Electrical Engineering and Computer Science Practice

Exponent®

Audible Noise Measurements at 138th Street Substation – Ocean City, Maryland

May, 2020

Exponent®
Failure Analysis Associates®

Audible Noise Measurements at 138th Street Substation – Ocean City, Maryland:

May 2020

Prepared for

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1200705.000 - 9078

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Limitations

At the request of Delmarva Power & Light (Delmarva), Exponent measured the levels of audible noise at locations around the 138th Street Substation. This report summarizes work performed on May 26 and 27, 2020, and presents the findings resulting from that work. Delmarva has confirmed to Exponent that the data contained herein are not subject to Critical Energy Infrastructure Information restrictions. Although Exponent has exercised usual and customary care in the conduct of this analysis, the responsibility for the use of this report remains fully with the client.

The findings presented herein are made to a reasonable degree of engineering and scientific certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available.

The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report, its findings, or conclusions presented herein other than for its intended use are at the sole risk of the user. The opinions and comments formulated during this assessment are based on measurements, observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any condition or measurement is expressed or implied.

Executive Summary

Delmarva Power & Light (Delmarva) upgraded the existing 138th Street Substation in Ocean City, Maryland, by adding a Static VAR Compensator for line voltage regulation. At the request of Delmarva, and in accordance with a Conditional Use Agreement with Ocean City, Maryland (#12-12100002) that called for semi-annual reporting of audible noise levels each January and July after the Static VAR compensator was placed in service, Exponent performed measurements of audible noise at 16 representative locations at the sidewalk in front of residences and property around the perimeter of the 138th Street Substation.

The audible noise measurements were taken during day time and night time hours on May 26 and 27, 2020, at 16 locations around the substation. Two additional audible noise measurements were performed along Sinepuxent Avenue in similar residential neighborhoods located approximately one-quarter mile or more north of the substation for comparison with noise levels away from the substation. A third measurement of audible noise was also taken away from the substation along Derrickson Avenue south of the substation for comparison.

The measured levels of audible noise are reported in units of decibels on the A-weighted scale (dB-A). Measurements were taken while the Static VAR Compensator and cooling fans were in operation in the substation in an effort to capture maximum noise from the substation with all equipment operating. Measured audible noise levels at all the locations were below the Ocean City Noise Ordinance's allowable noise limits (65 dB-A for day time periods, and 55 dB-A for night time periods, or below the lower noise limits of 60 dB-A day time and 50 dB-A night time at locations where the presence of a discrete tone was determined).

Introduction

Delmarva Power & Light (Delmarva) upgraded the existing 138th Street Substation in Ocean City, Maryland, by adding a Static VAR Compensator for line voltage regulation. At the request of Delmarva Power & Light (Delmarva), and in accordance with the Conditional Use Agreement (#12-12100002) with Ocean City, Maryland, that calls for semi-annual reporting of audible noise levels each January and July, after the Static VAR compensator (SVC) was placed in service at the 138th Street Substation, Exponent performed measurements of audible noise at 16 representative locations at the sidewalk in front of residences across the street around the perimeter from the 138th Street Substation in Ocean City, Maryland. Similar audible noise measurements taken in June 2014, December 2014, July 2015, January 2016, May 2016, January 2017, June 2017, January 2018, May 2018, January 2019, June 2019, and January 2020 have been reported previously.

The substation is located between 137th Street and 138th Street and bordered by Sinepuxent Avenue and Derrickson Avenue. The substation is bordered by residential neighborhoods to the north and west. The substation's eastern side is across the street from an Elk's Lodge and the substation's south side is across the street from a water treatment plant. Coastal Highway (Route 528) is one block east of the substation and is the main north-south thoroughfare in Ocean City with multiple lanes. The Atlantic Ocean is approximately two blocks east of the substation. An aerial view of the 138th Street Substation and surrounding area is shown in Figure 1.

Audible noise measurements were performed between the day time hours of 7:00 pm and 9:00 pm on May 26, 2020. Night time measurements were performed between 11:00 pm on May 26, and 1:00 am on May 27, 2020. Audible noise measurements were taken during day time and night time hours at two locations adjacent to residential neighborhoods along Sinepuxent Avenue in the general vicinity of the substation but located approximately one-quarter mile or more north of the substation to determine neighborhood audible noise levels for comparison. A measurement of the audible noise also was taken at an additional location for comparison (northwest corner of the intersection of Derrickson Avenue and 136th Street), one block south of the substation. This

location was at a similar distance from the water treatment plant, as was a residence on Derrickson Avenue and 137th Street, across from the southwest corner of the substation.

The substation has four large driveway access doors with external security fencing in front of them; two on the north side along 138th Street and two on the south side along 137th Street. These driveway access doors are normally kept closed and the fencing locked. During the audible noise measurements on May 26 and 27, the southwest driveway access door along 137th Street was open although the external fencing was still locked as shown in Figure 2.

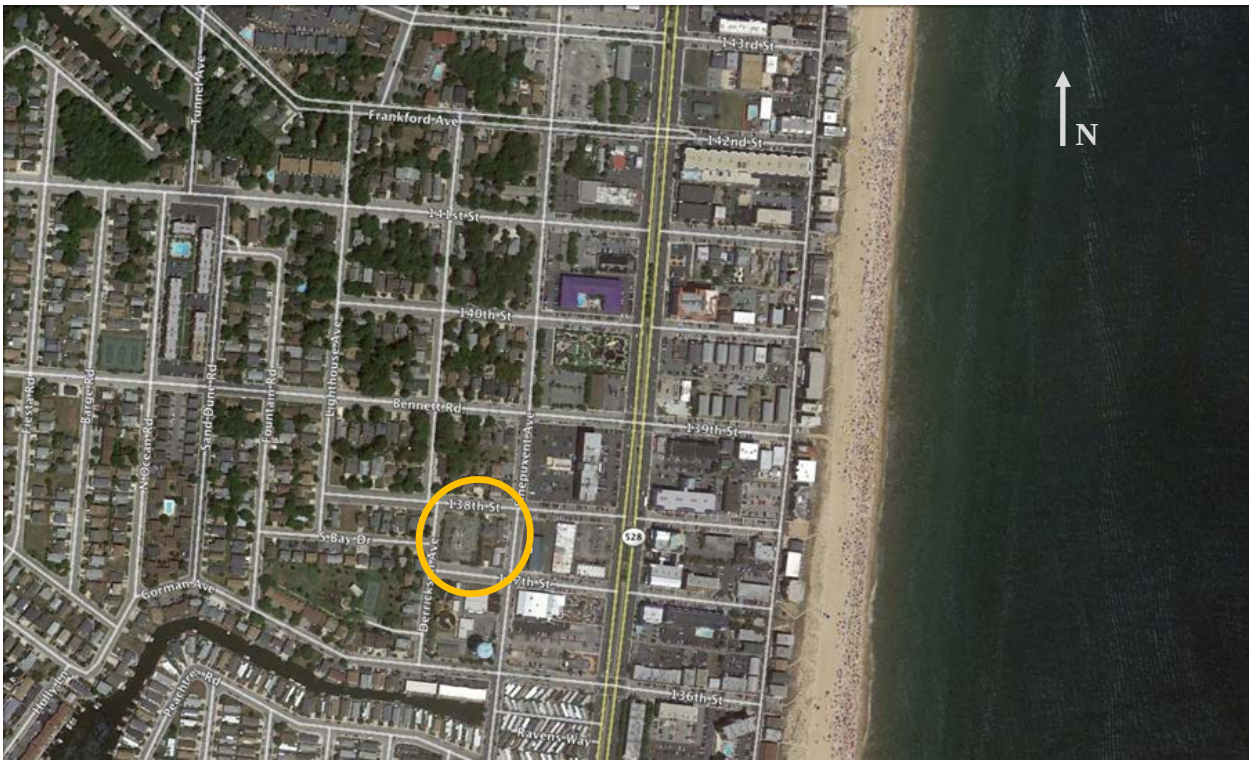

Figure 1. Aerial view showing 138th Street Substation and adjacent area (circled).

The substation is one block west of the multi-lane Coastal Highway and is across the street from residential neighborhoods to the north and west. A water treatment plant is across the street on the south side of the substation and an Elk's Lodge is across the street on the east side of the substation.

Figure 2. Driveway access door to the substation that was open during the audible noise measurements May 26 and 27, 2020. The open driveway access door is along 137th Street on the southwest side of the substation, facing the water treatment plant.

Noise Limits

In general, the municipal noise ordinances in Ocean City follow the form of the Maryland State Noise Regulations. Permissible levels are 65 decibels on the A-weighted scale (dB-A) during day time hours (between 7 AM and 10 PM) and 55 dB-A during night time hours (between 10 PM and 7 AM). In addition, if there are prominent discrete tones determined to be present in the audible noise, the permissible limits are 5 decibels less (i.e., 60 dB-A during the day and 50 dB-A during the night).[1,2]

As noted above, audible noise levels are measured in dB-A, which indicates that an A-weighting factor is applied to the audible noise levels. The A-weighting factor closely corresponds to the response of the human ear to sound pressure levels (audible noise) and its use is required by the Ocean City and Maryland codes that pertain to audible noise.

[1] Ocean City, Maryland Code of Ordinances – Chapter 30, Article 5, Division 6, Section 30-367 - Maximum noise levels in residential districts. (http://library.municode.com/index.aspx?clientId=12833&stateId=20&stateName=Maryland)

[2] State of Maryland, Department of Environment, COMAR Section 26.02.03.02 – Environmental Noise Standards. (http://www.dsd.state.md.us/comar/getfile.aspx?file=26.02.03.02.htm).

Measurements

Equipment

Audible noise measurements were taken at approximately ear height (~5 feet) using a Brüel & Kjær (B&K) 2270 audible noise meter with a half-inch microphone. The meter is a Type I meter that exceeds the specifications of a Type II meter and is compliant with ANSI S1.4 (2014).[3] One-third (1/3) octave band measurements of the audible noise from 12 Hertz (Hz) to 20 kilohertz (kHz) with no weighting also were taken to allow for further analysis. The calibration of the audible noise meter was confirmed before and after the measurements. See calibration certificate in Appendix A.

Measurement Locations

Audible noise measurements were taken at 16 representative locations around the perimeter across the street from the 138th Street Substation at the sidewalk in front of adjacent properties during day time and night time hours on May 26 and 27, 2020. To determine neighborhood noise levels in the area, audible noise measurements were also taken during day time and night time hours at locations in residential neighborhoods similar to those adjacent to the 138th Street Substation. Two locations for additional neighborhood measurements were along Sinepuxent Avenue, approximately one-quarter mile or more north of the substation. Audible noise measurements were also taken at a location on the northwest corner of the intersection of Derrickson Avenue and 136th Street, south of the substation.

The day time audible noise measurements at background locations and around the substation were performed between the hours of 7:00 pm and 9:00 pm on May 26, 2020. The night time audible noise measurements were performed between 11:00 pm on May 26 and 1:00 am on May 27, 2020. The locations where the measurements were performed are listed in Table 1 and shown graphically in Figure 3 (locations ‘a’ through ‘p’ around the substation), Figure 4 (neighborhood noise measurement locations ‘r’ and ‘s’), Figure 5 (neighborhood noise measurement ‘t’), and Figure 6 (area of all measurement locations).

[3] See calibration certification - Appendix A.

Figure 3. Aerial view showing 138th Street Substation and location of audible noise measurements (‘a’ through ‘p’) across the street around the perimeter of the substation on the sidewalk in front of adjacent properties.

The aerial reference image of the substation is overlaid with a shaded rectangle to highlight the location of the substation.

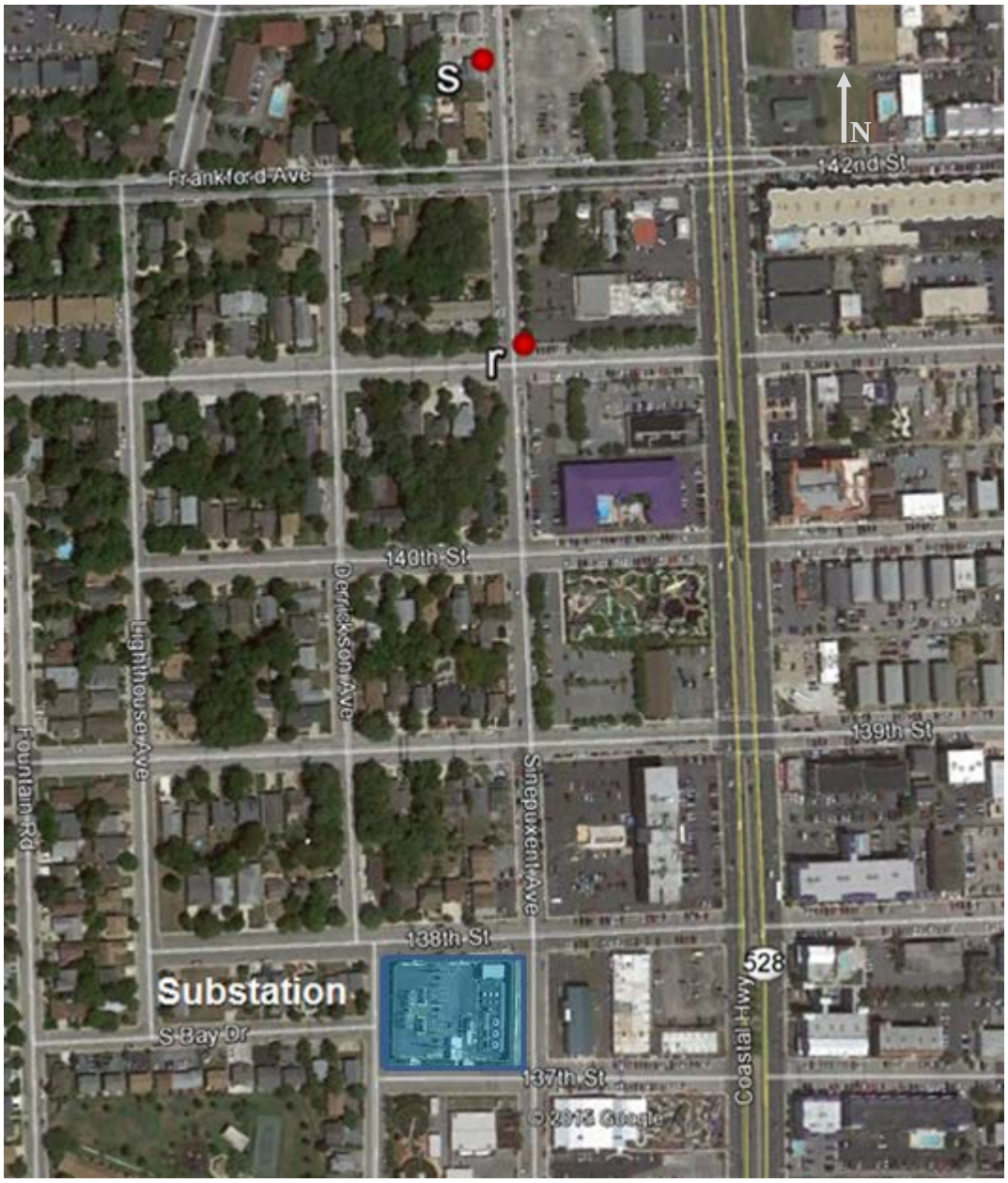

Figure 4. Aerial view showing the locations of the neighborhood noise measurements ('r' and 's') adjacent to residential neighborhoods at similar distances as the substation from the Coastal Highway and the Atlantic Ocean.

