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Environmental Noise Survey and Computer Modelling
For

Southwest Anthony Henday Drive
In
Edmonton, Alberta

Prepared for:
UMA Engineering Ltd.

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APEGGA Permit to Practice #P7735

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Executive Summary

aci Acoustical Consultants Inc., of Edmonton AB, was retained by UMA Engineering Ltd. (on behalf of Alberta Infrastructure and Transportation [AIT]) to conduct an environmental noise assessment along the southwest 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 computer noise models for current and future road alignments. Site work was conducted for aci in May, 2007 by S. Bilawchuk, M.Sc., P.Eng.

The results of the Current Conditions noise monitoring indicated noise levels which were generally 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 Whitemud Drive, Calgary Trail / Gateway Boulevard).

Baseline Noise Monitoring Results

Monitor	$L_{eq}24$ (dBA)	L_{eq}Day (dBA)	L_{eq}Night (dBA)
M-1 (North of 87 Ave, East of AHD)	53.5	53.3	54.0
M-2 (NW of Whitemud Drive / AHD Intersection)	54.9	54.7	55.3
M-3 (SE of Whitemud Drive / AHD Intersection)	53.0	53.6	51.8
M-4 (East of AHD at Ormsby)	56.6	56.6	56.5
M-5 (East of AHD at Jamieson Place)	55.5	55.0	56.1
M-6 (East of AHD, at Wedgewood Heights)	57.2	58.1	55.1
M-7 (North of AHD at Cameron Heights, South of Noise Wall)	65.7	66.8	62.8
M-8 (East of AHD at Haddow)	52.1	52.5	51.2
M-9 (In Between AHD Lanes at Concrete Section)	73.8	75.0	70.4
M-10 (In Between AHD Lanes at Asphalt Section)	72.8	74.0	69.3
M-11 (North of AHD at Twin Brooks)	56.4	57.0	55.1
M-12 (South of AHD, West of 111 Street)	50.7	51.7	48.2
M-13 (South of AHD, West of Calgary Trail)	60.7	61.4	59.0
M-14 (North of AHD, West of Calgary Trail)	55.3	55.7	54.5

[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.

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

The noise modeling results for the Future Conditions (with maximum capacity for AHD and a very 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 Infrastructure and Transportation, no additional noise mitigation measures are required throughout the entire study area.**

Finally, as part of the study, noise measurements were conducted adjacent to equivalent sections of concrete road surface and asphalt road surface (i.e. the same traffic conditions and at the same time). The monitoring indicated that the concrete was approximately 1.0 dBA higher than the asphalt surface throughout the entire monitoring. This occurred in both the broadband results and in each 1/3 octave band between 400 Hz and 8000 Hz. Subjectively this difference, although possibly more pronounced within the vehicle, would be completely imperceptible away from the road

Future Noise Modeling Results

Receptor	L_{eq}24 (dBA)	L_{eq}24 Increase Relative to Current Conditions (dBA)	L_{eq}Day (dBA)	L_{eq}Night (dBA)
R1	54.0	2.1	55.4	49.2
R2	55.0	2.1	56.5	50.2
R3	55.8	2.2	57.3	51.1
R4	60.6	2.7	62.0	56.0
R5	57.1	2.1	58.6	52.3
R6	55.7	2.2	57.1	50.9
R7	57.3	2.5	58.7	52.5
R8	61.5	2.4	62.9	56.8
R9	58.0	2.5	59.5	53.2
R10	58.2	2.2	59.7	53.6
R11	58.4	2.4	59.9	53.7
R12	58.8	2.4	60.3	54.1
R13	58.6	2.5	60.0	53.8
R14	57.3	2.6	58.8	52.5
R15	57.1	3.5	58.5	52.3
R16	56.3	3.2	57.8	51.5
R17	56.3	3.2	57.8	51.5
R18	58.6	3.3	60.1	53.8
R19	59.1	3.1	60.6	54.0
R20	58.6	3.3	60.1	53.7
R21	56.4	3.6	57.9	51.6
R22	59.6	3.5	61.1	54.8
R23	57.9	3.5	59.4	53.2
R24	55.2	3.5	56.6	50.4
R25	61.2	3.2	62.7	56.4
R26	52.3	3.5	53.8	47.6
R27	57.2	3.6	58.6	52.4
R28	55.9	3.6	57.3	51.1
R29	57.0	4.2	58.4	52.3
R30	55.5	4.0	56.9	50.7
R31	57.0	3.7	58.5	52.3
R32	55.4	5.7	56.3	53.0
R33	57.8	3.6	59.2	53.4
R34	56.7	1.8	58.1	51.9
R35	57.6	1.9	59.1	52.9
R36	57.8	2.5	59.2	53.0
R37	57.7	3.2	59.2	53.0
R38	59.7	3.4	61.2	54.9
R39	57.0	3.2	58.5	52.4
R40	57.7	3.5	59.1	52.9
R41	57.7	3.8	59.1	53.2
R42	56.0	3.8	57.4	51.5
R43	56.2	4.9	57.7	51.6
R44	58.7	5.2	60.1	54.0
R45	59.3	5.4	60.7	54.6
R46	56.9	5.4	58.4	52.2
R47	60.3	5.6	61.8	55.6
R48	62.1	5.6	63.6	57.5
R49	59.7	6.1	61.1	55.0
R50	62.1	5.9	63.5	57.4
R51	59.5	3.8	60.9	54.9

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1.0 Introduction

aci Acoustical Consultants Inc., of Edmonton AB, was retained by UMA Engineering Ltd. (on behalf of Alberta Infrastructure and Transportation [AIT]) to conduct an environmental noise assessment along the southwest 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 computer noise models for current and future road alignments. Site work was conducted for aci in May, 2007 by S. Bilawchuk, M.Sc., P.Eng.

2.0 Location Description

Anthony Henday Drive (AHD) Southwest spans from the west end to the south end within the Transportation and Utilities Corridor (TUC), as shown in Figs. 1a – 1c. The study area includes AHD as far north as 87 Avenue and spans until (and including) the interchange at Calgary Trail / Gateway Boulevard. Within this range the total distance of AHD is approximately 19km. Currently, there are numerous light controlled intersections and grade separated interchanges. In the future, the intersections will be replaced with grade separated interchanges (with much of the preliminary earth work completed). In addition, the interchange at Calgary Trail / Gateway Boulevard was only completed to handle north, west, and south traffic with the southeast section of AHD scheduled to open in the fall of 2007. Along the way, there are several speed limit changes (largely due to the intersections) ranging from 70 km/hr up to 100 km/hr. Throughout, the road is twinned with two lanes in each direction.

Of importance for this study is the road surface material. From 87 Avenue until Lessard Road, the road surface is comprised of conventional asphalt pavement (ACP). Starting at Lessard Road, however, the material used is Portland Cement Concrete Pavement (PCCP). This concrete has a screeded surface with the grooves oriented parallel to the direction of traffic flow. The concrete continues until the interchange at Calgary Trail / Gateway Boulevard except at the various bridges along the way. These are topped with conventional asphalt. Part of the purpose of the study was to evaluate the noise from the concrete relative to conventional asphalt.

Surrounding AHD through much of the study area is residential development, consisting of single family and multi-family dwellings. In many areas, there is a substantial setback from the roadway to the residential structures, however, there are some areas where the residential lots are approximately 50 m from the roadway. Future plans have several new residential development areas flanking AHD on both sides starting from approximately Lessard Road until approximately 127 Street.

Topographically, the land surrounding the AHD between 87 Avenue and Lessard Road is generally flat with only small hills between the roadway and the residential structures. The ground is covered with field grasses and small patches of trees and bushes. The roadway is generally visible from the residential structures. South of Lessard Road, is the Wedgewood Ravine which is a small ravine filled with tall trees and bushes. This will provide a moderate level of sound absorption for the houses nearby. Further southeast of this (south of Cameron Heights Drive) is the North Saskatchewan River Valley. Here the road reduces in elevation where it crosses the river with two separate bridges then increases in elevation on the southeast side. Within the river valley, the ground is covered with trees, bushes, and field grasses.

Beyond the River Valley to the southeast, the land is generally flat and covered with field grasses and small patches of trees and bushes. This continues until the Whitemud Creek Ravine which is generally a small ravine filled with trees and bushes. Further east beyond this, the land is again generally flat and covered with field grasses (with the exception of a small band of trees and bushes following the Blackmud Creek Ravine). This is so until (and surrounding) the interchange at Calgary Trail / Gateway Boulevard.

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 fourteen 24-hour noise monitorings were conducted. The locations for each were selected based on consultation with personnel from AIT and UMA 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 weekdays under "typical" traffic conditions. In particular, measurement times avoided 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. Each monitoring was 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 and Appendix II for a description of the acoustical terminology. 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 400m north of 87 Avenue and 440m east of AHD (northbound lanes) as shown in Figs. 1a and 2. This put the monitor approximately 15m west of the rear property line for the residence at 9004–190 Street. At this location, there was direct line-of-sight to AHD, 87 Avenue, and the interchange between the two as well as to the nearby residential structures to the east. The noise monitor was started at 08:00 on Monday May 14, 2007 and ran for 24-hours until 08:00 on Tuesday May 15, 2007.

Monitor 2

The noise Monitor 2 was located 165m north of Whitemud Drive and 400m west of AHD (southbound lanes) as shown in Figs. 1a and 3. This put the monitor approximately 3m southeast of the rear property line for the residence at 348 Pearson Crescent (Lewis Estates). At this location, there was direct line-of-sight to AHD, Whitemud Drive, and the interchange between the two. The noise monitor was started at 08:30 on Monday May 14, 2007 and ran for 24-hours until 08:30 on Tuesday May 15, 2007.

Monitor 3

The noise Monitor 3 was located 300m south of Whitemud Drive and 400m east of AHD (northbound lanes) as shown in Figs. 1a and 4. This put the monitor on top of a small hill approximately 50m west of the residence at 7419–190A Street (across the street). At this location, there was direct line-of-sight to AHD, and the interchange between AHD and Whitemud Drive as well as partial line-of-sight to Whitemud Drive. The noise monitor was started at 09:00 on Monday May 14, 2007 and ran for 24-hours until 09:00 on Tuesday May 15, 2007.

Monitor 4

The noise Monitor 4 was located 550m north of 62 Avenue and 240m east of AHD (northbound lanes) as shown in Figs. 1a and 5. This put the monitor adjacent to the TUC fence and approximately 7m west of the rear fence of the residence at 1255 Ormsby Lane. At this location, there was direct line-of-sight to AHD. The noise monitor was started at 09:30 on Monday May 14, 2007 and ran for 24-hours until 09:30 on Tuesday May 15, 2007.

Monitor 5

The noise Monitor 5 was located 400m north of Lessard Road and 225m east of AHD (northbound lanes) as shown in Figs. 1a and 6. This put the monitor approximately 10m west of the rear fence of the residence at 19055–49 Avenue. At this location, there was direct line-of-sight to AHD and partial line-of-sight to Lessard Road. The noise monitor was started at 10:00 on Monday May 14, 2007 and ran for 24-hours until 10:00 on Tuesday May 15, 2007.

Monitor 6

The noise Monitor 6 was located 810m south of Lessard Road and 100m northeast of (perpendicular to) AHD (northbound lanes) as shown in Figs. 1b and 7. This put the monitor approximately 40m west of the rear fence of the residence at 1644 Welbourn Cove (Wedgewood Heights). At this location, there was partial line-of-sight to AHD through a row of trees. The noise monitor was started at 11:00 on Tuesday May 15, 2007 and ran for 24-hours until 11:00 on Wednesday May 16, 2007.

Monitor 7

The noise Monitor 7 was located 370m west of Cameron Heights Drive and 50m north of (perpendicular to) AHD (northbound lanes) as shown in Figs. 1b and 8. This put the monitor approximately 12m south of the rear fence of the residence at 151 Caldwell Way (Cameron Heights). At this location, there was direct line-of-sight to AHD. The noise monitor was started at 12:00 on Tuesday May 15, 2007 and ran for 24-hours until 12:00 on Wednesday May 16, 2007.

Monitor 8

The noise Monitor 8 was located 800m north of Terwillegar Drive and 240m northeast of (perpendicular to) AHD (northbound lanes) as shown in Figs. 1b and 9. This put the monitor approximately 5m west of the rear fence-line of the residence at 1622 Haswell Court (Haddow). At this location, there was no line-of-sight to AHD due to the small hill/berm to the west of the monitor. The noise monitor was started at 12:30 on Tuesday May 15, 2007 and ran for 24-hours until 12:30 on Wednesday May 16, 2007.

Monitor 9

The noise Monitor 9 was located approximately 750m west of the bridge over Whitemud Creek Ravine midway between the east and west bound lanes for AHD as shown in Figs. 1b and 10. This put the monitor exactly 14m from the yellow-line in each direction with obvious line-of-sight to each direction. The road surface at this location was Concrete. The noise monitor was started at 13:30 on Tuesday May 15, 2007 and ran for 24-hours until 13:30 on Wednesday May 16, 2007.

Monitor 10

The noise Monitor 10 was located approximately 170m west of the bridge over Whitemud Creek Ravine midway between the east and west bound lanes for AHD as shown in Figs. 1b and 11. This put the monitor exactly 14m from the yellow-line in each direction with obvious line-of-sight to each direction. The road surface at this location was conventional Asphalt. The noise monitor was started at 13:30 on Tuesday May 15, 2007 and ran for 24-hours until 13:30 on Wednesday May 16, 2007.

Monitor 11

The noise Monitor 11 was located 200m north of AHD (westbound lanes) and 900m west of 111 Street, as shown in Figs. 1c and 12. This put the monitor approximately 8m south of the rear fence-line of the residence at 803 – 115A Street (Twin Brooks). At this location, there was direct line-of-sight to AHD with just a small hill/berm to the south of the monitor (negligible effect on the sound propagation between AHD and the monitor). The noise monitor was started at 11:00 on Wednesday May 30, 2007 and ran for 24-hours until 11:00 on Thursday May 31, 2007.

Monitor 12

The noise Monitor 12 was located 240m south of AHD (eastbound lanes) and 160m west of 111 Street, as shown in Figs. 1c and 13. This put the monitor approximately 50m north of the multi-family building on MacEwan Road. At this location, there was direct line-of-sight to AHD (west of the on-ramp), to 111 Street and to the ramp from AHD eastbound to 111 Street. The noise monitor was started at 13:30 on Thursday May 31, 2007 and ran for 24-hours until 13:30 on Friday June 1, 2007.

Monitor 13

The noise Monitor 13 was located 550m south of AHD (eastbound lanes) and 90m west of Calgary Trail, as shown in Figs. 1c and 14. This put the monitor directly adjacent to the rear fence-line of the residence at 363 Blackburn Drive East. The noise monitor was elevated approximately 0.2m above the fence height to eliminate reflections. At this location, there was direct line-of-sight to Calgary Trail but none to AHD due to the topography associated with the interchange. The noise monitor was started at 11:30 on Wednesday May 30, 2007 and ran for 24-hours until 11:30 on Thursday May 31, 2007.

Monitor 14

The noise Monitor 14 was located 320m north of AHD (eastbound lanes) and 340m west of Calgary Trail, as shown in Figs. 1c and 15. This put the monitor approximately 8.0m south of the rear fence-line of the residence at 10459 – 105 Street. At this location, there was direct line-of-sight to Calgary Trail, to the interchange, and to sections of AHD east of the interchange. The noise monitor was started at 12:00 on Wednesday May 30, 2007 and ran for 24-hours until 12:00 on Thursday May 31, 2007.

Weather Monitors

The weather monitor which accompanied the noise Monitors 1 – 10 was located approximately 50m east of AHD (northbound lanes) and 800m south of Whitemud Drive. The monitor was set-up on top of a small hill which placed it at the highest ground elevation in the area. There were no trees or structures nearby, resulting in un-obstructed air movement for more accurate wind measurements. The weather monitor which accompanied the noise Monitors 11 – 14 was located approximately 60m north of AHD (westbound lanes) and 600m west of 111 Street. The monitor was set-up at the AHD fence-line in an open area with no trees or structures nearby.

3.3. Computer Noise Modeling

The computer noise modeling was conducted using the CADNA/A (version 3.6.119) 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 were added to the areas surrounding the Wedgewood Ravine, the North Saskatchewan River Valley, the Whitemud Creek Ravine and the Blackmud Creek Ravine. As well, grass was modeled in the appropriate locations. 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 noise sources (i.e traffic conditions), buildings, topography, and roadway layout. This included all of the at-grade intersections with stop-and-go traffic. Current traffic conditions were obtained from AIT and the City of Edmonton.
2) Future conditions (approximately 20 years) with projected traffic volumes (maximum volumes on 4-lane twinned configuration) on AHD and grade separated interchanges at:
   a. 62 Avenue
   b. Lessard Road
   c. Cameron Heights Drive
   d. Terwillegar 2nd Structure
   e. 142 / 156 Street
   f. 127 Street
   g. Full Calgary Trail / Gateway Boulevard Interchange

   Note that the future traffic volumes included the maximum capacity for AHD (i.e. 20,000 vehicles per day per lane for a total 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 because of full interchange development) 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 5 m x 5 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 Infrastructure and 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 Infrastructure and 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 14 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. In general, 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.

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.

Detailed analysis for each location is provided below.

Table 1. Summary of Noise Monitoring Results

Monitor	L_{eq}24 (dBA)	L_{eq}Day (dBA)	L_{eq}Night (dBA)
M-1	53.5	53.3	54.0
M-2	54.9	54.7	55.3
M-3	53.0	53.6	51.8
M-4	56.6	56.6	56.5
M-5	55.5	55.0	56.1
M-6	57.2	58.1	55.1
M-7	65.7	66.8	62.8
M-8	52.1	52.5	51.2
M-9	73.8	75.0	70.4
M-10	72.8	74.0	69.3
M-11	56.4	57.0	55.1
M-12	50.7	51.7	48.2
M-13	60.7	61.4	59.0
M-14	55.3	55.7	54.5

5.2. Specific Locations Results

Monitor 1

The broadband A-weighted sound levels measured at Monitor 1 are shown in Fig. 16 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 17. The results indicate a relatively constant noise source associated with AHD and 87 Avenue. 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. At this location, the wind did not have a significant impact on the results since it was medium from the north-northwest for much of the start and then quite low from the south for the remainder. Thus, the noise monitor was essentially cross-wind from AHD for the entire time.

Monitor 2

The broadband A-weighted sound levels measured at Monitor 2 are shown in Fig. 18 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 19. The results indicate a relatively constant noise source associated with AHD and Whitemud Drive. 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 and Whitemud Drive, as well as the significant increase from 05:00 – 07:00 which is still within the night-time period. At this location, the wind may have had a slight impact on the results since it was medium from the north-northwest for much of the start and then quite low from the south for the remainder. Thus, the noise monitor was essentially cross-wind from AHD for the entire time but downwind from Whitemud Drive for the later-half of the monitoring (i.e. slightly higher sound levels).

Monitor 3

The broadband A-weighted sound levels measured at Monitor 3 are shown in Fig. 20 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 21. The results indicate a relatively constant noise source associated with AHD and Whitemud Drive. There was a slight decrease in the night-time and a notable increase during the morning rush-hour. The morning rush-hour was not as significant as at the previous locations, resulting in an L_{eq}Night that was slightly lower than the L_{eq}Day (although still not the typical 5 – 10 dBA reduction). At this location, the wind did not have a significant impact on the results since it was medium from the north-northwest for much of the start and then quite low from the south for the remainder. Thus, the noise monitor was essentially cross-wind from AHD for the entire time.

Monitor 4

The broadband A-weighted sound levels measured at Monitor 4 are shown in Fig. 22 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 23. The results indicate a very constant noise source associated with AHD. There was a slight decrease in the night-time and a notable increase during the morning rush-hour. Again, due to the increase from 05:00 – 07:00, the typical night-time reduction of 5 – 10 dBA was not observed. At this location, the wind did not have a significant impact on the results since it was medium from the north-northwest for much of the start and then quite low from the south for the remainder. Thus, the noise monitor was essentially cross-wind from AHD for the entire time.

Monitor 5

The broadband A-weighted sound levels measured at Monitor 5 are shown in Fig. 24 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 25. The results are almost identical to those of Monitor 4, and indicate a relatively constant noise source associated with AHD. There was a slight decrease in the night-time and a notable increase during the morning rush-hour. Again, due to the increase from 05:00 – 07:00, the typical night-time reduction of 5 – 10 dBA was not observed. At this location, the wind did not have a significant impact on the results since it was medium from the north-northwest for much of the start and then quite low from the south for the remainder. Thus, the noise monitor was essentially cross-wind from AHD for the entire time.

Monitor 6

The broadband A-weighted sound levels measured at Monitor 6 are shown in Fig. 26 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 27. The results indicate a relatively constant noise source associated with AHD. There was a slight decrease in the night-time and a notable increase during the morning rush-hour. Again, due to the increase from 05:00 – 07:00, the typical night-time reduction of 5 – 10 dBA was not observed, however, the reduction was more than at other locations. At this location, the wind did have a slight impact on the results since it slowly increased in amplitude throughout the monitoring, starting from the east and then shifted out of the south. Thus, the noise monitor would have been downwind from AHD near the end of the monitoring, resulting in the higher sound levels observed for the last couple of hours.

Monitor 7

The broadband A-weighted sound levels measured at Monitor 7 are shown in Fig. 28 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 29. The results are very similar to those at Monitor 6 (although much higher in amplitude) indicating a relatively constant noise source associated with AHD. There was a slight decrease in the night-time and a notable increase during the morning rush-hour. Unlike all previous locations, however, the L_{eq}Night was much closer to the typical 5 – 10 dBA reduction compared to the L_{eq}Day, likely due to the proximity to AHD and the complete dominance of the road on the noise levels. At this location, the wind did have a slight impact on the results since it slowly increased in amplitude throughout the monitoring, starting from the east and then shifted out of the south. Thus, the noise monitor would have been downwind from AHD near the end of the monitoring, resulting in the higher sound levels observed for the last couple of hours.

Monitor 8

The broadband A-weighted sound levels measured at Monitor 8 are shown in Fig. 30 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 31. The results indicate a relatively constant noise source associated with AHD. There was a slight decrease in the night-time and a notable increase during the morning rush-hour. As with many other locations, the typical 5 – 10 dBA night-time reduction was not observed. At this location, the wind did have fairly significant impact on the results since it slowly increased in amplitude throughout the monitoring, starting from the east and then shifted out of the south. Thus, the noise monitor would have been upwind from AHD at the start (resulting in the lower noise levels) and then gradually would have shifted to crosswind from AHD and downwind from Terwillegar Drive (resulting in higher noise levels).

Monitors 9 & 10

The broadband A-weighted sound levels measured at Monitors 9 & 10 are shown in Figs. 32 & 33, respectively while the 1/3 octave band sound levels obtained for the entire 24-hour period at both locations are shown in Fig. 34. The results indicate a relatively constant noise source associated with AHD. There was a notable decrease in the night-time and a slight increase during the morning rush-hour. Due to the complete dominance of AHD at these locations (i.e. all other noise sources were much lower), the typical night-time reduction of 5 – 10 dBA was indeed observed. Given the proximity to the roads and complete dominance of traffic noise, the meteorological effects would have been completely minimal at both locations.

Of importance with Monitors 9 & 10 is the relative difference between the two locations. Monitor 9 was adjacent to the concrete road surface while Monitor 10 was adjacent to the asphalt road surface. It can be seen from Table 1 that the concrete was approximately 1.0 dBA higher than the asphalt throughout the monitoring. The 1/3 octave band data shown in Fig. 34 indicate that the two surfaces were essentially identical up until approximately 400 Hz where there was a consistent difference of approximately 1.0 dB in each 1/3 octave band until approximately 8000 Hz where the data started to converge again. This covers much of the important audio spectrum and is the reason for the 1.0 dBA overall increase. Note that the lowest frequencies resulted in slight differences, but this is likely largely due to wind-effects and may not specifically be a result of the road surface.

Monitor 11

The broadband A-weighted sound levels measured at Monitor 11 are shown in Fig. 35 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 36. The results indicate a relatively constant noise source associated with AHD. There was a slight decrease in the night-time and a notable increase during both the afternoon and morning rush-hour traffic. As with many other locations, the typical 5 – 10 dBA night-time reduction was not observed. Also, at this location, the wind was approximately 10 – 15 km/hr from the south – southeast for the duration of the monitoring. This put the noise monitor downwind and resulted in "worst case" noise levels.

Monitor 12

The broadband A-weighted sound levels measured at Monitor 12 are shown in Fig. 37 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 38. The results indicate a relatively constant noise source associated with the surrounding roads (i.e. AHD, 111 Street, on/off ramps). There was a notable decrease in the night-time and a notable increase during the morning rush-hour traffic. As with many other locations, the typical 5 – 10 dBA night-time reduction was not observed. Also, at this location, the wind was approximately 5 – 10 km/hr from the south – southeast for the duration of the monitoring. This put the noise monitor upwind from AHD and cross-wind from 111 Street. The significance of this is not fully known since the relative impact from AHD v.s. 111 Street will depend on the traffic volumes and the wind direction. In general, however, a northeast wind is likely to result in the highest noise levels and those obtained are likely to be 2 – 3 dBA lower than the typical conservative noise levels.

Monitor 13

The broadband A-weighted sound levels measured at Monitor 13 are shown in Fig. 39 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 40. The results indicate a relatively constant noise source associated with traffic on Calgary Trail and Gateway Boulevard. There was a slight decrease in the night-time and only a marginal increase during the morning rush-hour traffic. As with many other locations, the typical 5 – 10 dBA night-time reduction was not observed. Also, at this location, the wind was approximately 10 – 15 km/hr from the south – southeast for the duration of the monitoring. This put the noise monitor essentially cross-wind from the noise source resulting in a neutral impact on the noise levels.

Monitor 14

The broadband A-weighted sound levels measured at Monitor 14 are shown in Fig. 41 while the 1/3 octave band sound levels obtained for the entire 24-hour period are shown in Fig. 42. The results indicate a relatively constant noise source associated with traffic on Calgary Trail / Gateway Boulevard, AHD, and the interchange. There was a slight decrease in the night-time and a notable increase during the morning rush-hour traffic. As with many other locations, the typical 5 – 10 dBA night-time reduction was not observed. Also, at this location, the wind was approximately 10 – 15 km/hr from the south – southeast for the duration of the monitoring. This put the noise monitor downwind and resulted in "worst case" noise levels.

5.3. Weather Conditions

The weather conditions for Monitors 1 – 5 were clear with a medium north/northwest wind at the start. The wind reduced and shifted out of the south overnight until the next morning. The temperature rose to approximately 17^0C during the day-time with a reduction to 6^0C overnight. The relative humidity saw a typical value of approximately 40% near the start and end with an increase to approximately 70% overnight.

The weather conditions for Monitors 6 – 10 were partly cloudy with a medium east/southeast wind at the start. The wind gradually increased and shifted out of the south overnight until the next morning. The temperature started and ended near 20^0C with a reduction to 10^0C overnight. The relative humidity saw a typical value of approximately 30% near the start and end with an increase to approximately 60% overnight.

The weather conditions for Monitors 11, 13, & 14 were clear with a medium south/southeast wind at the start. The wind remained consistent throughout the duration of the monitoring. The temperature rose to approximately 24^0C during the day-time with a reduction to 10^0C overnight. The relative humidity saw a typical value of approximately 40 – 50% near the start and end with an increase to approximately 85% overnight.

The weather conditions for Monitor 12 was clear with a medium south/southeast wind at the start. The wind remained consistent throughout the duration of the monitoring. The temperature rose to approximately 27^0C during the day-time with a reduction to 12^0C overnight. The relative humidity saw a typical value of approximately 30% near the start and end with an increase to approximately 80% overnight.

At no point was the weather considered detrimental to the data obtained. 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 except for Monitor 12. As noted in Section 5.2, the monitoring results are approximately 3 dBA lower than they would be if the wind was from the north (i.e. from AHD to the monitor). The modeling conditions included wind from AHD toward the monitor as well as from 111 Street towards the monitor. Thus the modeling results are closer to indicative conservative conditions.

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

Receptor	L_{eq}24 (dBA)	L_{eq}Day (dBA)	L_{eq}Night (dBA)
M-1	53.3 (-0.2)	54.8	48.7
M-2	55.2 (+0.3)	56.7	50.8
M-3	55.0 (+2.0)	56.2	51.9
M-4	56.5 (+0.0)	58.0	51.9
M-5	55.8 (+0.3)	57.3	51.1
M-6	57.8 (+0.6)	59.3	53.0
M-7	65.6 (-0.1)	67.0	60.8
M-8	53.3 (+1.2)	54.8	48.5
M-9	74.0 (+0.2)	75.5	69.3
M-10	72.8 (+0.0)	74.3	68.1
M-11	56.7 (+0.3)	58.2	52.0
M-12	54.7 (+4.0)	56.1	49.7
M-13	60.6 (+0.0)	62.1	56.0
M-14	56.0 (+0.8)	57.5	51.4

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 51 locations were selected as representative of worst-case noise levels. 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 AIT 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. 43a – 43g. 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	51.9	53.3	47.2	AHD
R2	52.9	54.4	48.3	AHD
R3	53.6	55.0	49.1	AHD
R4	57.9	59.3	53.4	87 Avenue by 7 dBA
R5	55.0	56.4	50.5	AHD
R6	53.5	54.9	49.5	AHD
R7	54.8	56.2	50.4	AHD and Whitemud Drive Essentially Equal
R8	59.1	60.0	56.9	Whitemud Drive by 8 dBA
R9	55.5	56.9	51.1	AHD
R10	56.0	56.9	53.7	Whitemud Drive by 5 dBA
R11	56.0	57.5	51.4	AHD
R12	56.4	57.9	51.7	AHD
R13	56.1	57.6	51.5	AHD
R14	54.7	56.1	50.0	AHD Followed Closely by Callingwood Road
R15	53.6	55.0	48.9	AHD
R16	53.1	54.5	48.4	AHD
R17	53.1	54.6	48.3	AHD
R18	55.3	56.7	50.5	AHD
R19	56.0	57.5	50.8	AHD
R20	55.3	56.7	50.5	AHD
R21	52.8	54.3	48.1	AHD
R22	56.1	57.5	51.3	AHD
R23	54.4	55.8	49.6	AHD
R24	51.7	53.1	46.9	AHD
R25	58.0	59.4	53.2	AHD
R26	48.8	50.3	44.0	AHD
R27	53.6	55.1	48.9	AHD
R28	52.3	53.8	47.5	AHD
R29	52.8	54.2	48.0	AHD and Terwillegar Drive Essentially Equal
R30	51.5	52.9	46.7	AHD
R31	53.3	54.8	48.8	AHD
R32	49.7	51.1	45.0	AHD
R33	54.2	55.6	49.5	AHD
R34	54.9	56.3	50.1	AHD
R35	55.7	57.2	51.0	AHD
R36	55.3	56.7	50.5	AHD
R37	54.5	55.9	49.7	AHD
R38	56.3	57.7	51.5	AHD
R39	53.8	55.2	49.1	111 Street Followed Closely by AHD
R40	54.2	55.6	49.3	AHD by 3 dBA then 111 Street
R41	53.9	55.3	49.2	111 Street by 4 dBA then AHD
R42	52.2	53.6	47.5	111 Street by 3 dBA then AHD
R43	51.3	52.8	46.7	AHD
R44	53.5	55.0	48.8	AHD
R45	53.9	55.3	49.2	AHD
R46	51.5	53.0	46.9	AHD
R47	54.7	56.1	50.0	AHD and Interchange Ramps
R48	56.5	57.9	51.9	Calgary Trail / Gateway Boulevard Followed Closely by Interchange Ramps
R49	53.6	55.1	49.0	AHD and Interchange Ramps
R50	56.2	57.7	51.6	AHD and Interchange Ramps
R51	55.7	57.1	51.2	Calgary Trail and Interchange Ramps

6.2. Future Conditions

The results of the noise modeling under future conditions (20 year) at the residential receptor locations are presented in Table 4 and shown in Figs. 44a – 44g. 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. At all locations, the L_{eq}24 sound levels will be below the limit of 65 dBA L_{eq}24 by at least 2.9 dBA 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.

