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PL2020-166

Verizon MSC Expansion
Noise Control

Bloomington, Minnesota

January 11, 2021

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esi engineering

Structures | Vibration | Noise | Monitoring
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Summary

The engineering to determine noise levels from the Verizon property were done:

- By qualified engineers
- Using standard calculation methods
- Considering ambient noise
- Using data from the equipment manufacturers
- With worst-case assumptions about equipment operation and environmental conditions

The resulting noise levels meet the MPCA code requirements. Further, Verizon will be required to prove by measurement that the requirements are being met after construction is completed.

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The Project Team

Verizon – owner

Morrison Hershfield - Architecture and Engineering

Subconsultant
Civil
Sunde Engineering
Bloomington, Minnesota

Subconsultant
Noise Control
ESI Engineering
Bloomington, Minnesota

Other Subs

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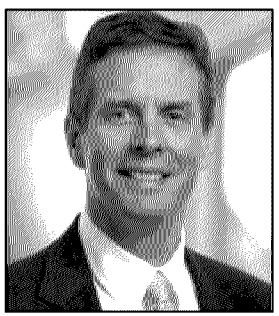
ESI Engineering

- Minnesota based consulting engineering firm since 1970
- Provide specialized engineering services
- Specialists in noise control, acoustics, vibration and structures for high force/shock



ANTHONY J. BAXTER, P.E.
Principal

Joined ESI in 2000
Licensed PE since 1992
31 Years of Engineering Experience

Academic Background:
Bachelor of Art in Business Administration/Finance – University of St. Thomas
Bachelor of Science in Mechanical Engineering – Iowa State University

Affiliations:
Member – American Society of Mechanical Engineers
Member – Acoustical Society of America
Member – Institute of Noise Control Engineering
Member – National Council of Acoustical Consultants

What has ESI been asked to do?

Evaluate and make recommendations for noise control for the new addition.

1. Gather information, drawings, requirements
2. Establish design goals, based on Code requirements, guidelines and our experience
3. Make measurements when necessary
4. Make assumptions, use our judgement, develop concepts for mitigation
5. Perform noise analysis and compare results with design goals
6. Develop methods to control noise, analyze performance and make recommendations that will meet the design goals
7. Prepare a report that summarizes our work, with details on recommendations
8. Review construction documents and submittals, and respond to RFI's
9. Perform post-construction measurements to determine if code requirements are met
10. Participate in City meetings

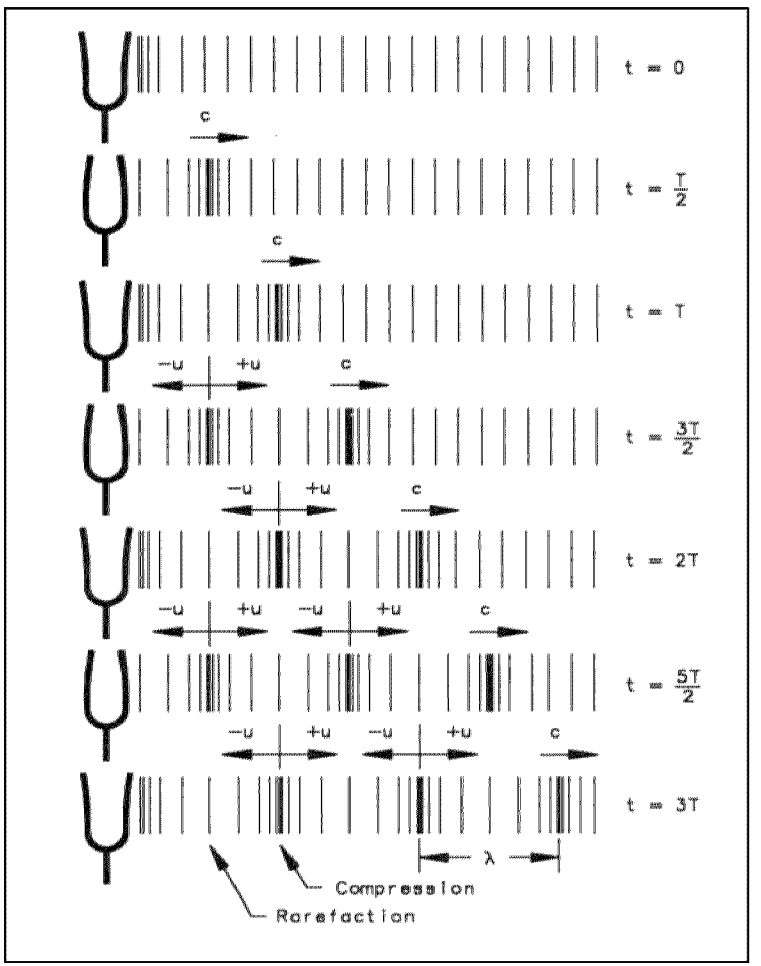
Sound Basics

Q. What are Sound Waves?

A. Pressure variations in air that the human ear can detect

c = 1130 ft/sec, 770 mph

$$\lambda := \frac{c}{f}$$



What is Sound Pressure Level?

(Also referred to as noise, sound, SPL, L_p)

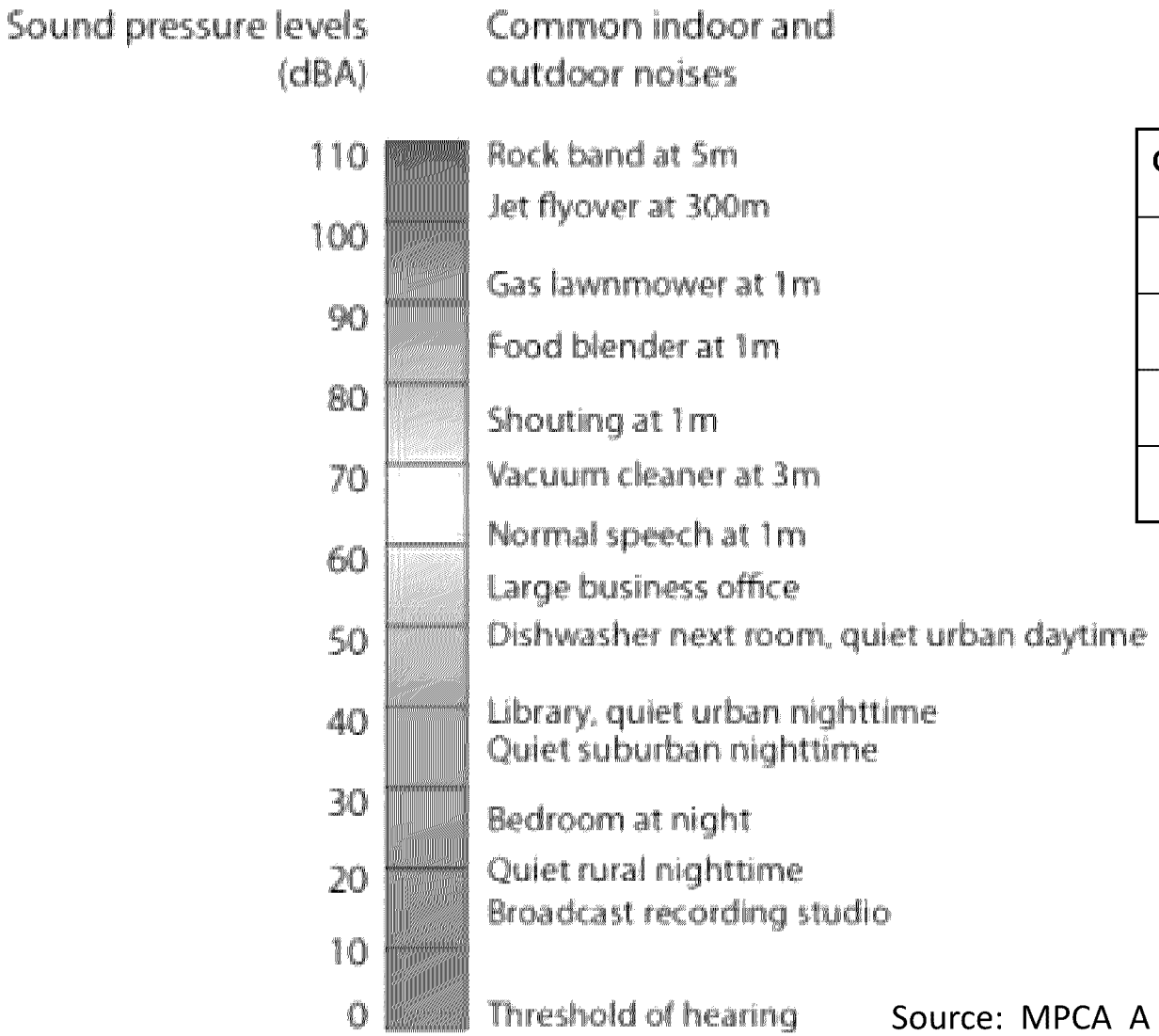
The quantity of airborne sound, measured in decibels, at a certain distance from a sound source.