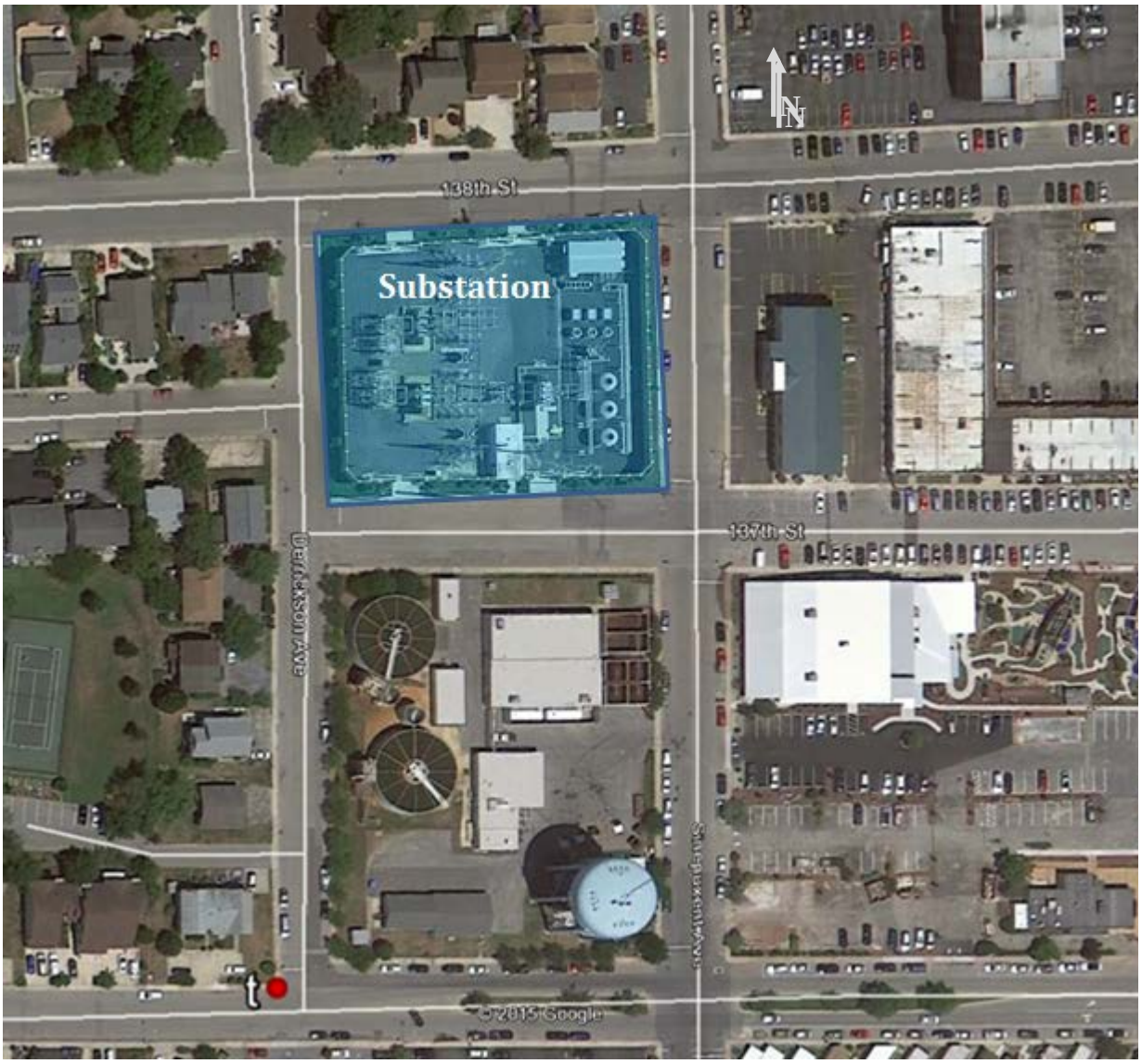

Figure 5. Aerial view showing the location of the neighborhood noise measurement ('t') in the lower left corner of the figure adjacent to a residential neighborhood at a similar distance to the water treatment plant as residences to the substation.

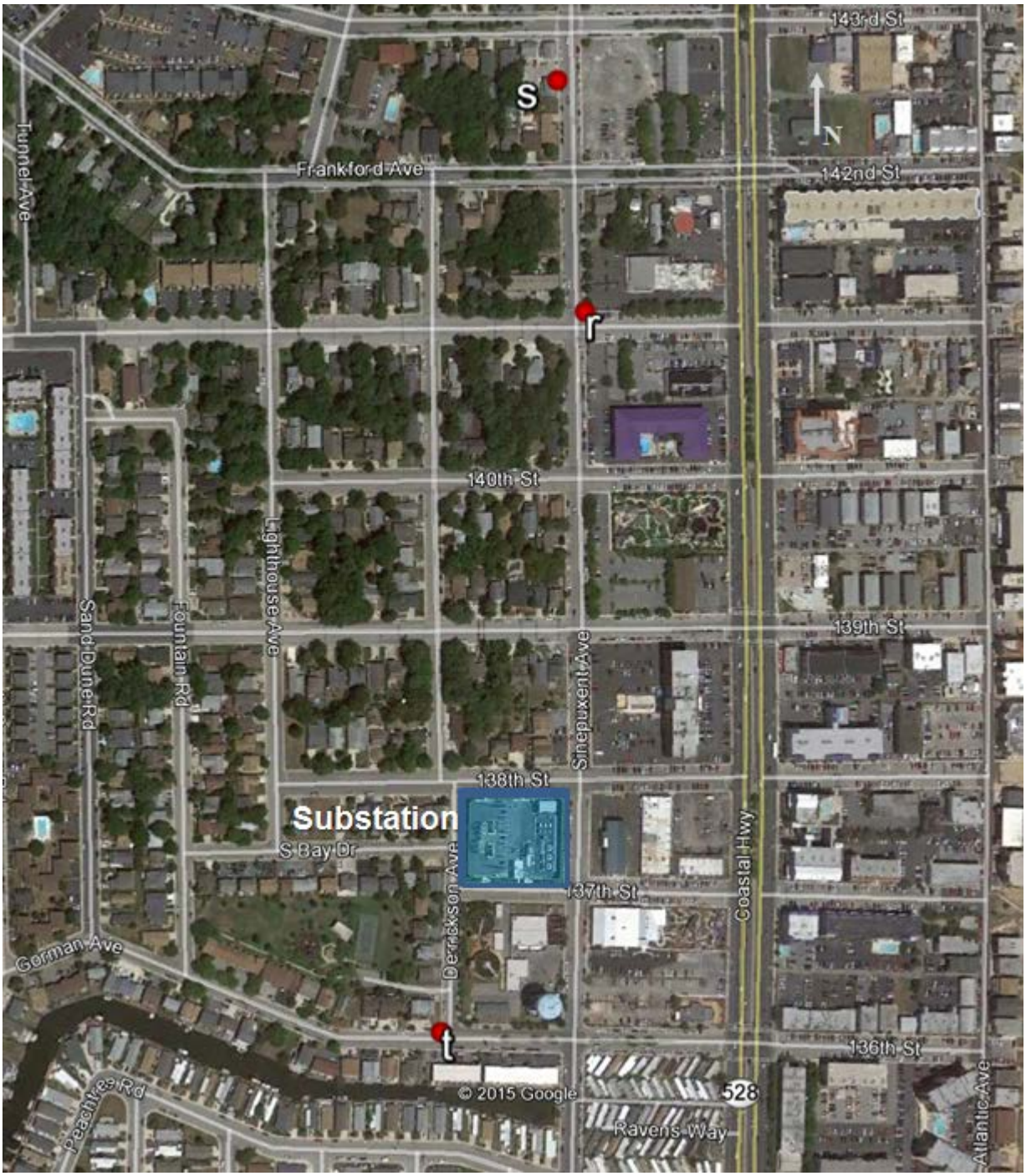

Figure 6. Aerial view showing the locations where all neighborhood noise measurements were taken (‘r’, ‘s’ at the upper center of the figure, and ‘t’ in the lower center of the figure) in relation to the substation and the Coastal Highway (Route 528).

Table 1. Locations of audible noise measurements

Location	Description
At sidewalk in front of adjacent property around the perimeter of the 138th Street Substation	
a	West side of water treatment plant – across the street from the southwest corner of the substation
b	Midway along water treatment plant – across the street from the middle of the south side of the substation
c	East side of water treatment plant – across the street from the southeast corner of the substation
d	Southeast corner of 137th Street and Sinepuxent Avenue – across the street from the southeast corner of the substation
e	South of Elk's Lodge – across the street from the southeast corner of the substation
f	Midway along Elk's Lodge – across the street from the middle of the east side of the substation
g	North of Elk's Lodge – across the street from the northeast corner of the substation
h	Northeast corner of 138th Street and Sinepuxent Avenue – across the street from the northeast corner of the substation
i	Gate at the side of 13801-A Sinepuxent Avenue – across the street from the north side of the substation
j	204 138th Street – across the street from the north side of the substation
k	206 138th Street – across the street from the north side of the substation
l	208 138th Street – across the street from the north side of the substation
m	Northeast corner of 138th Street and Derrickson Avenue – across the street from the northwest corner of the substation
n	Side of northern residence along Derrickson Avenue – across the street from the west side of the substation
o	Side of southern residence along Derrickson Avenue – across the street from the southwest corner of the substation
p	Southwest side of 137th Street and Derrickson Avenue – across the street from the southwest corner of the substation
Locations for Measurement of Background Noise for Comparison	
r	Northeast corner of the intersection of 141st Street and Sinepuxent Avenue
s	14203-A Sinepuxent Avenue – west side of Sinepuxent Avenue
t	Northwest corner of the intersection of 136th Street and Derrickson Avenue

Measurement Results

The audible noise measurements were taken during times relatively free from discernible brief extraneous noise intrusions such as passing cars, trucks, or motorcycles on the nearby roads; passing planes, helicopters, fireworks; as well as pumps, fans, motor, or heating, ventilation, and air conditioning activity at the adjacent properties. A-weighted noise measurements were taken at each location. Un-weighted, one-third octave band measurements were also measured at each location to assess the occurrence of prominent discrete tones in the noise measurements and to allow more detailed analysis.

Noise measurements were made during day time and night time hours with the substation operating with the SVC and all cooling fans running. During the measurements on May 26 and 27 the driveway door on the southwest side of the substation was open. All other substation doors were closed. The weather conditions during the period when audible noise measurements were taken were fair with temperatures gradually cooling during the measurement periods from 70ºF to 63ºF for the day time measurements and 61ºF to 59ºF for the night time measurements. Winds were generally 1 to 4 mph during the day time period, with occasional brief gusts to 7 mph. When audible noise measurements were recorded, the wind speeds were typically less than 3 mph. During the night-time period the winds were generally calm to 1 mph with fog like conditions. The winds were generally calm when the audible noise mesurements were recorded.

The day time and night time A-weighted audible noise measurements at each location (‘a’ through ‘p’) along the perimeter across the street from the 138th Street Substation property with the SVC and cooling fans running are listed in Table 2 along with noise measurements that were made at remote locations away from the substation (‘r’, ‘s’, and ‘t’). The audible noise measurements were made with the microphone facing toward the substation at approximately ear height (~5 feet), unless noted otherwise.

The allowable noise for adjacent residentially-zoned properties in Ocean City, Maryland, is 65 dB-A during day time hours (7 am to 10 pm) and 55 dB-A during night time hours (10 pm to 7 am). Noise regulations for the State of Maryland further reduce these levels by 5 decibels if prominent discrete tones are determined. The one-third octave band spectrum for each

measurement location was checked for prominent discrete tones per State of Maryland Noise Standards.[4] The results of the audible noise measurements are discussed below.

Table 2. Measured audible noise (dB-A weighting)

	Day Time Period (7 AM to 10 PM)	Night Time Period (10 PM to 7 AM)
Location	**SVC and All Fans**	**SVC and All Fans**
At sidewalk in front of adjacent property around the perimeter of the 138th Street Substation		
a	50	50
b	50	49
c	49	48
d	48	48+
e	46	50+
f	47	48
g	48	45
h	45	43
i	43	44
j	42	44
k	43	45
l	46	47+
m	46	46
n	46	46
o	51	51
p	53	54
Neighborhood Locations away from Substation§		
r	40 - 42	35 - 35
s	46 - 45	41-39
t	47 - 49	48-48

+ Discrete tone measured in 125 Hz 1/3 octave band. Level in compliance with reduced night time level of 50 dB-A.
§ Sound levels shown are for measurements made at the beginning and end of the measurement period, respectively.

[4] State of Maryland, Department of Environment, COMAR Section 26.02.03.01 – Environmental Noise Standards. (http://www.dsd.state.md.us/comar/getfile.aspx?file=26.02.03.01.htm).

