

PL202000166

PL2020-166

Verizon MSC Expansion Noise Control

Bloomington, Minnesota

January 11, 2021

Anthony J. Baxter, PE
Andrew A.J. Schmitt



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.

The Project Team

Verizon – owner

Morrison Hershfield - Architecture and Engineering

Subconsultant

Civil

Sunde Engineering

Bloomington, Minnesota

Subconsultant

Noise Control

ESI Engineering

Bloomington, Minnesota

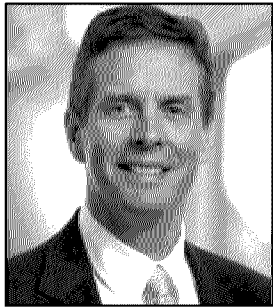
Other Subs

ESI Engineering

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- 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

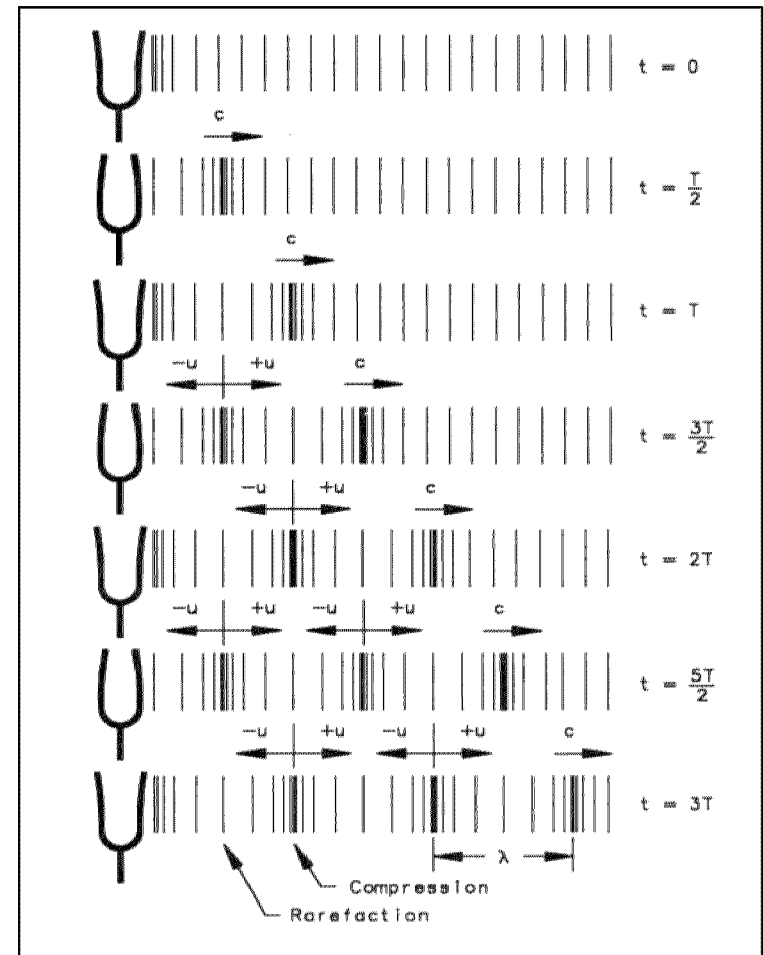
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Q. What are Sound Waves?

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

$c = 1130 \text{ ft/sec}, 770 \text{ mph}$

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



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.