$$L_p := 20 \cdot \log\left(\frac{P}{P_{ref}}\right)$$ **dB - decibel**

$$P_{ref} := 20 \cdot \left(10^{-6}\right) \cdot Pa$$ ~ 0.000000003 psi

3 nano psi

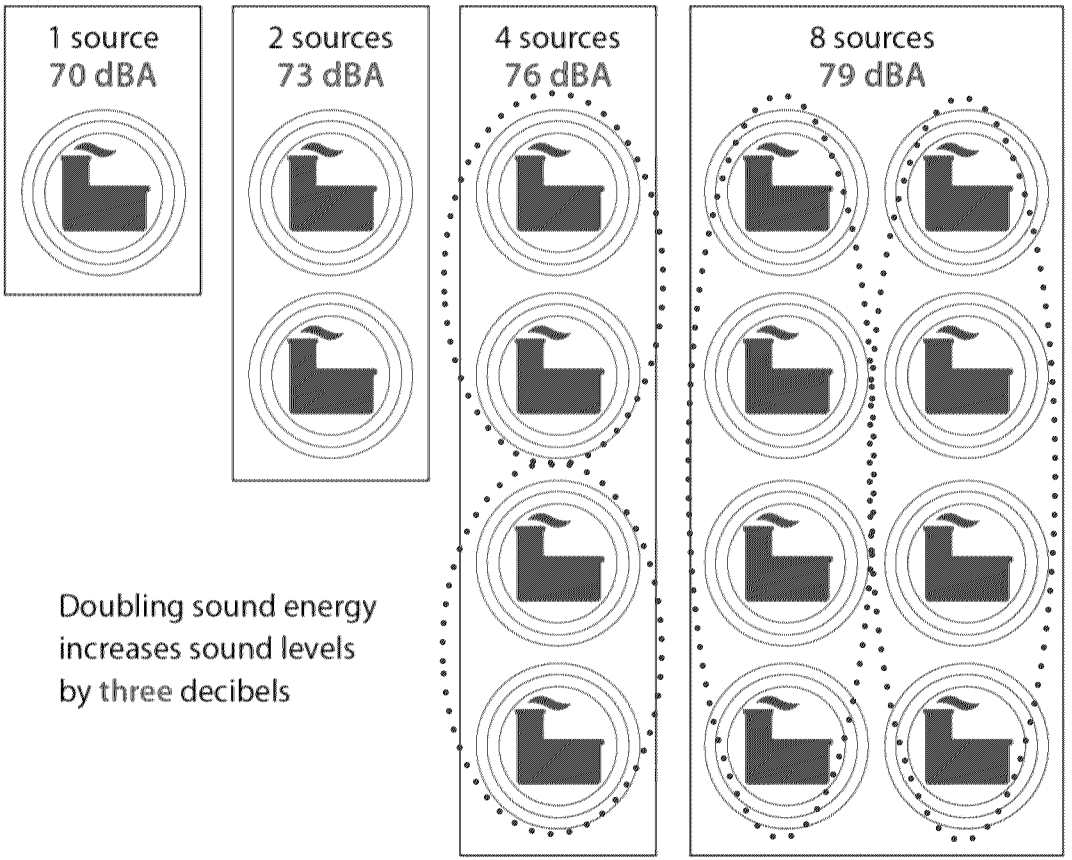
Human Perception of Sound



Change in Level dB	Human Perception
1	Not Noticable
3	Barely Noticable
5	Clearly Noticable
10	Twice as Loud

Source: MPCA A Guide to Noise Control in Minnesota

Addition of Decibel Levels



Source: MPCA A Guide to Noise Control in Minnesota

Addition of Decibel Levels

$L_p := 50 \cdot dB$

$2 \cdot L_p = 100 \cdot dB$ Wrong!

$L_{total} := 10 \cdot \log\left(10^{\frac{50 \cdot dB}{10}} + 10^{\frac{50 \cdot dB}{10}}\right) = 53.0 \cdot dB$ Two equal levels are 3 dB higher.

$L_{sum} := 10 \cdot \log\left(10^{\frac{40 \cdot dB}{10}} + 10^{\frac{50 \cdot dB}{10}}\right) = 50.4 \cdot dB$ More than 10 dB difference, no change.

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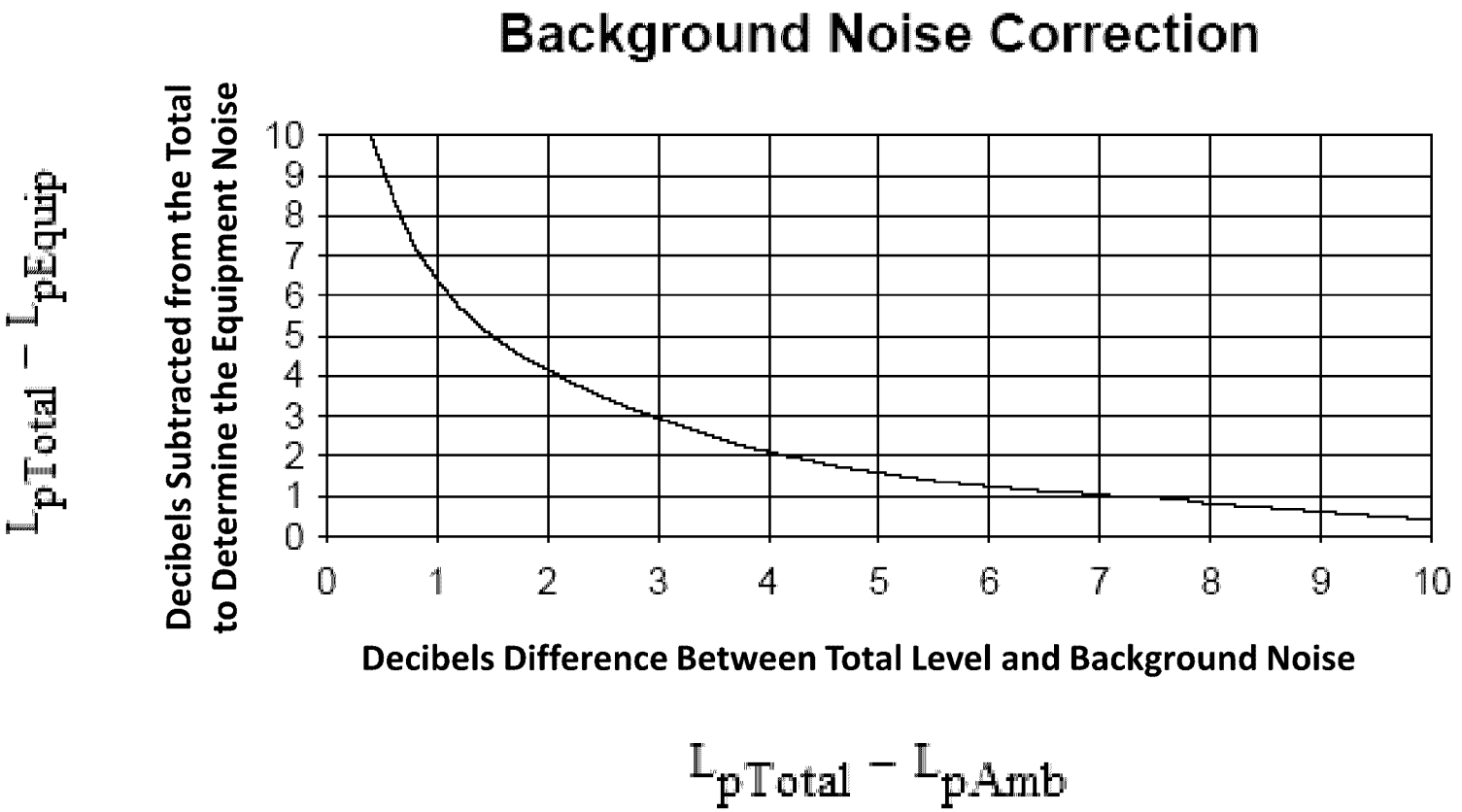
MPCA Correction for Ambient Noise