At receptor locations north of Whitemud Drive, the relative increases were less than 3.0 dBA due to the already high traffic volumes on AHD in the area. South of Whitemud Drive, the relative increases are approximately 3.0 dBA due to an approximate doubling of traffic on both AHD and City of Edmonton roadways. Moving further southeast, the relative increases are near 3.5 dBA. The largest relative increases are for receptors close to AHD between 111 Street and Calgary Trail. The current traffic volumes on AHD are lower here than anywhere else on AHD. Thus, when increased to the maximum of 80,000 vehicles per day, the relative increase in noise levels will be the greatest.

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 20 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	54.0	2.1	55.4	49.2
R2	55.0	2.1	56.5	50.2
R3	55.8	2.2	57.3	51.1
R4	60.6	2.7	62.0	56.0
R5	57.1	2.1	58.6	52.3
R6	55.7	2.2	57.1	50.9
R7	57.3	2.5	58.7	52.5
R8	61.5	2.4	62.9	56.8
R9	58.0	2.5	59.5	53.2
R10	58.2	2.2	59.7	53.6
R11	58.4	2.4	59.9	53.7
R12	58.8	2.4	60.3	54.1
R13	58.6	2.5	60.0	53.8
R14	57.3	2.6	58.8	52.5
R15	57.1	3.5	58.5	52.3
R16	56.3	3.2	57.8	51.5
R17	56.3	3.2	57.8	51.5
R18	58.6	3.3	60.1	53.8
R19	59.1	3.1	60.6	54.0
R20	58.6	3.3	60.1	53.7
R21	56.4	3.6	57.9	51.6
R22	59.6	3.5	61.1	54.8
R23	57.9	3.5	59.4	53.2
R24	55.2	3.5	56.6	50.4
R25	61.2	3.2	62.7	56.4
R26	52.3	3.5	53.8	47.6
R27	57.2	3.6	58.6	52.4
R28	55.9	3.6	57.3	51.1
R29	57.0	4.2	58.4	52.3
R30	55.5	4.0	56.9	50.7
R31	57.0	3.7	58.5	52.3
R32	55.4	5.7	56.3	53.0
R33	57.8	3.6	59.2	53.4
R34	56.7	1.8	58.1	51.9
R35	57.6	1.9	59.1	52.9
R36	57.8	2.5	59.2	53.0
R37	57.7	3.2	59.2	53.0
R38	59.7	3.4	61.2	54.9
R39	57.0	3.2	58.5	52.4
R40	57.7	3.5	59.1	52.9
R41	57.7	3.8	59.1	53.2
R42	56.0	3.8	57.4	51.5
R43	56.2	4.9	57.7	51.6
R44	58.7	5.2	60.1	54.0
R45	59.3	5.4	60.7	54.6
R46	56.9	5.4	58.4	52.2
R47	60.3	5.6	61.8	55.6
R48	62.1	5.6	63.6	57.5
R49	59.7	6.1	61.1	55.0
R50	62.1	5.9	63.5	57.4
R51	59.5	3.8	60.9	54.9

6.3. Future 20 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

The analysis of varying traffic volume does not require modifications to the noise model. 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 10% (likely maximum error in 20 year planning horizon), there will be a 0.4 dBA increase.** As an aside, typical traffic volumes on 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.

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 5 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 – 0.5 dBA. When reducing the speed to 90 km/hr, the noise levels decreased by 0.1 – 0.4 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 5. 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 (dBA)		L_{eq}24 with 90 km/hr on AHD (dBA)	Relative Decrease Compared to 100 km/hr (dBA)
R1	54.4	0.4		53.7	-0.3
R2	55.4	0.4		54.7	-0.3
R3	56.1	0.3		55.6	-0.2
R4	60.7	0.1		60.5	-0.1
R5	57.5	0.4		56.8	-0.3
R6	56.0	0.3		55.4	-0.3
R7	57.5	0.2		57.0	-0.3
R8	61.5	0		61.4	-0.1
R9	58.3	0.3		57.7	-0.3
R10	58.4	0.2		58.1	-0.1
R11	58.9	0.5		58.1	-0.3
R12	59.3	0.5		58.5	-0.3
R13	59.0	0.4		58.2	-0.4
R14	57.7	0.4		57.0	-0.3
R15	57.4	0.3		56.8	-0.3
R16	56.7	0.4		56.0	-0.3
R17	56.8	0.5		56.0	-0.3
R18	59.0	0.4		58.2	-0.4
R19	59.3	0.2		58.9	-0.2
R20	59.0	0.4		58.2	-0.4
R21	56.8	0.4		56.1	-0.3
R22	60.0	0.4		59.2	-0.4
R23	58.4	0.5		57.5	-0.4
R24	55.6	0.4		54.8	-0.4
R25	61.7	0.5		60.8	-0.4
R26	52.8	0.5		52.0	-0.3
R27	57.6	0.4		56.8	-0.4
R28	56.3	0.4		55.5	-0.4
R29	57.2	0.2		56.8	-0.2
R30	55.8	0.3		55.1	-0.4
R31	57.4	0.4		56.7	-0.3
R32	55.6	0.2		55.1	-0.3
R33	58.2	0.4		57.5	-0.3
R34	57.1	0.4		56.3	-0.4
R35	58.1	0.5		57.3	-0.3
R36	58.2	0.4		57.4	-0.4
R37	58.2	0.5		57.4	-0.3
R38	60.1	0.4		59.3	-0.4
R39	57.3	0.3		56.8	-0.2
R40	58.0	0.3		57.4	-0.3
R41	57.9	0.2		57.5	-0.2
R42	56.3	0.3		55.8	-0.2
R43	56.5	0.3		56.0	-0.2
R44	59.0	0.3		58.4	-0.3
R45	59.6	0.3		59.0	-0.3
R46	57.2	0.3		56.7	-0.2
R47	60.6	0.3		60.1	-0.2
R48	62.3	0.2		62.0	-0.1
R49	59.9	0.2		59.5	-0.2
R50	62.2	0.1		62.0	-0.1
R51	59.5	0.0		59.5	0.0

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 16% and 14%, respectively 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 the future 20 % heavy trucks will fall outside of this range. The results are shown in Table 6. It can be seen that **the relative sound level increase with 21% daytime and 19% night-time heavy trucks is approximately 0.1 – 0.8 dBA. The relative sound level decrease with 11% daytime and 9% night-time heavy trucks is approximately 0.2 – 0.9 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.

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 15%, 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. As such, **increasing the traffic volume by 10%, increasing the traffic speed to 110 km/hr, and increasing the heavy trucks to 21% daytime and 19% night-time will result in an overall maximum increase of approximately 1.7 dBA.** Even with this increase, the highest sound level at any residential receptor will still be below the limit of 65 dBA.

Table 6. 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	54.6	0.6		53.3	-0.7
R2	55.6	0.6		54.3	-0.7
R3	56.3	0.5		55.3	-0.5
R4	60.7	0.1		60.4	-0.2
R5	57.7	0.6		56.4	-0.7
R6	56.2	0.5		55.1	-0.6
R7	57.7	0.4		56.8	-0.5
R8	61.6	0.1		61.3	-0.2
R9	58.5	0.5		57.5	-0.5
R10	58.5	0.3		58.0	-0.2
R11	59.1	0.7		57.7	-0.7
R12	59.5	0.7		58.0	-0.8
R13	59.3	0.7		57.8	-0.8
R14	57.9	0.6		56.7	-0.6
R15	57.6	0.5		56.5	-0.6
R16	56.9	0.6		55.6	-0.7
R17	57.0	0.7		55.6	-0.7
R18	59.3	0.7		57.8	-0.8
R19	59.5	0.4		58.6	-0.5
R20	59.2	0.6		57.8	-0.8
R21	57.0	0.6		55.7	-0.7
R22	60.3	0.7		58.8	-0.8
R23	58.6	0.7		57.1	-0.8
R24	55.9	0.7		54.3	-0.9
R25	61.9	0.7		60.4	-0.8
R26	53.1	0.8		51.5	-0.8
R27	57.9	0.7		56.3	-0.9
R28	56.5	0.6		55.1	-0.8
R29	57.4	0.4		56.5	-0.5
R30	56.0	0.5		54.8	-0.7
R31	57.6	0.6		56.3	-0.7
R32	55.8	0.4		54.9	-0.5
R33	58.5	0.7		57.1	-0.7
R34	57.4	0.7		55.9	-0.8
R35	58.3	0.7		56.9	-0.7
R36	58.5	0.7		56.9	-0.9
R37	58.4	0.7		56.9	-0.8
R38	60.4	0.7		58.9	-0.8
R39	57.5	0.5		56.5	-0.5
R40	58.3	0.6		57.0	-0.7
R41	58.1	0.4		57.2	-0.5
R42	56.5	0.5		55.5	-0.5
R43	56.9	0.7		55.5	-0.7
R44	59.4	0.7		57.9	-0.8
R45	59.9	0.6		58.5	-0.8
R46	57.5	0.6		56.2	-0.7
R47	61.0	0.7		59.6	-0.7
R48	62.7	0.6		61.5	-0.6
R49	60.3	0.6		58.9	-0.8
R50	62.7	0.6		61.3	-0.8
R51	59.7	0.2		59.2	-0.3

7.0 Conclusion

The results of the Current Conditions noise monitoring indicated noise levels which were generally 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 Whitemud Drive, Calgary Trail / Gateway Boulevard).

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

The noise modeling results for the Future Conditions (with maximum capacity for AHD and a very 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 Infrastructure and Transportation, no additional noise mitigation measures are required throughout the entire study area.**

Finally, as part of the study, noise measurements were conducted adjacent to equivalent sections of concrete road surface and asphalt road surface (i.e. the same traffic conditions and at the same time). The monitoring indicated that the concrete was approximately 1.0 dBA higher than the asphalt surface throughout the entire monitoring. This occurred in both the broadband results and in each 1/3 octave band between 400 Hz and 8000 Hz. Subjectively this difference, although possibly more pronounced within the vehicle, would be completely imperceptible away from the road.

8.0 References

- *"Noise Attenuation Guidelines for Provincial Highways Under Provincial Jurisdiction Within Cities and Urban Areas"* DRAFT version, by Alberta Infrastructure and 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.

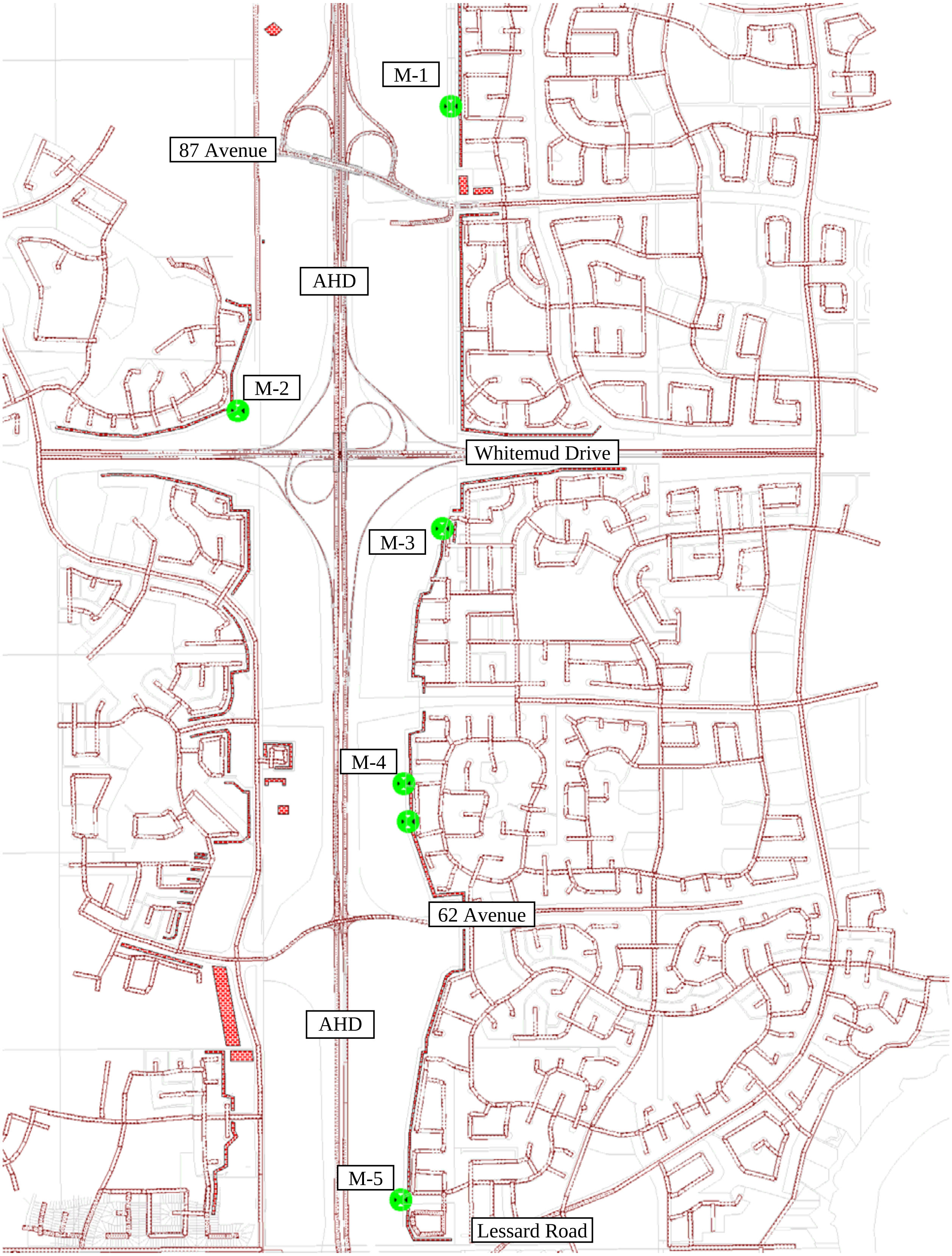

Figure 1a. Noise Study Area (87 Avenue to Lessard Road)

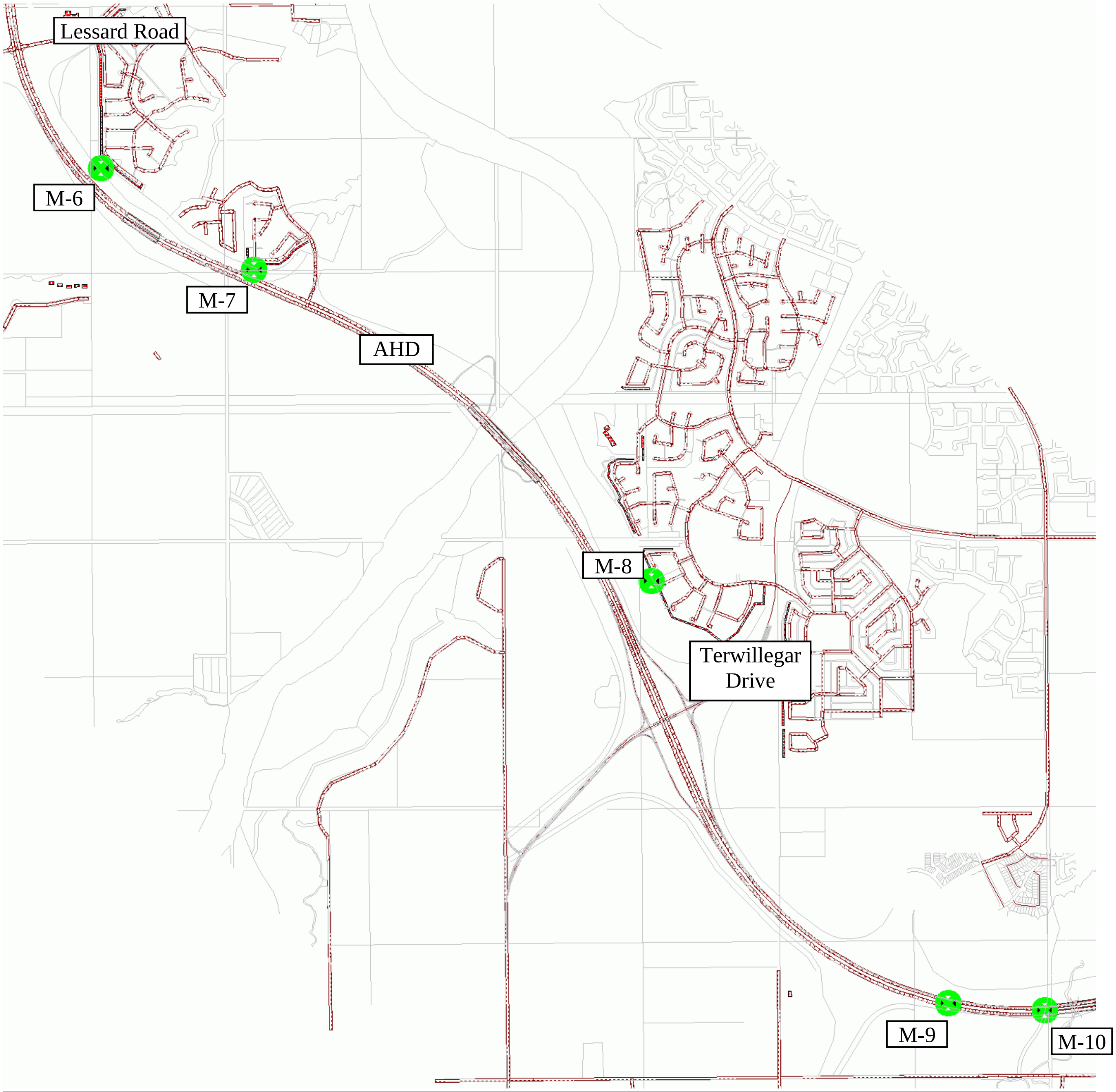

Figure 1b. Noise Study Area (Lessard Road to Whitemud Creek)

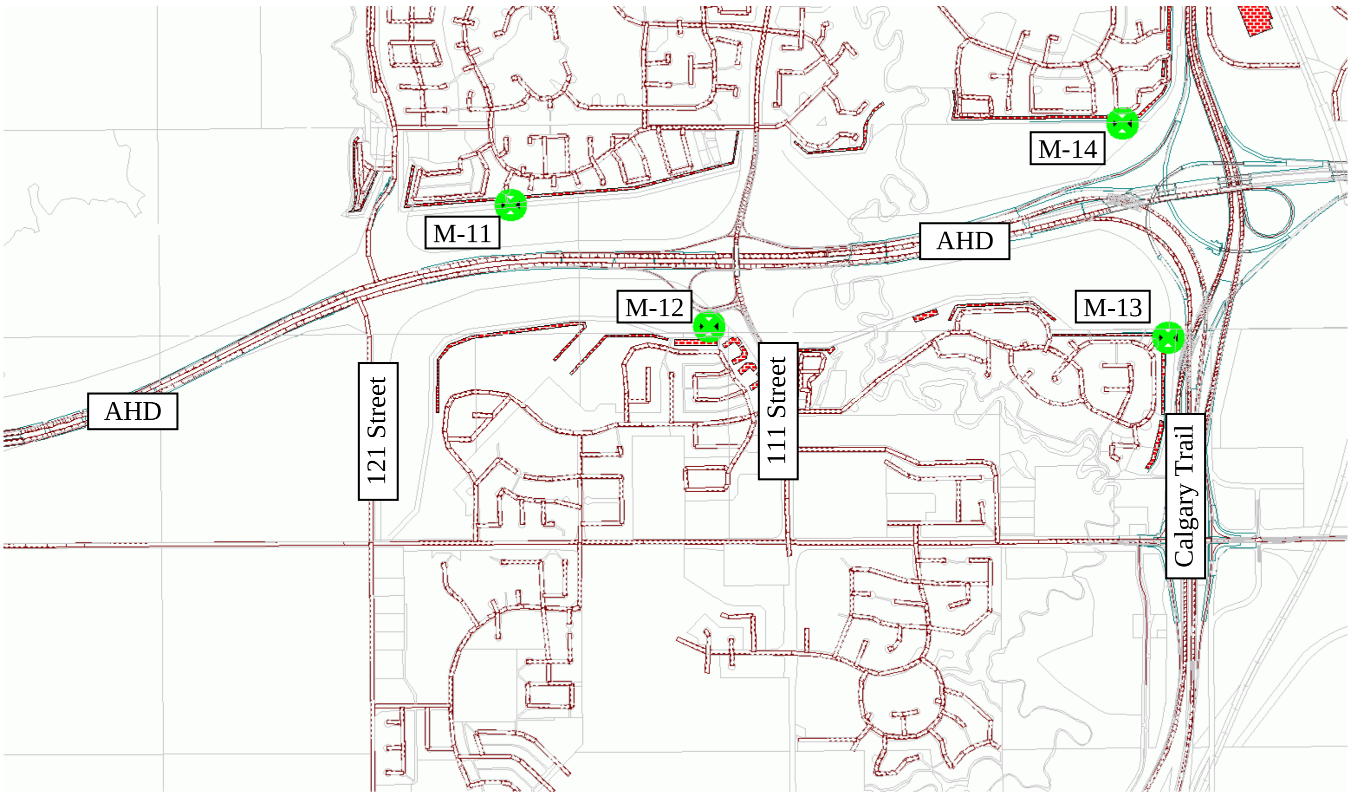

Figure 1c. Noise Study Area (Whitemud Creek to Calgary Trail / Gateway Boulevard)

