BAIRD REPLACEMENT SUBSTATION PROJECT NOISE EVALUATION

B&V PROJECT NO. 186535

PREPARED FOR

The United Illuminating Company

28 MAY 2015

Table of Contents

LIST OF TABLES

LIST OF FIGURES

Executive Summary

The United Illuminating Company (UI) is proposing to replace the existing Baird Substation located at 1770 Stratford Avenue, Stratford, Connecticut with a new substation (Project) located in the adjacent lot to the northeast. The Project will include the installation of two (2) 30/40/50 MVA transformers and HVAC equipment associated with the ancillary control enclosure and PDC enclosures.

The Project is subject to state and local regulations regarding noise emissions. However, the Town of Stratford regulations are more restrictive than those specified by the State of Connecticut. As such, the noise level standards in Chapter 142 of the Town Code have been used to evaluate regulatory compliance of the Project. To ensure regulatory compliance, the Project must meet the following:

- The sound levels associated with the Project should not exceed 45 dBA along the residential zoning boundaries to the north and south.
- The sound levels associated with the Project should not exceed 62 dBA along the commercial zoning boundaries to the east and west.

In order to characterize the existing acoustical environment surrounding the Project, an ambient sound level survey was conducted. The sound level survey was conducted at two (2) locations selected to represent nearby noise-sensitive receptors (homes & church). Measured ambient sound levels in the vicinity of the Project ranged from 52 dBA to 64 dBA. The quietest periods occurred during the early morning hours (2:00AM, 11 March) when traffic on Interstate 95 had subsided. In general, the existing ambient conditions at the nearest noise-sensitive receptors are influenced by traffic on local roads and Interstate 95, train traffic, existing Baird Substation, VIP car wash dryer fans, and wind blowing in the tress.

An acoustical model was developed to predict the sound levels due solely to the Project. The predicted Project noise emissions do not include noise associated with either site development or construction. The primary noise sources associated with the Project will include the two (2) 30/40/50 MVA transformers. Project sound pressure levels along the adjacent residential zoning boundaries to the north (residential neighborhood) and south (Russian Orthodox Church) are anticipated to be 44 dBA and 41 dBA, respectively. Project sound levels along the adjacent commercial zoning boundaries to the east (Two Roads Brewery) and the west (Savings Auto Center) are anticipated to be 48 dBA and 43 dBA, respectively. As such, the Project is expected comply with the noise regulations specified by the Town of Stratford and State of Connecticut.

1.0 Introduction

The United Illuminating Company (UI) is proposing to replace the existing Baird Substation (existing substation) located at 1770 Stratford Avenue, Stratford, Connecticut with a new Substation (Project) located in the adjacent lot to the northeast. Based on available design information and drawings, the Project will include the installation of two (2) 30/40/50 MVA transformers and HVAC equipment associated with the ancillary control enclosure and PDC enclosures. For reference, an aerial view of the existing substation and the Project are shown in Figure 1-1.

In support of the Project, a noise evaluation has been conducted to address the following questions:

- *What noise regulations are applicable to the Project?*
- *What are the current existing ambient sound levels in the vicinity of the Project?*
- *What are the expected environmental noise emissions associated with the Project?*
- *What (if any) noise mitigation measures are anticipated to be necessary for the Project to support compliance with the applicable noise regulations?*

Figure 1-1 Aerial view of the existing substation and Project

2.0 Applicable Noise Regulations

Regulations, standards, and guidelines related to environmental noise emissions were investigated and reviewed to determine applicability to the Project. No quantifiable noise requirements or guidelines in Fairfield County were identified. However, the following sections summarize the noise regulations established by the State of Connecticut and the Town of Stratford and the applicability of each.

2.1 STATE OF CONNECTICUT

The state regulation governing noise is contained in the Regulations of Connecticut State Agencies (RCSA) Title 22a, Section 22a-69-1 to 22a-69-7.4. The statutes provide limits that are based on the noise zone and time of day. Noise zones are established based on the Standard Land Use Classification Manual of Connecticut.

- Class A noise zone generally includes residential areas where human beings sleep or areas where serenity and tranquility are essential to the intended use of the land such as residential areas (single and multi-family), hotels, hospitals, and religious facilities.
- Class B noise zone generally includes commercial areas where human beings converse and such conversation is essential to the intended use of the land such as retail business, professional services, and recreational activities.
- Class C noise zone generally includes industrial areas where protection against damage to hearing is essential and the necessity for conversation is limited such as manufacturing facilities, utility uses, and agricultural activities.

The Substation site is designated as a Class C noise zone. In accordance with the designations and the noise limits detailed in RCSA Section 22a-69-3.5, noise zone boundaries and corresponding noise limits adjacent to the Substation are shown in Figure 2-1. Compliance with these specified limits is determined by measuring the A-weighted sound pressure level at one (1) foot beyond the emitter's boundary inside the receptor's noise zone. The emitter's zone includes contiguous rights of way for streets, highways, railroads, and waters of the state.

In addition to these limits, there is a 5 dB penalty (reduction in the applicable limit) when a prominent discrete tone is present. Per the statute, a prominent discrete tone is "the presence of acoustic energy concentrated in a narrow frequency range". The determination of the tone is relative to the sound pressure levels in the adjacent frequency bands as specified in RCSA Section 22a-69-1.2 (r). If a discrete tone exists, the daytime and nighttime limits are reduced to 56 dBA and 46 dBA, respectively, for noise from a Class C noise zone to a Class A noise zone.

Although these limits are objective and straightforward, the statute also contains language that can be used to file a complaint. For example, Section 22a-69-1.5 states that "compliance of a source with these Regulations is not a bar to a claim of nuisance by any person. A violation of any portion of these regulations shall not be deemed to create a nuisance per se." This would seem to permit some leeway in determining whether a source is a nuisance or not regardless of whether it meets the objective requirements.

Figure 2-1 Project noise limits per the State of Connecticut

2.2 TOWN OF STRATFORD

The Town of Stratford identifies noise level standards in Chapter 142 of the Town Code. Unlike the State of Connecticut, which establishes limits based on land use, the Town of Stratford noise level standards are specified for the zoning designations of the emitting and receiving land and the time of day. Based upon zoning information provided by UI, the Project site is currently zoned both industrial and commercial. However, due to the lower noise limits associated with the commercial zoning designation, the entire Project property has been conservatively assumed to be a commercial zone. As such, the noise limits and corresponding zone boundaries adjacent to the Project are shown in Figure 2-2.

