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Environmental Noise Survey and Computer Modelling
For

Southeast Anthony Henday Drive
In
Edmonton, Alberta

Prepared for:

Alberta Transportation

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Executive Summary

aci Acoustical Consultants Inc., of Edmonton AB, was retained by Alberta Transportation (AT) to conduct an environmental noise assessment along the southeast section of Anthony Henday Drive (AHD) in Edmonton, Alberta. The purpose of the work was to conduct 24-hour environmental noise monitorings at various locations adjacent to the roadway and generate a computer noise model with current and future traffic conditions and compare the results to the AT noise guidelines. Site work was conducted for aci in June and July, 2008 by S. Bilawchuk, M.Sc., P.Eng.

The results of the Current Conditions noise monitoring indicated noise levels which were well below the permissible sound level of 65 dBA L_{eq}24[1]. In most locations, AHD was the dominant noise source. However there were locations at which other intersecting City streets either contributed a significant amount or were dominant (i.e. adjacent to 91 Street, 66 Street, 50 Street, 34 Street).

Baseline Noise Monitoring Results

Monitor	L_{eq}24 (dBA)	L_{eq}Day (dBA)	L_{eq}Night (dBA)
M1 (North of AHD, East of 91 Street)	52.0	51.8	52.2
M2 (North of AHD, Between 66 & 91 Streets)	56.6	56.6	56.7
M3 (North of AHD, Between 50 & 66 Streets)	55.7	56.0	55.3
M4 (North of AHD, East of 50 Street)	55.4	55.6	55.2
M5 (North of AHD, Between 34 & 50 Streets)	53.8	52.6	55.2
M6 (South of AHD, West of 66 Street)	52.1	52.7	51.1

The noise modeling results for Current Conditions matched well with the measurement results. The modeled noise levels at the additional residential outdoor amenity receptor locations were similar to those of the measured locations. No receptors exceeded the limit of 65 dBA L_{eq}24.

The noise modeling results for the Future Conditions (with projected traffic volumes for year 2037 of 80,000 vehicles per day on AHD and a conservative estimate of double traffic volumes on intersecting city streets) indicated noise levels which were still below the limit of 65 dBA L_{eq}24 at all locations. Further, a sensitivity analysis of the traffic volumes, traffic speeds, and % heavy trucks indicated that even with significant increases in all three, the noise levels at all receptor locations will still be below the limit of 65 dBA L_{eq}24. **As such, based on the criteria set forth by Alberta Transportation, no additional noise mitigation measures are required throughout the entire study area.**

[1] The term L_{eq} represents the energy equivalent sound level. This is a measure of the equivalent sound level for a specified period of time accounting for fluctuations.

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1.0 Introduction

aci Acoustical Consultants Inc., of Edmonton AB, was retained by Alberta Transportation (AT) to conduct an environmental noise assessment along the southeast section of Anthony Henday Drive (AHD) in Edmonton, Alberta. The purpose of the work was to conduct 24-hour environmental noise monitorings at various locations adjacent to the roadway and generate a computer noise model with current and future traffic conditions and compare the results to the AT noise guidelines. Site work was conducted for aci in June and July, 2008 by S. Bilawchuk, M.Sc., P.Eng.

2.0 Location Description

Anthony Henday Drive (AHD) currently spans from the intersection at highway 16 the northwest section of the City of Edmonton and runs until the intersection with Highway 14/216 in the southeast end of the City, all within the Transportation and Utilities Corridor (TUC). The study area for the southeast portion, as shown in Figs. 1a – 1d, includes AHD starting at 91 Street (west end of study area) to 17 Street (east end of study area. Within this range the total distance of AHD is approximately 4.8 km. AHD itself is a six-lane divided road from 91 Street to 50 Street and then a four-lane divided road from 50 Street to Highway 16 (paved with conventional asphalt) with interchanges having access to all directions at 91 & 50 & 17 Street, as well as fly-over bridges in which north-south traffic does not have access to AHD at 66 & 34 Street. The speed limit on AHD within the study area is 100 km/hr.

To the north of AHD (starting from 91 Street heading east) the closest receptors are all single family dwellings which back onto the TUC. Setback distances from AHD to the nearest houses varies with the closest being approximately 200 m. Most of the lots have either a chain-link fence or a wood fence with wide gaps between the boards (offering essentially no acoustical shielding). In addition, most of the receptors have essentially an un-obstructed line-of-sight to AHD because of minimal vegetation within the TUC (only field grasses). This continues throughout the entire span from 91 Street until 34 Street with only small groups of trees in some locations providing some additional shielding. In addition, some of the receptors have blocked line-of-sight due to small hills in between the backyards and AHD. These topographical features have been included in the noise model. Finally, east of 34 Street there is currently no development.

To the south of AHD (starting from 91 Street heading east) there are new 2-storey multi-family dwellings (i.e. duplexes) immediately south of the TUC (approximately 550 m from AHD). In this area there is also an electrical substation which is interconnected to the large overhead power-lines running east-west within the TUC just south of AHD. Further east is more new residential development which is located approximately 375 m south of AHD. Just west of 66 Street are older acreage style lots which back onto the TUC (again about 375 m setback). East of 66 Street there is additional new residential development (single and duplex houses) with a 2.44 m (8-ft) solid screen wood fence at the rear lot. This continues until approximately midway between 66 Street and 50 Street where the development stops. There is no further residential development near the TUC until east of 34 Street where there is a single residence approximately 500 m south of AHD and near 17 Street where there are some acreage-style lots approximately 850 m south of AHD. Topographically, the land in the area is similar to the north with essentially un-obstructed line-of-sight throughout much of the area and ground covered mostly with field grasses and some small patches of trees.

In most areas, the distance setback from AHD to the residential structures will result in a meaningful amount of ground absorption with the field grasses. In addition, other areas will benefit from the dense tree and bush vegetation adjacent to the roadway. Refer to Section 3.3 for a more detailed description of the sound absorptive noise modeling parameters used.

3.0 Measurement & Modeling Methods

3.1. Environmental Noise Monitoring (General)

As part of the study, a total of six (6) 24-hour noise monitorings were conducted. The locations for each were selected based on consultation with personnel from AT as well as site specific observations and accessibility.

The measurements were conducted collecting broadband A-weighted as well as 1/3 octave band sound levels. This enabled a detailed analysis of the noise climate. The noise monitorings were conducted during a weekday under "typical" traffic conditions. In particular, measurements avoided any holidays, construction activity re-routing nearby, and other occurrences which would affect the normal traffic on the road. In addition, the monitorings were conducted in spring/summer conditions (i.e. no snow cover) with dry road surfaces, no precipitation, and low wind-speeds. The monitorings were accompanied by a 24-hour digital audio recording for more detailed post process analysis. Finally, a portable weather monitor was used within the area to obtain local weather conditions. Refer to Appendix I for a detailed description of the measurement equipment used, Appendix II for a description of the acoustical terminology, and Appendix III for a list of common noise sources. All noise measurement instrumentation was calibrated at the start of the measurements and then checked afterwards to ensure that there had been no calibration drift over the duration of the measurements.

3.2. Environmental Noise Monitoring (Specific Locations)

Monitor 1

The noise Monitor 1 was located 340 m north of AHD (westbound lanes) and 260 m east of 91 Street as shown in Figs. 1a and 2. This put the monitor approximately 15 m southwest of the rear property line for the residence at 8523–10 Avenue. At this location, there was direct line-of-sight to the 91 Street overpass and to the nearby residences, as well as partial line-of-sight to AHD through the earth berms to the south and southeast. The noise monitor was started at 13:00 on Tuesday June 3, 2008 and ran for 24-hours until 13:00 on Wednesday June 4, 2008.

Monitor 2

The noise Monitor 2 was located 185 m north of AHD (westbound lanes) and 500 m west of 66 Street as shown in Figs. 1a and 3. This put the monitor approximately 15 m south of the rear property line for the residence at 7215–10 Avenue. At this location, there was direct line-of-sight to AHD, to the 66 Street overpass, and to the nearby residences. The noise monitor was started at 13:15 on Tuesday June 3, 2008 and ran for 24-hours until 13:15 on Wednesday June 4, 2008.

Monitor 3

The noise Monitor 3 was located 200 m north of AHD (westbound lanes) and 700 m west of 50 Street as shown in Figs. 1a and 4. This put the monitor approximately 20 m south of the rear property line for the residence at 5827–10 Avenue. At this location, there was direct line-of-sight to AHD (through a break in the trees) and to the nearby residences. There was no line-of-sight to either 66 Street or 50 Street. The noise monitor was started at 13:45 on Tuesday June 3, 2008 and ran for 24-hours until 13:45 on Wednesday June 4, 2008.

Monitor 4

The noise Monitor 4 was located 225 m north of AHD (westbound lanes) and 230 m east of 50 Street as shown in Figs. 1a and 5. This put the monitor approximately 10 m south of the rear property line for the residence at 4803–10 Avenue. In addition, this located the monitor approximately 40 m from the closest ramp for the interchange between AHD and 50 Street. At this location, there was direct line-of-sight to AHD, to the interchange and ramps for 50 Street, and to the nearby residences. The noise monitor was started at 14:30 on Tuesday June 3, 2008 and ran for 24-hours until 14:30 on Wednesday June 4, 2008.

Monitor 5

The noise Monitor 5 was located 210 m north of AHD (westbound lanes) and 510 m west of 34 Street as shown in Figs. 1a and 6. This put the monitor approximately 10 m south of the rear property line for the residence at 3907–10 Avenue. At this location, there was direct line-of-sight to AHD to the south (there was a small hill to the southeast just removing the direct line-of-sight), to 34 Street in the distance, and to the nearby residences. The noise monitor was started at 14:45 on Tuesday June 3, 2008 and ran for 24-hours until 14:45 on Wednesday June 4, 2008.

Monitor 6

The noise Monitor 6 was located 370 m south of AHD (Eastbound lanes) and 240 m west of 66 Street as shown in Fig. 1a. This put the monitor approximately 2 m north of the rear property line for the residence at 6920–2 Avenue SW. At this location, there was direct line-of-sight to AHD for several hundred meters in each direction to 66 Street in the distance, and to the nearby residences. The noise monitor was started at 15:30 on Monday July 7, 2008 and ran for 24-hours until 15:30 on Tuesday July 8, 2008.

Weather Monitor

The weather monitor was located approximately 30 m north of AHD (westbound lanes) and 680 m west of 66 Street at the AHD right-of-way fence-line. The monitor was set-up on top of a small hill which placed it at a relatively high ground elevation. There were no trees or structures nearby, resulting in un-obstructed air movement for more accurate wind measurements.

3.3. Computer Noise Modeling

The computer noise modeling was conducted using the CADNA/A (version 3.7.123) software package. CADNA/A allows for the modeling of various noise sources such as road, rail, and various stationary sources. In addition, topographical features such as land contours, vegetation, and bodies of water can be included. Finally, meteorological conditions such as temperature, relative humidity, wind-speed and wind-direction can be included in the calculations.

The default calculation method for traffic noise in CADNA/A follows the German Standard RLS-90. It is aci's experience that this calculation method is very accurate under the conditions present for this study. The calculation method used for noise propagation follows the ISO standard 9613-2. All receiver locations were assumed as being downwind from the source(s). In particular, as stated in Section 5 of the ISO document:

> "Downwind propagation conditions for the method specified in this part of IS0 9613 are as specified in 5.4.3.3 of IS0 1996-2:1987, namely
>
> - wind direction within an angle of ± 45^0 of the direction connecting the centre of the dominant sound source and the centre of the specified receiver region, with the wind blowing from source to receiver, and
> - wind speed between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground.
>
> The equations for calculating the average downwind sound pressure level LAT(DW) in this part of IS0 9613, including the equations for attenuation given in clause 7, are the average for meteorological conditions within these limits. The term average here means the average over a short time interval, as defined in 3.1.
>
> These equations also hold, equivalently, for average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear, calm nights".

Throughout the study area, the ground was given an absorption coefficient of 0.6. In addition, trees and field grasses were added where appropriate to match existing conditions. As a result, all sound level propagation calculations are considered representative of summertime conditions for all surrounding residents.

Note that not every commercial building and house in the area was modeled. Only the first row of buildings (in relation to the major roadways) were included, since these are the ones which will have the highest sound levels and will result in the greatest impact and level of shielding for structures further in.

As part of the study, various scenarios were modeled including:

1) Current conditions with existing road configurations and traffic volumes present during the noise monitoring traffic volumes. The baseline noise monitoring was used as a calibration method for the model.

2) Future conditions (approximately 30 years) with existing (final) road configurations and projected traffic volumes. The future traffic volumes included the projected traffic volumes for year 2037 of 80,000 vehicles per day and an estimate of traffic volumes for all intersecting City of Edmonton roadways (i.e. double current traffic volumes). This estimate was done because

detailed traffic projections for the intersecting City roadways were not available at the time of noise model generation. These parameters, however, are considered worst case since they were modeled at full speed (i.e. 100 km/hr on entire AHD) and many of the roadways may not even be able to handle the modeled traffic volumes without significant reductions in traffic speeds (i.e. gridlock). Even with increased volumes, if the traffic speeds are reduced, the noise levels will reduce as well.

3) Future conditions (as in item #2) with a sensitivity analysis on the traffic parameters listed below. This involved modification of the various parameters to determine their effect on noise levels.
    a. Traffic counts
    b. Traffic speeds
    c. Traffic composition (i.e. % heavy vehicles)

The computer noise modeling results were calculated in two ways. First, sound levels were calculated at specific receiver locations. This included the noise monitor locations as well as several representative residential backyard locations. Next, the sound levels were calculated using a 10.0 m x 10.0 m grid over the entire study area. This provided color noise contours for easier visualization of the results.

Refer to Appendix IV for a list of the computer noise modeling parameters.

4.0 Permissible Sound Levels

Environmental noise levels from road traffic are commonly described in terms of equivalent sound levels or L_{eq}. This is the level of a steady sound having the same acoustic energy, over a given time period, as the fluctuating sound. In addition, this energy averaged level is A–weighted to account for the reduced sensitivity of average human hearing to low frequency sounds. These L_{eq} in dBA, which are the most common environmental noise measure, are often given for day-time (07:00 to 22:00) L_{eq}Day and night-time (22:00 to 07:00) L_{eq}Night while other criteria use the entire 24-hour period as L_{eq}24.

The criteria used to evaluate the road and rail noise in the study area are based on the draft document entitled *"Noise Attenuation Guidelines for Provincial Highways Under Provincial Jurisdiction Within Cities and Urban Areas"* by Alberta Transportation. The document specifies:

> "For construction or improvement of highways through cities and other urban areas where noise in residential areas is expected to exceed 65 dBA L_{eq}24, Alberta Transportation will consider noise mitigation..."

The noise levels are to be measured for the first row of dwellings adjacent to the highway at 1.5 m above ground level, 15 m from the dwelling's façade.

5.0 Monitoring Results

5.1. Overall Summary

The noise monitoring results at all 6 locations are shown in Table 1. The information shows the broadband A-weighted L_{eq}24, L_{eq}Day and L_{eq}Night sound levels. At all monitoring locations, traffic noise on AHD was the dominant noise source. Some locations had influences from other nearby roads and from creatures such as birds and crickets. The data obtained from all monitoring locations has been modified to remove abnormal events such as human activity near the monitors, excessive bird chirping, etc. In general, the broadband and 1/3 octave band noise levels associated with each of the 6 locations are very similar with small differences to due relative distance from AHD and small effects from the terrain and vegetation. It can be seen that the current noise climate in the area at all monitored locations is well below the limit of 65 dBA L_{eq}24.

Table 1. Summary of Noise Monitoring Results

Monitor	L_{eq}24 (dBA)	L_{eq}Day (dBA)	L_{eq}Night (dBA)
M1	52.0	51.8	52.2
M2	56.6	56.6	56.7
M3	55.7	56.0	55.3
M4	55.4	55.6	55.2
M5	53.8	52.6	55.2
M6	52.1	52.7	51.1

The broadband A-weighted sound levels and 1/3 octave band sound levels obtained for the entire 24-hour measurement periods at all 6 locations are shown in Figs. 7 – 18. The results indicate a relatively constant noise source associated with AHD and adjacent streets. There was a slight decrease in the night-time and a notable increase during the morning rush-hour. Typically traffic noise results in a decrease during the night of 5 – 10 dBA. This was not seen, however, due to the relatively constant traffic on AHD, as well as the significant increase from 05:00 – 07:00 which is still within the night-time period.

The 1/3 octave band results for each location show the typical trend of low frequency noise (near 63 – 80 Hz) resulting from engines and exhaust, mid-high frequency noise (near 1000 Hz) resulting from tire noise and at some locations very high frequency noise (near 5000 Hz) resulting from bird and cricket chirping.

5.2. Weather Conditions

The weather conditions for locations 1 – 5 were partly cloudy with an east – southeast wind at 5 – 15 km/hr from about 13:00 – 20:00 (i.e. crosswind/downwind). After about 20:00, the wind-speeds reduced and became low out of the south until late morning when they slightly increased from the east – northeast. At no point was the weather considered detrimental to the data obtained. Further, given that the predominant wind direction is west – northwest, the residents north of AHD will typically have a cross-wind or an up-wind condition relative to AHD. Statistically, a down-wind condition will occur much less of the time.

The weather conditions for location 6 were partly cloudy throughout with a high west wind to start. This high wind remained until about 20:00 when it started to subside and eventually reduced to calm and shifted out of the northeast and then the east and then south until about 04:00. After approximately 04:00 the wind shifted out of the west where it generally remained for the rest of the monitoring period. The wind increased until approximately 11:00 where it reached approximately 20 km/hr and remained as such until the end of the monitoring period. Due to the high wind, noise level data was removed from 15:30 (i.e. start of monitoring period) until 20:00. Otherwise, the weather conditions were within acceptable parameters relative to the data obtained. For most of the time the wind was from the west (i.e. crosswind). There was a period with a southerly wind, however the conditions were near calm. As such, there would have been no negative impact from the wind.

Weather data obtained on site for the various noise monitoring days are presented in Appendix V.

6.0 Modelling Results

6.1. Current Conditions

The results of the noise modeling under current conditions at the noise monitoring locations are presented in Table 2. The noise monitoring results were used to augment the ground cover sound absorption such that the modeling results were consistent with the monitoring results. In general, the modeling results tend to slightly over-predict the noise levels. This is preferred since it represents conservative results. All locations fall within 2.0 dBA of the monitoring results.

Table 2. Noise Modeling Results Under Current Conditions at Monitor Locations

Receptor	L_{eq}24 (dBA)	L_{eq}Day (dBA)	L_{eq}Night (dBA)
M1	53.6 (+1.7)	54.5	51.5
M2	56.8 (+0.2)	57.5	55.3
M3	56.2 (+0.5)	56.9	54.7
M4	55.8 (+0.4)	56.5	54.0
M5	53.7 (-0.1)	54.4	52.3
M6	52.4 (+0.3)	53.2	50.8

Note: (±X.X) = relative difference compared to noise monitoring results

The results of the noise monitoring at the various residential backyard locations are presented in Table 3. A total of 29 locations were selected as representative of the potential for the highest noise levels throughout the study area. In addition to the noise levels provided, an indication of the dominant road noise source is provided. This was done because, if noise mitigation is required, there are some locations in which the AHD is not the dominant noise source, rather a City of Edmonton road is dominant. In these areas, it is not AT which is responsible for noise mitigation, but rather the City of Edmonton. All of the current noise levels are well under the limit of 65 dBA L_{eq}24. In addition, most of the highest noise levels are at locations in which AHD is not the dominant noise source.

In addition to the information presented in Table 3, the L_{eq}24 color noise contours for the entire study area are shown in Figs. 19a – 19d. The color contours provide a very good representation of where the "hot" spots are and the relative contribution from each of the nearby roadways for the various receptor locations.

Table 3. Noise Modeling Results Under Current Conditions at Residential Receptor Locations

Receptor	L_{eq}24 (dBA)	L_{eq}Day (dBA)	L_{eq}Night (dBA)	Dominant Noise Source
R1	52.8	53.8	50.4	91 Street and AHD (approximately equal)
R2	54.9	55.7	52.9	AHD followed by 91 Street (about 4 dBA difference)
R3	56.1	56.8	54.4	AHD
R4	55.8	56.5	54.3	AHD
R5	56.4	57.1	55.0	AHD
R6	56.1	56.8	54.6	AHD followed by 66 Street (about 8 dBA difference)
R7	56.7	57.6	54.5	66 Street followed by AHD (about 2 dBA difference)
R8	53.0	53.8	51.4	AHD followed by 66 Street (about 4 dBA difference)
R9	55.6	56.2	54.1	AHD
R10	56.3	56.9	54.8	AHD
R11	57.3	58.0	55.8	AHD
R12	59.9	60.9	57.3	50 Street followed by AHD (about 8 dBA difference)
R13	56.9	57.7	55.1	AHD followed by 50 Street (about 4 dBA difference)
R14	55.6	56.4	54.0	AHD followed by 50 Street (about 7 dBA difference)
R15	54.9	55.6	53.3	AHD followed by 50 Street (about 8 dBA difference)
R16	54.3	55.0	52.8	AHD
R17	53.5	54.2	52.1	AHD
R18	52.8	53.5	51.4	AHD
R19	52.1	52.8	50.4	AHD followed by 34 Street (about 4 dBA difference)
R20	57.2	58.2	54.6	91 Street followed by AHD (about 5 dBA difference)
R21	53.3	54.2	51.1	AHD followed by 91 Street (about 3 dBA difference)
R22	52.3	53.2	50.5	AHD
R23	52.6	53.4	51.0	AHD
R24	54.5	55.3	52.7	66 Street and AHD (approximately equal)
R25	54.2	55.0	52.5	AHD followed by 66 Street (about 3 dBA difference)
R26	51.5	52.2	50.1	AHD
R27	53.7	54.4	52.2	AHD
R28	50.8	51.5	49.2	AHD
R29	47.8	48.6	46.1	AHD followed by 17 Street (about 4 dBA difference)

6.2. Future Conditions

The results of the noise modeling under future conditions (approximately 30 years) at the residential receptor locations are presented in Table 4 and shown in Figs. 20a – 20d. The L_{eq}24, L_{eq}Day and L_{eq}Night sound levels are presented in Table 4 along with the relative increase in the L_{eq}24 compared to current conditions. The relative increases are approximately 2.7 – 3.4 dBA due to an approximate doubling of traffic on both AHD and City of Edmonton roadways. It is very important to note that, in general, a minimum 2.0 – 3.0 dBA increase is required for most people to notice that there has even been a change. An increase of 5.0 dBA is considered significant, and an increase of 10.0 dBA is generally considered to be about twice as loud. These increases will occur over a period of approximately 30 years. As such, this vary gradual change will not be subjectively noticeable to most people living nearby.

Table 4. Noise Modeling Results Under Future Conditions at Residential Receptor Locations

Receptor	L_{eq}24 (dBA)	L_{eq}24 Increase Relative to Current Conditions (dBA)	L_{eq}Day (dBA)	L_{eq}Night (dBA)
R1	55.5	2.7	56.4	53.3
R2	57.8	2.9	58.6	56.0
R3	59.3	3.2	60.0	57.7
R4	59.1	3.3	59.8	57.6
R5	59.7	3.3	60.4	58.3
R6	59.4	3.3	60.1	57.9
R7	59.8	3.1	60.7	57.7
R8	56.3	3.3	57.0	54.7
R9	58.9	3.3	59.6	57.5
R10	59.6	3.3	60.3	58.2
R11	60.7	3.4	61.4	59.2
R12	62.9	3.0	64.0	60.4
R13	60.1	3.2	61.0	58.3
R14	58.9	3.3	59.7	57.2
R15	58.2	3.3	58.9	56.6
R16	57.6	3.3	58.3	56.2
R17	56.8	3.3	57.5	55.4
R18	56.1	3.3	56.8	54.7
R19	55.3	3.2	56.1	53.7
R20	60.0	2.8	61.0	57.5
R21	56.0	2.7	56.9	54.0
R22	55.3	3.0	56.1	53.6
R23	55.8	3.2	56.5	54.2
R24	57.7	3.2	58.5	55.9
R25	57.4	3.2	58.2	55.7
R26	54.9	3.4	55.6	53.4
R27	57.0	3.3	57.7	55.5
R28	54.1	3.3	54.8	52.5
R29	51.1	3.3	51.8	49.4

At all locations, the L_{eq}24 sound levels will be below the limit of 65 dBA L_{eq}24 by at least 2.1 dBA[1] and at most locations the difference will be greater than 5 dBA. As will be discussed in Section 6.3, even with a significant increase in traffic speeds, increased volumes, and increased % heavy trucks, the noise levels will still be below 65 dBA L_{eq}24. As such, additional noise mitigation will not be required throughout the entire study area.