$$L_{pTotal} := L_{pAmb} + L_{pEquip}$$

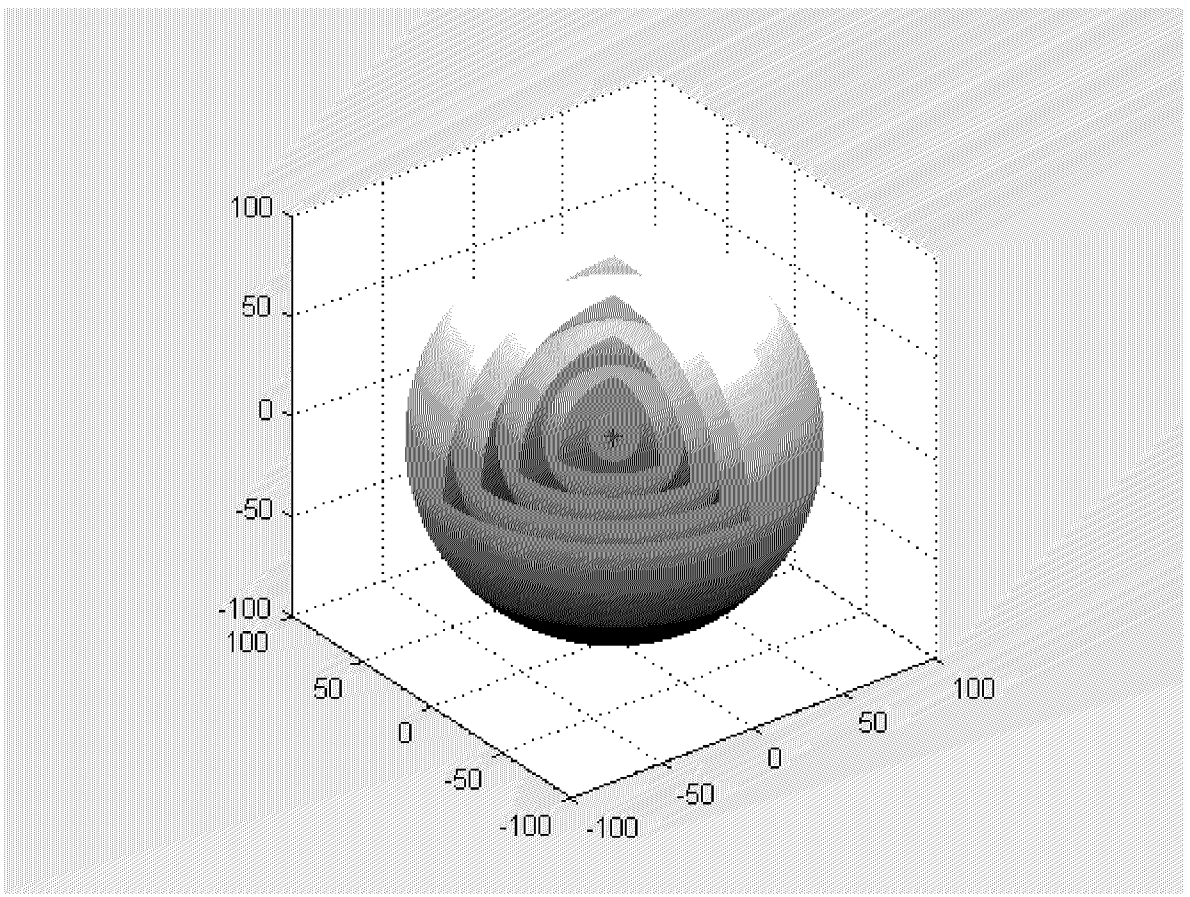


Source: MPCA A Guide to Noise Control in Minnesota

Geometrical Divergence

Spherical radiation of point source in free space

6 dB reduction for a doubling of distance



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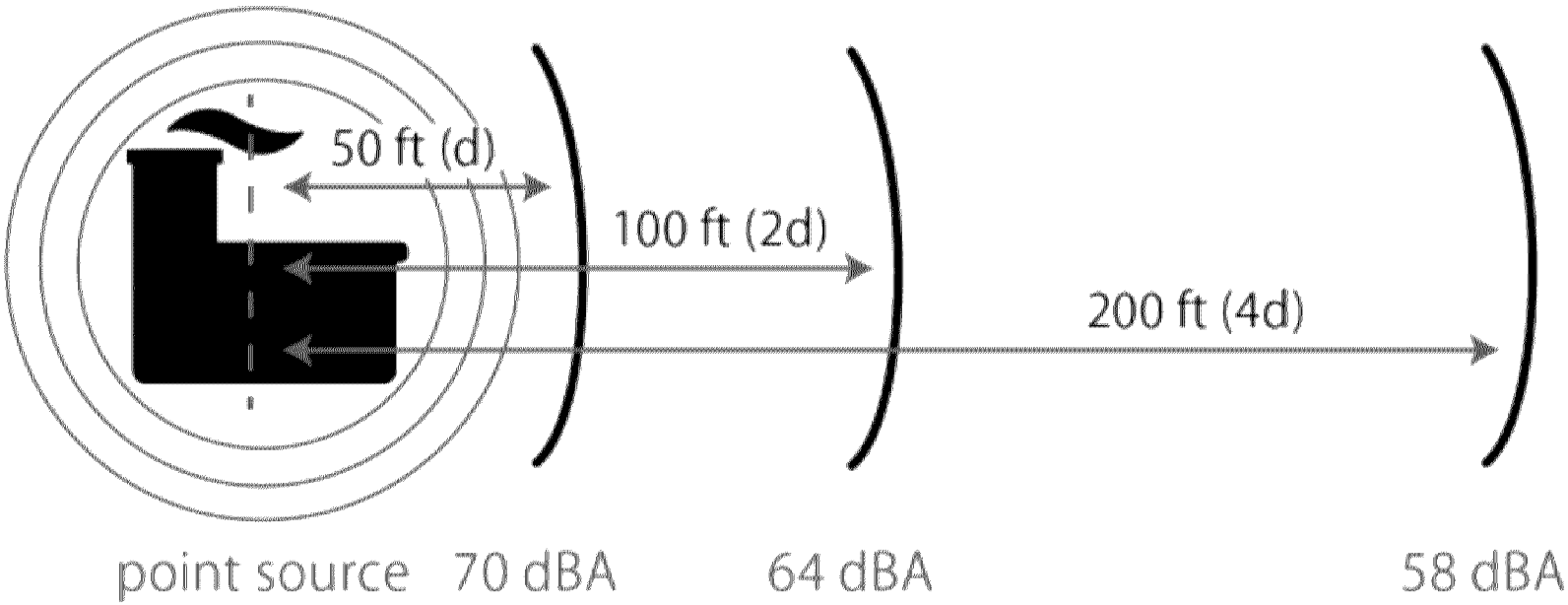
Noise Attenuation with Distance

Every doubling of distance results in a 6 dB reduction in the sound level.