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. Noise Monitor 6

Figure 8. Noise Monitor 7

Figure 9. Noise Monitor 8

Figure 10. Noise Monitor 9

Figure 11. Noise Monitor 10

Figure 12. Noise Monitor 11

Figure 13. Noise Monitor 12

Figure 14. Noise Monitor 13

Figure 15. Noise Monitor 14

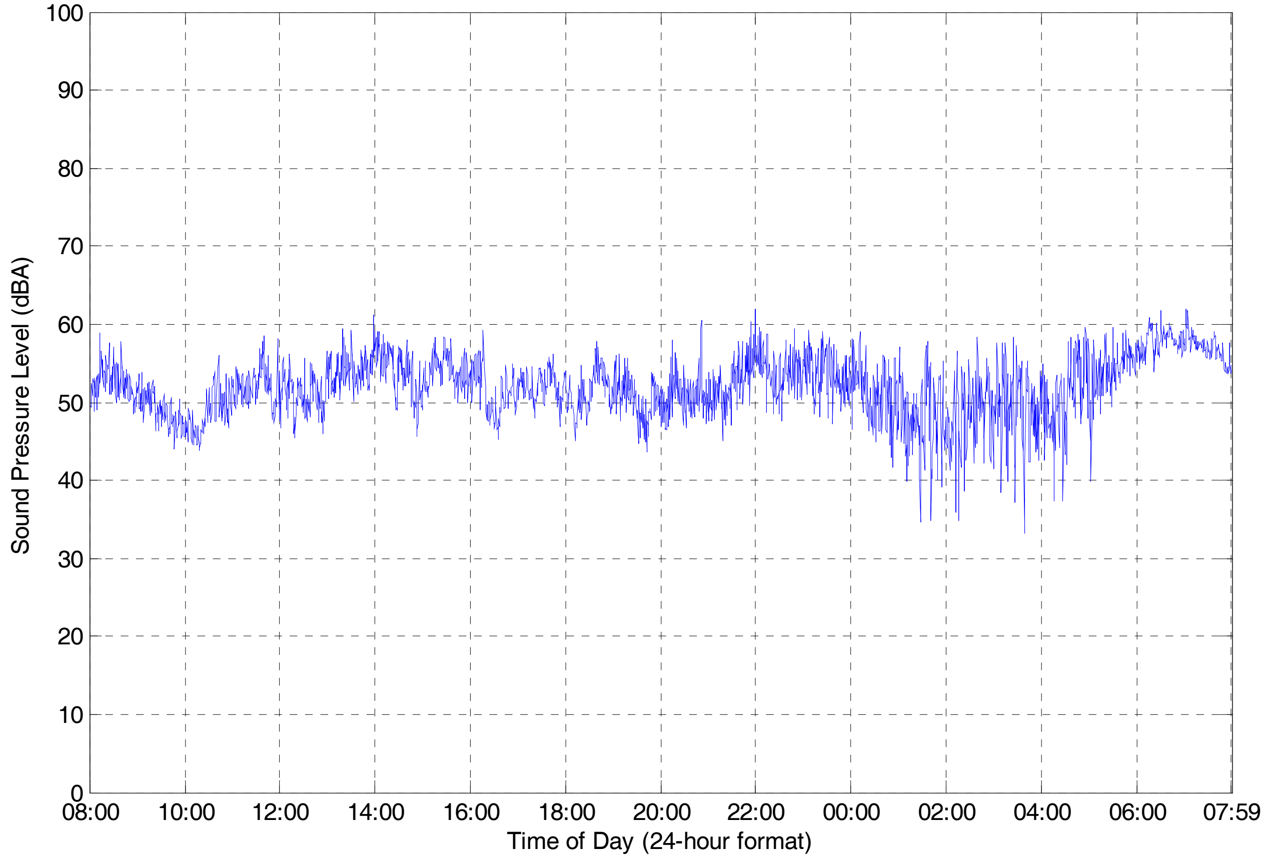

Figure 16. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 1

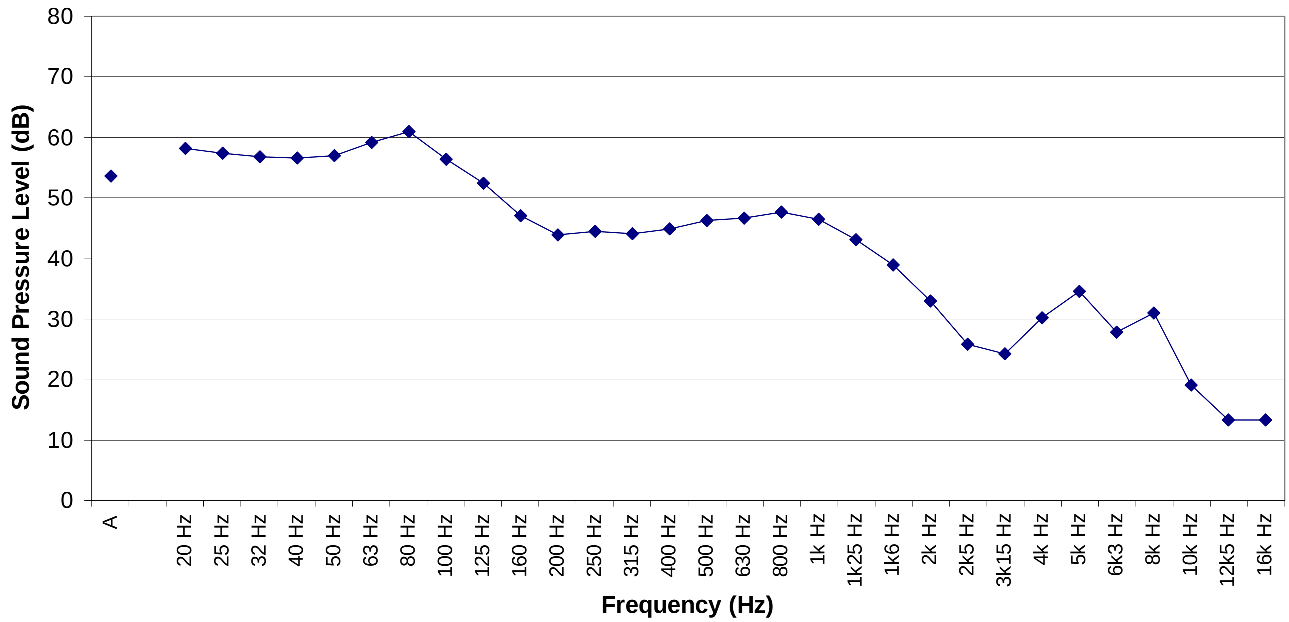

Figure 17. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 1

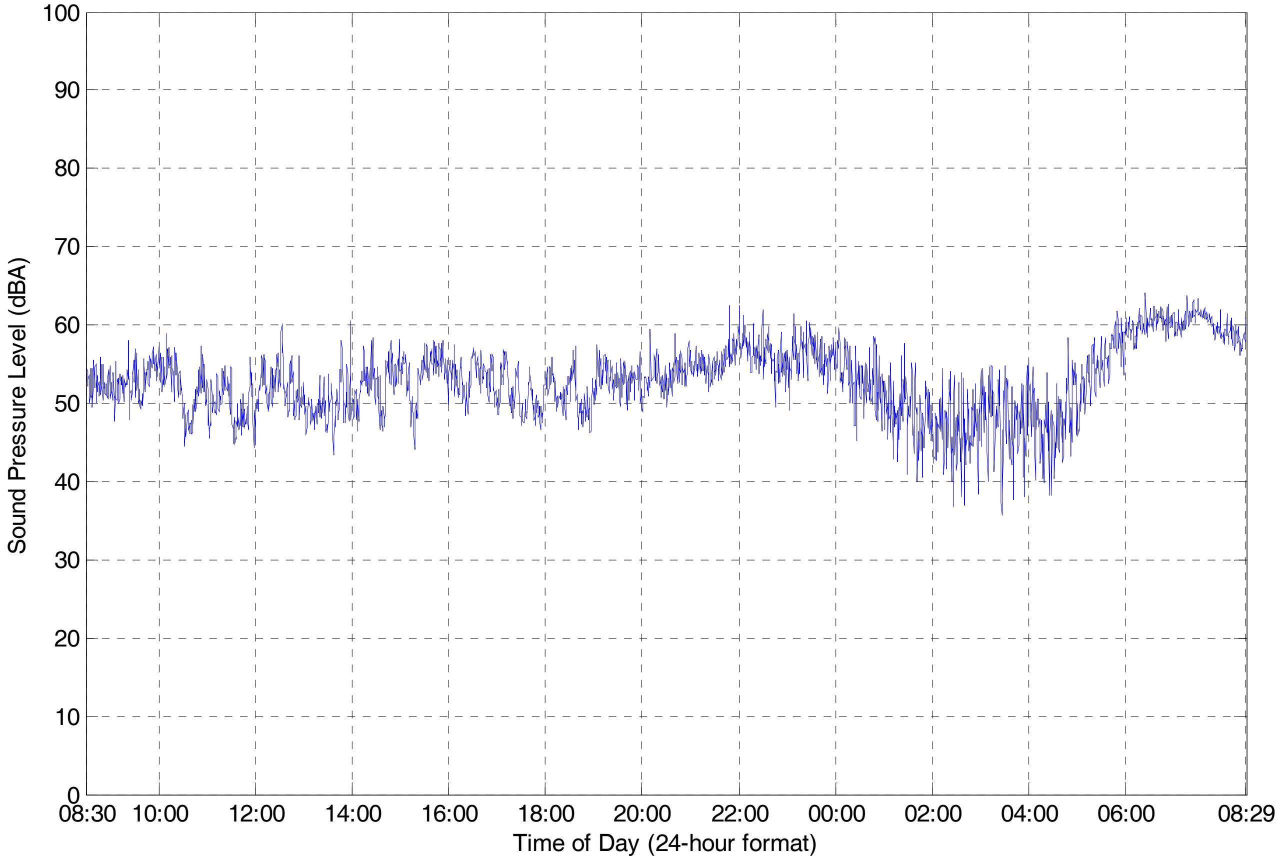

Figure 18. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 2

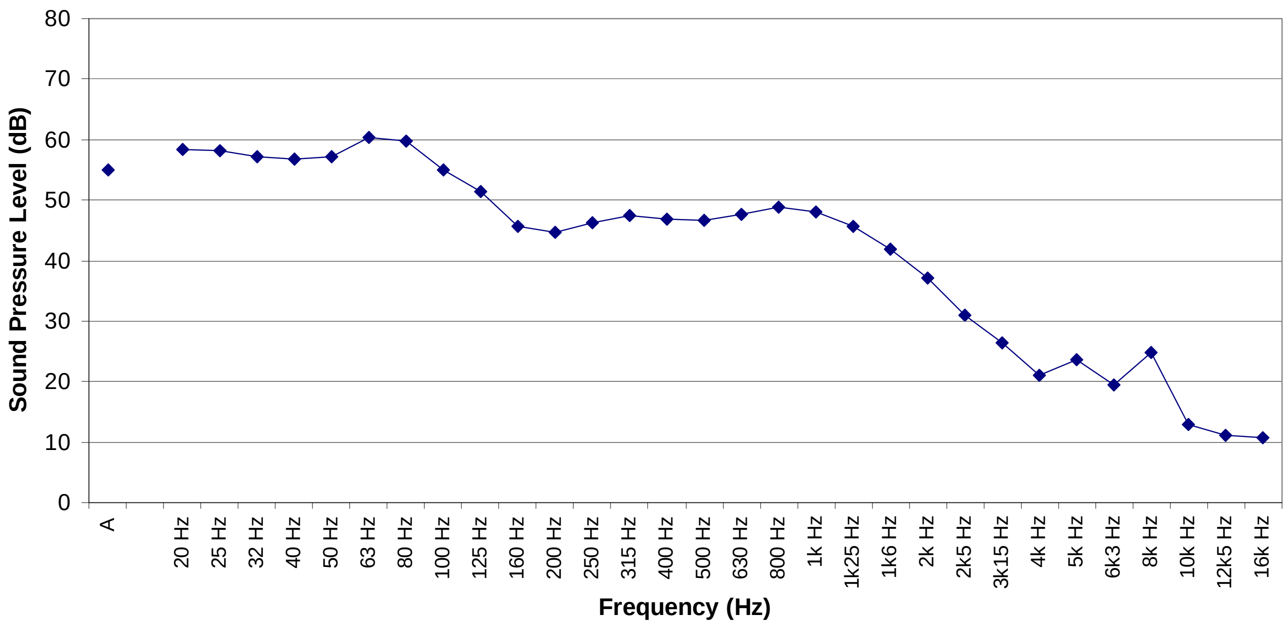

Figure 19. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 2

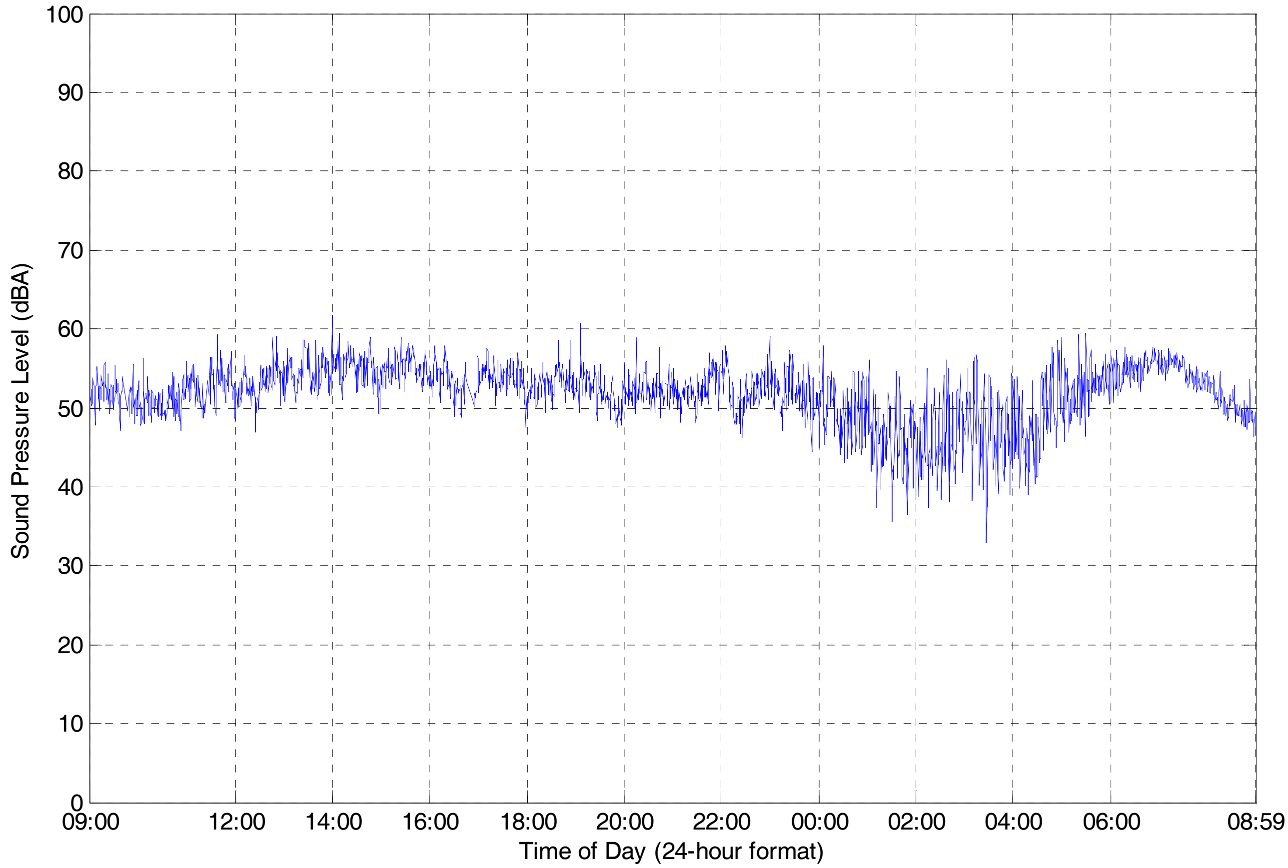

Figure 20. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 3

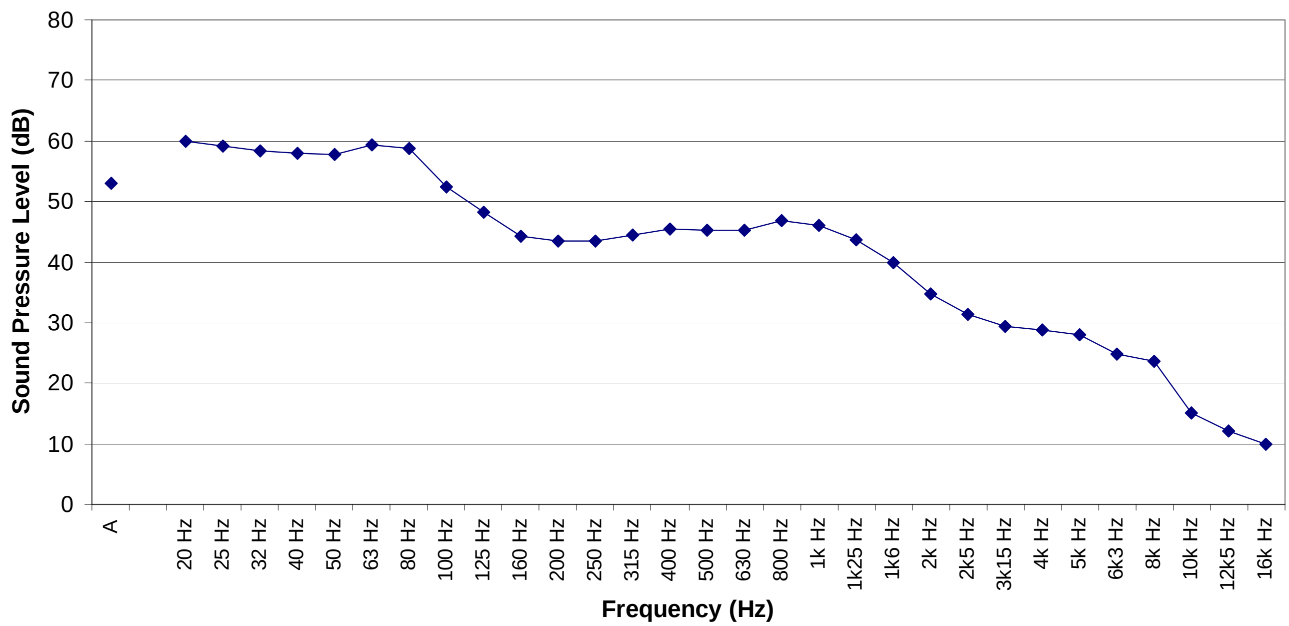

Figure 21. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 3

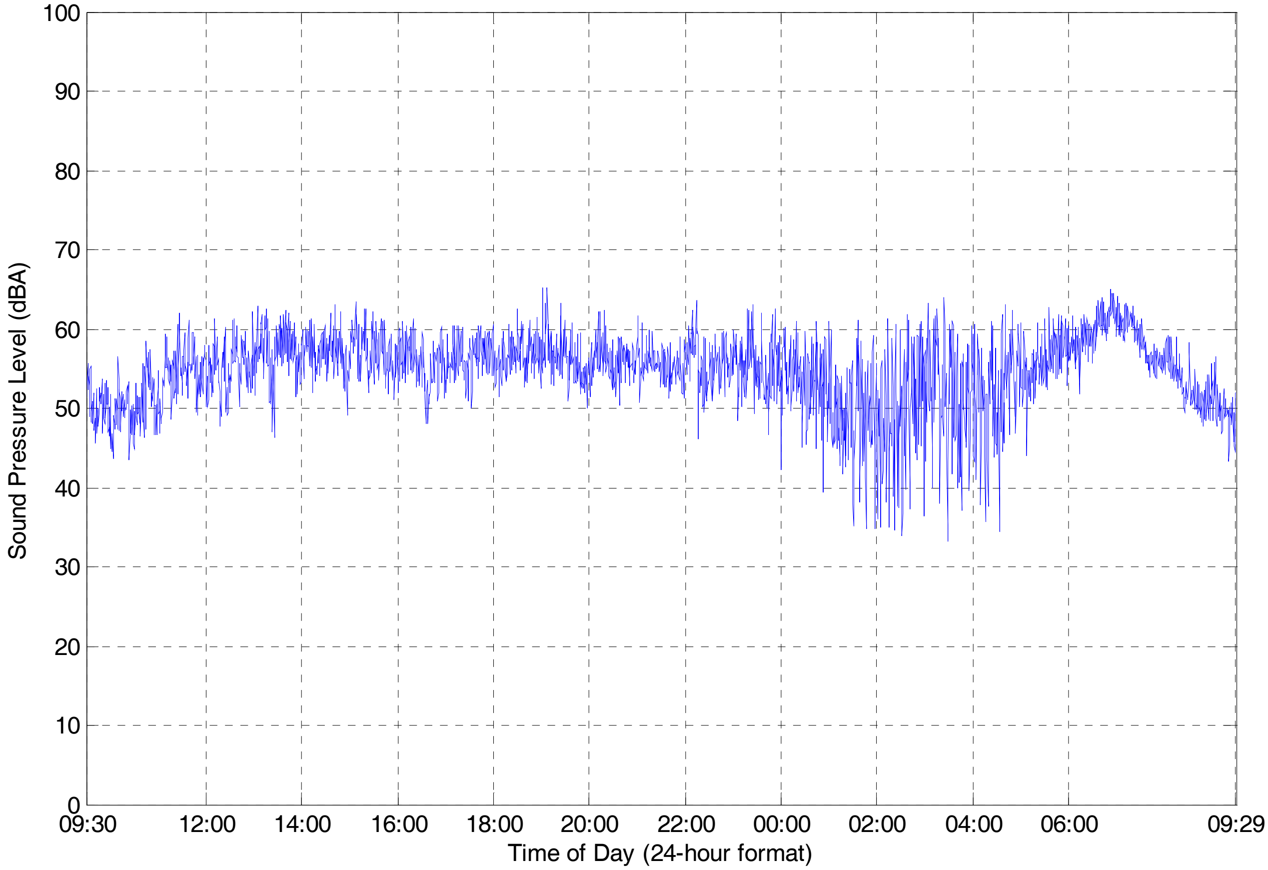

Figure 22. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 4

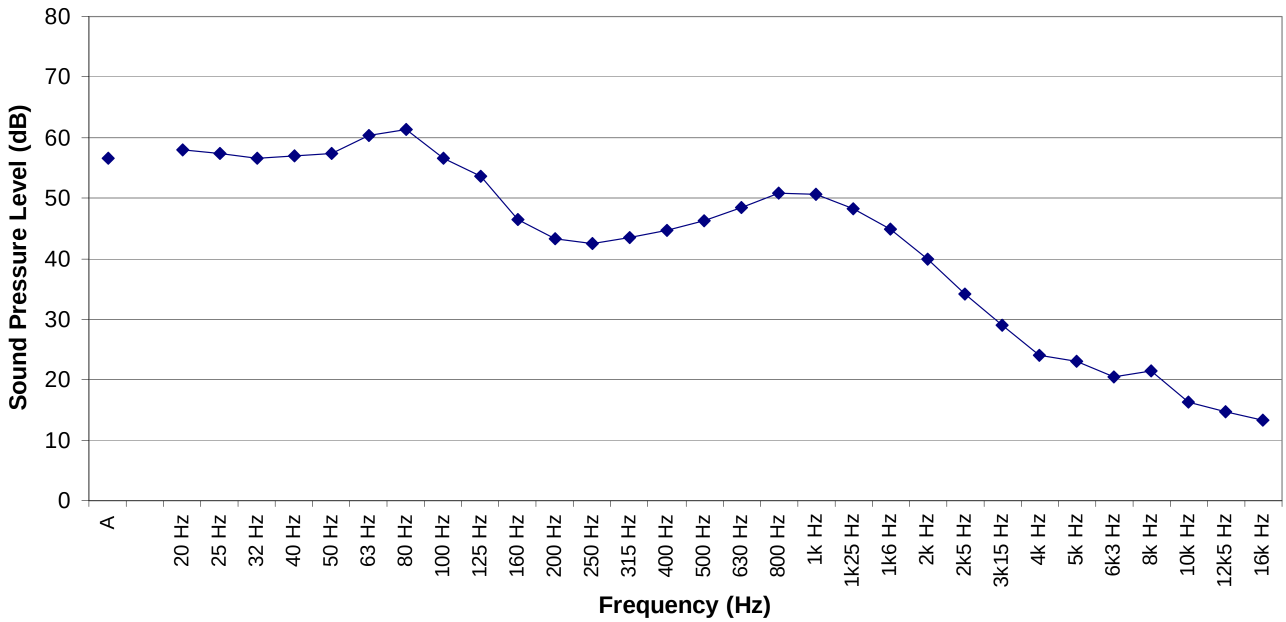

Figure 23. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 4

