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***NOISE IMPACT ANALYSIS FOR
UNIVERSITY STATION***

WESTWOOD, MASSACHUSETTS

January 2013

**NOISE IMPACT ANALYSIS FOR
UNIVERSITY STATION
WESTWOOD, MASSACHUSETTS**

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1.0 EXECUTIVE SUMMARY

The objective of this study is to determine whether the operation of the proposed University Station (here in referred to as the Project) in Westwood, Massachusetts will comply with the Massachusetts Department of Environmental Protection (MassDEP) Noise Policy and the Town of Westwood Noise Regulation.

University Station will have approximately 2.1 million gross square foot (sf) of development consisting of retail, office, residential and hotel space. The Project will be located on approximately 130 acres of primarily vacant, partially cleared land located in the former University Avenue Industrial Park adjacent to the I-93/I-95 interchange and within walking distance of the MBTA Route 128 Station on the Providence/Stoughton Commuter Rail Line in Westwood. The first step was to measure sound levels at locations near the Project site to document the existing acoustic environment prior to construction of the proposed project. The second step was to use the Cadna-A acoustic model, based on International Standard ISO 9613, to calculate the sound levels from mechanical equipment on the buildings in the Project. The calculated sounds levels at the property lines and nearby residences were then compared with limits in the MassDEP Noise Policy and the Westwood Noise Regulation.

Baseline sound level monitoring was conducted at three locations representative of the nearby residential areas. These measurements were completed during a late night period to characterize the quieter existing sound levels in the residential areas and establish the background level used in the MassDEP Noise Policy. Sound monitoring was done at three Noise Sensitive Areas (NSAs): 1) a residence at 190 Partridge Drive, which is located north of the Project site; 2) a residence at 10 Endicott Street, which is located northeast of the Project site, and 3) a residence at the intersection Whitewood Road and Juniper Ridge Road, which is located east of the Project site. The dominant sources of sound were high speed motor vehicles on I-95, local area businesses, periodic aircraft over flights, and natural sounds.

The principal stationary sound sources from the Project will be rooftop heating, ventilating and air

conditioning (HVAC) units used for climate control in buildings. The Cadna-A acoustic modeling assumed simultaneous operation of all HVAC equipment at maximum load. Future maximum sound levels were calculated at the three NSAs and the maximum sound levels from the Project range from 44.2 dBA at NSA 2 to 46.5 dBA at NSA 1, which fully comply with the Town of Westwood noise standard of 50 dBA at night in residential areas. In addition, the maximum sound levels from the Project will increase the lowest nighttime background sound levels by only 1.2 dBA to 2.8 dBA, well below the 10-dBA incremental limit allowed by the MassDEP Noise Policy. Therefore, the Project will fully comply with the MassDEP Noise Policy. Whereas the Project is at the concept level of design, best estimates of rooftop mechanical systems were made, and low-noise units were specified for two office buildings (Office A and B) closest to NSA 1 and for three residential buildings (Residential A1, A2 and B) closest to NSA 3, to ensure compliance with the MassDEP and Westwood noise limits. Sound power design limits for these buildings are given in Section 5.0. Actual sound levels from the Project will be substantially less than presented here since it is unlikely that all mechanical equipment would operate simultaneously.

Construction of the Project will require the use of equipment that may be audible from off-site locations. Project construction will consist of demolition, site clearing, excavation, foundation work, steel erection, and finishing work. Work on these phases will overlap. No pile driving is planned, though some metal sheeting may need to be installed with a non-impact driver. No vibrations from project construction will be perceptible off site. The sound levels resulting from construction activities vary greatly depending on such factors such as the type of equipment, the specific equipment model, the operations being performed, and the overall condition of the equipment. Maximum projected sound levels will be similar to existing maximum daytime sound levels at these same locations from traffic on nearby roadways. Thus, the temporary sound of construction will not create a noise nuisance condition and will be similar in character to existing daytime sound levels in the nearby residential areas.

Reasonable efforts will be made to minimize the impact of noise resulting from construction activities. The following list of noise mitigation measures are planned and will be incorporated into

construction management guidelines for the project:

- Construction activities that produce significant noise will be limited to daytime hours.
- All exhaust mufflers will be in good working order, and regular maintenance and lubrication of equipment will be required.

2.0 COMMON MEASURES OF COMMUNITY NOISE

The unit of sound pressure is the decibel (dB). The decibel scale is logarithmic to accommodate the wide range of sound intensities to which the human ear is subjected. A property of the decibel scale is that the sound pressure levels of two separate sounds are not directly additive. For example, if a sound of 70 dB is added to another sound of 70 dB, the total is only a 3-decibel increase (or 73 dB), not a doubling to 140 dB. Thus, every 3 dB increase represents a doubling of sound energy. For broadband sounds, a 3 dB change is the minimum change perceptible to the human ear. Table 1 below gives the perceived change in loudness of different changes in sound pressure levels.

TABLE 1
SUBJECTIVE EFFECT OF CHANGES IN SOUND PRESSURE LEVELS

Change in Sound Pressure Level	Perceived Change in Loudness
3 dB	Just perceptible
5 dB	Noticeable
10 dB	Twice (or half) as loud

Non-steady noise exposure in a community is commonly expressed in terms of the A-weighted sound level (dBA); A-weighting approximates the frequency response of the human ear. Levels of many sounds change from moment to moment. Some are sharp impulses lasting one-second or less, while others rise and fall over much longer periods of time. There are various measures of sound pressure designed for different purposes. To establish the background sound level in an area, the L_{90} metric, which is the sound level exceeded 90 percent of the time, is typically used. The L_{90} can also be thought of as the level representing the quietest 10 percent over a given time period. The L_{eq} , or equivalent sound level, is the steady-state sound level over a period of time that has the same acoustic energy as the fluctuating sounds that actually occurred during that same period. It is commonly referred to as the average sound level. The L_{max} , or maximum sound level, represents the

one-second peak level experienced during a given time period. These measures are generally reported to the nearest whole decibel as broadband sound pressure level, i.e., broadband meaning includes sounds at all frequencies. Sound level data also typically include an analysis of the sound spectrum into its various frequency components to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves, and typically the frequency analysis examines eleven octave bands from 16 to 16,000 Hz. The MassDEP Noise Policy states that a source creates a pure tone if acoustic energy is concentrated in a narrow frequency range and one octave band has a sound level 3 dB greater than both adjacent octave bands.