Source: MPCA A Guide to Noise Control in Minnesota

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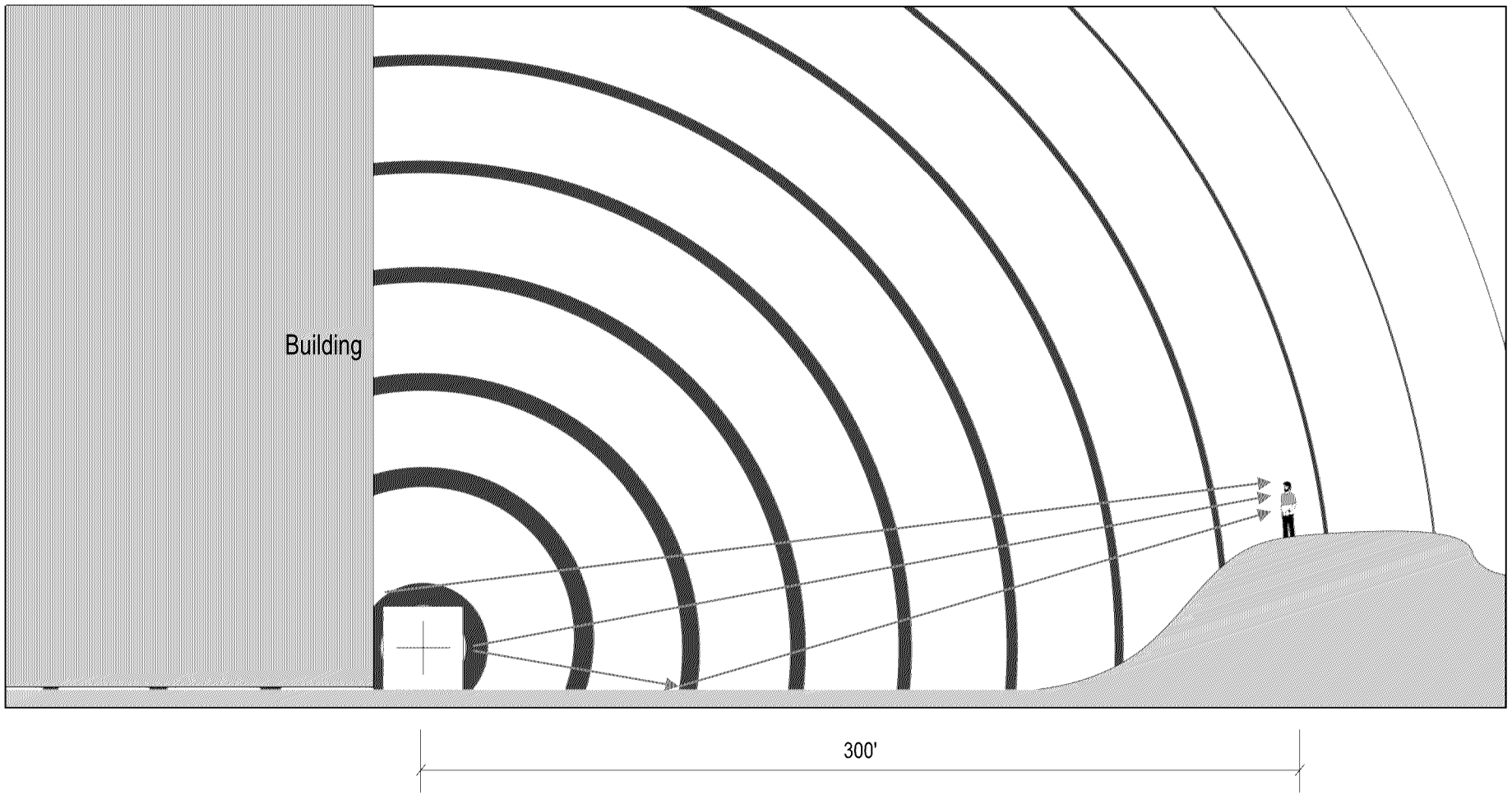
Reflections



Air Absorption

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This reduces noise at distances from the source.

At 0 F, 25% RH
500 Hz - 1.4 dB/1000 ft
4000 Hz - 2.4 dB/1000 ft

Relative Humidity (%)	Temp-erature (˚F)	Attenuation in dB per 1000 ft						
		63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
25	59	0.1	0.2	0.4	0.7	1.8	5.9	20.4
	68	0.1	0.2	0.5	0.8	1.6	4.7	16.4
	77	0.1	0.2	0.5	0.9	1.7	4.1	13.3
	86	0.0	0.2	0.5	1.1	2.0	4.0	11.3
50	59	0.0	0.1	0.4	0.7	1.3	3.1	10.1
	68	0.0	0.1	0.4	0.9	1.5	3.0	8.6
	77	0.0	0.1	0.4	1.0	1.9	3.3	7.8
	86	0.0	0.1	0.3	1.0	2.3	3.9	7.7
75	59	0.0	0.1	0.3	0.7	1.4	2.7	7.2
	68	0.0	0.1	0.3	0.8	1.7	2.9	6.7
	77	0.0	0.1	0.3	0.9	2.0	3.5	6.8
	86	0.0	0.1	0.2	0.8	2.3	4.3	7.3

Wind Gradient

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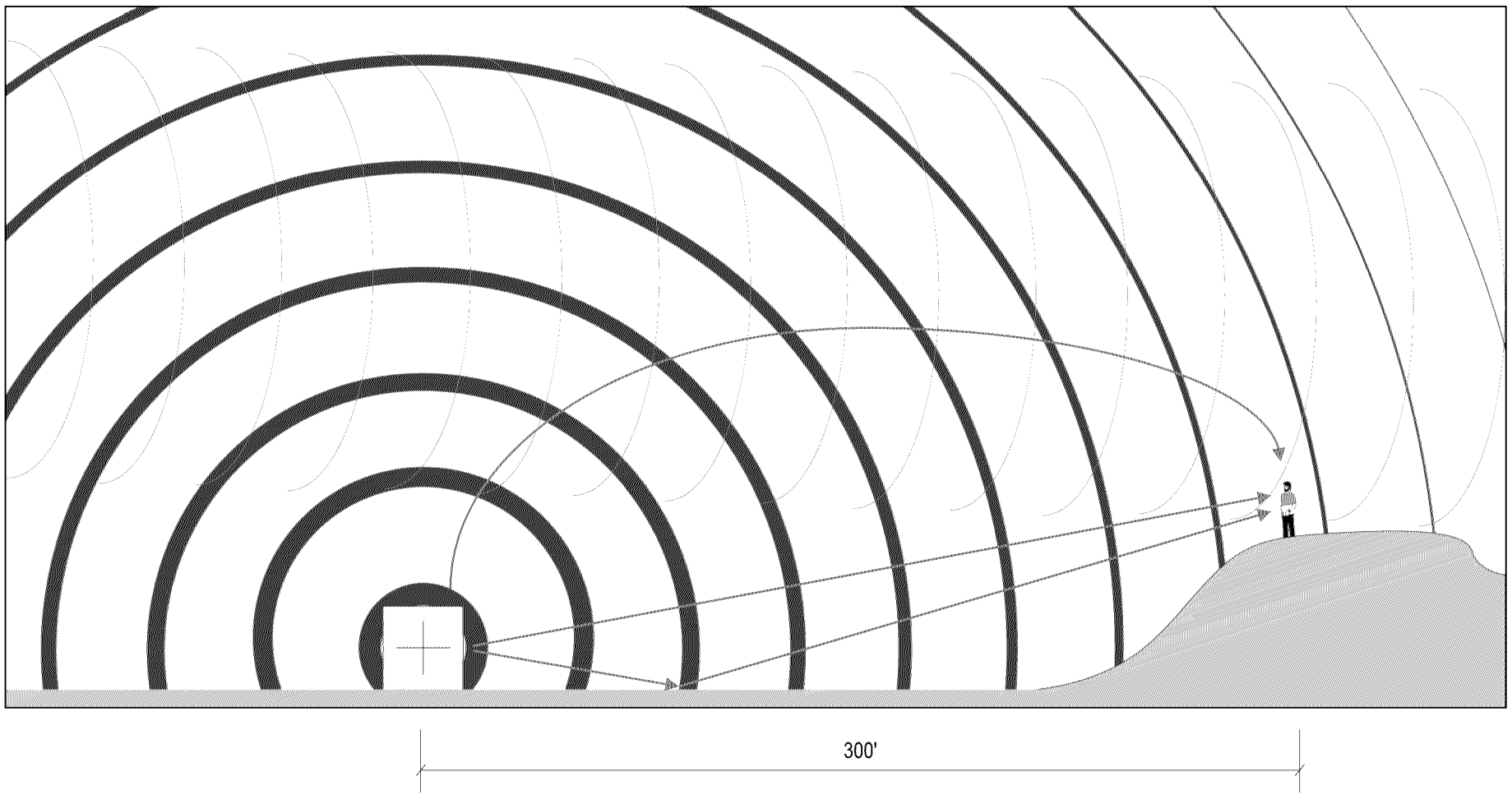
Tends to bend the sound downward for downwind receivers