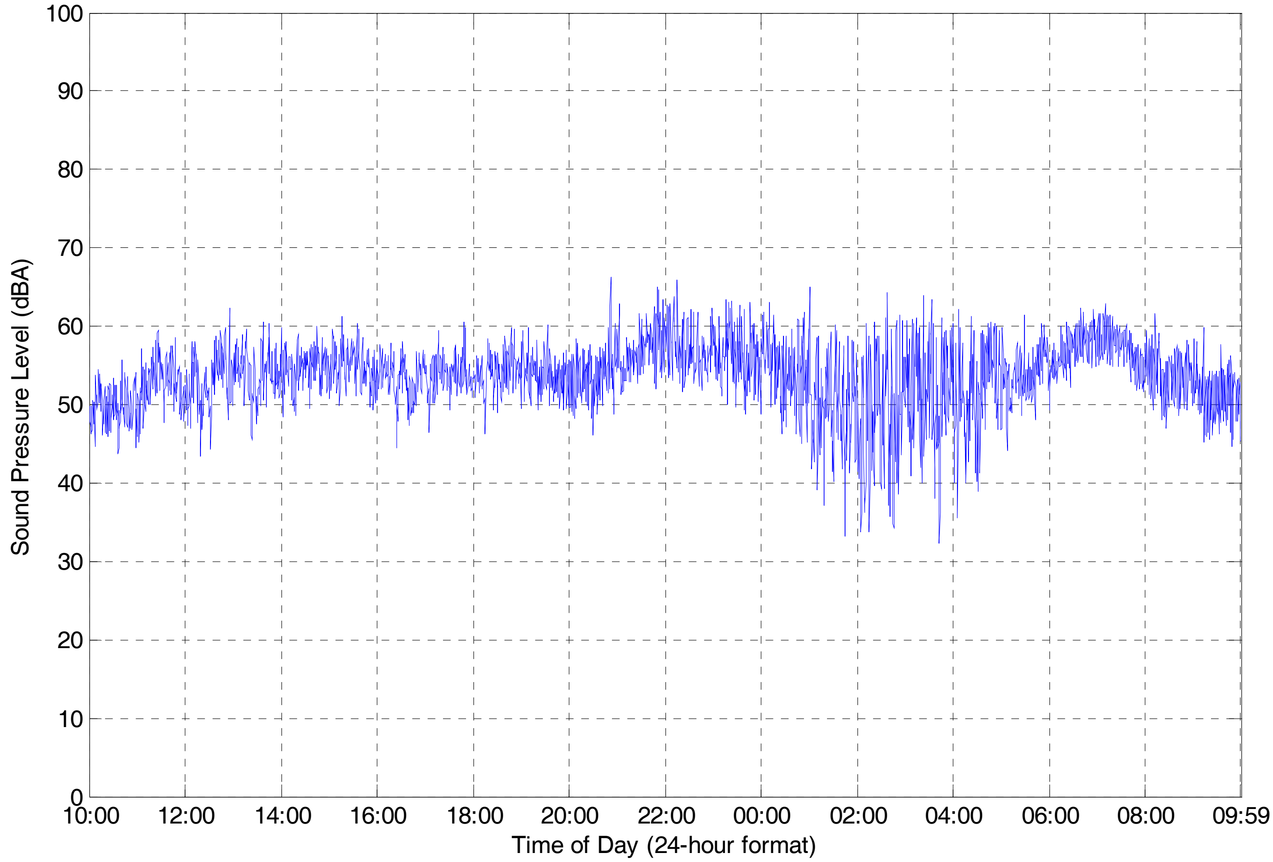

Figure 24. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 5

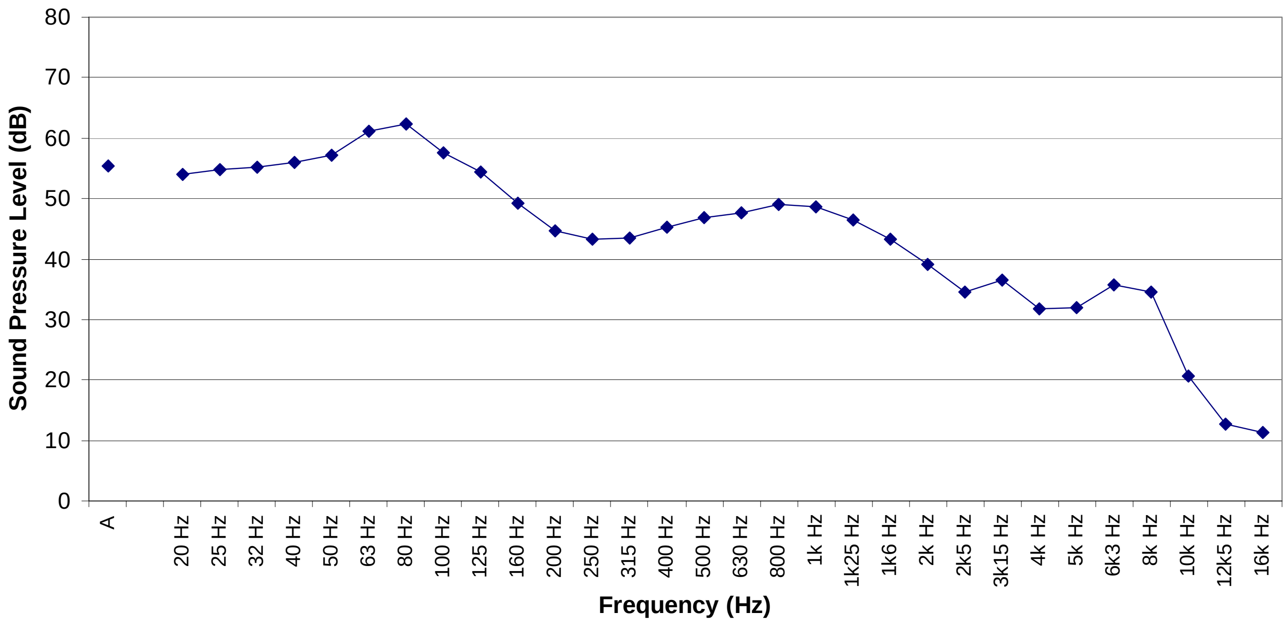

Figure 25. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 5

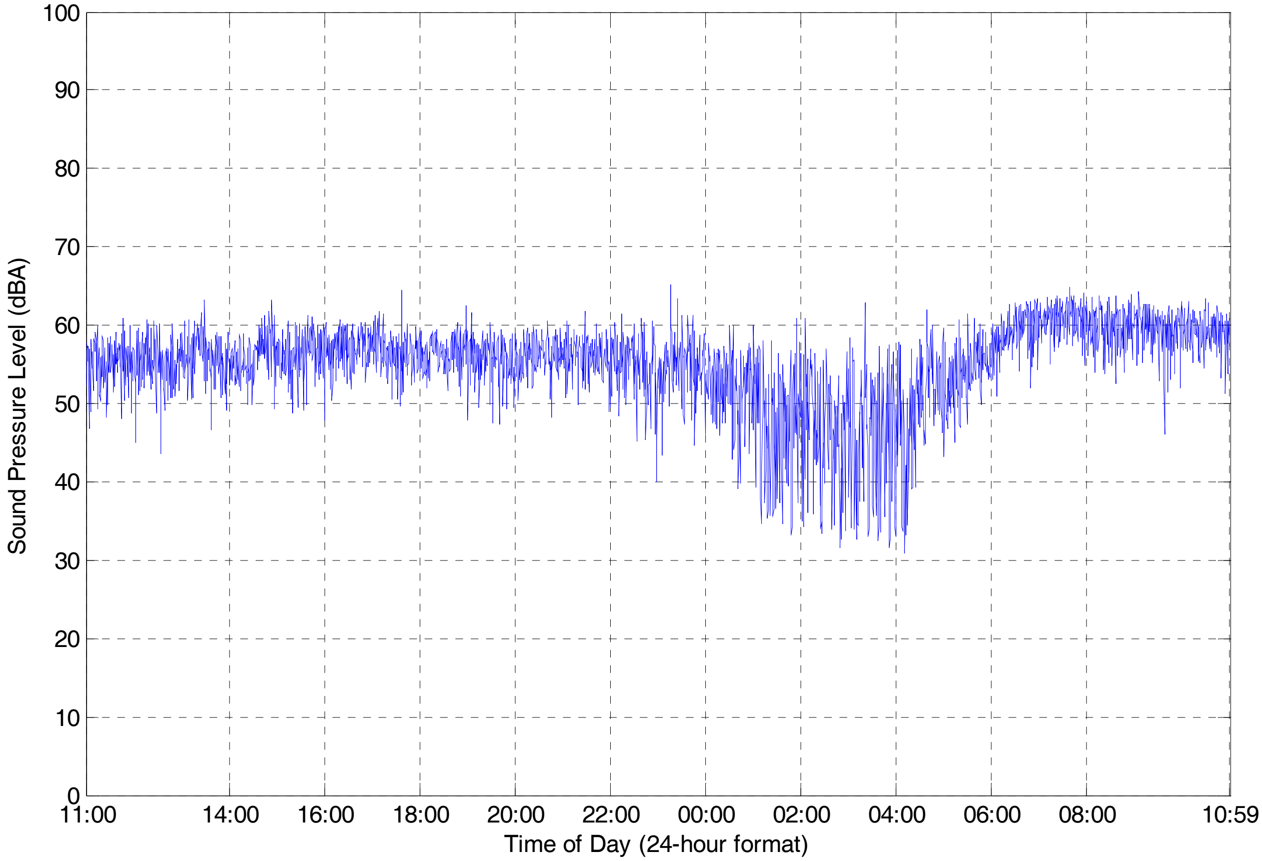

Figure 26. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 6

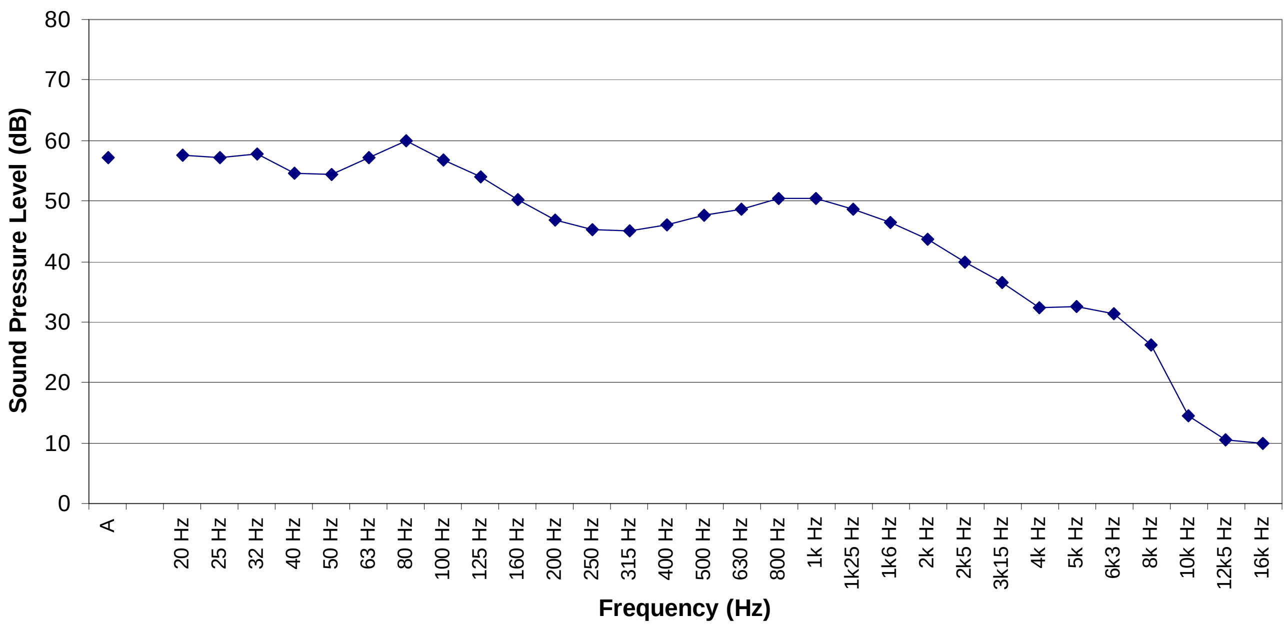

Figure 27. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 6

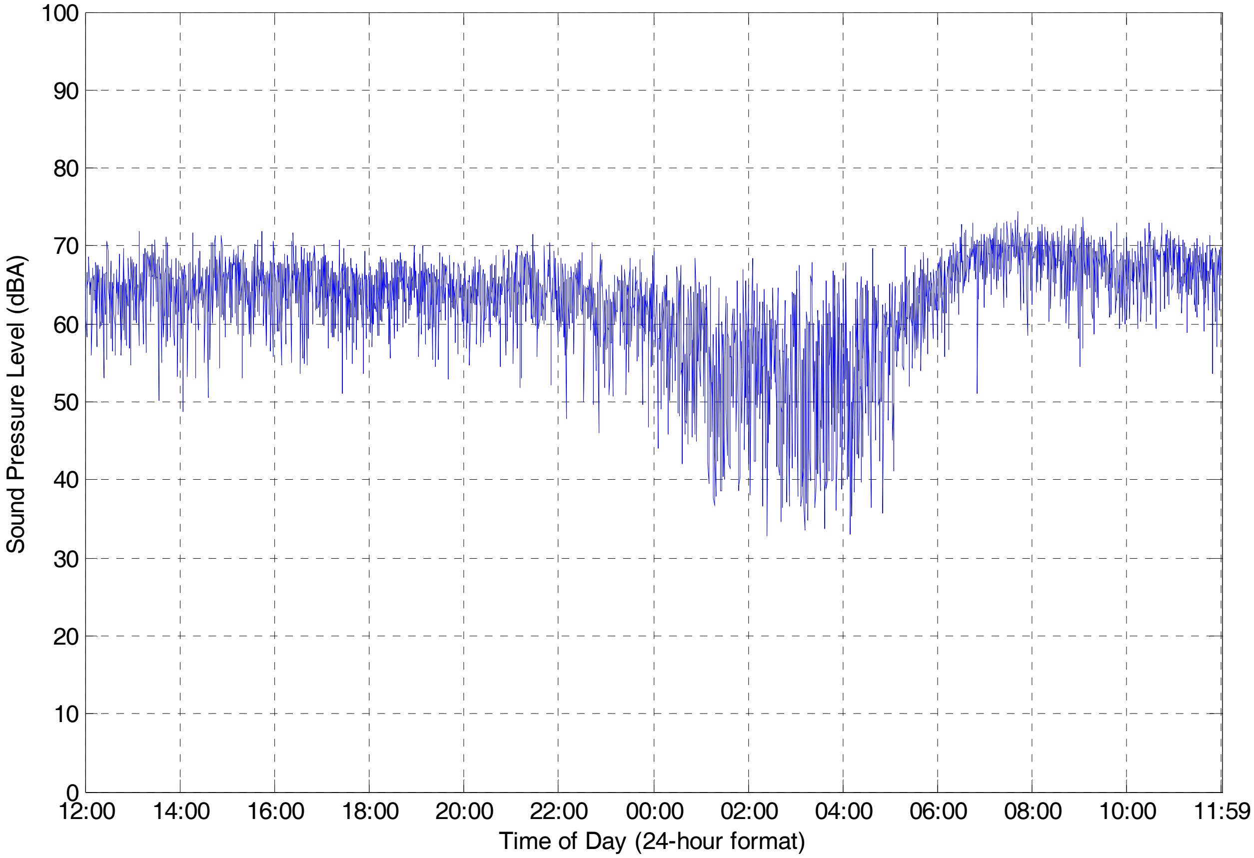

Figure 28. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 7

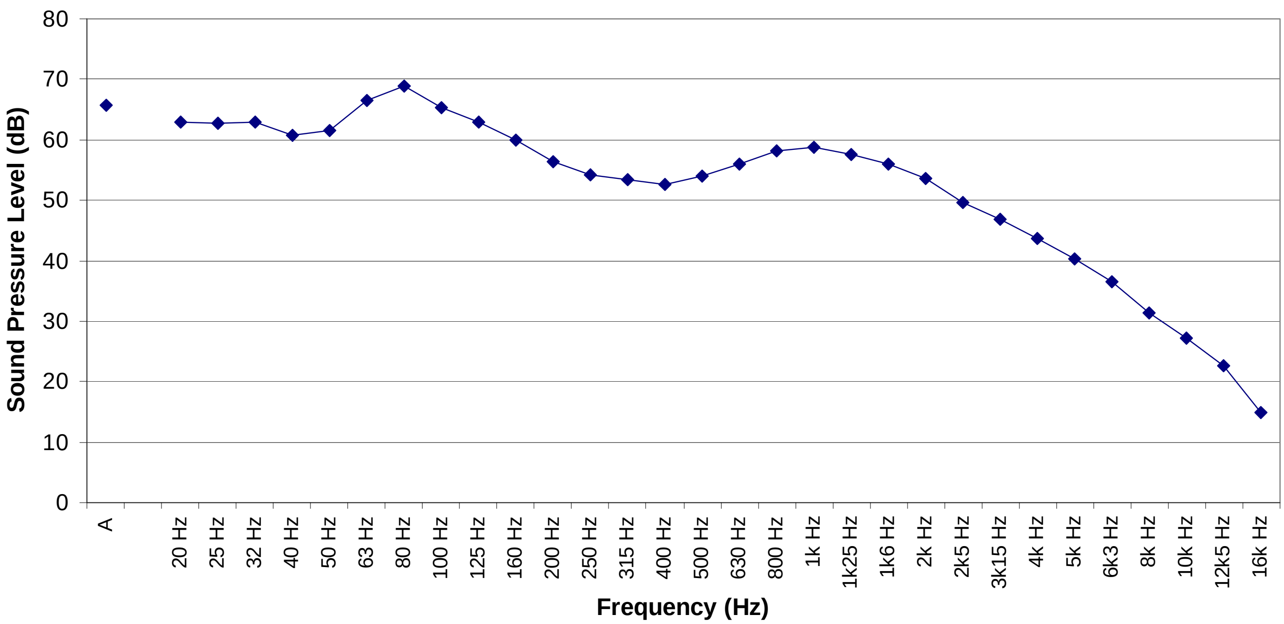

Figure 29. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 7

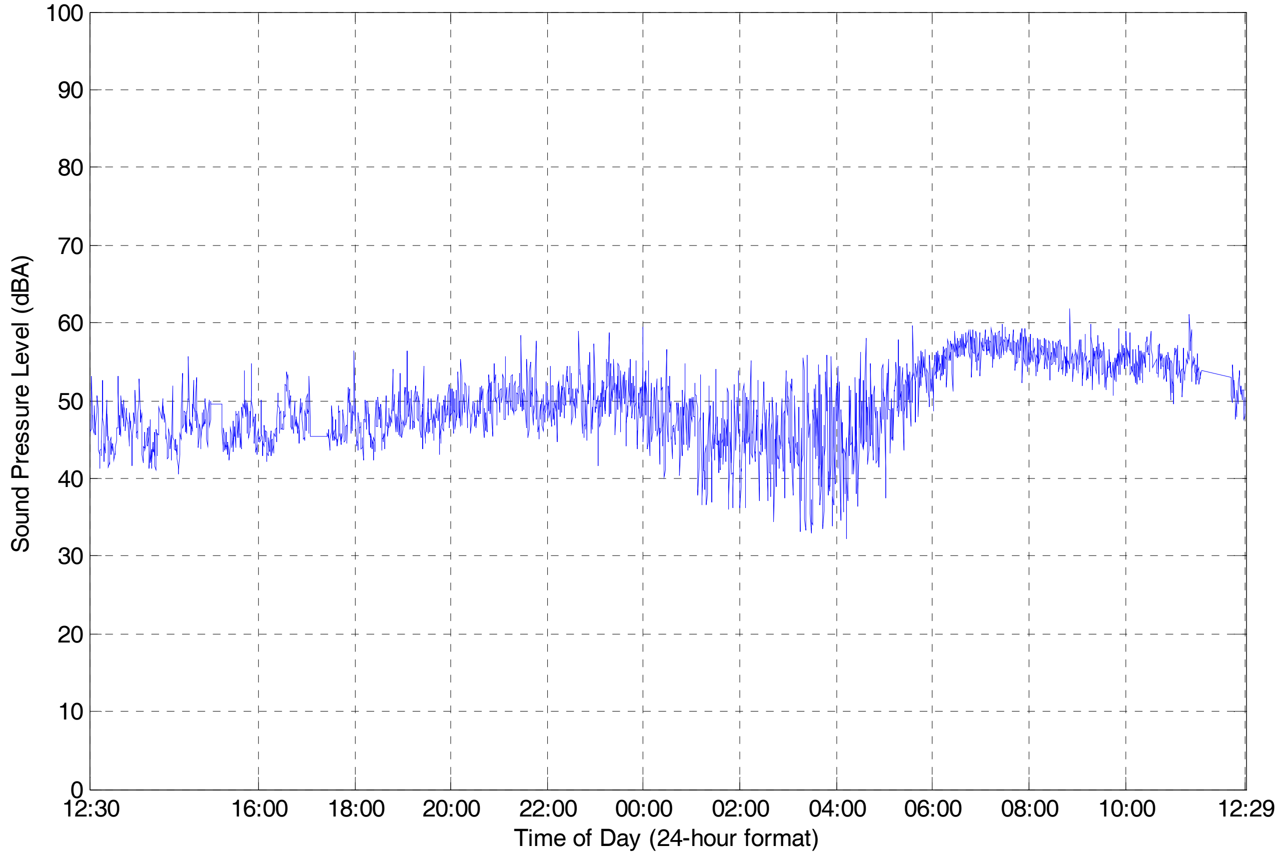

Figure 30. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 8

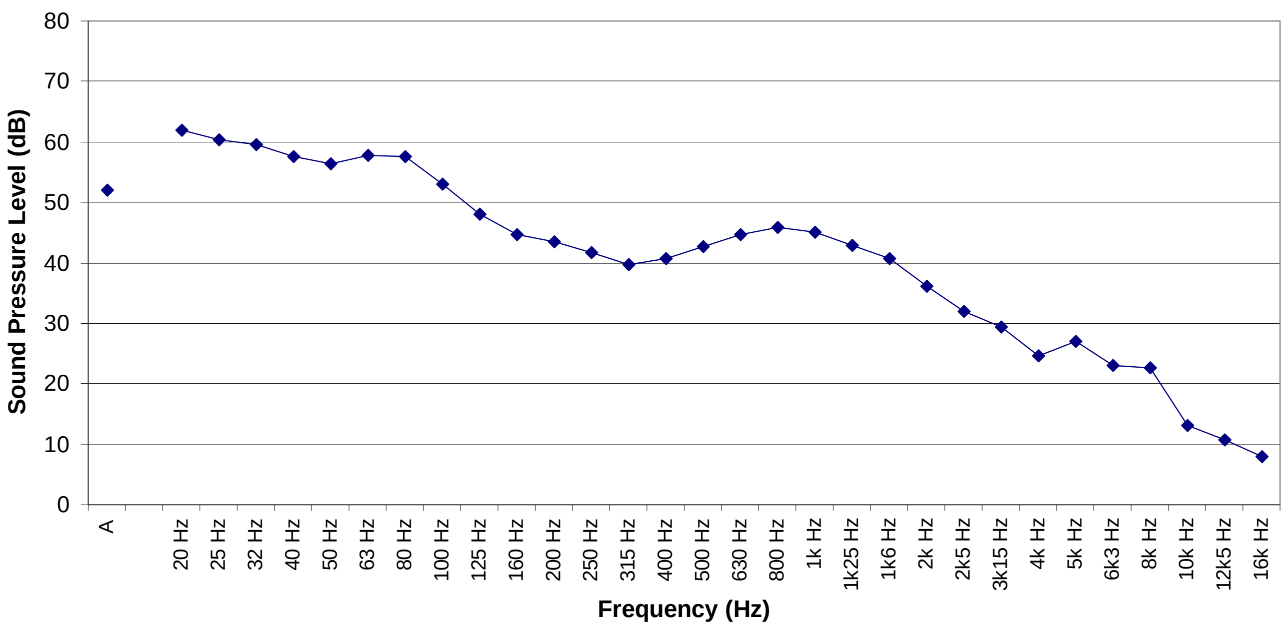

Figure 31. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 8

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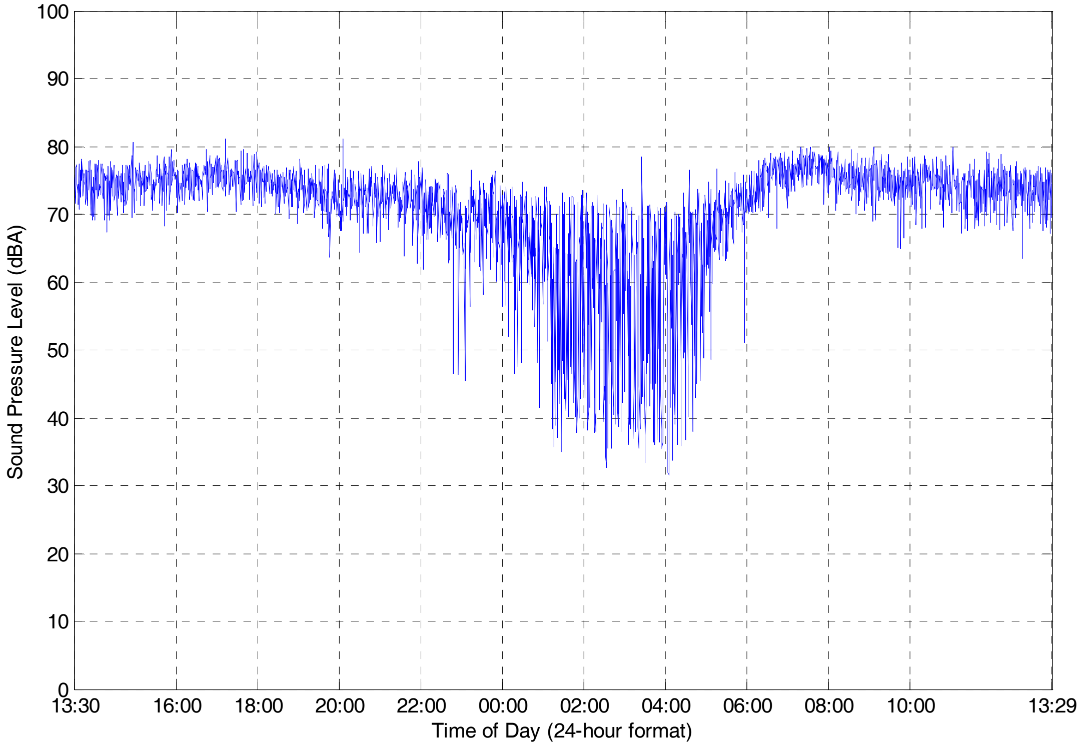

Figure 32. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 9 (Concrete)

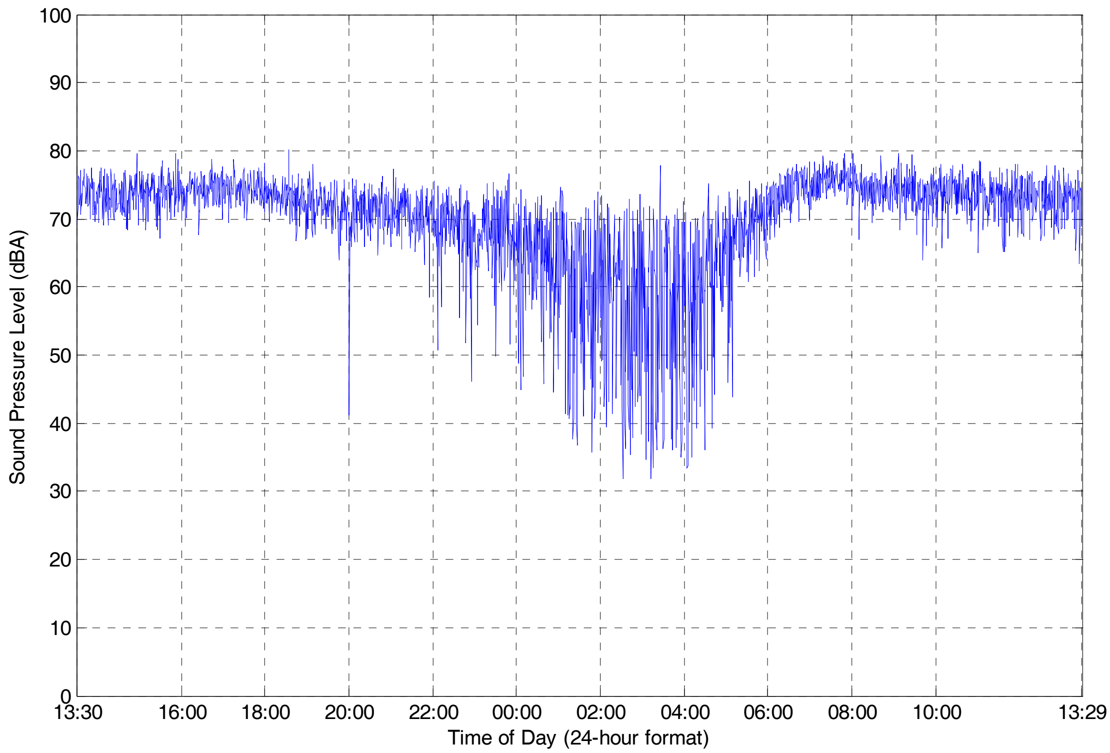

Figure 33. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 10 (Asphalt)

