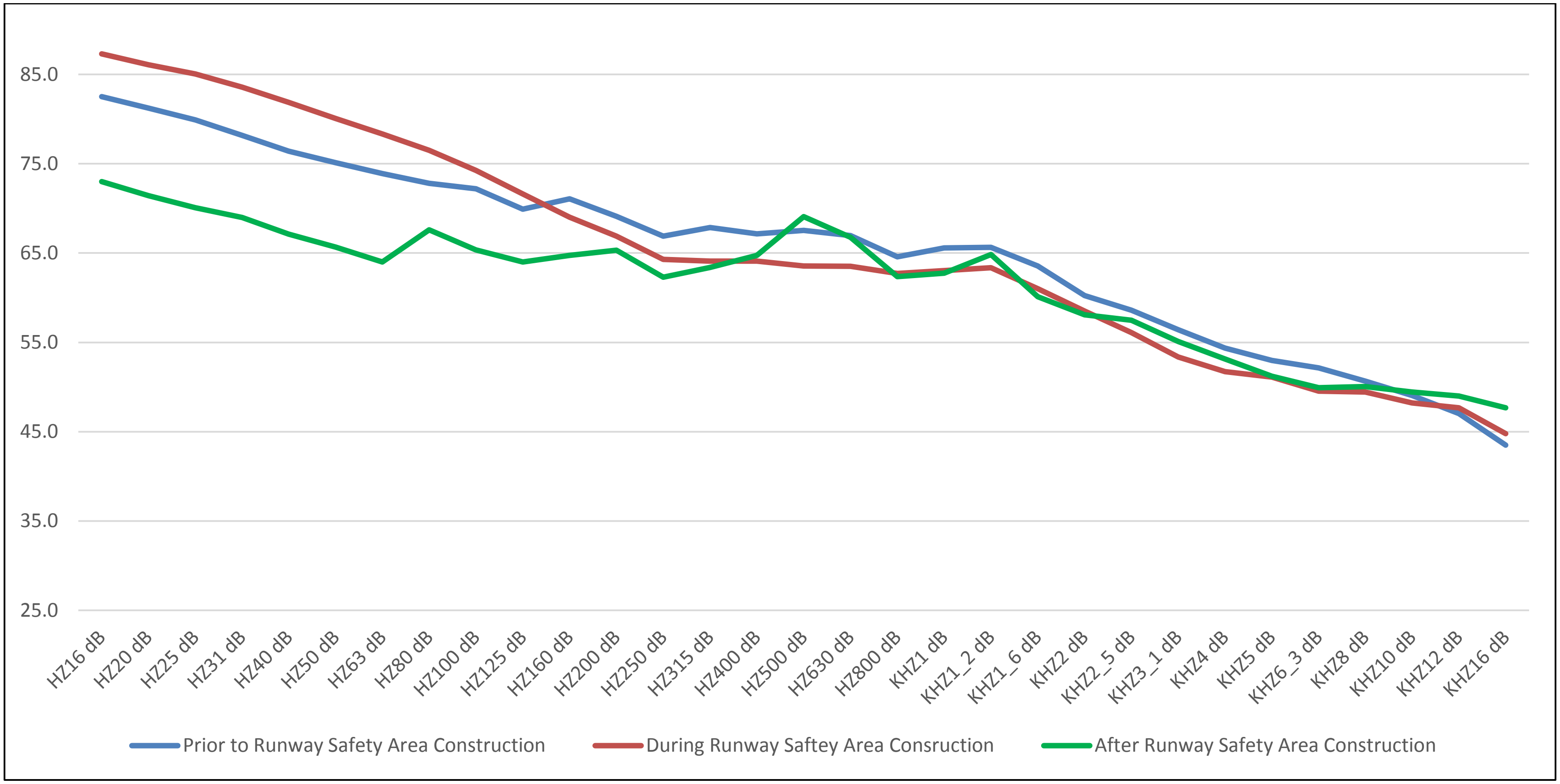

Figure 4. NMT 10 – Unweighted Spectral Noise Level Averages (dB)

Table 5. NMT 11 – Unweighted Spectral Noise Level Averages (dB)