Day Time Measurement Results

All locations were in compliance with day time audible noise levels. The average of the measurements of audible noise around the substation (locations 'a' through 'p') during the day was 47 dB-A. This is a bit higher than the average of the audible noise at locations 'r', 's', and 't' (45 dB-A) in similar neighborhoods away from the substation but not a just-noticeable-difference. A difference of at least 3 dB in sound levels is needed before there is a notable change in the level detected by the human ear.[5] No prominent discrete tones were determined to be present in any of the day time measurements.

Night Time Measurement Results

All locations were in compliance with night time audible noise levels. The average of the audible noise measurements around the substation (locations 'a' through 'p') at night, 47 dB-A, is higher than the night-time sound levels measured in similar neighborhoods at locations 'r', 's', and 't' (average of 41 dB-A). Additional analysis of the one-third octave spectrums (Appendix B) determined that there was a prominent discrete tone present in the 125 Hz 1/3 octave band in the night time measurement at locations 'd', 'e', and 'l' (Figure 3: 'd' and 'e' are , southeast of the substation at the corner of Sinexpuxent Avenue and 137th Street; and 'l' is northwest of the substation). Additional analysis of the one-third octave spectrums (Appendix B) determined that there was a prominent discrete tone present in the 125 Hz 1/3 octave band in the night time measurement at locations 'd', 'e', and 'l' (Figure 3: 'd' and 'e' are , southeast of the substation at the corner of Sinexpuxent Avenue and 137th Street; and 'l' is northwest of the substation along 138th Street). The audible noise measurement at the locations 'd', 'e' and 'l' (48, 50, and 47 dB-A respectively) were in compliance with the reduced night time level of 50 dB-A even though a discrete tone was determined. No prominent discrete tones were determined to be present in any of the other night time measurements.

[5] Hansen CH. Fundamentals of Acoustics. In: Occupational Exposure to Noise: Evaluation, Prevention and Control. Goelzer B, Hansen CH, Sehrndt GA (Eds.). Lyon, France: World Health Organization, 2001. Available at http://www.who.int/occupational_health/publications/occupnoise/en/.

Conclusions

Day Time

The dB-A levels of audible noise that were measured at locations on the sidewalk in front of adjacent properties across the street around the perimeter of the 138th Street Substation during day time hours comply with the Ocean City Noise Ordinance, and the State of Maryland's allowable limits for day time hours.

Night Time

The dB-A levels of audible noise at the same locations adjacent to the 138th Substation were measured during night time hours and also comply with the Ocean City Noise Ordinance, and the State of Maryland's allowable night time limits.

The measured audible noise levels at each location considered all audible noise sources, which included background neighborhood noise as well as noise from the substation. The audible noise due only to the substation will be less than the total audible noise measured at any particular location. The additional effort of removing the contribution of background neighborhood noise from the measurements in order to determine the noise contribution from just the substation was not performed since the total audible noise levels from all sources at all locations comply with the Ocean City Audible Noise Ordinance.

Appendix A

Calibration Certificates

Certificate of Calibration

Asset ID 13667

Work Order 31743

Certificate Number: 31743
Certificate Date: 5/14/2020

Manufacturer: Bruel & Kjaer
Model: 2270,4231,BZ-7223,BZ-7224,BZ-722
Serial Number: 3006112
Description: Modular Platform Sound Level Meter w/Freq

Date Received: 11/26/2018
Date of Calibration: 11/26/2018
Recommended Due Date: 8/1/2020
Temperature: 23.90 °C
Relative Humidity: 38.3 %RH

Cal Procedure
BE 1713-27

Customer Name: Advanced Test Equipment Corporation
Customer Address:: 10401 Roselle Street, San Diego CA 92121
PO Number:
CRM Order Number: End of Rental

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC's Active Use Calibration System.
This calibration conforms to the requirements of ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994 (R2002).
In the attached measurement results, deviation may be expressed with units, Measured Value (MV) - Nominal Value (NV) or as a proportion of the nominal value ((MV-NV)/NV), expressed without units with a scalar multiplier such as % (0.01), or as a ratio of the units (mA/A, µV/V, etc.)
Descriptions such as µA/A, µV/V, and others, where used to annotate results or column headings are the preferred replacements for what was historically labeled as "ppm" or parts-per-million and described the results in that column, unless otherwise noted by units symbols.
Where applicable, the expanded uncertainty of measurement at the time of test is given in the following pages. They are calculated in accordance with the method described in the ISO Guide to the Expression of Uncertainty in Measurement (GUM). The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k, such that the confidence level approximates 95%.
This Calibration certificate may contain data that is not covered by the A2LA Scope of Accreditation. Unaccredited material, where applicable is indicated by an asterisk (*), or confined to clearly marked sections. Functional (Pass / Fail) tests are not accredited.
No statement of compliance with specifications is made or implied on this certificate. However, measurement results are reviewed, where applicable, to establish where any measurement result exceeded the manufacturer's specifications.
Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Standards Utilized

Asset I.D.	Manufacturer	Model No.	Description	Cal. Date	Due Date
L-12153	Bruel & Kjaer	BRUE-4231	94/114dB SPL Sound Pressure Level Calibrator, 1kH	11/15/2018	11/15/2019

Calibration Performed By:		Authorized by:	
Lucero, Lawrenze M	Technician	Javier Estrada	05/14/2020
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications

ATEC Corporation
10401 Roselle St.
San Diego, CA 92121

Telephone 888-488-2832
Facsimile 858-588-6570
Internet www.ATECorp.com

QF21/122713

Certificate of Calibration

Asset ID 14410

Work Order 30074

Certificate Number: 30074
Certificate Date: 5/14/2020

Manufacturer: Bruel & Kjaer
Model: 4231
Serial Number: 3009615
Description: 94/114dB SPL Sound Pressure Level Calibrato

Date Received: 06/12/2018
Date of Calibration: 5/30/2018
Recommended Due Date: 8/30/2020
Temperature: 23.70 °C
Relative Humidity: 40.1 %RH

Cal Procedure
SW 2.3.4 TYPE 7794 PROCEDURE 4231 COMPLETE

Customer Name: Advanced Test Equipment Corporation
Customer Address:: 10401 Roselle Street, San Diego CA 92121
PO Number:
CRM Order Number: Return from Repair and/or Calibration

Comments:
Calibration performed by an Authorized Subcontractor.

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC's Active Use Calibration System.
This calibration conforms to the requirements of ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994 (R2002).
In the attached measurement results, deviation may be expressed with units, Measured Value (MV) - Nominal Value (NV) or as a proportion of the nominal value ((MV-NV)/NV), expressed without units with a scalar multiplier such as % (0.01), or as a ratio of the units (mA/A, µV/V, etc.) Descriptions such as µA/A, µV/V, and others, where used to annotate results or column headings are the preferred replacements for what was historically labeled as "ppm" or parts-per-million and described the results in that column, unless otherwise noted by units symbols.
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No statement of compliance with specifications is made or implied on this certificate. However, measurement results are reviewed, where applicable, to establish where any measurement result exceeded the manufacturer's specifications.
Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Swann, William A	Technician	Javier Estrada	05/14/2020
Name	Title	Metrology Supervisor	Certificate Date

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QF21/122713

Appendix B

Audible Noise Spectrums

Audible Noise Spectrums

Measurements of the un-weighted audible noise level in each one-third octave band were made across the street at locations around the perimeter of the 138th Street Substation on the sidewalk in front of properties adjacent to the substation and at the locations remote from the substation, as shown in Figures 3, 4, 5, and 6 in the main body of this report. The additional un-weighted audible noise one-third octave band measurements were made to allow for evaluation of prominent discrete tones and for flexibility in future use of the measured levels.

Weighted audible noise levels, such as dB-A or dB-C (decibels with A or C weighting, respectively) or other weighted audible noise levels, can be calculated at a location by using the un-weighted one-third octave band measurements and applying the appropriate weighting factors. The A or C weighting factors for the various octave bands generally result in a decrease to the un-weighted audible noise level measured for a particular one-third octave band.

Prominent discrete tones are considered to be present if the unweighted dB level of a one-third octave band is: 15 dB greater than the arithmetic average of the two adjacent one-third octave bands for center frequencies at or below 125 Hz; 8 dB greater, for center frequencies between 160 Hz and 400 Hz; and 5 dB greater, for frequencies at or above 500 Hz.[6] If a discrete tone is determined to be present in the spectrum, then the allowable dB-A level is reduced by 5 dB to 60 dB-A during the day time hours (7 am to 10 pm) and 50 dB-A during night time hours (10 pm to 7 am). The spectrum at each location was checked for the presence of prominent discrete tones. A prominent discrete tone in the 125 Hz one-third octave band was determined to be present at locations ‘d’, ‘e’ and ‘l’ during the night time measurements, but the overall levels at locations ‘d’, ‘e’ and ‘l’ complied with the reduced night time level of 50 dB-A that applies when a discrete tone is determined.

The audible noise level in each one-third octave band is listed below at the measurement locations for day and night conditions with the SVC and all cooling fans turned on (Table B-1a and Table B-1b for day time; Table B-2a and Table B-2b for night time). The one-third octave band audible noise spectra are also plotted in Figures B-1 through B-16, below, for each of the locations around the substation. The audible noise levels in each one-third octave band at noise locations (‘r’, ‘s’, and ‘t’) away from the substation are listed in Table B-3a and Table B-3b for day time and night time and plotted in Figures B-17, B-18, and B-19.

[6] State of Maryland, Department of Environment, COMAR Section 26.02.03.01 – Definitions. (http://www.dsd.state.md.us/comar/getfile.aspx?file=26.02.03.01.htm)

Table B-1a. Unweighted audible noise spectrum (day time: SVC and all cooling fans ON)

Location	1/3 Octave Band Center Frequency (Hz)																	
	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630
a	44.2	43.6	45.6	46.5	44.7	46.5	44.8	46.2	47.7	47.9	57.5	46.6	48.8	48.6	44.5	44.7	41.0	40.3
b	42.1	44.2	48.1	49.9	46.6	48.2	45.7	44.8	46.4	44.6	48.9	45.5	43.8	45.8	45.0	46.2	38.9	38.6
c	44.2	44.5	44.1	46.2	43.3	45.6	44.1	45.7	45.4	47.1	57.7	43.6	41.5	41.4	42.0	44.4	41.9	39.9
d	45.5	42.0	47.5	49.9	45.4	45.8	44.0	45.3	44.8	48.1	60.3	44.4	42.7	41.7	39.0	41.2	36.5	35.5
e	43.0	41.1	41.6	43.1	43.1	47.4	42.8	44.1	44.9	44.4	51.1	43.0	42.4	42.4	39.5	41.4	35.2	35.4
f	41.2	41.4	42.1	46.0	44.0	47.8	45.8	45.3	44.0	46.3	56.1	43.6	41.8	41.6	40.5	42.6	37.3	37.0
g	42.3	42.0	42.3	43.5	43.3	46.6	45.5	47.2	47.6	47.7	57.3	49.0	43.3	43.2	42.5	41.1	38.5	38.4
h	40.3	38.0	38.7	41.0	42.0	46.3	43.5	43.3	45.2	45.2	54.6	42.2	40.8	38.0	37.7	38.5	35.4	34.6
i	41.1	40.1	39.4	38.5	41.2	48.1	43.2	41.5	42.2	42.8	49.0	40.9	38.8	38.5	36.3	37.1	36.9	33.8
j	41.2	38.7	37.7	41.5	41.0	44.4	40.2	41.3	41.5	39.6	41.4	39.2	36.9	36.5	35.5	37.3	34.3	33.0
k	39.3	37.6	39.3	40.3	40.7	44.6	42.0	42.5	43.2	41.0	49.1	40.1	38.0	38.6	36.0	38.2	34.8	34.4
l	39.7	38.0	41.0	42.4	40.7	45.9	42.9	42.6	43.3	45.6	57.6	40.7	37.5	36.9	35.7	38.2	35.5	33.7
m	39.5	38.5	39.1	40.6	39.8	45.3	43.7	40.7	41.2	42.8	50.3	44.7	45.1	43.4	41.5	45.0	35.4	33.6
n	43.4	43.2	44.1	41.6	41.5	46.1	42.1	42.9	44.0	44.6	50.0	46.4	46.2	44.7	38.2	39.4	37.1	36.4
o	42.5	40.9	45.1	42.7	45.9	46.7	44.9	46.1	46.3	46.6	56.2	47.5	45.8	47.1	46.3	47.2	44.3	41.4
p	43.4	43.3	44.6	43.8	47.1	46.0	45.3	46.1	46.1	46.5	45.0	46.9	47.3	48.8	50.7	51.3	43.2	42.3

Table B-1b. Unweighted audible noise spectrum (day time: SVC and all cooling fans ON)

Location	1/3 Octave Band Center Frequency (Hz)														
	800	1,000	1,250	1,600	2,000	2,500	3,150	4,000	5,000	6,300	8,000	10,000	12,500	16,000	20,000
a	39.7	38.7	37.6	35.3	33.8	33.0	33.2	31.4	28.1	28.3	27.6	25.3	23.0	18.8	13.9
b	39.7	38.3	36.4	36.0	35.3	36.7	31.8	29.6	27.6	26.5	26.1	25.1	23.6	20.4	16.3
c	38.8	36.8	34.1	32.2	32.6	30.5	29.2	27.2	24.2	22.7	21.9	19.9	16.8	12.4	9.7
d	35.2	34.5	33.6	31.9	29.9	29.2	29.5	30.2	23.7	19.0	17.6	14.8	12.1	8.9	8.7
e	32.9	32.6	31.6	29.2	28.8	26.4	25.4	23.6	20.2	18.2	16.3	13.4	9.7	7.5	8.4
f	34.8	34.1	33.0	31.3	29.6	28.0	26.8	25.4	21.7	18.7	16.9	13.7	10.0	7.6	8.4
g	37.0	34.9	34.4	32.5	31.8	30.0	29.7	26.9	23.1	21.4	19.9	16.7	11.7	8.5	8.2
h	33.7	32.2	30.7	29.1	27.6	25.4	23.6	21.9	20.0	18.9	17.2	14.8	11.8	8.6	8.6
i	32.8	31.4	30.7	28.4	27.1	26.1	25.9	25.5	24.9	24.8	24.0	22.5	20.5	16.8	12.8
j	33.1	30.1	29.5	27.5	26.1	25.2	25.6	25.6	25.7	25.4	24.9	24.2	22.4	19.7	15.8
k	32.0	30.1	28.9	27.5	26.2	25.8	26.1	25.7	26.2	27.4	27.4	26.4	25.4	22.5	18.1
l	31.7	30.7	29.8	27.9	27.5	26.7	26.6	25.8	26.3	26.7	26.5	25.1	23.7	19.8	15.3
m	33.3	32.1	32.2	30.2	28.5	26.8	25.5	23.6	23.0	23.9	23.3	21.5	18.9	14.6	10.6
n	36.5	35.7	32.9	31.7	30.3	27.9	26.8	24.8	23.4	23.1	22.5	21.0	18.5	14.5	11.4
o	38.7	39.5	37.5	35.8	33.5	31.1	29.2	27.9	24.7	23.2	22.1	20.3	18.6	14.4	10.9
p	42.9	40.2	39.5	38.4	37.2	34.3	31.6	30.2	27.9	26.8	25.8	23.5	20.6	16.2	11.4