The acoustic environment in a suburban area such as Westwood results from numerous sources. Major contributors are motor vehicle traffic on I-95 and local roadways, as well as from existing businesses located in the area. Typical sound levels associated with various activities and environments are presented in Table 2.

TABLE 2
COMMON SOUND LEVELS

Activity	dBA
Threshold of pain	130
Chipping on metal	120
Loud rock band	110
Jack hammer	100
Jet airliner 1 mile away	95
Threshold of hearing damage	90
Freeway traffic - downtown streets	80
Urban residential area	70
Normal conversation	60
Busy suburban area	50
Quiet suburban area	40
Rural area	30
Wilderness area	25
Threshold of audibility	0

3.0 NOISE REGULATIONS

3.1 MassDEP Noise Policy

The Massachusetts Department of Environmental Protection (MassDEP) regulates noise through 310 CMR 7.10, "Air Pollution Control". In these regulations "air contaminant" is defined to include sound and a condition of "air pollution" includes the presence of an air contaminant in such concentration and duration as to "cause a nuisance" or "unreasonably interfere with the comfortable enjoyment of life and property".

Regulation 7.10 prohibits "unnecessary emissions" of noise. The MassDEP Noise Policy (Policy Statement 90-001, February 1, 1990) interprets a violation of this noise regulation to have occurred if the source causes either:

- (1) An increase in the broadband sound pressure level of more than 10 dBA above the ambient, or
- (2) A "pure tone" condition

The ambient background level is defined as the L_{90} level as measured during equipment operating hours. A "pure tone" condition occurs when any octave band sound pressure level exceeds both of the two adjacent octave band sound pressure levels by 3 dB or more.

The MassDEP does not regulate sound from construction activity and does not regulate sound from motor vehicles accessing the site or the truck backup notification alarms as required by the Occupational Safety and Health Administration (OSHA). Therefore, the provisions described above only apply to the sound of mechanical equipment proposed for the Project and its operation.

3.2 Town of Westwood Noise Control Ordinance

The Town of Westwood Zoning Bylaw Section 6.6 establishes standards for sound from a commercial site as received by different zones. The most stringent limit of 50 dB applies at night for sound received in a residential area more than 200 feet from a state numbered highway, which applies to all residential areas abutting the Project site. A nighttime limit of 60 dB applies to commercial/industrial property off the premises of University Station. It is assumed that these standards are A-weighted limits (dBA). If the generated noise has a single dominant frequency above 4,800 Hz, the above stated standards are reduced by 5 dBA.

4.0 EXISTING ACOUSTIC ENVIRONMENT

Existing baseline sound levels were measured at three locations representative of the nearest Noise Sensitive Areas and the Project's property boundaries in 2005. The existing acoustic environment, dominated by highway traffic noise, has not changed significantly since then and the measurements taken are still valid. These measurements were completed during a late night period to characterize the quieter existing sound levels in the residential areas and establish the background level used in the MassDEP Noise Policy. Measurements were made at publicly accessible locations, 5 feet above grade, and away from vertical reflective surfaces. The three baseline sound level measurement locations are presented in Figure 1, details of which are summarized below:

1. **Partridge Drive - Residential.** Measurements were completed adjacent to #190 Partridge Drive which is located north of the Project site.
2. **Endicott Street - Residential.** Measurements were completed adjacent to #10 Endicott Street which is located northeast of the Project site.
3. **Whitewood Road - Residential.** Measurements were completed at the intersection Whitewood Road and Juniper Ridge Road. The measurement location is east of the Project site.

Weather conditions during the nighttime sound survey were acceptable for accurate acoustic measurements during the period from 11:00 p.m. to 2:00 a.m. on December 15 and 16, 2005. Skies were overcast with no precipitation, temperatures ranged from 20° to 30°F, and wind speeds were variable from 0 to 4 mph. The dominant sources of sound were high speed motor vehicles on I-95, local area businesses, periodic aircraft over flights, and natural sounds.

All measurements were taken by an acoustic engineer using a CEL model 593 real-time sound level analyzer equipped with a model CEL 250 ½" precision condenser microphone, windscreen, and frequency analyzer. The CEL model 593 analyzer has an operating range of 5 dB to 140 dB, and an overall frequency range of 3.5 to 20,000 Hz. This meter meets or exceeds all requirements set forth in the American National Standards Institute (ANSI) Type 1 Standards for quality and accuracy. Prior to and immediately following the measurement session, the sound analyzer was calibrated (no level adjustment was required) with an ANSI Type 1 calibrator which has an accuracy traceable to the National Institute of Standards and Technology (NIST). All instrumentation was laboratory

calibrated within the previous 12-month period. For the measurement session, the microphone was fitted with a 3" windscreen to negate the effect of air movement across microphone diaphragm. All data were downloaded to a computer following the measurement session for the purposes of storage and further analysis.

Summaries of the baseline measurement results are provided in Table 3. At the three measurement locations, average sound levels (L_{eq}) range from 48 to 52 dBA, maximum (L_{max}) sound levels range from 50 to 55 dBA, and the background (L_{90}) levels range from 47 to 51 dBA. These L_{90} levels establish the ambient level for the MassDEP Noise Policy and serve as the basis for Project limits on regulated sources of sound. Under the MassDEP Policy, offsite sound generated by the Project must not exceed 57 to 61 dBA (10 dBA higher than the measured background L_{90} sound levels), as shown in Table 3. Analysis of the measurements reveal no pure tones in the existing sound environment and overall baseline levels that are typical of a suburban area which is situated near a major transportation corridor.