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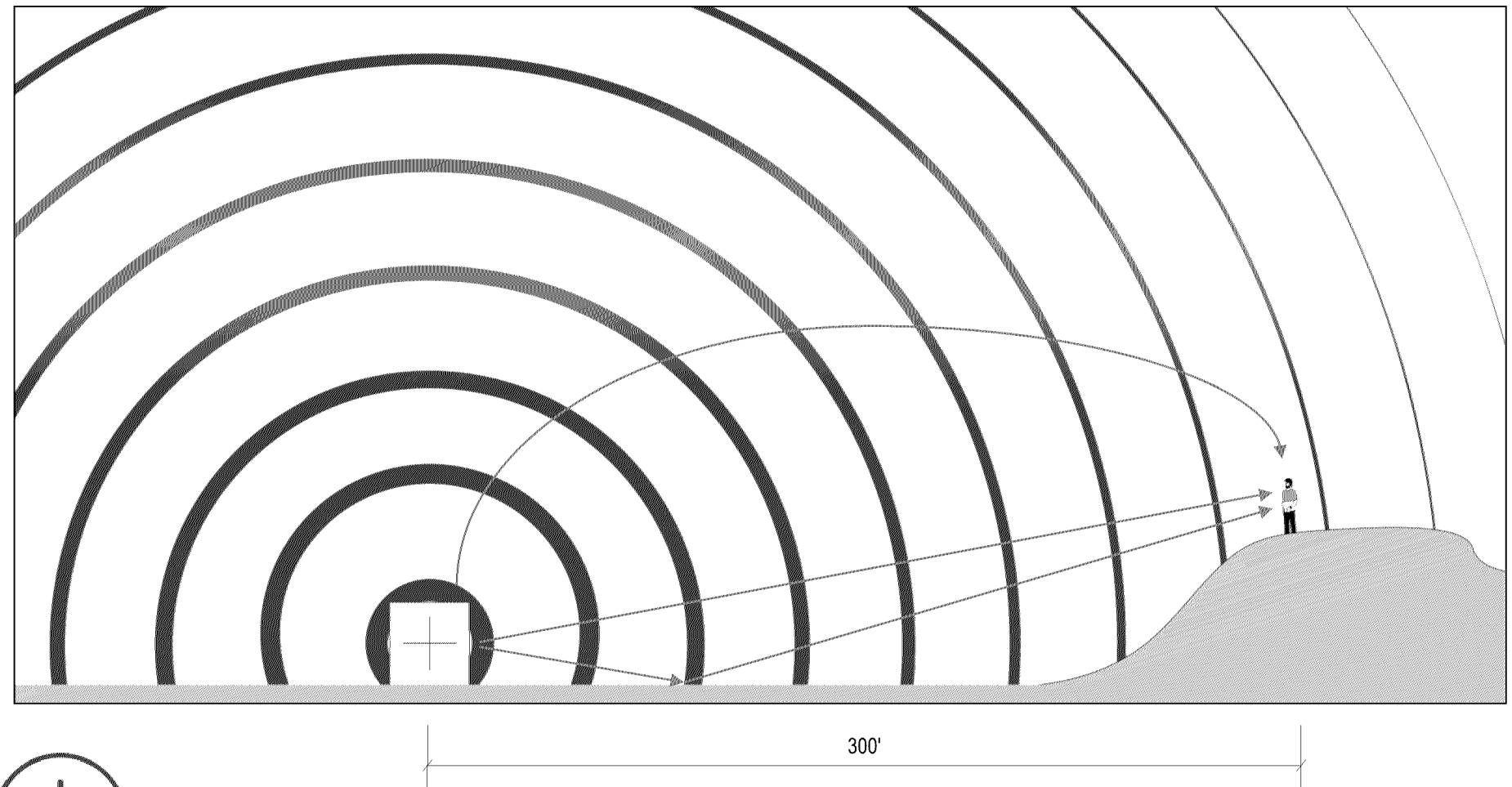
Temperature Inversion

Tends to bend sounds wave downward



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Calculation Methods

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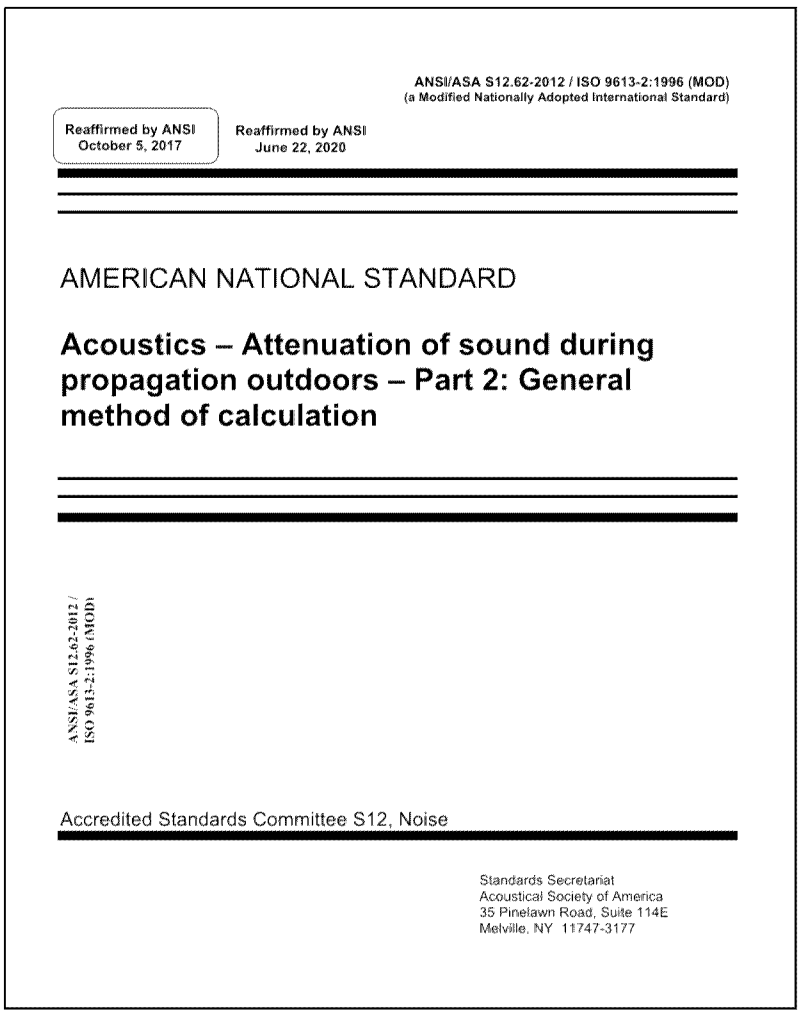
Generally follows the methods outlined in ANSI/ASA standard S12.62-2012 Acoustics – Attenuation of Sound Propagation Outdoors – Part 2: General Method of Calculation (reaffirmed June 22, 2020).

The standard has methods to predict noise levels in meteorological conditions that are favorable to propagation – moderately downwind or under a well-developed but moderate temperature inversion.

"These conditions are chosen for stable propagation (i.e., accuracy of measurement and prediction) and also to provide an appropriate condition for [meeting] a specific community noise limit – i.e., a level which is seldom exceeded."


ANSI/ASA S12.62-2012 / ISO 9613-2:1996 (MOD)
(a Modified Nationally Adopted International Standard)

Reaffirmed by ANSI
October 5, 2017

Reaffirmed by ANSI
June 22, 2020

AMERICAN NATIONAL STANDARD

Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation

ANSI/ASA S12.62-2012 /
ISO 9613-2:1996 (MOD)

Accredited Standards Committee S12, Noise

Standards Secretariat
Acoustical Society of America
35 Pinelawn Road, Suite 114E
Melville, NY 11747-3177

Calculation Methods

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$$L_p = L_w + DI + A_{div} + A_{bar} + \{A_{atm} + A_{gr} + A_{fol} + A_{housing}\}$$

Excess Attenuation Terms

L_w - equipment sound power
DI - directivity correction (used to account for reflections)
A_{div} - geometrical divergence
A_{bar} - barrier attenuation

Excess Attenuation Terms – they will only reduce noise levels:
A_{atm} - atmospheric absorption
A_{gr} - ground attenuation
A_{fol} - foliage attenuation
$A_{housing}$ - screening by houses

One difference in the calculations used for Verizon and the ANSI/ASA method is in the barrier attenuation calculation. ESI uses an equation that is published in many references and has been widely used for decades. The standard has an equation that includes ground attenuation, which we want to exclude because of varying conditions . ***The equation used by ESI has slightly less barrier attenuation, which results in higher noise predictions.***

Calculation Assumptions

- Ignore excess attenuation terms – will always result in higher predicted noise levels
- Loudest equipment operating conditions
- Model assumes receivers are downwind, or a temperature inversion exists

We don't model all conditions, only the worst-case.

If we meet the requirements for these worst-case conditions, we are okay for all conditions.

