Appendix F: Noise Analysis

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TECHNICAL MEMORANDUM

To:	Erik Mas Fuss & O'Neill, Inc. 1550 Main Street, Suite 400 Springfield, MA 01103
From:	Zachary Weiss and Christopher Bajdek
Date:	January 22, 2018
Subject:	Environmental Noise Assessment for the Proposed Pequonnock Substation in Bridgeport, Connecticut
Reference:	HMMH Project Number 308720.000

Summary of Findings

HMMH was retained by Fuss & O'Neill, Inc. (F&O) to conduct an environmental noise assessment for United Illuminating's (UI) proposed Pequonnock substation project, located on the east side of Singer Avenue in Bridgeport, Connecticut (the "Project"). The major components of the proposed substation include two (2) 30/40/50 MVA transformers, a GIS building, and a PDC unit. This memorandum summarizes the applicable noise ordinances and regulations, presents the results of short-term noise monitoring, and documents the results of the noise modeling and operational noise assessment.

HMMH evaluated facility noise levels with respect to the sound level limits contained in the State of Connecticut Department of Energy and Environmental Protection (DEEP) noise regulations and the City of Bridgeport noise ordinance.

We used the ISO-9613 standard for sound propagation with the SoundPLAN® computer noise model to compute operational noise levels from the proposed substation at noise-sensitive receptors located along the western property lines and in the surrounding community. Under the assumptions stated in this report, predicted noise levels from the two 30/40/50 MVA transformers are expected to be within the allowable sound level limits for adjacent land uses in the surrounding community and at the property line. In addition, when considered in the context of existing ambient sound levels, the 30/40/50 MVA transformers are not expected to produce prominent discrete tones under the definitions contained in the DEEP noise regulations.

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1. Introduction

HMMH was retained by Fuss & O'Neill, Inc. (F&O) to conduct an environmental noise assessment for United Illuminating's (UI) proposed Pequonnock substation project, located on the east side of Singer Avenue in Bridgeport, Connecticut (the "Project"). The major components of the proposed substation include two (2) 30/40/50 MVA transformers, a GIS building, and a PDC unit. This memorandum summarizes the applicable noise ordinances and regulations, presents the results of short-term noise monitoring, and documents the results of the noise modeling and operational noise assessment. Attached to this memorandum are two appendices. Appendix A provides supplemental information about the fundamentals of acoustics. Appendix B contains the figures referenced in the body of this memorandum.

2. Applicable Noise Ordinances and Regulations

Both the State of Connecticut Department of Energy and Environmental Protection (DEEP)[1] and the City of Bridgeport[2] prescribe the same A-weighted maximum sound pressure levels, based upon land use at the noise emitter and receptor. Table 1 provides a summary of these maximum levels.

Table 1. Maximum Allowable Sound Pressure Levels based on the City Ordinance and State Regulations

Emitter Land Use	Receptor Land Use			
	Industial (All Times)	Commercial (All Times)	Residential (Day)*	Residential (Night)*
Residential	62 dBA	55 dBA	55 dBA	45 dBA
Commercial	62 dBA	62 dBA	55 dBA	45 dBA
Industrial	70 dBA	66 dBA	61 dBA	51 dBA

Source: Regulations of Connecticut State Agencies, TITLE 22a: Environmental Protection, Control of Noise, 22a-69-1 to 22a-69-7.4, 2015.
Notes:
*The State of Connecticut defines "day" as the hours from 7 a.m. to 10 p.m. (and night as 10 p.m. to 7 a.m.) for all days of the week. In comparison, the City of Bridgeport defines "day" as 7 a.m. to 6 p.m. (and "night" as 6 p.m. to 7 a.m.) from Monday through Friday. On Saturday and Sunday, the City defines "day" as 9 a.m. to 6 p.m. (and "night" as 6 p.m. to 9 a.m.).

Various noise receptors were considered in this study. Under the Connecticut State Code, ST-1 is considered an Industrial receptor, while, ST-2 through ST-4 are Residential receptors. The Project as it is proposed will constitute an industrial emitter. Using these criteria, the maximum permissible level for the Project at the three residential sites is 61 dBA during the day, and 51 dBA during the night.

The state ordinance also provides specific criteria defining prominent discrete tones for each one third octave band from 100 Hz to 20 kHz, based upon each band level's relation to its upper and lower neighboring band levels. Where a discrete tone exists, it is considered excessive noise, if its level exceeds 5 dBA below the criteria in Table 1.

[1] Regulations of Connecticut State Agencies, TITLE 22a: Environmental Protection, Control of Noise, 22a-69-1 to 22a-69-7.4, 2015.
[2] City of Bridgeport, Code of Ordinances, Chapter 8.80 – Noise Control Regulations.

3. Existing Conditions

The measured noise levels summarized in this section serve as a baseline against which the Project's impact on the total ambient sound level will be determined. These ambient measurements include noise from the neighboring PSE&G Power Plant (PSEG), which was not included in the noise prediction model. The following subsections describe the measurement methods and procedures and summarize the measured noise levels from the short-term measurements.

3.1 Noise Measurement Methods and Procedures

Between April 13 and 14, 2017, HMMH personnel conducted short-term attended measurements at four locations on the western side of the Project. One site was on the western property line of the project (ST-1), two were at nearby residences (ST-2 & ST-3), and a fourth was at a place of worship (ST-4). Both daytime (between 7 a.m. to 10 p.m.) and nighttime (between 10 p.m. and 7 a.m.) measurements of 20 minutes were taken at all four sites. An additional daytime measurement also was taken at ST-1, due to irregular noise sources during the first measurement period. In total, ambient sound levels were obtained for nine complete 20-minute measurement periods. Figure 1 provides a map of the four locations in relation to the proposed substation, while Figures 2 to 5 show photographs of the noise monitoring sites. Note that all of the figures have been included as attachments to this memorandum.

All sound level measurements were performed with HMMH-owned Bruel & Kjaer model 2250 sound level meters that meet the requirements of American National Standard S1.4 for Type 1 precision sound measurement instruments. The sound measurement system (comprised of a microphone, preamplifier, and sound level meter) was calibrated at the beginning and end of each measurement period using an acoustic calibrator following procedures that are traceable to the National Institute of Standards and Technology (NIST). Sound level data were recorded onto a flash card, which was removed from the sound level meter and downloaded to a personal computer for subsequent analysis.

The noise monitors also collected and stored continuous time histories of 1-second sound level data in one-third octave bands. Additionally, audio recordings were captured to aid in the process of source identification.

3.2 Existing Noise Levels from Short-term Noise Monitors

During each measurement period, HMMH personnel maintained a detailed log of the noise sources that were audible at each site. For the analysis, we grouped the observed noise sources into three categories: typical, atypical (insignificant), and atypical (significant). Typical noise sources included I-95 traffic (the dominant source during all measurement periods), local street traffic, pedestrians, PSEG, and birds. All of these sources would likely be present to a similar degree regardless of measurement date or time period. Atypical noise sources included train pass-bys, train horns, the Bridgeport Bluefish Stadium, wind gusts, and certain motorcycle pass-bys. Although all of these sources may be considered common in the area, their presence is highly determined by either measurement date (e.g. the stadium), or the specific 20-minute time period during which the measurement was performed (e.g. trains, motorcycles, and wind).

The noise from the stadium, present only intermittently during the daytime at ST-1 & ST-2, was determined to have an insignificant effect on the overall L_{eq} for these sites. However, wind-induced noise during the daytime measurement at ST-3, a motorcycle pass-by during the daytime measurement at ST-4, and train pass-bys and horns during every measurement period were all determined to have significant effects. To allow effective comparison of ambient levels across measurement periods, we excluded these atypical (significant) events on a second by second basis using the collected time history data, and calculated a "filtered" L_{eq} for each site.