Table B-2a. Unweighted audible noise spectrum (night time: SVC and all cooling fans ON)

Location	1/3 Octave Band Center Frequency (Hz)																	
	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630
a	42.3	41.6	43.2	42.1	43.9	45.2	44.4	43.4	48.5	46.6	52.7	46.6	46.7	47.7	45.7	45.9	40.2	41.5
b	42.4	41.1	43.2	44.9	46.2	46.1	44.8	44.4	43.7	46.0	56.4	45.0	44.6	50.5	43.6	43.5	37.9	37.7
c	43.4	41.0	40.2	42.0	40.2	42.8	41.6	43.3	43.5	46.1	57.5	43.1	40.5	39.5	40.7	43.2	42.1	38.9
d	42.9	38.6	41.1	38.4	40.1	41.3	39.7	42.4	43.0	48.9	61.6	43.6	40.7	39.5	38.0	40.6	35.8	35.7
e	42.3	40.0	38.1	38.9	42.0	43.8	40.0	44.0	45.0	50.7	64.1	44.7	43.4	44.3	42.5	45.1	37.4	35.7
f	40.6	37.2	38.3	39.1	40.4	45.0	40.8	41.3	42.6	46.9	59.4	43.9	42.1	40.6	43.0	46.3	37.8	34.4
g	35.6	34.4	36.7	38.6	41.1	47.7	41.2	43.2	42.3	43.7	53.7	41.1	38.7	37.3	38.7	40.3	33.4	32.3
h	36.7	35.9	37.6	38.6	40.1	45.4	41.3	42.9	40.4	41.7	49.3	40.3	39.2	36.8	38.3	40.3	34.3	31.5
i	40.5	36.7	33.9	34.5	39.2	49.8	41.6	40.8	41.1	41.1	49.1	40.4	38.3	37.9	39.1	41.7	35.2	34.1
j	41.4	35.4	35.6	38.4	39.1	40.5	38.8	38.5	40.7	41.7	51.4	40.3	37.3	36.9	36.5	37.1	32.4	33.4
k	37.8	37.8	38.2	36.7	38.3	45.7	37.1	40.1	39.9	43.1	55.7	39.5	37.1	37.9	37.4	39.8	36.9	34.4
l	38.6	35.2	36.9	37.6	38.3	42.7	37.8	38.6	40.4	46.7	60.0	39.8	36.5	36.2	36.3	39.2	33.7	33.4
m	37.7	35.9	36.4	36.2	37.8	42.7	39.0	39.1	40.6	42.2	52.4	44.4	43.0	43.8	41.4	44.8	34.7	33.1
n	39.1	43.2	42.7	38.4	39.2	43.0	39.3	41.4	42.5	42.9	48.7	45.2	45.8	44.0	38.1	39.5	37.7	36.6
o	42.3	40.0	42.6	40.9	45.4	44.6	41.9	44.7	45.4	46.7	57.3	48.8	46.7	44.7	47.1	49.6	44.0	40.4
p	42.2	42.3	40.3	40.6	42.5	44.8	43.3	43.4	46.3	47.7	56.5	46.7	48.3	50.0	51.5	51.2	43.0	43.9

Table B-2b. Unweighted audible noise spectrum (night time: SVC and all cooling fans ON)

Location	1/3 Octave Band Center Frequency (Hz)														
	800	1,000	1,250	1,600	2,000	2,500	3,150	4,000	5,000	6,300	8,000	10,000	12,500	16,000	20,000
a	40.9	38.3	36.1	33.8	34.0	31.5	30.2	29.4	28.5	28.3	27.5	25.5	22.9	18.6	13.5
b	38.4	37.6	35.8	35.8	34.6	34.9	30.7	28.9	27.6	27.3	26.8	25.5	23.8	20.6	16.6
c	38.5	36.8	32.9	30.9	30.5	29.1	27.0	26.3	24.0	23.6	23.2	20.9	18.1	13.7	10.3
d	35.3	32.0	32.3	29.0	27.1	26.4	24.8	23.7	20.6	19.2	18.2	15.6	12.6	9.2	8.5
e	34.0	33.6	32.5	29.6	29.2	27.4	25.0	23.7	21.6	20.2	18.3	15.0	11.7	8.3	8.3
f	33.5	31.4	31.4	28.9	28.1	26.5	24.7	23.2	21.5	19.7	17.6	14.6	11.1	8.1	8.5
g	32.3	29.2	28.6	26.9	25.9	24.0	21.3	19.5	18.2	17.1	15.1	13.1	10.7	8.3	8.3
h	31.1	29.1	28.1	27.0	26.6	24.2	22.0	20.3	19.1	18.4	17.2	14.8	12.1	8.5	8.4
i	32.3	31.3	30.3	27.7	26.7	26.7	27.3	27.2	27.4	27.1	27.0	25.3	22.6	18.7	13.9
j	31.9	30.0	29.1	26.9	26.9	26.7	27.6	27.5	27.2	27.2	26.9	26.3	25.2	22.7	18.5
k	31.6	30.4	28.1	26.9	26.3	26.9	28.4	28.5	28.7	29.0	29.2	28.7	28.3	25.5	21.2
l	31.4	30.3	29.0	26.7	27.2	27.1	28.6	29.2	29.6	29.9	30.1	28.7	27.5	23.9	18.9
m	32.8	31.9	31.6	30.2	27.9	26.2	26.1	25.6	25.4	25.2	25.1	23.3	20.7	16.2	11.7
n	35.8	34.2	32.4	31.9	29.6	27.6	26.9	25.3	23.9	23.6	23.4	21.9	20.0	15.9	11.9
o	37.3	38.9	36.8	35.5	33.6	31.3	29.0	27.1	24.6	23.3	22.5	20.3	18.4	14.4	10.9
p	42.4	40.9	39.6	37.9	36.4	34.3	31.8	30.9	28.7	26.9	25.4	22.4	18.2	12.8	9.5

Table B-3a. Unweighted audible noise spectrum (comparison locations)

Location	1/3 Octave Band Center Frequency (Hz)																	
	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630
May 26 (day)																		
r-Day (7:22 pm)	44.4	43.4	44.4	43.7	42.8	45.1	43.7	43.4	44.0	44.3	42.9	37.7	35.2	33.5	31.2	30.4	28.6	27.9
s-Day (7:25 pm)	39.3	36.9	40.4	45.8	44.3	45.7	43.6	44.2	44.8	44.4	43.1	41.4	41.3	38.3	37.2	37.2	34.1	34.2
t-Day (7:33 pm)	44.4	43.3	43.4	42.4	41.9	43.2	43.2	43.9	43.3	43.1	43.2	46.6	46.7	44.2	40.4	41.5	39.1	38.9
r-Day (8:48 pm)	43.8	42.7	42.5	43.5	43.3	43.6	46.0	43.0	43.3	41.8	42.3	39.4	37.4	36.2	33.3	32.8	31.6	32.1
s-Day (8:54 pm)	41.4	38.4	39.8	43.2	47.0	46.5	43.0	42.9	42.7	43.1	42.6	40.6	40.6	39.4	38.5	36.1	34.5	35.5
t-Day (8:36 pm)	39.5	41.6	42.5	43.5	42.7	42.4	44.1	44.8	43.4	44.4	44.2	47.5	46.7	42.6	40.8	43.4	41.2	40.6
May 26 (night)																		
r-Night (11:21 pm)	38.4	37.1	37.6	36.2	36.9	36.7	37.5	38.6	38.7	39.1	38.0	35.5	32.9	31.7	29.1	28.1	26.1	25.3
s-Night (11:14 pm)	38.8	34.5	37.8	41.5	42.7	40.4	39.6	41.7	41.8	40.3	41.5	39.7	38.1	36.1	34.6	33.4	30.4	29.3
t-Night (11:29 pm)	41.9	41.3	41.2	41.0	40.7	41.0	44.1	44.4	42.9	43.7	41.4	46.4	46.1	42.9	41.2	44.9	40.4	41.0
May 27 (night)																		
r-Night (12:42 am)	34.6	34.6	35.3	36.2	36.3	34.8	35.6	37.3	39.2	38.2	37.3	34.9	32.7	30.9	28.8	27.9	25.0	24.3
s-Night (12:45 am)	36.6	33.2	35.7	39.4	41.6	39.1	37.2	38.5	39.1	39.8	39.1	37.6	36.9	35.2	33.1	31.2	28.8	29.1
t-Night (12:35 am)	38.0	40.0	40.3	41.2	41.4	40.8	43.4	42.7	42.6	44.0	41.7	47.4	47.3	42.0	40.3	44.1	40.4	40.6

Table B-3b. Unweighted audible noise spectrum (comparison locations)

Location	1/3 Octave Band Center Frequency (Hz)														
	800	1,000	1,250	1,600	2,000	2,500	3,150	4,000	5,000	6,300	8,000	10,000	12,500	16,000	20,000
May 26 (day)															
r-Day (7:22 pm)	28.3	28.9	27.4	26.6	24.7	24.2	20.8	16.8	13.7	12.4	9.9	8.4	7.5	7.0	8.3
s-Day (7:25 pm)	35.5	35.6	35.0	34.1	32.3	31.1	28.2	22.6	17.1	12.6	9.1	7.7	7.1	6.8	8.3
t-Day (7:33 pm)	38.6	35.0	33.0	32.5	30.7	29.1	25.6	22.8	18.5	14.5	11.0	8.3	7.2	6.7	8.2
r-Day (8:48 pm)	32.1	31.9	30.9	28.9	27.1	24.5	21.7	22.2	17.2	12.2	9.5	7.8	7.1	6.8	8.4
s-Day (8:54 pm)	34.1	37.2	35.0	32.5	31.0	28.7	24.6	20.5	15.7	10.8	7.7	7.1	6.9	6.8	8.5
t-Day (8:36 pm)	41.4	38.7	37.2	34.9	32.0	30.0	26.1	23.8	19.6	15.2	12.1	8.7	7.2	6.7	8.0
May 26 (night)															
r-Night (11:21 pm)	25.1	24.0	22.9	21.0	20.4	17.3	13.9	10.8	9.1	8.2	7.4	7.3	7.1	6.8	8.4
s-Night (11:14 pm)	28.5	28.6	28.4	27.7	25.5	24.0	21.5	19.3	14.9	13.5	10.2	8.5	7.2	6.7	8.1
t-Night (11:29 pm)	41.8	35.6	35.6	31.7	30.9	28.7	25.3	23.2	19.4	15.2	12.3	9.0	7.3	6.7	8.1
May 27 (night)															
r-Night (12:42 am)	23.2	22.0	20.6	19.3	17.9	16.3	13.0	11.4	9.2	8.5	7.8	7.4	7.1	6.8	8.3
s-Night (12:45 am)	28.1	27.7	27.4	26.0	24.9	21.1	19.1	16.4	14.5	13.2	10.3	8.4	7.2	6.8	8.1
t-Night (12:35 am)	41.5	34.7	34.9	31.6	30.7	28.2	25.1	22.9	19.2	15.3	12.4	9.0	7.2	6.7	8.4

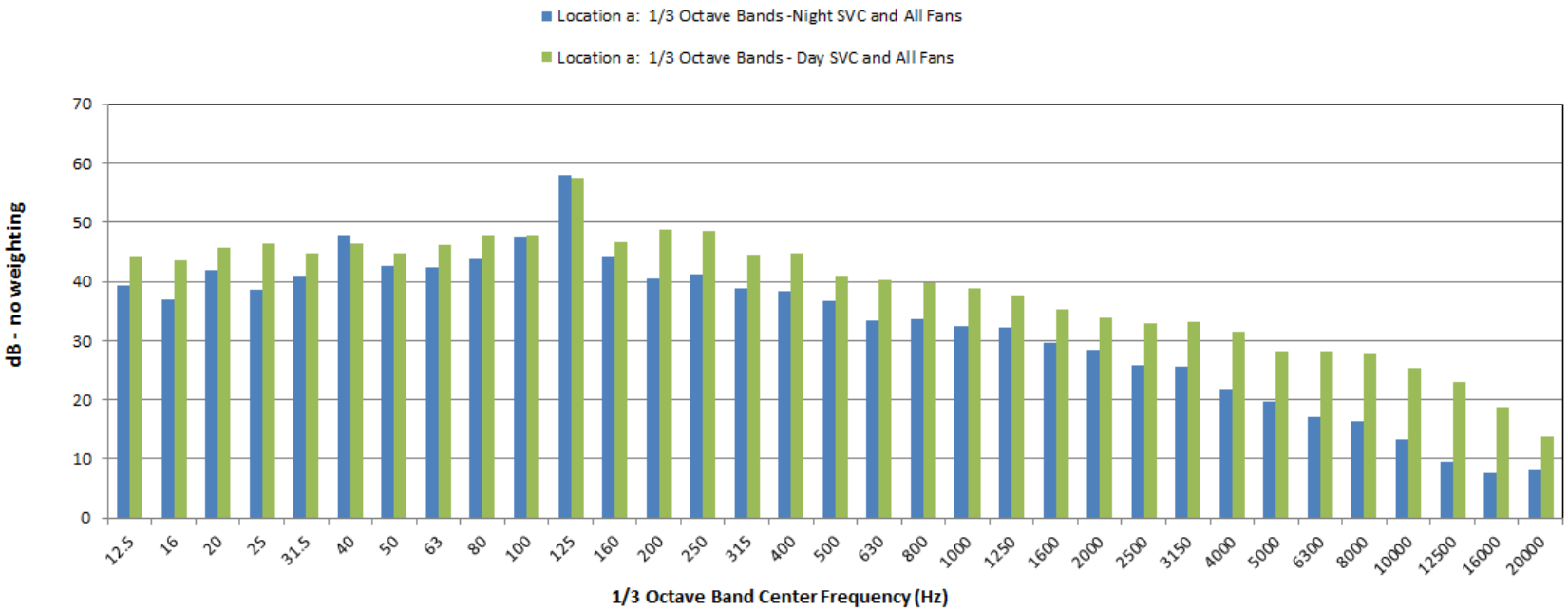

Figure B-1. Unweighted audible noise spectrum – location ‘a’.