Figure 2-2 Project noise limits per the Town of Stratford

2.3 NOISE REGULATION APPLICABILITY

Since the Project will operate during both daytime and nighttime hours the Project will need to comply with the more restrictive nighttime limits. Based on the regulations reviewed, the nighttime limits specified by the Town of Stratford are more stringent and have been used as the design basis for the Project. Regulatory compliance with the Town of Stratford limits will subsequently result in compliance with the limits specified by the State of Connecticut.

As such, to ensure compliance with the most restrictive noise limits, the Project must meet the following:

- The sound levels associated with the Project should not exceed 45 dBA along the residential zoning boundaries (refer to Figure 2-2).
- The sound levels associated with the Project should not exceed 62 dBA along the commercial zoning boundaries (refer to Figure 2-2).

3.0 Existing Acoustical Environment

An ambient sound level survey was conducted in order to characterize the existing acoustical environment in the area surrounding the Project site prior to the installation and operation of the new Substation. This section describes the results of the survey and the nature of the existing acoustical environment.

3.1 SURVEY PROCEDURE AND CONDITIONS

The ambient sound level survey was conducted March 9 through March 11, 2015. The survey procedure was based on relevant portions of general industry standards including, but not limited to ANSI S1.13, ANSI S12.9, and ANSI S12.18. Sound level measurements were conducted using Type 1 and Type 2 sound level meters that met the requirements of ANSI S1.4. The sound level meters were field calibrated immediately before and after each measurement period. All equipment had been laboratory calibrated within the last 12 months. A list of the measurement equipment utilized during the survey and copies of corresponding calibration certificates are included in Appendix A.

With the exception of a few periods of light precipitation during the evening (March 10) and early morning hours (March 11) of the survey, meteorological conditions were suitable for environmental noise monitoring. Temperatures ranged from approximately 28 to 50°F and skies were generally clear or overcast. Wind speeds ranged from 0 to 4 mph with sporadic gusts up to 14 mph. The temperature, humidity, and wind speed trends during the hours of the ambient sound level survey are detailed in Appendix B.

Additionally, it is important to note that snow cover was present during the survey. However, the snow cover was not considered to be a light, powder but rather a heavy, dense snow pack simulating hard ground and thus was deemed acceptable for environmental sound level measurements.

In order to effectively quantify and qualify the existing daily sound levels surrounding the Project site, the ambient survey included continuous sound level monitoring and short-term (attended) sound level measurements. Noise measurement locations (NML's) were selected to represent nearby noise-sensitive receptors (homes & church). Geographic coordinates and the location of each measurement location are summarized in Table 3-1 and identified on Figure 3-1.

Several sound level metrics were used to quantify the fluctuating environmental noise. These metrics included the L10, L50, and L90 sound levels. The L90 sound level is generally considered representative of the residual or background sound level (i.e., without discrete noise events such as occasional traffic, aircraft, etc.), the L50 sound level is considered the median sound level, and the L10 sound level is generally considered the intrusive sound level (i.e., with the occasional discrete events such as traffic, aircraft, etc.). For a more detailed discussion regarding the acoustical terminology referenced within this report please refer to Appendix C.

Table 3-1 Nosie Measurement Locations (NML's)

LOCATION	UTM COORDINATES ZONE 18 (m E/m N)	LOCATION DESCRIPTION	TYPE OF MONITORING
NML1	655652 / 4561075	End of Jackson Avenue, residential neighborhood, north of the Project site.	Continuous and Short-term
NML2	655792 / 4560871	South of the Project site, along Old Honeyspot Rd, St. Nichols Russian Orthodox Church parking lot.	Short-term