Frequency	Prior to Runway Safety Area Construction	During Runway Safety Area Construction	After Runway Safety Area Construction	Change During to Prior	Change After from Prior	Change After from During
16 HZ	68.3	69.5	63.8	1.2	-4.6	-5.7
20 HZ	67.1	67.5	62.4	0.4	-4.7	-5.1
25 HZ	69.7	68.3	66.1	-1.5	-3.6	-2.2
31 HZ	70.8	67.2	65.6	-3.6	-5.2	-1.7
40 HZ	70.5	68.1	66.9	-2.4	-3.6	-1.3
50 HZ	75.3	69.9	71.5	-5.4	-3.7	1.7
63 HZ	77.7	72.7	74.7	-5.0	-3.0	2.0
80 HZ	78.8	74.4	77.0	-4.4	-1.8	2.6
100 HZ	77.9	74.1	77.7	-3.7	-0.1	3.6
125 HZ	74.0	71.0	74.8	-3.0	0.8	3.8
160 HZ	73.1	69.9	72.8	-3.2	-0.3	2.9
200 HZ	71.9	69.1	72.8	-2.8	0.9	3.7
250 HZ	69.1	65.9	69.3	-3.2	0.2	3.3
315 HZ	66.8	65.2	66.5	-1.6	-0.3	1.2
400 HZ	65.0	64.2	63.9	-0.8	-1.1	-0.3
500 HZ	65.6	63.0	62.7	-2.6	-3.0	-0.4
630 HZ	61.7	64.3	60.1	2.6	-1.6	-4.1
800 HZ	61.1	64.4	58.7	3.3	-2.4	-5.7
1 KHZ	60.3	63.2	58.2	2.9	-2.1	-5.0
1.2 KHZ	59.7	62.8	57.0	3.1	-2.7	-5.8
1.6 KHZ	57.5	60.7	55.0	3.3	-2.4	-5.7
2 KHZ	55.6	60.3	56.1	4.7	0.5	-4.2
2.5 KHZ	54.7	59.3	55.1	4.6	0.4	-4.2
3.1 KHZ	54.0	59.6	51.1	5.6	-2.8	-8.4
4 KHZ	53.7	63.3	49.2	9.5	-4.6	-14.1
5 KHZ	55.2	62.9	47.0	7.6	-8.2	-15.8
6.3 KHZ	55.8	64.0	45.4	8.2	-10.3	-18.5
8 KHZ	55.0	65.6	45.9	10.6	-9.1	-19.7
10 KHZ	54.2	64.2	45.1	10.0	-9.1	-19.1
12 KHZ	50.5	60.6	42.6	10.1	-7.9	-18.0
16 KHZ	45.1	55.8	38.2	10.7	-6.8	-17.6