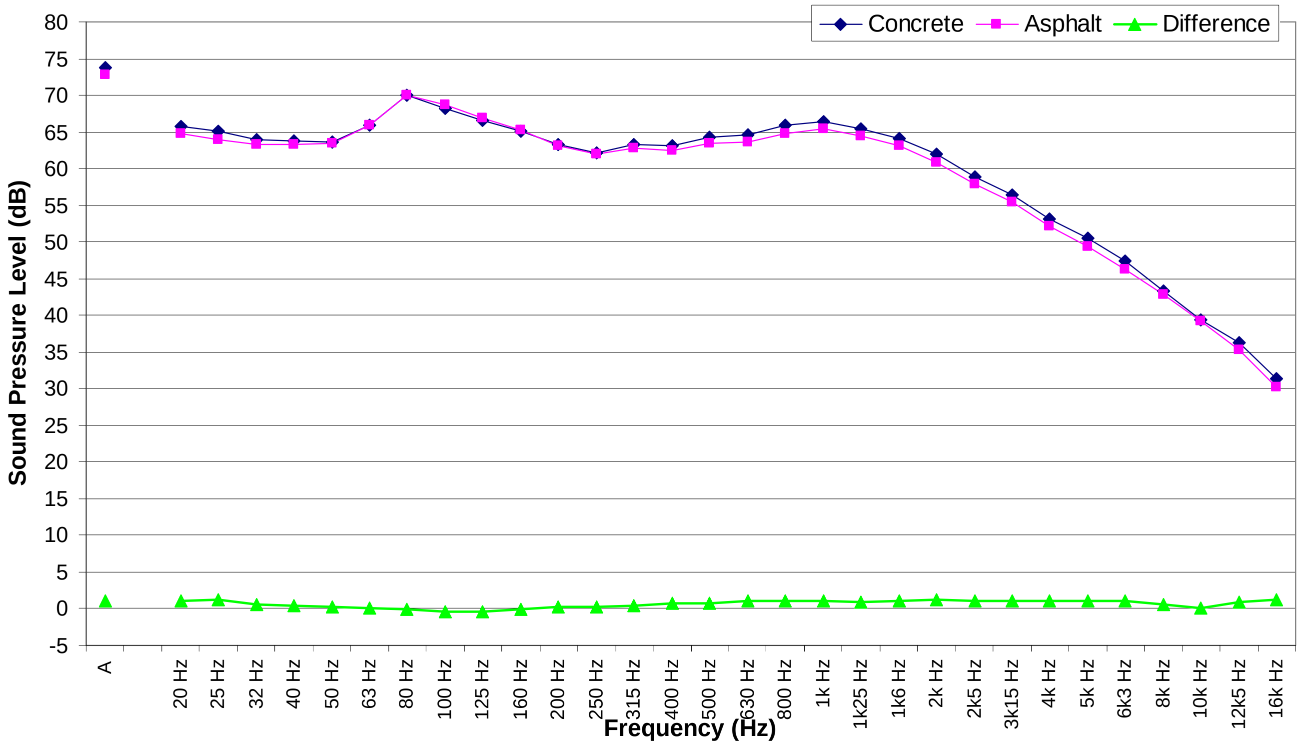

Figure 34. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitors 9 & 10

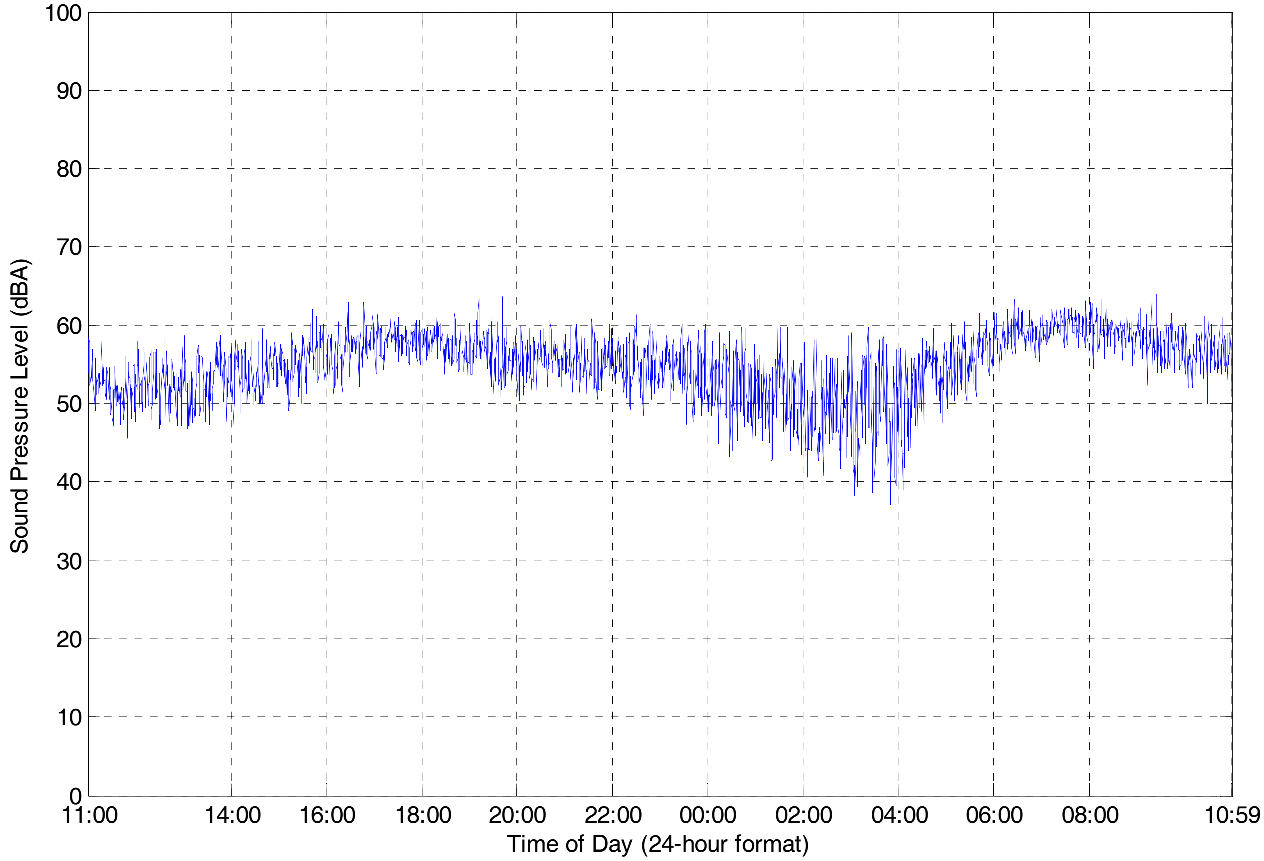

Figure 35. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 11

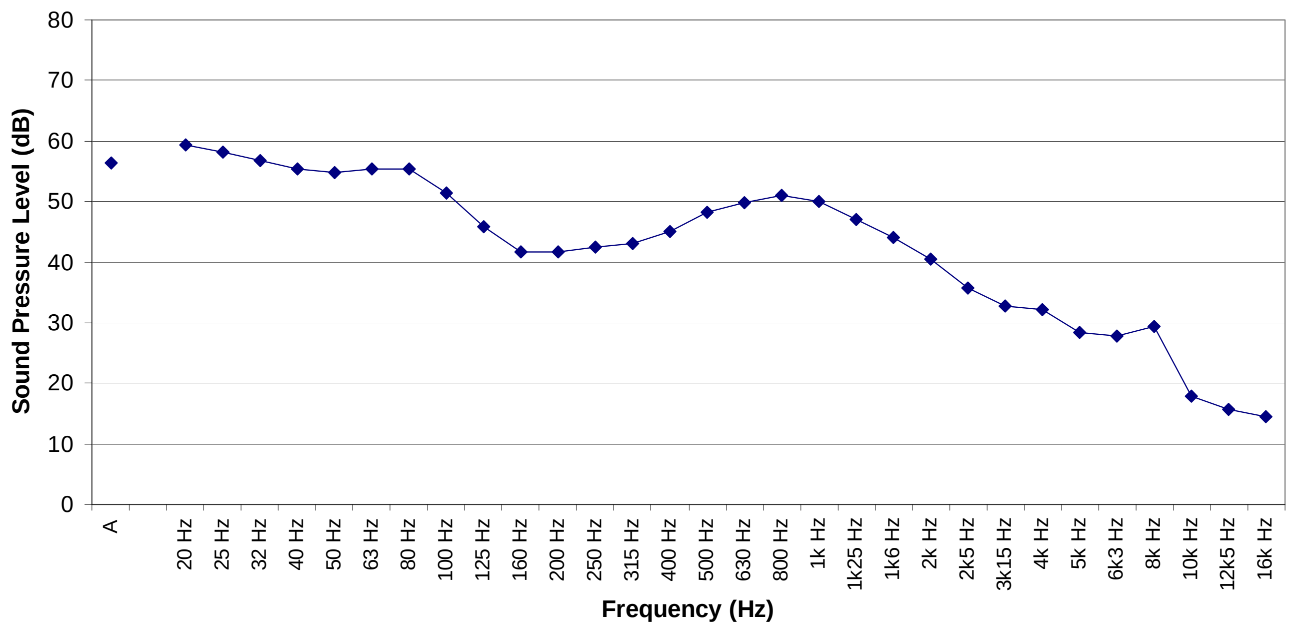

Figure 36. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 11

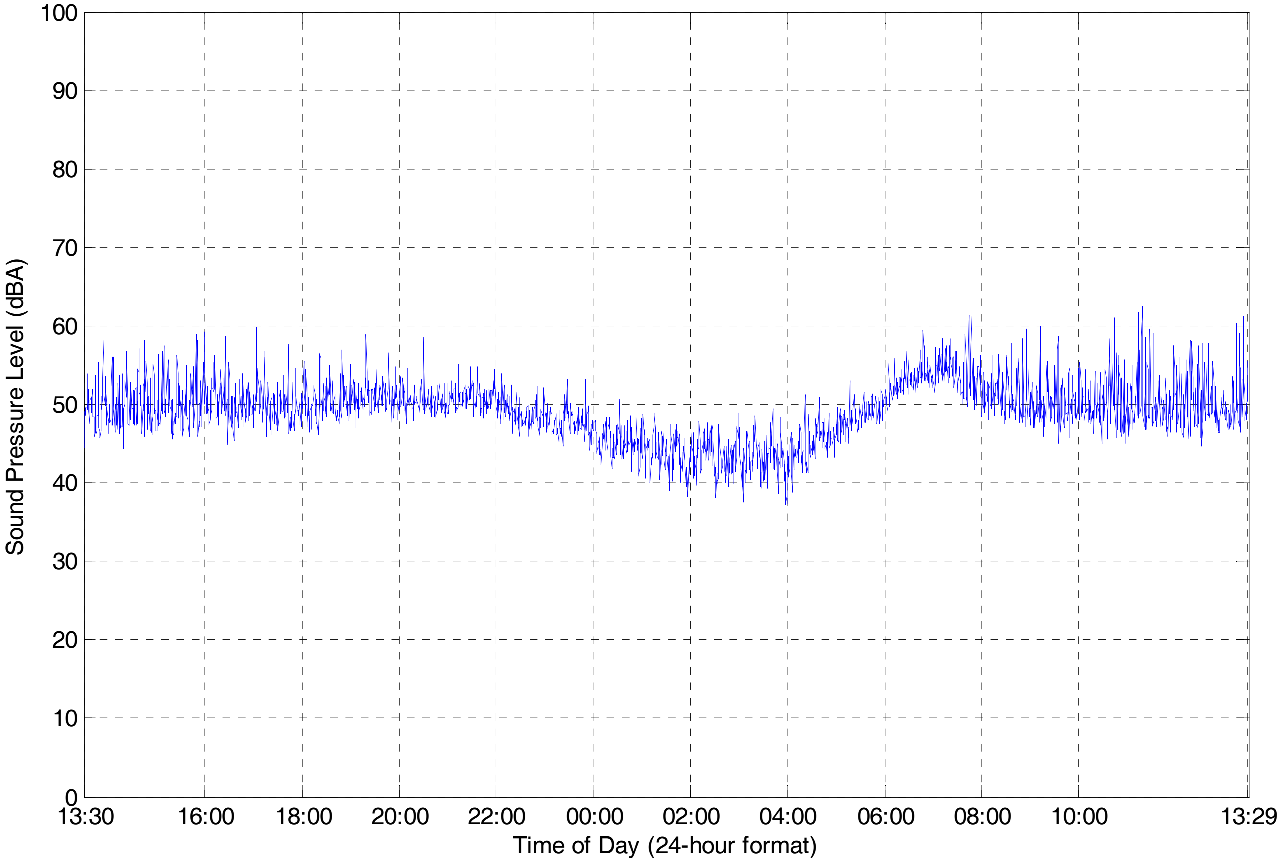

Figure 37. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 12

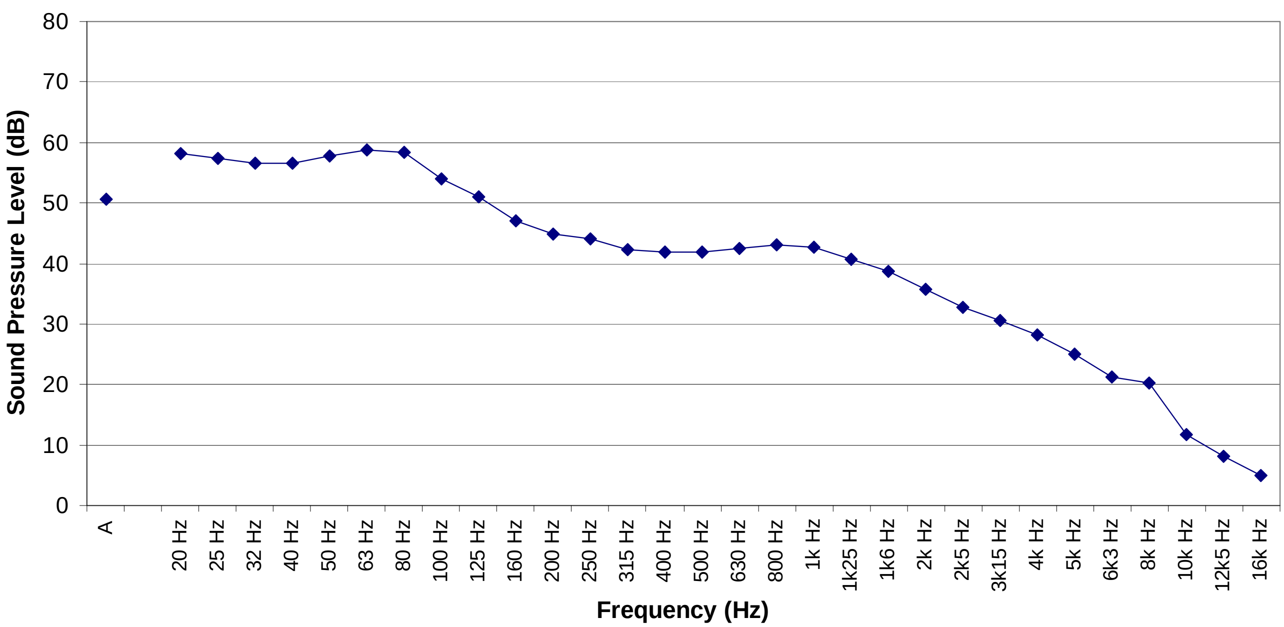

Figure 38. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 12

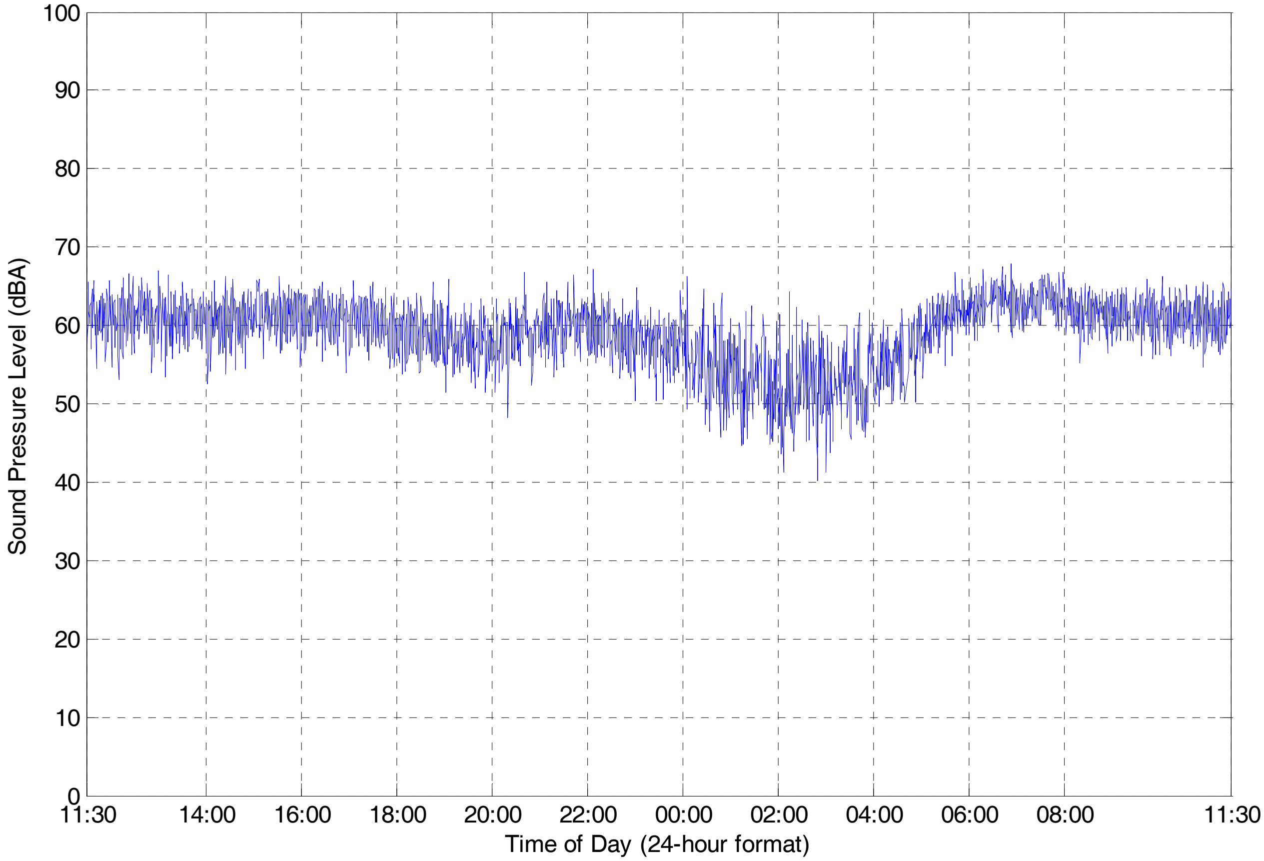

Figure 39. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 13

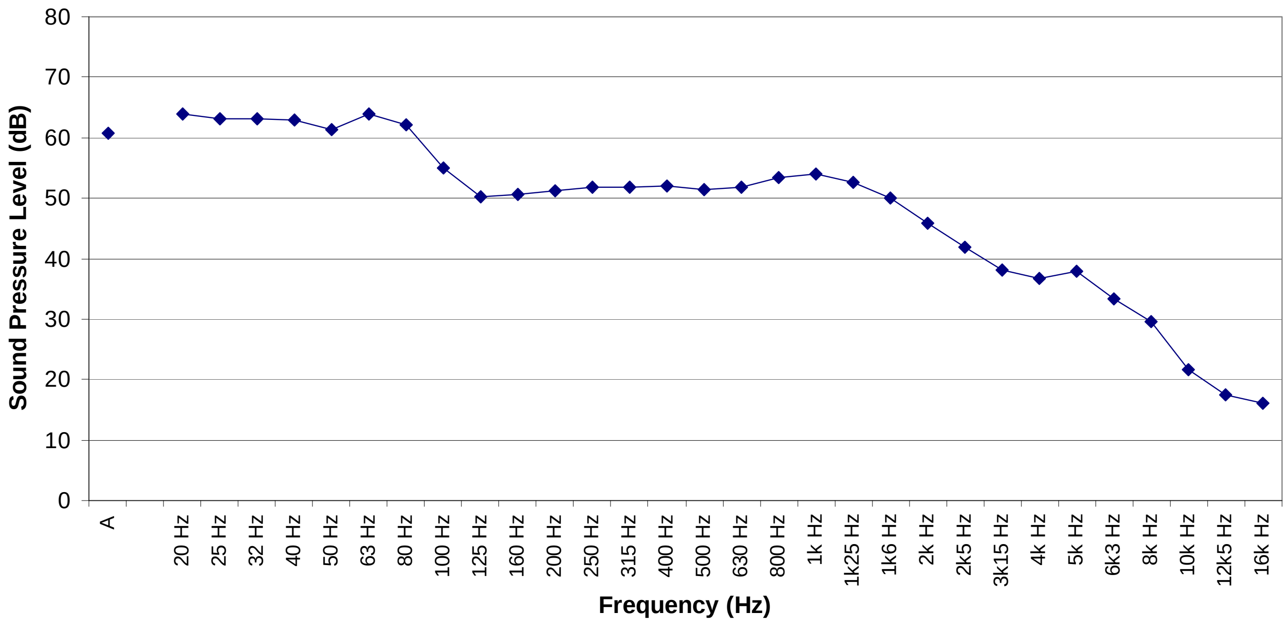

Figure 40. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 13

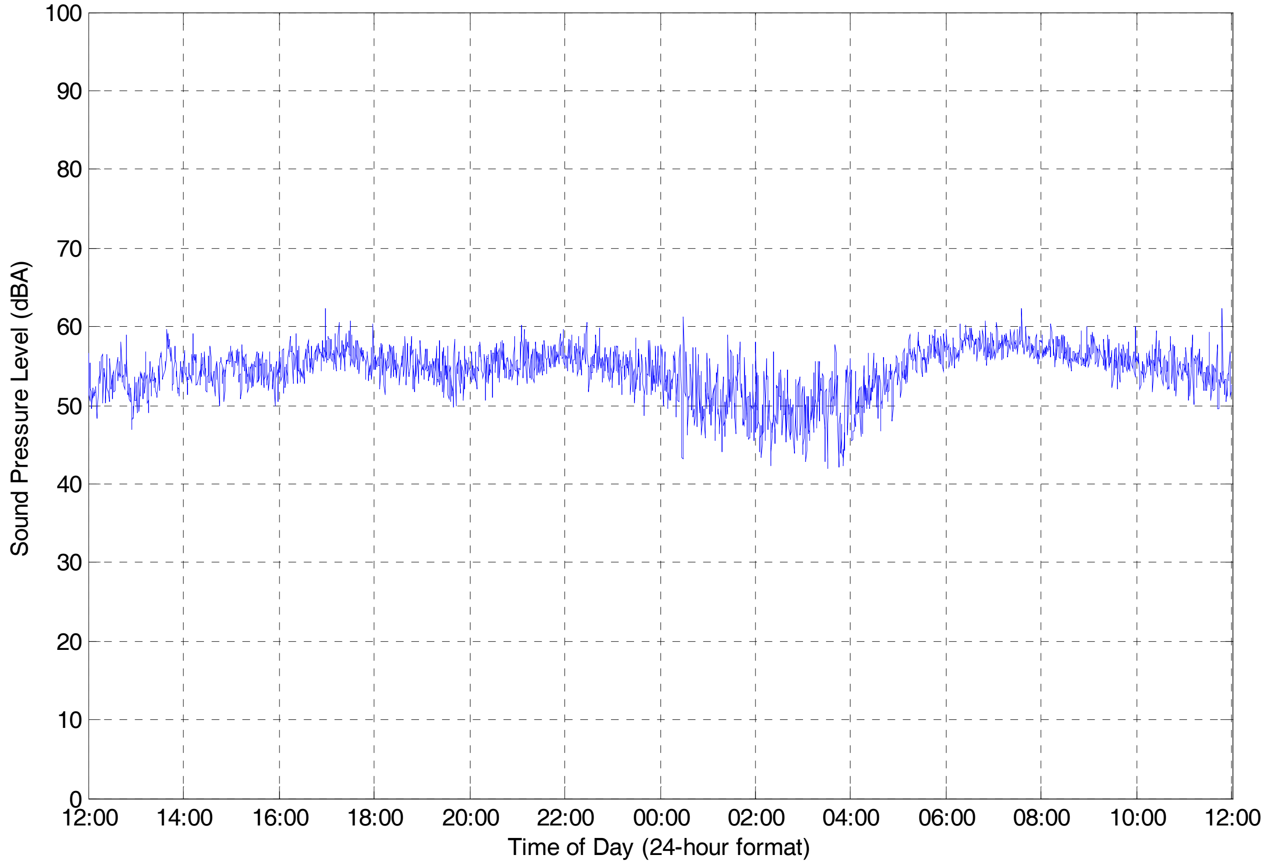

Figure 41. 24-Hour Broadband A-Weighted L_{eq} Sound Levels at Monitor 14

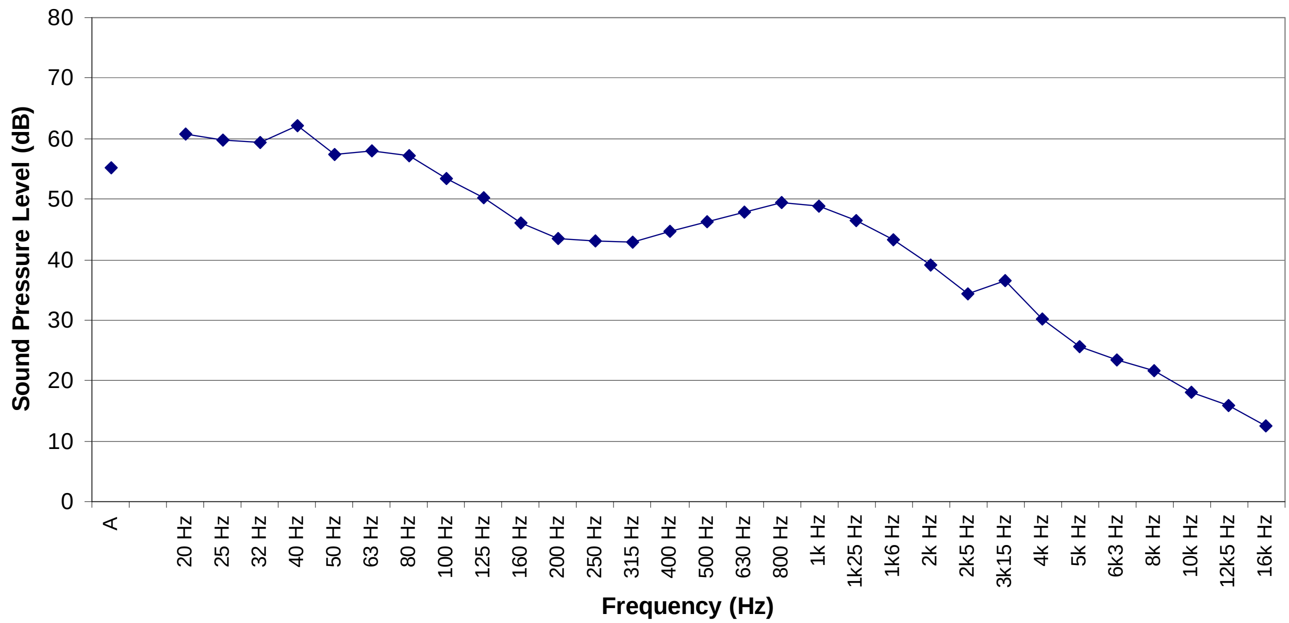

Figure 42. 24-Hour 1/3 Octave L_{eq} Sound Levels at Monitor 14

Figure 43a. 24-Hour Noise Modeling Results for Current Conditions

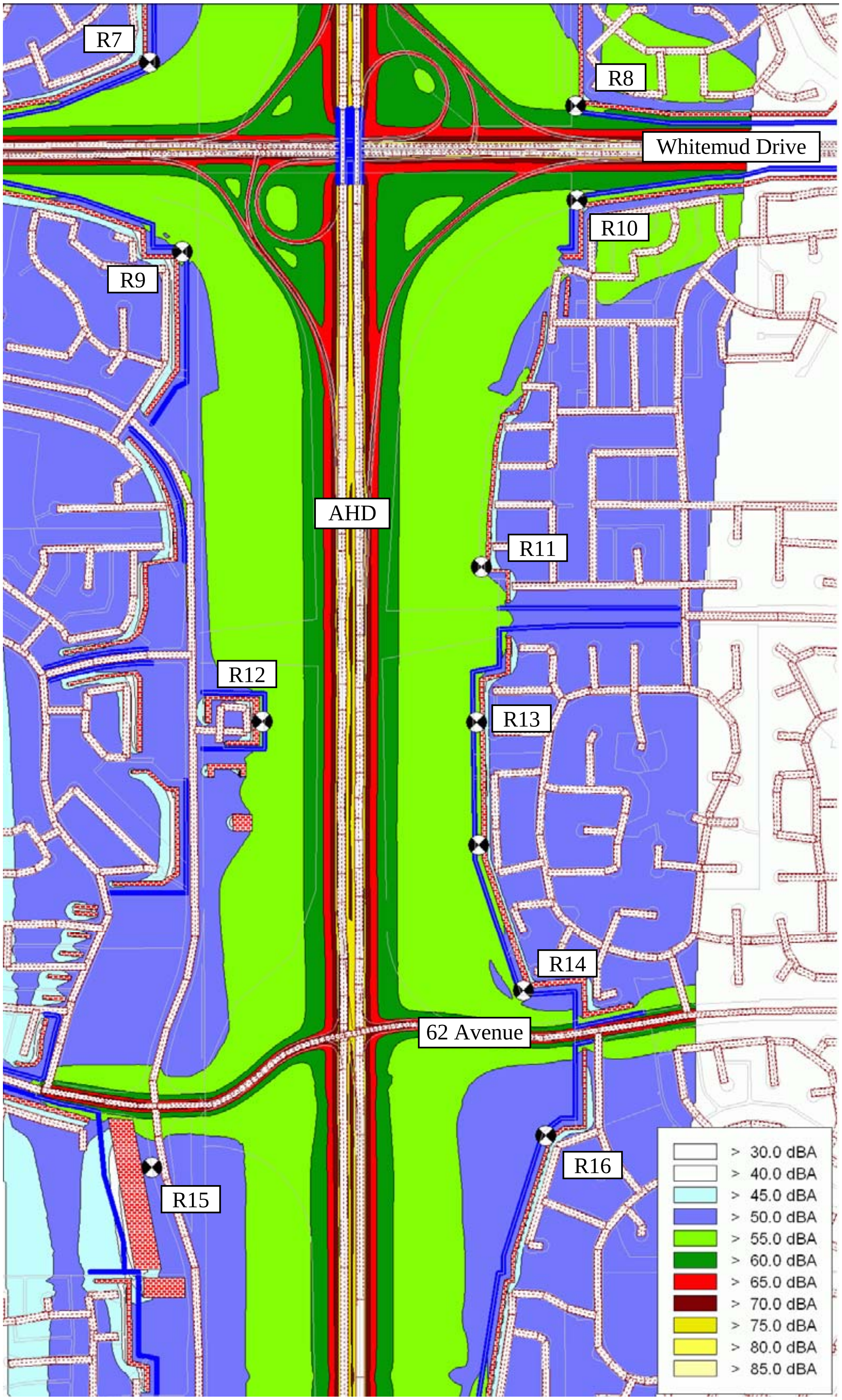

Figure 43b. 24-Hour Noise Modeling Results for Current Conditions

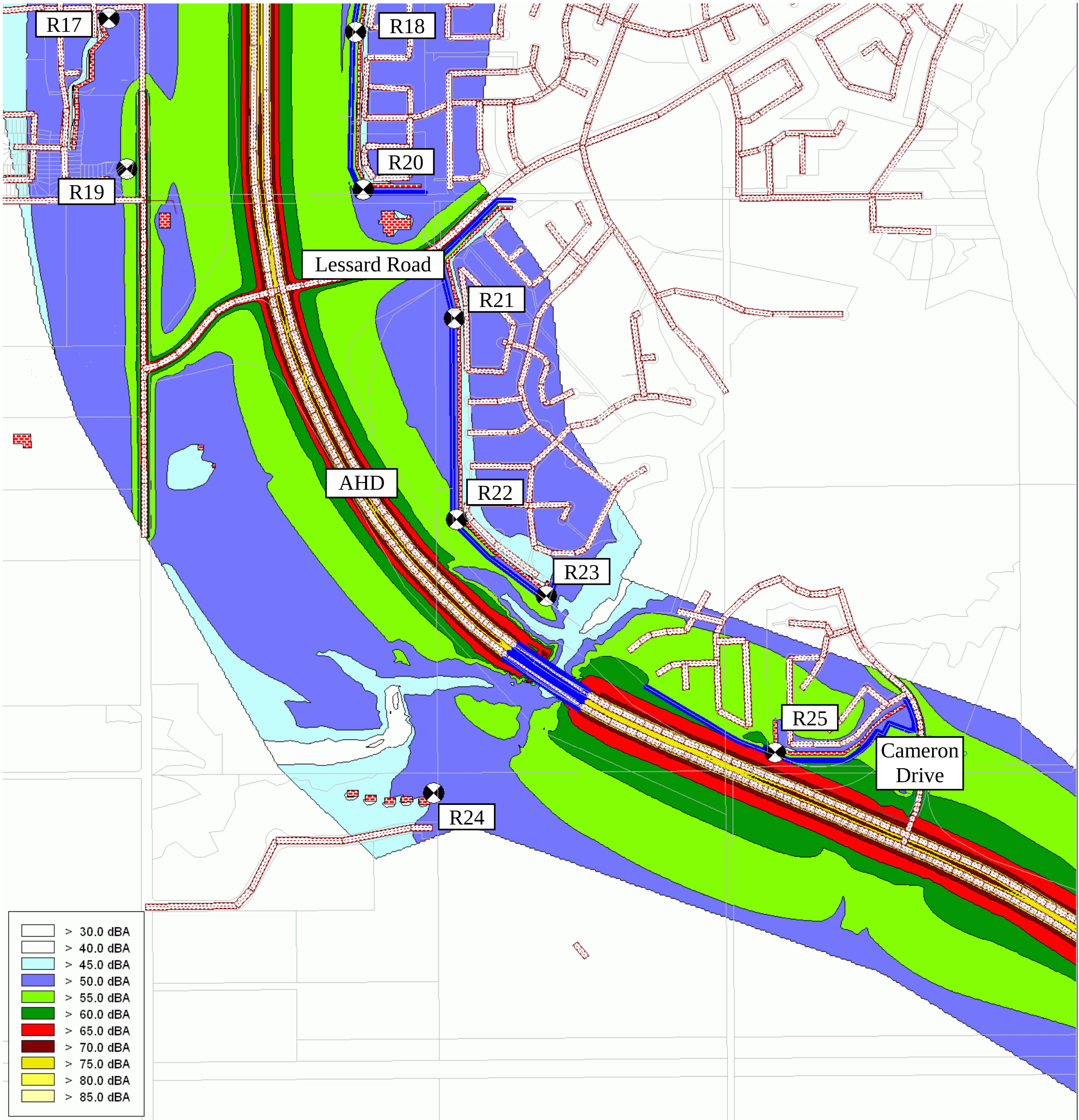

Figure 43c. 24-Hour Noise Modeling Results for Current Conditions

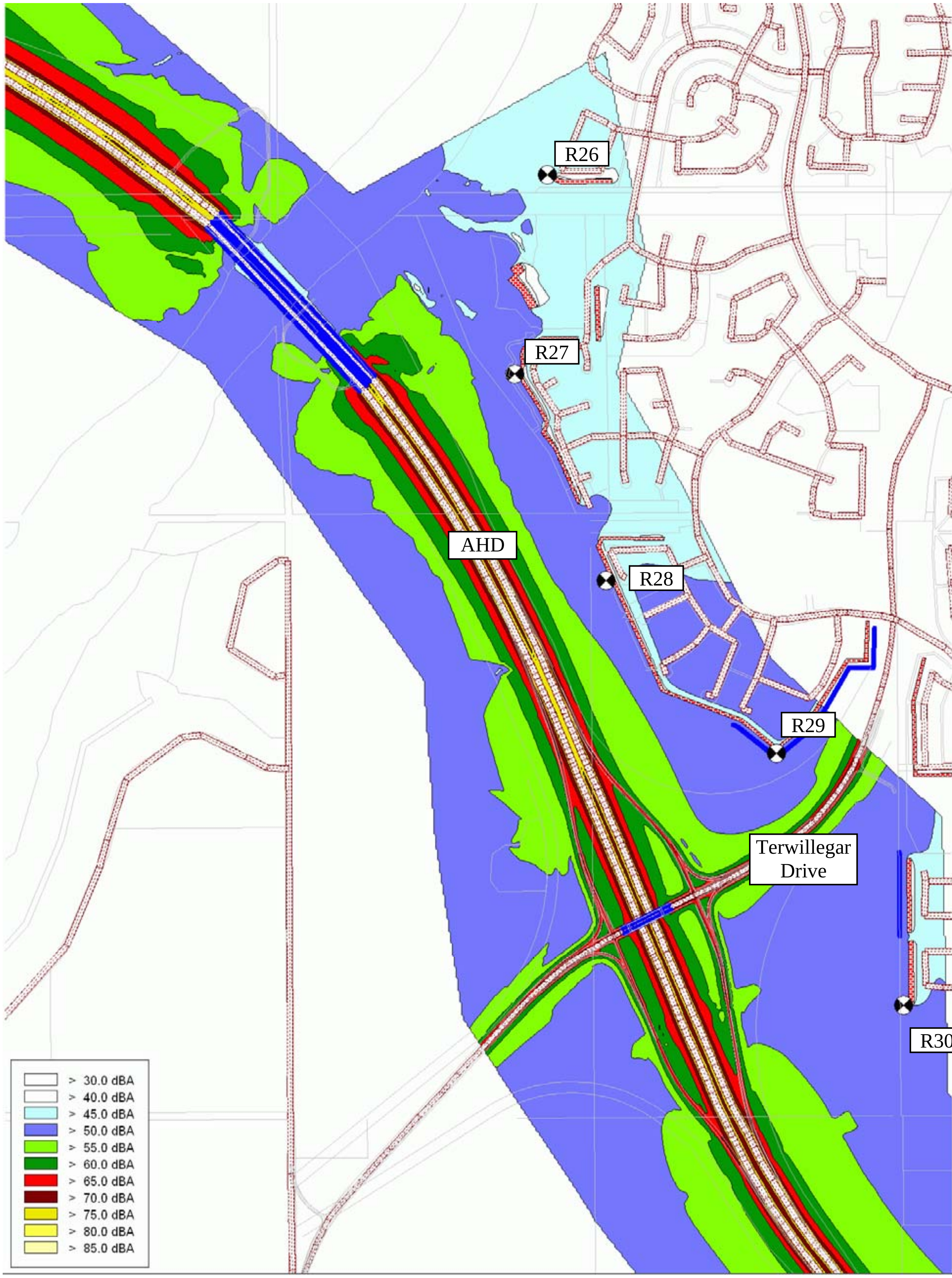

Figure 43d. 24-Hour Noise Modeling Results for Current Conditions

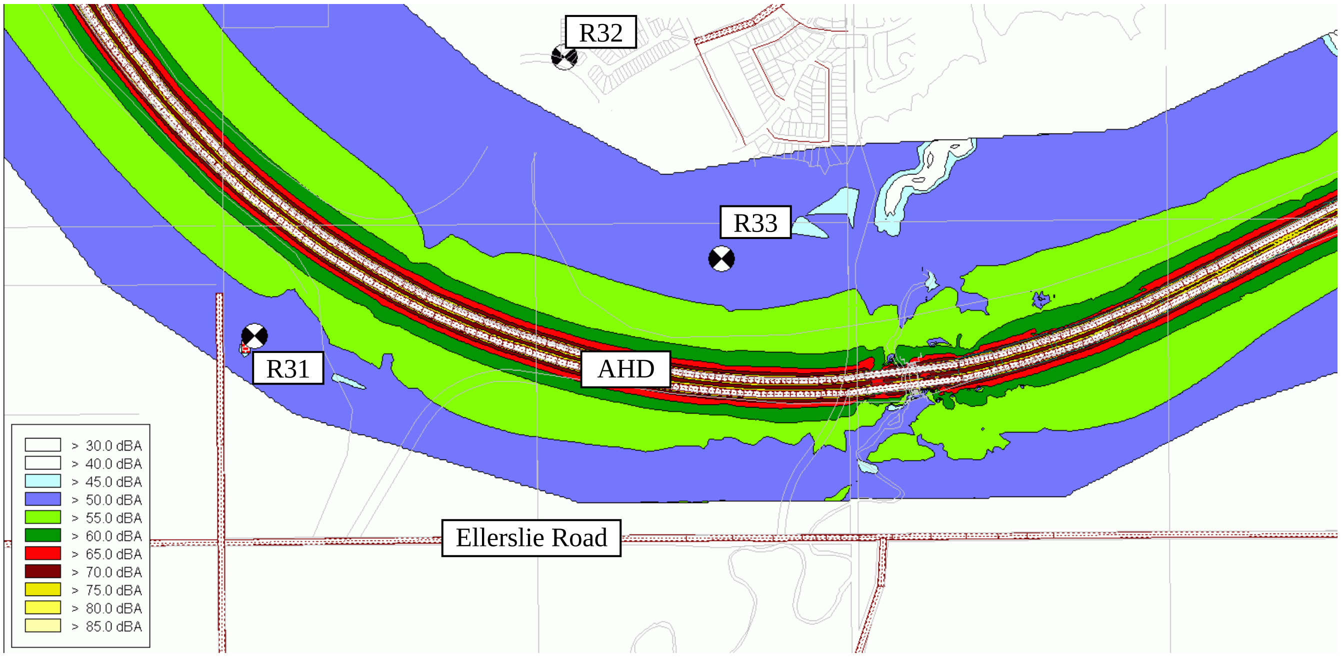

Figure 43e. 24-Hour Noise Modeling Results for Current Conditions

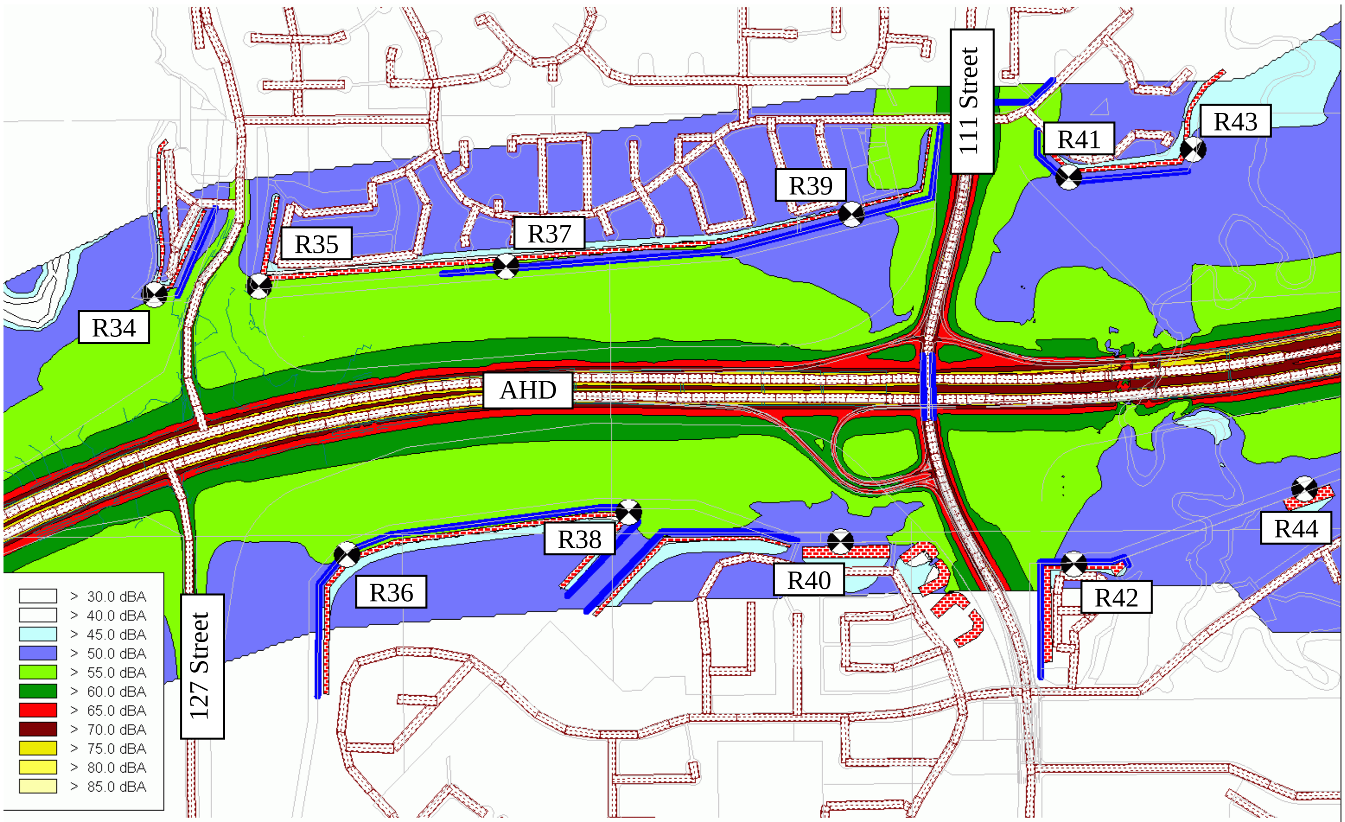

Figure 43f. 24-Hour Noise Modeling Results for Current Conditions

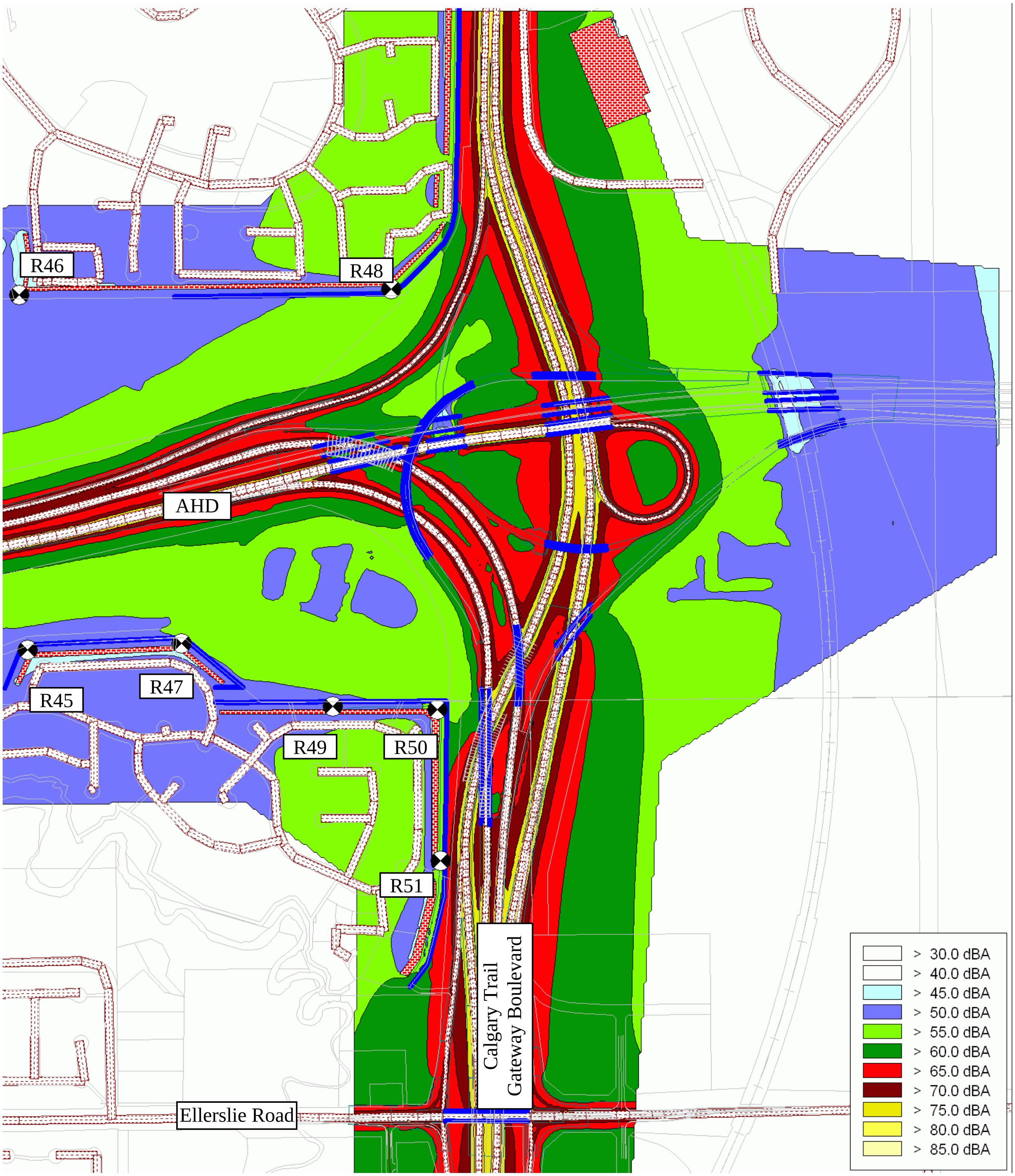

Figure 43g. 24-Hour Noise Modeling Results for Current Conditions

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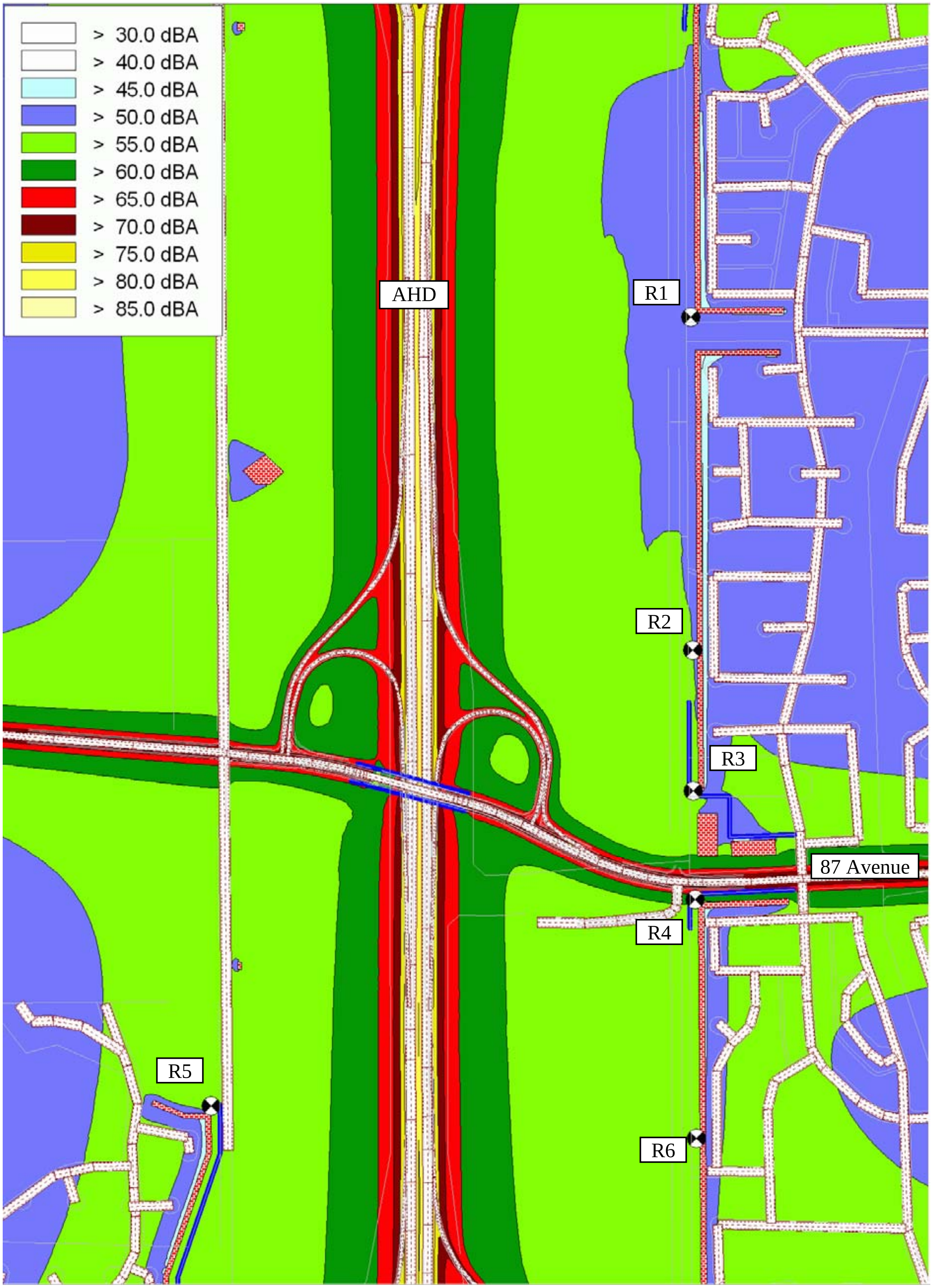

Figure 44a. 24-Hour Noise Modeling Results for Future Conditions

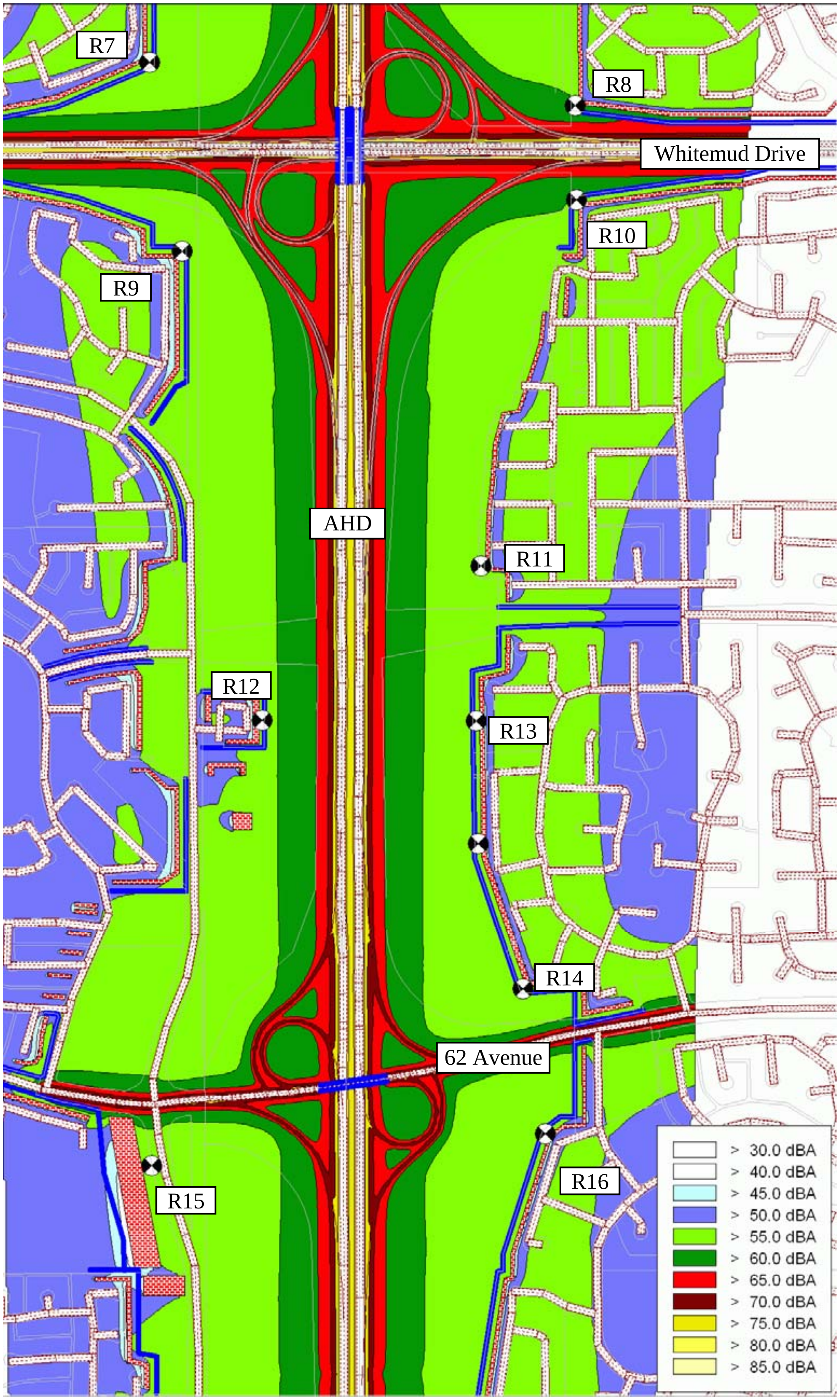

Figure 44b. 24-Hour Noise Modeling Results for Future Conditions

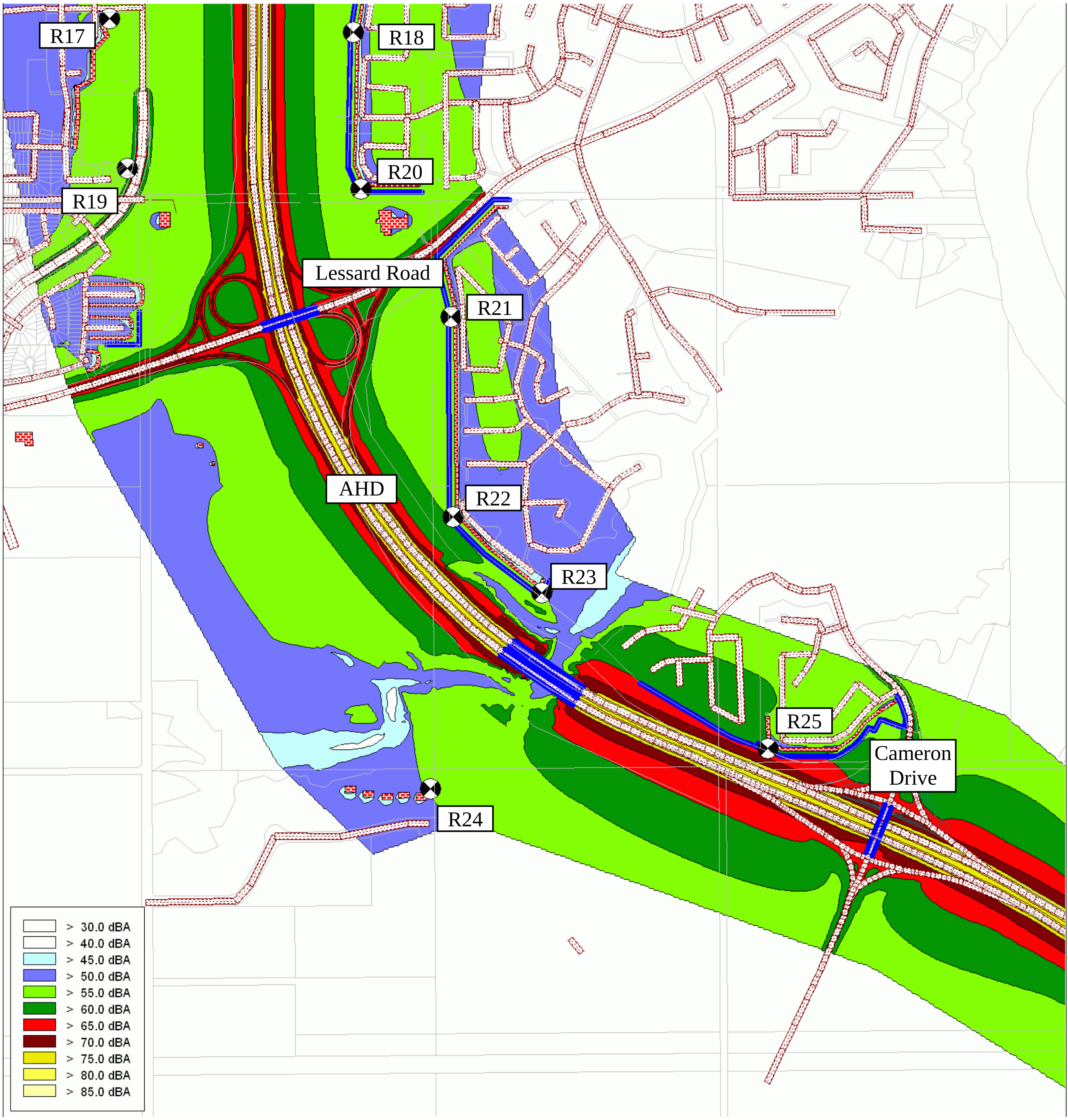

Figure 44c. 24-Hour Noise Modeling Results for Future Conditions

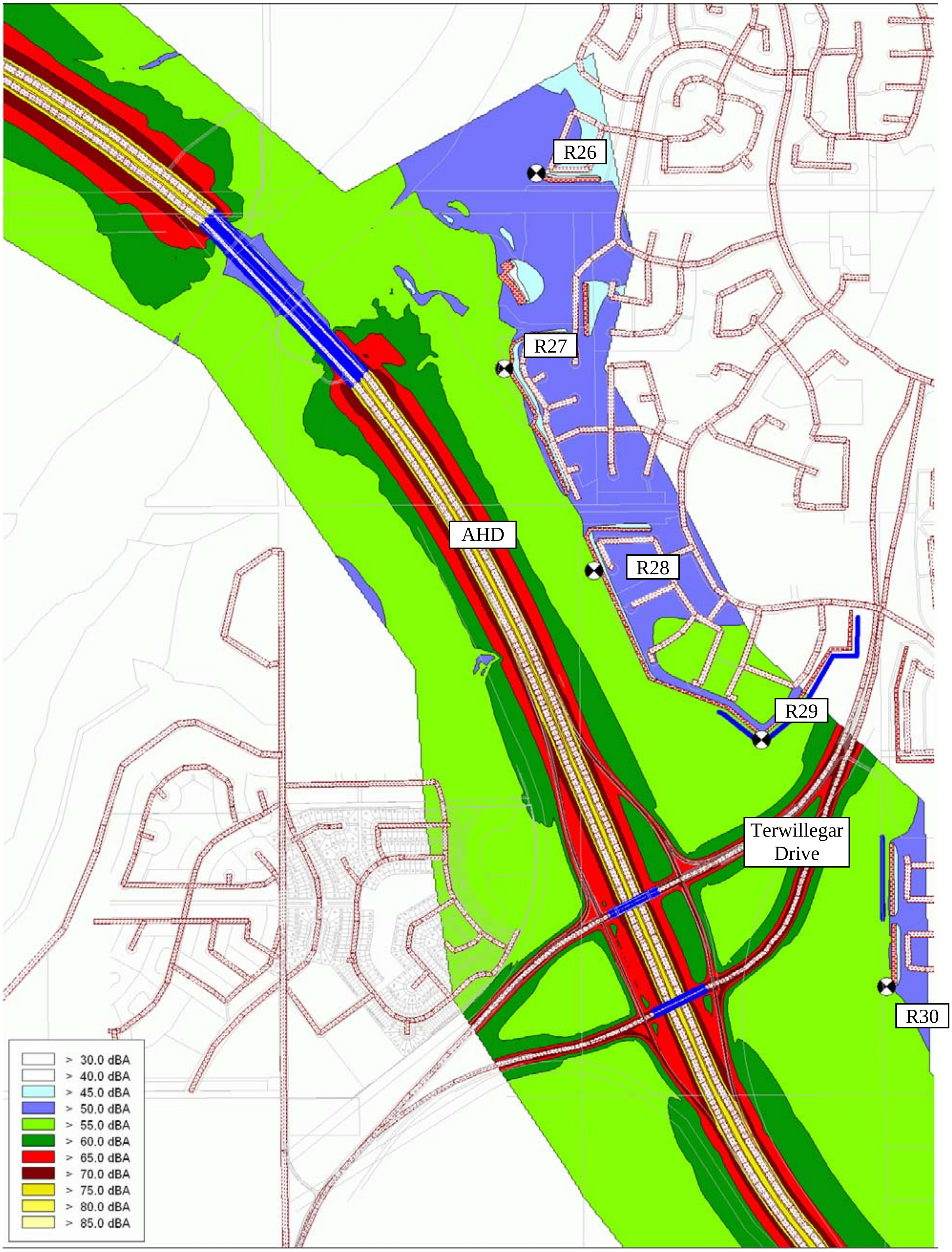

Figure 44d. 24-Hour Noise Modeling Results for Future Conditions

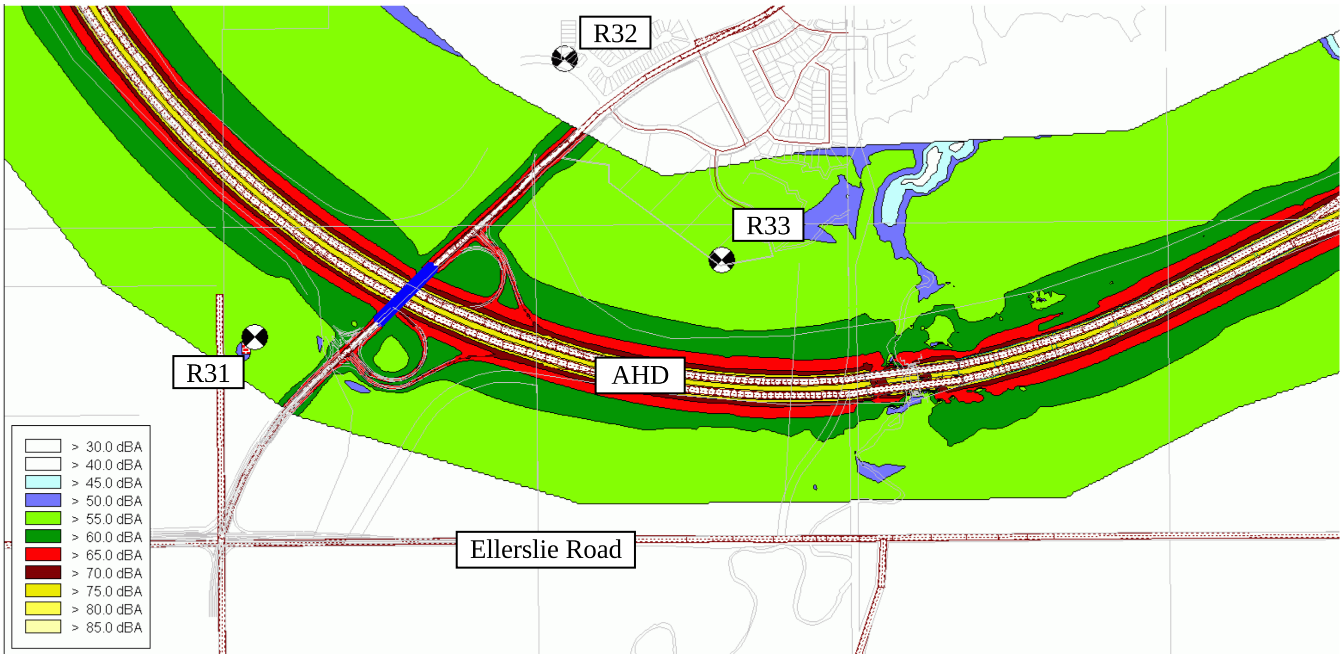

Figure 44e. 24-Hour Noise Modeling Results for Future Conditions

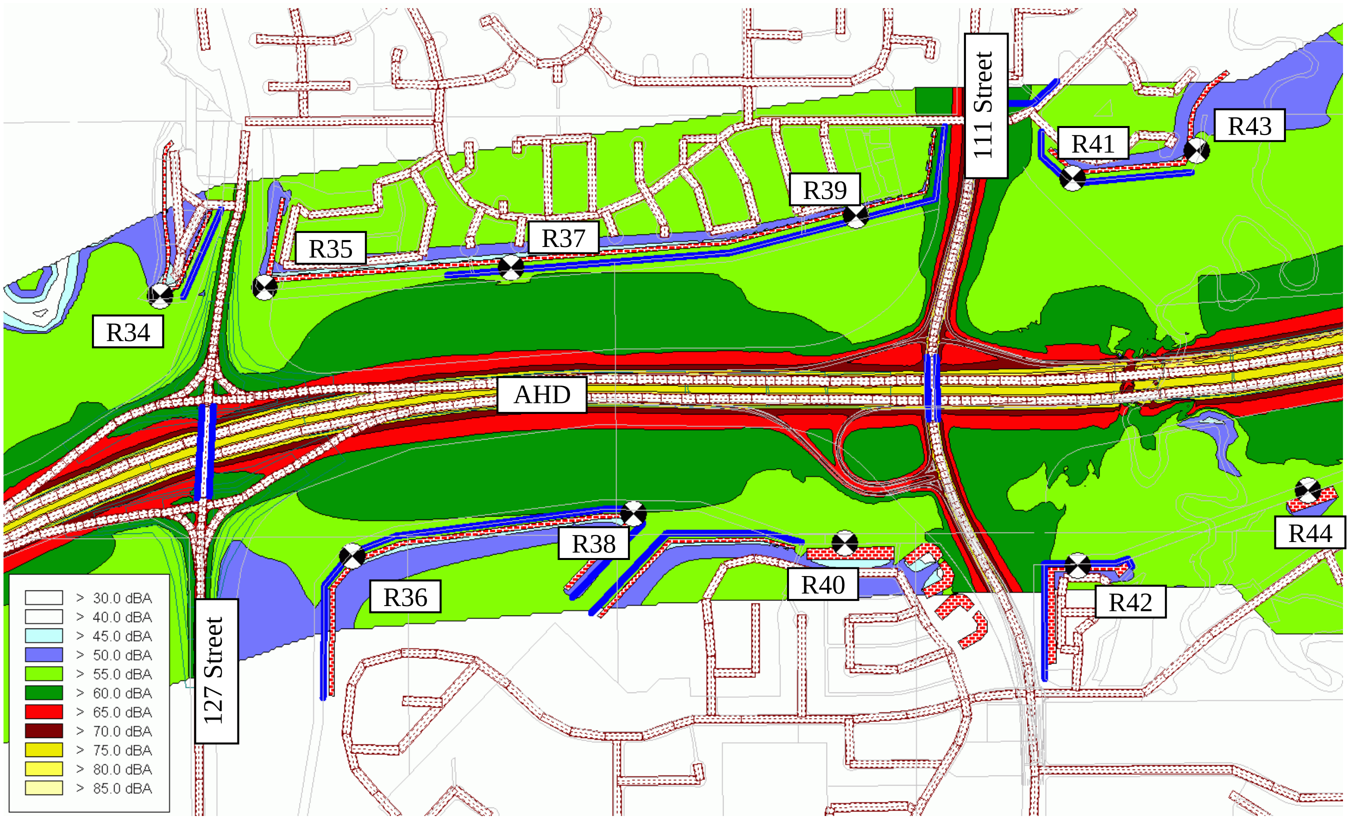

Figure 44f. 24-Hour Noise Modeling Results for Future Conditions

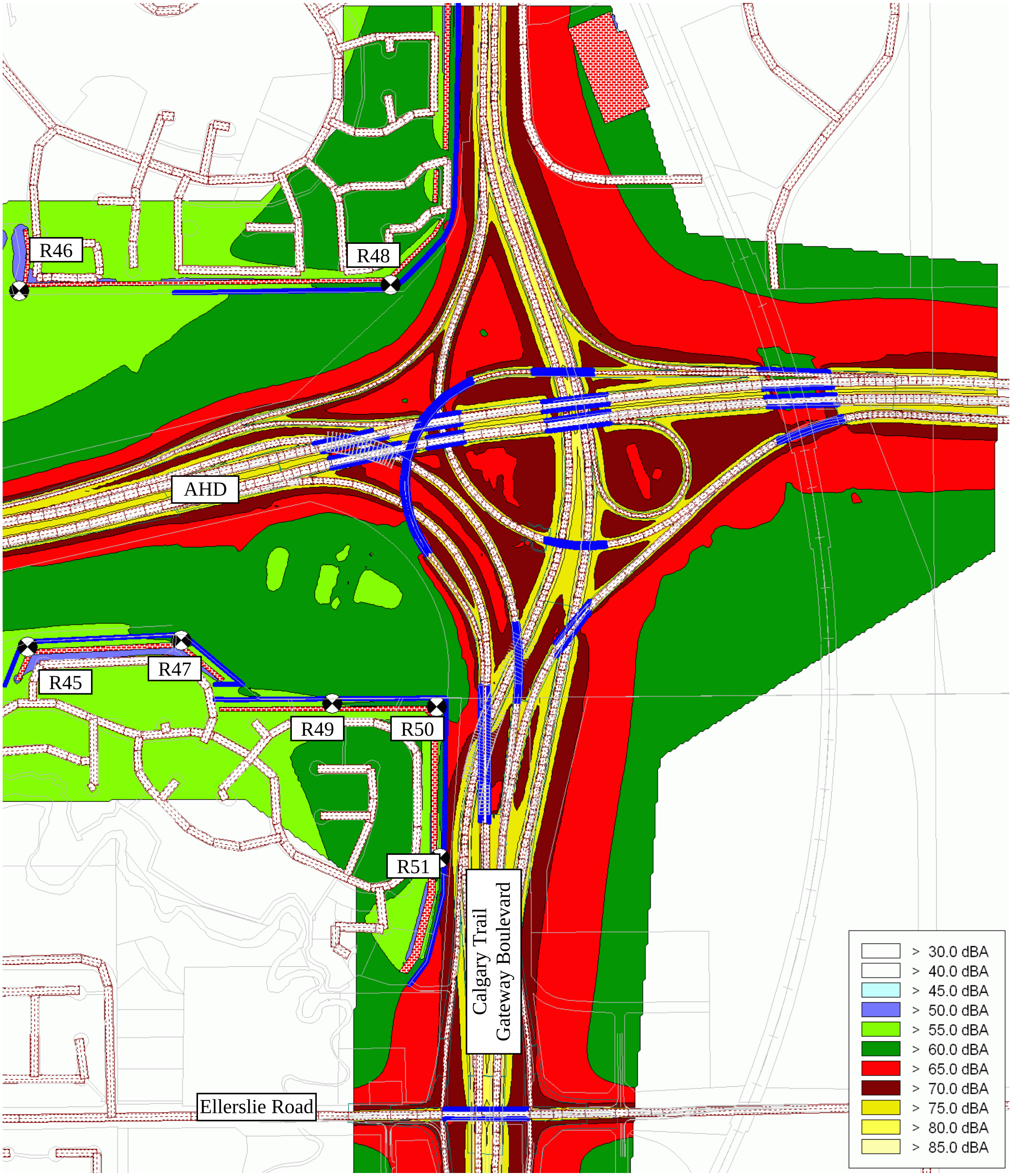

Figure 44g. 24-Hour Noise Modeling Results for Future Conditions

Appendix I

MEASUREMENT EQUIPMENT USED

Monitors 4, 5, 9, 10, 13, 14