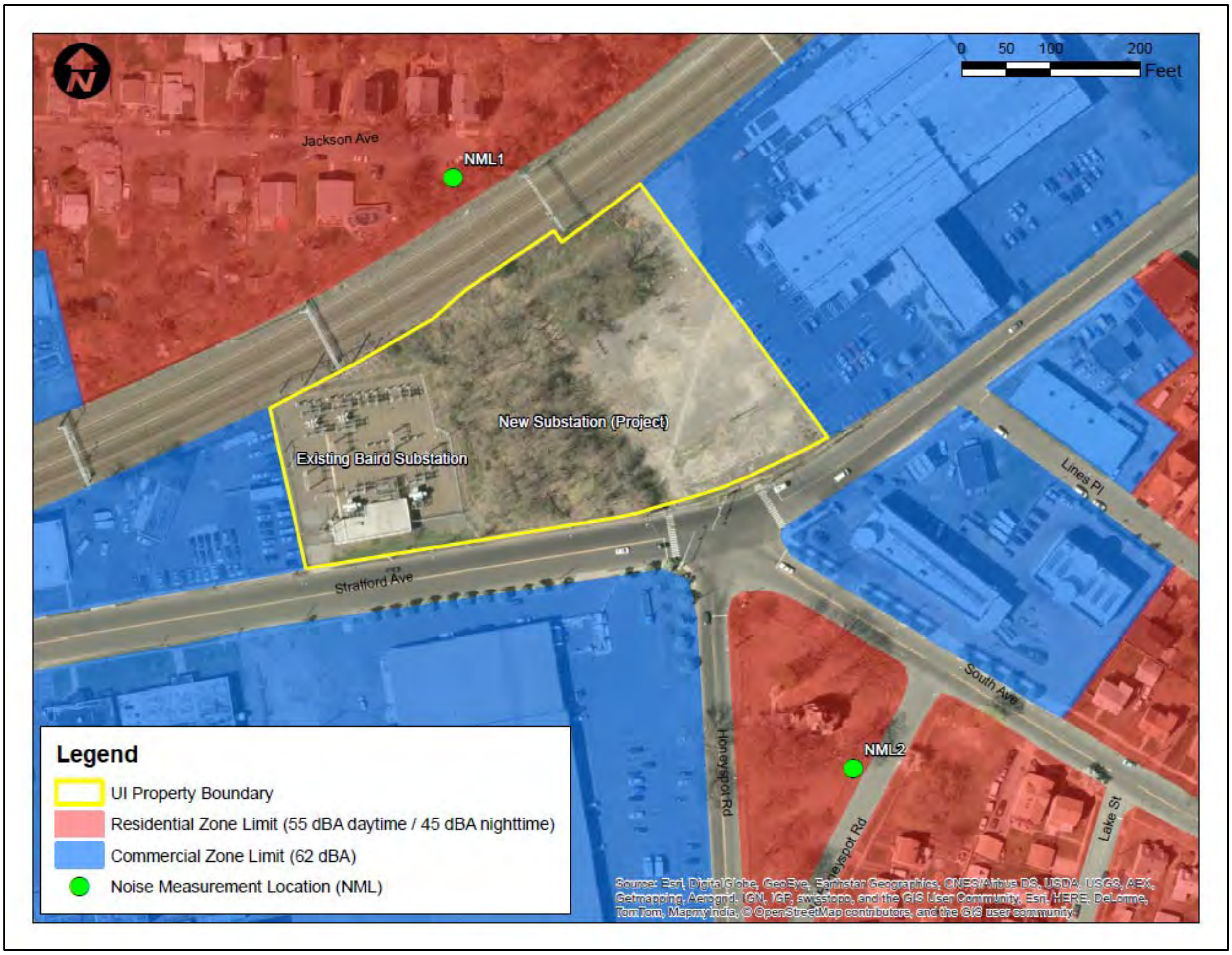


Figure 3-1 Noise measurement locations (NML's)

3.2 SURVEY RESULTS

The ambient sound level survey included continuous sound level monitors and short-term (attended) sound level measurements. Continuous sound level monitoring collected sound level data at NML1 throughout the survey period. Short-term, 10 to 20-minute, measurements were conducted periodically at both NML's in order to qualify the existing overall conditions and quantify the existing spectral conditions during various daytime and nighttime hours. The subsequent sections detail the survey results at each measurement location.

3.2.1 NML1: Representative of the Nearest Noise Sensitive Properties along Jackson Ave

Sound level measurements were conducted at NML1 to capture the acoustical environment experienced by the noise-sensitive receptors (homes) north of the Project along Jackson Avenue. The 45-hour monitoring results are detailed in Figure 3-2 and provide an indication of the daily sound level trends. The background sound levels (L_{90}) ranged from 52 dBA to 63 dBA during the daytime hours (8:00AM to 9:00PM) and 52 dBA to 64 dBA during the nighttime hours (9:00PM to 8:00AM). The quietest periods occurred during the early morning hours (2:00AM, 11 March) when traffic on Interstate 95 had subsided.

It is important to note that the L_{90} sound levels represent the background conditions without the influence of discrete events such as dogs barking, aircraft flyovers, etc. The L_{10} sound levels, shown in Figure 3-3, are generally representative of the higher sound levels that occurred during noisy discrete events.

Short-term sound level measurements were also conducted at NML1 during both daytime and nighttime hours and are shown in Figure 3-3. The short-term measurements are consistent with the continuous monitoring results. Influential noise sources observed during the short-term measurements included traffic on Interstate 95 and Stratford Avenue, Metro train traffic, VIP car wash dryer fans, existing Baird Substation transformer hum, and neighbors talking.

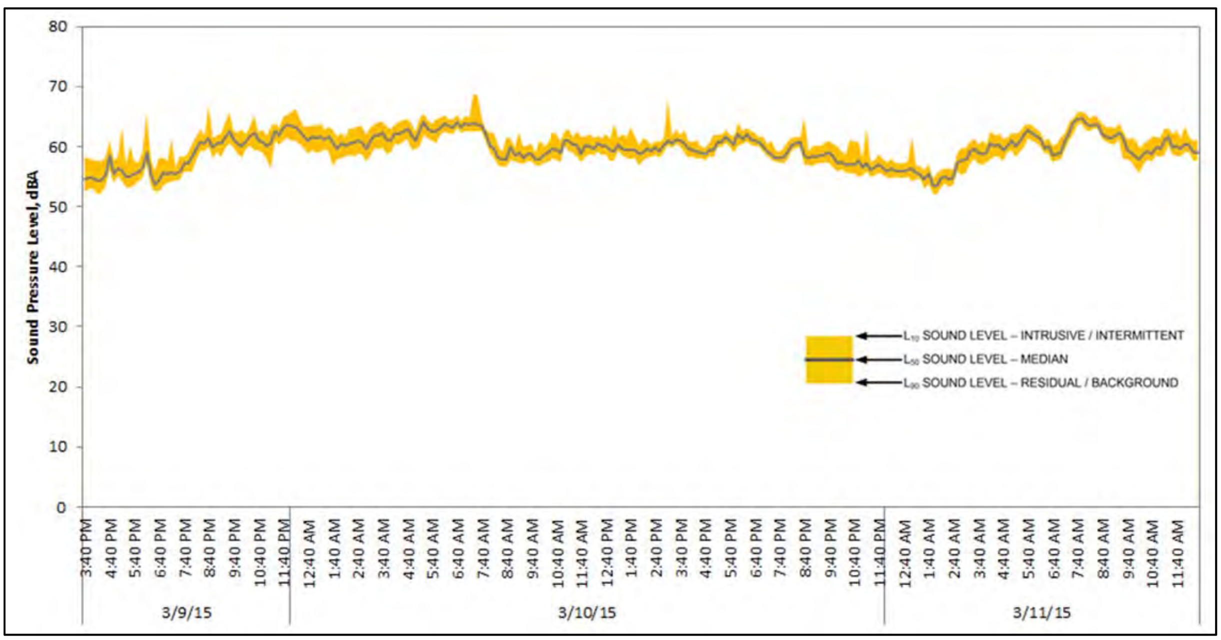


Figure 3-2 NML1 continuous monitoring results (10 min measurement interval)