[1] The location which was closest to 65 dBA Leq24 was R12 which is dominated by traffic on 50 Street and not AHD

6.3. Future 30 Year Conditions Sensitivity Analysis

As part of the study, a sensitivity analysis was performed for the main traffic parameters associated with AHD. These included the overall traffic volumes, the traffic speeds, and the % heavy trucks. Each was evaluated with an increase and a decrease relative to the future conditions modeled.

6.3.1. Traffic Volume Analysis

As with any noise source, the relative change in noise level with changing quantity is a simple logarithmic function as indicated below:

$$\Delta SPL = 10\log_{10}\left(relative\ change\right)$$

This means that if the traffic volumes, for example, are doubled, there will be a 3.0 dBA increase. **If there is an increase in traffic volumes of 25% (likely maximum error in 30 year planning horizon), there will be a maximum 1.0 dBA increase for locations in which the noise climate is dominated by AHD (i.e. relative to other City Streets).** At locations in which the noise climate has a greater influence by City Streets, changes in traffic volumes on AHD will have less of an impact. Table 5 shows the $L_{eq}24$ results for both the 100,000 and 60,000 vehicles per day conditions as well as the relative change in noise levels at all modeled receptor locations. As an aside, typical traffic volumes on typical urban roads only vary a few % from day-to-day. This means that changes in noise levels from day-to-day are almost entirely dictated by environmental and meteorological conditions, and not by varying traffic volumes.

Table 5. Effects of Changing AHD Traffic Volumes at Residential Receptor Locations

Receptor	L_{eq}24 with 100,000 Vehicles Per Day on AHD (dBA)	Relative Increase Compared to 80,000 Vehicles Per Day		L_{eq}24 with 60,000 Vehicles Per Day on AHD (dBA)	Relative Decrease Compared to 80,000 Vehicles Per Day
R1	56.0	0.5		54.9	-0.6
R2	58.5	0.7		56.9	-0.9
R3	60.1	0.8		58.2	-1.1
R4	60.0	0.9		57.9	-1.2
R5	60.7	1.0		58.5	-1.2
R6	60.3	0.9		58.3	-1.1
R7	60.2	0.4		59.4	-0.4
R8	57.1	0.8		55.3	-1.0
R9	59.9	1.0		57.7	-1.2
R10	60.5	0.9		58.4	-1.2
R11	61.6	0.9		59.5	-1.2
R12	63.1	0.2		62.8	-0.1
R13	60.8	0.7		59.4	-0.7
R14	59.7	0.8		57.9	-1.0
R15	59.1	0.9		57.1	-1.1
R16	58.6	1.0		56.5	-1.1
R17	57.8	1.0		55.6	-1.2
R18	57.1	1.0		55.0	-1.1
R19	56.1	0.8		54.4	-0.9
R20	60.2	0.2		59.7	-0.3
R21	56.7	0.7		55.3	-0.7
R22	56.1	0.8		54.3	-1.0
R23	56.7	0.9		54.7	-1.1
R24	58.4	0.7		57.0	-0.7
R25	58.2	0.8		56.6	-0.8
R26	55.8	0.9		53.7	-1.2
R27	57.9	0.9		55.8	-1.2
R28	54.9	0.8		53.0	-1.1
R29	51.7	0.6		50.2	-0.9

6.3.2. Traffic Speed Analysis

In order to determine the effect of different traffic speeds, two scenarios were modeled. The baseline future conditions case included a speed of 100 km/hr on AHD throughout the entire study area. This speed was increased to 110 km/hr and then decreased to 90 km/hr to determine the relative change compared to 100 km/hr. It is highly unlikely that the traffic speeds will fall outside of this range. Table 6 shows the L_{eq}24 results for both the 110 km/hr and 90 km/hr conditions as well as the relative change in noise levels at all modeled receptor locations. **When increasing the speed to 110 km/hr, the noise levels increased by 0.1 – 0.6 dBA. When reducing the speed to 90 km/hr, the noise levels decreased by 0.0 – 0.5 dBA.** Given that a minimum 2.0 – 3.0 dBA change is required before most people start to notice a change, changing the traffic speeds will not significantly impact the perceived noise climate.

Table 6. Effects of Changing AHD Traffic Speed at Residential Receptor Locations

Receptor	L_{eq}24 with 110 km/hr on AHD (dBA)	Relative Increase Compared to 100 km/hr		L_{eq}24 with 90 km/hr on AHD (dBA)	Relative Decrease Compared to 100 km/hr
R1	55.8	0.3		55.2	-0.3
R2	58.2	0.4		57.4	-0.4
R3	59.8	0.5		58.8	-0.5
R4	59.6	0.5		58.6	-0.5
R5	60.3	0.6		59.2	-0.5
R6	60.0	0.6		59.0	-0.4
R7	60.0	0.2		59.6	-0.2
R8	56.7	0.4		55.9	-0.4
R9	59.5	0.6		58.4	-0.5
R10	60.1	0.5		59.1	-0.5
R11	61.2	0.5		60.2	-0.5
R12	63.0	0.1		62.9	0.0
R13	60.5	0.4		59.8	-0.3
R14	59.4	0.5		58.5	-0.4
R15	58.7	0.5		57.8	-0.4
R16	58.2	0.6		57.1	-0.5
R17	57.4	0.6		56.3	-0.5
R18	56.7	0.6		55.7	-0.4
R19	55.8	0.5		54.9	-0.4
R20	60.1	0.1		59.8	-0.2
R21	56.4	0.4		55.7	-0.3
R22	55.8	0.5		54.9	-0.4
R23	56.3	0.5		55.4	-0.4
R24	58.1	0.4		57.4	-0.3
R25	57.8	0.4		57.1	-0.3
R26	55.4	0.5		54.4	-0.5
R27	57.5	0.5		56.5	-0.5
R28	54.6	0.5		53.6	-0.5
R29	51.4	0.3		50.7	-0.4

6.3.3. % Heavy Trucks Analysis

In order to determine the effect of varying % heavy trucks, two scenarios were modeled. The baseline future conditions case included day-time and night-time % heavy trucks of 11% on AHD throughout the entire study area. These values were increased by 5% and then decreased by 5% to determine a relative range of values. It is un-likely that in the future 30 years, the % heavy trucks will fall outside of this range. The results are shown in Table 7. It can be seen that **the relative sound level increase with 16% heavy trucks is approximately 0.2 – 0.9 dBA. The relative sound level decrease with 6% heavy trucks is approximately 0.1 – 1.0 dBA.** Again, given that a minimum 2.0 – 3.0 dBA change is required before most people start to notice a change, it will take a significant change to the % heavy trucks before most people will notice the difference.

Table 7. Effects of Changing AHD % Heavy Trucks at Residential Receptor Locations

Receptor	L_{eq}24 With 5% Greater Heavy Trucks on AHD (dBA)	Relative Increase Compared to Future Baseline (dBA)		L_{eq}24 With 5% Fewer Heavy Trucks on AHD (dBA)	Relative Decrease Compared to Future Baseline (dBA)
R1	55.9	0.4		55.0	-0.5
R2	58.4	0.6		57.1	-0.7
R3	60.0	0.7		58.3	-1.0
R4	59.9	0.8		58.1	-1.0
R5	60.6	0.9		58.7	-1.0
R6	60.2	0.8		58.5	-0.9
R7	60.1	0.3		59.5	-0.3
R8	57.0	0.7		55.5	-0.8
R9	59.7	0.8		57.9	-1.0
R10	60.4	0.8		58.6	-1.0
R11	61.4	0.7		59.7	-1.0
R12	63.1	0.2		62.8	-0.1
R13	60.7	0.6		59.5	-0.6
R14	59.6	0.7		58.1	-0.8
R15	58.9	0.7		57.3	-0.9
R16	58.4	0.8		56.6	-1.0
R17	57.7	0.9		55.8	-1.0
R18	57.0	0.9		55.1	-1.0
R19	56.0	0.7		54.5	-0.8
R20	60.2	0.2		59.7	-0.3
R21	56.6	0.6		55.4	-0.6
R22	56.0	0.7		54.5	-0.8
R23	56.6	0.8		54.9	-0.9
R24	58.3	0.6		57.1	-0.6
R25	58.1	0.7		56.7	-0.7
R26	55.7	0.8		53.9	-1.0
R27	57.8	0.8		56.0	-1.0
R28	54.8	0.7		53.2	-0.9
R29	51.6	0.5		50.4	-0.7

In general, the effect of changing the % heavy trucks is logarithmic. The difference between 0% and 1% is significant (approximately 0.7 dBA) while the difference between 10% and 11% is much less (approximately 0.2 dBA). Since the current and future modeled % heavy trucks are near 11%, small % changes will not have a significant impact.

6.3.4. Cumulative Sensitivity Analysis

With the information provided by the sensitivity analysis for each of the three main traffic parameters, it is possible to determine a cumulative effect if all three are taken into account simultaneously. The results are presented in Table 8. Relative increases for locations which are most directly impacted by AHD are as high as 1.9 dBA. At locations in which the noise climate is most directly impacted by City of Edmonton roadways, the increases are generally less than 1.0 dBA. It can be seen that **increasing the traffic volume by 25%, increasing the traffic speed to 110 km/hr, and increasing the heavy trucks to 16% will result in noise levels that are still below the limit of 65 dBA L_{eq}24 at all locations.**

Table 8. Effects of Cumulative Effects on Noise Levels at Residential Receptor Locations

Receptor	Future L_{eq}24 With 25% Additional Vehicles, Speed of 110 km/hr, 5% Greater Heavy Trucks on AHD (dBA)	Relative Increase Compared to Future Baseline (dBA)
R1	56.6	1.1
R2	59.2	1.4
R3	60.9	1.6
R4	60.8	1.7
R5	61.6	1.9
R6	61.2	1.8
R7	60.7	0.9
R8	57.8	1.5
R9	60.7	1.8
R10	61.3	1.7
R11	62.3	1.6
R12	63.6	0.7
R13	61.5	1.4
R14	60.5	1.6
R15	59.8	1.6
R16	59.4	1.8
R17	58.7	1.9
R18	58.0	1.9
R19	56.9	1.6
R20	60.7	0.7
R21	57.4	1.4
R22	56.9	1.6
R23	57.5	1.7
R24	59.1	1.4
R25	58.9	1.5
R26	56.6	1.7
R27	58.7	1.7
R28	55.7	1.6
R29	52.3	1.2

7.0 Conclusion

The results of the Current Conditions noise monitoring indicated noise levels which were well below the permissible sound level of 65 dBA L_{eq}24. In most locations, AHD was the dominant noise source. However there were locations at which other intersecting City streets either contributed a significant amount or were dominant (i.e. adjacent to 91 Street, 66 Street, 50 Street, 34 Street).

The noise modeling results for Current Conditions matched well with the measurement results. The modeled noise levels at the additional residential outdoor amenity receptor locations were similar to those of the measured locations. No receptors exceeded the limit of 65 dBA L_{eq}24.

The noise modeling results for the Future Conditions (with projected traffic volumes for year 2037 of 80,000 vehicles per day on AHD and a conservative estimate of double traffic volumes on intersecting city streets) indicated noise levels which were still below the limit of 65 dBA L_{eq}24 at all locations. Further, a sensitivity analysis of the traffic volumes, traffic speeds, and % heavy trucks indicated that even with significant increases in all three, the noise levels at all receptor locations will still be below the limit of 65 dBA L_{eq}24. **As such, based on the criteria set forth by Alberta Transportation, no additional noise mitigation measures are required throughout the entire study area.**

8.0 References

- *"Noise Attenuation Guidelines for Provincial Highways Under Provincial Jurisdiction Within Cities and Urban Areas"* DRAFT version, by Alberta Transportation. January 31, 2006.
- City of Edmonton Urban Traffic Noise Policy (C506), 2004
- International Organization for Standardization (ISO), *Standard 1996-1, Acoustics – Description, measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures, 2003*, Geneva Switzerland.
- International Organization for Standardization (ISO), *Standard 9613-1, Acoustics – Attenuation of sound during propagation outdoors – Part 1: Calculation of absorption of sound by the atmosphere, 1993*, Geneva Switzerland.
- International Organization for Standardization (ISO), *Standard 9613-2, Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation, 1996*, Geneva Switzerland.

Figure 1a. Noise Study Area (91 Street – 66 Street)

Figure 1b. Noise Study Area (66 Street – 50 Street)

Figure 1c. Noise Study Area (50 Street – 34 Street)

Figure 1d. Noise Study Area (34 Street – 17 Street)