Requirements for Outdoor Noise

- Minnesota Administrative Rules Chapter 7030: Noise Pollution Control, prepared by the Minnesota Pollution Control Agency (MPCA), has requirements for maximum allowable sound levels by receiving land use and time of day.

Noise Area Classification	Receiver Type	Daytime (7AM - 10PM)		Nighttime (10PM - 7AM)	
		L10	L50	L10	L50
1	Residential	65 dBA	60 dBA	55 dBA	50 dBA
2	Commercial	70 dBA	65 dBA	70 dBA	65 dBA
3	Industrial	80 dBA	75 dBA	80 dBA	75 dBA

- From 7030.0040 – Noise Standards

  "These standards are consistent with speech, sleep, annoyance, and hearing conservation requirements for receivers in areas grouped according to land activities by the noise area classification (NAC) system…"

This is a clear, objective standard that, in the end, is measurable.

Requirements for Outdoor Noise

- Minnesota Administrative Rules 7030.0060 Measurement Methodology, § Subpart 1. Measurement location - "Measurement of sound must be made at or within the applicable NAC at the point of human activity which is nearest to the noise source."

What is the applicable NAC?

7030.0050 Noise Area Classification
Subpart 1. Applicability. The noise area classification is based on the land use activity at the location of the receiver and determines the noise standards applicable to the land use activity….

The MPCA receiver location has always been interpreted to mean the point of human activity that is nearest to the source, and the requirements are for the receiving land use.

Page 13 of the MPCA guide says "Measurements should be made in the appropriate NAC, at the area of normal outdoor human activity nearest the noise source. The monitoring location may not necessarily be at the property line; for instance, if the property of the complainant is large and residential outdoor activity is limited to a backyard patio (possibly such as on a farm).

The Site

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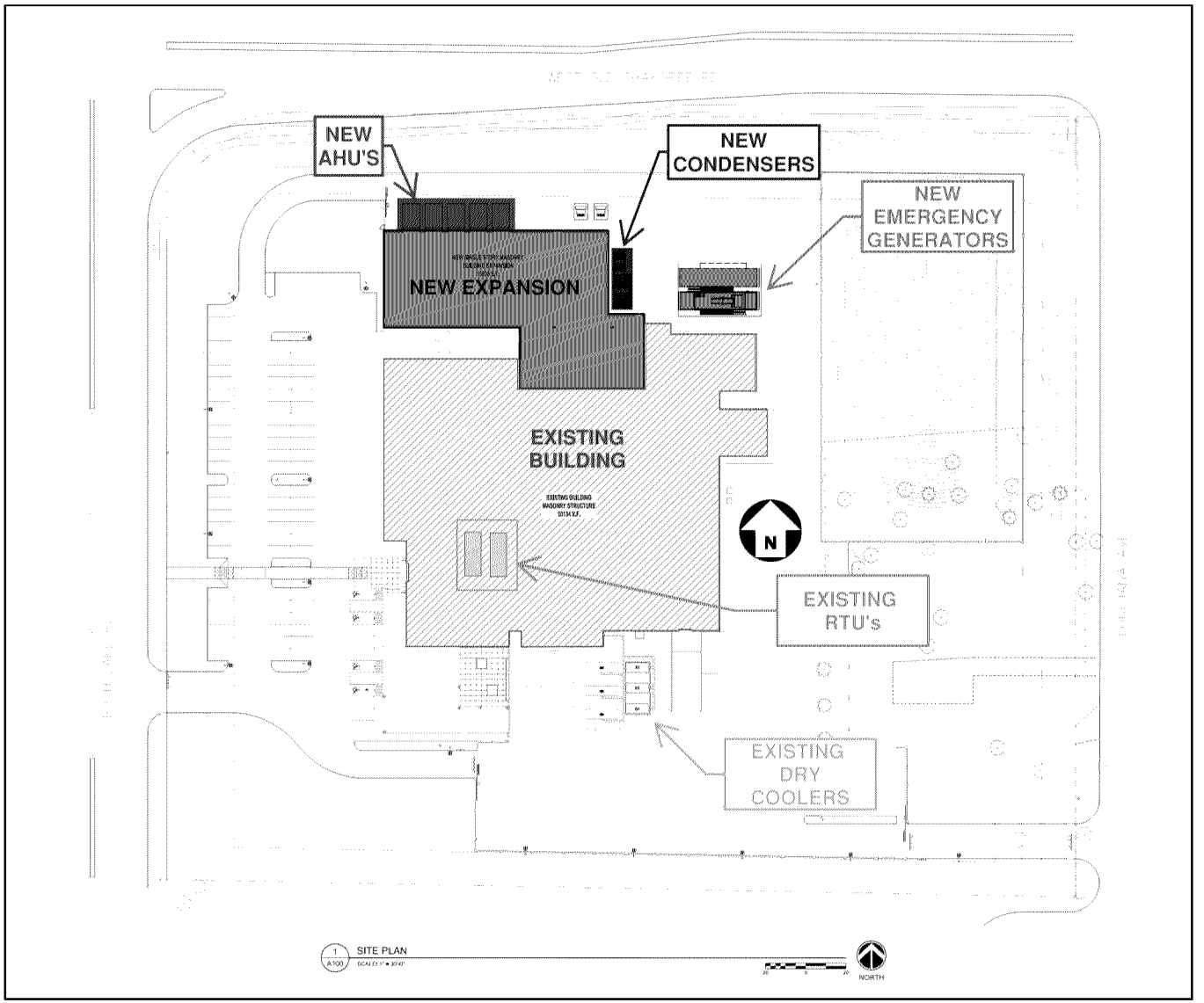

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Ambient Noise – Nighttime

Results of Noise Measurements
1:15 AM to 2:30 AM on October 27, 2020

	Measurement Results, dBA			
Location	L10	L50	L90	L_{Aeq}
A	43	38	37	41
B	44	42	40	43
C	43	37	36	40
D	39	38	37	38
E	40	37	36	38
F	40	38	36	38
G	43	41	40	42
H	42	40	38	40
I	43	40	38	41
J	43	42	41	42
K	38	36	35	36
L	41	36	34	38
M	41	40	38	40
N	43	42	41	42
O	54	53	52	53
P	58	57	57	58

Generator Noise

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Results of Generator Noise Measurements on October 30th and November 13th, 2020

Location	L_{Aeq} Measurement Results, dBA			
	Daytime (10/30/20)			Nighttime (11/13/20)
	Admin Generator Only, L_{Aeq}	Admin & Network A, L_{Aeq}	Network B Only, L_{Aeq}	Network B Only, L_{Aeq}
A	68	69	68	65
B	72	71	71	62 / 60
C	55	55	53	49
D	49	-	-	47
G	-	-	-	56
H	-	-	-	47
J	55	53	54	40
M	52	45	56	40
Q	49	44	55	-
P	51	58	54	60
R	-	63	58	58