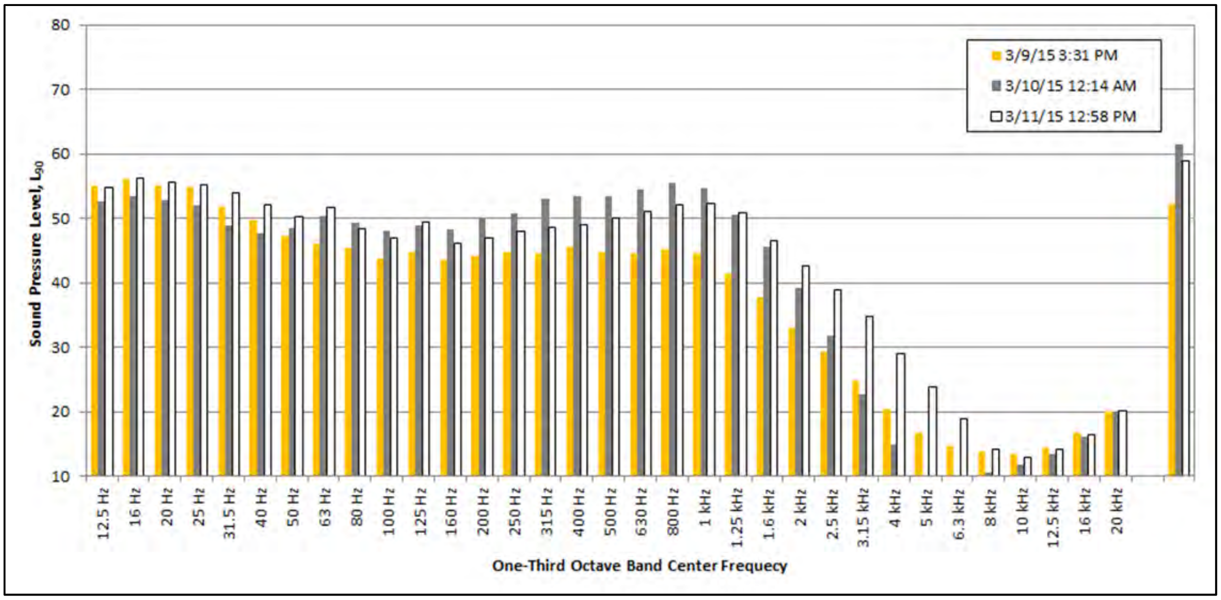


Figure 3-3 **NML1 short-term measurement results**

3.2.2 NML2: Representative of the Nearest Noise Sensitive Properties along Old Honeyspot Rd

Short-term sound level measurements were conducted at NML2 during both daytime and nighttime hours to capture the acoustical environment experienced by the noise-sensitive receptors (church & homes) south of the Project along Old Honeyspot Road. The details of the measurement location are shown in Figure 3-4. Influential noise sources observed during the short-term measurements included local traffic on Stratford Rd, South Ave, and Interstate 95, Metro and distant train traffic, VIP car wash dryer fans, and wind blowing through the trees.

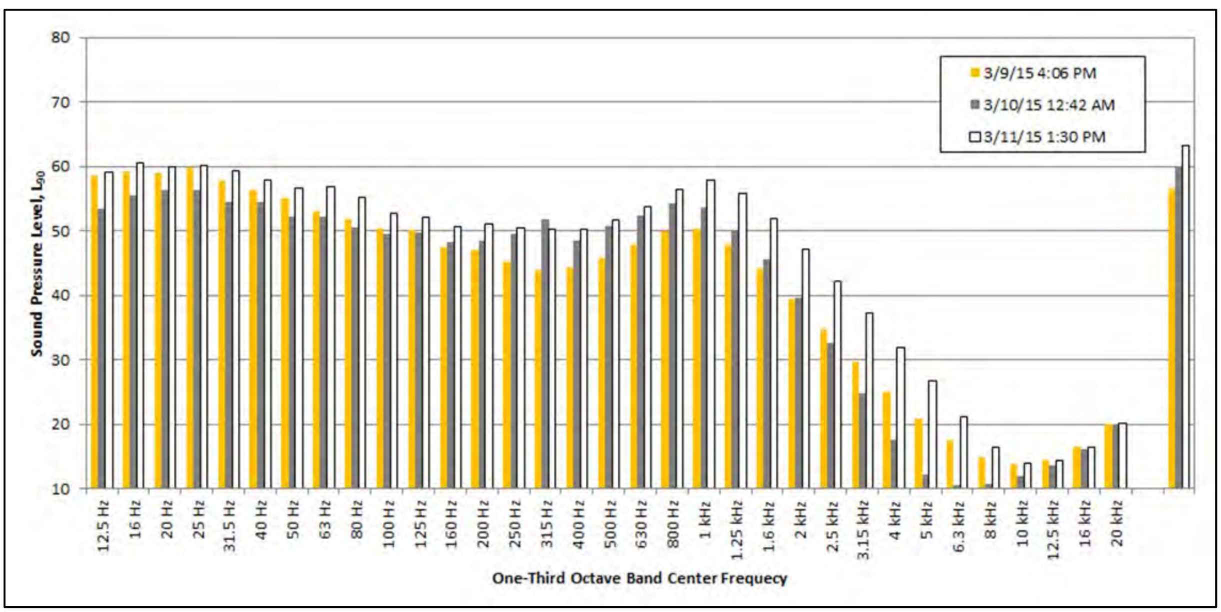


Figure 3-4 **NML2 short-term measurement results (L_{90})**

3.3 SURVEY RESULTS SUMMARY

As summarized in Table 3-2, the existing ambient sound levels in the vicinity of the Project site ranged from 52 dBA to 64 dBA at the two survey locations. The quietest periods occurred during the early morning hours (2:00AM, 11 March) when traffic on Interstate 95 had subsided. In general, the existing ambient conditions at the nearest noise-sensitive receptors are influenced by traffic on local roads and Interstate 95, train traffic, existing Baird Substation, VIP car wash dryer fans, and wind blowing in the tress.

Table 3-2 Summary of Survey Results

LOCATION	RANGE OF DAYTIME BACKGROUND SOUND LEVELS (10 min L_{90}), dBA	RANGE OF NIGHTTIME BACKGROUND SOUND LEVELS (10 min L_{90}), dBA	OBSERVED NOISE SOURCES
NML1	52 – 63	52 –64	Interstate 95 and Stratford Avenue traffic, train traffic, VIP car wash, existing Baird Substation, and neighbors talking
NML2	57 (4:06 PM, 9 March)[1] 63 (1:30 PM, 11 March)	60 (12:42 AM, 10 March)[1]	Stratford Rd, South Ave, and Interstate 95 traffic, train traffic, VIP car wash, and wind in the trees

Notes:
1. **20 minute measurement period**

4.0 Project Noise Emissions

The environmental noise emissions from the Project have been predicted in order to evaluate compliance with the applicable noise regulations. This section discusses noise emissions solely from the Project and is based on the equipment layout drawing provided by the project design team which is included in Appendix D.