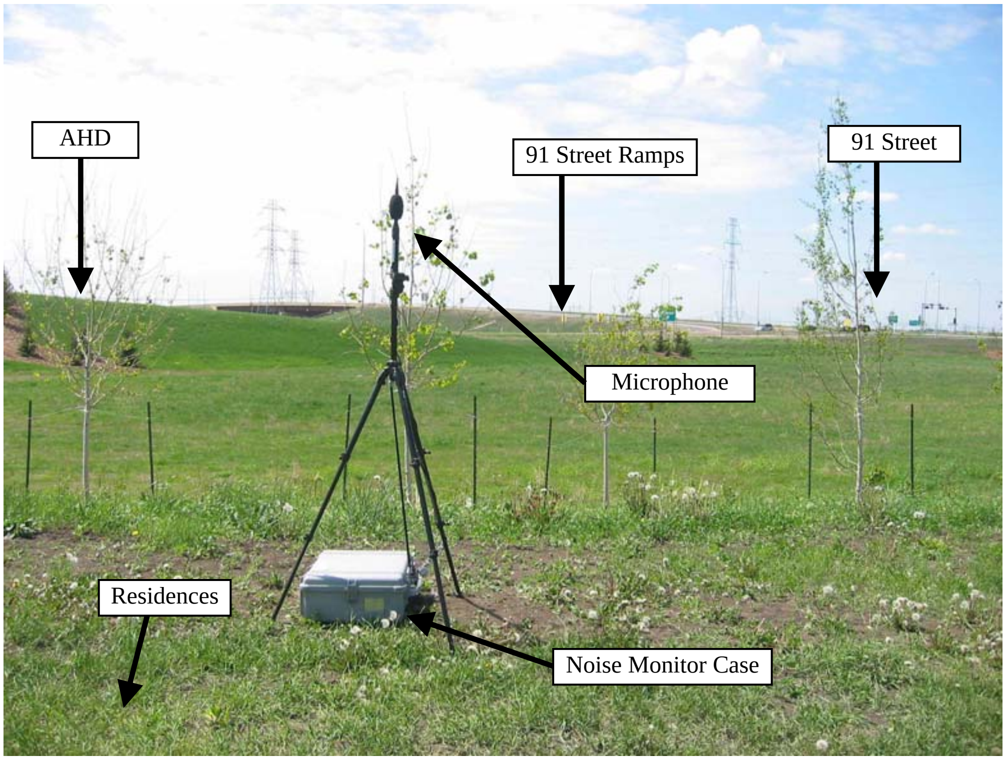

Figure 2. Noise Monitor 1

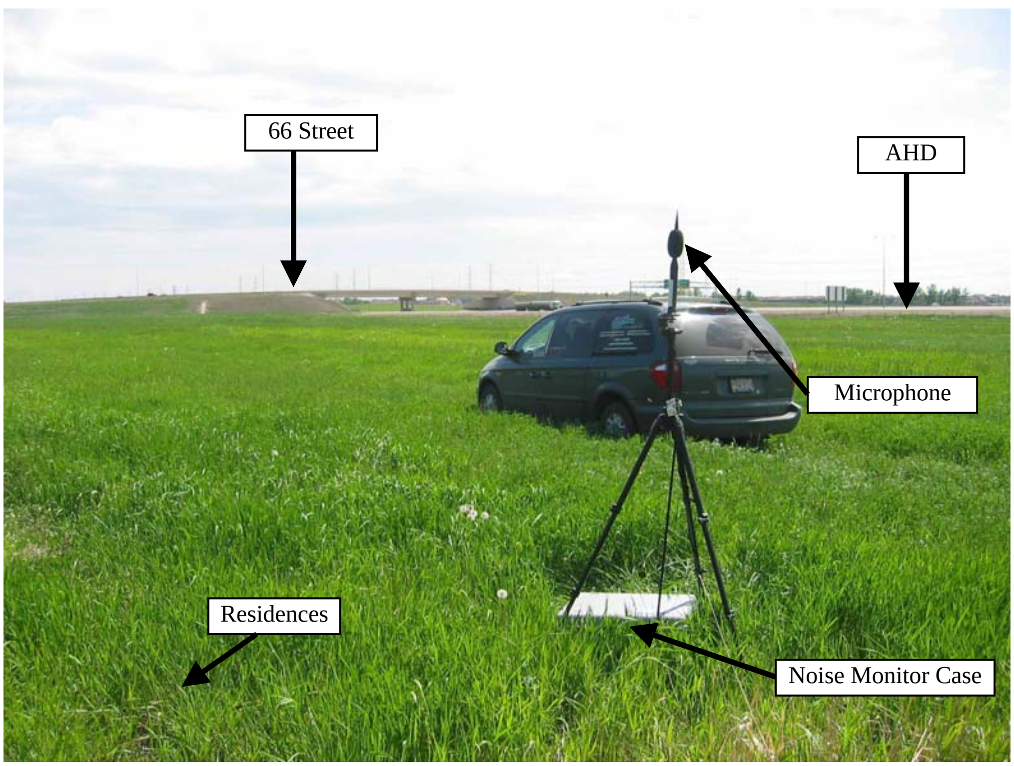

Figure 3. Noise Monitor 2

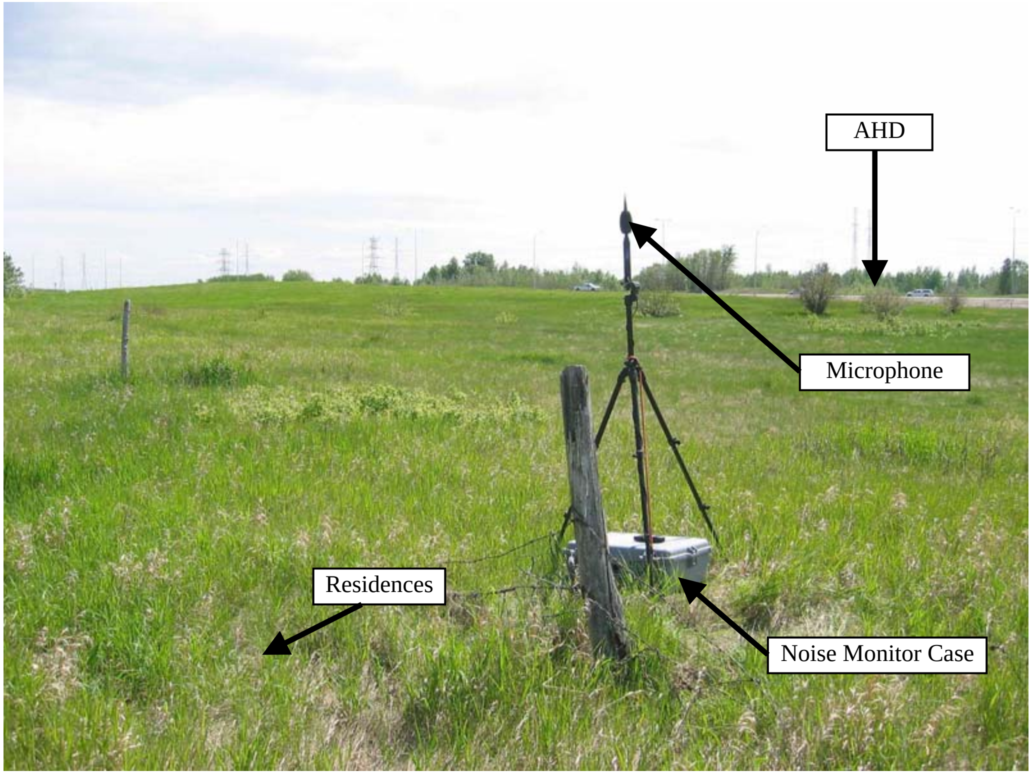

Figure 4. Noise Monitor 3

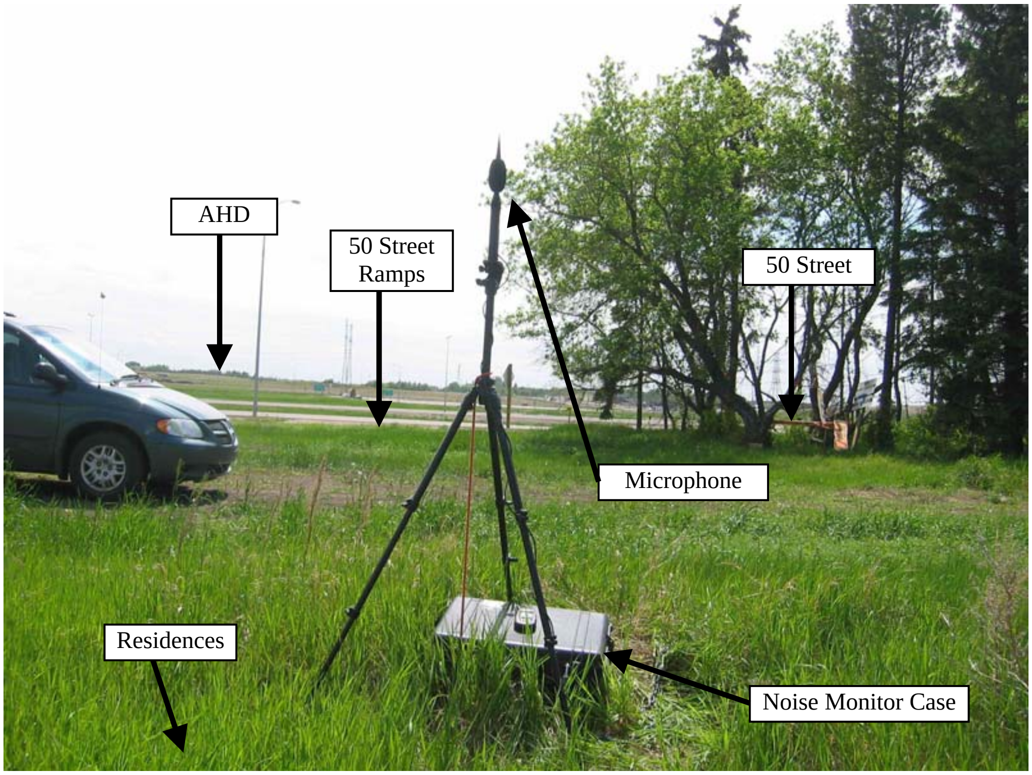

Figure 5. Noise Monitor 4

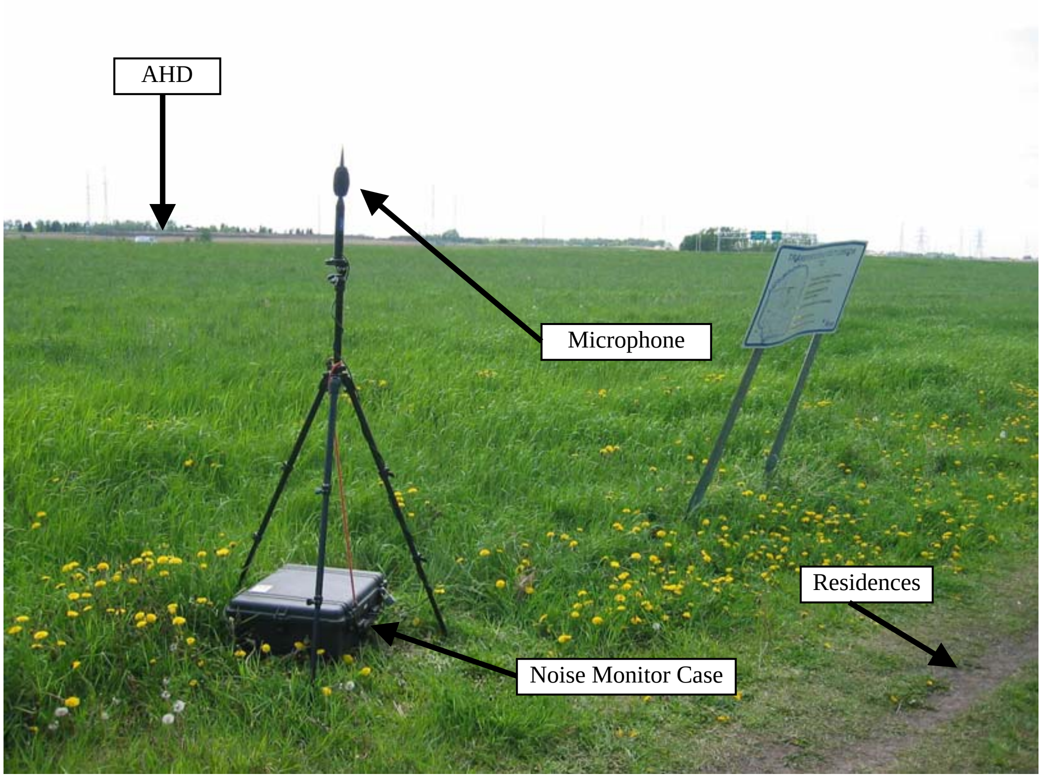

Figure 6. Noise Monitor 5

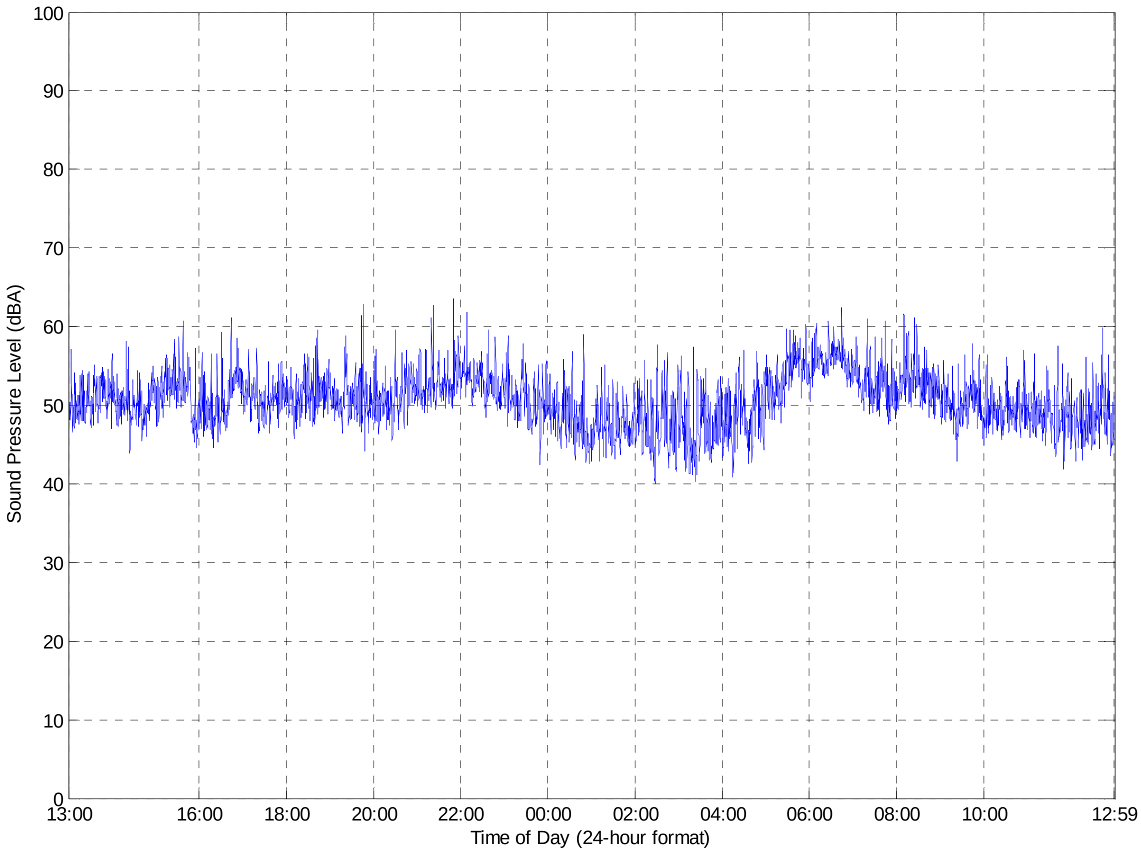

Figure 7. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 1

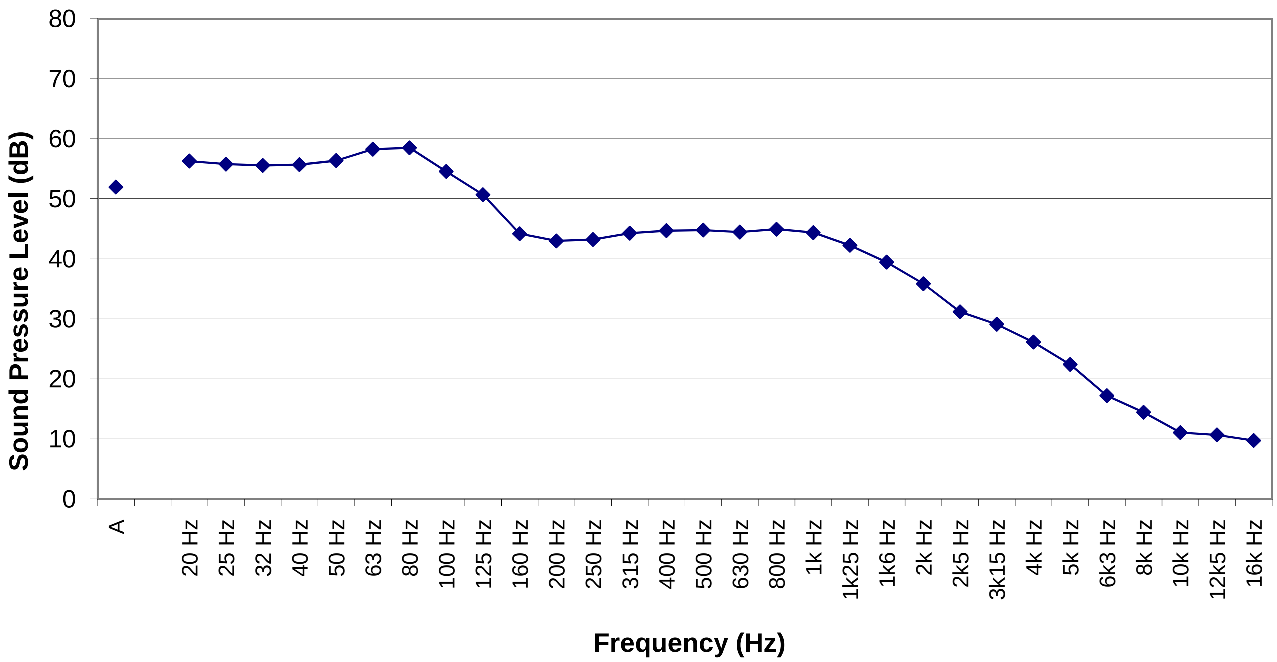

Figure 8. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 1

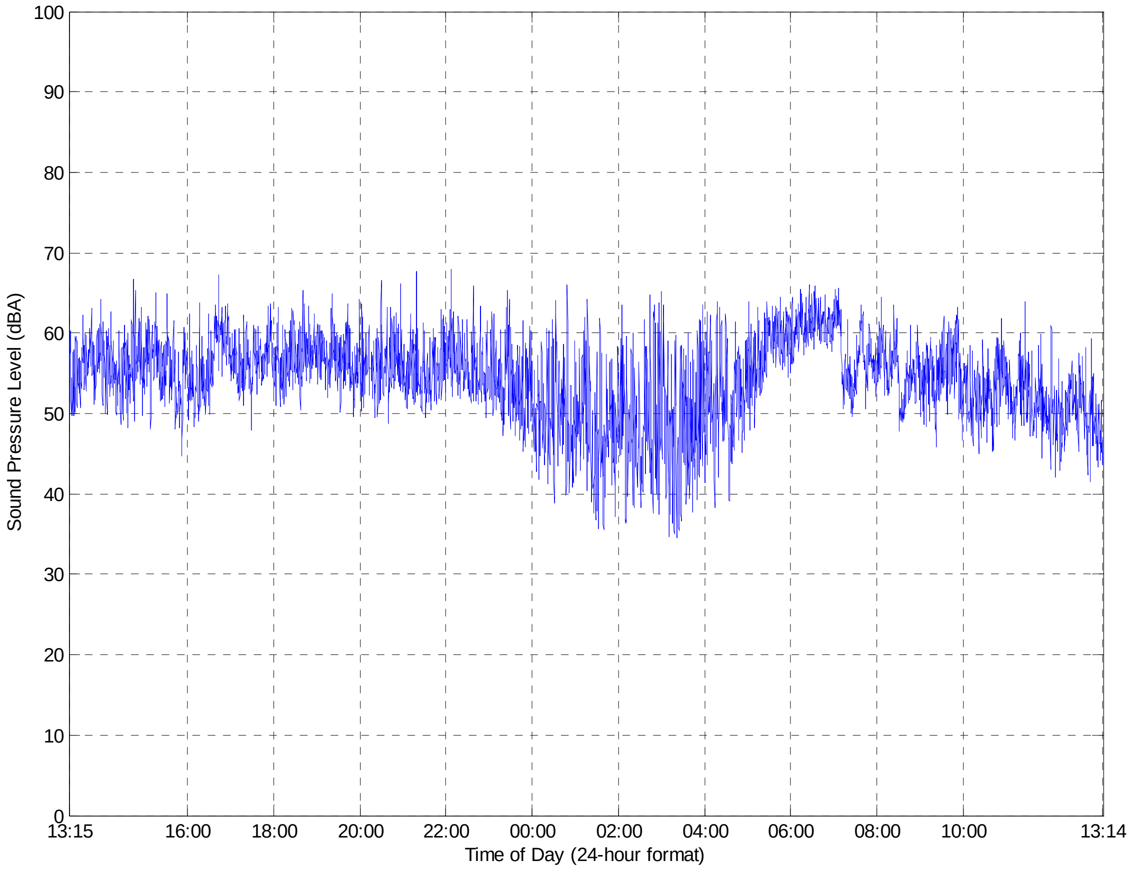

Figure 9. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 2

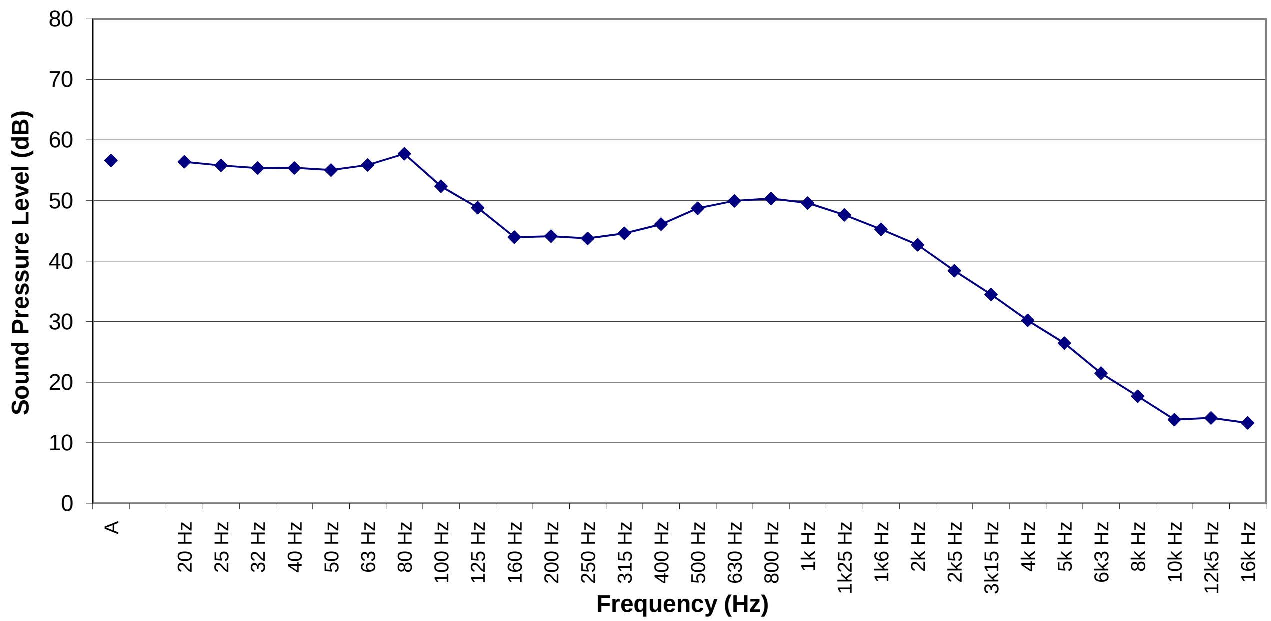

Figure 10. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 2

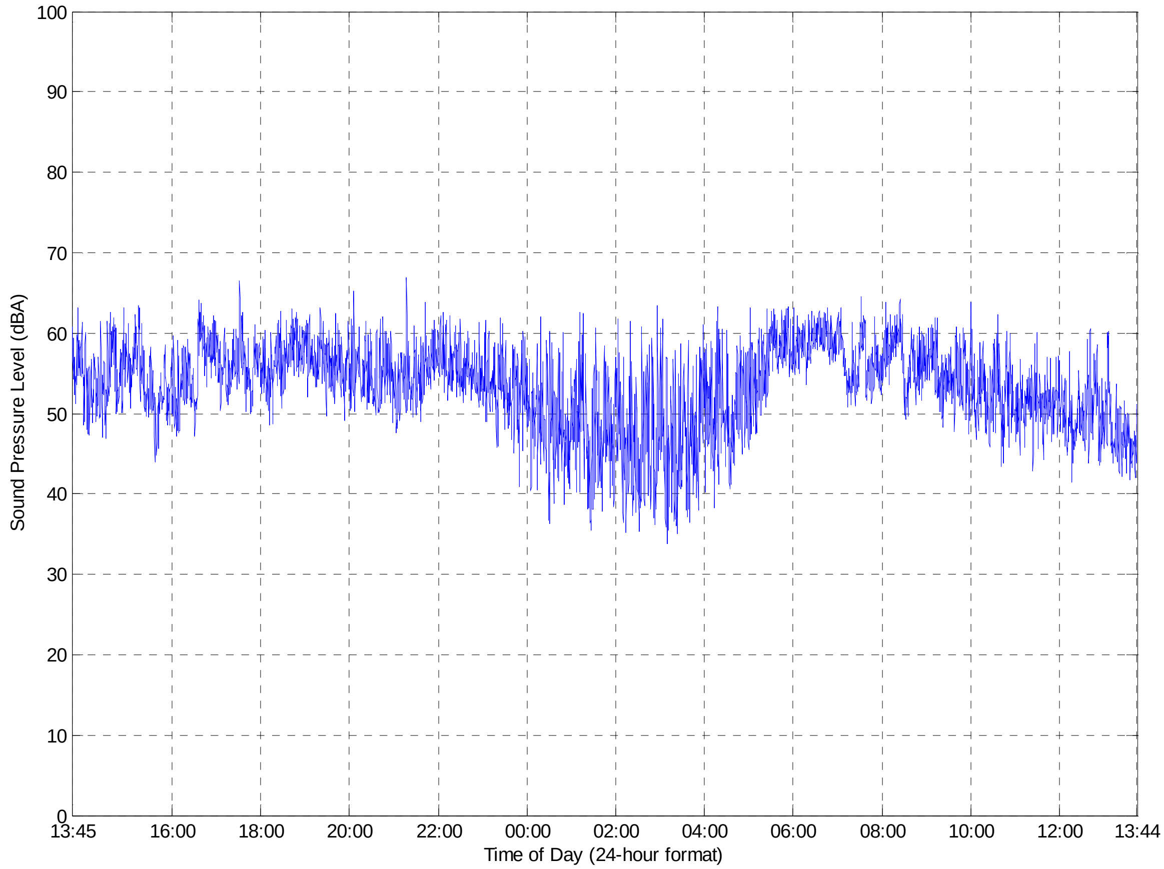

Figure 11. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 3

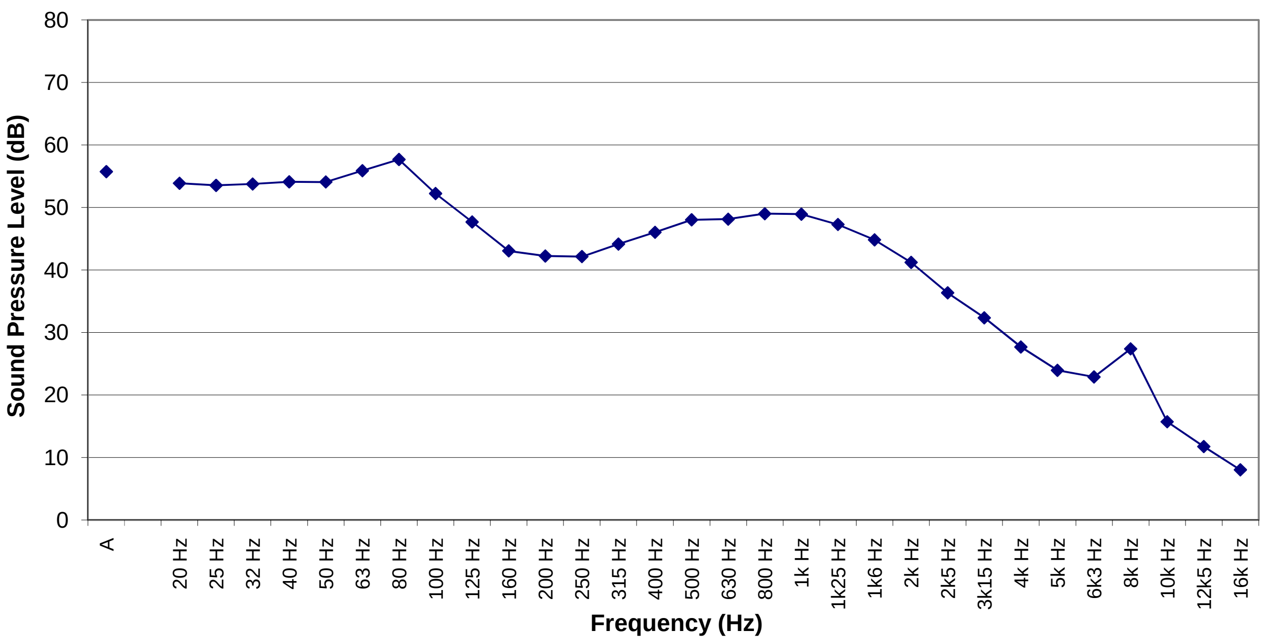

Figure 12. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 3

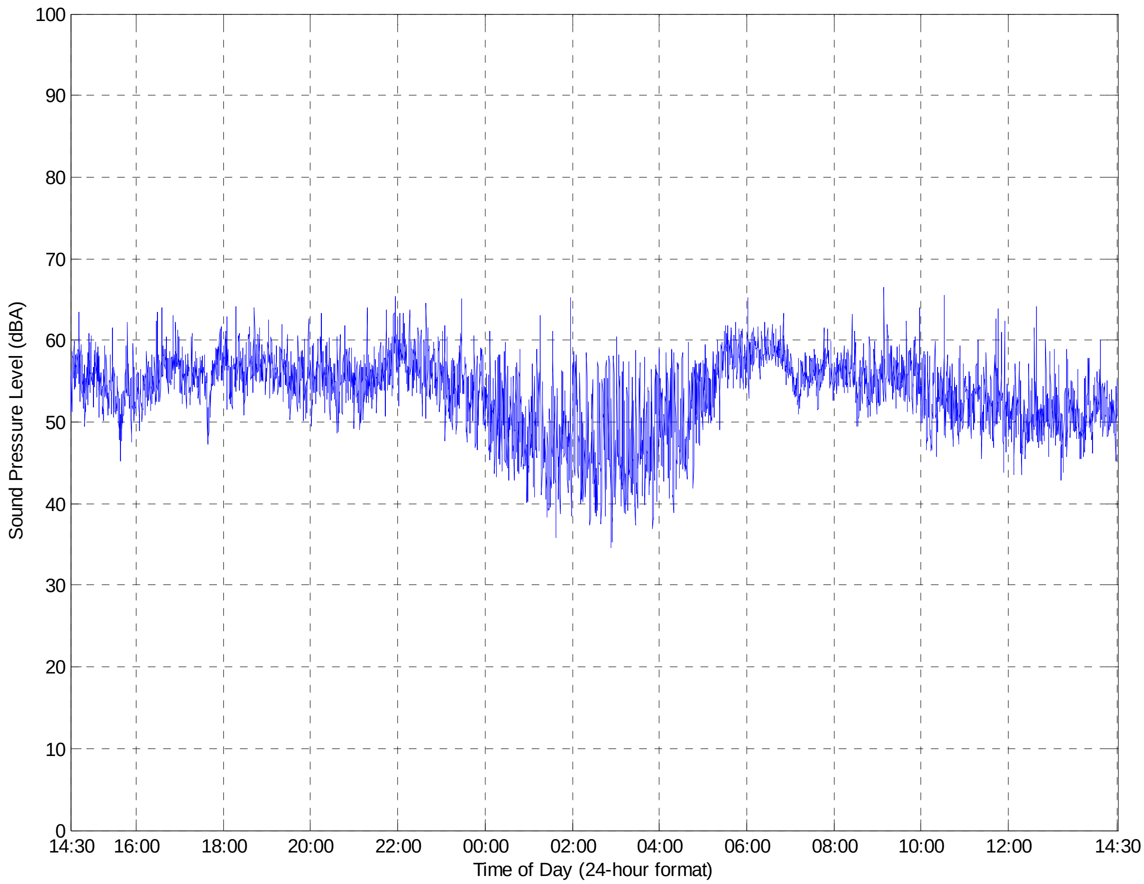