Table 2 shows the unfiltered and filtered levels measured during the daytime, while Table 3 shows the same for the nighttime. Figures 6 and 7 in Appendix B provides unweighted ambient sound level data (in terms of L_{eq}) in one-third octave bands for the daytime and nighttime periods, respectively. Figure 8 in Appendix B provides spectral ambient sound level data in terms of the L_{90} for the nighttime period. The spectra in Figure 8 represent the lowest sound pressure levels in each 1/3 octave band during the monitoring period.

Table 2. Short-term Daytime Ambient Sound Level Measurements

Site	Address	Date	Time Start	Duration, Minutes	Unfiltered L_{eq}, dBA	Filtered L_{eq}, dBA	Seconds Excluded	Percentage of Time Excluded
ST-1 (1)*	[Property Line]	4/13/2017	2:07 PM	20	63.0	62.9	35	2.9%
ST-1 (2)**	[Property Line]	4/13/2017	5:46 PM	20	62.0	61.6	85	7.1%
ST-2	418 Main St.	4/13/2017	4:00 PM	20	61.6	60.6	91	7.6%
ST-3	77 Whiting St.	4/13/2017	3:03 PM	20	62.8	62.7	132	11.0%
ST-4	477 Broad Street	4/13/2017	5:00 PM	20	65.5	62.7	104	8.7%

Source: HMMH, 2017
Notes:
*Trucks were onsite during this measurement period. The results represent high-activity ambient levels.
**Repeat measurement during period without trucks onsite. The results represent typical ambient levels.

Table 3. Short-term Nighttime Ambient Level Noise Measurements

Site	Address	Date	Time Start	Duration, Minutes	Unfiltered L_{eq}, dBA	Filtered L_{eq}, dBA	Seconds Excluded	Percentage of Time Excluded
ST-1	[Property Line]	4/13/2017	10:28 PM	20	57.2	56.9	70	5.8%
ST-2	418 Main St.	4/13/2017	11:11 PM	20	57.4	57.3	3	0.3%
ST-3	77 Whiting St.	4/14/2017	12:03 AM	20	58.1	58.0	27	2.3%
ST-4	477 Broad St.	4/14/2017	1:05 AM	20	58.7	55.5	87	7.3%

Source: HMMH, 2017.

Measured ambient sound levels exceeded the limits in Table 1 for five of the six measurement periods at residential land uses. The (filtered) ambient sound level at ST-2 measurement was only 0.4 dBA below the maximum allowable level. Since Site ST-1 represents industrial land use, the applicable sound level limit is 70 dBA during both daytime and nighttime periods – ambient sound levels did not exceed this limit during any of the three measurement periods at Site ST-1.

The allowable sound level limits in Table 1 do not apply to highway noise, the dominant contributing noise source to the ambient L_{eq} during all nine measurement periods. Therefore, the exceedances are not currently in violation of the noise ordinances. However, they do effect how the added noise from the Project is to be evaluated. Specifically, the state regulation stipulates that in this circumstance, the added noise is considered excessive if it exceeds the current ambient level by 5 dBA.

HMMH obtained two samples of daytime ambient sound levels at Site ST-1. We observed irregular noise conditions during the first daytime period beginning at 2:07 PM and decided to sample ambient sound levels for another daytime period. During the first daytime period, the PSEG gates, roughly 120 feet from the noise monitor, were open, and heavy trucks were entering and exiting every two minutes. Additionally, about eight minutes into the first measurement, a heavy truck parked about 50 feet to the east of the noise monitor and idled for the rest of the measurement while loading equipment. As a result, the first daytime measurement at ST-1 (denoted as ST-1 (1) in Table 2) represents a high-activity ambient level, while the second measurement (ST-1 (2) in Table 2) represents a typical-activity ambient level.

4. Predicted Noise Levels from the Substation

This section describes the noise prediction model, summarizes the input to the model, and presents the predicted operational noise levels and the results of the assessment.

4.1 Noise Prediction Model

The SoundPLAN® computer noise model was used for computing operational noise levels from the proposed substation to noise-sensitive receptors at the western property lines and in the surrounding community. An industry standard, SoundPLAN® was developed by Braunstein + Berndt GmbH to provide estimates of sound levels at distances from specific noise sources taking into account the effects of terrain features including relative elevations of noise sources, receivers, and intervening objects (buildings, hills, trees), and ground effects due to areas of hard ground (pavement, water) and soft ground (grass, field, forest). In addition to computing sound levels at specific receiver positions, SoundPLAN® can produce noise contour graphics that show areas of equal and similar sound level.

The sound propagation model within SoundPLAN that was used for this study was ISO 9613-2.[3] This international standard propagation model is used nearly universally in the U.S. for environmental noise studies, due to its conservative propagation equations. ISO 9613-2 uses “worst-case” downwind propagation conditions in all directions, and accounts for variations in terrain and the effects of ground type.

4.2 Noise Model Input

As input, SoundPLAN incorporated a geometric model of the study area and reference noise levels for the two proposed 30/40/50 MVA transformers, which are the dominant noise source associated with the proposed project. HMMH developed a three-dimensional geometric model of the study area from aerial photography and elevation information obtained in Google Earth Pro© for off-site

[3] International Organization for Standardization (ISO), International Standard ISO 9613-2, “Acoustics – Attenuation of Sound during Propagation Outdoors”, Part 2: General Method of Calculation, 1996-12-15.

buildings and structures and from the latest conceptual plan[4] and sections[5,6] of the substation for on-site buildings and structures. All buildings were modeled as objects that both obstruct (attenuate) and reflect the sound emitted from a source. The SoundPLAN model of the substation included reflections of the 3rd order.

The two 30/40/50 MVA transformers were modeled as omnidirectional point sources, each having a NEMA rated sound level of 78 dBA,[7] or an overall sound power level of 93.6 dBA based on procedures published by the Edison Electric Institute.[8]

As noted in Section 2, the Connecticut DEEP noise regulation includes provisions and penalties for sources of sound that produce prominent discrete tones. Since spectral sound level data were not available for the transformers, HMMH applied a one-third octave band noise spectrum for a typical transformer[9] to the overall sound power level. Figure 9 in Appendix B shows the spectral sound power levels that were used as input to the SoundPLAN model. As shown in Figure 9, the (unweighted) transformer spectrum includes peaks in the 1/3 octave bands centered at 125 and 400 Hz. As noted in the next section, the assessment of substation noise included an evaluation of prominent discrete tones.

4.3 Presentation of Results

For the purposes of the noise assessment, five additional receptors (ST-1A, ST-1B, ST-2A, ST-2B, and ST-2C) were included in the noise model along with the four short-term monitoring sites, as follows:

- Sites ST-1A and ST-1B are located near the property line of the proposed facility – the land use is industrial.
- Site ST-2A represents residential land use – specifically, a patio location at the exterior of 418 Main Street.
- Sites ST-2B and ST-2C represent the 2nd and 3rd floor balconies at 418 Main Street – these receptors were modeled at heights of 15 and 25 feet above ground level (AGL), respectively.[10]

Table 4 summarizes the computed A-weighted noise levels due to the 30/40/50 MVA transformers (only) at each of the four measurement sites identified in Section 3 and at the five additional receptors described above. Table 4 also shows the land use designation for each receptor and the allowable sound level limits based on the state regulations and the City's ordinance.