Ambient Noise

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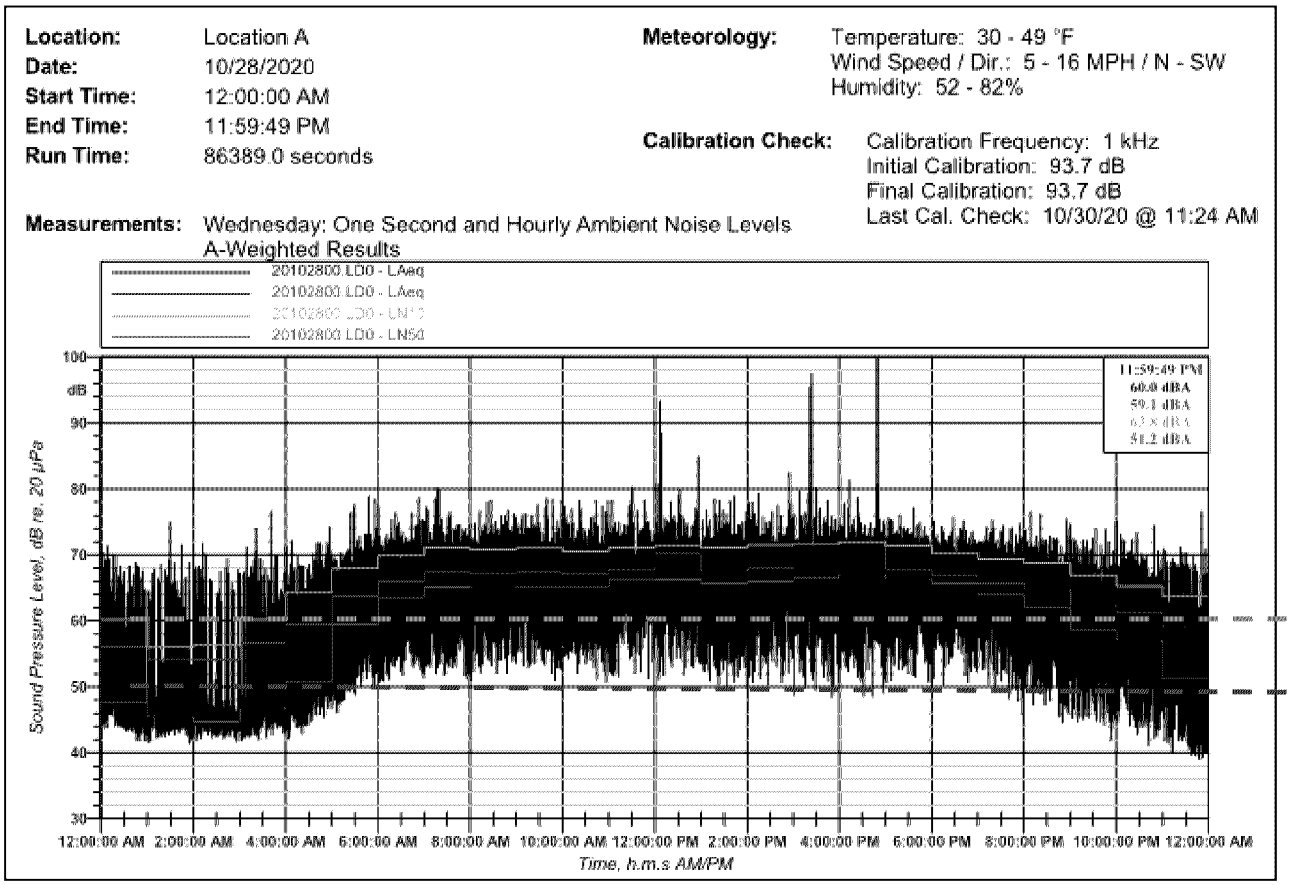
Location: Location A
Date: 10/28/2020
Start Time: 12:00:00 AM
End Time: 11:59:49 PM
Run Time: 86389.0 seconds

Meteorology: Temperature: 30 - 49 °F
Wind Speed / Dir.: 5 - 16 MPH / N - SW
Humidity: 52 - 82%

Calibration Check: Calibration Frequency: 1 kHz
Initial Calibration: 93.7 dB
Final Calibration: 93.7 dB
Last Cal. Check: 10/30/20 @ 11:24 AM

Measurements: Wednesday: One Second and Hourly Ambient Noise Levels
A-Weighted Results



60 dBA
Daytime

50 dBA
Nighttime

Noise was monitored for seven consecutive days at Location A. The hourly L50 noise levels were about 65 dBA during the daytime and in the 38 to 44 dBA range in the nighttime. The primary noise source was traffic on Old Shakopee Road. These measurements do not include the dry coolers which were not operating.

Calculations

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Calculations

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Anticipated worst-case conditions assumed

The MSC is designed with redundancy to assure that the building is always operating.

- (5) air handling units operating at 80% fan speed (may never happen)
- (2) small condensing units at 100% (only one will operate at a time)
- (4) large condensing units at 100% (only two will operate at a time)
- (3) dry coolers on the south side of the buildings at 100%
- Included topography

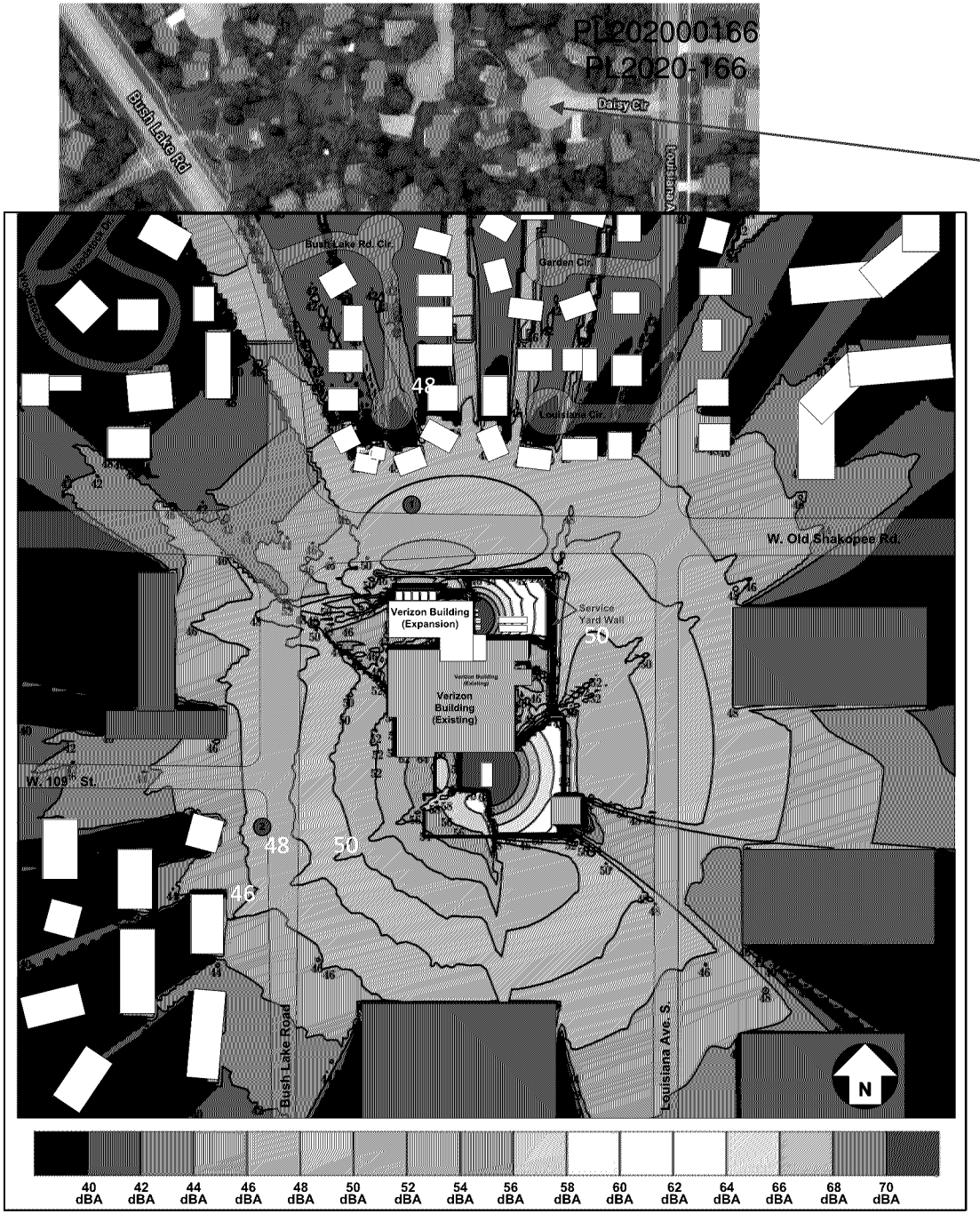
- Generators are separate issue. They will only operate during the daytime for maintenance and will be run alone.

50 dB + 50 dB = 53 dB

50 dB + 60 dB = 60.4 dB

sources that are 10 dB less than the generator noise can be ignored

Results



Daisy Court
< 44 dBA (worst-case conditions)

Loc. 1 – 48 dBA
(worst-case conditions)

Loc. 2 – 47 dBA
(worst-case conditions)

Both meet the 50 dBA requirement.