4.1 PROJECT NOISE MODELING

The environmental noise emissions associated with the Substation have been modeled using noise prediction software (Cadna/A version 4.5.151), which is based on methodologies specified in ISO 9613. The model simulated the outdoor propagation of sound from each noise source and accounted for sound wave divergence, atmospheric and ground sound absorption, and sound shielding due to interceding barriers, buildings, and terrain. A database was developed which specified the location, and octave-band sound levels of each noise source. A receptor grid was specified which covered the entire area of interest. The model calculated the sound pressure levels within the receptor grid based on the octave-band sound level contribution of each noise source. Finally, a noise contour plot was produced based on the overall sound pressure levels within the receptor grid, including at specific receptor locations.

To account for increased transformer sound levels associated with peak Project loading conditions modeling was based on normal operation consistent with Summer months which includes noise contributions from the transformer cooling fans. The noise model did not consider any abnormal or upset operating conditions. Various structures associated with the Project were included in the model to account for their shielding effect.

4.2 PROJECT EQUIPMENT SPECIFICATIONS

The primary noise sources associated with the Project will be the two (2) 30/40/50 MVA transformers and the HVAC equipment associated with the ancillary control enclosure and PDC enclosures. Equipment sound levels used to develop the acoustical model are shown in Table 4-1 and are based on a combination of measured data of similar substation installations and information received from past equipment suppliers.

Please note that any deviations from the current site arrangement, the assumed equipment specifications, or the acoustical design elements outlined herein, may affect the overall Project noise emissions and thus the modeling results presented below. If such design or specification changes occur, the noise emissions should be re-evaluated to determine the impacts of the proposed design change.

Table 4-1 Equipment Sound Levels for the Project

EQUIPMENT	QTY	EQUIPMENT SOUND LEVELS	BASIS
30/40/50 MVA transformer	2	75 dBA per IEEE C57.12.90 9 (FOA, fans operation)	In-house[1]
5 Ton HVAC Unit (Control Bldg.)	2	75 dBA @ 3 ft (1)	In-house[1]
6 Ton HVAC Unit (PDC's)	2	75 dBA @ 3 ft (1)	In-house[1]

Notes:
1. **In-house data is based on a combination of measured data of similar substation installations and information received from past equipment suppliers.**

4.3 REGULATORY COMPLIANCE

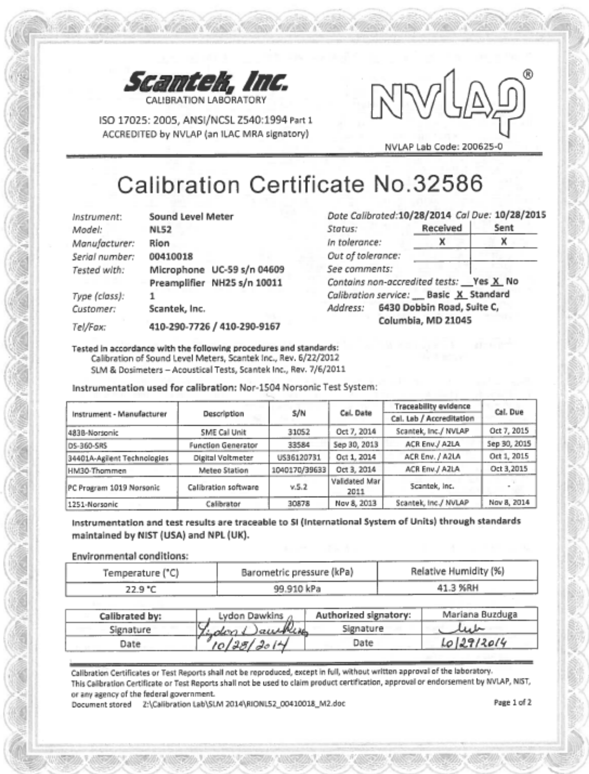
The calculated sound pressure levels associated with the Project are presented in Figure 4-1. It is important to note that the calculated noise emissions only include noise from the Project and are exclusive of any other sound sources, including background noise. Project sound pressure levels along the adjacent residential zoning boundaries to the north (residential neighborhood) and south (Russian Orthodox Church) are anticipated to be 44 dBA and 41 dBA, respectively. Project sound levels along the adjacent commercial zoning boundaries to the east (Two Roads Brewery) and the west (Savings Auto Center) are anticipated to be 548 dBA and 43 dBA, respectively. As such, the Project is expected comply with the noise regulations specified by the Town of Stratford and State of Connecticut.

Figure 4-1 Project A-weighted sound pressure levels, normal operation consistent with Summer months.

Appendix A. Ambient Survey Test Equipment

Table A-1 Ambient Survey Test Equipment

MODEL	SERIAL NUMBER	LAST CALIBRATION DATE
Rion Model NL-52	00410018	28 October 2014
Rion Model NL-22 (#1)	01110135	15 July 2014
CEL 177 Acoustic Calibrator	558038	15 July 2014



Scantek, Inc.
CALIBRATION LABORATORY
ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1
ACCREDITED by NVLAP (an ILAC MRA signatory)

NVLAP Lab Code: 200625-0

Calibration Certificate No.32586

Instrument: Sound Level Meter
Model: NL52
Manufacturer: Rion
Serial number: 00410018
Tested with: Microphone UC-59 s/n 04609
Preamplifier NH25 s/n 10011
Type (class): 1
Customer: Scantek, Inc.
Tel/Fax: 410-290-7726 / 410-290-9167

Date Calibrated: 10/28/2014 Cal Due: 10/28/2015

Status:	Received	Sent
In tolerance:	X	X
Out of tolerance:		
See comments:		

Contains non-accredited tests: __Yes X No
Calibration service: __ Basic X Standard
Address: 6430 Dobbin Road, Suite C, Columbia, MD 21045

Tested in accordance with the following procedures and standards:
Calibration of Sound Level Meters, Scantek Inc., Rev. 6/22/2012
SLM & Dosimeters – Acoustical Tests, Scantek Inc., Rev. 7/6/2011

Instrumentation used for calibration: Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	31052	Oct 7, 2014	Scantek, Inc./ NVLAP	Oct 7, 2015
DS-360-SRS	Function Generator	33584	Sep 30, 2013	ACR Env./ A2LA	Sep 30, 2015
34401A-Agilent Technologies	Digital Voltmeter	US36120731	Oct 1, 2014	ACR Env. / A2LA	Oct 1, 2015
HM30-Thommen	Meteo Station	1040170/39633	Oct 3, 2014	ACR Env./ A2LA	Oct 3,2015
PC Program 1019 Norsonic	Calibration software	v.5.2	Validated Mar 2011	Scantek, Inc.	-
1251-Norsonic	Calibrator	30878	Nov 8, 2013	Scantek, Inc./ NVLAP	Nov 8, 2014

Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK).