TABLE 3

**EXISTING SOUND LEVELS AT THREE LOCATIONS
NEAR THE PROPOSED UNIVERSITY STATION PROJECT
FROM 11:00 P.M. TO 2:00 A.M. DECEMBER 15 AND 16, 2005**

Sound Level Measurement	NSA 1 Partridge Drive	NSA 2 Endicott Street	NSA 3 Whitewood Road
Octave Bands L_{90}(dB)			
16 Hz	54	50	54
31.5 Hz	52	49	52
63 Hz	50	46	50
125 Hz	47	44	49
250 Hz	46	45	47
500 Hz	47	47	50
1,000 Hz	44	44	48
2,000 Hz	27	28	35
4,000 Hz	12	12	16
8,000 Hz	12	12	12
16,000 Hz	13	13	13
Broadband (dBA)			
L_{max}	54	50	55
L_{eq}	48	48	52
L_{90}	47	48	51
Existing Pure Tone Condition?	No	No	No
MassDEP Noise Policy Limit (dBA)*	57	58	61

* Defined as a 10 dBA incremental increase relative to the existing nighttime baseline (L_{90})

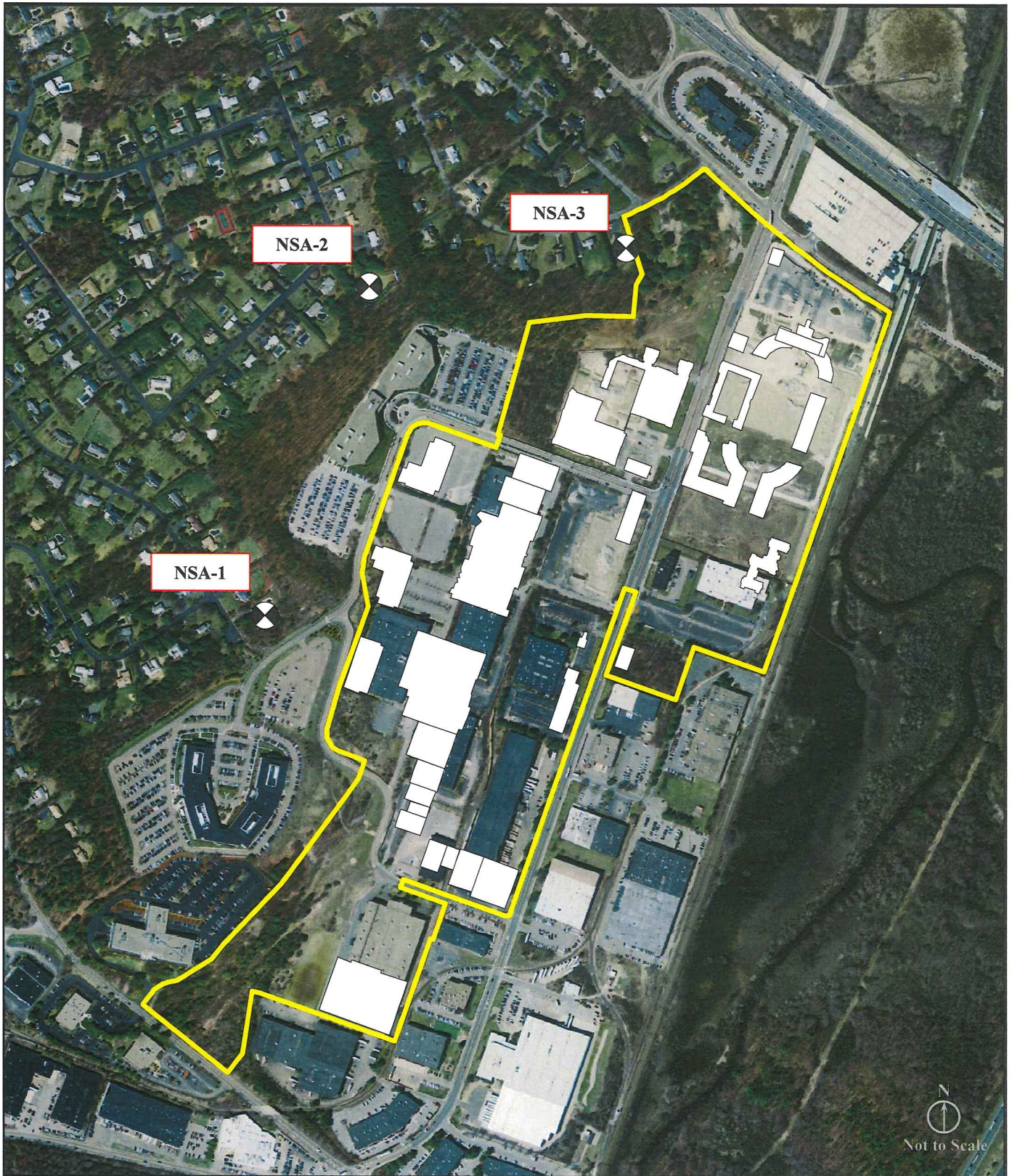


Figure 1.

Project Site and Noise Monitoring Locations
University Station
Westwood, MA



5.0 CALCULATED FUTURE SOUND LEVELS

The primary sources of continuous operational sound are rooftop-mounted heating, ventilating, and air conditioning (HVAC) equipment for building comfort. The acoustic profiles from all potential sources operating concurrently under full load conditions were integrated into the acoustic modeling analysis to determine the resultant sound levels from the site under a worst-case scenario. Standard-design Trane (or equivalent) 25-ton HVAC units were assumed to be installed on all buildings, except those buildings closest to NSA 1 and NSA 3. Carrier (or equivalent) low-noise HVAC units were assumed to be installed on the two office buildings closest to NSA 1 (Office A and B) and on three residential buildings closest to NSA 3 (Residential A1, A2 and B). According to the manufacturers, the reference sound pressure level of a Trane HVAC unit is 69 dBA at a distance of 25 feet away and for a Carrier low-noise unit it is 56.3 dBA at 25 feet. The size and number of the HVAC units required for each building were estimated based on 1 ton of HVAC capacity per 400 square feet of space. Whereas the Project is at the concept level of design, the actual mechanical equipment selected for each building may be different than these study estimates. As a design guide, for each of the two office buildings (Office A and B), the total sound power level¹ of rooftop equipment should not exceed 95 dBA, and for each of the three residential buildings (Residential A1, A2 and B), the total sound power level¹ of rooftop equipment should not exceed 100 dBA.