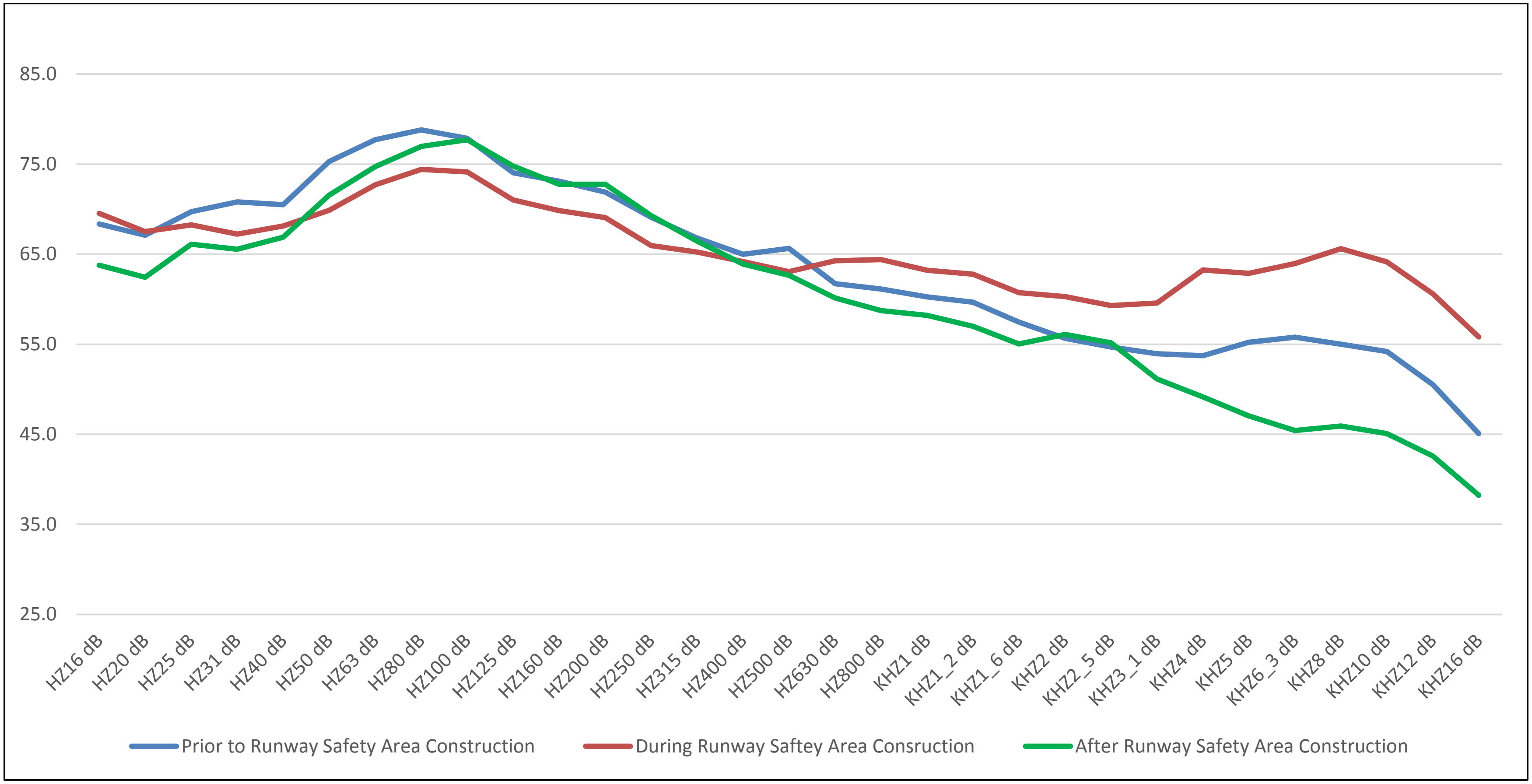

Figure 5. NMT 11 – Unweighted Spectral Noise Level Averages (dB)

Table 6. Runway 01L - NMT's 8, 9, 10 and 11 – Unweighted Spectral Noise Level Averages (dB)