Figure 13. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 4

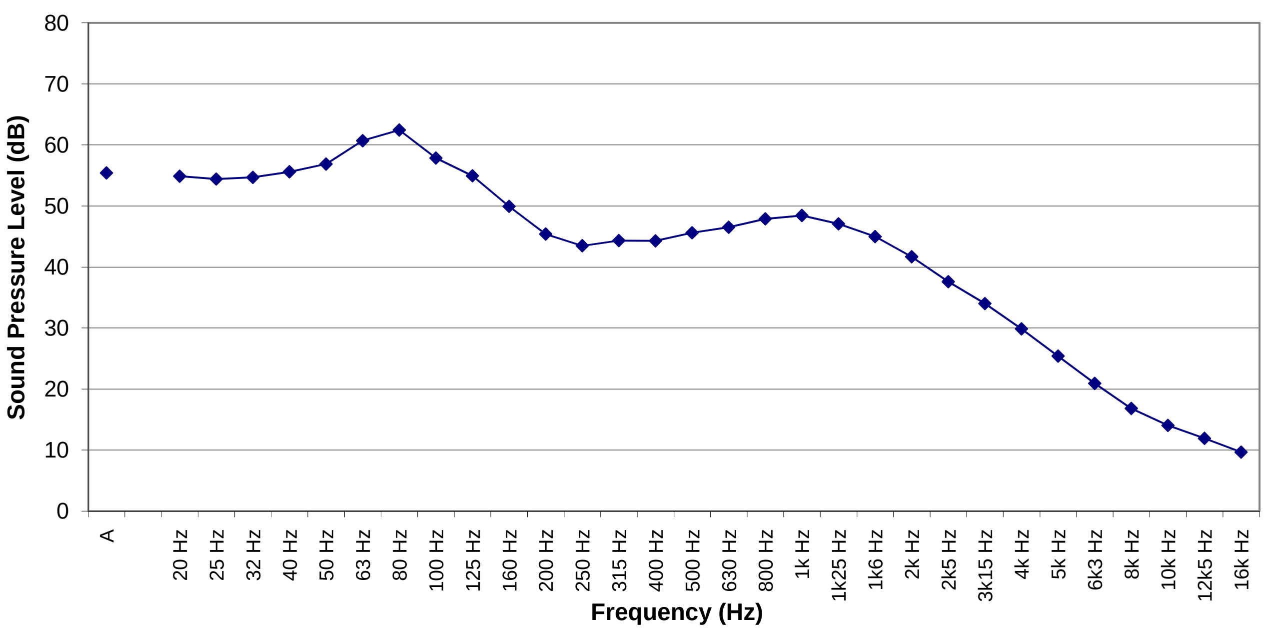

Figure 14. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 4

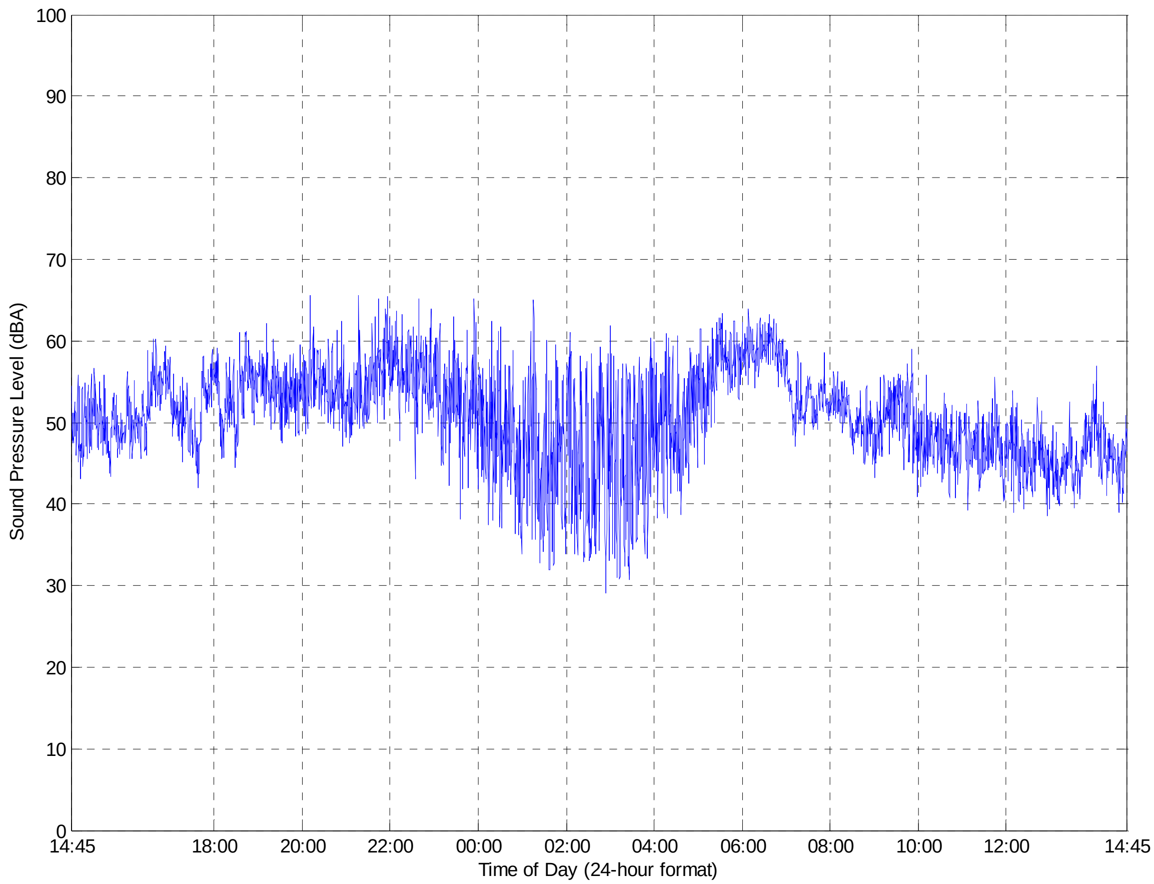

Figure 15. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 5

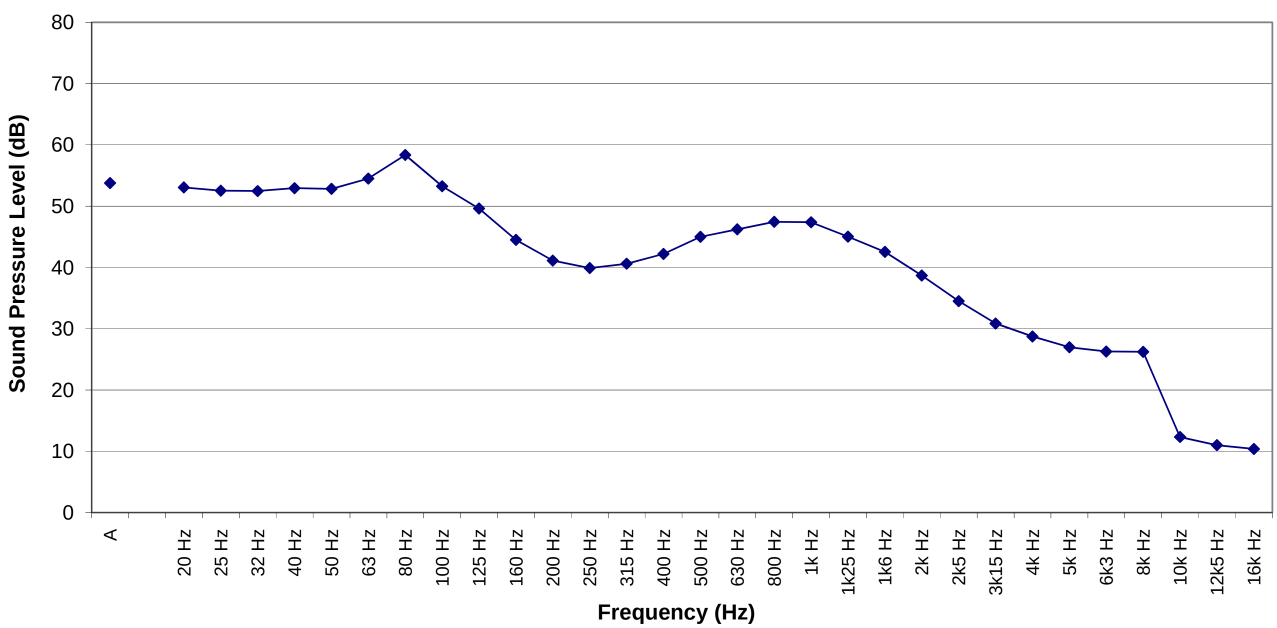

Figure 16. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 5

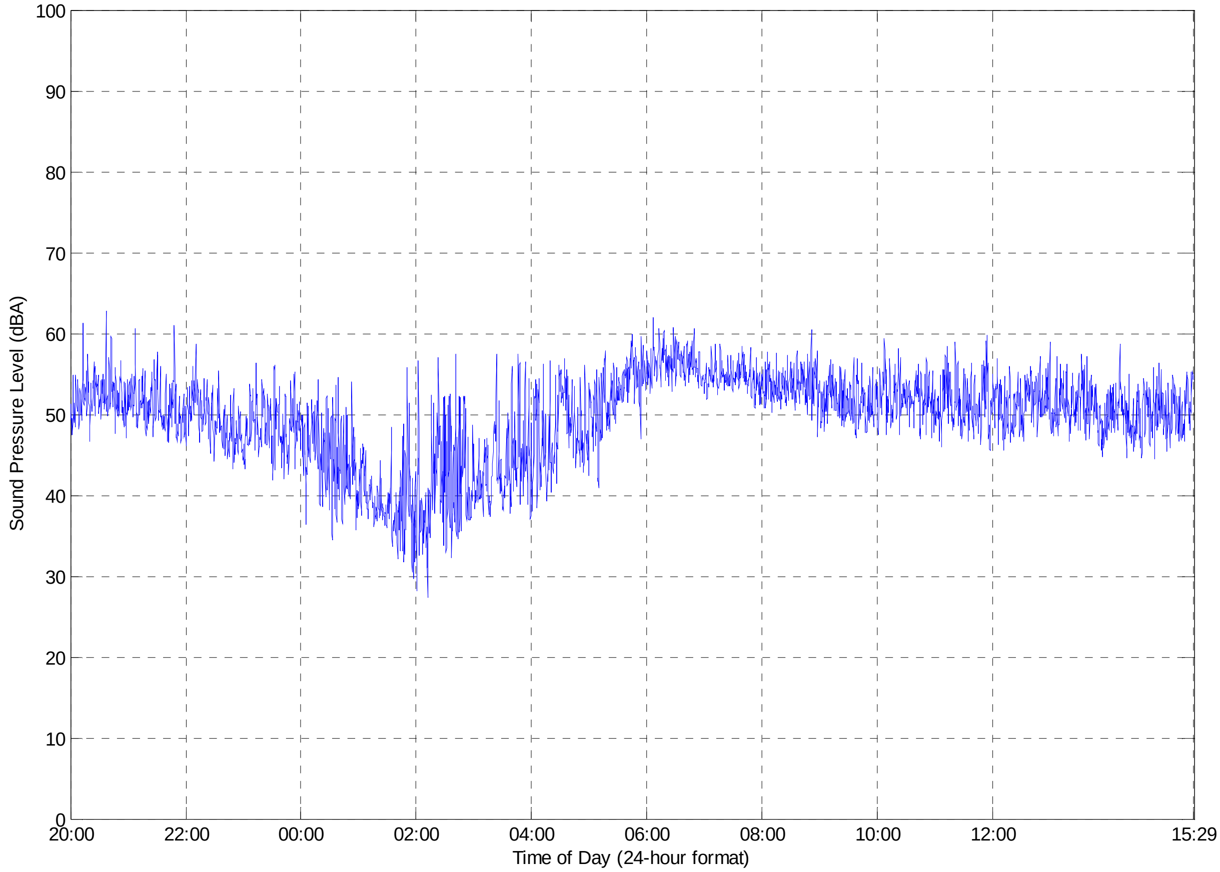

Figure 17. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 6

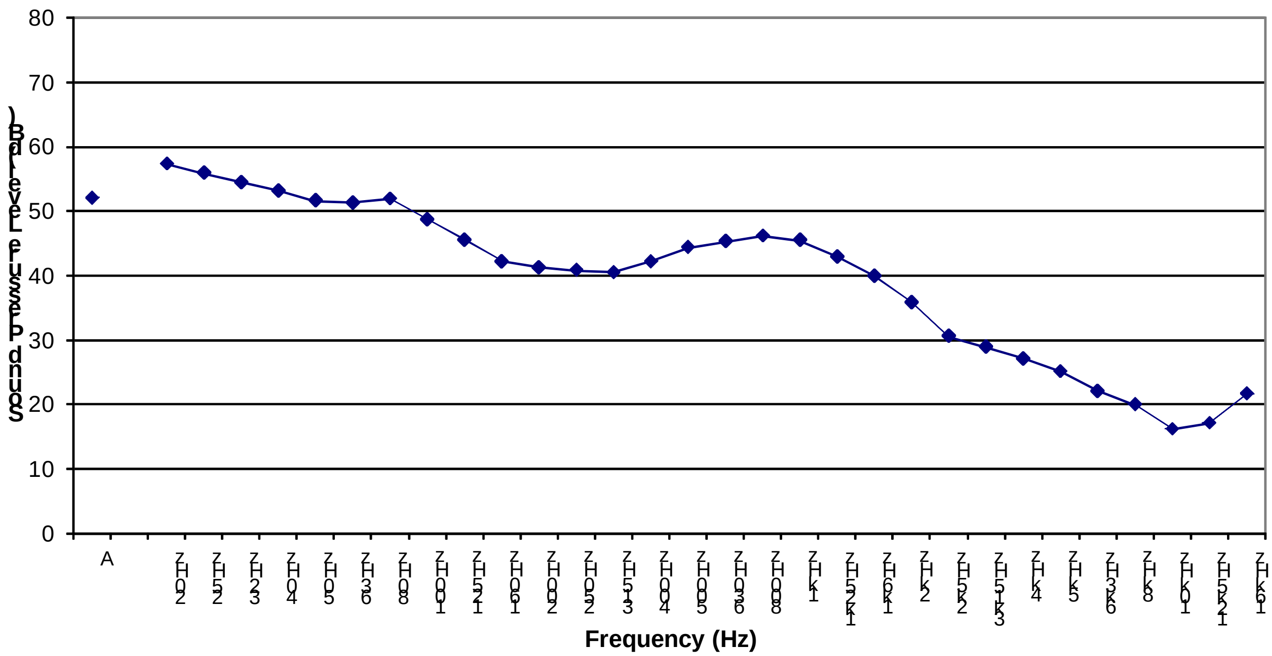

Figure 18. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 6

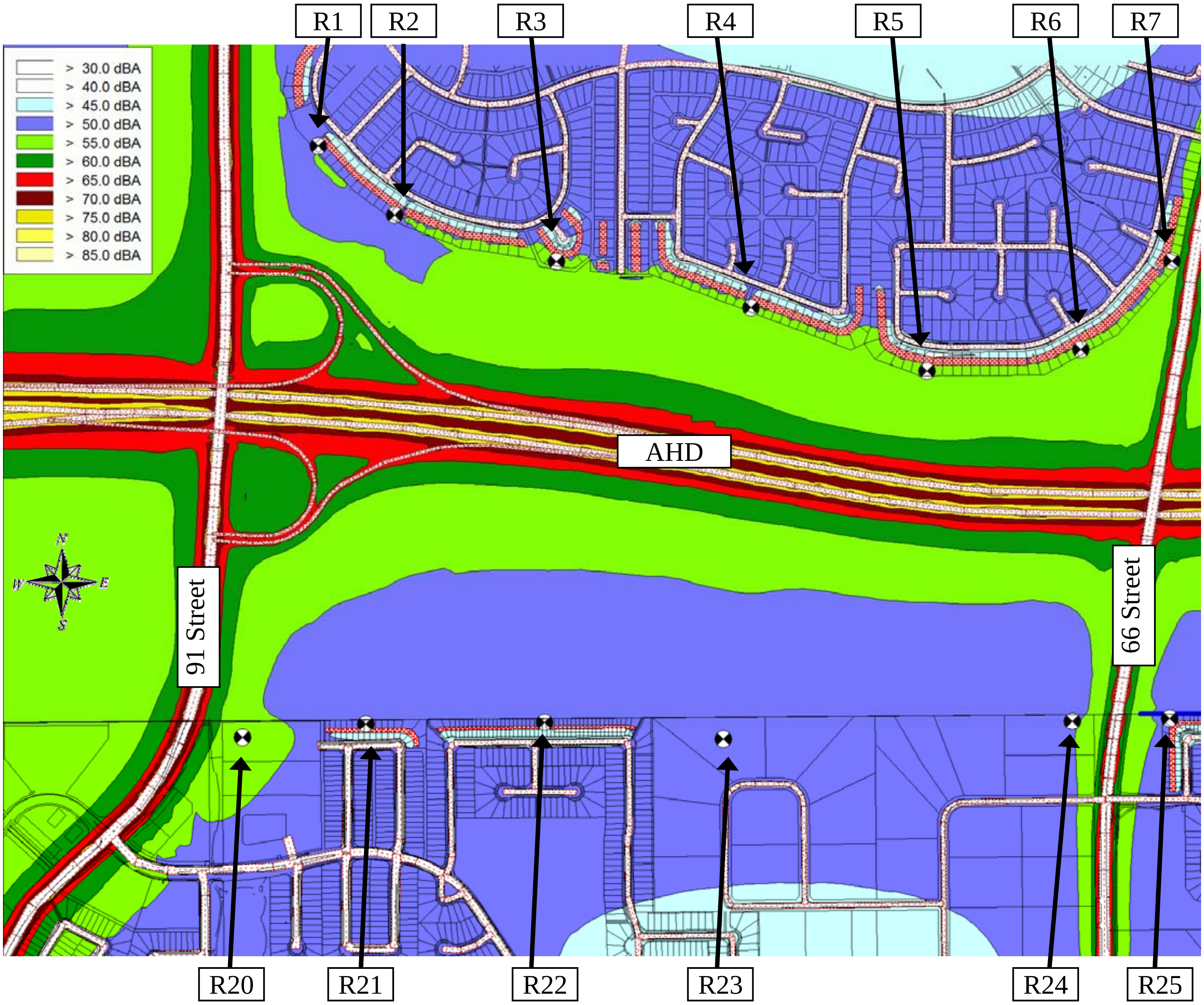

Figure 19a. Current Conditions L_{eq}24 Sound Levels (91 Street – 66 Street)

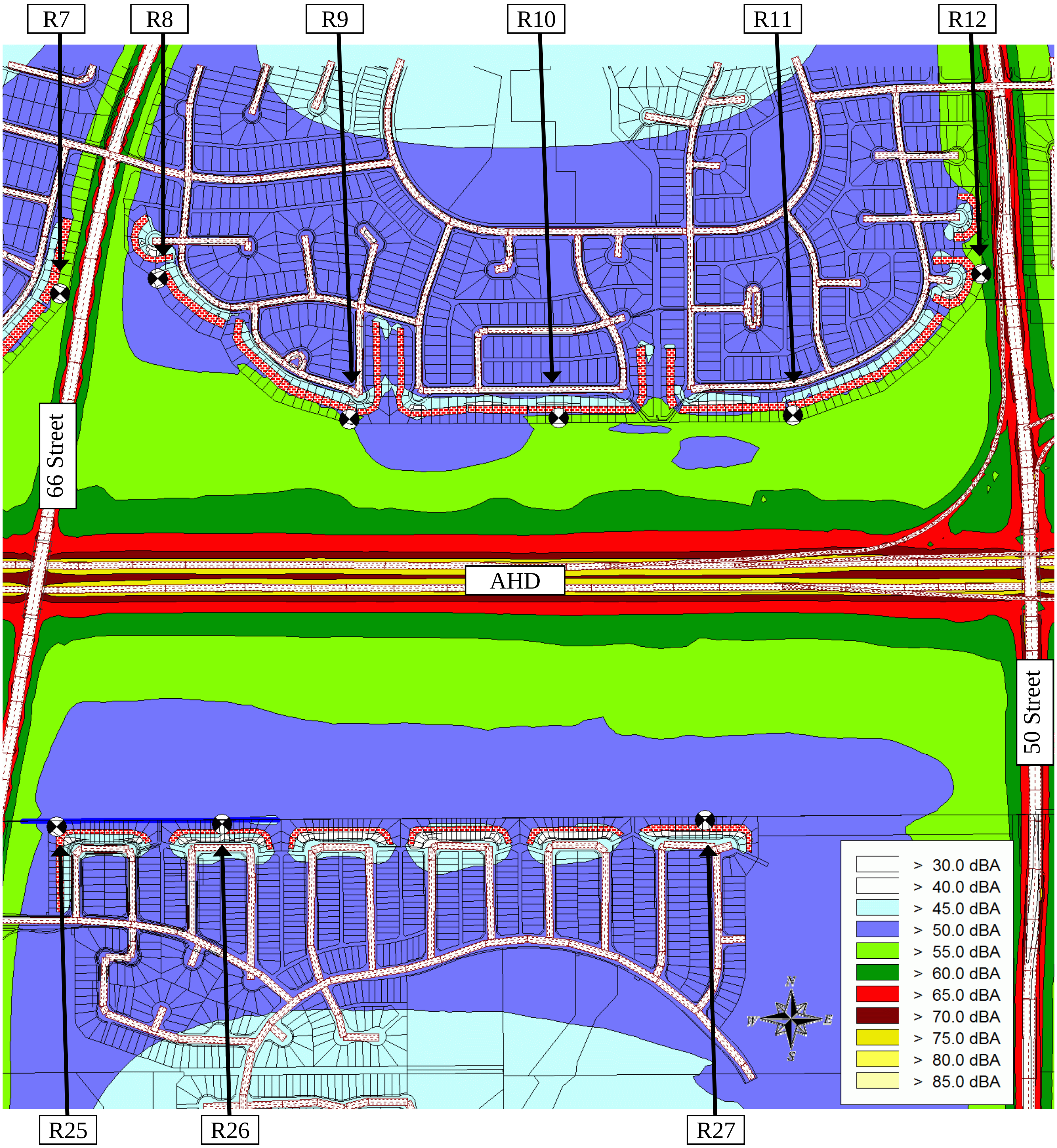

Figure 19b. Current Conditions L_{eq}24 Sound Levels (66 Street – 50 Street)

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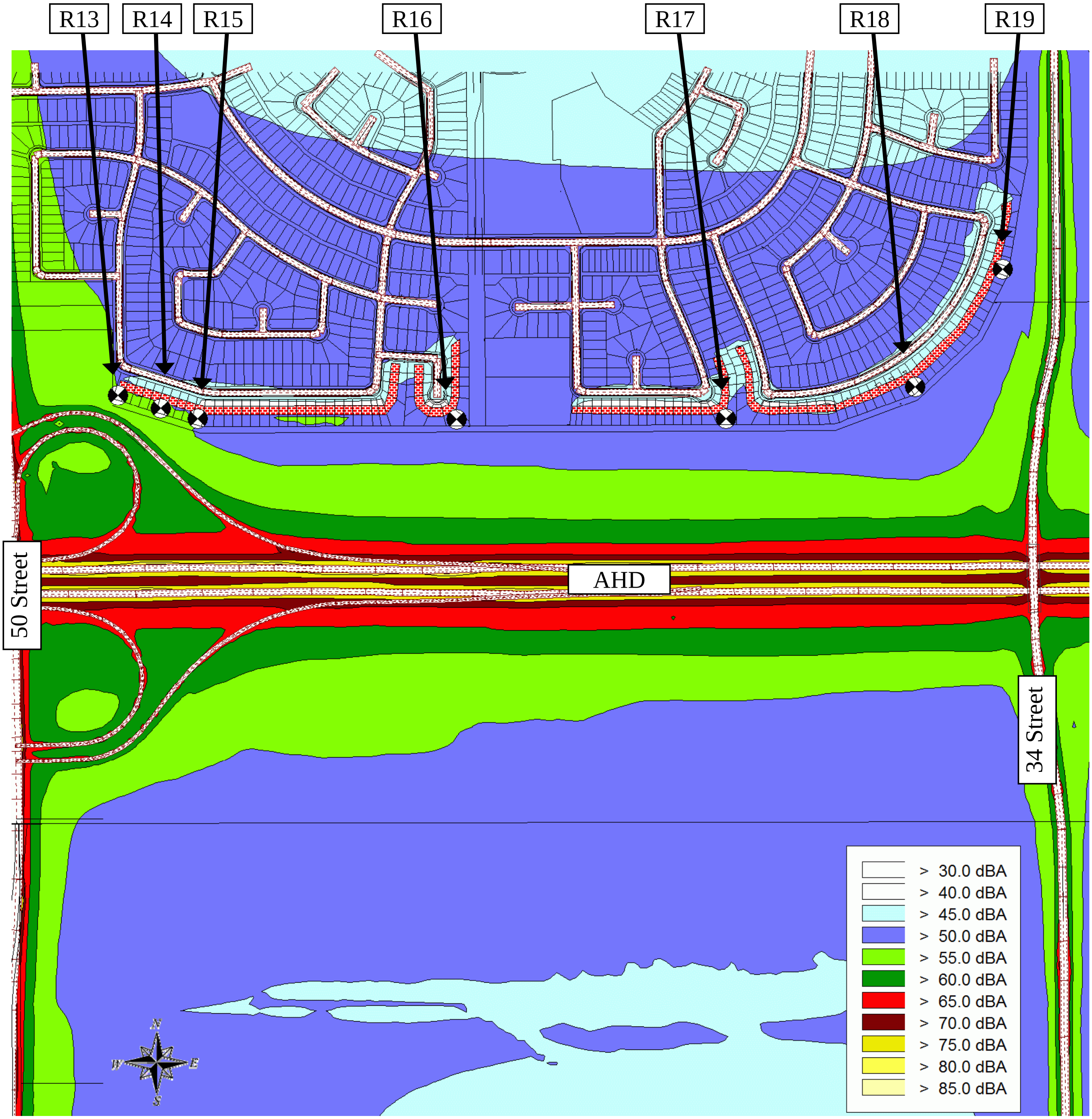

Figure 19c. Current Conditions L_{eq}24 Sound Levels (50 Street – 34 Street)