5.1 Methodology

Future maximum sound levels at the upper floors of the nearest residences were calculated with the Cadna-A acoustic model assuming simultaneous operation of all rooftop HVAC equipment at maximum load. This is a highly unlikely scenario, selected to establish the worst-case condition. Cadna-A is a sophisticated 3-D model for sound propagation and attenuation based on International Standard ISO 9613². Atmospheric absorption is the process by which sound energy is absorbed by the air and was calculated using ANSI S1.26-1995.³ Absorption of sound assumed standard day

¹ The sound power level is not the same as the same pressure level which is what people hear, though both are expressed on a decibel level scale. The sound power level is defined as $10 \cdot \log_{10} (W/W_0)$, where W is the sound power of the source in Watts and W_0 is the reference power of 10^{-12} Watts.

² International Standard, ISO 9613-2, Acoustics – Attenuation of Sound During Propagation Outdoors, -- Part 2 General Method of Calculation.

³ American National Standards Institute, ANSI S1.26-1995, American National Standard Method for the Calculation

conditions and is significant at large distances and at high frequencies. ISO 9613 was used to calculate propagation and attenuation of sound energy by hemispherical divergence with distance, surface reflection, ground, and shielding effects by barriers, buildings, and ground topography. Offsite topography was determined using MassGIS digital elevation data for the study area.

The predicted maximum sound levels are conservative because:

1. The model assumes a ground-based temperature inversion, such as may occur on a clear, calm night when sound propagation is at a maximum. This worst-case condition is infrequent.
2. Rooftop HVAC equipment will be designed with excess capacity to ensure the buildings could operate even with the failure of some fan condenser units. Thus, it is unlikely that all HVAC equipment would ever operate simultaneously, as assumed in the model.
3. Hard ground surface ($G=0$) was assumed for all buildings and parking lots. A mixed surface representative of winter frozen ground conditions ($G=0.5$) was assumed for all vegetated surfaces.

Future maximum sound levels were predicted at three noise sensitive areas (NSAs) that represent the upper floors of the nearest residences and residential property lines:

- NSA 1 - Partridge Drive
- NSA 2 - Endicott Street
- NSA3 - Whitewood Road

Future sound levels were calculated at the upper floors of the noise sensitive areas, which could receive the greatest potential effects of the Project. Locations below these upper floors will receive less sound because the lower the elevation of the receptor, the more shielding it will experience from the acoustic screens and building rooflines. Therefore, sound levels at ground level are lower than the predicted maximum levels at the noise sensitive receptors.

5.2 Results and Compliance

Future maximum sound levels were calculated at the three NSAs based on simultaneous operation of all HVAC equipment at maximum load. As documented in Table 4, the maximum sound levels from the Project range from 44.2 dBA at NSA 2 to 46.5 dBA at NSA 1, and these maximum sound levels comply with the Town of Westwood noise standard of 50 dBA at night in residential areas.

Table 5 presents the compliance demonstration for the MassDEP Noise Policy. The maximum sound levels from the Project will increase the lowest nighttime background sound levels by only 1.2 dBA to 2.8 dBA, well below the 10-dBA incremental limit allowed by the MassDEP Noise Policy. Therefore, the Project will fully comply with the MassDEP Noise Policy. Actual sound levels from the Project will be substantially less than those presented in Table 5 since it is unlikely that all sound sources would operate simultaneously. Design values for sound power level of rooftop equipment for two office and three residential buildings are listed in Section 5.0.

Figure 2 presents color-coded decibel contours for the maximum sound impacts from the project. It shows that the maximum project sound in all nearby residential areas will be well below the 50 dBA nighttime limit set by the Town of Westwood bylaw. The figure also shows that maximum project sound will comply with the 60 dBA limit set by the Bylaw for commercial and industrial areas off the premises of University Station, including the 295 University Avenue office building, the Citizen's Bank building, New England Sports Academy, and the NSTAR Headquarters building.

TABLE 4

**WESTWOOD NOISE REGULATION COMPLIANCE DEMONSTRATION FOR
PROJECT SOUND LEVELS AT THE CLOSEST NOISE SENSITIVE AREAS**

Noise Sensitive Areas	Predicted Maximum Sound Level from the Project (dBA)	Town Regulation's Residential Limit (dBA)	Complies with Town Noise Regulation?
NSA-1: Partridge Drive	46.5	50	Yes
NSA-2: Endicott Street	44.2	50	Yes
NSA-3: Whitewood Road	45.9	50	Yes

TABLE 5

**MASSDEP NOISE POLICY COMPLIANCE DEMONSTRATION FOR PROJECT
SOUND LEVELS AT THE CLOSEST NOISE SENSITIVE AREAS**

Noise Sensitive Areas	Lowest Measured Background Sound Level (L₉₀) (dBA)	Predicted Maximum Sound Level from the Project (dBA)	Total Predicted Sound Level (dBA)	Predicted Sound Level Increase (dBA)	Complies with MassDEP Noise Policy?
NSA-1: Partridge Drive	47	46.5	49.8	2.8	Yes
NSA-2: Endicott Street	48	44.2	49.5	1.5	Yes
NSA-3: Whitewood Road	51	45.9	52.2	1.2	Yes