Frequency	Prior to Runway Safety Area Construction	During Runway Safety Area Construction	After Runway Safety Area Construction	Change During to Prior	Change After from Prior	Change After from During
16 HZ	74.2	77.5	70.7	3.3	-3.4	-6.8
20 HZ	72.8	76.1	69.3	3.4	-3.5	-6.8
25 HZ	71.7	75.1	69.5	3.4	-2.2	-5.6
31 HZ	70.3	73.7	68.2	3.4	-2.1	-5.5
40 HZ	68.0	71.9	64.3	3.9	-3.7	-7.6
50 HZ	68.4	70.8	64.8	2.4	-3.6	-5.9
63 HZ	69.1	70.6	66.6	1.5	-2.6	-4.1
80 HZ	69.4	69.6	68.0	0.1	-1.4	-1.6
100 HZ	69.1	68.1	68.1	-1.0	-1.0	-0.1
125 HZ	67.2	67.3	67.2	0.2	0.1	-0.1
160 HZ	66.6	65.9	65.8	-0.6	-0.7	-0.1
200 HZ	64.9	64.4	64.9	-0.6	0.0	0.5
250 HZ	64.3	63.2	63.4	-1.2	-0.9	0.3
315 HZ	64.5	63.7	63.8	-0.8	-0.8	0.1
400 HZ	66.6	64.2	66.9	-2.4	0.3	2.7
500 HZ	67.0	65.3	65.4	-1.7	-1.6	0.1
630 HZ	65.7	65.4	65.9	-0.4	0.2	0.6
800 HZ	65.2	64.0	64.3	-1.2	-1.0	0.2
1 KHZ	63.9	63.2	62.9	-0.7	-1.0	-0.3
1.2 KHZ	61.2	61.8	62.2	0.5	1.0	0.5
1.6 KHZ	58.6	59.7	59.7	1.0	1.1	0.1
2 KHZ	55.7	57.1	57.2	1.4	1.5	0.1
2.5 KHZ	53.4	55.2	56.2	1.9	2.8	1.0
3.1 KHZ	50.1	53.5	53.8	3.3	3.6	0.3
4 KHZ	48.1	54.7	50.9	6.6	2.8	-3.8
5 KHZ	47.2	54.2	48.7	7.0	1.5	-5.5
6.3 KHZ	47.4	57.9	48.8	10.6	1.4	-9.1
8 KHZ	46.8	58.3	49.3	11.5	2.5	-9.0
10 KHZ	46.4	55.7	48.6	9.2	2.1	-7.1
12 KHZ	43.7	52.4	47.2	8.7	3.5	-5.2
16 KHZ	39.8	48.0	44.1	8.2	4.3	-3.9