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

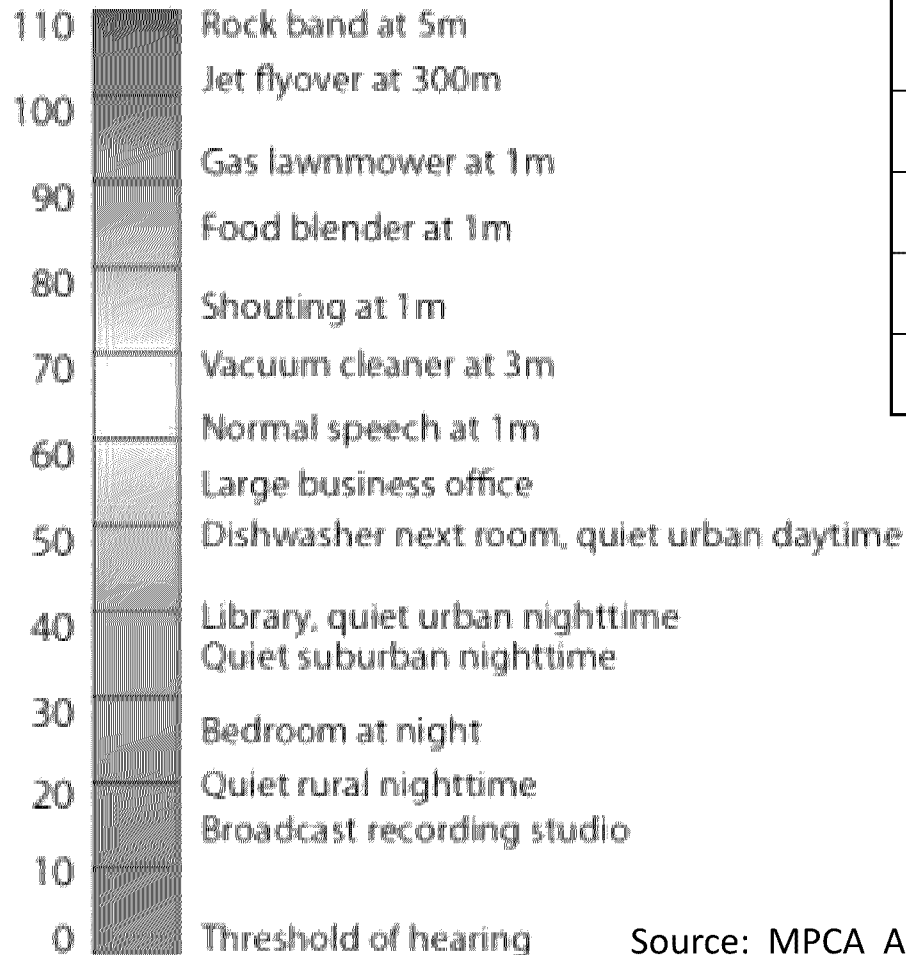
$$P_{\text{ref}} := 20 \cdot (10^{-6}) \cdot \text{Pa} \quad \sim 0.000000003 \text{ psi}$$

3 nano psi

Human Perception of Sound

Sound pressure levels
(dBA)