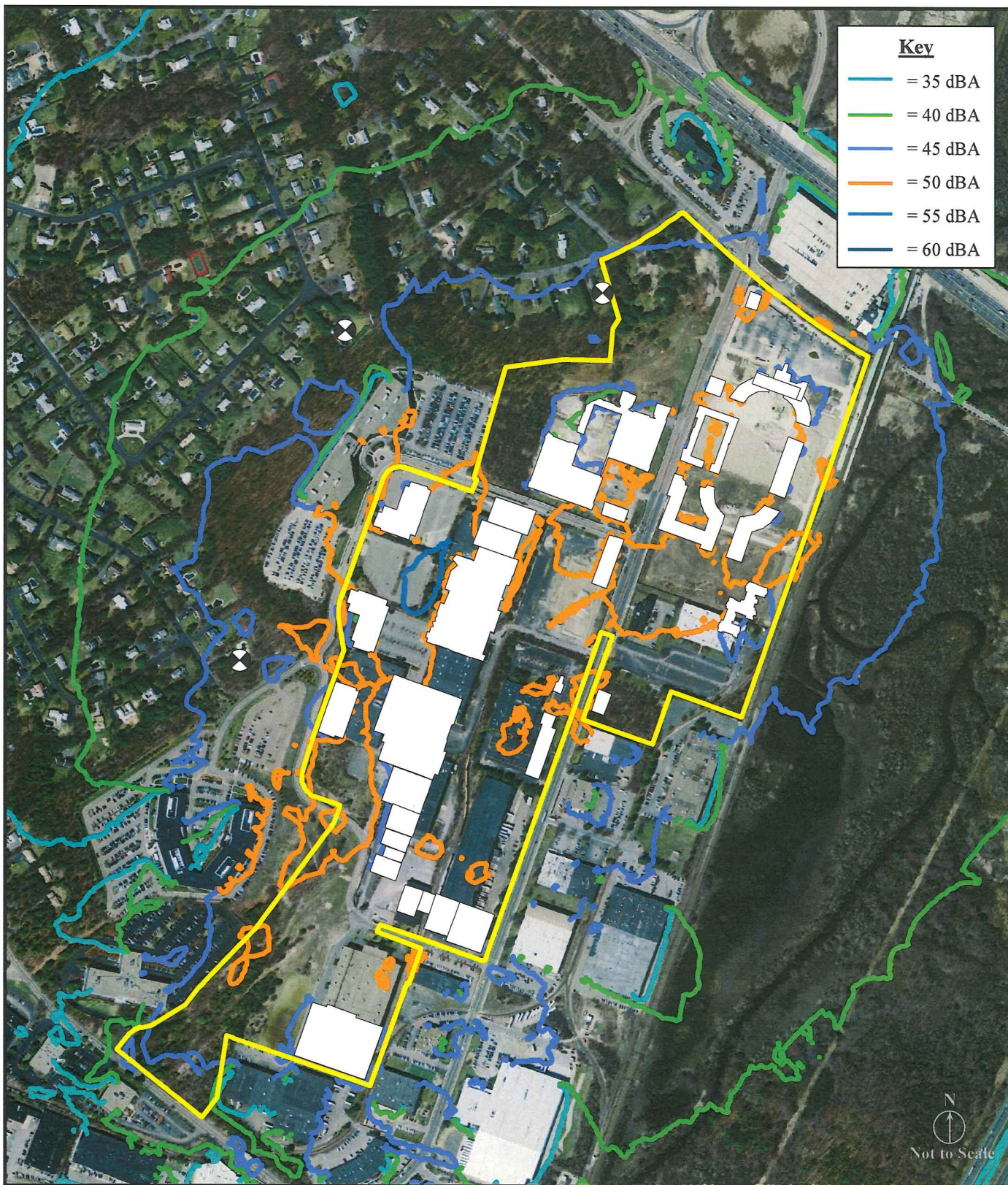


Figure 2.

**Maximum Project Sound Levels
University Station
Westwood, MA**



6.0 CONSTRUCTION NOISE AND VIBRATION

Construction of the Project will require the use of equipment that may be audible from off-site locations. Project construction will consist of demolition, site clearing, rock ledge blasting and rock processing, excavation, foundation work, steel erection, and finishing work. Work on these phases will overlap. No pile driving is planned, though some metal sheeting may need to be installed with a non-impact driver. No vibrations from project construction will be perceptible off site. The sound levels resulting from construction activities vary greatly depending on such factors such as the type of equipment, the specific equipment model, the operations being performed, and the overall condition of the equipment.

The U.S. Environmental Protection Agency⁴ has published data on the average sound levels for typical construction phases. Following the EPA method, sound levels were projected from the acoustic center of the building footprint to the closest residential uses. This calculation conservatively assumes all equipment operating concurrently onsite for the specified construction phase. The results of these calculations are presented in Table 6 and show estimated construction sound levels at the nearest residential properties will be between 60 and 76 dBA. These levels are similar to existing maximum daytime sound levels at these same locations from traffic on nearby roadways. Thus, the temporary sound of construction will not create a noise nuisance condition and will be similar in character to existing daytime sound levels in the nearby residential areas.

Reasonable efforts will be made to minimize the impact of noise resulting from construction activities. The following list of noise mitigation measures are planned and would be incorporated into construction management guidelines for the project:

- Construction activities that produce significant noise will be limited to daytime hours.
- All exhaust mufflers will be in good working order, and regular maintenance and lubrication of equipment will be required.

⁴ U.S. EPA, Noise From Construction Equipment and Operations, Building Equipment, and Home Appliances, December, 1971.