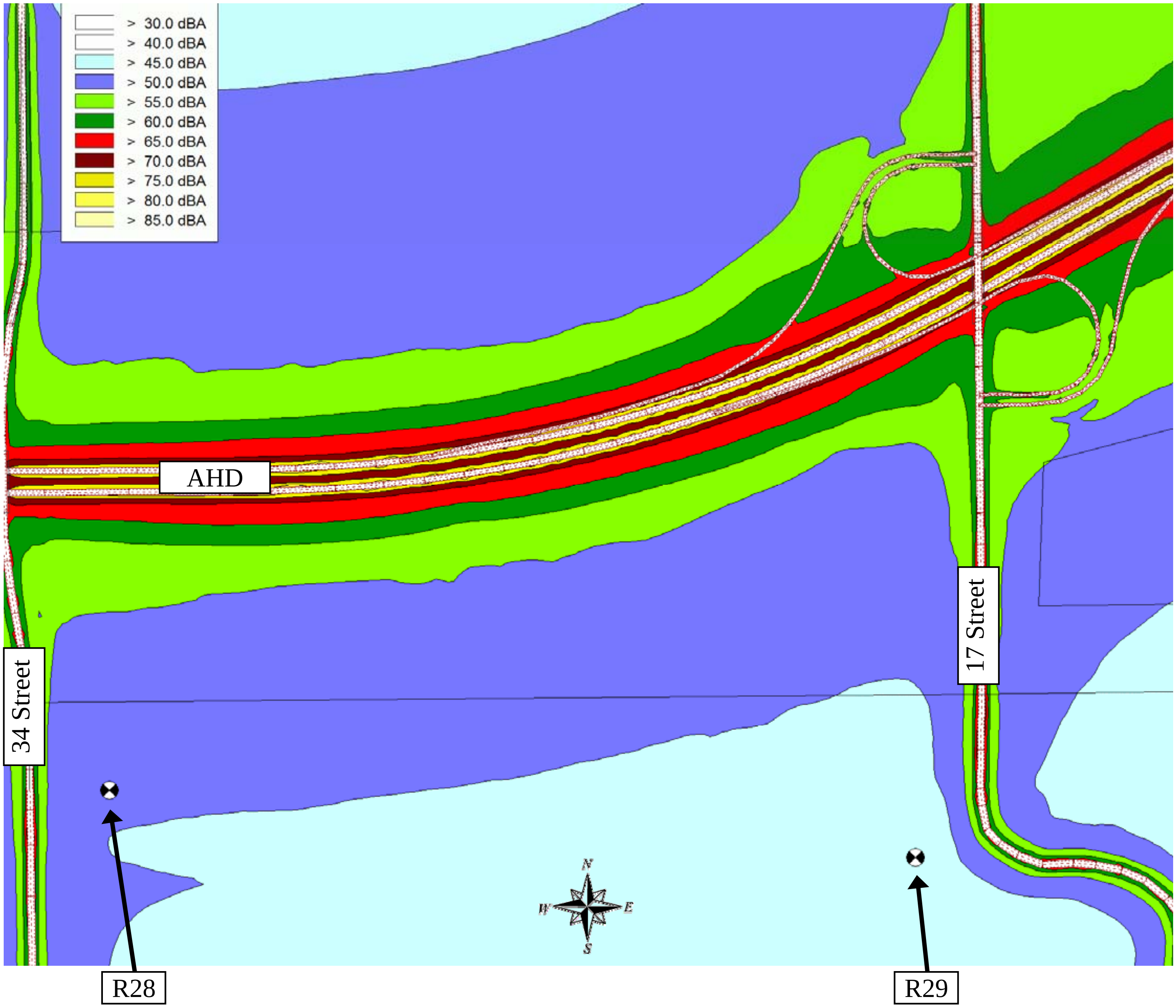

Figure 19d. Current Conditions L_{eq}24 Sound Levels (34 Street – 17 Street)

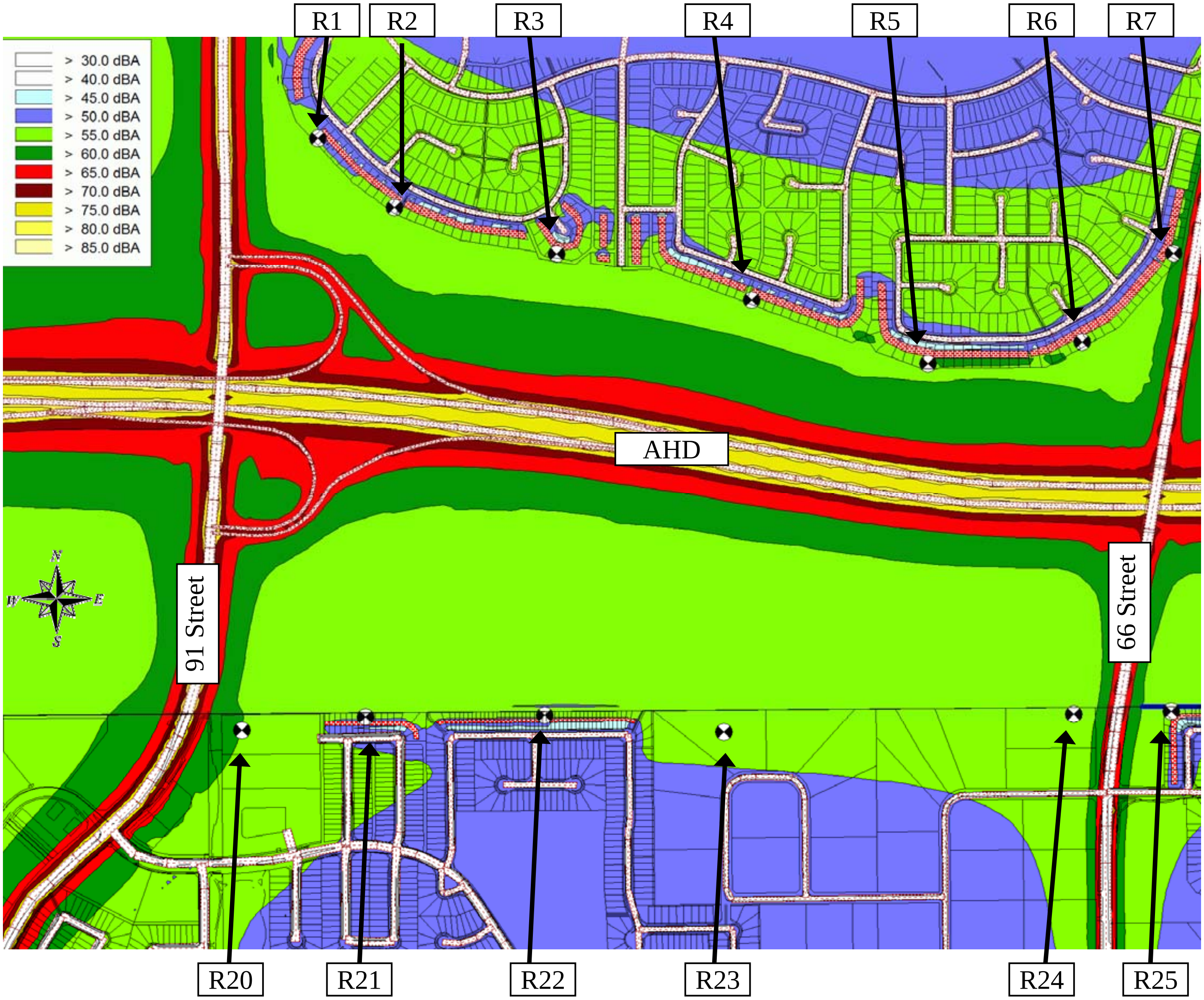

Figure 20a. Future Conditions L_{eq}24 Sound Levels (91 Street – 66 Street)

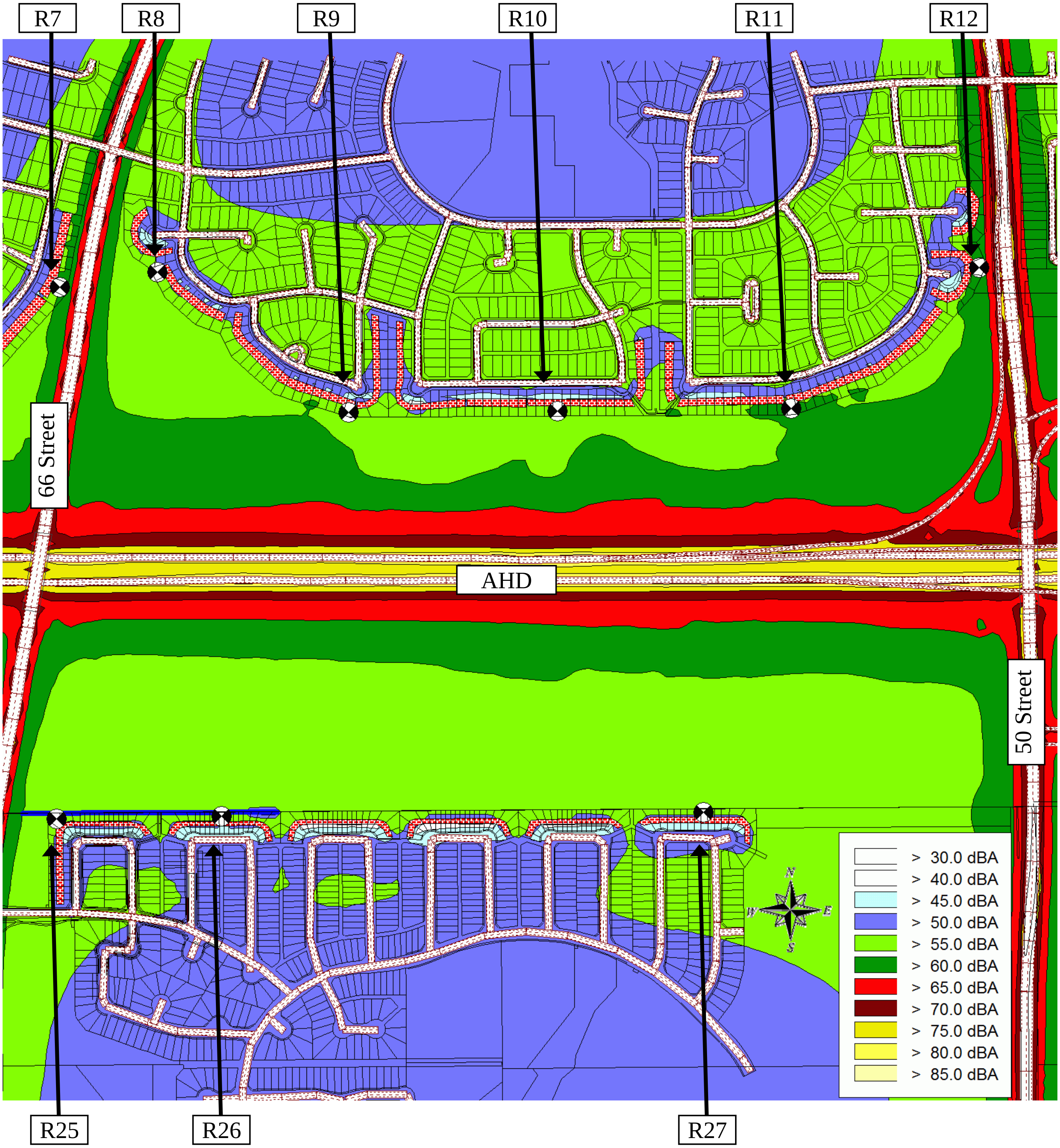

Figure 20b. Future Conditions L_{eq}24 Sound Levels (66 Street – 50 Street)

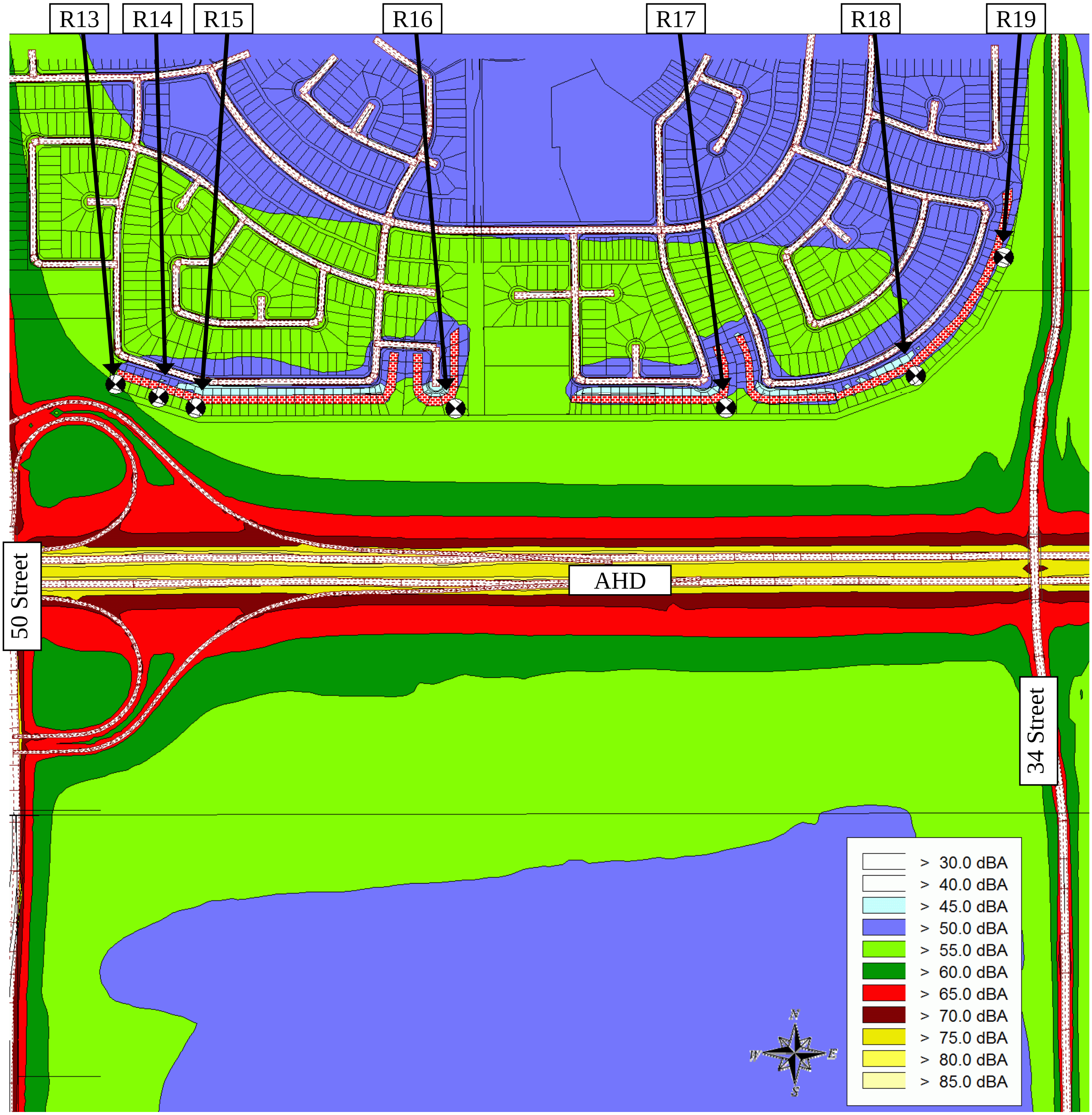

Figure 20c. Future Conditions L_{eq}24 Sound Levels (50 Street – 34 Street)

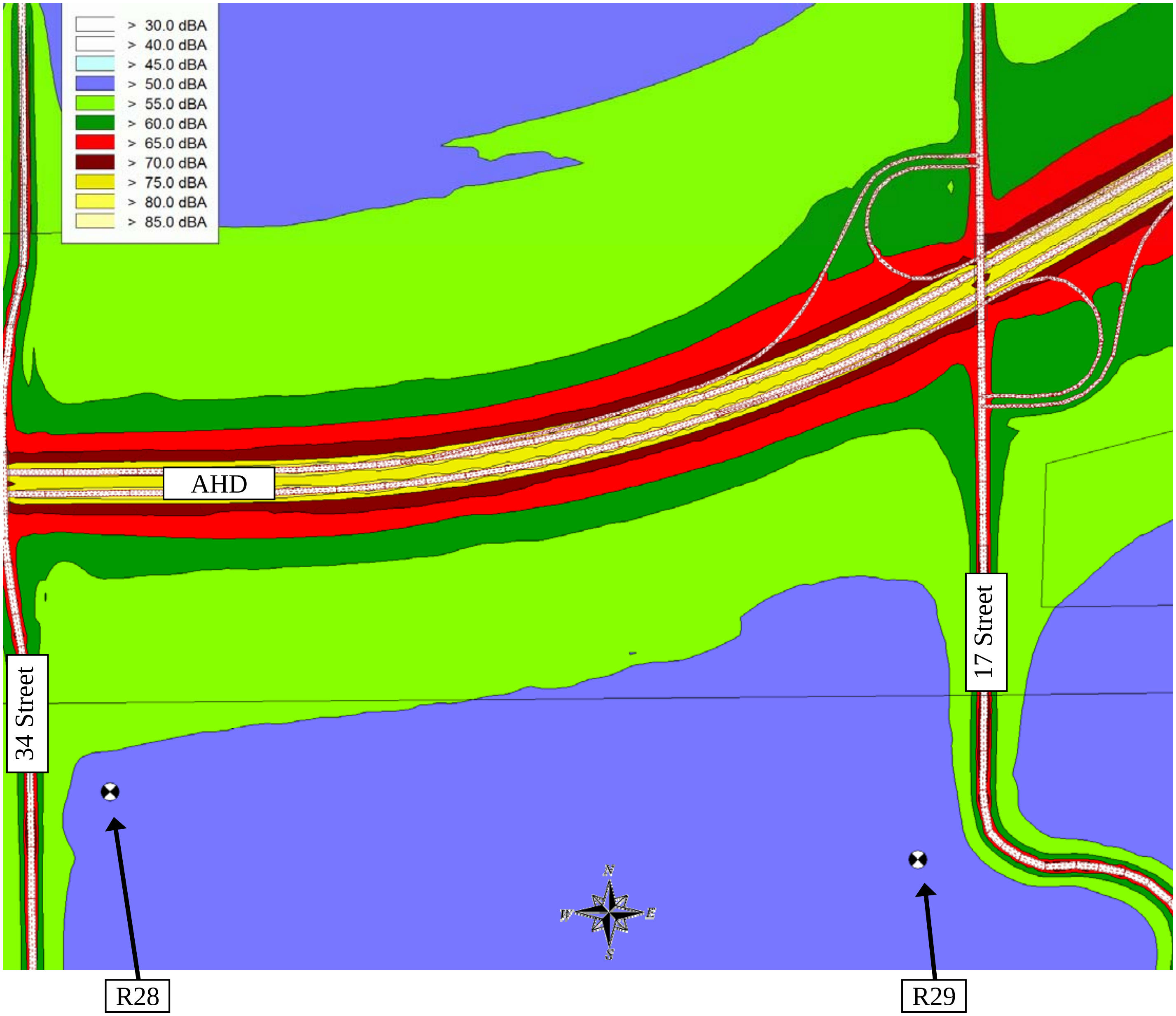

Figure 20d. Future Conditions L_{eq}24 Sound Levels (34 Street – 17 Street)

Appendix I

MEASUREMENT EQUIPMENT USED

Monitors 1, 2, & 6

The environmental noise monitoring equipment used at Monitors 1, 2, & 6 consisted of Brüel and Kjær Type 2250 Precision Integrating Sound Level Meters enclosed in environmental cases with tripods and weather protective microphone hoods. The systems acquired data in 15-second L_{eq} samples using 1/3 octave band frequency analysis and overall A-weighted and C-weighted sound levels. The sound level meters conform to Type 1, ANSI S1.4, ANSI S1.43, IEC 61672-1, IEC 60651, IEC 60804 and DIN 45657. The 1/3 octave filters conform to S1.11 – Type 0-C, and IEC 61260 – Class 0. The calibrators conform to IEC 942 and ANSI S1.40. The sound level meters, pre-amplifiers and microphones were certified on February 26, 2007 / September 24, 2007 and the calibrators (type B&K 4231) were certified on May 30, 2008 / September 23, 2007 by a NIST NVLAP Accredited Calibration Laboratory for all requirements of ISO 17025: 1999 and relevant requirements of ISO 9002:1994, ISO 9001:2000 and ANSI/NCSL Z540: 1994 Part 1. Simultaneous digital audio was recorded directly on the sound level meter using a 8 kHz sample rate for more detailed post-processing analysis. Refer to the next section in the Appendix for a detailed description of the various acoustical descriptive terms used.

Monitor 3

The environmental noise monitoring equipment used at Monitor 3 consisted of a Brüel and Kjær Type 2260 Precision Integrating Sound Level Meter enclosed in an environmental case, a tripod, and a weather protective microphone hood. The system acquired data in 15-second L_{eq} samples using 1/3 octave band frequency analysis and overall A-weighted and C-weighted sound levels. The sound level meter conforms to Type 1, ANSI S1.4, ANSI S1.43, IEC 61672-1, IEC 60651, IEC 60804 and DIN 45657. The 1/3 octave filters conform to S1.11 – Type 0-C, and IEC 61260 – Class 0. The calibrator conforms to IEC 942 and ANSI S1.40. The sound level meter, pre-amplifier, and microphone were certified on December 18, 2006 and calibrator (B&K Type 4230) was certified on December 14, 2007 by a NIST NVLAP Accredited Calibration Laboratory for all requirements of ISO 17025: 1999 and relevant requirements of ISO 9002:1994, ISO 9001:2000 and ANSI/NCSL Z540: 1994 Part 1. Simultaneous digital audio recording was conducted with a Marantz PMD-670 professional grade audio recorder utilizing a sample rate of 48 kHz and an MP3 conversion rate of 80 kbps. The audio signal was passed directly from the sound level meter. Refer to the next section in the Appendix for a detailed description of the various acoustical descriptive terms used.

Monitors 4 & 5

The environmental noise monitoring equipment used at Monitors 4 & 5 consisted of Larson Davis System 824 Precision Integrating Sound Level Meters enclosed in environmental cases with tripods and weather protective microphone hoods. The systems acquired data in 15-second L_{eq} samples using 1/3 octave band frequency analysis and overall A-weighted and C-weighted sound levels. The sound level meters conform to Type 1, ANSI S1.4, IEC 60651, and IEC 60804. The 1/3 octave filters conform to S1.11 – Type 1C, and IEC 61260 – Class 1. The calibrators conform to IEC 60942 and ANSI S1.40. The sound level meters, pre-amplifiers, microphones, and calibrators (type Larson Davis CAL 200) were re-certified on December 17, 2007 by a NIST NVLAP Accredited Calibration Laboratory for all requirements of ISO 17025: 1999 and relevant requirements of ISO 9002: 1994 and ANSI/NCSL Z540: 1994 Part 1. Simultaneous digital audio recording was conducted with Marantz PMD-670 professional grade audio recorders utilizing a sample rate of 48 kHz and an MP3 conversion rate of 80 kbps. The audio signals were passed directly from the sound level meters. Refer to the next section in the Appendix for a detailed description of the various acoustical descriptive terms used.

Weather Monitor

The weather monitoring equipment used for the study consisted of a NovaLynx 110-WS-16D data acquisition box, with a 200-WS-02E wind-speed and wind-direction sensor, a 110-WS-16TH temperature and relative humidity sensor and a 110-WS-16THS solar radiation shield. The data acquisition box and a battery were located in a weather protective case. The sensors were mounted on a tripod at approximately 5 m above ground. The system was set up to record data in 5-minute averages obtaining average wind-speed, peak wind-speed, wind-direction, temperature and relative humidity.

Record of Calibration Results

Description	Date	Time	Pre / Post	Calibration Level	Calibrator Model	Serial Number
Monitor #1	June 3 2008	13:00	Pre	93.9 dBA	B&K 4231	2575493
Monitor #1	June 4 2008	13:00	Post	93.8 dBA	B&K 4231	2575493
Monitor #2	June 3 2008	13:15	Pre	93.9 dBA	B&K 4231	2594693
Monitor #2	June 4 2008	13:15	Post	93.7 dBA	B&K 4231	2594693
Monitor #3	June 3 2008	13:45	Pre	93.9 dBA	B&K 4230	566599
Monitor #3	June 4 2008	13:45	Post	93.9 dBA	B&K 4230	566599
Monitor #4	June 3 2008	14:30	Pre	114.0 dBA	Larson Davis Cal200	3657
Monitor #4	June 4 2008	14:30	Post	114.0 dBA	Larson Davis Cal200	3657
Monitor #5	June 3 2008	14:45	Pre	114.0 dBA	Larson Davis Cal200	4092
Monitor #5	June 4 2008	14:45	Post	114.0 dBA	Larson Davis Cal200	4092
Monitor #6	July 7 2008	12:20	Pre	93.9 dBA	B&K 4231	2594693
Monitor #6	July 8 2008	15:40	Post	93.7 dBA	B&K 4231	2594693

Larson Davis Unit #1 SLM Calibration Certificate

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2007-101468

Instrument Model 824, Serial Number 2627, was calibrated on 18DEC2007. The instrument meets factory specifications per Procedure D0001.8046, IEC 61672-1:2002 Class 1; IEC 60651-2001, 60804-2000 and ANSI S1.4-1983 Type 1 1/3, 1/1 Oct. Filters; S1.11-1986 Type 1C; IEC61260-am1-2001 Class 1 .