Confirmed with additional hand calculations

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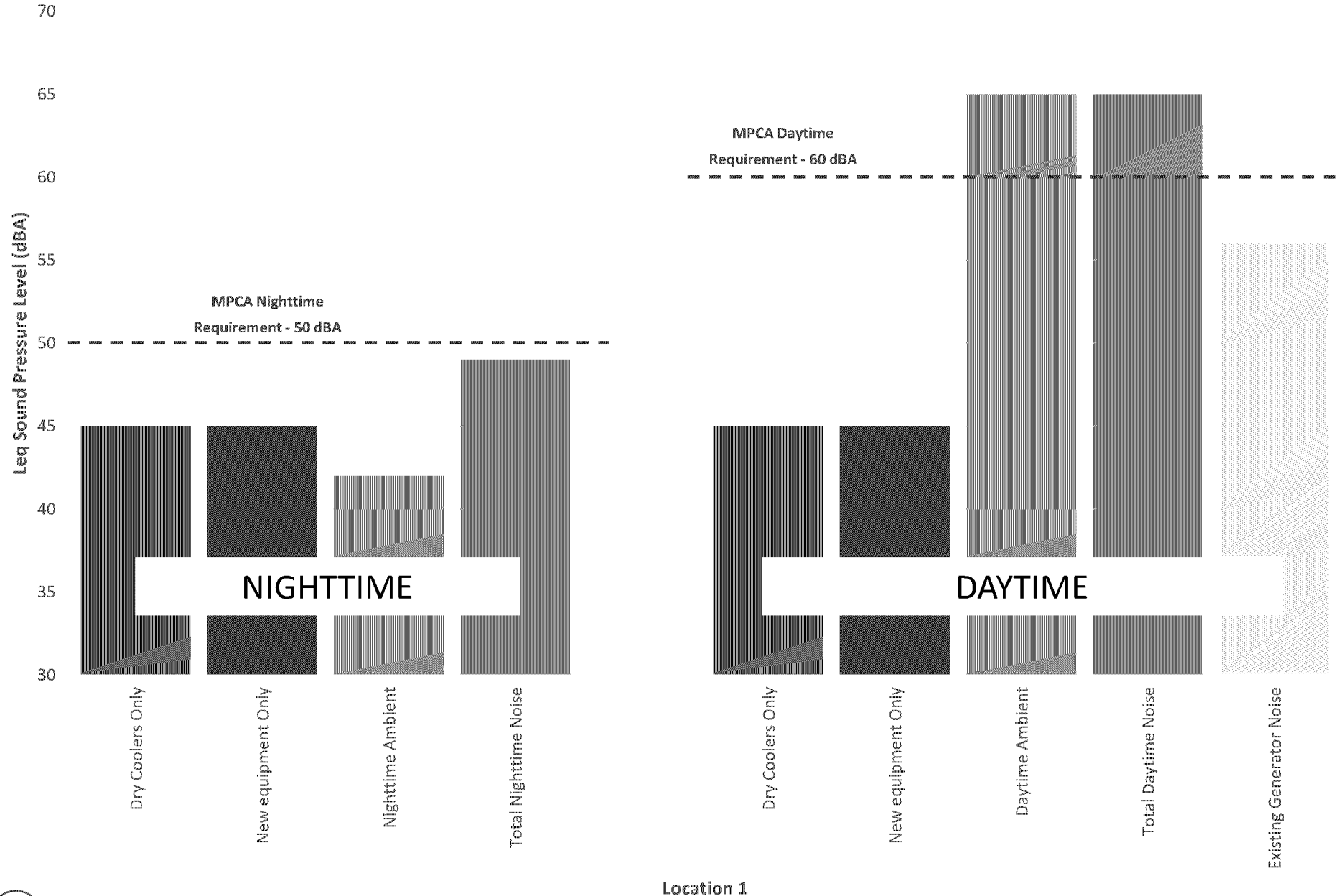
Predicted Noise Levels at Location #1



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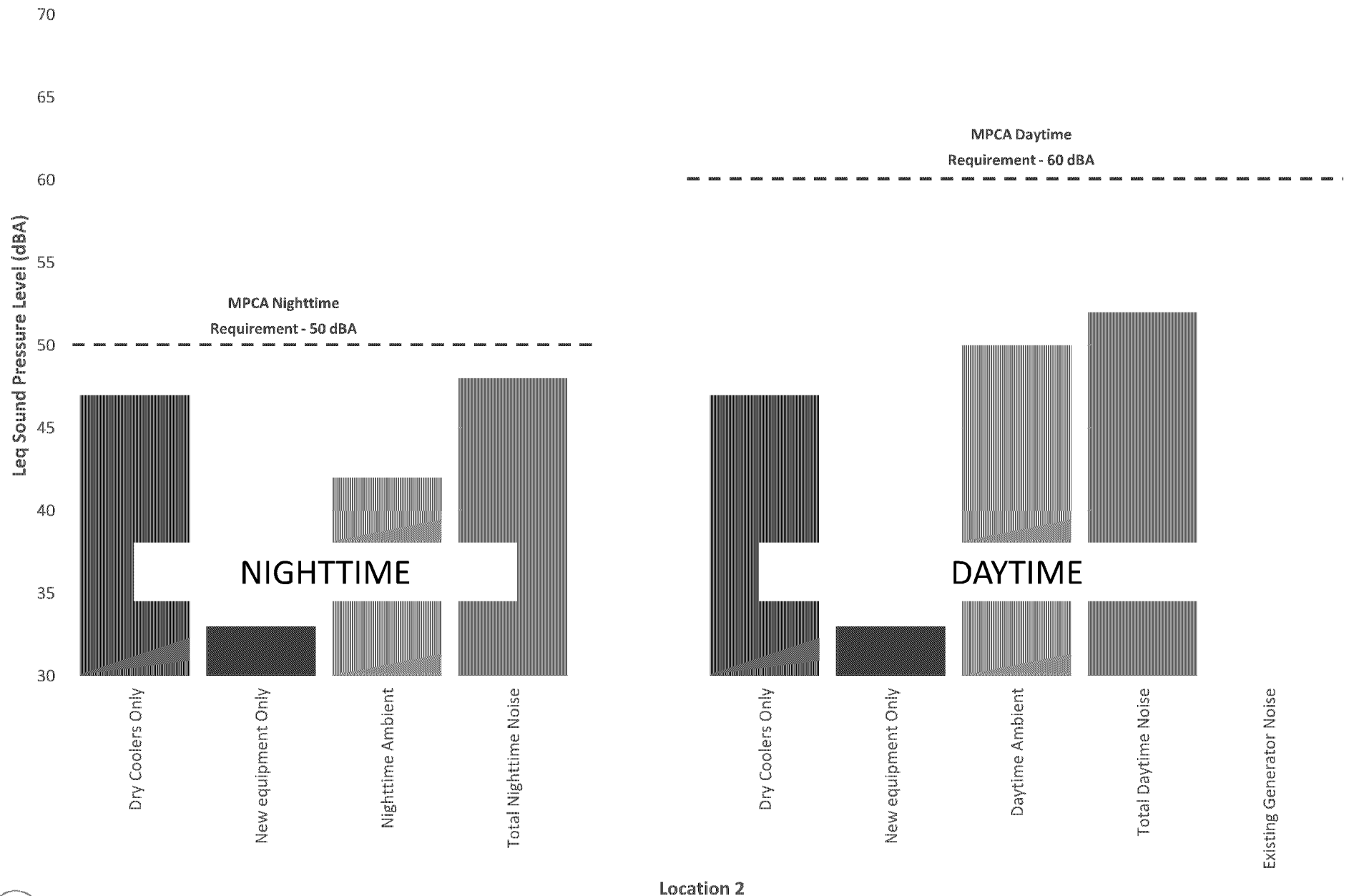
Predicted Noise Levels at Location #2



Final Steps

The calculations and mitigation design relied on basis of design equipment selections, which is common at this stage of a project. The engineering team will continue to review documentation for equipment as it is submitted, to check assumptions, operating conditions and equipment sound power levels.

Verizon is committed to meeting the MPCA noise requirements on this project. Final measurements will determine if the requirements are being met.

Response to Residents

1. The calculations were not “adjusted solely to attain an apparent compliance”, and it is disappointing that our professional ethics are in question.
2. The changes that were made to calculation assumptions were done to better represent the actual operating conditions for the new equipment. In addition to reducing the condenser fan speed, noise from the existing dry coolers was added to the calculations and the barrier wall height was increased.
3. We have been told that the fan speeds will not operate above 80% of full speed and the max speed of 80% will be set in the control system.
4. The two cases that were presented to show “non-compliance” were incorrect. The equipment sound levels were not those represented, and the method used to estimate the noise level was wrong.
5. ESI is often asked to make final noise measurements to show project compliance. This is done transparently with all parties involved.

Summary

The engineering to determine noise levels from the Verizon property were done:

- By qualified engineers
- Using standard calculation methods
- Considering ambient noise
- Using data from the equipment manufacturers
- With worst-case assumptions about equipment operation and environmental conditions

The resulting noise levels meet the MPCA code requirements. Further, Verizon will be required to prove by measurement that the requirements are being met after construction is completed.