Figure 10 in Appendix B shows the noise exposure contours produced by the 30/40/50 MVA transformers (only) in 4-decibel intervals. This figure shows the effects of buildings and structures on

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[4] "Preliminary Concept, Site Arrangement, Standard GIS-PRI Site Pequonnock Substation," No. PEQ-PR-SK2, Revision A, dated 01/05/18.

[5] "Preliminary Concept, Sections 1& 2, Standard GIS-PRI Site Pequonnock Substation," No. PEQ-PR-SK3, Revision A, dated 01/05/18.

[6] "Preliminary Concept, Section 3, Standard GIS-PRI Site Pequonnock Substation," No. PEQ-PR-SK4, Revision A, dated 01/05/18.

[7] Email message from Richard Pinto to Erik Mas and Christopher Mocciae with subject "RE: Phase II Scope of Study Comments New Pequonnock Substation/Conceptual Design," dated 12/13/2017 at 11:17 a.m.

[8] Edison Electric Institute, "Electric Power Plant Environmental Noise Guide," Volume I, pp. 4-16 to 4-17, 1978.

[9] Cyril M. Harris (ed.), "Handbook of Acoustical Measurements and Noise Control," Third Edition, McGraw-Hill Inc., p. 35.2, 1991.

[10] With the exception of the balcony locations, all receptors were modeled at a standard height of 5 feet AGL.

sound propagation from the transformers. Note that this figure does not account for the sound from existing noise sources (such as traffic on the interstate highway, traffic on local roads, etc.).

Table 4. Predicted Overall Sound Levels from the Substation (Only)

Receptor/ Meas. Site ID	Description	Predicted Facility Noise Level (dBA)	Land Use	Applicable Sound Level Limit (dBA)
ST-1	Property line	35.3	Industrial	70 all times
ST-1A	Property line at Kiefer St.	45.8	Industrial	70 all times
ST-1B	Property line at NW corner	49.0	Industrial	70 all times
ST-2	418 Main Street	40.0	Residential	61 day / 51 night
ST-2A	Ground floor patio of nearest residence (at 5 feet AGL)	40.1	Residential	61 day / 51 night
ST-2B	Lower balcony of nearest residence (at 15feet AGL)	42.4	Residential	61 day / 51 night
ST-2C	Upper balcony of nearest residence (at 25 feet AGL)	44.7	Residential	61 day / 51 night
ST-3	77 Whiting St.	30.5	Residential	61 day / 51 night
ST-4	477 Broad Street	37.0	Residential	61 day / 51 night

Source: HMMH, 2018.

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Table 5 shows the predicted facility noise levels in the context of the daytime ambient sound levels, which are given in terms of the filtered L_{eq}. The "Total" sound level in Table 5 is the combination (decibel summation) of the predicted facility noise level and the ambient L_{eq} for each receptor and/or measurement site. As shown in Table 5, the Total sound level exceed the applicable daytime limit at ST-3 and ST-4.

Both the Connecticut DEEP noise regulation and the City noise ordinance have a provision for areas with high background (ambient) noise. These regulations state:

"In those individual cases where the background noise levels caused by sources not subject to these regulations exceed the standards contained in this chapter, a source shall be considered to cause excessive noise if the noise emitted by such source exceeds the background noise levels by five dBA…"

While the Total sound level exceeds the daytime sound level limit, this does not represent a violation of either the state regulation or the City ordinance because the sound levels due to the proposed facility are *lower* than the background (ambient) sound level. In this case, traffic noise from I-95 and the local roads dominates the background sound levels. Traffic noise is not subject to the limits in Table 1.

Table 5. Predicted Overall Sound Levels from the Substation with Daytime Ambient Sound Levels

Receptor / Measurement Site ID	Allowable Daytime Limit (dBA)	Predicted Facility Noise Level (dBA)	Daytime Ambient* L_{eq} (dBA)	Daytime Total** Sound Level (dBA)	Increase in Daytime Sound Level (dB)***
ST-1	70	35.3	61.6	61.6	0.0
ST-1A‡	70	45.8	61.6	61.7	0.1
ST-1B‡	70	49.0	61.6	61.9	0.2
ST-2	61	40.0	60.6	60.6	0.0
ST-2A‡‡	61	40.1	60.6	60.6	0.0
ST-2B‡‡	61	42.4	60.6	60.7	0.1
ST-2C‡‡	61	44.7	60.6	60.7	0.1
ST-3	61	30.5	62.7	62.7	0.0
ST-4	61	37.0	62.7	62.7	0.0

Source: HMMH, 2018.
* The Daytime Ambient L_{eq} is the Filtered L_{eq} from Table 2.
** The "Total" sound level is the decibel addition of the Predicted Facility Noise Level and the Ambient L_{eq}. See Appendix A for more information on adding decibels.
*** Apparent discrepancies are due to rounding.
‡ Sites ST-1A and ST-1B are assumed to have the same ambient sound level as Site ST-1.
‡‡ Sites ST-2A, ST-2B, and ST-2C are assumed to have the same ambient sound level as Site ST-2.

Table 6 shows the predicted facility noise levels in the context of the nighttime ambient sound levels, which are given in terms of the filtered L_{eq}. Following a similar line of reasoning, predicted noise levels from the two 30/40/50 MVA transformers are expected to be in compliance with the applicable nighttime sound level limits at adjacent properties.

Transformer noise also was evaluated for the presence of prominent discrete tones at the western property line and in the community. As shown in Figures 11 to 13 in Appendix B, the estimated 1/3 octave band sound levels from the transformers were added to the nighttime ambient sound levels in 1/3 octave bands at each measurement site and receptor. In the context of existing ambient sound levels, the 30/40/50 MVA transformers are not expected to produce prominent discrete tones under the definitions contained in the Connecticut DEEP noise regulations.

Table 6. Predicted Overall Sound Levels from the Substation with Nighttime Ambient Sound Levels

Receptor / Measurement Site ID	Allowable Nighttime Limit (dBA)	Predicted Facility Noise Level (dBA)	Nighttime Ambient* L_{eq} (dBA)	Nighttime Total** Sound Level (dBA)	Increase in Nighttime Sound Level (dBA)***
ST-1	70	35.3	56.9	57.0	0.0
ST-1A‡	70	45.8	56.9	57.3	0.3
ST-1B‡	70	49.0	56.9	57.6	0.6
ST-2	51	40.0	57.3	57.3	0.1
ST-2A‡‡	51	40.1	57.3	57.3	0.1
ST-2B‡‡	51	42.4	57.3	57.4	0.1
ST-2C‡‡	51	44.7	57.3	57.5	0.2
ST-3	51	30.5	58.0	58.0	0.0
ST-4	51	37.0	55.5	55.6	0.1

Source: HMMH, 2018.
* The Nighttime Ambient L_{eq} is the Filtered L_{eq} from Table 3.
** The "Total" sound level is the decibel addition of the Predicted Facility Noise Level and the Ambient L_{eq}. See Appendix A for more information on adding decibels.
*** Apparent discrepancies are due to rounding.
‡ Sites ST-1A and ST-1B are assumed to have the same ambient sound level as Site ST-1.
‡‡ Sites ST-2A, ST-2B, and ST-2C are assumed to have the same ambient sound level as Site ST-2.

5. Conclusions

Under the assumptions stated in this report, predicted noise levels from the two 30/40/50 MVA transformers are expected to be within the allowable sound level limits for adjacent land uses in the surrounding community and at the property line. In addition, when considered in the context of existing ambient sound levels, the 30/40/50 MVA transformers are not expected to produce prominent discrete tones under the definitions contained in the Connecticut DEEP noise regulations.

APPENDIX A. Fundamentals of Acoustics

This attachment describes the noise terminology and metrics used in this report.