Environmental conditions:

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
22.9 °C	99.910 kPa	41.3 %RH

Calibrated by:	Lydon Dawkins	Authorized signatory:	Mariana Buzduga
Signature	Lydon Dawkins	Signature	[signature]
Date	10/28/2014	Date	10/29/2014

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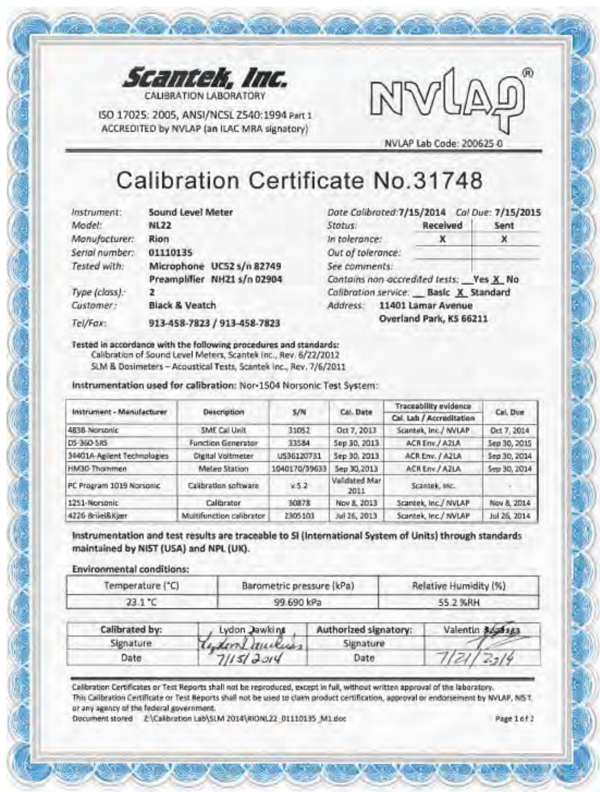
Page 1 of 2



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ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1
ACCREDITED by NVLAP (an ILAC MRA signatory)

NVLAP Lab Code: 200625-0

Calibration Certificate No.31748

Instrument: Sound Level Meter
Model: NL22
Manufacturer: Rion
Serial number: 01110135
Tested with: Microphone UC52 s/n 82749
Preamplifier NH21 s/n 02904
Type (class): 2
Customer: Black & Veatch
Tel/Fax: 913-458-7823 / 913-458-7823

Date Calibrated: 7/15/2014 Cal Due: 7/15/2015

Status:	Received	Sent
In tolerance:	X	X
Out of tolerance:		
See comments:		

Contains non-accredited tests: __Yes X No
Calibration service: __ Basic X Standard
Address: 11401 Lamar Avenue, Overland Park, KS 66211

Tested in accordance with the following procedures and standards:
Calibration of Sound Level Meters, Scantek Inc., Rev. 6/22/2012
SLM & Dosimeters – Acoustical Tests, Scantek Inc., Rev. 7/6/2011

Instrumentation used for calibration: Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	31052	Oct 7, 2013	Scantek, Inc./ NVLAP	Oct 7, 2014
DS-360-SRS	Function Generator	33584	Sep 30, 2013	ACR Env./ A2LA	Sep 30, 2015
34401A-Agilent Technologies	Digital Voltmeter	US36120731	Sep 30, 2013	ACR Env. / A2LA	Sep 30, 2014
HM30-Thommen	Meteo Station	1040170/39633	Sep 30,2013	ACR Env./ A2LA	Sep 30, 2014
PC Program 1019 Norsonic	Calibration software	v.5.2	Validated Mar 2011	Scantek, Inc.	-
1251-Norsonic	Calibrator	30878	Nov 8, 2013	Scantek, Inc./ NVLAP	Nov 8, 2014
4226-Brüel&Kjær	Multifunction calibrator	2305103	Jul 26, 2013	Scantek, Inc./ NVLAP	Jul 26, 2014

Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK).

Environmental conditions:

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
23.1 °C	99.690 kPa	55.2 %RH

Calibrated by:	Lydon Dawkins	Authorized signatory:	Valentin [illegible]
Signature	Lydon Dawkins	Signature	[signature]
Date	7/15/2014	Date	7/21/2014

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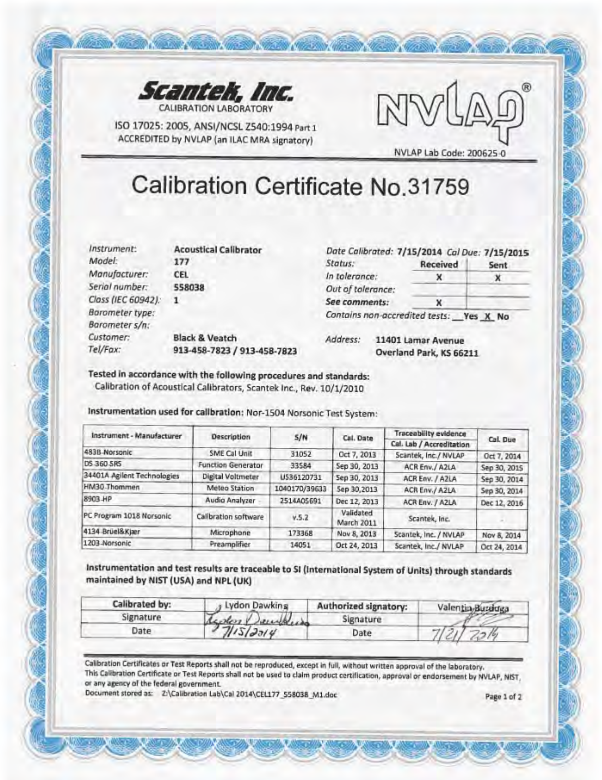
Page 1 of 2



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ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1
ACCREDITED by NVLAP (an ILAC MRA signatory)

NVLAP Lab Code: 200625-0

Calibration Certificate No.31759

Instrument: **Acoustical Calibrator**
Model: **177**
Manufacturer: **CEL**
Serial number: **558038**
Class (IEC 60942): **1**
Barometer type:
Barometer s/n:
Customer: **Black & Veatch**
Tel/Fax: **913-458-7823 / 913-458-7823**