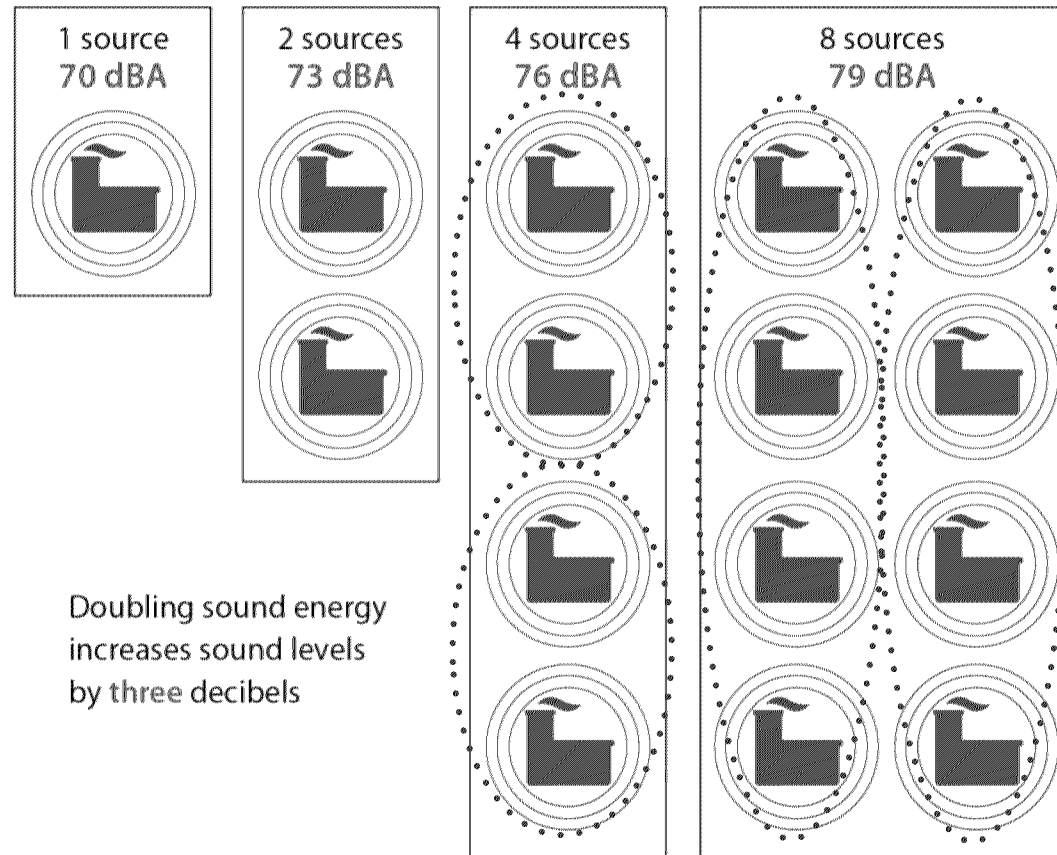
Common indoor and
outdoor noises



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

$$L_p := 50 \cdot \text{dB}$$

$$2 \cdot L_p = 100 \cdot \text{dB} \quad \text{Wrong!}$$

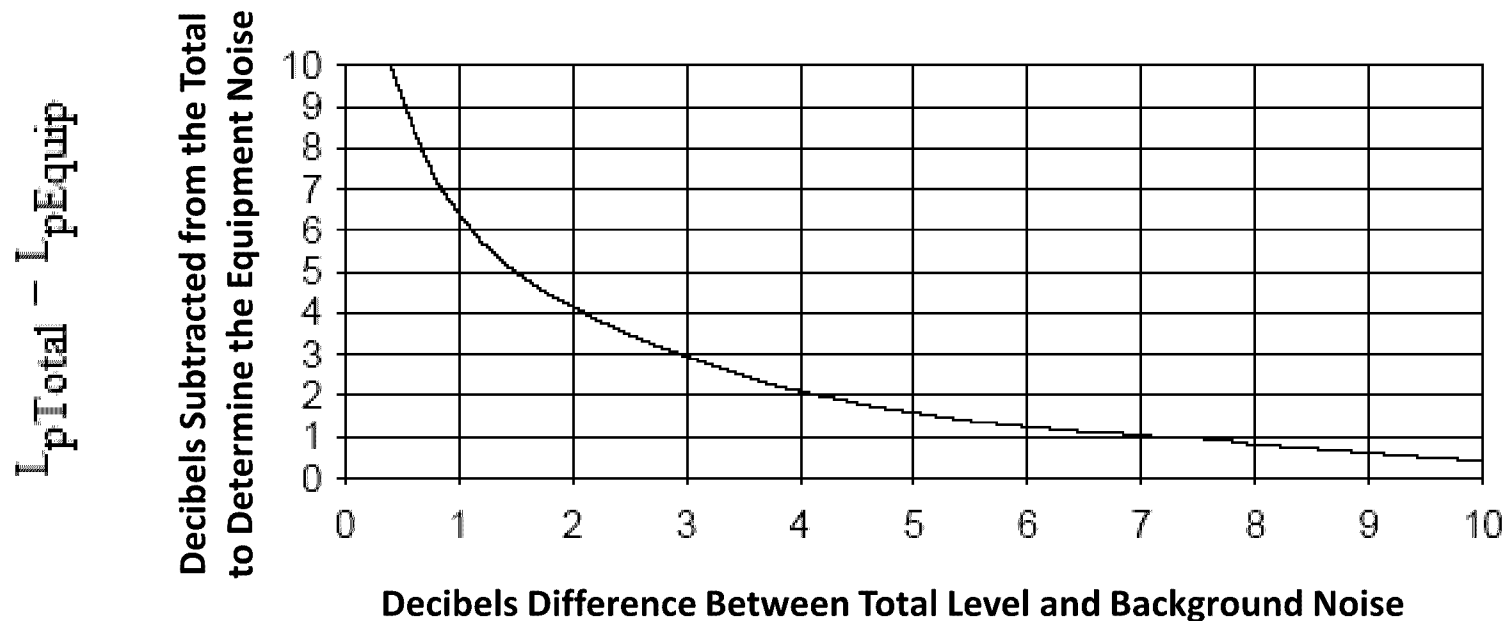
$$L_{\text{total}} := 10 \cdot \log \left(10^{\frac{50 \cdot \text{dB}}{10}} + 10^{\frac{50 \cdot \text{dB}}{10}} \right) = 53.0 \cdot \text{dB} \quad \text{Two equal levels are 3 dB higher.}$$