Decibels (dB), Frequency and the A-weighted Sound Level (dBA)
Loudness is a subjective quantity that enables a listener to order the magnitude of different sounds on a scale from soft to loud. Although the perceived loudness of a sound is based somewhat on its frequency and duration, chiefly it depends upon the sound pressure level. Sound pressure level is a measure of the sound pressure at a point relative to a standard reference value; sound pressure level is always expressed in decibels (dB).

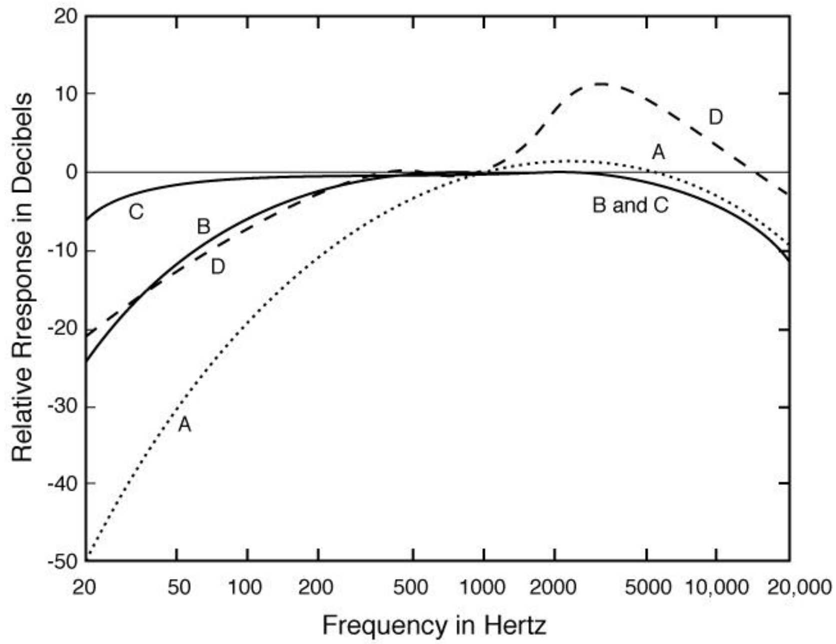
Decibels are logarithmic quantities, so combining decibels is unlike common arithmetic. For example, if two sound sources each produce 100 dB operating individually and they are then operated together, they produce 103 dB. Each doubling of the number of sources produces another three decibels of noise. A tenfold increase in the number of sources makes the sound pressure level go up 10 dB, and a hundredfold increase makes the level go up 20 dB. If two sources differ in sound pressure level by more than 10 decibels, then operating together, the total level will approximately equal the level of the louder source; the quieter source doesn't contribute significantly to the total.

People hear changes in sound level according to the following rules of thumb: 1) a change of 1 decibel or less in a given sound's level is generally not readily perceptible except in a laboratory setting; 2) a 5-dB change in a sound is considered to be generally noticeable in a community setting; and 3) it takes approximately a 10-dB change to be heard as a doubling or halving of a sound's loudness.

Another important characteristic of sound is its frequency, or "pitch." This is the rate of repetition of sound pressure oscillations as they reach our ears. Frequency is expressed in units known as Hertz (abbreviated "Hz" and equivalent to one cycle per second). Sounds heard in the environment usually consist of a range of frequencies. The distribution of sound energy as a function of frequency is termed the "frequency spectrum."

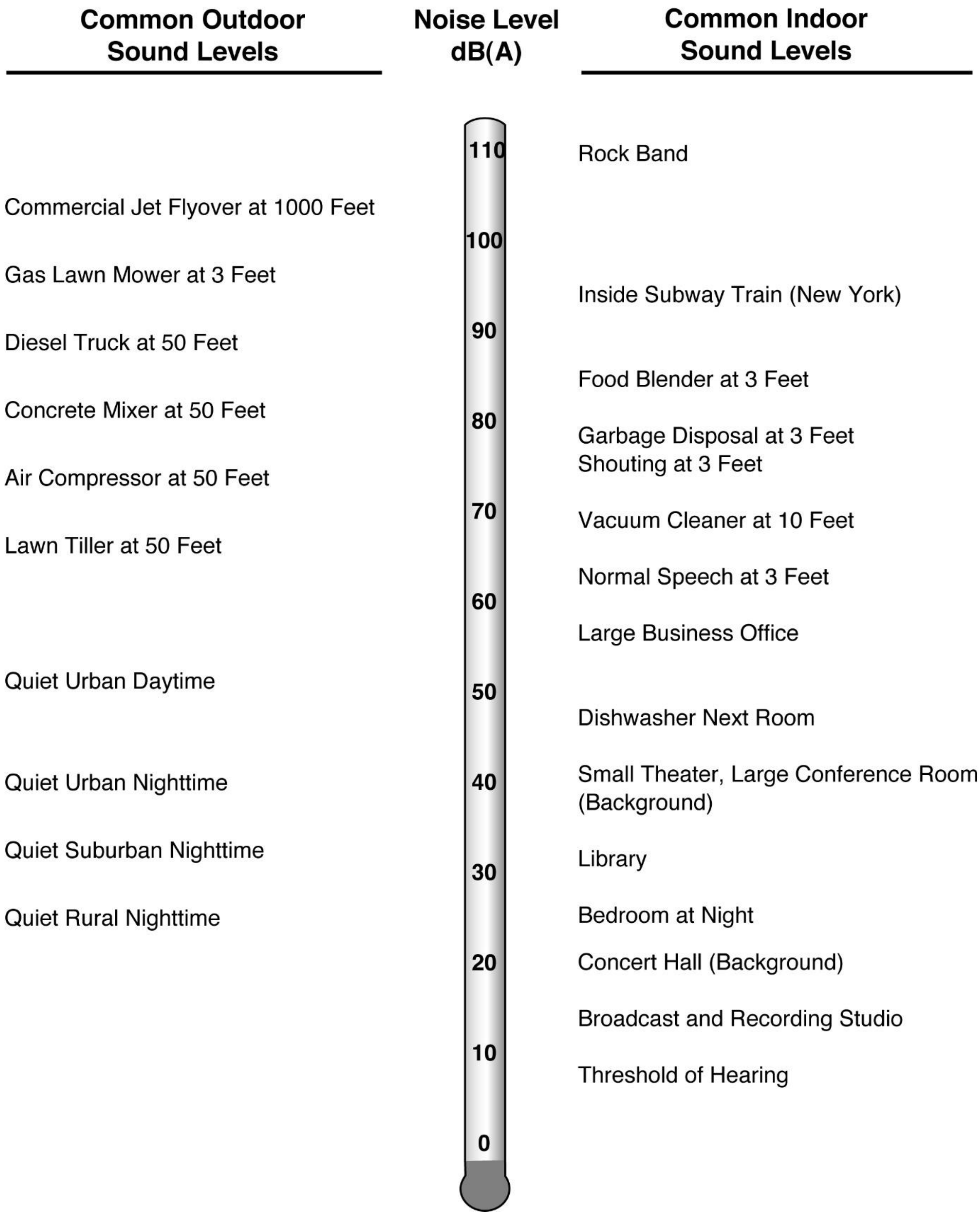
The human ear does not respond equally to identical noise levels at different frequencies. Although the normal frequency range of hearing for most people extends from a low of about 20 Hz to a high of 10,000 Hz to 20,000 Hz, people are most sensitive to sounds in the voice range, between about 500 Hz to 2,000 Hz. Therefore, to correlate the amplitude of a sound with its level as perceived by people, the sound energy spectrum is adjusted, or "weighted."