Instrument found to be in calibration as received: YES
Date Calibrated: 18DEC2007

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	LDSigGn/2209	0662/0114	12 Months	26JAN2008	2007-89316

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 23 ° Centigrade

Relative Humidity: 17 %

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"As received" data is the same as shipped data.
Tested with PRM902 S/N 2588

Signed: [signature]
Technician: Sean Childs

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

Larson Davis Unit #1 Microphone Calibration Certificate

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2007-101505

Microphone Model 2551, Serial Number 0782, was calibrated on 18DEC2007. The microphone meets current factory specifications per Test Procedure D0001.8161.

Instrument found to be in calibration as received: YES
Date Calibrated: 18DEC2007

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	2559	2506	12 Months	30JAN2008	14714-1
Larson Davis	2900	0575	12 Months	25JUN2008	2007-94768
Larson Davis	CAL250	42630	12 Months	30JUL2008	2007-96065
Larson Davis	PRM915	0102	12 Months	27AUG2008	2007-97054
Larson Davis	2559	3034LF	12 Months	30AUG2008	2007-96903
Larson Davis	PRM902	0529	12 Months	06SEP2008	2007-97452
Larson Davis	PRM902	0528	12 Months	06SEP2008	2007-97451
Larson Davis	MTS1000 / 2201	1000 / 0100	12 Months	11SEP2008	2007-SM907
Larson Davis	PRM902	0206	12 Months	09NOV2008	2007-99774
Larson Davis	PRM916	0102	12 Months	09NOV2008	2007-99777
Hewlett Packard	34401A	3146A62099	12 Months	12NOV2008	3711739

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Environmental test conditions as printed on microphone calibration chart.

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"AS RECEIVED" data is the same as shipped data.

Signed: Abraham Ortega
Technician: Abraham Ortega

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

Larson Davis Unit #1 Preamplifier Calibration Certificate

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2007-101430

Instrument Model PRM902, Serial Number 2588, was calibrated on 18DEC2007. The instrument meets factory specifications per Procedure D0001.8126.

Instrument found to be in calibration as received: YES
Date Calibrated: 18DEC2007

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	LDSigGn/2209	0617 / 0104	12 Months	29JAN2008	2007-89357
Hewlett Packard	34401A	US36033460	12 Months	07JUN2008	299527

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 23 ° Centigrade Relative Humidity: 17 %

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"As received" data is the same as shipped data.

Signed:
Technician: Sean Childs

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

Larson Davis Unit #1 Calibrator Calibration Certificate

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2007-101394

Instrument Model CAL200, Serial Number 3657, was calibrated on 17DEC2007. The instrument meets factory specifications per Procedure D0001.8190.

Instrument found to be in calibration as received: YES
Date Calibrated: 17DEC2007

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	2559	2506	12 Months	30JAN2008	14714-1
Schaevitz	P3061-15PSIA	17588	12 Months	06MAR2008	297162
Larson Davis	2900	0661	12 Months	04APR2008	2007-91426
Hewlett Packard	34401A	US36033460	12 Months	07JUN2008	299527
Hewlett Packard	34401A	3146A10352	12 Months	28JUN2008	300163
Larson Davis	PRM915	0112	12 Months	11SEP2008	2007-97636
Larson Davis	PRM902	0480	12 Months	11SEP2008	2007-97631
Larson Davis	MTS1000/2201	0111	12 Months	11SEP2008	2007-SM907

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Environmental test conditions as shown on calibration report.

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

Before: 113.94 dB, 93.95 dB, 1000.1 Hz @ sea level.
After: Refer to Certificate of Measured Output.

Signed: Scott Montgomery
Technician: Scott Montgomery

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

Larson Davis Unit #2 SLM Calibration Certificate

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2007-101655

Instrument Model 824, Serial Number 2920, was calibrated on 20DEC2007. The instrument meets factory specifications per Procedure D0001.8046, IEC 61672-1:2002 Class 1; IEC 60651-2001, 60804-2000 and ANSI S1.4-1983 Type 1 1/3, 1/1 Oct. Filters; S1.11-1986 Type 1C; IEC61260-am1-2001 Class 1 .

Instrument found to be in calibration as received: YES
Date Calibrated: 20DEC2007

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	LDSigGn/2209	0617 / 0104	12 Months	29JAN2008	2007-89357

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 23 ° Centigrade Relative Humidity: 21 %

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"As received" data is the same as shipped data.
Tested with PRM902 S/N 3048

Signed:
Technician: Sean Childs

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

Larson Davis Unit #2 Microphone Calibration Certificate

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2007-101504

Microphone Model 377B02, Serial Number 103984, was calibrated on 18DEC2007. The microphone meets current factory specifications per Test Procedure D0001.8167.

Instrument found to be in calibration as received: YES
Date Calibrated: 18DEC2007

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	2559	2506	12 Months	30JAN2008	14714-1
Larson Davis	2900	0575	12 Months	25JUN2008	2007-94768
Hewlett Packard	34401A	3146A10352	12 Months	28JUN2008	300163
Larson Davis	CAL250	42630	12 Months	30JUL2008	2007-96065
Larson Davis	PRM915	0102	12 Months	27AUG2008	2007-97054
Larson Davis	MTS1000 / 2201	1000 / 0100	12 Months	11SEP2008	2007-SM907
Larson Davis	PRM902	0206	12 Months	09NOV2008	2007-99774
Larson Davis	PRM916	0102	12 Months	09NOV2008	2007-99777
Hewlett Packard	34401A	3146A62099	12 Months	12NOV2008	3711739

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Environmental test conditions as printed on microphone calibration chart.

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"AS RECEIVED" data is the same as shipped data.

Signed: Abraham Ortega
Technician: Abraham Ortega

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

Larson Davis Unit #2 Preamplifier Calibration Certificate

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2007-101431

Instrument Model PRM902, Serial Number 3048, was calibrated on 18DEC2007. The instrument meets factory specifications per Procedure D0001.8126.

Instrument found to be in calibration as received: YES
Date Calibrated: 18DEC2007

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	LDSigGn/2209	0617 / 0104	12 Months	29JAN2008	2007-89357
Hewlett Packard	34401A	US36033460	12 Months	07JUN2008	299527

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 23 ° Centigrade

Relative Humidity: 17 %

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"As received" data is the same as shipped data.

Signed: Sean Childs
Technician: Sean Childs

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

Larson Davis Unit #2 Calibrator Calibration Certificate

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2007-101396

Instrument Model CAL200, Serial Number 4092, was calibrated on 17DEC2007. The instrument meets factory specifications per Procedure D0001.8190.

Instrument found to be in calibration as received: YES
Date Calibrated: 17DEC2007

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	2559	2506	12 Months	30JAN2008	14714-1
Schaevitz	P3061-15PSIA	17588	12 Months	06MAR2008	297162
Larson Davis	2900	0661	12 Months	04APR2008	2007-91426
Hewlett Packard	34401A	US36033460	12 Months	07JUN2008	299527
Hewlett Packard	34401A	3146A10352	12 Months	28JUN2008	300163
Larson Davis	PRM915	0112	12 Months	11SEP2008	2007-97636
Larson Davis	PRM902	0480	12 Months	11SEP2008	2007-97631
Larson Davis	MTS1000/2201	0111	12 Months	11SEP2008	2007-SM907

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Environmental test conditions as shown on calibration report.

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

Before: 113.94 dB, 93.93 dB, 1000.2 Hz @ sea level.
After: Refer to Certificate of Measured Output.

Signed: Scott Montgomery
Technician: Scott Montgomery

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

B&K 2250 Unit #2 Calibration Certificate(s)

MANUFACTURER'S CERTIFICATE OF CONFORMANCE

We certify that Brüel & Kjær -2250--- Serial No 2575774
has been tested and passed all production tests, confirming compliance with the manufacturer's published specification at the date of the test.

The final test has been performed using calibrated equipment, traceable to National or International Standards or by ratio measurements.

Brüel & Kjær is certified under ISO 9001:2000 assuring that all calibration data for test equipment are retained on file and are available for inspection upon request.

Nærum 26-feb-2007

Torben Bjørn
Vice President
Operations

Please note that this document is not a calibration certificate, for information on our calibration services please contact your nearest Brüel & Kjær Service Center.

BA 0238 – 15

WORLD HEADQUARTERS: DK-2850 Nærum · Denmark
Telephone: +45 45 80 05 00 · Fax: +45 45 80 14 05 · http://www.bksv.com · e-mail: info@bksv.dk

Brüel & Kjær

Prepolarized Free-field 1/2" Microphone Type 4189

Bruel & Kjær **Calibration Chart**

Serial No:	**2573766**	
Open-circuit Sensitivity*, S_0:	***-26.8***	dB re 1V/Pa
Equivalent to:	***45.5***	mV/Pa
Uncertainty, 95 % confidence level	0.2	dB
Capacitance:	13.3	pF
Valid At:		
Temperature:	23	°C
Ambient Static Pressure:	101.3	kPa
Relative Humidity:	50	%
Frequency:	251.2	Hz
Polarization Voltage, external:	0	V

Sensitivity Traceable To:
DPLA: Danish Primary Laboratory of Acoustics
NIST: National Institute of Standards and Technology, USA

IEC 61094-4: Type WS 2 F

Environmental Calibration Conditions:
99.8 kPa 24 °C 53 % RH

Procedure: 704215 **Date:** 6. Feb. 2007 **Signature:** BK

$^*K_0 = -26 - S_0$ Example: $K_0 = -26 - (-26.2) = +0.2$ dB

DC 0224 – 12

aci acoustical consultants inc

B&K 2250 Unit #2 Calibrator Calibration Certificate

Scantek, Inc.
CALIBRATION LABORATORY

ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1 and relevant requirements of ISO 9002:1994 ACCREDITED by NVLAP (an ILAC and APLAC signatory)

NVLAP®

NVLAP Lab Code: 200625-0

Calibration Certificate No.17998

Instrument:	**Acoustical Calibrator**
Model:	**4231**
Manufacturer:	**Brüel and Kjær**
Serial number:	**2575493**
Class (IEC 60942):	**1**
Barometer type:	
Barometer s/n:	

Date Calibrated:	**5/30/2008**	
Status:	**Received**	**Sent**
In tolerance	X	X
Out of tolerance:		
See comments:		

Contains non-accredited tests: __Yes _X_ No

Customer: **Acoustical Consultants, Inc**
Tel/Fax: **780-414-6373/-6376**

Address: **9920 63rd Avenue, Suite 107, Edmonton AB T6E 0G9**

Tested in accordance with the following procedures and standards:
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005

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

Instrument - Manufacturer	Description	S/N	Cal date	Traceability evidence Cal.Lab / Accreditation
483B-Norsonic	SME Cal Unit	25747	Jan 15, 2008	Scantek, Inc./NVLAP
DS-360-SRS	Function Generator	61646	Nov 19, 2007	Davis Inotek / AClass
34401A-Agilent Technologies	Digital Voltmeter	MY41022043	Nov 13, 2007	Transcat / NVLAP
DPI 141-Druck	Pressure Indicator	790/00	Nov 9, 2006	Transcat / A2LA
8903A-HP	Audio Analyzer	2514A05691	Jan 2, 2008	Transcat/ NVLAP
HMP233-Vaisala Oyj	Humidity & Temp. Transmitter	V3820001	May 7, 2008	Transcat/ NVLAP
PC Program 1018 Norsonic	Calibration software	v.44	Validated May 2006	-
1253-Norsonic	Calibrator	28326	Mar 3, 2008	NPL (UK) / UKAS
1203-Norsonic	Preamplifier	14059	Jan 4, 2008	Scantek, Inc./ NVLAP
4180-Bruel&Kjaer	Microphone	2246115	Mar 3, 2008	NPL (UK) / UKAS

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

Calibrated by	Javier Albarracin	**Checked by**	Mariana Buzduga
Signature	[signature]	Signature	[signature]
Date	5/30/08	Date	5/30/08

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Page 1 of 2

B&K 2250 Unit #3 Calibration Certificate(s)

OB. NR | LOC.

MANUFACTURER'S CERTIFICATE OF CONFORMANCE

We certify that Brüel & Kjær -2250--- Serial No 2600498 has been tested and passed all production tests, confirming compliance with the manufacturer's published specification at the date of the test.

The final test has been performed using calibrated equipment, traceable to National or International Standards or by ratio measurements.

Brüel & Kjær is certified under ISO 9001:2000 assuring that all calibration data for test equipment are retained on file and are available for inspection upon request.

Nærum 24-sep-2007

Torben Bjørn
Vice President
Operations

Please note that this document is not a calibration certificate, for information on our calibration services please contact your nearest Brüel & Kjær Service Center.

BA 0238 – 15

WORLD HEADQUARTERS: DK-2850 Nærum · Denmark
Telephone: +45 45 80 05 00 · Fax: +45 45 80 14 05 · http://www.bksv.com · e-mail: info@bksv.dk

Brüel & Kjær

Bruel & Kjær

Prepolarized Free-field 1/2" Microphone Type 4189

Calibration Chart

Serial No: 2595637

Open-circuit Sensitivity*, S_0:	*-26.0*	dB re 1V/Pa
Equivalent to:	*50.0*	mV/Pa
Uncertainty, 95 % confidence level	0.2	dB
Capacitance:	*13.0*	pF
Valid At:		
Temperature:	23	°C
Ambient Static Pressure:	101.3	kPa
Relative Humidity:	50	%
Frequency:	251.2	Hz
Polarization Voltage, external:	0	V

Sensitivity Traceable To:
DPLA: Danish Primary Laboratory of Acoustics
NIST: National Institute of Standards and Technology, USA

IEC 61094-4: Type WS 2 F

Environmental Calibration Conditions:
98.9 kPa 23 °C 50 % RH

Procedure: 704215 **Date:** 26. Jun. 2007 **Signature:** K.P

$^*K_0 = -26 - S_0$ Example: $K_0 = -26 - (-26.2) = +0.2$ dB

BC 0224 – 12

Calibration Chart

Brüel & Kjær Type 4231 Serial No. 2594693

Sound Pressure Level: 94.00 or 114.00 dB ±0.20 dB
(re 20 μPa at reference conditions)

Frequency: 1000 Hz ±0.1%

Distortion: <1%

Reference Conditions:

Temperature:	23°C
Pressure:	101.325 kPa
Humidity:	50% RH
Load:	0.25 cm³ (½" Brüel & Kjær Mic.)

Date: 23/07/07 Signed: AS

B&K 2260 SLM Calibration Certificate

Scantek, Inc.
CALIBRATION LABORATORY

ISO 17025: 1999, ANSI/NCSL Z540:1994 Part 1 and relevant requirements of ISO 9002:1994 ACCREDITED by NVLAP (an ILAC and APLAC signatory)

NVLAP®
NVLAP Lab Code: 200625-0

Calibration Certificate No.15577

Instrument: **Sound Level Meter**
Model: **2260**
Manufacturer: **Brüel and Kjær**
Serial number: **1823779**
Tested with: **Microphone 4189 s/n 2021315**
Preamplifier ZC 0026 s/n N/A
Type (class): **1**
Customer: **Acoustical Consultants, Inc.**
Tel/Fax: **780-414-6373/-6376**

Date Calibrated: **12/20/2006**

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: **Suite 107, 9920-63 Avenue Edmonton, Alberta, Canada**

Tested in accordance with the following procedures and standards:
Calibration of Sound Level Meters, Scantek Inc., 06/07/2005
SLM & Dosimeters – Acoustical Tests, Scantek Inc., 06/15/2005

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

Instrument - Manufacturer	Description	S/N	Cal date	Traceability evidence Cal. Lab / Accreditation
483B-Norsonic	SME Cal Unit	25747	Feb 22, 2006	Scantek, Inc.
DS-360-SRS	Function Generator	33584	Dec 12, 2006	Scantek, Inc.
34401A-Agilent Technologies	Digital Voltmeter	MY41022043	Nov 3, 2006	Transcat / NVLAP
DPI 141-Druck	Digital Barometer	790/00-04	Nov 9, 2006	Transcat / NVLAP
HMP233-Vaisala	Temp.& Humidity Transmitter	V3820001	Oct 26, 2006	Transcat / NVLAP
PC Program 1019 Norsonic	Calibration software	v.44	Validated May 2006	-
1253-Norsonic	Calibrator	25726	Feb 22, 2006	Scantek, Inc.

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 (%)
22.6 °C	100.917 kPa	39.7 %RH

Calibrated by	Michael Watnoski	**Checked by**	Mariana Buzduga
Signature	[signature]	Signature	[signature]
Date	20 DEC 2006	Date	12/20/06

Calibration Certificates or Test Reports shall not be reproduced, except in full, without written approval of the laboratory.
This Calibration Certificate or Test Reports shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the federal government.
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B&K 2260 Microphone Calibration Certificate

Scantek, Inc.
CALIBRATION LABORATORY

ISO 17025: 1999, ANSI/NCSL Z540:1994 Part 1 and relevant requirements of ISO 9002:1994 ACCREDITED by NVLAP (an ILAC and APLAC signatory)

NVLAP®

NVLAP Lab Code: 200625-0

Calibration Certificate No.15578

Instrument: **Microphone**
Model: **4189**
Manufacturer: **Brüel & Kjær**
Serial number: **2021315**

Date Calibrated: **12/18/2006**

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

Contains non-accredited tests: **_X_ Yes __ No**

Customer: **Acoustical Consultants, Inc.**
Tel/Fax: **780-414-6373/-6376**

Address: **Suite 107, 9920-63 Avenue Edmonton, Alberta, Canada**

Tested in accordance with the following procedures and standards:
Procedure for Calibration of Measurement Microphones, Scantek Inc., 06/15/2005

Instrumentation used for calibration: N-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal date	Traceability evidence Cal. Lab / Accreditation
483B-Norsonic	SME Cal Unit	25747	Feb 22, 2006	Scantek, Inc.
DS-360-SRS	Function Generator	33584	Dec 12, 2006	Scantek, Inc.
34401A-Agilent Technologies	Digital Voltmeter	MY41022043	Nov 3, 2006	Transcat / NVLAP
DPI 141-Druck	Digital Barometer	790/00-04	Nov 9, 2006	Transcat / NVLAP
HMP233-Vaisala	Temp.& Humidity Transmitter	V3820001	Oct 26, 2006	Vaisala / A2LA
PC Program 1017 Norsonic	Calibration software	v.4.24g	Validated Jan 2004	-
1253-Norsonic	Calibrator	22909	May 23, 2005	NPL (UK)
1203-Norsonic	Preamplifier	14059	Feb 22, 2006	Scantek, Inc./NVLAP
4180-Bruel&Kjaer	Microphone	2246115	May 19, 2005	NPL (UK)

Instrumentation and test results are traceable to SI - BIPM through standards maintained by NPL (UK) and NIST (USA)

Calibrated by	Michael Watnoski	**Checked by**	Mariana Buzduga
Signature	Michael Watnoski	Signature	[signature]
Date	18 DEC 2006	Date	12/20/06

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B&K 4230 Calibrator Calibration Certificate

Scantek, Inc.
CALIBRATION LABORATORY

ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1 and relevant requirements of ISO 9002:1994 ACCREDITED by NVLAP (an ILAC and APLAC signatory)

NVLAP®
NVLAP Lab Code: 200625-0

Calibration Certificate No.17203

Instrument:	**Acoustical Calibrator**
Model:	**4230**
Manufacturer:	**Brüel and Kjær**
Serial number:	**566599**
Class (IEC 60942):	**1**
Barometer type:	
Barometer s/n:	

Date Calibrated: **12/14/2007**

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

Contains non-accredited tests: __Yes _X_ No

Customer: **Acoustical Consultants, Inc.**
Tel/Fax: **780-414-6373/ -6376**

Address: **Suite 107, 9920-63 Ave**
Edmonton, Alberta
Canada T6E 0G9

Tested in accordance with the following procedures and standards:
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005

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

Instrument - Manufacturer	Description	S/N	Cal date	Traceability evidence Cal. Lab / Accreditation
483B-Norsonic	SME Cal Unit	25747	Apr 16, 2007	Scantek, Inc.
DS-360-SRS	Function Generator	61646	Nov 19, 2007	Davis Inotek / AClass
34401A-Agilent Technologies	Digital Voltmeter	US36120731	Aug 22, 2007	Transcat / NVLAP
DPI 141-Druck	Pressure Indicator	790/00	Nov 9, 2006	Transcat / A2LA
N-840-Norsonic	Real Time Analyzer	17846	Jan 19, 2007	Scantek, Inc.
HMP233-Vaisala Oyj	Humidity & Temp. Transmitter	V3820001	Oct 26, 2006	Scantek, Inc.
PC Program 1018 Norsonic	Calibration software	v.44	Validated May 2006	-
1253-Norsonic	Calibrator	22909	Dec 4, 2006	NPL (UK) / UKAS
1203-Norsonic	Preamplifier	14059	Jan 2, 2007	Scantek, Inc./ NVLAP
4180-Bruel&Kjaer	Microphone	2246115	Dec 6, 2006	NPL (UK) / UKAS

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

Calibrated by	Valentin Buzduga	**Checked by**	Mariana Buzduga
Signature	[signature]	Signature	[signature]
Date	12/14/2007	Date	12/14/07

Document stored as: C:\Nor1504\CalCal\2007\BNK4230_566599_M1.doc

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Appendix II

THE ASSESSMENT OF ENVIRONMENTAL NOISE (GENERAL)

Sound Pressure Level

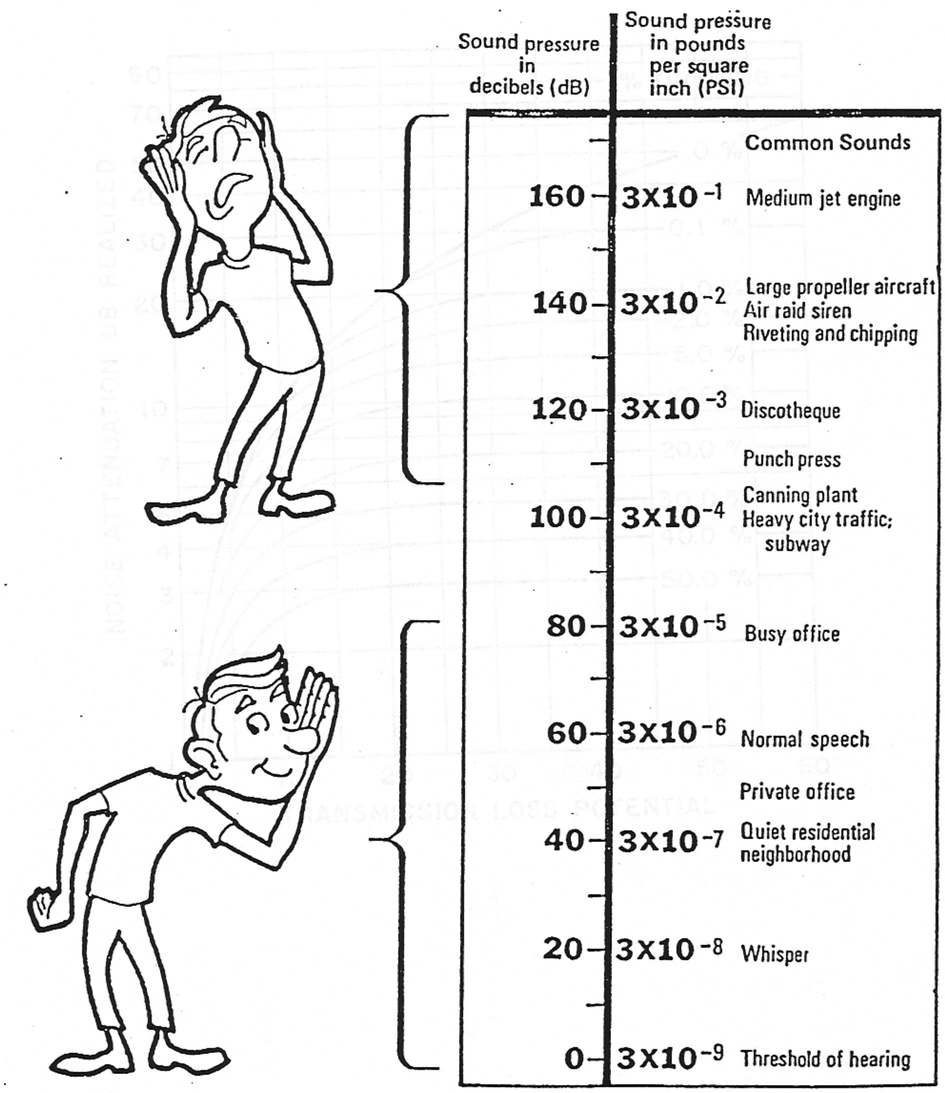
Sound pressure is initially measured in Pascal's (Pa). Humans can hear several orders of magnitude in sound pressure levels, so a more convenient scale is used. This scale is known as the decibel (dB) scale, named after Alexander Graham Bell (telephone guy). It is a base 10 logarithmic scale. When we measure pressure we typically measure the RMS sound pressure.

$$SPL = 10\log_{10}\left[\frac{P_{RMS}^{2}}{P_{ref}^{2}}\right] = 20\log_{10}\left[\frac{P_{RMS}}{P_{ref}}\right]$$

Where: SPL = Sound Pressure Level in dB
P_{RMS} = Root Mean Square measured pressure (Pa)
P_{ref} = Reference sound pressure level ($P_{ref} = 2\text{x}10^{-5}$ Pa = 20 μPa)

This reference sound pressure level is an internationally agreed upon value. It represents the threshold of human hearing for "typical" people based on numerous testing. It is possible to have a threshold which is lower than 20 μPa which will result in negative dB levels. As such, zero dB does not mean there is no sound!