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

MPCA Correction for Ambient Noise

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

Background Noise Correction



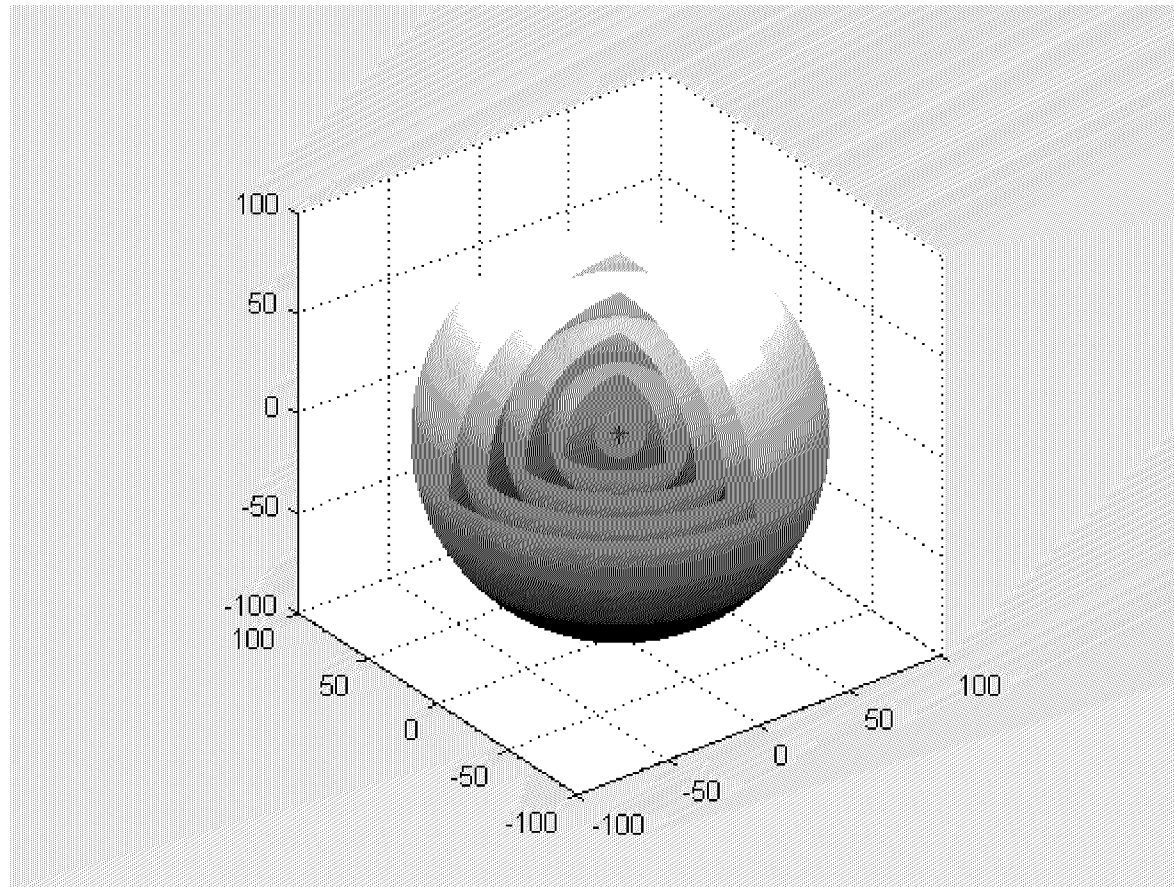