The weighting system most commonly used to correlate with people's response to noise is "A-weighting" (or the "A-filter") and the resultant noise level is called the "A-weighted noise level" (dBA). The A-filter significantly de-emphasizes those parts of the frequency spectrum from a noise source that occurs both at lower frequencies (those below about 500 Hz) and at very high frequencies (above 10,000 Hz) where we do not hear as well. The filter has very little effect, or is nearly "flat," in the middle range of frequencies between 500 and 10,000 Hz. In addition to representing human hearing sensitivity, A-weighted sound levels have been found to correlate better than other weighting networks with human perception of "noisiness." One of the primary reasons for this is that the A-weighting network emphasizes the frequency range where human speech occurs, and noise in this range interferes with speech communication. Another reason is that the increased hearing sensitivity makes noise more annoying in this frequency range. The following figure shows the relative response of various weighting networks including the A weighting network.



Relative Response of A-, B-, C-, and D-Weighting Networks

The following figure shows common indoor and outdoor A-weighted sound levels and the environments or sources that produce them.



Common Outdoor and Indoor A-weighted Sound Levels

Maximum Sound Level (Lmax)

The variation in sound level over time often makes it convenient to describe a particular noise "event" by its maximum sound level, abbreviated as Lmax or LAmax. The maximum level describes only one dimension of an event; it provides no information on the cumulative noise exposure. In fact, two events with identical maxima may produce very different total exposures. One may be of very short duration, while the other may continue for an extended period and be judged much more annoying. The Sound Exposure Level metric corrects for this deficiency.

Equivalent Sound Level (L_{eq})

The Equivalent Sound Level, abbreviated Leq, is a measure of the total exposure resulting from the accumulation of A-weighted sound levels over a particular period of interest -- for example, an hour, an 8-hour school day, nighttime, or a full 24-hour day. However, because the length of the period can be different depending on the time frame of interest, the applicable period should always be identified or clearly understood when discussing the metric. Such durations are often identified through a subscript, for example Leq1h, or Leq(24).

The Leq may be thought of as a constant sound level over the period of interest that contains as much sound energy as (is “equivalent” to) the actual time-varying sound level with its normal peaks and valleys. It is important to recognize, however, that the two signals (the constant one and the time-varying one) would sound very different from each other. Also, the “average” sound level suggested by Leq is not an arithmetic value, but a logarithmic, or “energy-averaged” sound level. Thus, the loudest events may dominate the noise environment described by the metric, depending on the relative loudness of the events.

Statistical Sound Level Descriptors

Statistical descriptors of the time-varying sound level are often used instead of, or in addition to Leq to provide more information about how the sound level varied during the time period of interest. The descriptor includes a subscript that indicates the percentage of time the sound level is exceeded during the period. The L50 is an example, which represents the sound level exceeded 50 percent of the time, and equals the median sound level. Another commonly used descriptor is the L10, which represents the sound level exceeded 10 percent of the measurement period and describes the sound level during the louder portions of the period. The L90 is often used to describe the quieter background sound levels that occurred, since it represents the level exceeded 90 percent of the period.

Sound Power Level

The sound power level is a fundamental measure of a source of sound and is a measure of the acoustic energy, or power, emitted by a source. Mathematically, the sound power level is ten times the logarithm (to the base 10) of a given sound power to the reference sound power (1 picowatt or 10-12 watt). The unit is the decibel.

APPENDIX B. FIGURES

Figure 1. Pre-Construction Noise Monitoring Locations from April 13 to 14, 2017

Figure 2. Photograph of Short-term Noise Monitor Location near the Project Property Line (ST-1)

Figure 3. Photograph of Short-term Noise Monitor Location near 418 Main St. (ST-2)

Figure 4. Photograph of Short-term Noise Monitor Location near 77 Whiting St (ST-3)

Figure 5. Photograph of Short-term Noise Monitor Location near 477 Broad St. (ST-4)