In general, a difference of 1 – 2 dB is the threshold for humans to notice that there has been a change in sound level. A difference of 3 dB (factor of 2 in acoustical energy) is perceptible and a change of 5 dB is strongly perceptible. A change of 10 dB is typically considered a factor of 2. This is quite remarkable when considering that 10 dB is 10-times the acoustical energy!


Sound pressure in decibels (dB)
Sound pressure in pounds per square inch (PSI)
Common Sounds
160 3X10 -1 Medium jet engine
140 3X10 -2 Large propeller aircraft
Air raid siren
Riveting and chipping
120 3X10 -3 Discotheque
Punch press
100 3X10 -4 Canning plant
Heavy city traffic; subway
80 3X10 -5 Busy office
60 3X10 -6 Normal speech
Private office
40 3X10 -7 Quiet residential neighborhood
20 3X10 -8 Whisper
0 3X10 -9 Threshold of hearing

Frequency

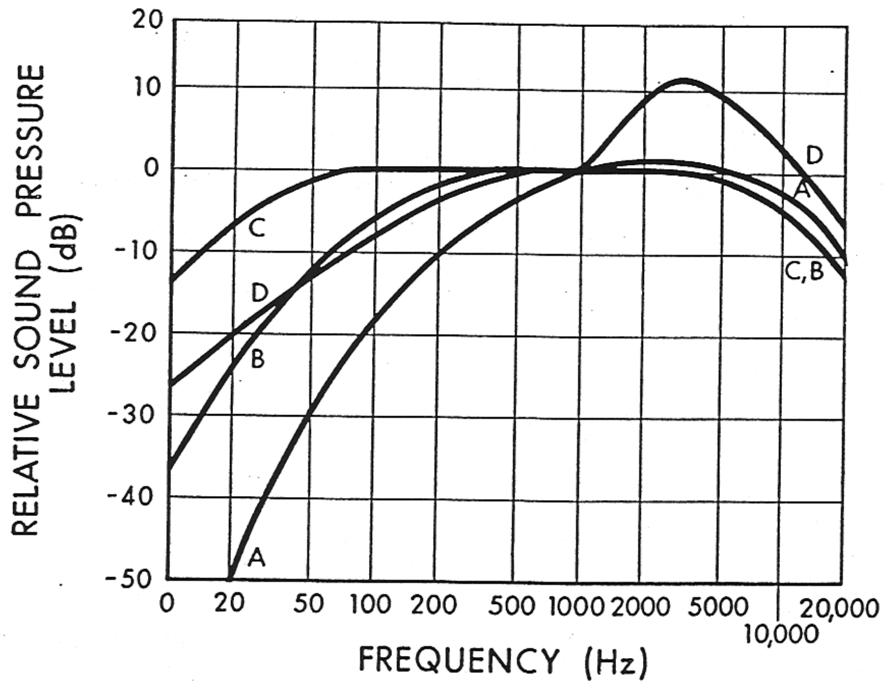
The range of frequencies audible to the human ear ranges from approximately 20 Hz to 20 kHz. Within this range, the human ear does not hear equally at all frequencies. It is not very sensitive to low frequency sounds, is very sensitive to mid frequency sounds and is slightly less sensitive to high frequency sounds. Due to the large frequency range of human hearing, the entire spectrum is often divided into 31 bands, each known as a 1/3 octave band.

The internationally agreed upon center frequencies and upper and lower band limits for the 1/1 (whole octave) and 1/3 octave bands are as follows:

Lower Band Limit	Whole Octave Center Frequency	Upper Band Limit
11	**16**	22
22	**31.5**	44
44	**63**	88
88	**125**	177
177	**250**	355
355	**500**	710
710	**1000**	1420
1420	**2000**	2840
2840	**4000**	5680
5680	**8000**	11360
11360	**16000**	22720

Lower Band Limit	1/3 Octave Center Frequency	Upper Band Limit
14.1	**16**	17.8
17.8	**20**	22.4
22.4	**25**	28.2
28.2	**31.5**	35.5
35.5	**40**	44.7
44.7	**50**	56.2
56.2	**63**	70.8
70.8	**80**	89.1
89.1	**100**	112
112	**125**	141
141	**160**	178
178	**200**	224
224	**250**	282
282	**315**	355
355	**400**	447
447	**500**	562
562	**630**	708
708	**800**	891
891	**1000**	1122
1122	**1250**	1413
1413	**1600**	1778
1778	**2000**	2239
2239	**2500**	2818
2818	**3150**	3548
3548	**4000**	4467
4467	**5000**	5623
5623	**6300**	7079
7079	**8000**	8913
8913	**10000**	11220
11220	**12500**	14130
14130	**16000**	17780
17780	**20000**	22390

Human hearing is most sensitive at approximately 3500 Hz which corresponds to the ¼ wavelength of the ear canal (approximately 2.5 cm). Because of this range of sensitivity to various frequencies, we typically apply various weighting networks to the broadband measured sound to more appropriately account for the way humans hear. By default, the most common weighting network used is the so-called "A-weighting". It can be seen in the figure that the low frequency sounds are reduced significantly with the A-weighting.



Combination of Sounds

When combining multiple sound sources the general equation is:

$$\Sigma SPL_n = 10\log_{10}\left[\sum_{i=1}^{n} 10^{\frac{SPL_i}{10}}\right]$$

Examples:

- Two sources of 50 dB each add together to result in 53 dB.
- Three sources of 50 dB each add together to result in 55 dB.
- Ten sources of 50 dB each add together to result in 60 dB.
- One source of 50 dB added to another source of 40 dB results in 50.4 dB

It can be seen that, if multiple similar sources exist, removing or reducing only one source will have little effect.

Sound Level Measurements

Over the years a number of methods for measuring and describing environmental noise have been developed. The most widely used and accepted is the concept of the Energy Equivalent Sound Level (L_{eq}) which was developed in the US (1970's) to characterize noise levels near US Air-force bases. This is the level of a steady state sound which, for a given period of time, would contain the same energy as the time varying sound. The concept is that the same amount of annoyance occurs from a sound having a high level for a short period of time as from a sound at a lower level for a longer period of time.
The L_{eq} is defined as:

$$L_{eq} = 10\log_{10}\left[\frac{1}{T}\int_0^T 10^{\frac{dB}{10}}\,dT\right] = 10\log_{10}\left[\frac{1}{T}\int_0^T \frac{P^2}{P_{ref}^2}\,dT\right]$$

We must specify the time period over which to measure the sound. i.e. 1-second, 10-seconds, 15-seconds, 1-minute, 1-day, etc. **An L_{eq} is meaningless if there is no time period associated**.

In general there a few very common L_{eq} sample durations which are used in describing environmental noise measurements. These include:

- L_{eq}24 - Measured over a 24-hour period
- L_{eq}Night - Measured over the night-time (typically 22:00 – 07:00)
- L_{eq}Day - Measured over the day-time (typically 07:00 – 22:00)
- L_{DN} - Same as L_{eq}24 with a 10 dB penalty added to the night-time

Statistical Descriptor

Another method of conveying long term noise levels utilizes statistical descriptors. These are calculated from a cumulative distribution of the sound levels over the entire measurement duration and then determining the sound level at xx % of the time.

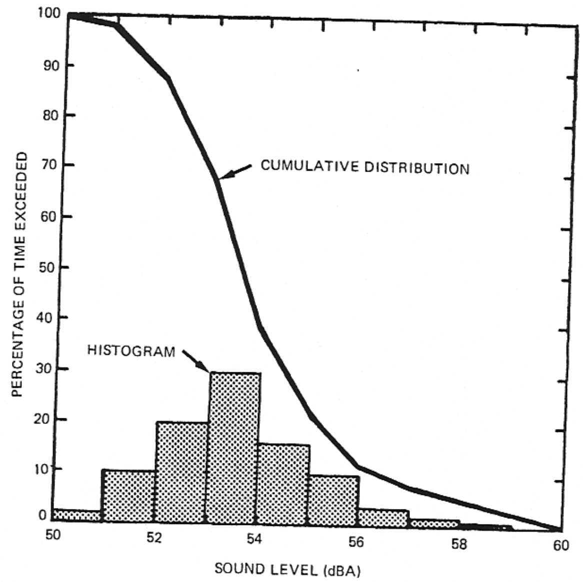


Figure 16.6 Statistically processed community noise showing histogram and cumulative distribution of A weighted sound levels.

Industrial Noise Control, Lewis Bell, Marcel Dekker, Inc. 1994

The most common statistical descriptors are:

L_{min} - minimum sound level measured
L_{01} - sound level that was exceeded only 1% of the time
L_{10} - sound level that was exceeded only 10% of the time.
- Good measure of intermittent or intrusive noise
- Good measure of Traffic Noise

L_{50} - sound level that was exceeded 50% of the time (arithmetic average)
- Good to compare to L_{eq} to determine steadiness of noise

L_{90} - sound level that was exceeded 90% of the time
- Good indicator of typical "ambient" noise levels

L_{99} - sound level that was exceeded 99% of the time
L_{max} - maximum sound level measured

These descriptors can be used to provide a more detailed analysis of the varying noise climate:

- If there is a large difference between the L_{eq} and the L_{50} (L_{eq} can never be any lower than the L_{50}) then it can be surmised that one or more short duration, high level sound(s) occurred during the time period.
- If the gap between the L_{10} and L_{90} is relatively small (less than 15 – 20 dBA) then it can be surmised that the noise climate was relatively steady.

Sound Propagation

In order to understand sound propagation, the nature of the source must first be discussed. In general, there are three types of sources. These are known as 'point', 'line', and 'area'. This discussion will concentrate on point and line sources since area sources are much more complex and can usually be approximated by point sources at large distances.

Point Source

As sound radiates from a point source, it dissipates through geometric spreading. The basic relationship between the sound levels at two distances from a point source is:

$$\therefore SPL_1 - SPL_2 = 20\log_{10}\left(\frac{r_2}{r_1}\right)$$

Where: SPL_1 = sound pressure level at location 1, SPL_2 = sound pressure level at location 2
r_1 = distance from source to location 1, r_2 = distance from source to location 2

Thus, the reduction in sound pressure level for a point source radiating in a free field is **6 dB per doubling of distance**. This relationship is independent of reflectivity factors provided they are always present. Note that this only considers geometric spreading and does not take into account atmospheric effects. Point sources still have some physical dimension associated with them, and typically do not radiate sound equally in all directions in all frequencies. The directionality of a source is also highly dependent on frequency. As frequency increases, directionality increases.

Examples (note no atmospheric absorption):

- A point source measuring 50 dB at 100m will be 44 dB at 200m.
- A point source measuring 50 dB at 100m will be 40.5 dB at 300m.
- A point source measuring 50 dB at 100m will be 38 dB at 400m.
- A point source measuring 50 dB at 100m will be 30 dB at 1000m.

Line Source

A line source is similar to a point source in that it dissipates through geometric spreading. The difference is that a line source is equivalent to a long line of many point sources. The basic relationship between the sound levels at two distances from a line source is:

$$SPL_1 - SPL_2 = 10\log_{10}\left(\frac{r_2}{r_1}\right)$$

The difference from the point source is that the '20' term in front of the 'log' is now only 10. Thus, the reduction in sound pressure level for a line source radiating in a free field is **3 dB per doubling of distance**.

Examples (note no atmospheric absorption):

- A line source measuring 50 dB at 100m will be 47 dB at 200m.
- A line source measuring 50 dB at 100m will be 45 dB at 300m.
- A line source measuring 50 dB at 100m will be 34 dB at 400m.
- A line source measuring 50 dB at 100m will be 40 dB at 1000m.

Atmospheric Absorption

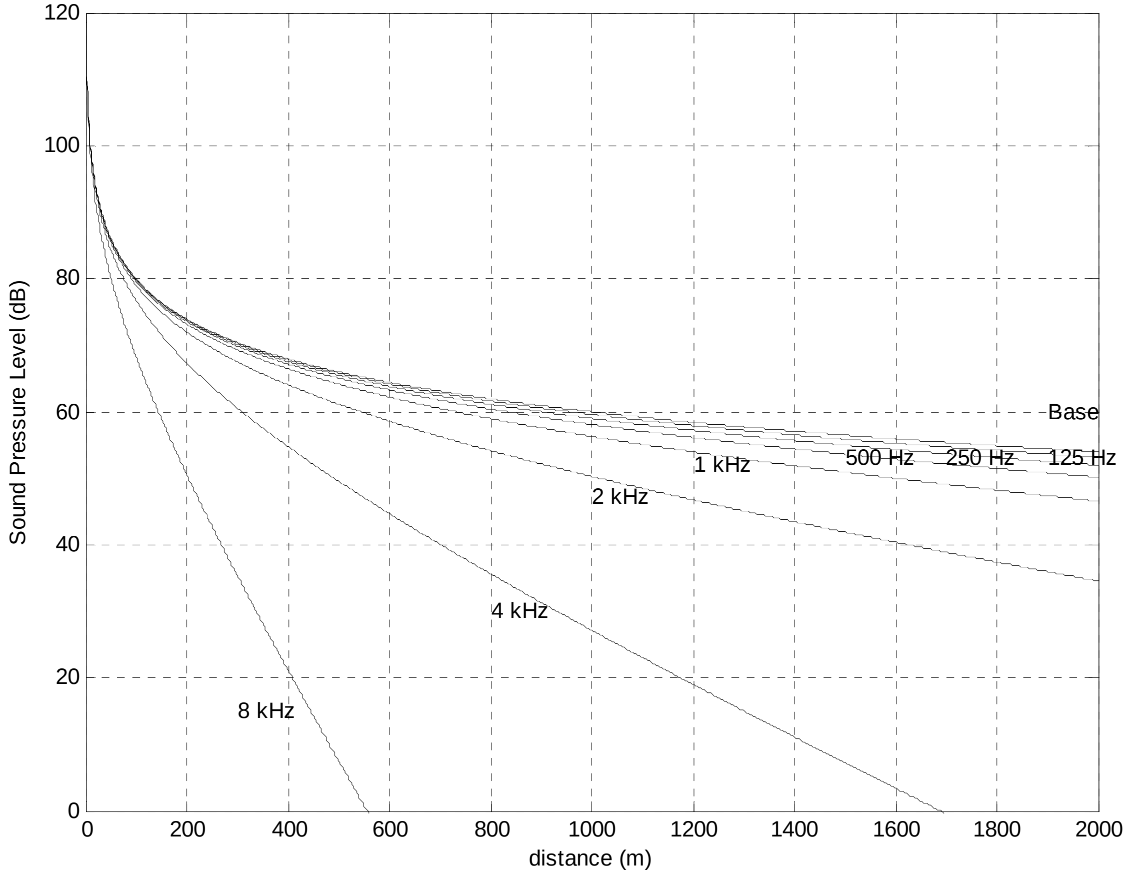
As sound transmits through a medium, there is an attenuation (or dissipation of acoustic energy) which can be attributed to three mechanisms:

1) **Viscous Effects** - Dissipation of acoustic energy due to fluid friction which results in thermodynamically irreversible propagation of sound.
2) **Heat Conduction Effects** - Heat transfer between high and low temperature regions in the wave which result in non-adiabatic propagation of the sound.
3) **Inter Molecular Energy Interchanges** - Molecular energy relaxation effects which result in a time lag between changes in translational kinetic energy and the energy associated with rotation and vibration of the molecules.

The following table illustrates the attenuation coefficient of sound at standard pressure (101.325 kPa) in units of dB/100m.

Temperature ^{o}C	Relative Humidity (%)	Frequency (Hz) 125	250	500	1000	2000	4000
30	20	0.06	0.18	0.37	0.64	1.40	4.40
	50	0.03	0.10	0.33	0.75	1.30	2.50
	90	0.02	0.06	0.24	0.70	1.50	2.60
20	20	0.07	0.15	0.27	0.62	1.90	6.70
	50	0.04	0.12	0.28	0.50	1.00	2.80
	90	0.02	0.08	0.26	0.56	0.99	2.10
10	20	0.06	0.11	0.29	0.94	3.20	9.00
	50	0.04	0.11	0.20	0.41	1.20	4.20
	90	0.03	0.10	0.21	0.38	0.81	2.50
0	20	0.05	0.15	0.50	1.60	3.70	5.70
	50	0.04	0.08	0.19	0.60	2.10	6.70
	90	0.03	0.08	0.15	0.36	1.10	4.10

- As frequency increases, absorption increases
- As Relative Humidity increases, absorption decreases
- There is no direct relationship between absorption and temperature
- **The net result of atmospheric absorption is to modify the sound propagation of a point source from 6 dB/doubling-of-distance to approximately 7 – 8 dB/doubling-of-distance (based on anecdotal experience)**



Atmospheric Absorption at 10°C and 70% RH

Meteorological Effects

There are many meteorological factors which can affect how sound propagates over large distances. These various phenomena must be considered when trying to determine the relative impact of a noise source either after installation or during the design stage.

Wind

- Can greatly alter the noise climate away from a source depending on direction
- Sound levels downwind from a source can be increased due to refraction of sound back down towards the surface. This is due to the generally higher velocities as altitude increases.
- Sound levels upwind from a source can be decreased due to a "bending" of the sound away from the earth's surface.
- Sound level differences of ±10dB are possible depending on severity of wind and distance from source.
- Sound levels crosswind are generally not disturbed by an appreciable amount
- Wind tends to generate its own noise, however, and can provide a high degree of masking relative to a noise source of particular interest.

Temperature

- Temperature effects can be similar to wind effects
- Typically, the temperature is warmer at ground level than it is at higher elevations.
- If there is a very large difference between the ground temperature (very warm) and the air aloft (only a few hundred meters) then the transmitted sound refracts upward due to the changing speed of sound.
- If the air aloft is warmer than the ground temperature (known as an *inversion*) the resulting higher speed of sound aloft tends to refract the transmitted sound back down towards the ground. This essentially works on Snell's law of reflection and refraction.
- Temperature inversions typically happen early in the morning and are most common over large bodies of water or across river valleys.
- Sound level differences of ±10dB are possible depending on gradient of temperature and distance from source.

Rain

- Rain does not affect sound propagation by an appreciable amount unless it is very heavy
- The larger concern is the noise generated by the rain itself. A heavy rain striking the ground can cause a significant amount of highly broadband noise. The amount of noise generated is difficult to predict.
- Rain can also affect the output of various noise sources such as vehicle traffic.

Summary

- In general, these wind and temperature effects are difficult to predict
- Empirical models (based on measured data) have been generated to attempt to account for these effects.
- Environmental noise measurements must be conducted with these effects in mind. Sometimes it is desired to have completely calm conditions, other times a "worst case" of downwind noise levels are desired.

Topographical Effects

Similar to the various atmospheric effects outlined in the previous section, the effect of various geographical and vegetative factors must also be considered when examining the propagation of noise over large distances.

Topography

- One of the most important factors in sound propagation.
- Can provide a natural barrier between source and receiver (i.e. if berm or hill in between).
- Can provide a natural amplifier between source and receiver (i.e. large valley in between or hard reflective surface in between).
- Must look at location of topographical features relative to source and receiver to determine importance (i.e. small berm 1km away from source and 1km away from receiver will make negligible impact).

Grass

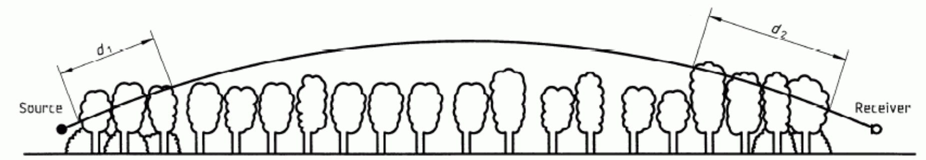
- Can be an effective absorber due to large area covered
- Only effective at low height above ground. Does not affect sound transmitted direct from source to receiver if there is line of sight.
- Typically less absorption than atmospheric absorption when there is line of sight.
- Approximate rule of thumb based on empirical data is:

$$A_g = 18\log_{10}(f) - 31 \qquad (dB/100m)$$

Where: A_g is the absorption amount

Trees

- Provide absorption due to foliage
- Deciduous trees are essentially ineffective in the winter
- Absorption depends heavily on density and height of trees
- No data found on absorption of various kinds of trees
- Large spans of trees are required to obtain even minor amounts of sound reduction
- In many cases, trees can provide an effective visual barrier, even if the noise attenuation is negligible.



NOTE — $d_f = d_1 + d_2$

For calculating d_1 and d_2, the curved path radius may be assumed to be 5 km.

Figure A.1 — Attenuation due to propagation through foliage increases linearly with propagation distance d_f through the foliage

Table A.1 — Attenuation of an octave band of noise due to propagation a distance d_f through dense foliage

Propagation distance d_f m	Nominal midband frequency Hz 63	125	250	500	1 000	2 000	4 000	8 000
$10 \leq d_f \leq 20$	Attenuation, dB: 0	0	1	1	1	1	2	3
$20 \leq d_f \leq 200$	Attenuation, dB/m: 0,02	0,03	0,04	0,05	0,06	0,08	0,09	0,12

Tree/Foliage attenuation from ISO 9613-2:1996

Bodies of Water

- Large bodies of water can provide the opposite effect to grass and trees.
- Reflections caused by small incidence angles (grazing) can result in larger sound levels at great distances (increased reflectivity, Q).
- Typically air temperatures are warmer high aloft since air temperatures near water surface tend to be more constant. Result is a high probability of temperature inversion.
- Sound levels can "carry" much further.

Snow

- Covers the ground for much of the year in northern climates.
- Can act as an absorber or reflector (and varying degrees in between).
- Freshly fallen snow can be quite absorptive.
- Snow which has been sitting for a while and hard packed due to wind can be quite reflective.
- Falling snow can be more absorptive than rain, but does not tend to produce its own noise.
- Snow can cover grass which might have provided some means of absorption.
- Typically sound propagates with less impedance in winter due to hard snow on ground and no foliage on trees/shrubs.

Appendix III

SOUND LEVELS OF FAMILIAR NOISE SOURCES

Used with Permission Obtained from EUB Guide 38: Noise Control Directive User Guide (November 1999)

Source[1]	Sound Level (dBA)
Bedroom of a country home	30
Soft whisper at 1.5 m	30
Quiet office or living room	40
Moderate rainfall	50
Inside average urban home	50
Quiet street	50
Normal conversation at 1 m	60
Noisy office	60
Noisy restaurant	70
Highway traffic at 15 m	75
Loud singing at 1 m	75
Tractor at 15 m	78-95
Busy traffic intersection	80
Electric typewriter	80
Bus or heavy truck at 15 m	88-94
Jackhammer	88-98
Loud shout	90
Freight train at 15 m	95
Modified motorcycle	95
Jet taking off at 600 m	100
Amplified rock music	110
Jet taking off at 60 m	120
Air-raid siren	130

[1] Cottrell, Tom, 1980, *Noise in Alberta*, Table 1, p.8, ECA80 - 16/1B4 (Edmonton: Environment Council of Alberta).