Date Calibrated: **7/15/2014** *Cal Due:* **7/15/2015**

Status:	**Received**	**Sent**
In tolerance:	X	X
Out of tolerance:		
See comments:	X	

Contains non-accredited tests: __Yes _X_ No

Address: **11401 Lamar Avenue**
Overland Park, KS 66211

Tested in accordance with the following procedures and standards:
Calibration of Acoustical Calibrators, Scantek Inc., Rev. 10/1/2010

Instrumentation used for calibration: Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	31052	Oct 7, 2013	Scantek, Inc./ NVLAP	Oct 7, 2014
DS 360-SRS	Function Generator	33584	Sep 30, 2013	ACR Env./ A2LA	Sep 30, 2015
34401A Agilent Technologies	Digital Voltmeter	US36120731	Sep 30, 2013	ACR Env. / A2LA	Sep 30, 2014
HM30-Thommen	Meteo Station	1040170/39633	Sep 30,2013	ACR Env./ A2LA	Sep 30, 2014
8903-HP	Audio Analyzer	2514A05691	Dec 12, 2013	ACR Env. / A2LA	Dec 12, 2016
PC Program 1018 Norsonic	Calibration software	v.5.2	Validated March 2011	Scantek, Inc.	-
4134-Brüel&Kjær	Microphone	173368	Nov 8, 2013	Scantek, Inc. / NVLAP	Nov 8, 2014
1203-Norsonic	Preamplifier	14051	Oct 24, 2013	Scantek, Inc./ NVLAP	Oct 24, 2014

Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK)

Calibrated by:	Lydon Dawkins	**Authorized signatory:**	Valentin Buzduga
Signature		Signature	
Date	7/15/2014	Date	7/21/2014

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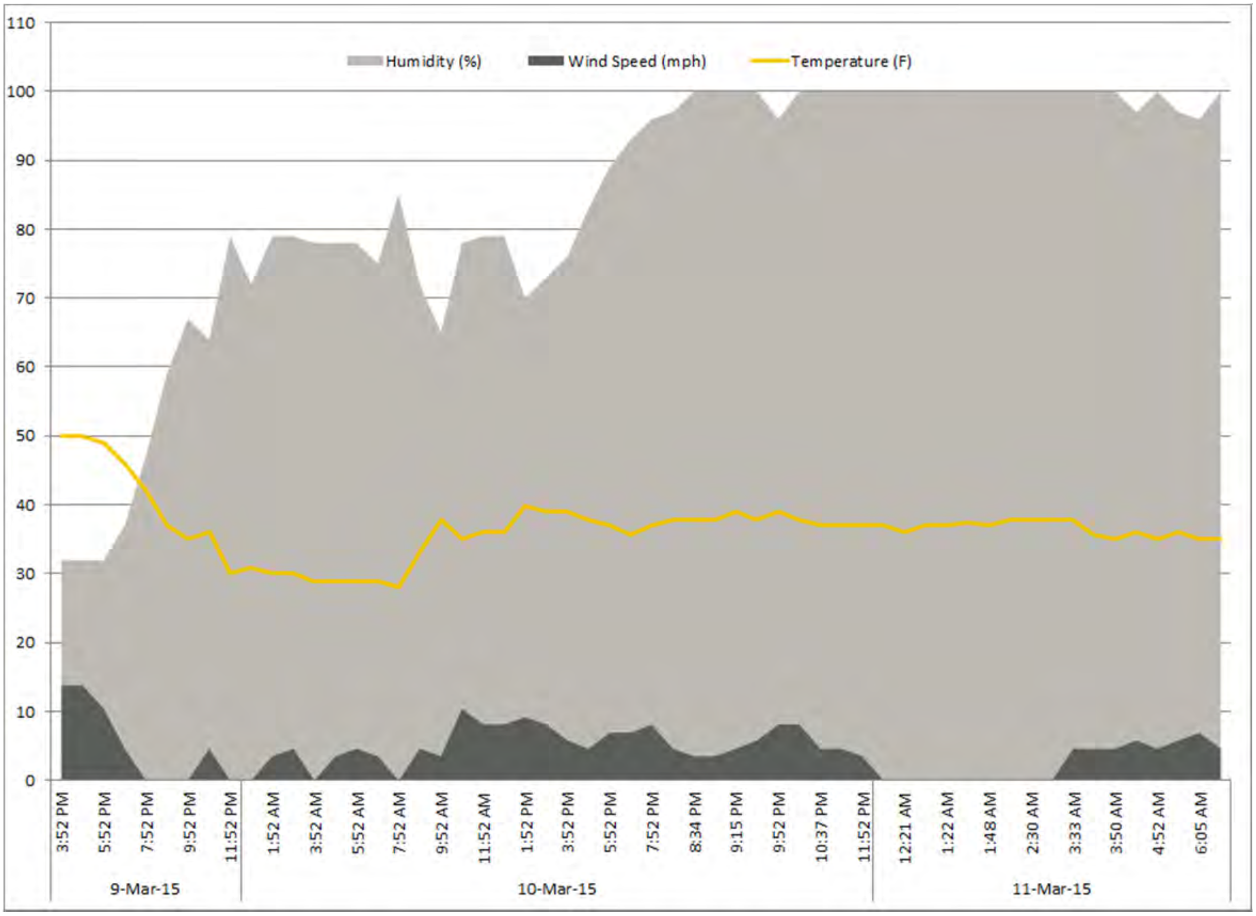
Page 1 of 2

Appendix B. Ambient Survey Meteorological Conditions



Appendix C. Acoustical Terminology

SOUND ENERGY

Sound is generated by the propagation of energy in the form of pressure waves. Being a wave phenomenon, sound is characterized by amplitude (sound level) and frequency (pitch). Sound amplitude is measured in decibels, dB. The decibel is the logarithmic ratio of a sound pressure to a reference sound pressure. Typically, 0 dB corresponds to the threshold of human hearing. A 3 dB change in a continuous broadband noise is generally considered "just barely perceptible" to the average listener. A 5 dB change is generally considered "clearly noticeable" and a 10 dB change is generally considered a doubling (or halving) of the apparent loudness (Bies and C.H. Hansen, Engineering Noise Control, 2009). For reference, the sound pressure levels and subjective loudness associated with common noise sources are shown in Table C-1.