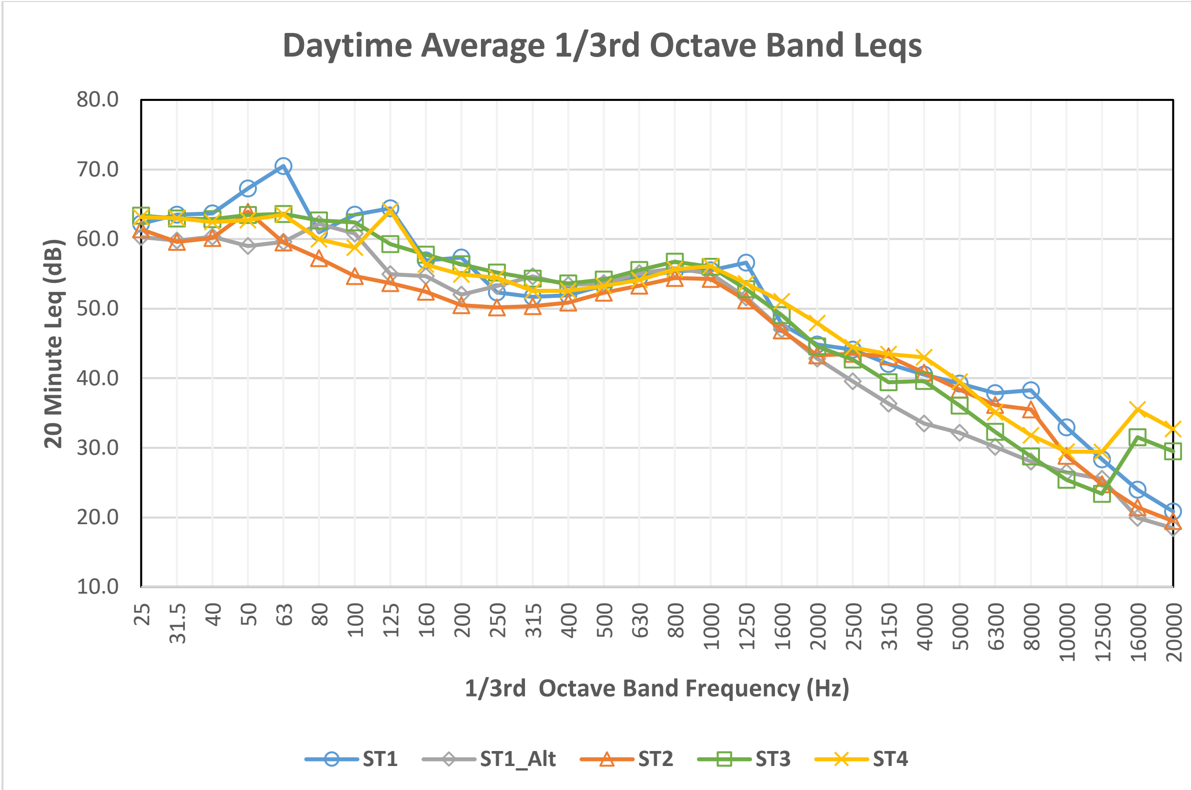


Figure 6. Daytime Ambient Sound Levels (Filtered L_{eq}) in 1/3 Octave Bands

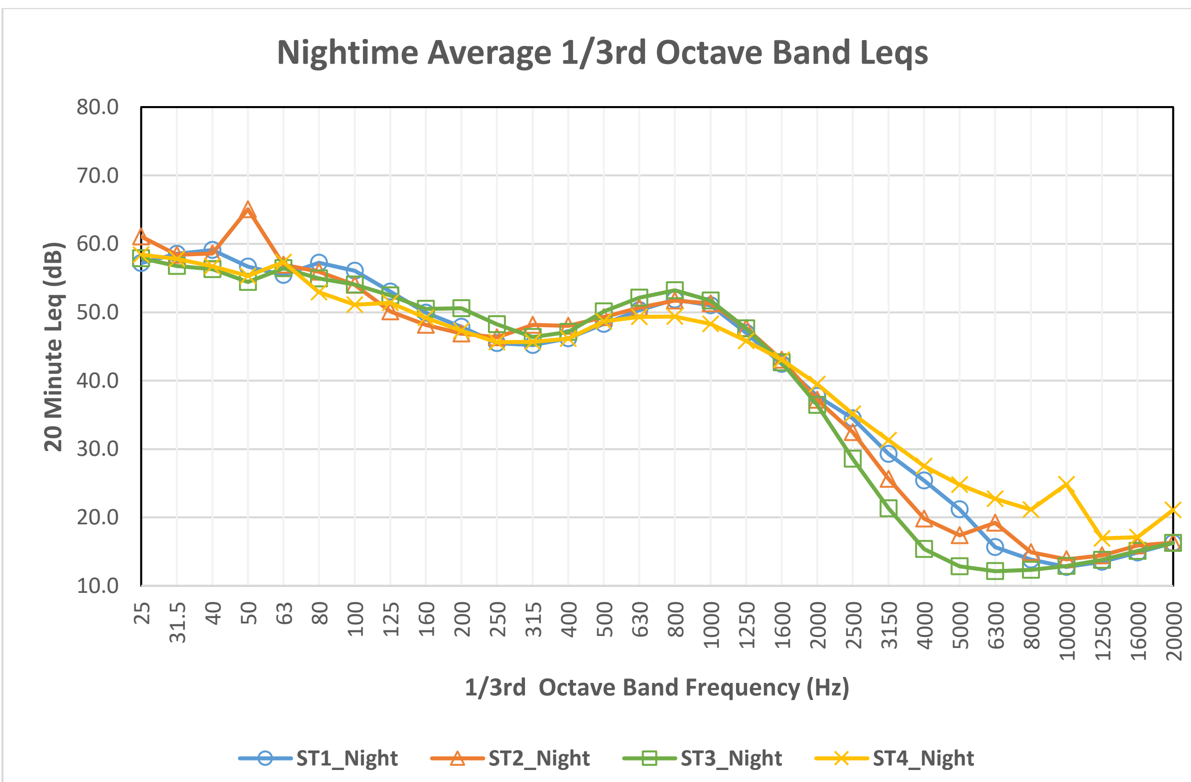


Figure 7. Nighttime Ambient Sound Levels (Filtered L_{eq}) in 1/3 Octave Bands

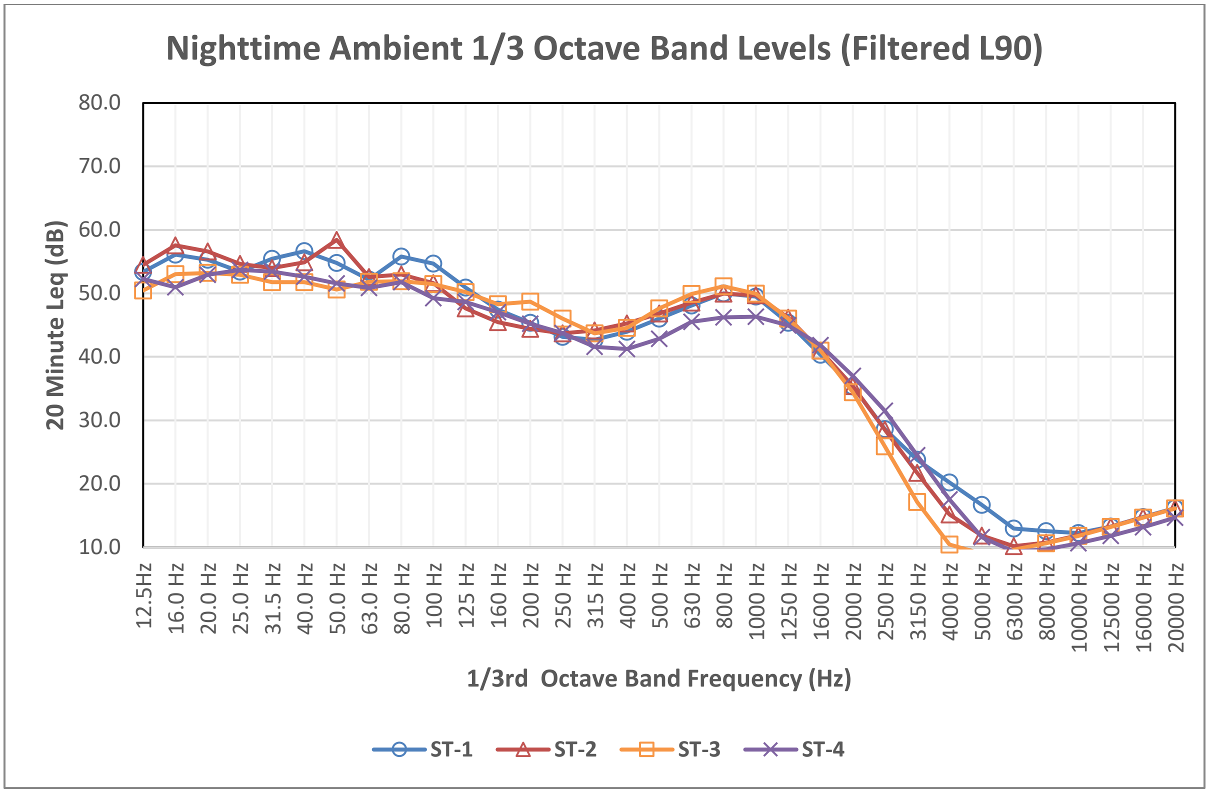