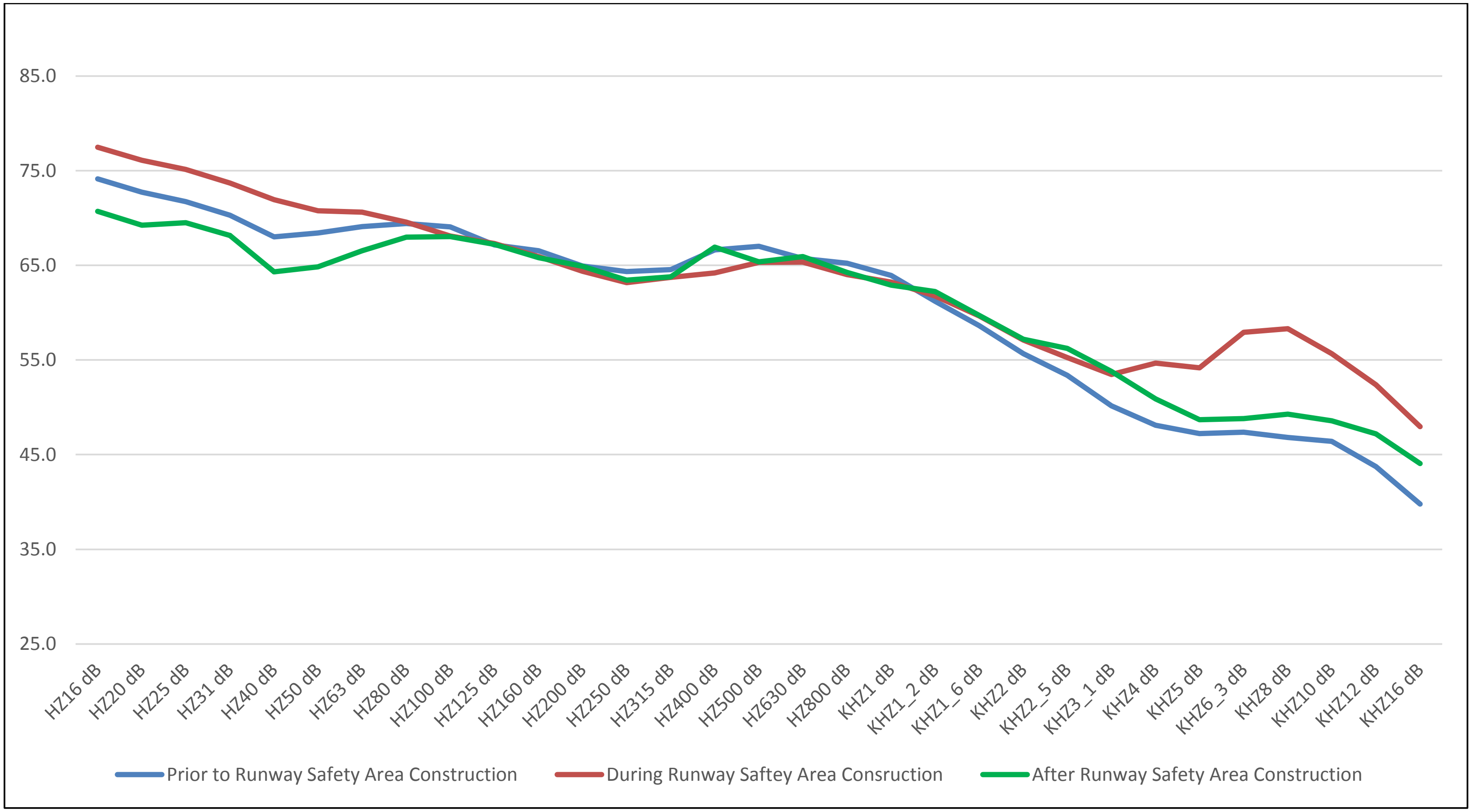

Figure 6. Spectral Noise Analysis Runway 01L - Prior, During and After Runway Safety Area Construction

Table 7. Runway 01R - NMT's 8, 9, 10 and 11 – Unweighted Spectral Noise Level Averages (dB)

Frequency	Prior to Runway Safety Area Construction	During Runway Safety Area Construction	After Runway Safety Area Construction	Change During to Prior	Change After from Prior	Change After from During
16 HZ	74.8	76.7	72.2	1.9	-2.6	-4.5
20 HZ	73.9	75.7	71.1	1.9	-2.7	-4.6
25 HZ	73.5	75.2	70.9	1.7	-2.6	-4.3
31 HZ	72.4	74.1	70.0	1.7	-2.4	-4.1
40 HZ	69.1	71.0	66.7	1.8	-2.4	-4.3
50 HZ	70.0	70.0	66.9	0.0	-3.1	-3.1
63 HZ	71.4	70.2	68.6	-1.2	-2.7	-1.5
80 HZ	72.3	70.6	70.4	-1.7	-1.9	-0.1
100 HZ	71.2	69.6	69.5	-1.6	-1.7	-0.2
125 HZ	69.8	68.6	68.4	-1.2	-1.4	-0.2
160 HZ	68.9	67.3	67.3	-1.5	-1.5	0.0
200 HZ	66.8	66.1	66.2	-0.7	-0.6	0.1
250 HZ	65.4	64.4	64.9	-1.0	-0.5	0.5
315 HZ	65.5	63.9	64.6	-1.6	-0.9	0.6
400 HZ	65.9	64.0	66.0	-1.9	0.0	1.9
500 HZ	65.1	64.7	65.3	-0.5	0.1	0.6
630 HZ	64.7	65.0	65.2	0.4	0.5	0.1
800 HZ	64.0	63.4	63.7	-0.6	-0.4	0.2
1 KHZ	62.9	62.6	62.4	-0.3	-0.4	-0.1
1.2 KHZ	60.3	60.6	61.5	0.3	1.2	0.9
1.6 KHZ	57.9	58.5	59.2	0.5	1.3	0.7
2 KHZ	55.5	56.0	57.1	0.5	1.6	1.1
2.5 KHZ	53.2	54.0	55.9	0.8	2.7	1.9
3.1 KHZ	49.9	50.8	53.1	0.9	3.1	2.2
4 KHZ	47.6	50.1	50.8	2.5	3.2	0.7
5 KHZ	45.9	48.4	48.4	2.5	2.5	-0.1
6.3 KHZ	44.1	47.1	47.7	3.1	3.6	0.6
8 KHZ	43.0	46.5	48.0	3.5	5.0	1.5
10 KHZ	42.5	45.8	49.3	3.4	6.9	3.5
12 KHZ	40.7	44.2	51.1	3.5	10.4	6.9
16 KHZ	36.6	40.8	48.6	4.2	12.0	7.8