TABLE 6

**MAXIMUM CONSTRUCTION SOUND LEVELS
AT THE CLOSEST RESIDENTIAL LOCATIONS**

Construction Phase	50 Feet from Source (L_{eq})	At Closest Residential Locations, (L_{eq})
Demolition and Site Clearing	84	66
Ledge Blasting and Rock Processing	94	76
Excavation Foundations	89	71
Vibratory Sheeting	88	70
Foundations	78	60
Erection	85	67
Finishing	89	71

APPENDIX A
NOISE MONITORING SUMMARIES

Westwood Station
Baseline Sound Level Measurements
NSA 1 - Partridge Drive

CEL SoundTrack - dB2 3.0 © CEL Instruments Ltd 1998

- Run summary -

Instrument CEL-593.C1T Version 7.21 Type 1
Instrument ID (DPB) 112240
Run mode Octave band Environmental
Run start 12/15/2005 23:23:30
Run end 12/15/2005 23:54:39
Run duration 000 00:31:09.74
Last calibration 12/15/2005 23:11:39
Measurement range 5 - 80 dB
Microphone response Free Field
Polarizing voltage Off
Time weighting F
Frequency weighting L, A
Exchange rate (Q) 3
Period time 30 min
Periods too short for LNs No
Profiles recorded No
Profile sample interval 1 s
Number of records 1

Events enabled No

Overload occurred No
Low battery occurred No
Pause was used No

- Period results -

Record number 1 : 1
Record start 12/16/2005 23:23:30.0
Period time 30 min
Periods too short for LNs No
Overload occurred No
Overload %time 0.00
Low battery occurred No
Pause was used No
Paused all the time No

Band (Hz)	Fw	Leq (dB)	SPLMAX F (dB)	LN10.0% F (dB)	LN50.0% F (dB)	LN90.0% F (dB)
Broadband	L	62.1	71.2	64.0	61.0	60.0
Broadband	A	48.4	54.2	50.0	48.0	47.0
16	L	58.3	70.7	61.0	57.0	54.0
32	L	54.7	62.1	57.0	54.0	52.0
63	L	51.8	56.2	53.0	52.0	50.0
125	L	48.7	53.8	50.0	48.0	47.0
250	L	47.5	51.4	49.0	47.0	46.0
500	L	48.2	53.7	50.0	48.0	47.0
1k	L	44.9	51.5	46.0	45.0	44.0
2k	L	28.1	38.7	29.0	28.0	27.0
4k	L	14.5	36.3	13.0	12.0	12.0
8k	L	13.3	31.9	13.0	12.0	12.0
16k	L	13.1	23.4	13.0	13.0	13.0

Westwood Station
Baseline Sound Level Measurements
NSA 2 - Endicott Street

CEL SoundTrack - dB2 3.0 © CEL Instruments Ltd 1998

- Run summary -

Instrument CEL-593.C1T Version 7.21 Type 1
Instrument ID (DPB) 112240
Run mode Octave band Environmental
Run start 12/16/2005 00:12:17
Run end 12/16/2005 00:42:28
Run duration 000 00:30:11.56
Last calibration 12/15/2005 23:11:39
Measurement range 5 - 80 dB
Microphone response Free Field
Polarizing voltage Off
Time weighting F
Frequency weighting L, A
Exchange rate (Q) 3
Period time 30 min
Periods too short for LNs No
Profiles recorded No
Profile sample interval 1 s
Number of records 1

Events enabled No

Overload occurred No
Low battery occurred No
Pause was used No

- Period results -

Record number 1 : 1
Record start 12/16/2005 00:12:17.0
Period time 30 min
Periods too short for LNs No
Overload occurred No
Overload %time 0.00
Low battery occurred No
Pause was used No
Paused all the time No

Band (Hz)	Fw	Leq (dB)	SPLMAX F (dB)	LN10.0% F (dB)	LN50.0% F (dB)	LN90.0% F (dB)
Broadband	L	59.4	69.8	61.0	58.0	57.0
Broadband	A	48.4	50.4	49.0	48.0	48.0
16	L	55.6	68.8	58.0	53.0	50.0
32	L	51.5	56.2	53.0	51.0	49.0
63	L	48.3	52.6	50.0	48.0	46.0
125	L	46.7	51.7	49.0	46.0	44.0
250	L	47.1	55.6	49.0	47.0	45.0
500	L	48.0	50.4	49.0	48.0	47.0
1k	L	45.2	47.3	46.0	45.0	44.0
2k	L	28.2	29.8	29.0	28.0	28.0
4k	L	13.1	21.4	14.0	12.0	12.0
8k	L	12.4	15.9	13.0	12.0	12.0
16k	L	12.9	13.2	13.0	13.0	13.0

Westwood Station
Baseline Sound Level Measurements
NSA 3 - Whitewood Road

CEL SoundTrack - dB2 3.0 © CEL Instruments Ltd 1998

- Run summary -

Instrument	CEL-593.C1T Version 7.21 Type 1
Instrument ID (DPB)	112240
Run mode	Octave band Environmental
Run start	12/16/2005 01:00:16
Run end	12/16/2005 01:33:14
Run duration	000 00:32:58.38
Last calibration	12/15/2005 23:11:39
Measurement range	5 - 80 dB
Microphone response	Free Field
Polarizing voltage	Off
Time weighting	F
Frequency weighting	L, A
Exchange rate (Q)	3
Period time	30 min
Periods too short for LNs	No
Profiles recorded	No
Profile sample interval	1 s
Number of records	1
Events enabled	No
Overload occurred	No
Low battery occurred	No
Pause was used	No

- Period results -

Record number	1 : 1
Record start	12/16/2005 01:06:16.0
Period time	1 min
Periods too short for LNs	No
Overload occurred	No
Overload %time	0.00
Low battery occurred	No
Pause was used	No
Paused all the time	No

Band (Hz)	Fw	Leq (dB)	SPLMAX F (dB)	LN10.0% F (dB)	LN50.0% F (dB)	LN90.0% F (dB)
Broadband	L	65.1	77.2	67.0	62.0	61.0
Broadband	A	52.2	55.3	53.0	52.0	51.0
16	L	62.7	76.1	65.0	58.0	54.0
32	L	55.9	63.1	59.0	55.0	52.0
63	L	52.3	56.6	54.0	52.0	50.0
125	L	51.7	56.7	54.0	51.0	49.0
250	L	49.0	52.3	50.0	49.0	47.0
500	L	51.4	54.1	53.0	51.0	50.0
1k	L	49.3	53.2	50.0	49.0	48.0
2k	L	36.9	42.6	39.0	37.0	35.0
4k	L	21.0	40.2	23.0	19.0	16.0
8k	L	14.1	34.9	13.0	12.0	12.0
16k	L	12.9	24.0	13.0	13.0	13.0