$$L_{pTotal} - L_{pAmb}$$

Source: MPCA A Guide to Noise Control in Minnesota

Geometrical Divergence

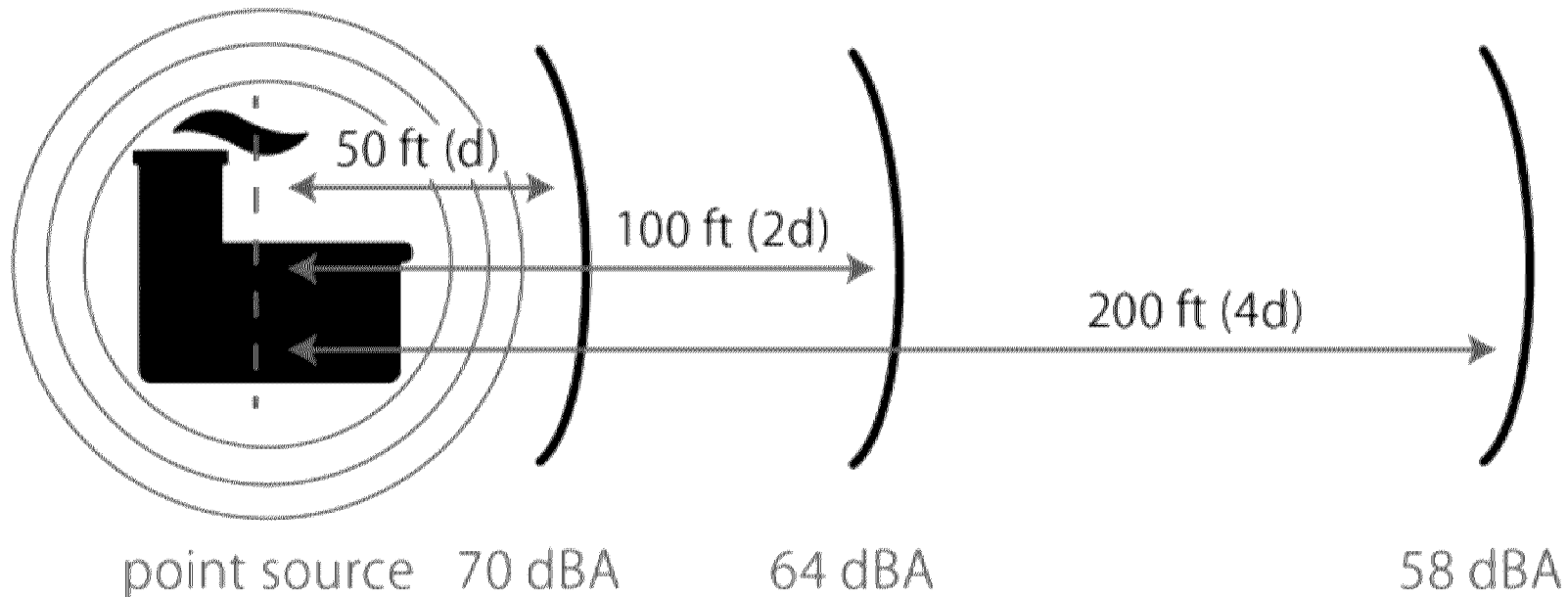
Spherical radiation of point source in free space