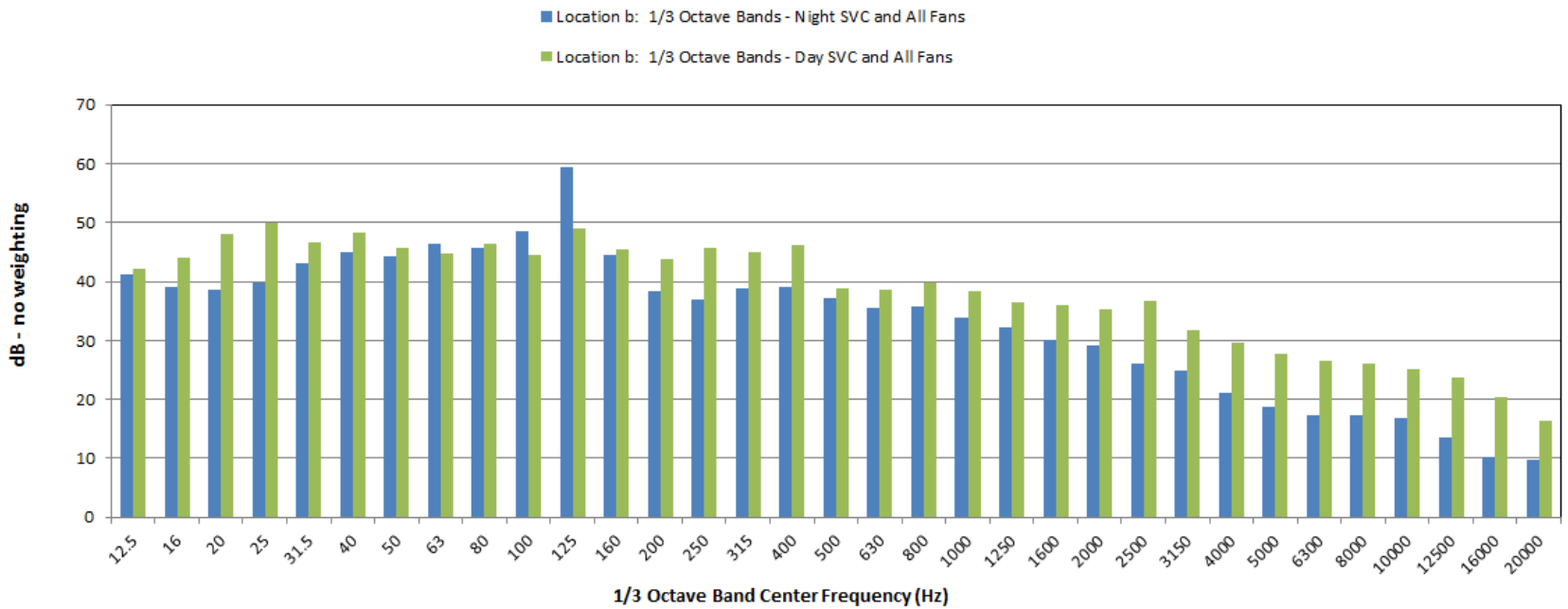

Figure B-2. Unweighted audible noise spectrum – location ‘b’.

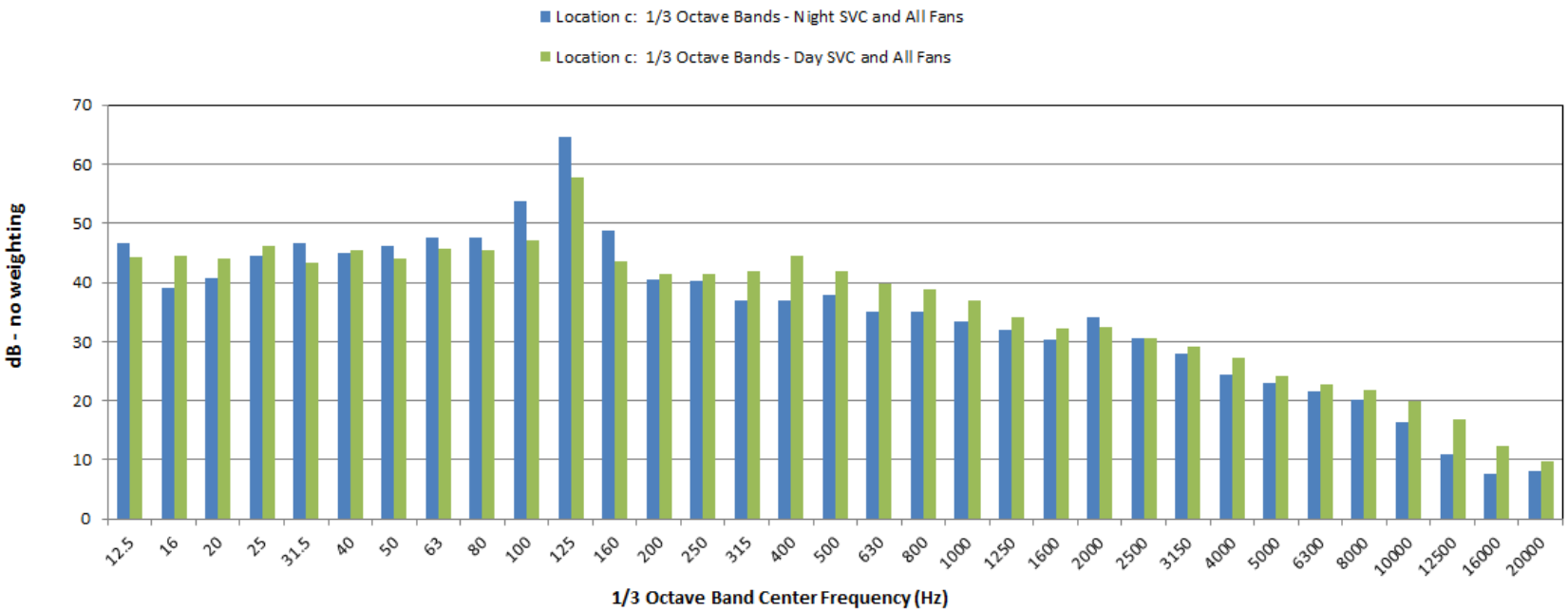

Figure B-3. Unweighted audible noise spectrum – location ‘c’.

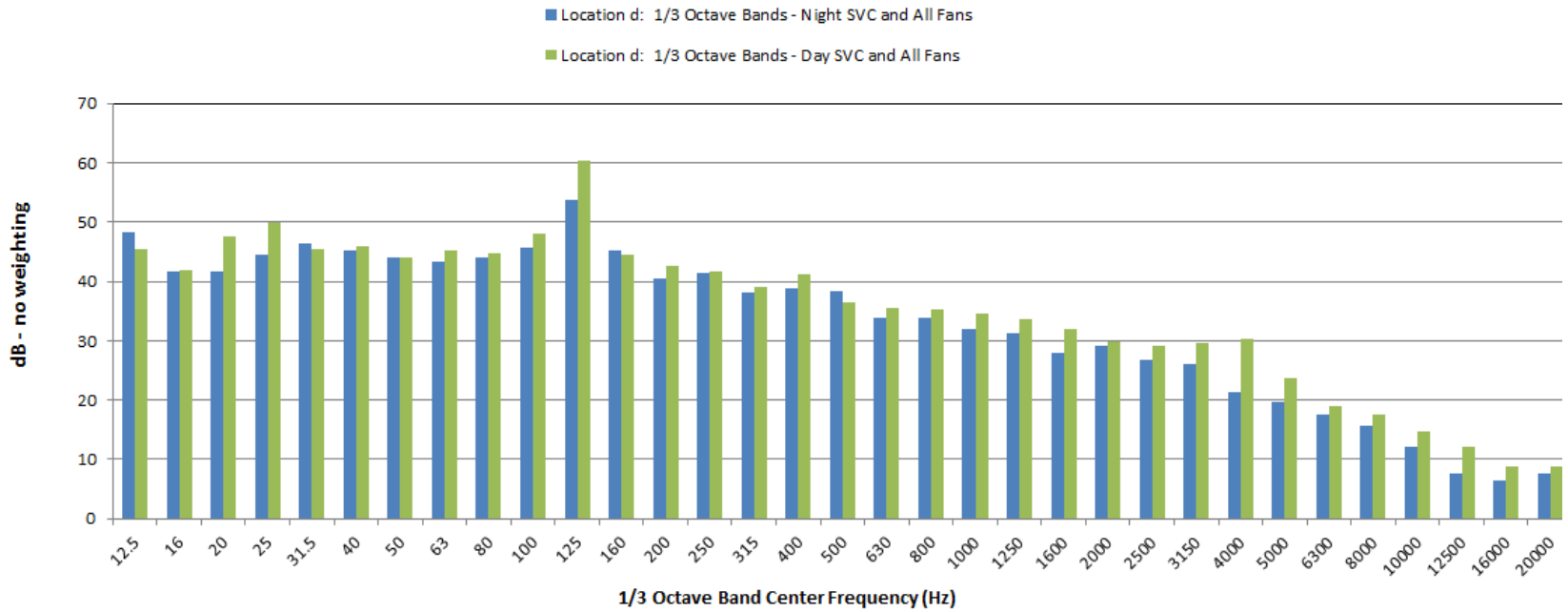

Figure B-4. Unweighted audible noise spectrum – location ‘d’.

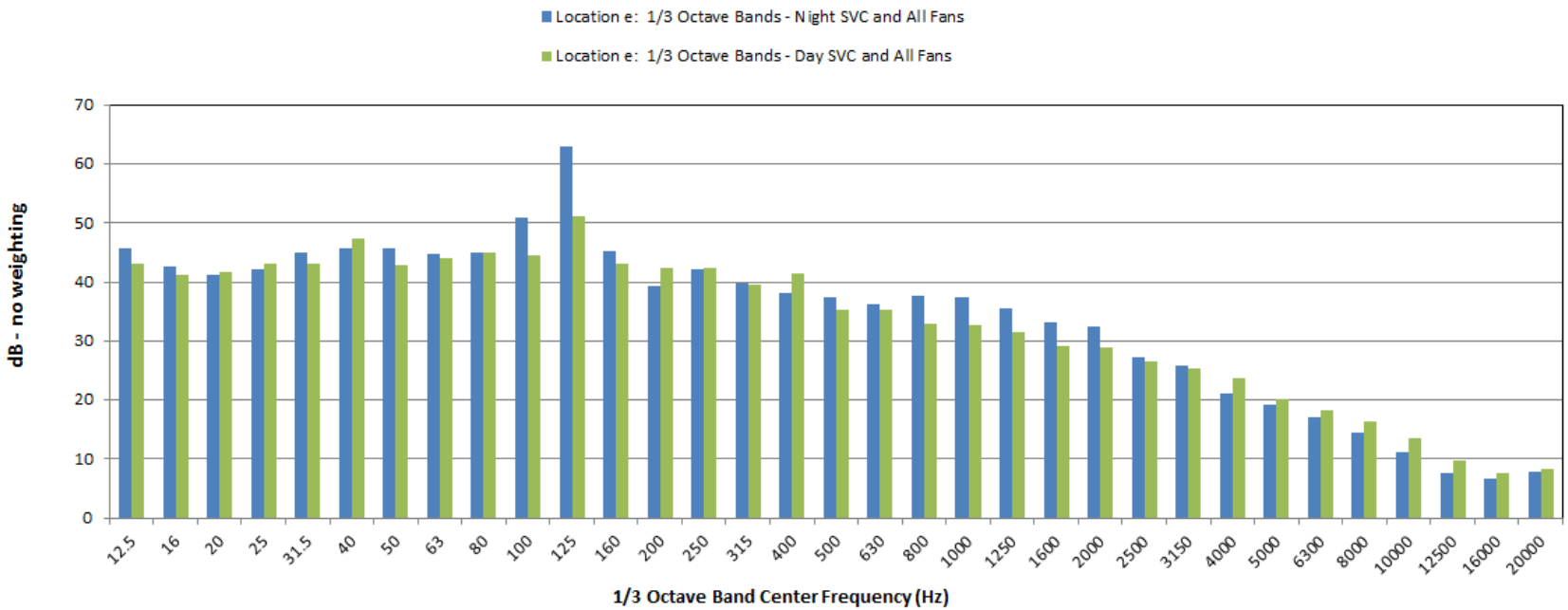

Figure B-5. Unweighted audible noise spectrum – location ‘e’.