APPENDIX B

CADNA-A MODELING RESULTS

Cadna Source Spectrum

Name	ID	Type	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Sound Power (dBA)
Trane Voyager 25 Ton HVAC		Lw	101	100	95	93	91	90	84	81	75	94
Carrier Low Noise HVAC	HVAC_20T_LN	Lw	81	81	84	80	78	77	73	68	63	81.3

Cadna Sound Receivers (Sensitive Receivers)

Name	Sound Level (dBA)	Type	Height (m)	Coordinates		
				X (m)	Y (m)	Z (m)
NSA-1	46.5	Total	4	228173.77	883992.54	52.35
NSA-2	44.2	Total	4	228327.17	884475.83	47.52
NSA-3	45.9	Total	4	228706.61	884531.86	28.2

Cadna Sources

Name	Building	Value	Unit	Sound Power (dBA)	Type	Correction dB(A)	Height (m)	X (m)	Y (m)	Z (m)
HVAC-1		Retail A HVAC	Trane 25 Ton	99.4	Lw	5.4	1	228511.04	883599.74	27.1
HVAC-2		Retail B HVAC	Trane 25 Ton	97.3	Lw	3.3	1	228469.48	883617.55	27.27
HVAC-3		Retail C HVAC	Trane 25 Ton	92.1	Lw	-1.9	1	228446.23	883635.85	27.71
HVAC-4		Retail D HVAC	Trane 25 Ton	95	Lw	1	1	228422.18	883638.43	27.9
HVAC-5		Retail E HVAC	Trane 25 Ton	94.8	Lw	0.8	1	228387.12	883688.32	29.54
HVAC-6		Retail F HVAC	Trane 25 Ton	91.4	Lw	-2.6	1	228399.73	883707.31	29.57
HVAC-7		Retail G HVAC	Trane 25 Ton	94.2	Lw	0.2	1	228402.09	883727.93	31.78
HVAC-8		Retail H HVAC	Trane 25 Ton	96.3	Lw	2.3	1	228412.1	883756.79	32.03
HVAC-9		Retail I HVAC	Trane 25 Ton	99.6	Lw	5.6	1	228418.19	883800.57	38.03
HVAC-10		Retail J HVAC	Trane 25 Ton	105.4	Lw	11.4	1	228430.56	883893.24	39.14
HVAC-11		Retail K HVAC	Trane 25 Ton	105.5	Lw	11.5	1	228514.91	884076.23	30.22
HVAC-12		Retail L HVAC	Trane 25 Ton	98.1	Lw	4.1	1	228551.27	884170.23	34.52
HVAC-13		Retail M HVAC	Trane 25 Ton	98.1	Lw	4.1	1	228571.56	884204.12	34.05
HVAC-14		Retail N HVAC	Trane 25 Ton	93.8	Lw	-0.2	1	228723.68	884209.83	28.04
HVAC-15		Retail O HVAC	Trane 25 Ton	96.7	Lw	2.7	1	228714.04	884136.83	27.84
HVAC-16		Retail P HVAC	Trane 25 Ton	88.3	Lw	-5.7	1	228642.62	883952.82	27.09
HVAC-17		Retail Q HVAC	Trane 25 Ton	97.6	Lw	3.6	1	228617.09	883860.94	27.32
HVAC-18		Retail R HVAC	Trane 25 Ton	106.1	Lw	12.1	1	228318.43	883432.43	27.07
HVAC-19		Retail T HVAC	Trane 25 Ton	94	Lw	0	1	228918.41	884390.81	25.95
HVAC-20		Retail U HVAC	Trane 25 Ton	94	Lw	0	1	228998.55	884362.61	26.34
HVAC-21-A		Office A HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228296.72	883891.43	45.82
HVAC-21-B		Office A HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228306.94	883920.41	45.82
HVAC-21-C		Office A HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228317.38	883950.84	45.82
HVAC-21-D		Office A HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228308.73	883887.69	45.82
HVAC-21-E		Office A HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228314.69	883905.69	45.82
HVAC-21-F		Office A HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228322.25	883928.36	45.82
HVAC-21-G		Office A HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228329.61	883946.46	45.82
HVAC-21-H		Office A HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228320.76	883883.81	45.82
HVAC-21-I		Office A HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228331	883911.66	45.82
HVAC-21-J		Office A HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228341.05	883942.48	45.82
HVAC-22-A		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228346.81	884030.07	42.59
HVAC-22-B		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228353.72	884014.21	42.59
HVAC-22-C		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228369.81	884021.65	42.59
HVAC-22-D		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228360.62	884036.88	42.59