Figure 8. Nighttime Ambient Sound Levels (Filtered L_{90}) in 1/3 Octave Bands

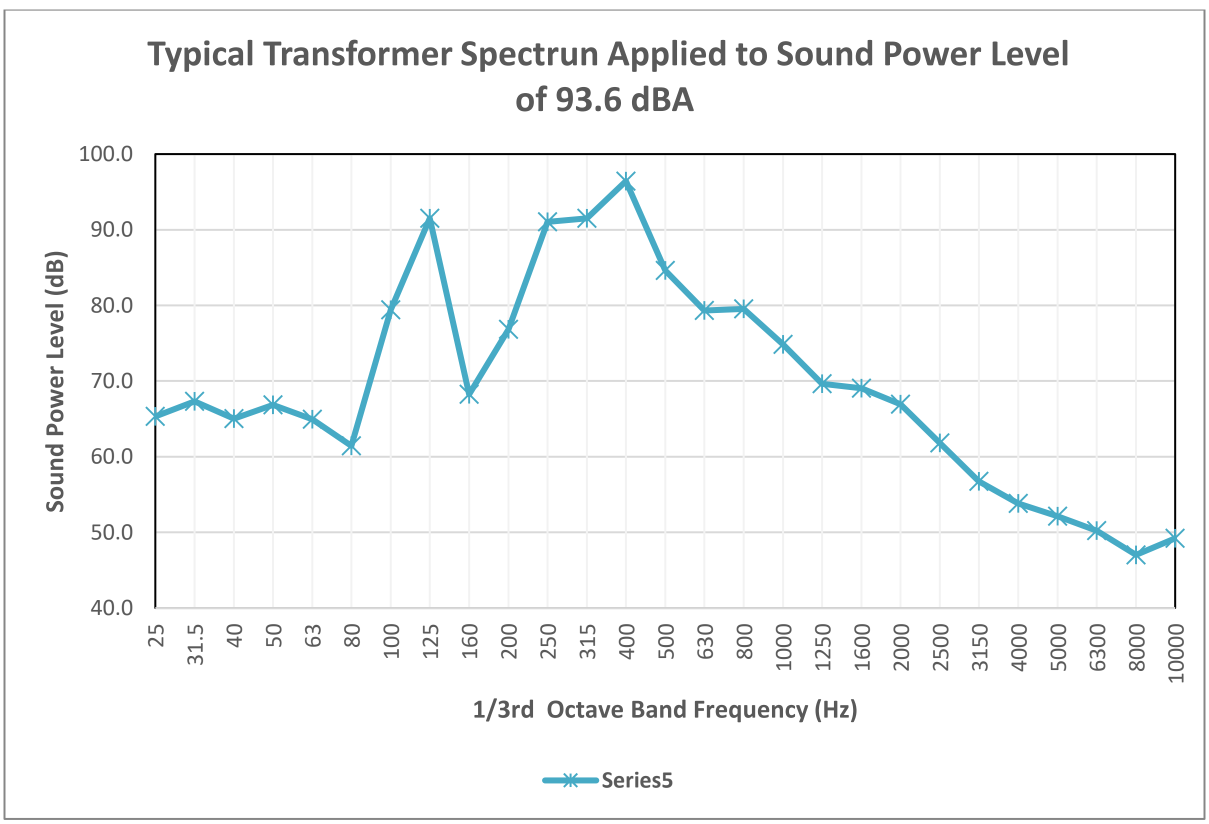


Figure 9. Estimated 1/3 Octave Band Sound Power Levels for the 30/40/50 MVA Transformer

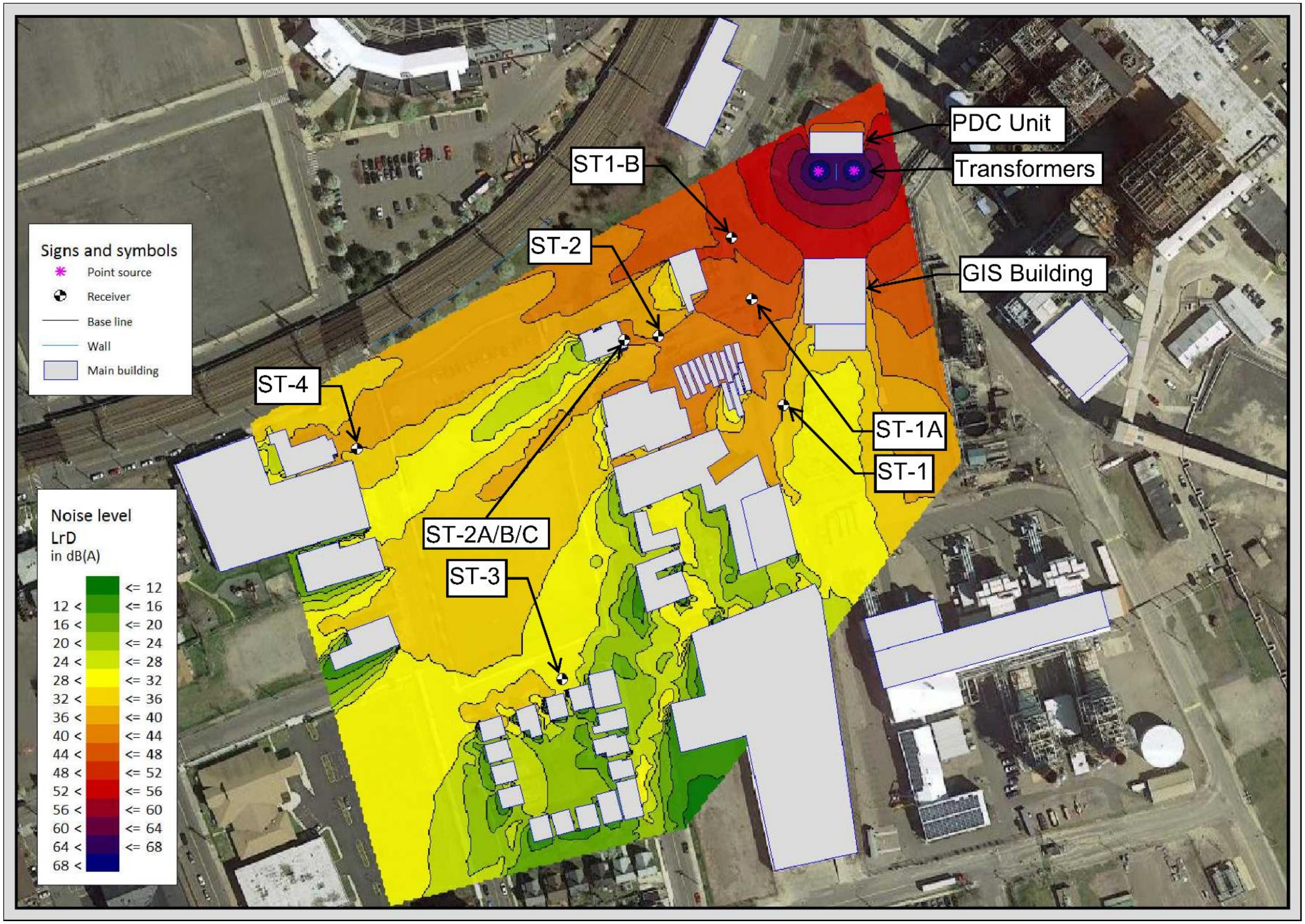


Figure 10. Noise Exposure Contours (in dBA) for Operation of the Two 30/40/50 MVA Transformers