The environmental noise monitoring equipment used at Monitors 4, 5, 9, 10, 13, & 14 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 30-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 conforms to IEC 60942 and ANSI S1.40. The sound level meter, pre-amplifier, microphone, and calibrator (type Larson Davis CAL 200) were re-certified on December 7, 2006 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.

Monitors 1, 2, 6, 7, 11

The environmental noise monitoring equipment used at Monitors 1, 2, 6, 7, & 11 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 30-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 June 9, 2005 / February 26, 2007 and the calibrators (type B&K 4231) were certified on June 23, 2006 / February 15, 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.

Monitors 3, 8, 12

The environmental noise monitoring equipment used at Monitors 3, 8, 12 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 30-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, microphone and calibrator (type B&K 4230) were certified on December 18, 2006 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.

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 2.5m 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
M1	May 14 2007	7:50	Pre	93.9 dBA	B&K 4231	2478139
M1	May 15 2007	8:10	Post	93.9 dBA	B&K 4231	2478139
M2	May 14 2007	8:20	Pre	93.9 dBA	B&K 4231	2575493
M2	May 15 2007	8:40	Post	93.9 dBA	B&K 4231	2575493
M3	May 14 2007	8:50	Pre	93.9 dBA	B&K 4230	566599
M3	May 15 2007	9:10	Post	93.7 dBA	B&K 4230	566599
M4	May 14 2007	9:20	Pre	114.0 dBA	Larson Davis Cal200	3657
M4	May 15 2007	9:40	Post	114.0 dBA	Larson Davis Cal200	3657
M5	May 14 2007	9:50	Pre	114.0 dBA	Larson Davis Cal200	4092
M5	May 15 2007	10:10	Post	114.0 dBA	Larson Davis Cal200	4092
M6	May 15 2007	10:50	Pre	93.9 dBA	B&K 4231	2478139
M6	May 16 2007	11:10	Post	93.9 dBA	B&K 4231	2478139
M7	May 15 2007	11:50	Pre	93.9 dBA	B&K 4231	2575493
M7	May 16 2007	12:10	Post	93.8 dBA	B&K 4231	2575493
M8	May 15 2007	12:20	Pre	93.9 dBA	B&K 4230	566599
M8	May 16 2007	12:40	Post	93.7 dBA	B&K 4230	566599
M9	May 15 2007	13:00	Pre	114.0 dBA	Larson Davis Cal200	3657
M9	May 16 2007	13:40	Post	114.0 dBA	Larson Davis Cal200	3657
M10	May 15 2007	13:20	Pre	114.0 dBA	Larson Davis Cal200	4092
M10	May 16 2007	13:50	Post	114.0 dBA	Larson Davis Cal200	4092
M11	May 30 2007	10:30	Pre	93.9 dBA	B&K 4231	2478139
M11	May 31 2007	11:10	Post	93.8 dBA	B&K 4231	2478139
M12	May 31 2007	13:15	Pre	93.9 dBA	B&K 4230	566599
M12	June 1 2007	13:40	Post	93.8 dBA	B&K 4230	566599
M13	May 30 2007	11:20	Pre	114.0 dBA	Larson Davis Cal200	3657
M13	May 31 2007	11:50	Post	113.8 dBA	Larson Davis Cal200	3657
M14	May 30 2007	11:50	Pre	114.0 dBA	Larson Davis Cal200	4092
M14	May 31 2007	12:20	Post	113.9 dBA	Larson Davis Cal200	4092

Larson Davis Unit #1 SLM Calibration Certificate

Larson Davis
A PCB Group Co.