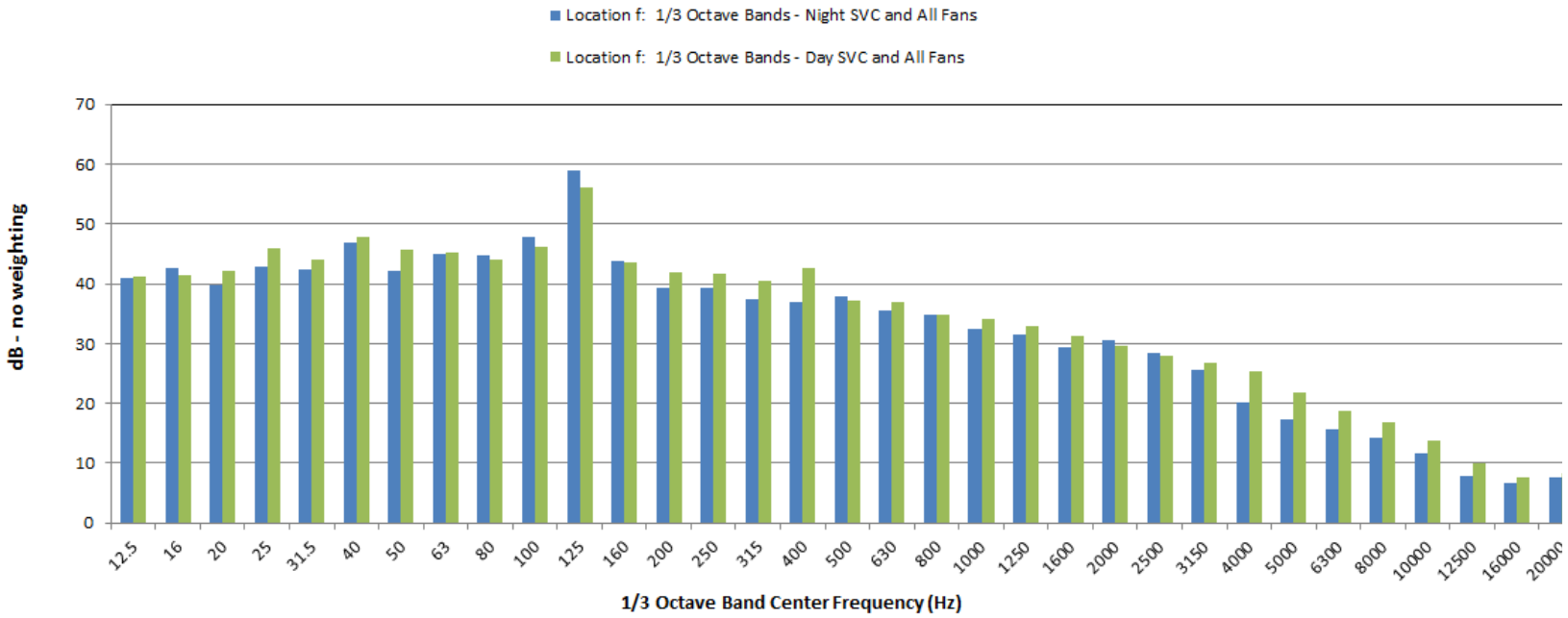

Figure B-6. Unweighted audible noise spectrum – location ‘f’.

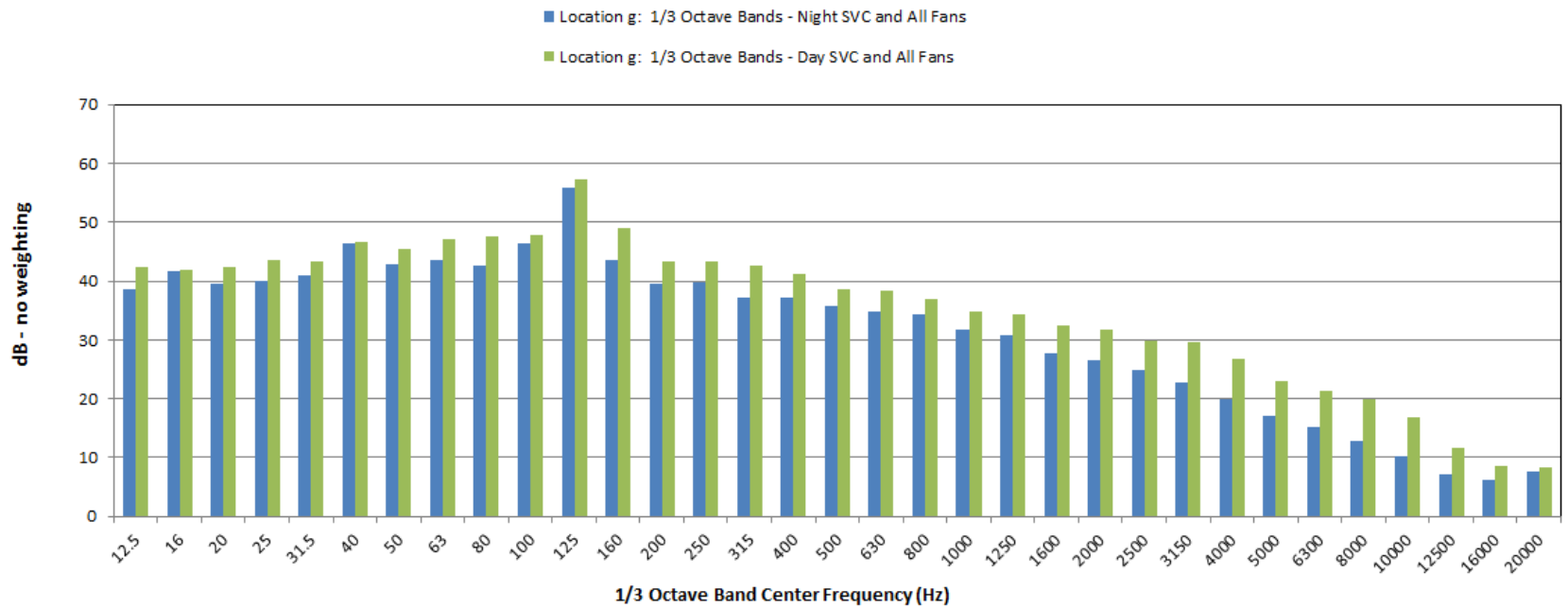

Figure B-7. Unweighted audible noise spectrum – location ‘g’.

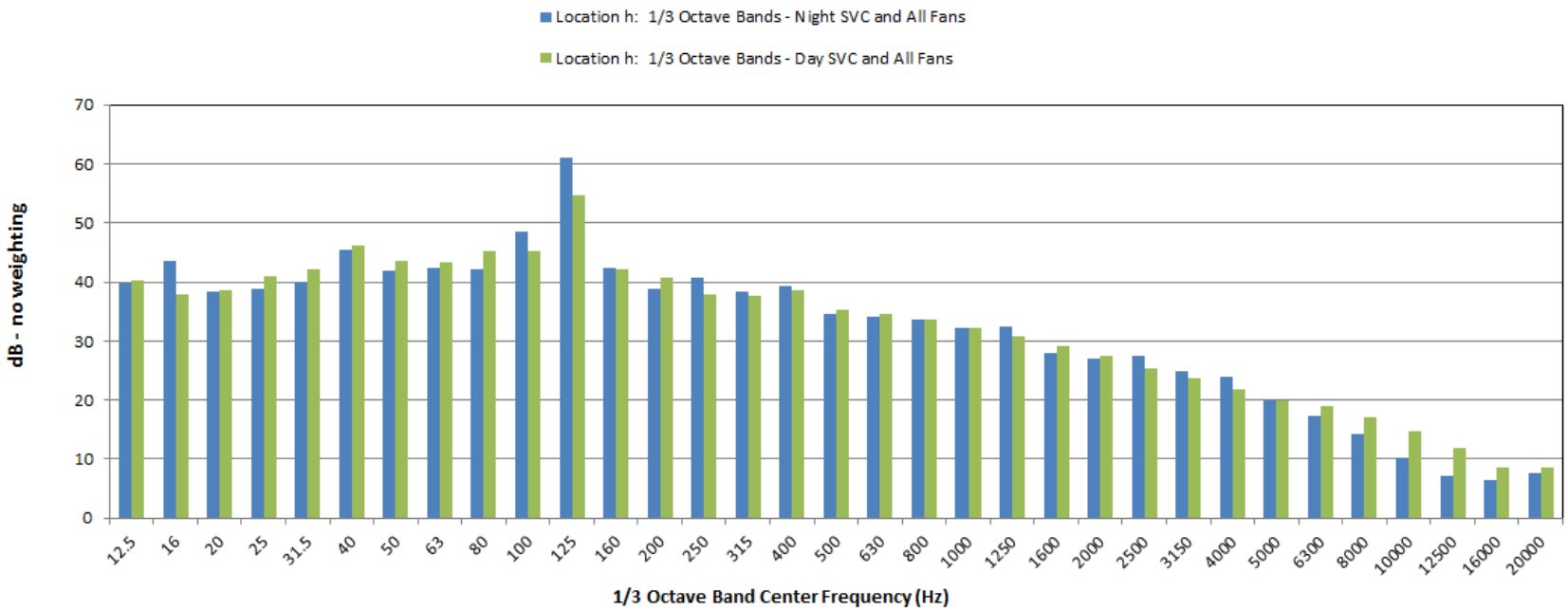

Figure B-8. Unweighted audible noise spectrum – location ‘h’.

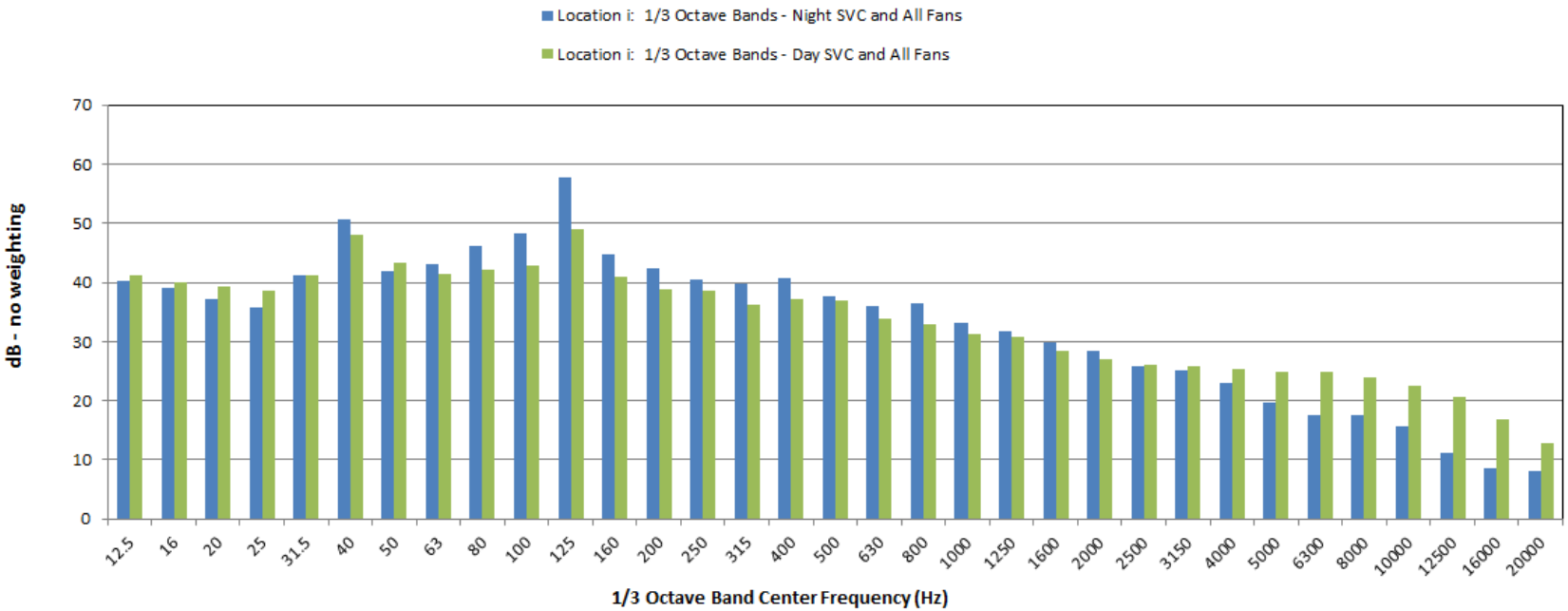

Figure B-9. Unweighted audible noise spectrum – location ‘i’.

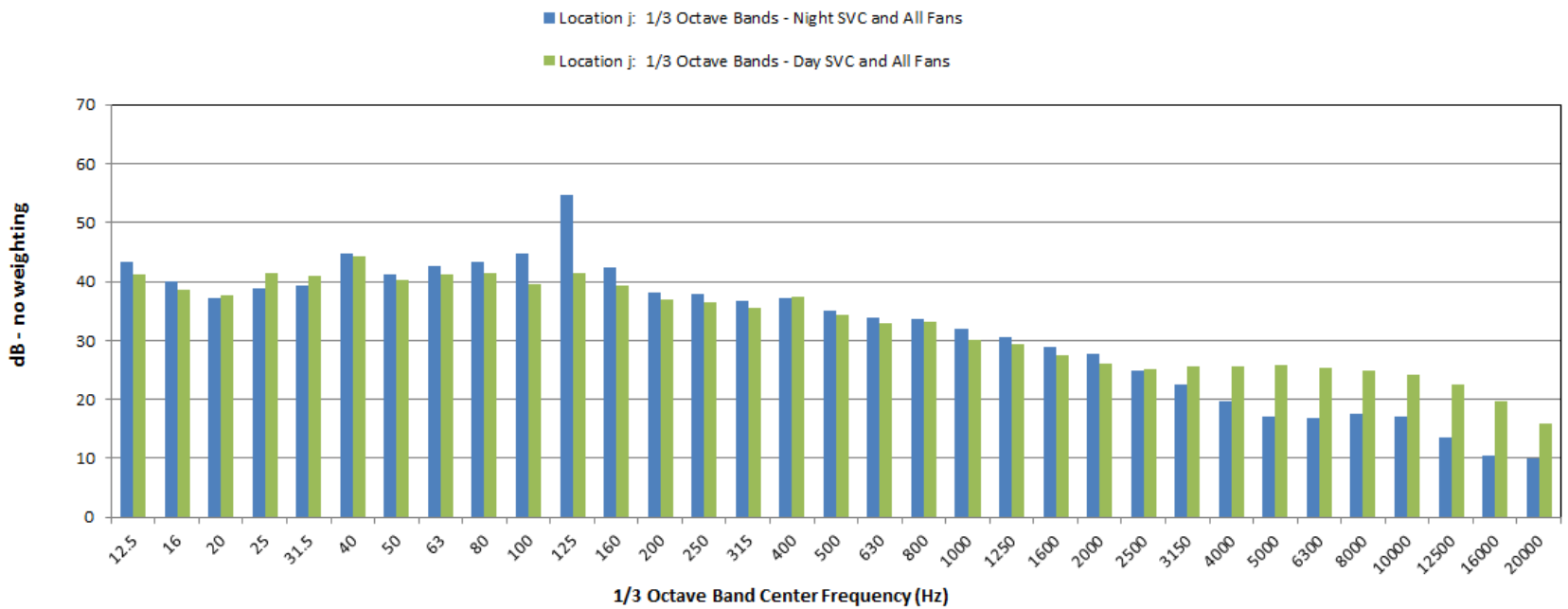

Figure B-10. Unweighted audible noise spectrum – location ‘j’.