Frequency is measured in hertz, Hz (cycles per second). Most sound sources (except those with pure tones) contain sound energy over a wide range of frequencies. In order to analyze sound energy over the range of frequencies, the sound energy is typically divided into sections called octave bands. Octave bands are identified by their center frequencies including 31.5, 63, 125, 250, 500 1000, 2000, 4000, and 8000 Hz. For more detailed analyses, narrow bands such as ⅓-octave bands or 1/12-octave bands are employed. The sum of the sound energy in all of the octave bands for a source represents the overall sound level of the source.

The normal human ear can hear frequencies ranging from 20 Hz to 20,000 Hz. At typical sound pressure levels, the human ear is more sensitive to sounds in the middle and high frequencies (1,000 to 8,000 Hz) than sounds in the low frequencies. Various weighting networks have been developed to simulate the frequency response of the human ear. The A-weighting network was developed to simulate the frequency response of the human ear to sounds at typical environmental levels. The A-weighting network emphasizes sounds in the middle to high frequencies and de-emphasizes sounds in the low frequencies. Most sound level instruments can apply these weighting networks automatically. Any sound level to which the A-weighting network has been applied is expressed in A-weighted decibels, dBA. To characterize sound that contains relatively more low frequency energy—and to approximate the ear’s response to relatively high sound levels—the C-weighting network was developed. C-weighting places more equal emphasis on low and high frequencies relative to A-weighting. Any sound level to which the C-weighting network has been applied is expressed in C-weighted decibels, dBC.

SOUND LEVEL METRICS

Noise in the environment is constantly fluctuating, such as when a car drives by, a dog barks, or a plane passes overhead. Therefore, noise metrics have been developed to quantify fluctuating environmental noise levels. These metrics include the equivalent-continuous sound level and the exceedance sound levels.

The equivalent-continuous sound level, L_{eq}, is used to represent the equivalent sound pressure level over a specified time period. The L_{eq} metric is the sound level of a steady-state sound that has the same (equivalent) total energy as the time-varying sound of interest, taken over a specified time period and covering a specified set of conditions. Thus, L_{eq} is a single-value level that expresses the time-averaged total energy of a widely varying or fluctuating sound level.

The exceedance sound level, Lx, is the sound level exceeded “x” percent of the sampling period and is referred to as a statistical sound level. The most common Lx values are L_{90}, L_{50}, and L_{10}. L_{90} is the sound level exceeded 90 percent of the sampling period. The L_{90} sound level represents the sound level without the influence of loud, transient noise sources and is therefore often referred to as the residual or background sound level (ANSI S12.9, Quantities and Procedures for Description and Measurement of Environmental Sound, 2003). The L_{50} sound level is the sound level exceeded 50 percent of the sampling period or the median sound level. The L_{10} sound level is the sound level exceeded 10 percent of the sampling period. The L_{10} sound level represents the occasional louder noises and is often referred to as the intrusive sound level. As previously discussed, the L_{90} environmental sound level typically represents the background (residual) sound level.

The variation between the L_{90}, L_{50}, and L_{10} sound levels can provide an indication of the variability of the acoustical environment. If the acoustical environment is perfectly steady, all values are identical. A large variation between the values indicates the environment experiences highly fluctuating sound levels. For instance, measurements near a roadway with frequent passing vehicles may cause a large variation in the statistical sound levels.

TYPICAL COMMUNITY SOUND LEVELS

Typical background (residual) sound levels in various types of communities are outlined in Table C-2 for reference. However, it is important to remember that each community is unique with regard to the sources of noise that contribute to the background sound levels.

HUMAN RESPONSE TO SOUND

Human response to sound is highly individualized. Annoyance is the most common issue regarding community noise. The percentage of people claiming to be annoyed by noise will generally increase as environmental sound levels increase. However, many other factors will also influence people's response to noise. These factors can include the character of the noise, the variability of the sound level, the presence of tones or impulses, and the time of day of the occurrence. Additionally, non-acoustical factors, such as the person's opinion of the noise source, the ability to adapt to the noise, the attitude towards the noise and those associated with it, and the predictability of the noise can also influence people's response. Response to noise varies widely from one person to another and with any particular noise, individual responses will range from "highly annoyed" to "not annoyed".

Table C-1 Typical Sound Pressure Levels Associated with Common Noise Sources

SOUND PRESSURE LEVEL, dBA	SUBJECTIVE EVALUATION	COMMON OUTDOOR ENVIRONMENT OR SOURCE	COMMON INDOOR ENVIRONMENT OR SOURCE
140	Deafening	Jet aircraft at 75 ft	
130	Threshold of pain	Jet aircraft during takeoff at a distance of 300 ft	
120	Threshold of feeling	Elevated Train	Hard rock band
110	Extremely loud	Jet flyover at 1000 ft	Inside propeller plane
100	Very loud	Power mower, motorcycle at 25 ft, auto horn at 10 ft	
90	Very loud	Propeller plane flyover at 1000 ft, noisy urban street	Full symphony or band, food blender, noisy factory
80	Moderately loud	Diesel truck (40 mph) at 50 ft	Inside auto at high speed, garbage disposal, dishwasher
70	Loud	B-757 cabin during flight	Close conversation, vacuum cleaner, electric typewriter
60	Moderate	Air-conditioner condenser at 15 ft, near highway traffic	General office
50	Quiet		Private office
40	Quiet	Farm field with light breeze, birdcalls	Soft stereo music in residence
30	Very quiet	Quiet residential neighborhood	Bedroom, average residence (without TV and stereo)
20	Just audible		Human breathing
10	Threshold of hearing		
0			

Source: Adapted by Black & Veatch from *Architectural Acoustics*, by David M. Egan (1988) and *Architectural Graphic Standards*, by Ramsey and Sleeper (1994.

Table C-2 Typical Daytime Background Sound Levels in Various Types of Communities

TYPE OF COMMUNITY	TYPICAL DAYTIME BACKGROUND SOUND PRESSURE LEVEL, dBA
Very Quiet Rural Areas	31 to 35
Quiet Suburban Residential	36 to 40
Normal Suburban Residential	41 to 45
Urban Residential	46 to 50
Noisy Urban Residential	51 to 55
Very Noisy Urban Residential	56 to 60
Adjacent Freeway or Major Airport	n/a

Source: Adapted by Black & Veatch from *Community Noise*, by the U.S. Environmental Protection Agency, (December 1971).

Appendix D. Site Arrangement Drawing