Certificate of Calibration and Conformance

Certificate Number 2006-87566

Instrument Model 824, Serial Number 2627, was calibrated on 12DEC2006. 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: 12DEC2006

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	LDSigGn/2209	0617 / 0104	12 Months	31JAN2007	2006-76574

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

Calibration Environmental Conditions

Temperature: 23 ° Centigrade Relative Humidity: 27 %

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 Corporate Headquarters. 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:
Technician: Sean Childs

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Larson Davis Unit #1 Microphone Calibration Certificate

Larson Davis
A PCB Group Co.

Certificate of Calibration and Conformance

Certificate Number 2006-86779

Microphone Model 2551, Serial Number 0782, was calibrated on 01DEC2006. The microphone meets current factory specifications per Test Procedure D0001.8161.

Instrument found to be in calibration as received: YES
Date Calibrated: 01DEC2006

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	2559	3026	12 Months	25MAY2007	14237-1
Larson Davis	2900	0575	12 Months	27JUN2007	2006-81604
Larson Davis	CAL250	42630	12 Months	03AUG2007	2006-82792
Larson Davis	2559	3034LF	12 Months	30AUG2007	2006-83723
Larson Davis	PRM902	0529	12 Months	06SEP2007	2006-83918
Larson Davis	PRM902	0528	12 Months	06SEP2007	2006-83919
Larson Davis	MTS1000 / 2201	1000 / 0100	12 Months	11SEP2007	2006-0911-1
Larson Davis	PRM915	0102	12 Months	13NOV2007	2006-86003
Larson Davis	PRM902	0206	12 Months	13NOV2007	2006-85999
Larson Davis	PRM916	0102	12 Months	13NOV2007	2006-86001
Hewlett Packard	34401A	3146A62099	12 Months	13NOV2007	294807

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 Corporate Headquarters. 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: Scott Montgomery
Technician: Scott Montgomery

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Larson Davis Unit #1 Preamplifier Calibration Certificate

Larson Davis
A PCB Group Co.

Certificate of Calibration and Conformance

Certificate Number 2006-87555

Instrument Model 902, Serial Number 2588, was calibrated on 12DEC2006. The instrument meets factory specifications per Procedure D0001.8167.

Instrument found to be in calibration as received: YES
Date Calibrated: 12DEC2006

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Hewlett Packard	34401A	US36023299	14 Months	04MAR2007	286223
Larson Davis	LDSigGn/2209	0445 / 0111	12 Months	13NOV2007	2006-86046

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

Calibration Environmental Conditions

Temperature: 23 ° Centigrade Relative Humidity: 27 %

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 Corporate Headquarters. 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

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Larson Davis Unit #1 Calibrator Calibration Certificate

Larson Davis
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Certificate of Calibration and Conformance

Certificate Number 2006-87202

Instrument Model CAL200, Serial Number 3657, was calibrated on 07DEC2006.
The instrument meets factory specifications per Procedure D0001.8190.

Instrument found to be in calibration as received: YES
Date Calibrated: 07DEC2006

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Schaevitz	P3061-15PSIA	17588	12 Months	16FEB2007	287327
Larson Davis	2900	0661	12 Months	04APR2007	2006-78704
Larson Davis	2559	2506	12 Months	18APR2007	14031-1
Hewlett Packard	34401A	US36033460	12 Months	02JUN2007	290347
Hewlett Packard	34401A	3146A10352	12 Months	23JUN2007	291010
Larson Davis	MTS1000/2201	0111	12 Months	11SEP2007	2006-0911-2
Larson Davis	PRM915	0112	12 Months	18SEP2007	2006-84212
Larson Davis	PRM902	0480	12 Months	18SEP2007	2006-84211

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 Corporate Headquarters. 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: 114.05 dB, 94.06 dB, 1000.3 Hz @ sea level.
After: 114.01 dB, 94.01 dB, 1000.3 Hz @ sea level.

Signed: Scott Montgomery
Technician: Scott Montgomery

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Larson Davis Unit #2 SLM Calibration Certificate

Larson Davis
A PCB Group Co.

Certificate of Calibration and Conformance

Certificate Number 2006-87567

Instrument Model 824, Serial Number 2920, was calibrated on 12DEC2006. 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: 12DEC2006

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	LDSigGn/2209	0662/0114	12 Months	31JAN2007	2006-76552

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

Calibration Environmental Conditions

Temperature: 23 ° Centigrade

Relative Humidity: 27 %

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 Corporate Headquarters. 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

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Larson Davis Unit #2 Microphone Calibration Certificate

~ Certificate of Calibration and Compliance ~

Microphone Model: 377B02 Serial Number: 103984 Manufacturer: PCB

Calibration Environmental Conditions

Environmental test conditions as printed on microphone calibration chart.

Reference Equipment

Manufacturer	Model #	Serial #	PCB Control #	Cal Date	Due Date
Hewlett Packard	34401A	MY41045214	LD-001	3/15/06	3/15/07
Larson Davis	PRM915	113	TA-470	2/15/06	2/15/07
Larson Davis	PRM902	2699	TA-468	2/3/06	2/2/07
Larson Davis	PRM916	104	LD-015	2/15/06	2/15/07
Larson Davis	CAL250	4147	LD-018	11/10/06	11/10/07
Larson Davis	2201	115	TA-472	2/15/06	2/15/07
Larson Davis	2900	664	CA-520	11/15/05	11/15/07
Larson Davis	PRA951-4	222	LD-026	8/16/06	8/16/07
Larson Davis	PRM902	2892	LD-004	3/20/06	3/20/07
Larson Davis	PRM902	2891	LD-003	3/20/06	3/20/07
Larson Davis	2559LF	3035	LD-005	3/20/06	3/20/07
Bruel & Kjaer	4192	2493416	LD-029	1/3/06	1/3/07
Larson Davis	ADP005	1	LD-017	3/15/05	3/15/07
Fisher Scientific	02-400	51253176	CA-897	8/3/06	8/3/07

Frequency sweep performed with B&K UA0033 electrostatic actuator.

Condition of Unit

As Found: N/A

As Left: New unit in tolerance

Notes

1. Calibration of reference microphone is traceable through PTB.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Open circuit sensitivity is measured using the insertion voltage method following procedure AT603-5.
6. Measurement uncertainty (95% confidence level with coverage factor of 2) for sensitivity is +/-0.20 dB.
7. A one-year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user.

Technician: Joe Ziewicki Date: December 12, 2006

ACCREDITED Cert. No. 1862.01

PCB PIEZOTRONICS VIBRATION DIVISION

3425 Walden Avenue, Depew, New York, 14043

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ID:3248797776.525

Page 1 of 2

Larson Davis Unit #2 Preamplifier Calibration Certificate

Larson Davis
A PCB Group Co.

Certificate of Calibration and Conformance

Certificate Number 2006-87556

Instrument Model 902, Serial Number 3048, was calibrated on 12DEC2006. The instrument meets factory specifications per Procedure D0001.8167.

Instrument found to be in calibration as received: YES
Date Calibrated: 12DEC2006

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Hewlett Packard	34401A	US36023299	14 Months	04MAR2007	286223
Larson Davis	LDSigGn/2209	0445 / 0111	12 Months	13NOV2007	2006-86046

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

Calibration Environmental Conditions

Temperature: 23 ° Centigrade

Relative Humidity: 27 %

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 Corporate Headquarters. 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

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Larson Davis Unit #2 Calibrator Calibration Certificate

Larson Davis

A PCB Group Co.

Certificate of Calibration and Conformance

Certificate Number 2006-87203

Instrument Model CAL200, Serial Number 4092, was calibrated on 07DEC2006. The instrument meets factory specifications per Procedure D0001.8190.

Instrument found to be in calibration as received: YES
Date Calibrated: 07DEC2006

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Schaevitz	P3061-15PSIA	17588	12 Months	16FEB2007	287327
Larson Davis	2900	0661	12 Months	04APR2007	2006-78704
Larson Davis	2559	2506	12 Months	18APR2007	14031-1
Hewlett Packard	34401A	US36033460	12 Months	02JUN2007	290347
Hewlett Packard	34401A	3146A10352	12 Months	23JUN2007	291010
Larson Davis	MTS1000/2201	0111	12 Months	11SEP2007	2006-0911-2
Larson Davis	PRM915	0112	12 Months	18SEP2007	2006-84212
Larson Davis	PRM902	0480	12 Months	18SEP2007	2006-84211

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 Corporate Headquarters. 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.

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Signed: Scott Montgomery
Technician: Scott Montgomery

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B&K 2250 Unit #1 Calibration Certificate(s)

OB. NR | LOC.

MANUFACTURER'S CERTIFICATE OF CONFORMANCE

We certify that Brüel & Kjær -2250--- Serial No 2488495
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 9-jun-2005

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

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Brüel & Kjær

Prepolarized Free-field 1/2" Microphone Type 4189

Bruel & Kjær — Calibration Chart

Serial No: 2471133

Open-circuit Sensitivity*, S_0:	-26.5	dB re 1V/Pa
Equivalent to:	47.2	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:
100.0 kPa 23 °C 50 % RH

Procedure: 704215 **Date:** 9. May. 2005 **Signature:**

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

BC 0224 – 12

B&K 4231 Unit #1 Calibrator 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.14810

Instrument:	**Acoustical Calibrator**
Model:	**4231**
Manufacturer:	**Brüel and Kjær**
Serial number:	**2478139**
Class (IEC 60942):	**1**
Barometer type:	
Barometer s/n:	

Date Calibrated: **6/23/2006**

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: **9920-63 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	Feb 22, 2006	Scantek, Inc.
DS-360-SRS	Function Generator	33584	Dec.6, 2005	Transcat / A2LA
34401A-Agilent Technologies	Digital Voltmeter	MY41022043	Nov.16, 2005	Transcat / A2LA
DPI140-Druck	Pressure Indicator	790/00	Oct.14, 2004	Transcat / A2LA
8903-HP	Audio Analyzer	2514A05691	Oct.26, 2004	Transcat / A2LA
HMP233-Vaisala Oyj	Humidity & Temp. Transmitter	V3820001	Nov.30, 2005	Transcat / A2LA
PC Program 1018 Norsonic	Calibration software	v.44	Validated May 2006	-
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 (International System of Units) through standards maintained by NIST (USA) and NPL (UK)

Calibrated by	Marc Nguessan	Checked by	Mariana Buzduga
Signature	[signature]	Signature	[signature]
Date	6/23/2006	Date	6/26/06

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Page 1 of 2

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

Calibration Chart

Brüel & Kjær Type 4231 Serial No. 2575493

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: 15-2-07 Signed: ASL

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:** BLK

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

DC 0224 – 12

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

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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

Document stored as: C:\Nor1504\MicCal\2006\B&K4189_2021315_M1.doc

Page 1 of 2

B&K 4230 Calibrator 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.15579

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

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

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 Avenue Edmonton, Alberta, Canada**

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	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
8903-HP	Audio Analyzer	2514A05691	Oct 26, 2004	Transcat / A2LA
HMP233-Vaisala	Temp.& Humidity Transmitter	V3820001	Oct 26, 2006	Transcat / A2LA
PC Program 1018 Norsonic	Calibration software	v.44	Validated May 2006	-
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 (International System of Units) through standards maintained by NIST (USA) and NPL (UK)

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

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Appendix II

THE ASSESSMENT OF ENVIRONMENTAL NOISE (GENERAL)

Sound Pressure Level

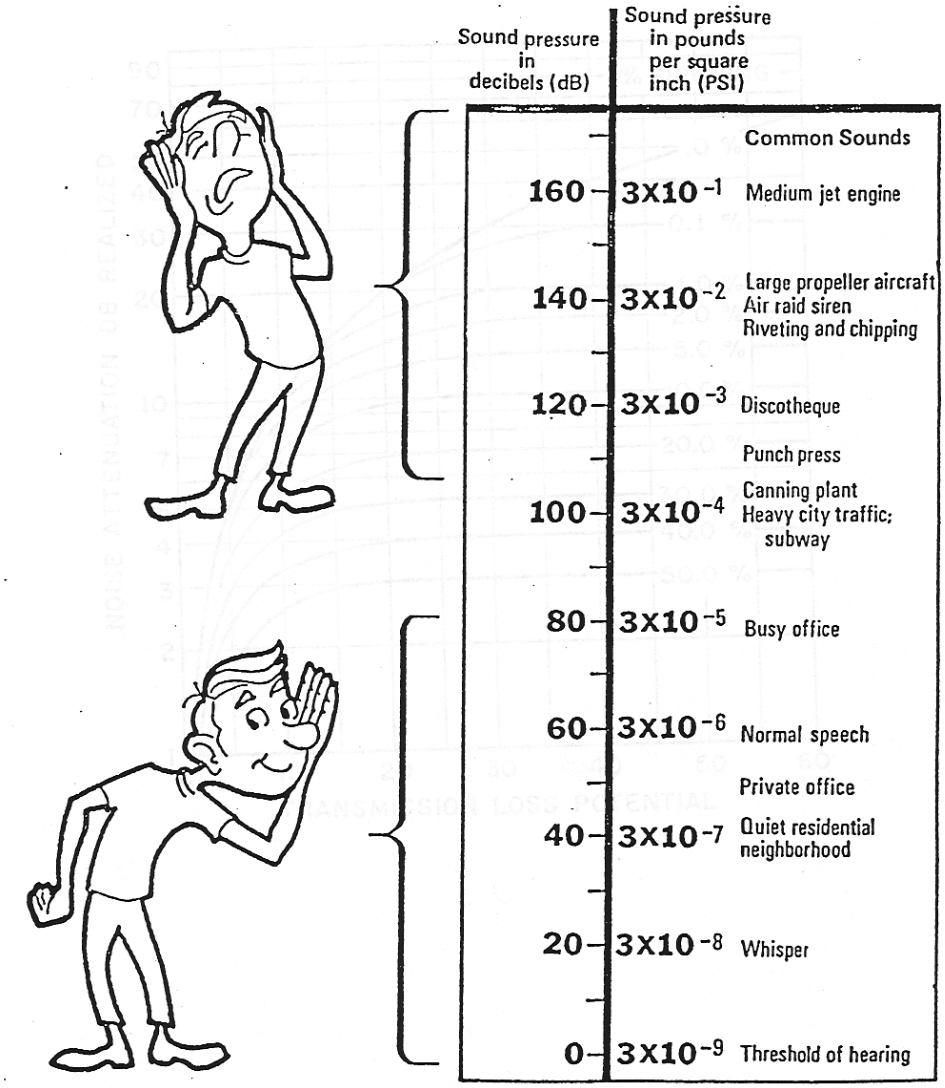
Sound pressure is initially measured in Pascal's (Pa). Humans can hear several orders of magnitude in sound pressure levels, so a more convenient scale is used. This scale is known as the decibel (dB) scale, named after Alexander Graham Bell (telephone guy). It is a base 10 logarithmic scale. When we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

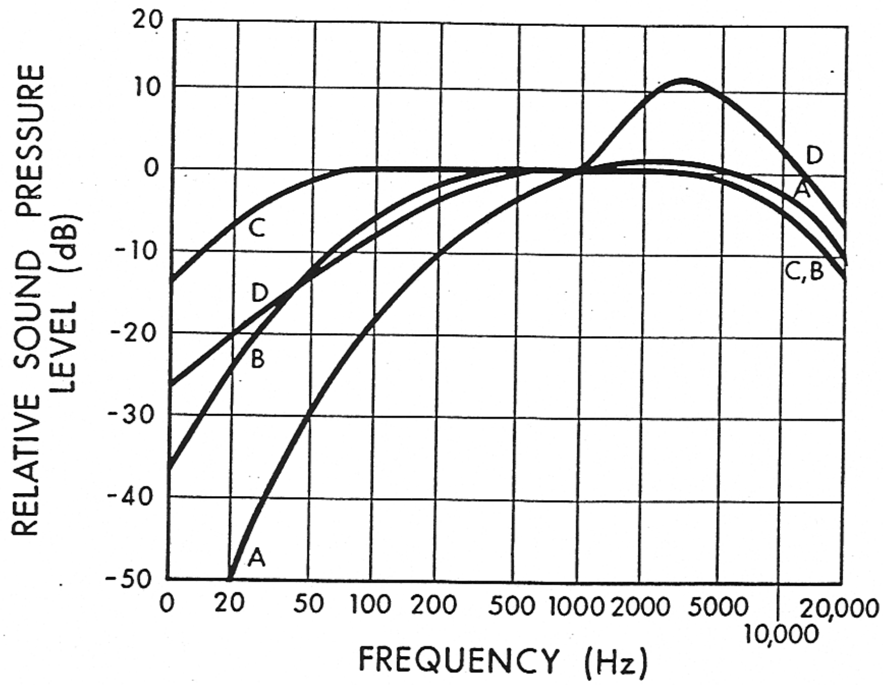
The range of frequencies audible to the human ear ranges from approximately 20 Hz to 20 kHz. Within this range, the human ear does not hear equally at all frequencies. It is not very sensitive to low frequency sounds, is very sensitive to mid frequency sounds and is slightly less sensitive to high frequency 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.

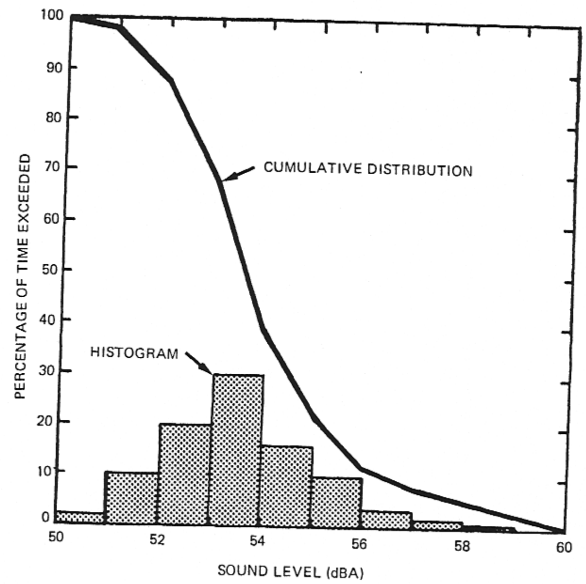


Figure 16.6 Statistically processed community noise showing histogram and cumulative distribution of A weighted sound levels.

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

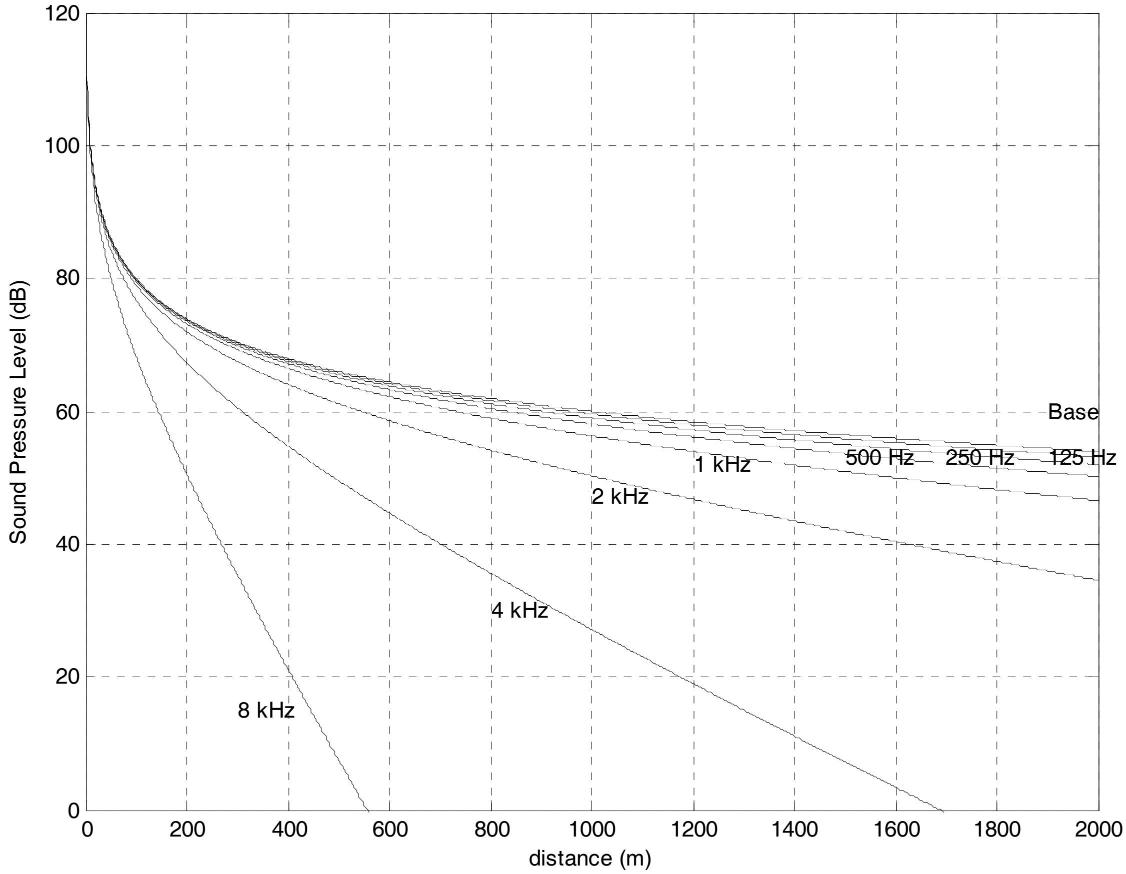
As sound transmits through a medium, there is an attenuation (or dissipation of acoustic energy) which can be attributed to three mechanisms:

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 °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

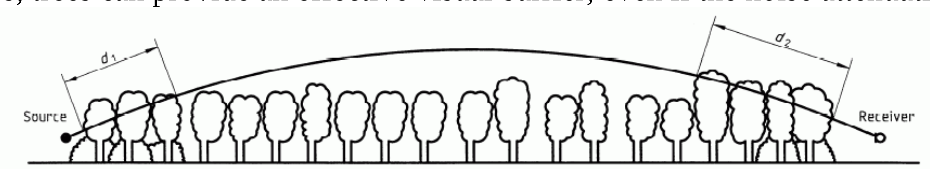
- Can be an effective absorber due to large area covered
- Only effective at low height above ground. Does not affect sound transmitted direct from source to receiver if there is line of sight.
- Typically less absorption than atmospheric absorption when there is line of sight.
- Approximate rule of 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
	Attenuation, dB:							
$10 \le d_f \le 20$	0	0	1	1	1	1	2	3
	Attenuation, dB/m:							
$20 \le d_f \le 200$	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

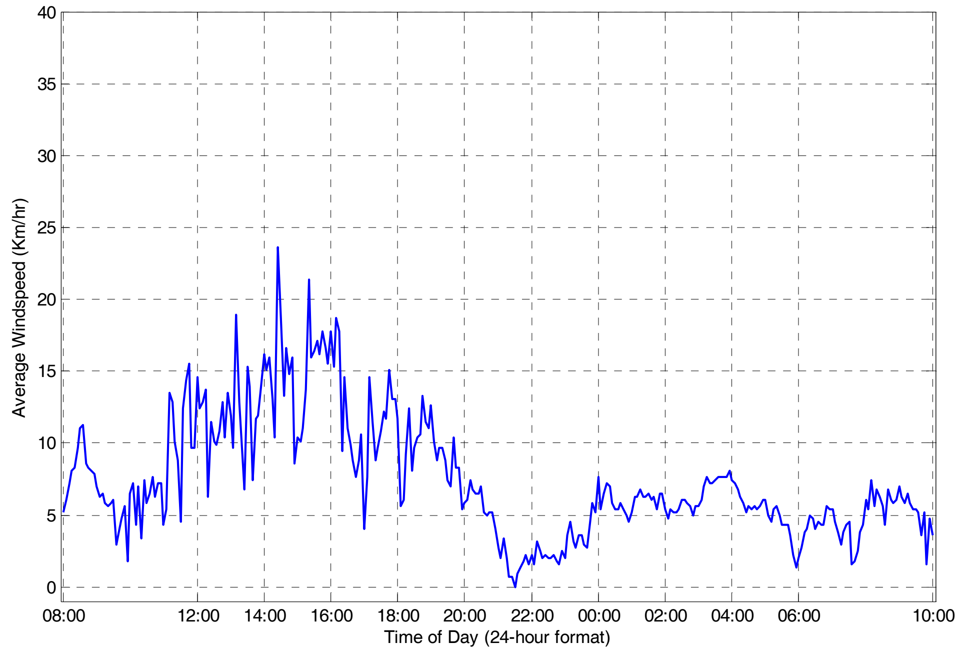
Road	Day (Vehicles Per Hour)	Day % Heavy Trucks	Night (Vehicles Per Hour)	Night % Heavy Trucks	Speed (km/hr)
100 Ave EB	1328	5	342	5	70
Stony Plain Road WB	1328	5	342	5	70
AHD North of Whitemud NB	1651	16	425	14	90
AHD North of Whitemud SB	1651	16	425	14	90
87 Ave East of AHD	879	3	227	3	60
All 87 Ave Ramps	100	3	10	3	70
Whitemud Drive East of AHD EB	1321	10	341	10	80
Whitemud Drive East of AHD WB	1321	10	341	10	80
Whitemud Drive West of AHD EB	790	5	204	5	80
Whitemud Drive West of AHD WB	790	5	204	5	80
All Whitemud to AHD Ramps	100	5	10	5	70
AHD North of 62 Ave NB	1456	16	375	14	90
AHD North of 62 Ave SB	1456	16	375	14	90
62 Ave West of AHD	943	3	243	3	50
Callingwood Road East of AHD	662	3	170	3	60
AHD North of Lessard Road NB	1177	16	304	14	90
AHD North of Lessard Road SB	1177	16	304	14	90
Lessard Road East of AHD	465	3	120	3	60
Lessard Road West of AHD	465	3	120	3	60
AHD North of Terwillegar Drive NB	1023	16	263	14	100
AHD North of Terwillegar Drive SB	1023	16	263	14	100
Cameron Drive	113	3	30	3	50
Terwillegar Drive North of AHD	768	3	198	3	70
Terwillegar Drive South of AHD	417	3	108	3	70
All Terwillegar Drive Ramps	100	5	10	5	70
AHD West of 127 Street EB	1020	16	263	14	100
AHD West of 127 Street WB	1020	16	263	14	100
127 Street North of AHD	58	3	15	3	60
127 Street South of AHD	118	3	30	3	60
AHD West of 111 Street EB	1045	16	269	14	100
AHD West of 111 Street WB	1045	16	269	14	100
111 Street North of AHD	1860	5	479	5	60
111 Street South of AHD	1860	5	479	5	60
All 111 Street Ramps	100	5	10	5	70
AHD West of Calgary Trail EB	764	16	197	14	100
AHD West of Calgary Trail WB	764	16	197	14	100
Clagary Trail North of AHD	2267	10	584	10	80
Gateway Blvd North of AHD	2267	10	584	10	80
Clagary Trail South of AHD	2117	10	545	10	110
Gateway Blvd South of AHD	2117	10	545	10	110
Gateway Blvd to AHD WB	382	16	99	14	90
Calgary Trail to AHD WB	382	16	99	14	90
AHD EB to Gateway Blvd	382	16	99	14	90
AHD EB to Calgary Trail	382	16	99	14	90
Ellerslie Road	1200	5	320	5	60
All Ellerslie Ramps	100	5	10	5	70

Future Conditions (20 Years)

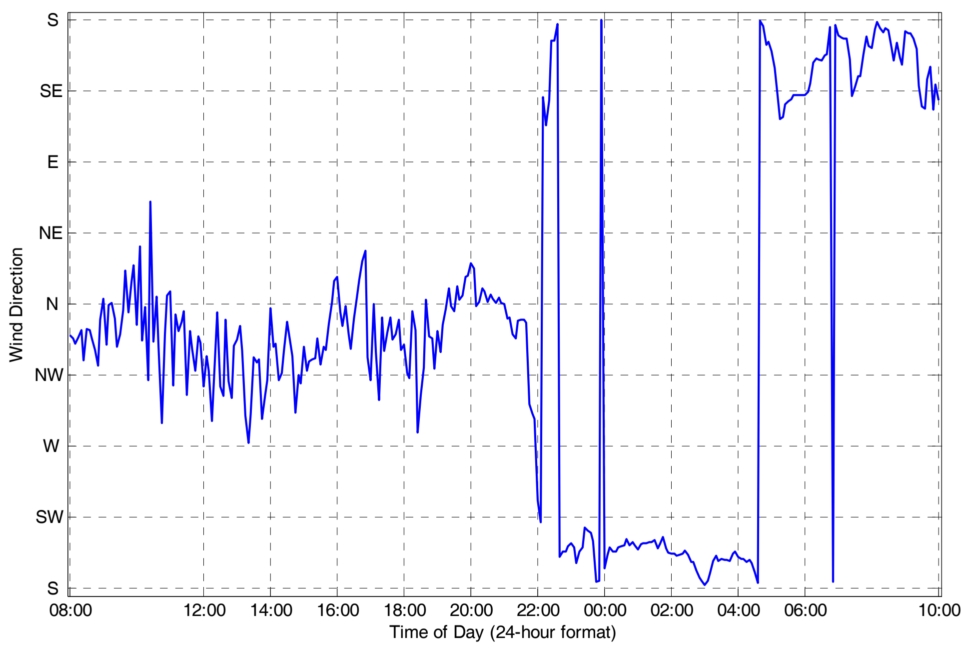
Road	Day (Vehicles Per Hour)	Day % Heavy Trucks	Night (Vehicles Per Hour)	Night % Heavy Trucks	Speed (km/hr)
100 Ave EB	2656	5	684	5	70
Stony Plain Road WB	2656	5	684	5	70
AHD North of Whitemud NB	2310	16	595	14	100
AHD North of Whitemud SB	2310	16	595	14	100
87 Ave East/West of AHD	1758	3	454	3	60
All 87 Ave Ramps	200	3	20	3	70
Whitemud Drive East of AHD EB	2642	10	682	10	80
Whitemud Drive East of AHD WB	2642	10	682	10	80
Whitemud Drive West of AHD EB	1580	5	408	5	80
Whitemud Drive West of AHD WB	1580	5	408	5	80
All Whitemud to AHD Ramps	200	5	20	5	70
AHD North of 62 Ave NB	2310	16	595	14	100
AHD North of 62 Ave SB	2310	16	595	14	100
62 Ave West of AHD	1886	3	486	3	60
Callingwood Road East of AHD	1324	3	340	3	60
Future Ramps for 62 Ave	200	5	20	5	70
AHD North of Lessard Road NB	2310	16	595	14	100
AHD North of Lessard Road SB	2310	16	595	14	100
Lessard Road East of AHD	930	3	240	3	60
Lessard Road West of AHD	930	3	240	3	60
Future Ramps for Lessard Road	200	5	20	5	70
AHD North of Terwillegar Drive NB	2310	16	595	14	100
AHD North of Terwillegar Drive SB	2310	16	595	14	100
Cameron Drive	226	3	60	3	50
Future Ramps for Cameron Drive	50	5	5	5	60
Terwillegar Drive North of AHD NB	1536	3	396	3	70
Terwillegar Drive North of AHD SB	1536	3	396	3	70
Terwillegar Drive South of AHD NB	834	3	216	3	70
Terwillegar Drive South of AHD SB	834	3	216	3	70
All Terwillegar Drive Ramps	200	5	20	5	70
AHD West of 127 Street EB	2310	16	595	14	100
AHD West of 127 Street WB	2310	16	595	14	100
156 Street North of AHD	760	3	130	3	70
156 Street South of AHD	760	3	130	3	70
Future Ramps for 156 Street	100	5	10	5	70
127 Street North of AHD	116	3	30	3	60
127 Street South of AHD	236	3	60	3	60
Future Ramps for 127 Street	50	5	5	5	70
AHD West of 111 Street EB	2310	16	595	14	100
AHD West of 111 Street WB	2310	16	595	14	100
111 Street North of AHD	3720	5	958	5	60
111 Street South of AHD	3720	5	958	5	60
All 111 Street Ramps	200	5	20	5	70
AHD West of Calgary Trail EB	2310	16	595	14	100
AHD West of Calgary Trail WB	2310	16	595	14	100
Clagary Trail North of AHD	4534	10	1168	10	80
Gateway Blvd North of AHD	4534	10	1168	10	80
Clagary Trail South of AHD	4234	10	1090	10	110
Gateway Blvd South of AHD	4234	10	1090	10	110
Gateway Blvd to AHD WB	764	16	200	14	90
Gateway Blvd to AHD EB	764	16	200	14	90
Calgary Trail to AHD WB	764	16	200	14	90
Calgary Trail to AHD EB	764	16	200	14	90
AHD EB to Gateway Blvd	764	16	200	14	90
AHD EB to Calgary Trail	764	16	200	14	90
AHD WB to Gateway Blvd	764	16	200	14	90
AHD WB to Calgary Trail	764	16	200	14	90
AHD WB to 111 Street	764	16	200	14	90
AHD East of Calgary Trail EB	2310	16	595	14	100
AHD East of Calgary Trail WB	2310	16	595	14	100
Ellerslie Road	2400	5	640	5	60
All Ellerslie Ramps	200	5	20	5	70