Cadna Sources

Name	Building	Value	Unit	Sound Power (dBA)	Type	Correction dB(A)	Height (m)	X (m)	Y (m)	Z (m)
HVAC-22-E		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228354.46	884050.97	42.59
HVAC-22-F		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228376.86	884042.9	42.59
HVAC-22-G		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228368.69	884058.78	42.59
HVAC-22-H		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228384.61	884064.76	42.59
HVAC-22-I		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228375.85	884079.22	42.59
HVAC-22-J		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228358.98	884074.13	42.59
HVAC-22-K		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228342.75	884068.54	42.59
HVAC-22-L		Office B HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228349.48	884088.28	42.59
HVAC-23		Office C HVAC	Trane 25 Ton	104.9	LW	10.9	1	228416.39	884202.11	41.94
HVAC-24		Office W HVAC	Trane 25 Ton	101.8	LW	7.8	1	228976.29	884278.01	27.43
HVAC-25		Office X HVAC	Trane 25 Ton	102.8	LW	8.8	1	228920.39	884190.94	27.21
HVAC-26		Restaurant A HVAC	Trane 25 Ton	93	LW	-1	1	228705.13	883930.61	22.21
HVAC-27		Restaurant B HVAC	Trane 25 Ton	92.1	LW	-1.9	1	228872.4	884395.75	22.02
HVAC-28		Restaurant C HVAC	Trane 25 Ton	90.8	LW	-3.2	1	228927.8	884519.88	20.59
HVAC-30		Hotel I HVAC	Trane 25 Ton	105.1	LW	11.1	1	228960.46	884396.74	38.56
HVAC-31		Assisted Living I HVAC	Trane 25 Ton	98	LW	4	1	228912.84	884069.97	30.26
HVAC-32-A		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228677.28	884333.33	35.27
HVAC-32-B		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228681.65	884346.12	35.27
HVAC-32-C		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228686.57	884358.57	35.27
HVAC-32-D		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228703.62	884369.94	35.27
HVAC-32-E		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228719.59	884364.32	35.27
HVAC-32-F		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228756.72	884321.7	35.27
HVAC-32-G		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228745.53	884376.86	35.27
HVAC-32-H		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228795.9	884357.92	35.27
HVAC-32-I		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228720.52	884295.9	35.27
HVAC-32-J		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228744.51	884287.53	35.27
HVAC-32-K		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228769.14	884278.85	35.27
HVAC-32-L		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228761.4	884295.11	35.27
HVAC-32-M		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228752.41	884309.48	35.27
HVAC-32-N		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228735.51	884303.95	35.27
HVAC-32-O		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228769.14	884317.05	35.27
HVAC-32-P		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228738.91	884342.08	35.27
HVAC-32-Q		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228748.93	884298.74	35.27
HVAC-32-R		Residential A1 HVAC_20T_LN	Carrier Low Noise 20-T	81.3	LW	0	1	228737.38	884357.89	35.27

Cadna Sources

Name	Building	Value	Unit	Sound Power (dBA)	Type	Correction dB(A)	Height (m)	X (m)	Y (m)	Z (m)
HVAC-32-S	Residential A1	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228771.98	884345.15	35.27
HVAC-32-T	Residential A1	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228790.61	884339.94	35.27
HVAC-32-U	Residential A1	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228755.48	884351.07	35.27
HVAC-32-V	Residential A1	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228785.79	884324.95	35.27
HVAC-32-W	Residential A1	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228760.69	884333.39	35.27
HVAC-32-X	Residential A1	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228742.93	884327	35.27
HVAC-32-Y	Residential A1	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228728.25	884317.21	35.27
HVAC-32-Z	Residential A1	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228777.03	884301.27	35.27
HVAC-33-A	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228629.97	884313.38	35.07
HVAC-33-B	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228643.44	884309.39	35.07
HVAC-33-C	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228660.54	884303.82	35.07
HVAC-33-D	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228624.94	884299.65	35.07
HVAC-33-E	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228640.26	884295.07	35.07
HVAC-33-F	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228656.76	884288.51	35.07
HVAC-33-G	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228619.37	884285.52	35.07
HVAC-33-H	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228636.68	884280.15	35.07
HVAC-33-I	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228652.59	884275.58	35.07
HVAC-33-J	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228614	884271.6	35.07
HVAC-33-K	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228632.7	884265.63	35.07
HVAC-33-L	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228643.85	884245.32	35.07
HVAC-33-M	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228608.03	884256.28	35.07
HVAC-33-N	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228627.53	884250.12	35.07
HVAC-33-O	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228690.34	884234.9	35.07
HVAC-33-P	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228668.1	884269.81	35.07
HVAC-33-Q	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228687.56	884250.51	35.07
HVAC-33-R	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228699.48	884258.77	35.07
HVAC-33-S	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228649.64	884260.12	35.07
HVAC-33-T	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228669.34	884256.95	35.07
HVAC-33-U	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228683.91	884263.32	35.07
HVAC-33-V	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228679.84	884225.62	35.07
HVAC-33-W	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228674.7	884240.75	35.07
HVAC-33-X	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228659.99	884233.26	35.07
HVAC-33-Y	Residential A2	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228658.99	884247.41	35.07
HVAC-34-A	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228850.54	884281.38	31.96

Cadna Sources

Name	Building	Value	Unit	Sound Power (dBA)	Type	Correction dB(A)	Height (m)	X (m)	Y (m)	Z (m)
HVAC-34-B	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228842.26	884284.15	31.96
HVAC-34-C	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228833.81	884287.07	31.96
HVAC-34-D	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228825.92	884289.83	31.96
HVAC-34-E	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228831.53	884296.06	31.96
HVAC-34-F	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228835.24	884306.41	31.96
HVAC-34-G	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228838.87	884316.75	31.96
HVAC-34-H	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228842.66	884326.85	31.96
HVAC-34-I	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228845.65	884336.01	31.96
HVAC-34-J	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228849.13	884345.79	31.96
HVAC-34-K	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228851.81	884354.48	31.96
HVAC-34-L	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228854.5	884361.9	31.96
HVAC-34-M	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228863.2	884356.6	31.96
HVAC-34-N	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228872.95	884353.11	31.96
HVAC-34-O	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228882.47	884349.59	31.96
HVAC-34-P	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228890.31	884346.67	31.96
HVAC-34-Q	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228899.88	884345.64	31.96
HVAC-34-R	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228897.75	884338.53	31.96
HVAC-34-S	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228894.67	884329.85	31.96
HVAC-34-T	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228891.91	884321.52	31.96
HVAC-34-U	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228889.23	884314.06	31.96
HVAC-34-V	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228886.23	884306.01	31.96
HVAC-34-W	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228883.7	884297.96	31.96
HVAC-34-X	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228880.54	884289.43	31.96
HVAC-34-Y	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228877.23	884278.86	31.96
HVAC-34-Z	Residential B	HVAC_20T_LN	Carrier Low Noise 20-T	81.3	Lw	0	1	228871.86	884273.33	31.96
HVAC-35	Residential C	HVAC	Trane 25 Ton	104.6	Lw	10.6	1	228832.29	884180.31	31.97