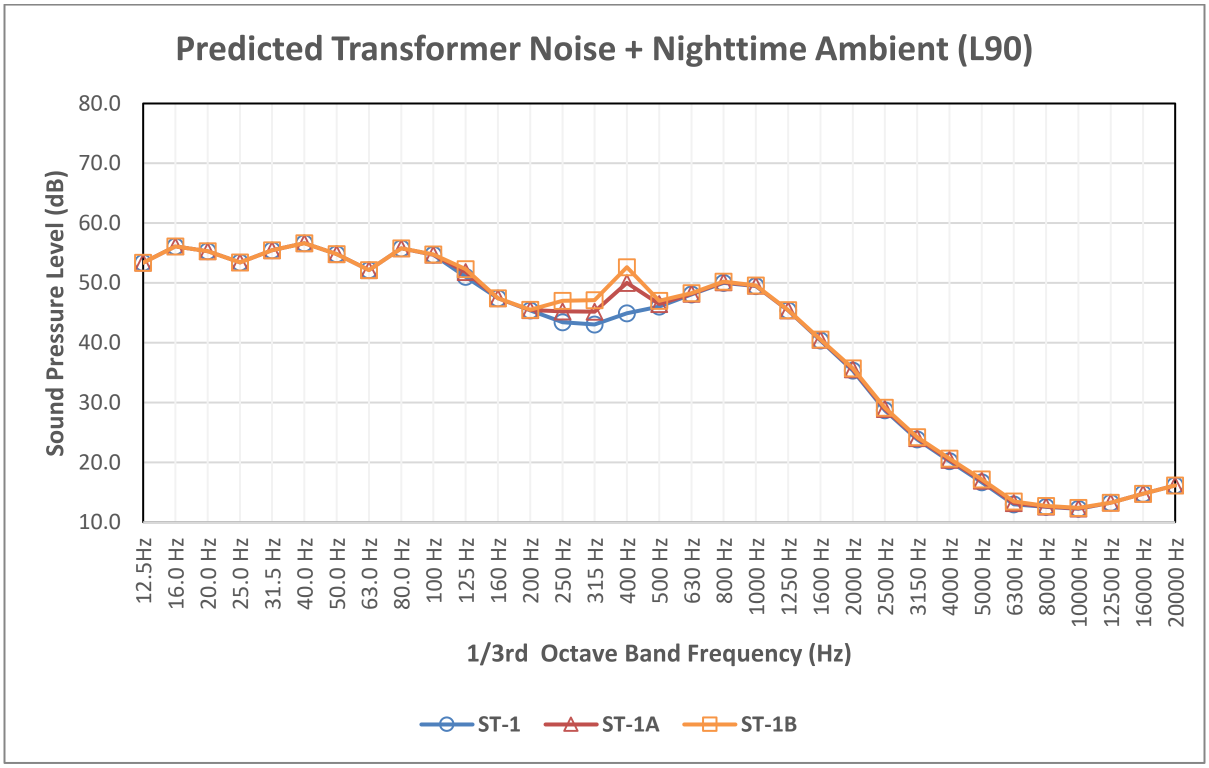


Figure 11. Predicted Transformer Noise Added to Ambient L_{90} in 1/3 Octave Bands at Sites ST-1/A/B

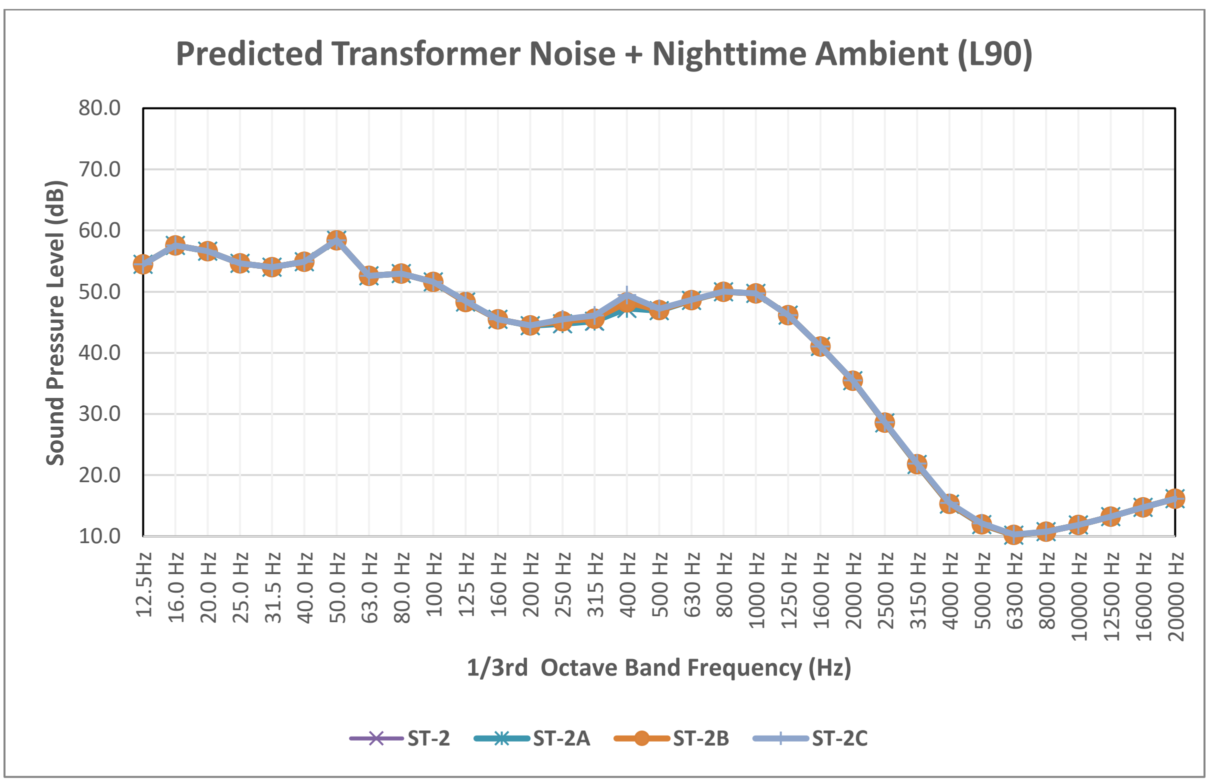


Figure 12. Predicted Transformer Noise Added to Ambient L_{90} in 1/3 Octave Bands at Sites ST-2/A/B/C

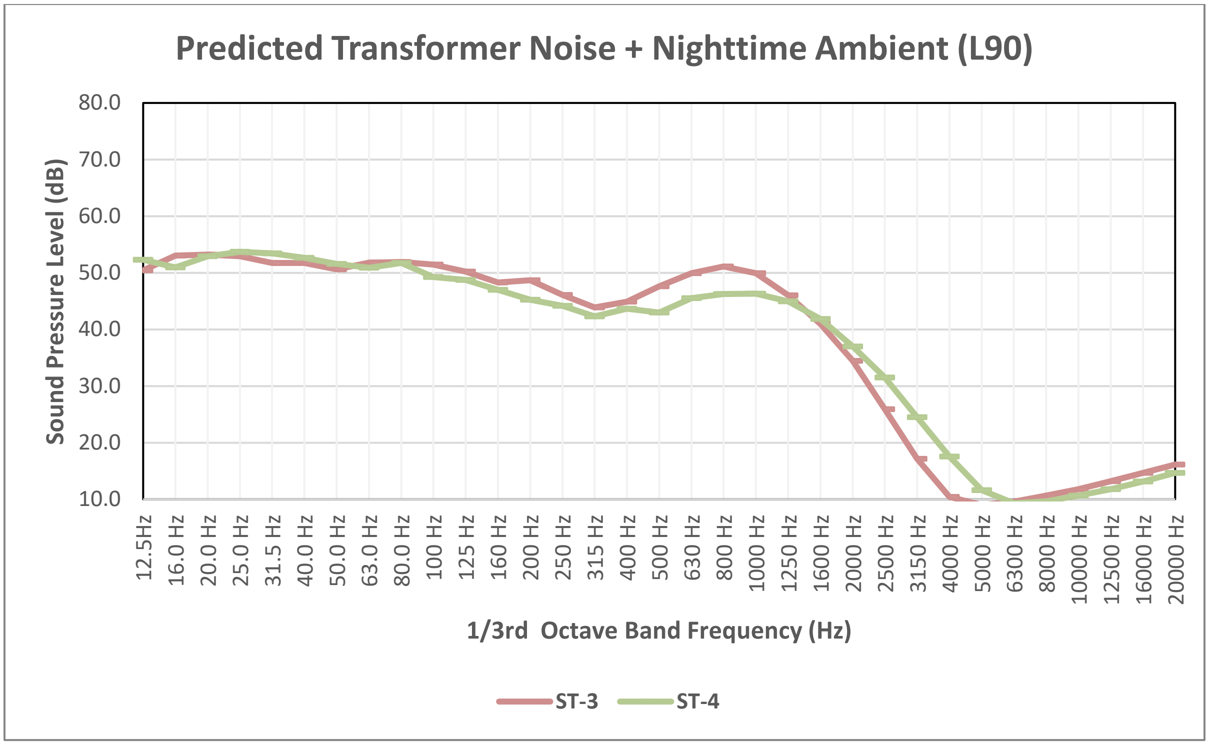


Figure 13. Predicted Transformer Noise Added to Ambient L_{90} in 1/3 Octave Bands at Sites ST-3/4