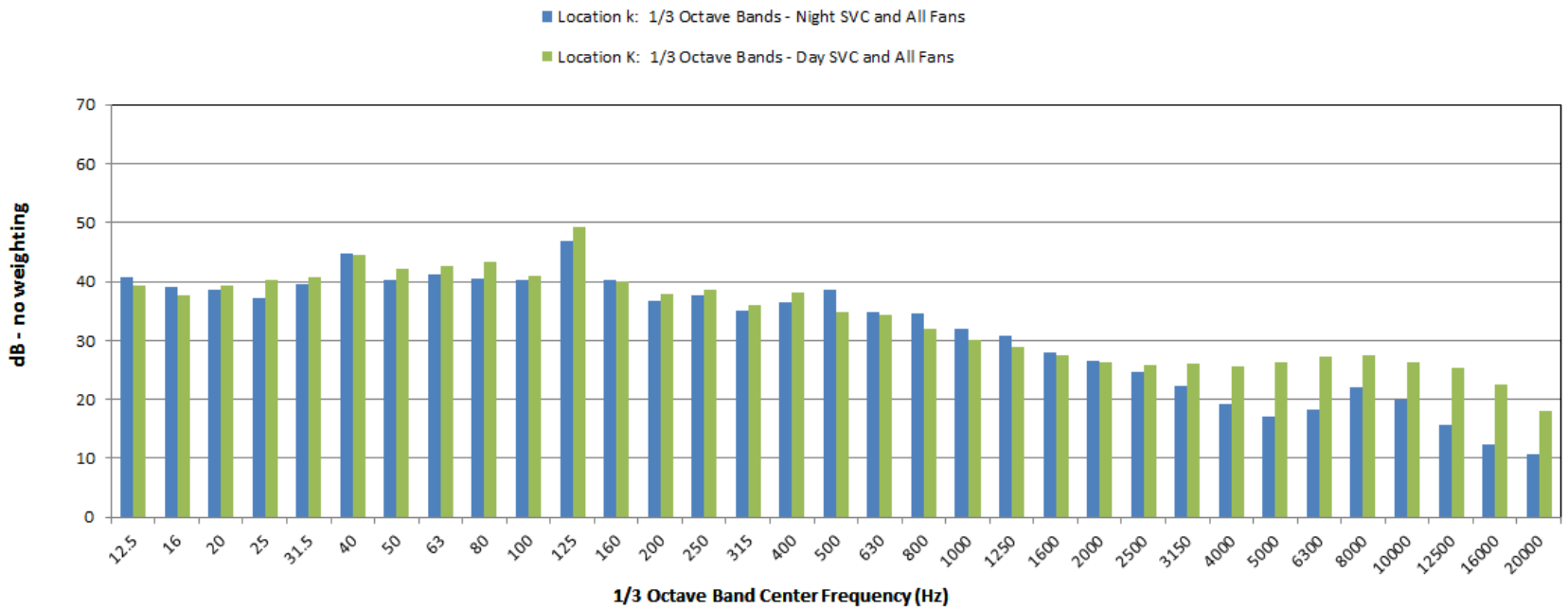

Figure B-11. Unweighted audible noise spectrum – location ‘k’.

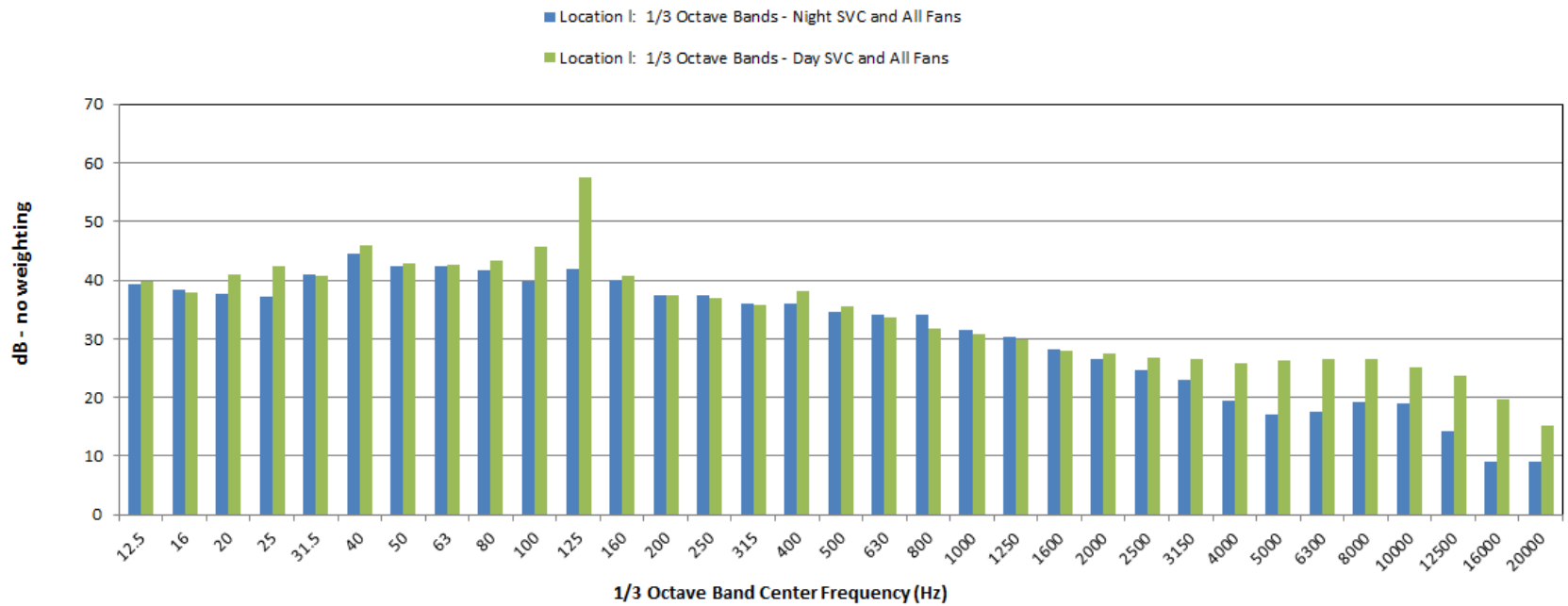

Figure B-12. Unweighted audible noise spectrum – location ‘l’.

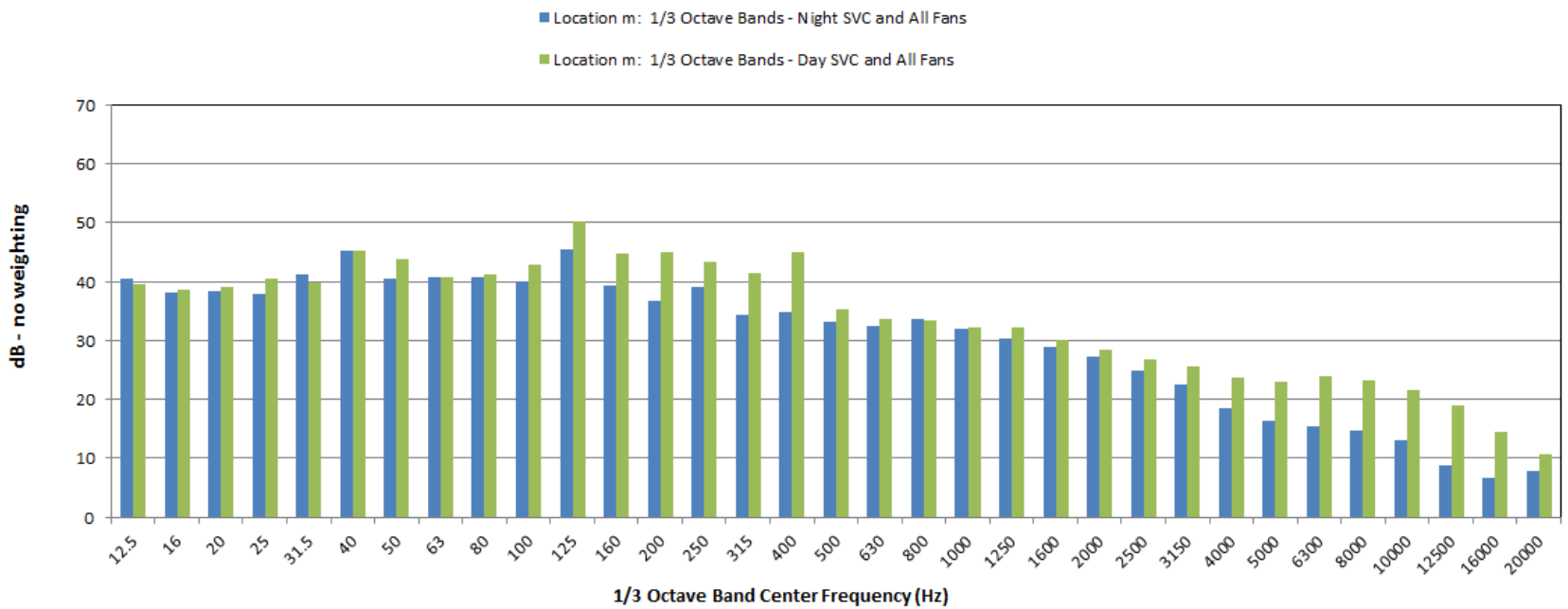

Figure B-13. Unweighted audible noise spectrum – location ‘m’.

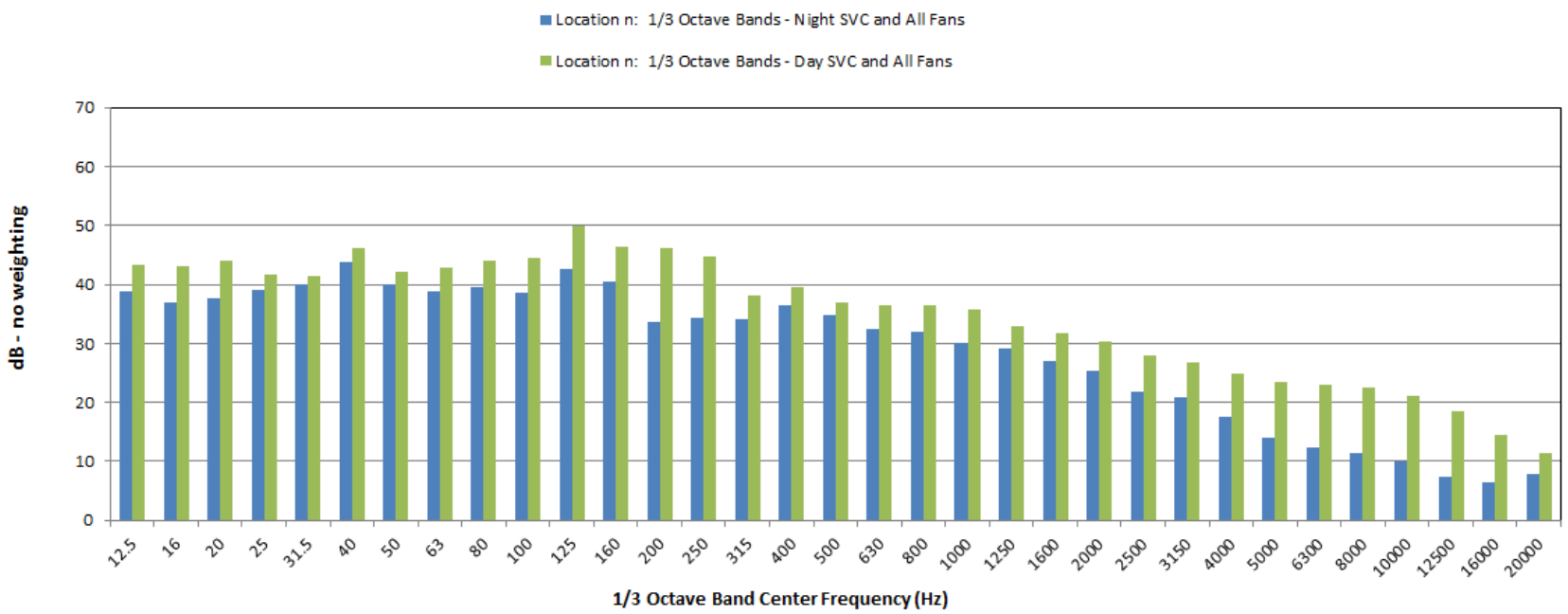

Figure B-14. Unweighted audible noise spectrum – location ‘n’.