Appendix V

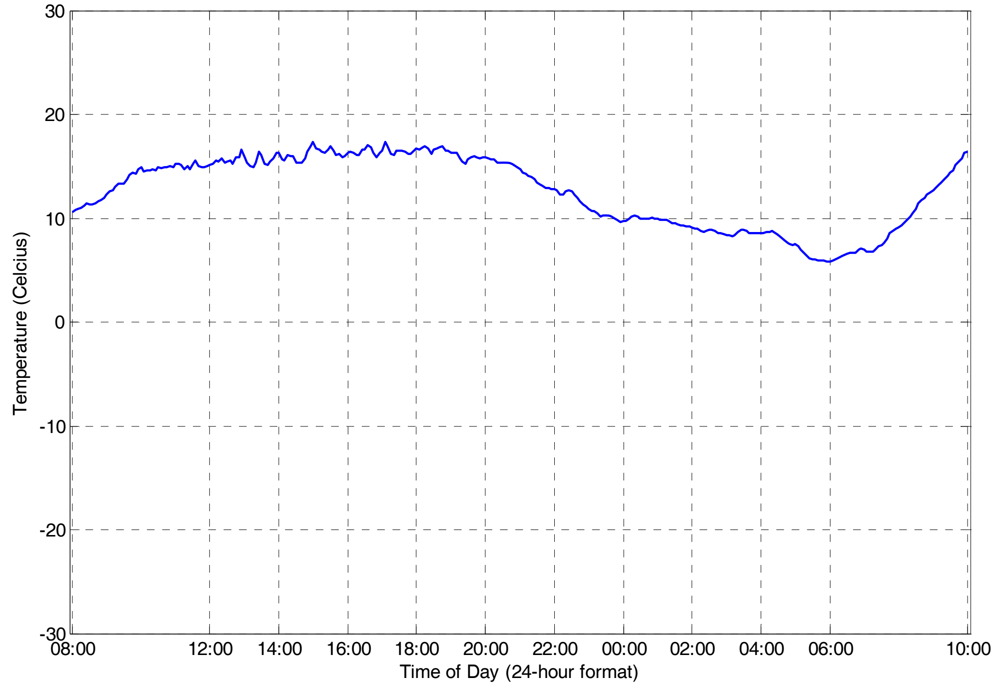
WEATHER DATA



Monitored Wind Speed for Monitors 1 - 5



Monitored Wind Direction for Monitors 1 - 5



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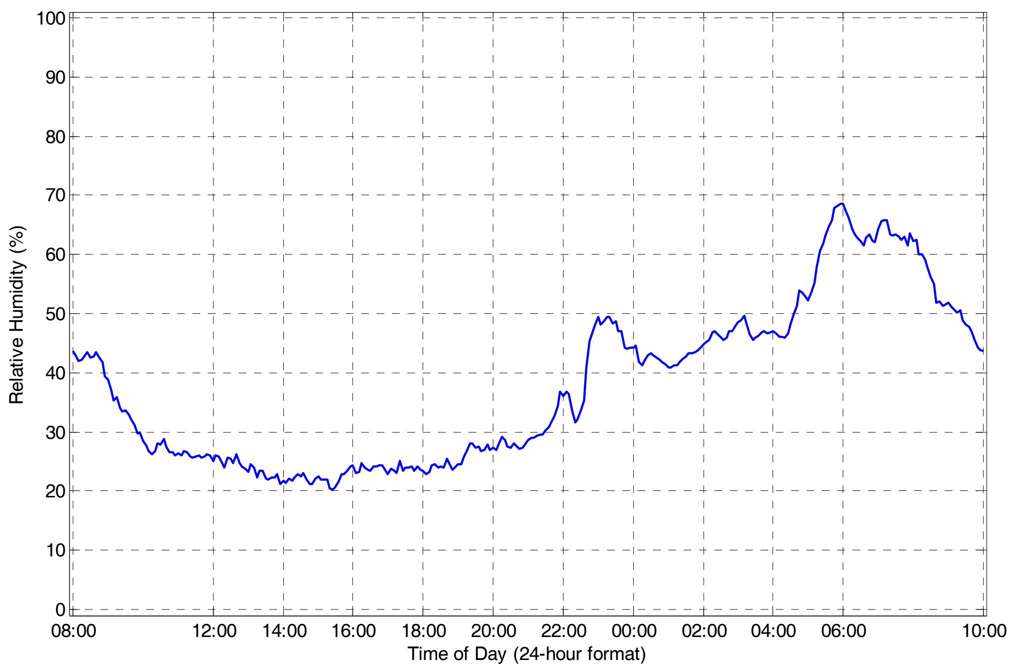
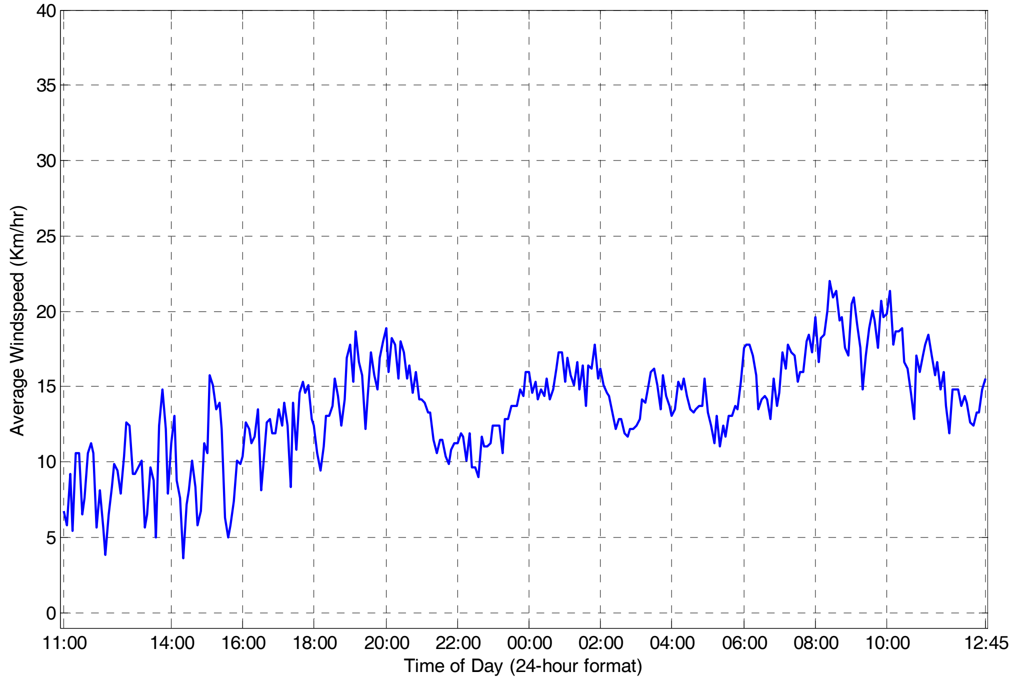
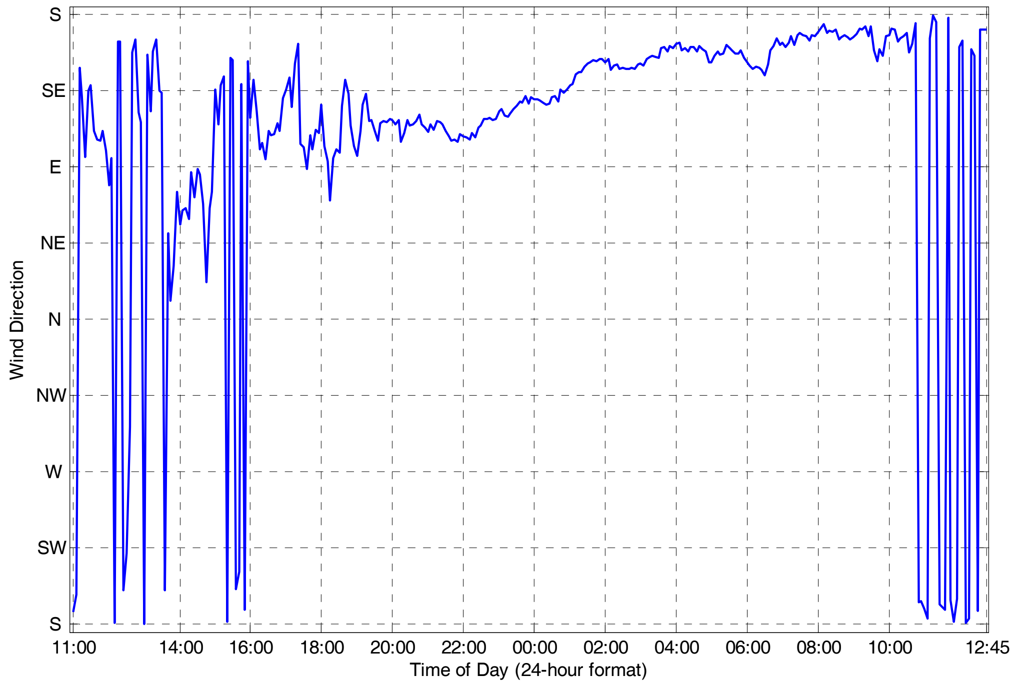


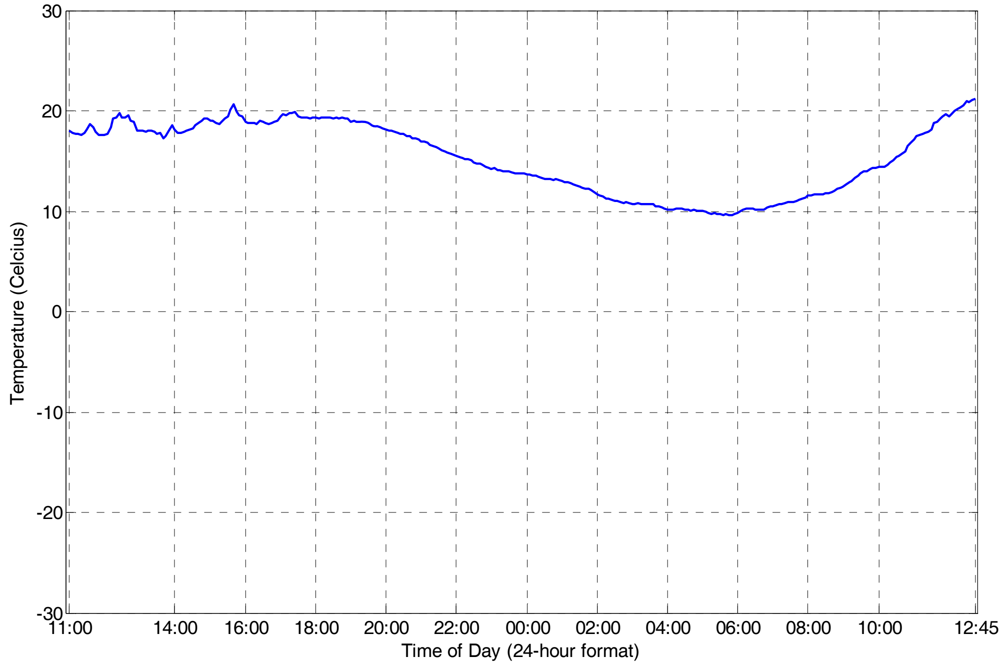
Monitored Relative Humidity for Monitors 1 - 5



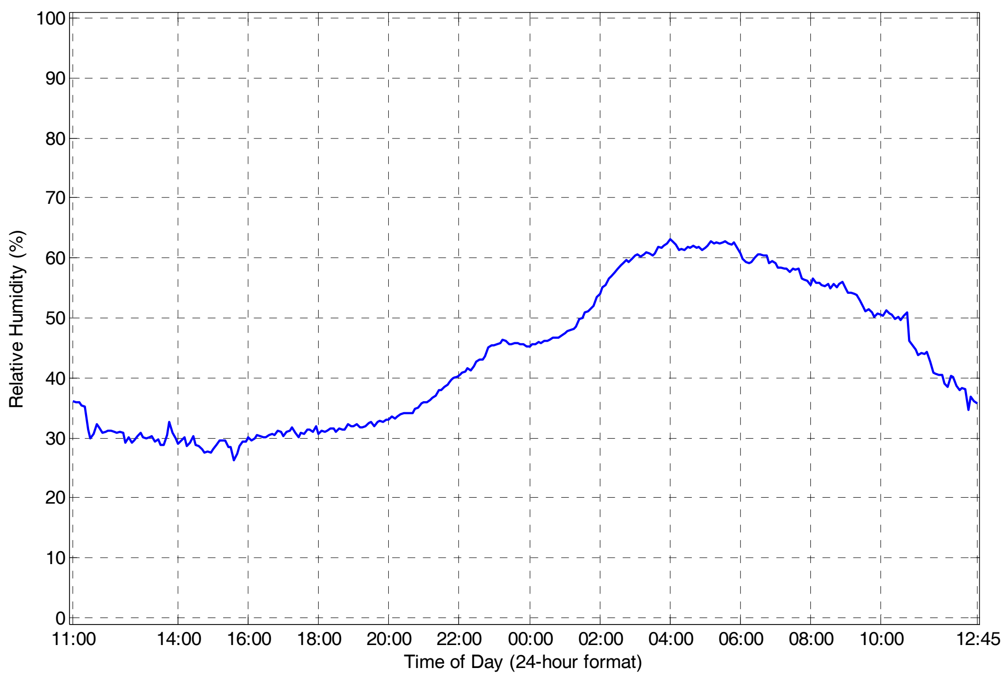
Monitored Wind Speed for Monitors 6 - 10



Monitored Wind Direction for Monitors 6 - 10



Monitored Temperature for Monitors 6 - 10



Monitored Relative Humidity for Monitors 6 - 10

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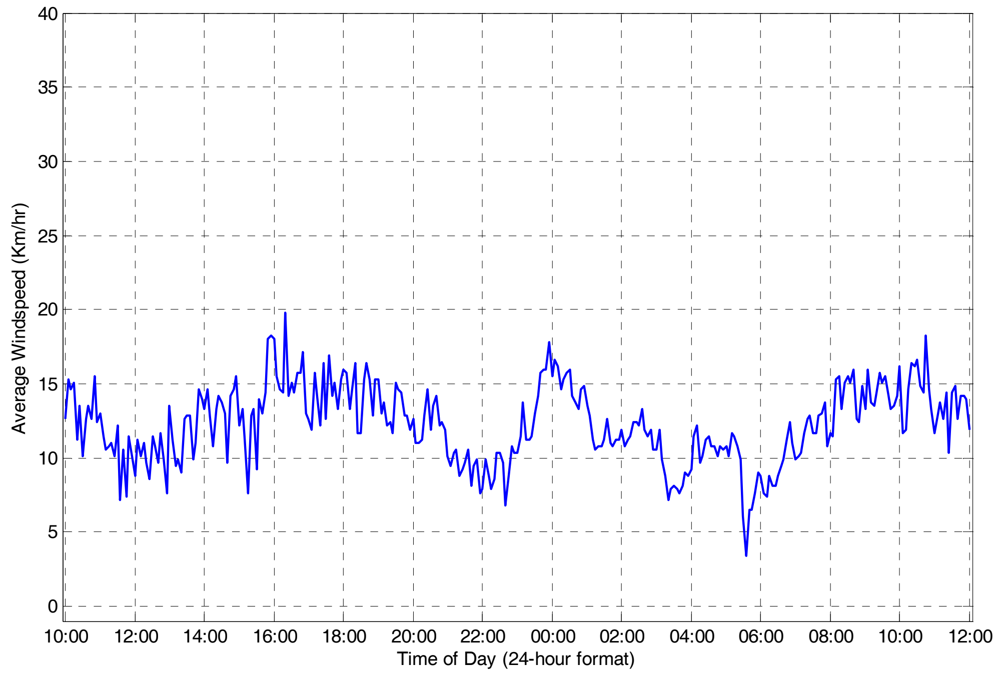
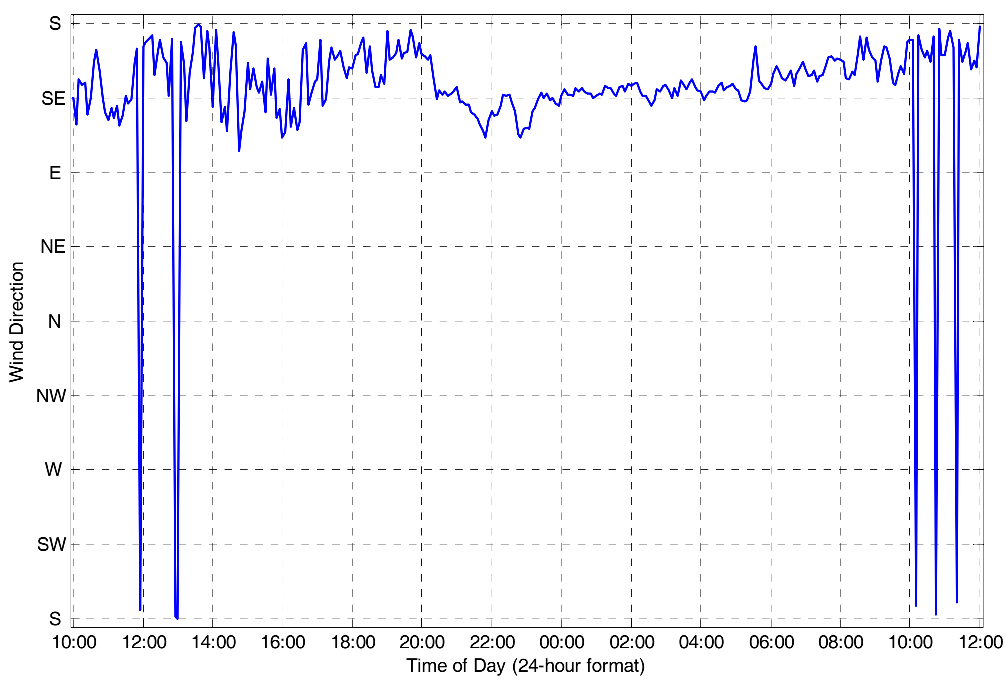
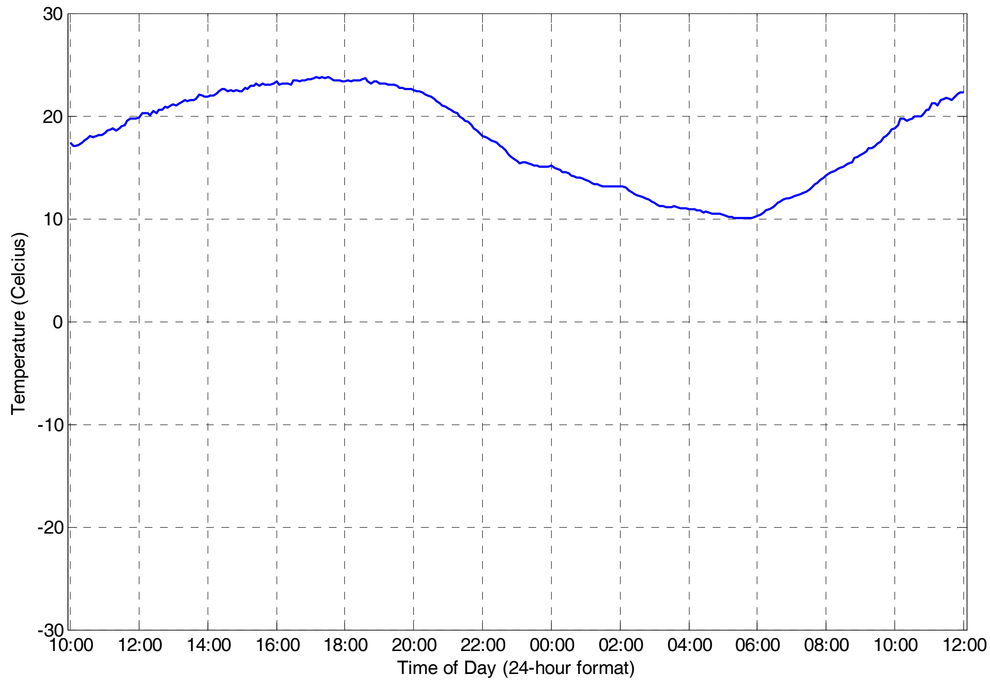


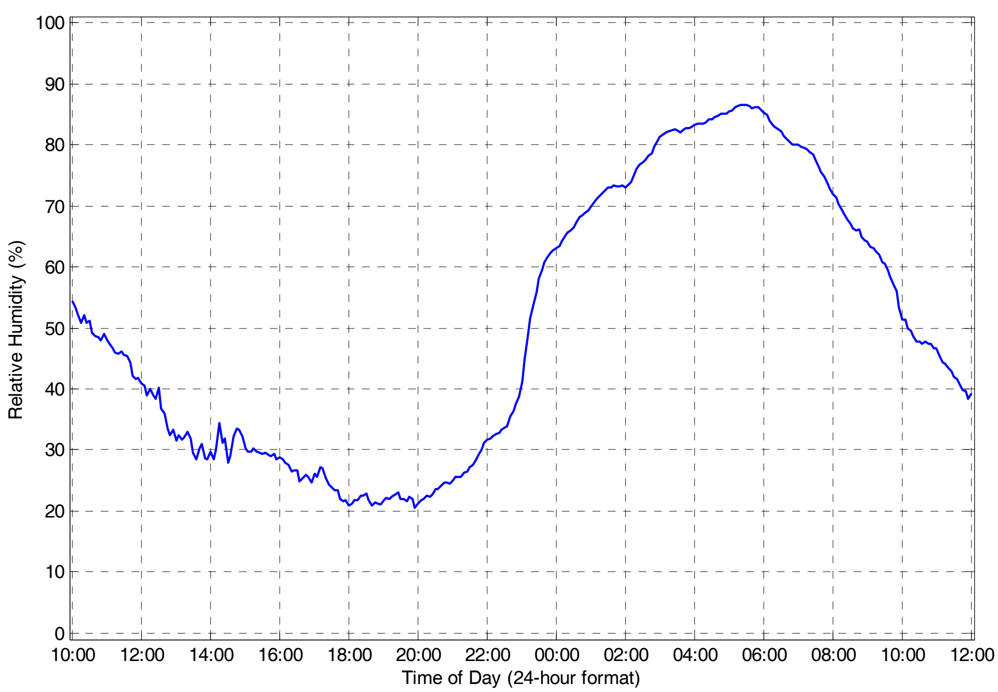
Monitored Wind Speed for Monitors 11, 13, 14



Monitored Wind Direction for Monitors 11, 13, 14

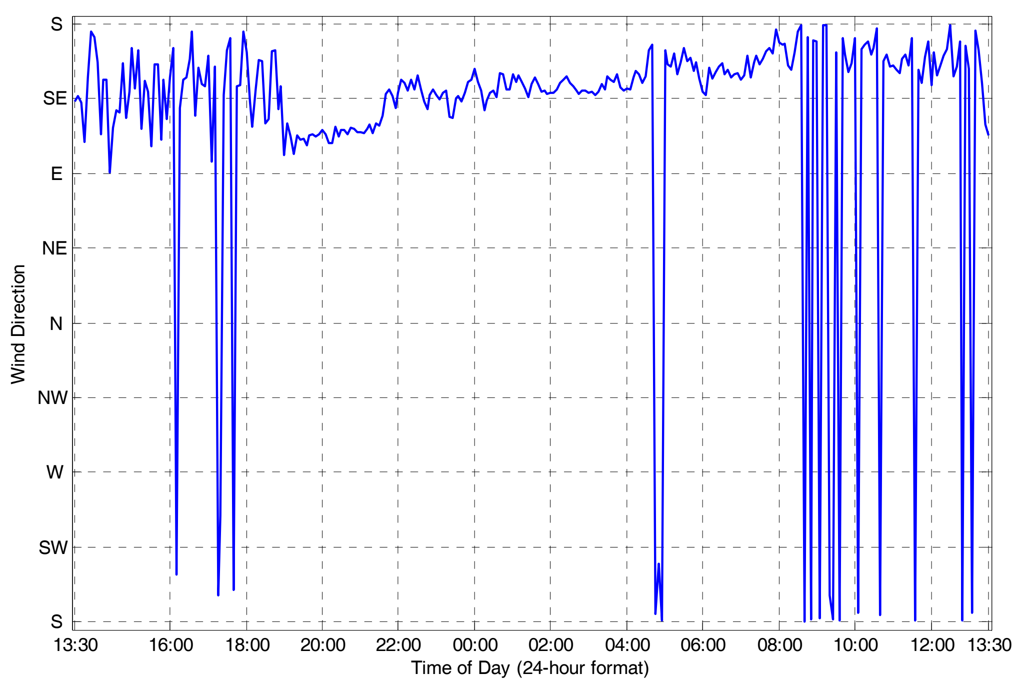


Monitored Temperature for Monitors 11, 13, 14

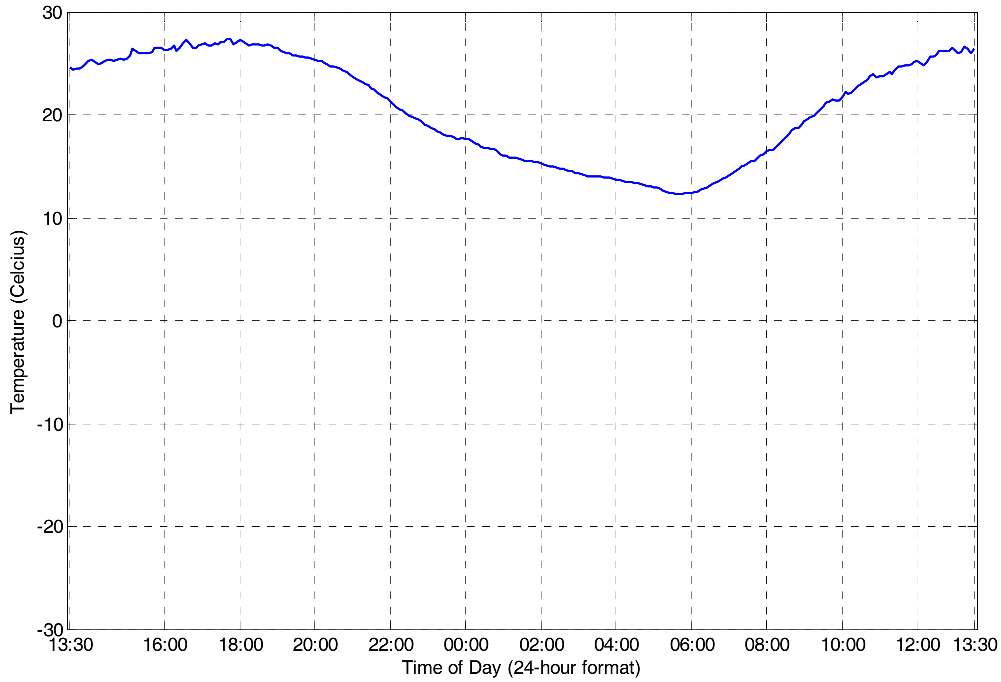


Monitored Relative Humidity for Monitors 11, 13, 14

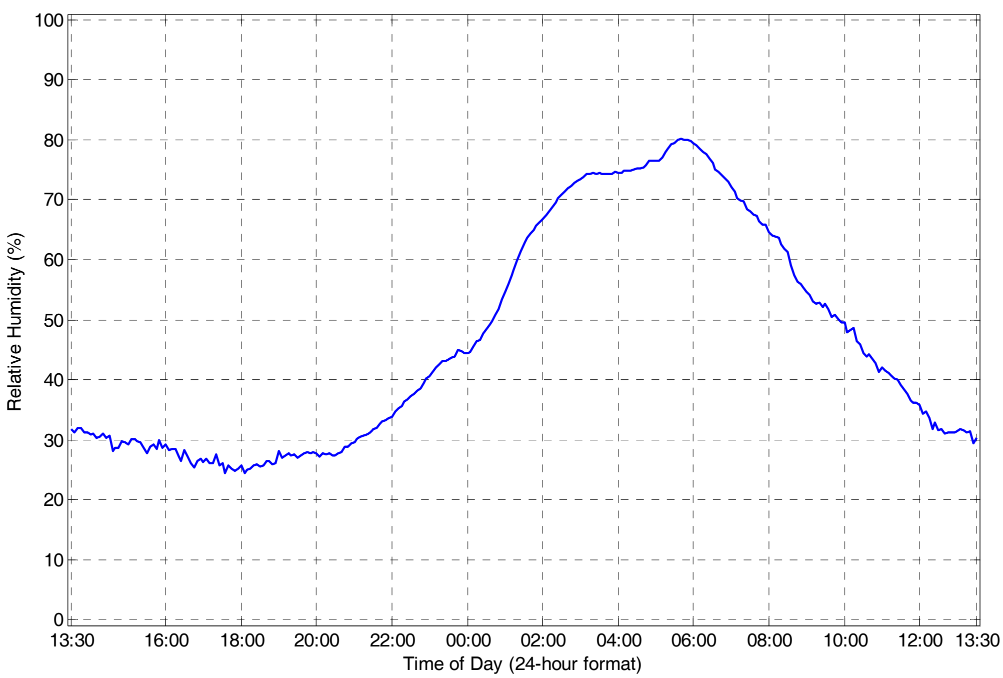
Monitored Wind Speed for Monitor 12



Monitored Wind Direction for Monitor 12



Monitored Temperature for Monitor 12



Monitored Relative Humidity for Monitor 12