SOUND LEVELS GENERATED BY COMMON APPLIANCES

Used with Permission Obtained from EUB Guide 38: Noise Control Directive User Guide (November 1999)

Source[1]	Sound level at 3 feet (dBA)
Freezer	38-45
Refrigerator	34-53
Electric heater	47
Hair clipper	50
Electric toothbrush	48-57
Humidifier	41-54
Clothes dryer	51-65
Air conditioner	50-67
Electric shaver	47-68
Water faucet	62
Hair dryer	58-64
Clothes washer	48-73
Dishwasher	59-71
Electric can opener	60-70
Food mixer	59-75
Electric knife	65-75
Electric knife sharpener	72
Sewing machine	70-74
Vacuum cleaner	65-80
Food blender	65-85
Coffee mill	75-79
Food waste disposer	69-90
Edger and trimmer	81
Home shop tools	64-95
Hedge clippers	85
Electric lawn mower	80-90

[1] Reif, Z. F., and Vermeulen, P. J., 1979, "Noise from domestic appliances, construction, and industry," Table 1, p.166, in Jones, H. W., ed., *Noise in the Human Environment*, vol. 2, ECA79-SP/1 (Edmonton: Environment Council of Alberta).

Appendix IV

NOISE MODELING PARAMETERS

Current Conditions

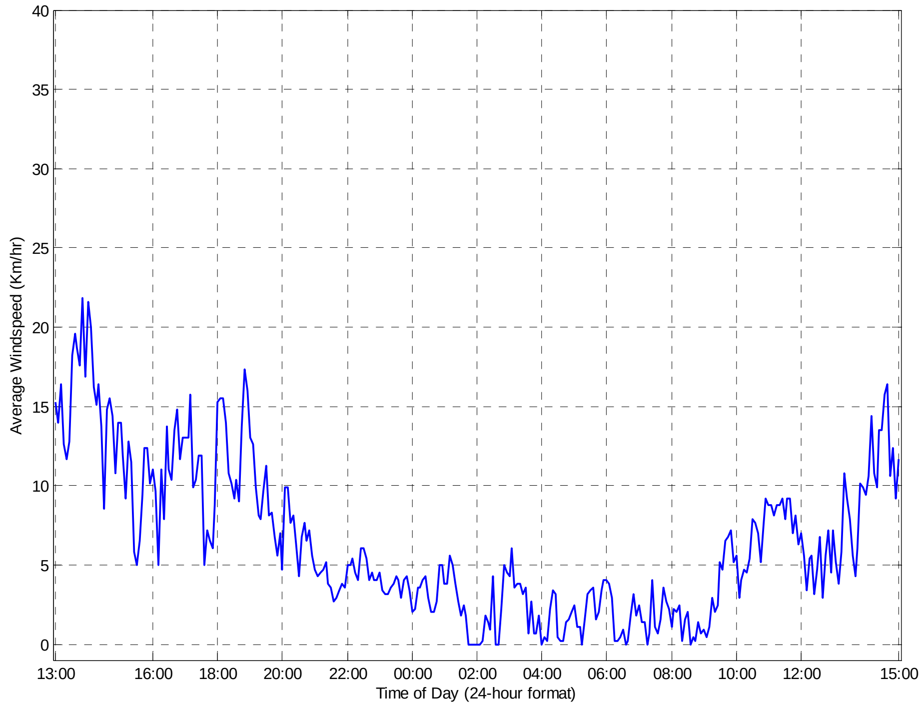
Road	Day (Vehicles Per Hour)	Day % Heavy Trucks	Night (Vehicles Per Hour)	Night % Heavy Trucks	Speed (km/hr)	Total Volume (vehicles per day)
AHD West of 91 Street EB	900	11	560	11	100	18540
AHD West of 91 Street WB	900	11	560	11	100	18540
91 Street North of AHD	1330	3	560	3	70	24990
91 Street South of AHD	1330	3	560	3	70	24990
91 Street Ramps	133	3	56	3	50	2499
AHD East of 91 Street EB	900	11	560	11	100	18540
AHD East of 91 Street WB	900	11	560	11	100	18540
66 Street North of AHD	350	3	150	3	60	6600
66 Street South of AHD	350	3	150	3	60	6600
AHD East of 66 Street EB	900	11	560	11	100	18540
AHD East of 66 Street WB	900	11	560	11	100	18540
50 Street North of AHD	1000	3	410	3	60	18690
50 Street South of AHD	1000	3	410	3	60	18690
50 Street Ramps	100	3	41	3	50	1869
AHD East of 50 Street EB	900	11	560	11	100	18540
AHD East of 50 Street WB	900	11	560	11	100	18540
34 Street North of AHD	130	3	60	3	60	2490
34 Street South of AHD	130	3	60	3	60	2490
AHD East of 34 Street EB	900	11	560	11	100	18540
AHD East of 34 Street WB	900	11	560	11	100	18540
17 Street North of AHD	155	3	75	3	60	3000
17 Street South of AHD	155	3	75	3	60	3000
17 Street Ramps	15	3	8	3	50	297
AHD East of 17 Street EB	900	11	560	11	100	18540
AHD East of 17 Street WB	900	11	560	11	100	18540
Hwy. 14 East of AHD EB	1110	11	210	11	100	18540
Hwy. 14 East of AHD WB	1110	11	210	11	100	18540
Hwy. 216 North of Hwy. 14 NB	1110	11	210	11	100	18540
Hwy. 216 North of Hwy. 14 SB	1110	11	210	11	100	18540
Ellerslie Road	680	5	300	5	60	12900

Future Conditions (30 Years)

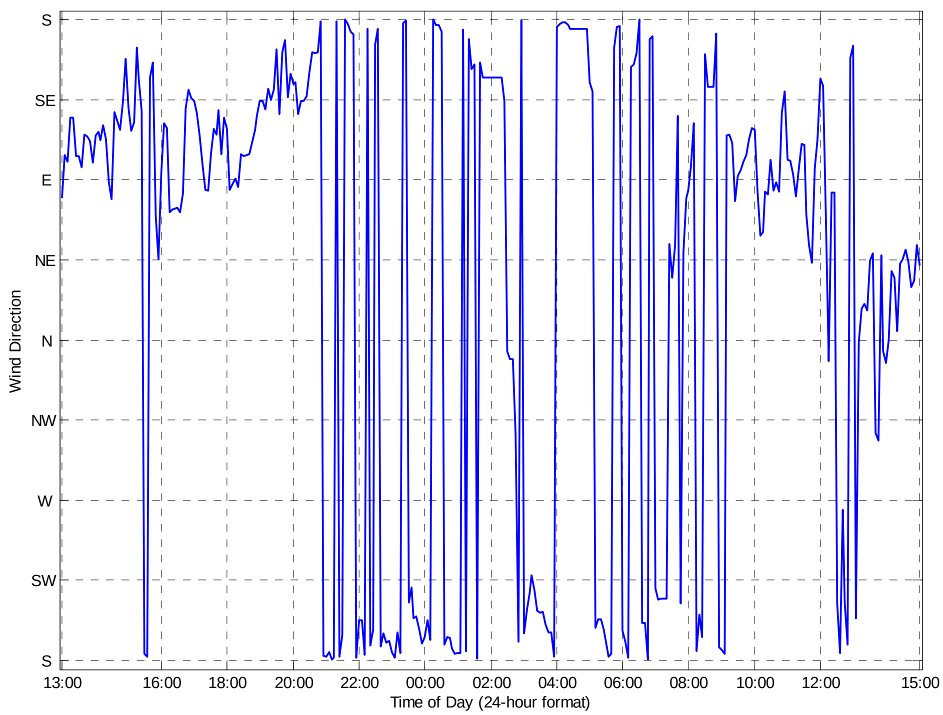
Road	Day (Vehicles Per Hour)	Day % Heavy Trucks	Night (Vehicles Per Hour)	Night % Heavy Trucks	Speed (km/hr)	Total Volume (vehicles per day)
AHD West of 91 Street EB	1950	11	1210	11	100	40140
AHD West of 91 Street WB	1950	11	1210	11	100	40140
91 Street North of AHD	2660	3	1120	3	70	49980
91 Street South of AHD	2660	3	1120	3	70	49980
91 Street Ramps	266	3	112	3	50	4998
AHD East of 91 Street EB	1950	11	1210	11	100	40140
AHD East of 91 Street WB	1950	11	1210	11	100	40140
66 Street North of AHD	700	3	300	3	60	13200
66 Street South of AHD	700	3	300	3	60	13200
AHD East of 66 Street EB	1950	11	1210	11	100	40140
AHD East of 66 Street WB	1950	11	1210	11	100	40140
50 Street North of AHD	2000	3	820	3	60	37380
50 Street South of AHD	2000	3	820	3	60	37380
50 Street Ramps	200	3	82	3	50	3738
AHD East of 50 Street EB	1950	11	1210	11	100	40140
AHD East of 50 Street WB	1950	11	1210	11	100	40140
34 Street North of AHD	260	3	120	3	60	4980
34 Street South of AHD	260	3	120	3	60	4980
AHD East of 34 Street EB	1950	11	1210	11	100	40140
AHD East of 34 Street WB	1950	11	1210	11	100	40140
17 Street North of AHD	310	3	150	3	60	6000
17 Street South of AHD	310	3	150	3	60	6000
17 Street Ramps	30	3	16	3	50	594
AHD East of 17 Street EB	1950	11	1210	11	100	40140
AHD East of 17 Street WB	1950	11	1210	11	100	40140
Hwy. 14 East of AHD EB	1950	11	1210	11	100	40140
Hwy. 14 East of AHD WB	1950	11	1210	11	100	40140
Hwy. 216 North of Hwy. 14 NB	1950	11	1210	11	100	40140
Hwy. 216 North of Hwy. 14 SB	1950	11	1210	11	100	40140
Ellerslie Road	1360	5	600	5	60	25800

Appendix V

WEATHER DATA



Monitored Wind Speed (June 3 – 4, 2008)



Monitored Wind Direction (June 3 – 4, 2008)

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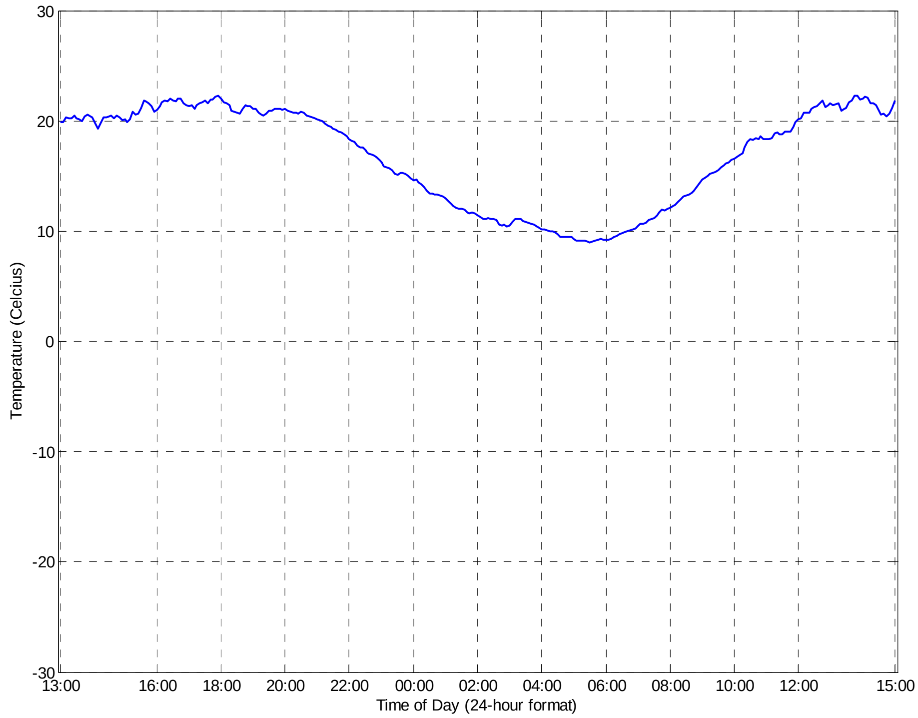
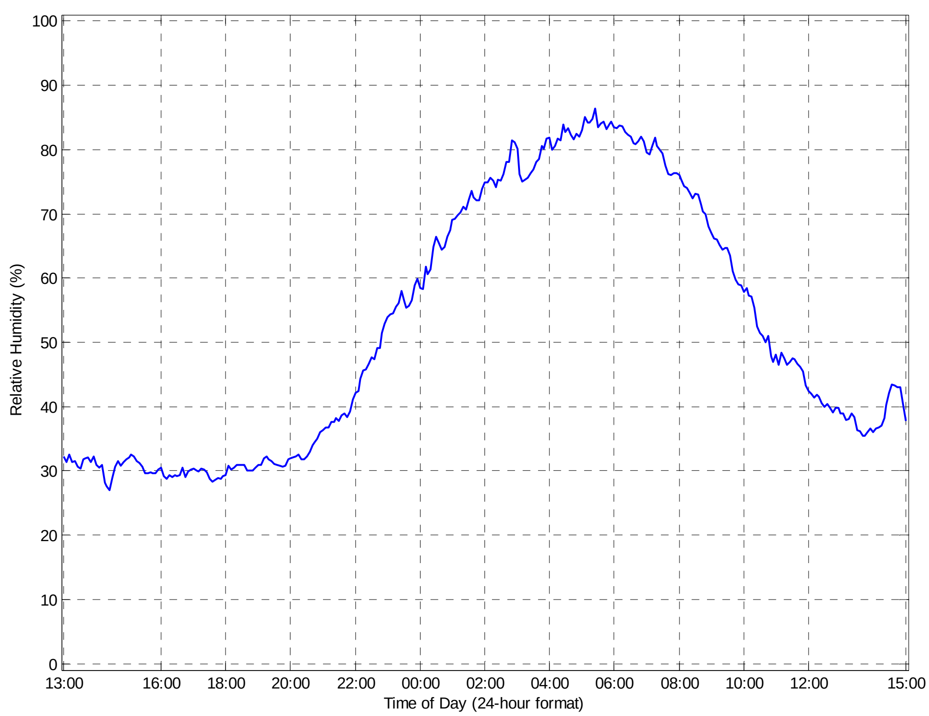
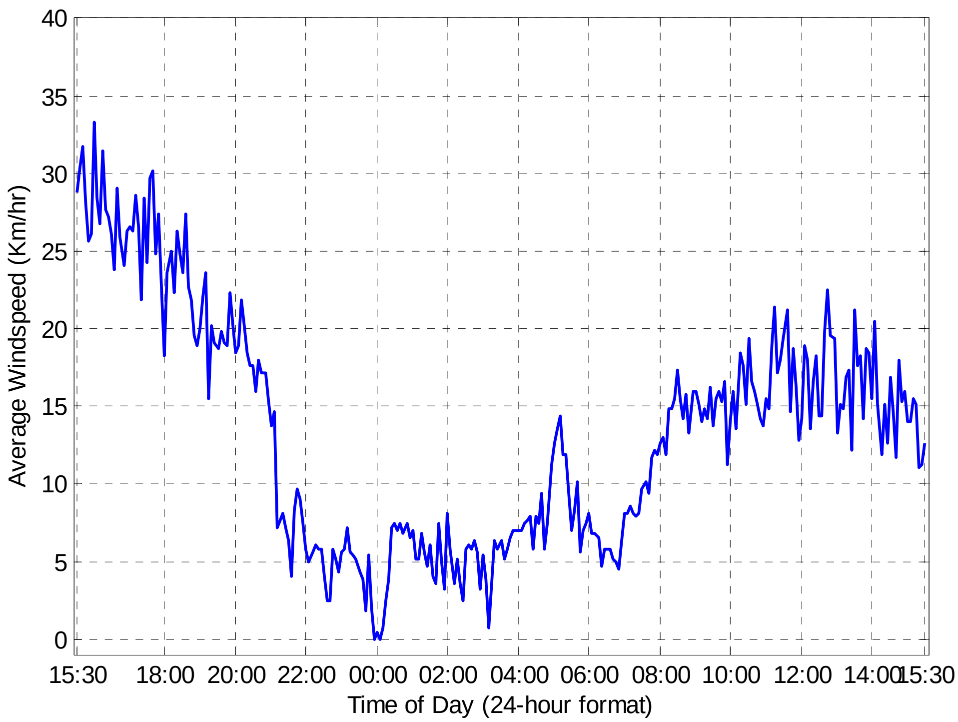


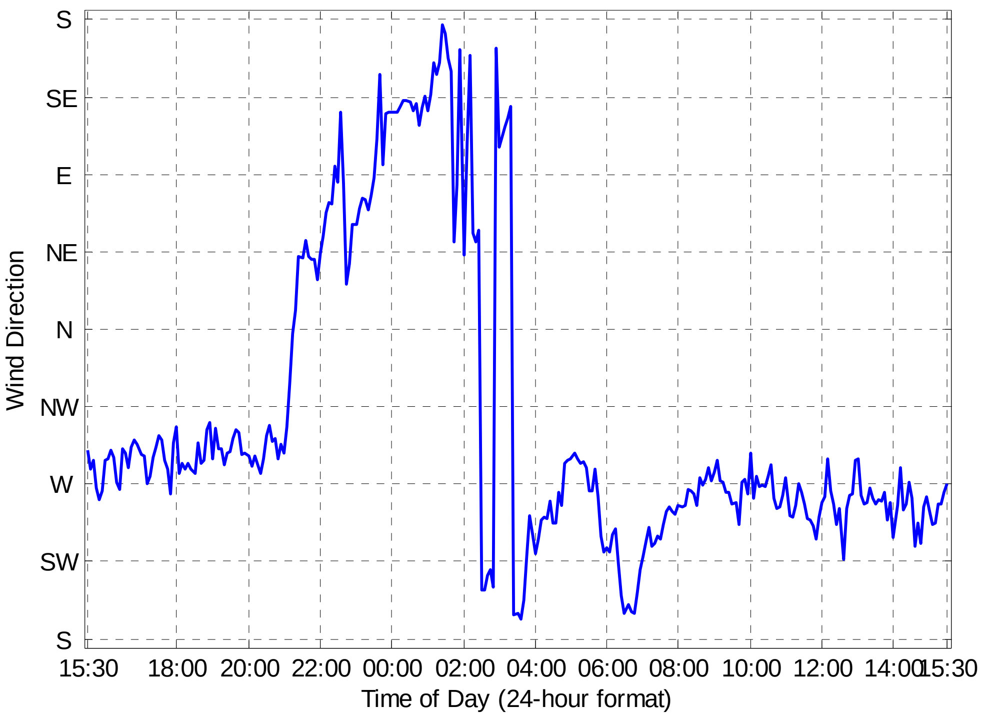
Monitored Temperature (June 3 – 4, 2008)



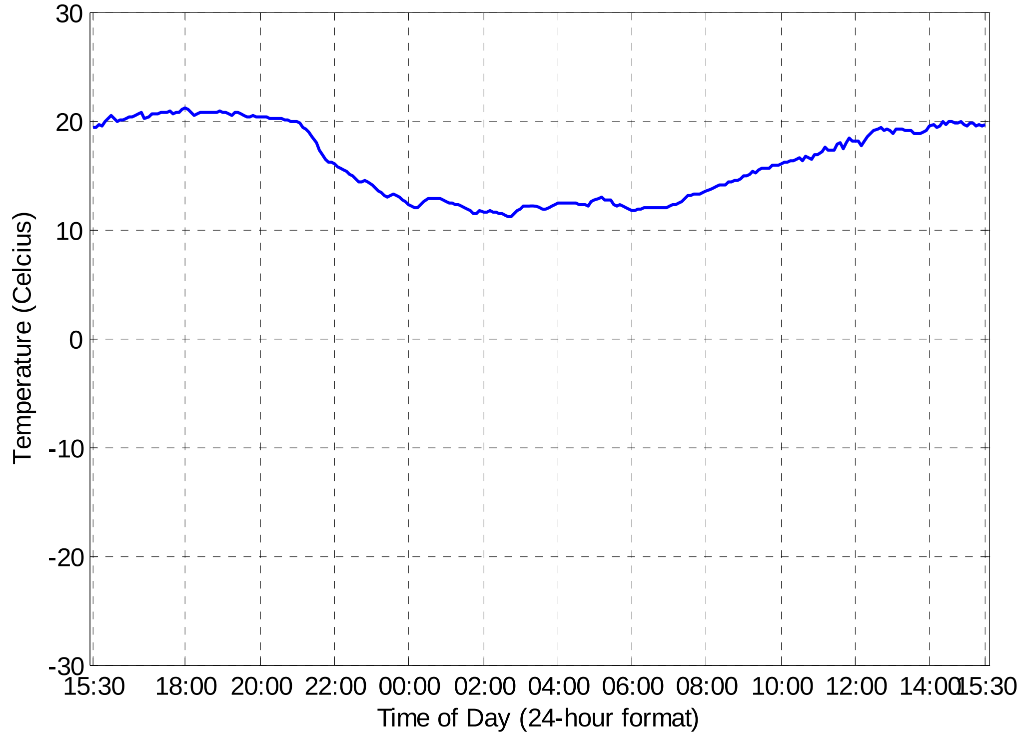
Monitored Relative Humidity (June 3 – 4, 2008)



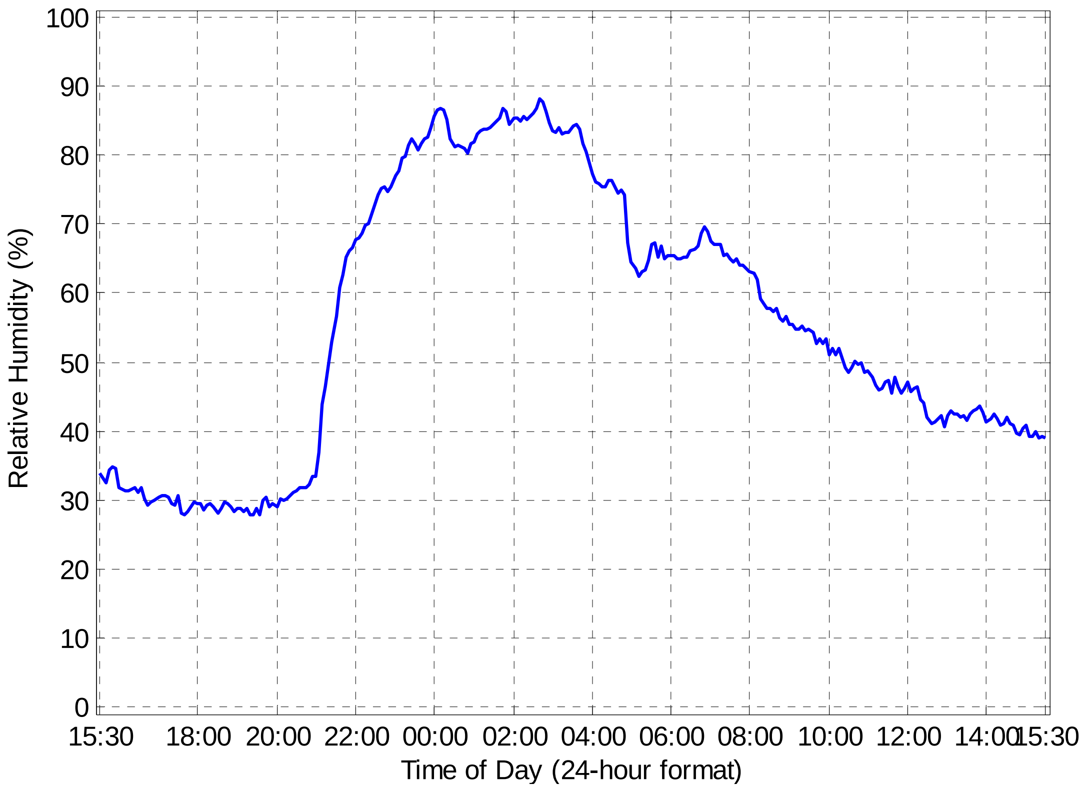
Monitored Wind Speed (July 7 – 8, 2008)



Monitored Wind Direction (July 7 – 8, 2008)



Monitored Temperature (July 7 – 8, 2008)



Monitored Relative Humidity (July 7 – 8, 2008)