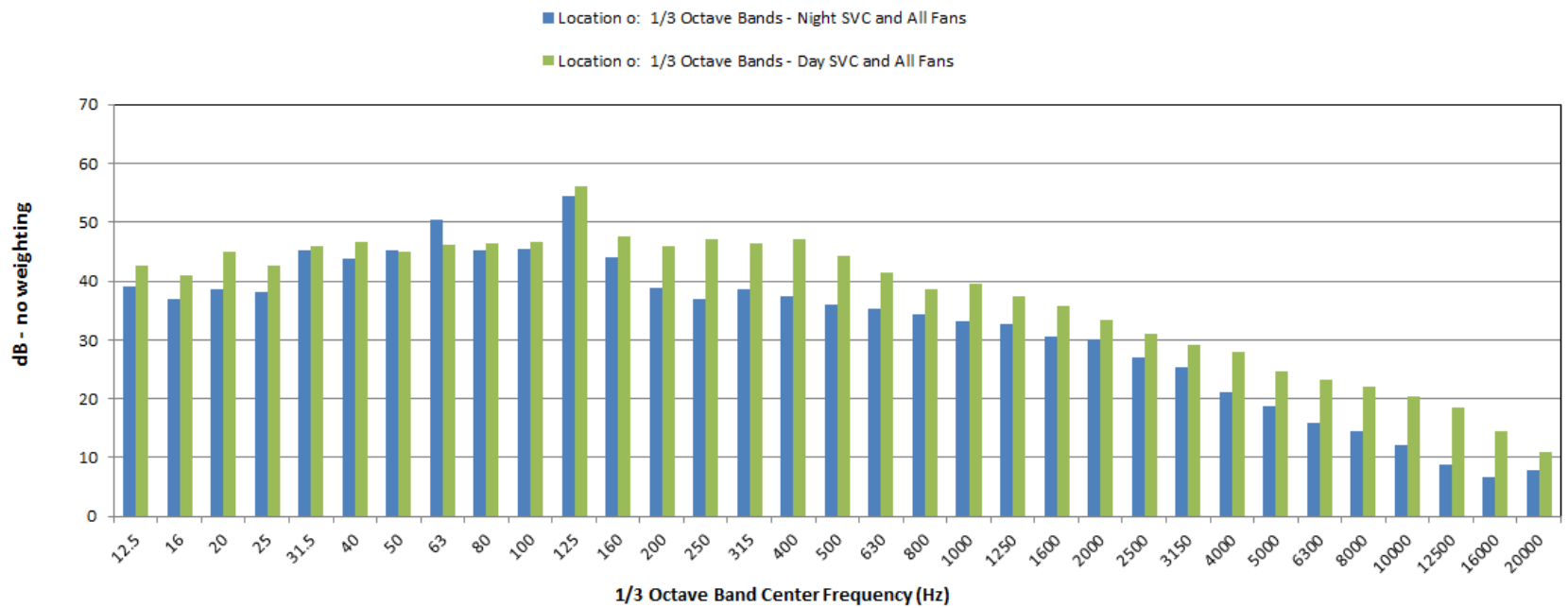

Figure B-15. Unweighted audible noise spectrum – location ‘o’.

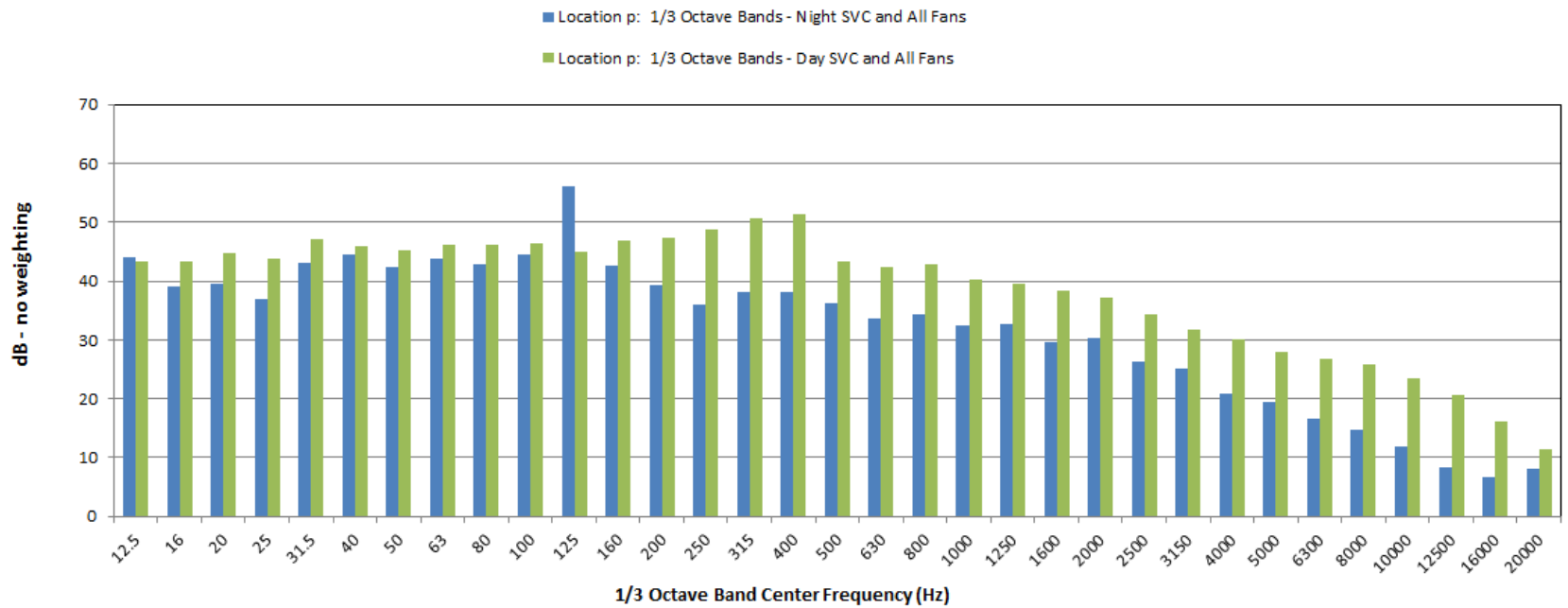

Figure B-16. Unweighted audible noise spectrum – location ‘p’.

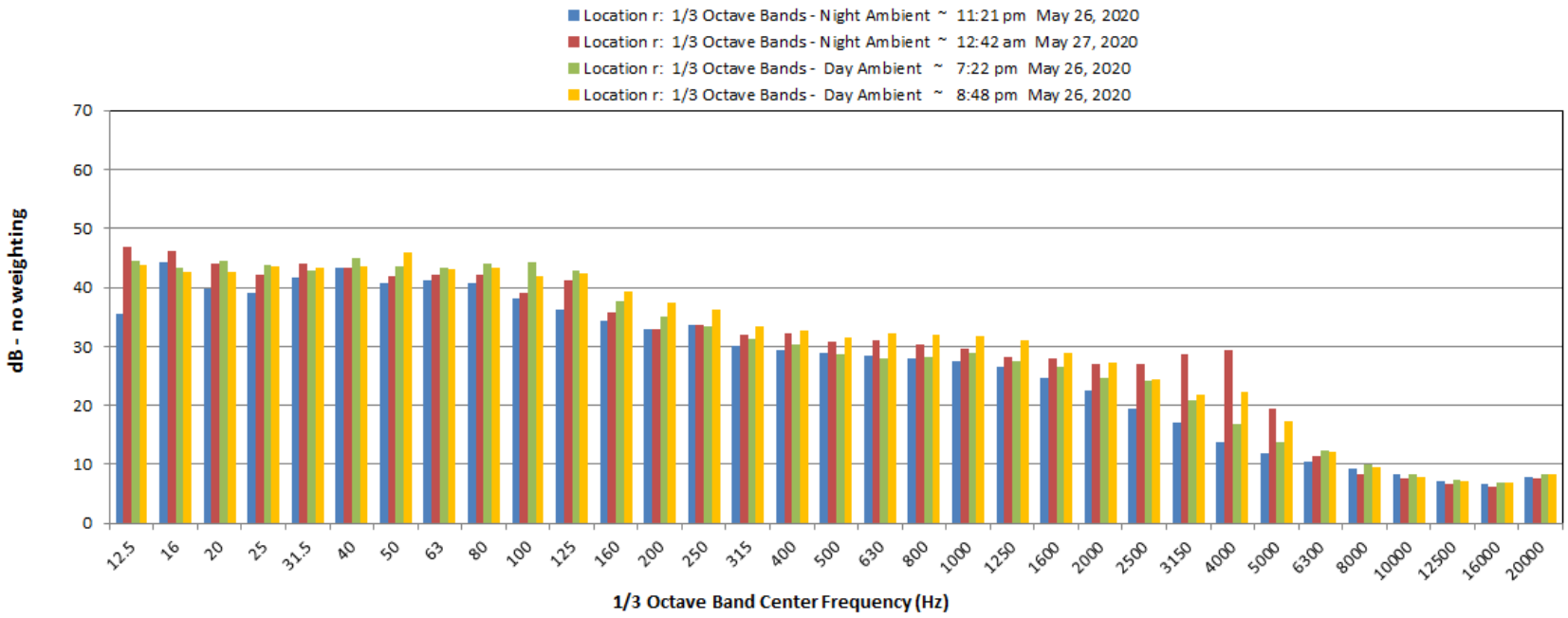

Figure B-17. Unweighted audible noise spectrum – ambient location ‘r’.

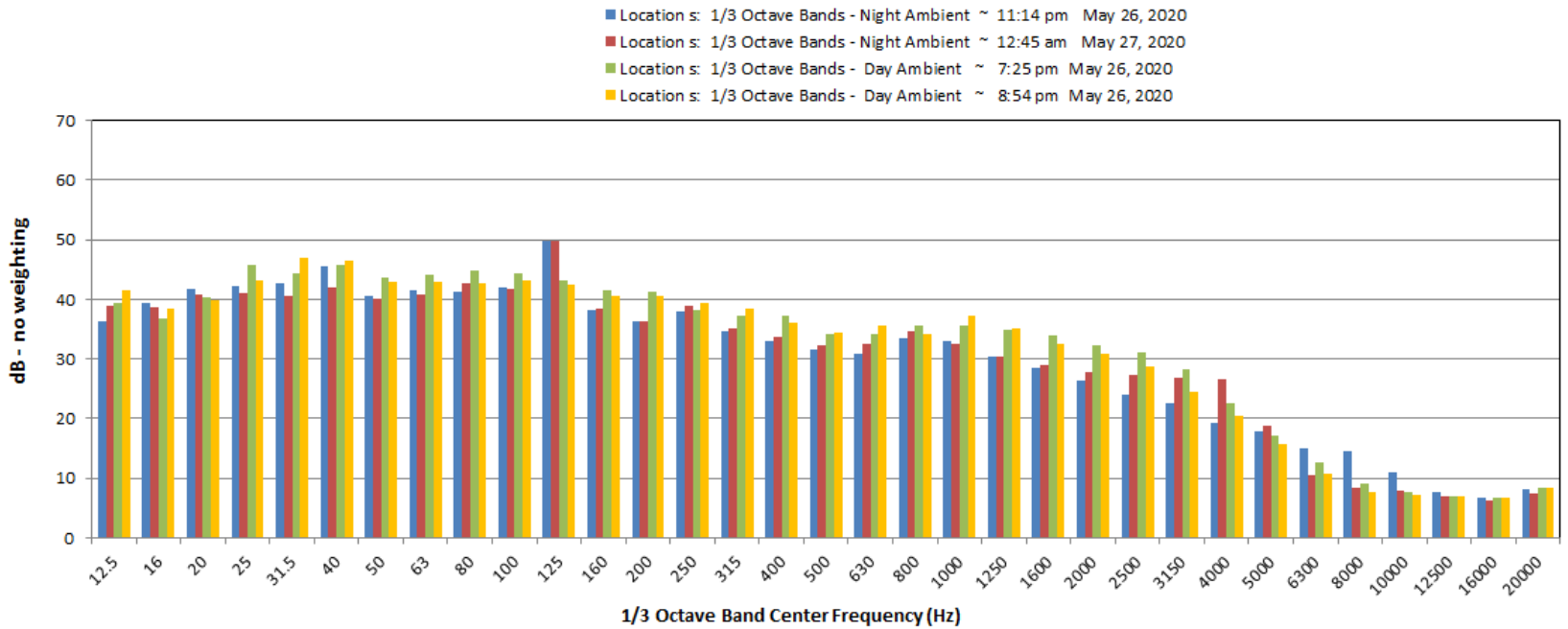

Figure B-18. Unweighted audible noise spectrum – ambient location ‘s’.

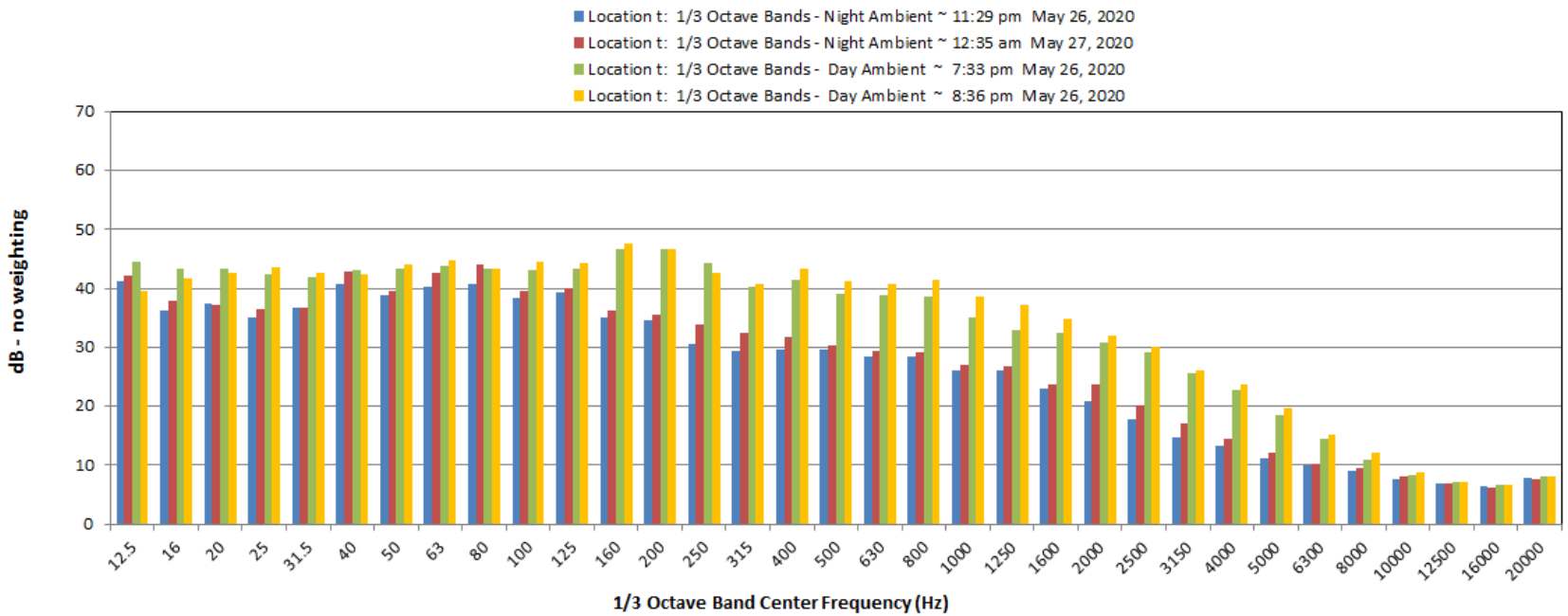

Figure B-19. Unweighted audible noise spectrum – ambient location ‘t’.