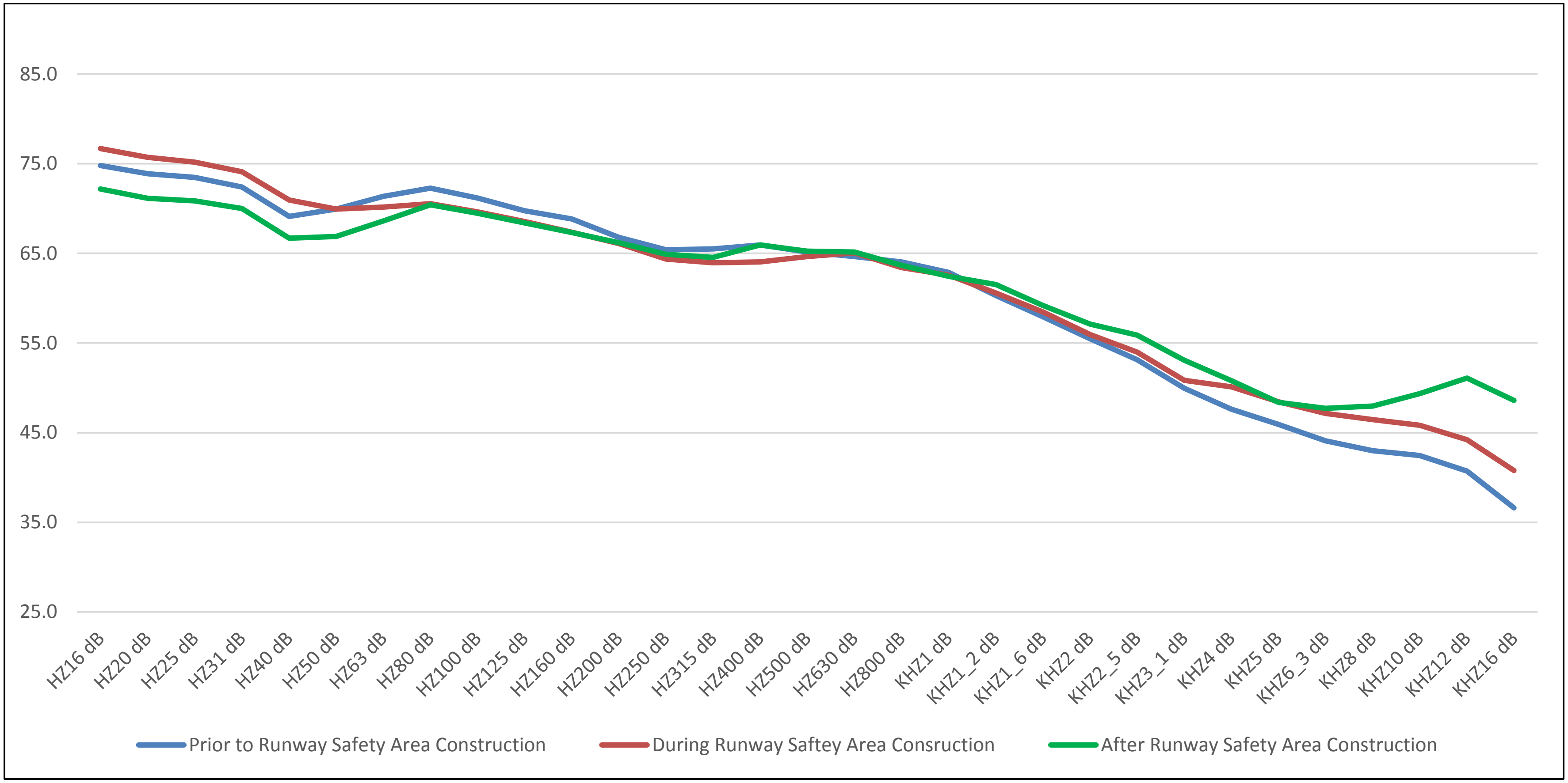

Figure 7. Runway 01R - NMT's 8, 9, 10 and 11 – Unweighted Spectral Noise Level Averages (dB)