6 dB reduction for a doubling of distance



Noise Attenuation with Distance

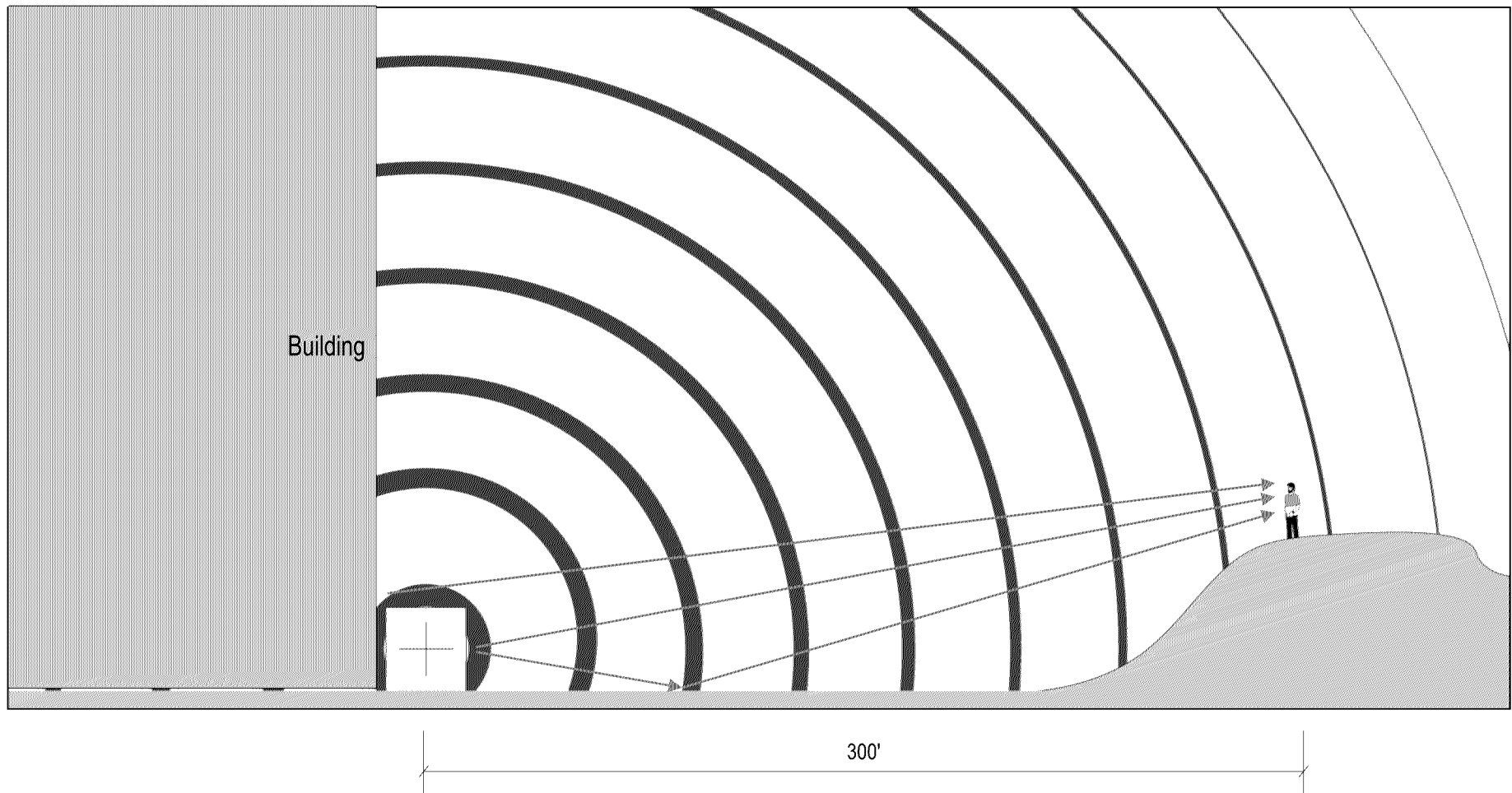
Every doubling of distance results in a 6 dB reduction in the sound level.



Source: MPCA A Guide to Noise Control in Minnesota

Reflections

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Air Absorption

This reduces noise at
distances from the source.

At 0 F, 25% RH

500 Hz - 1.4 dB/1000 ft

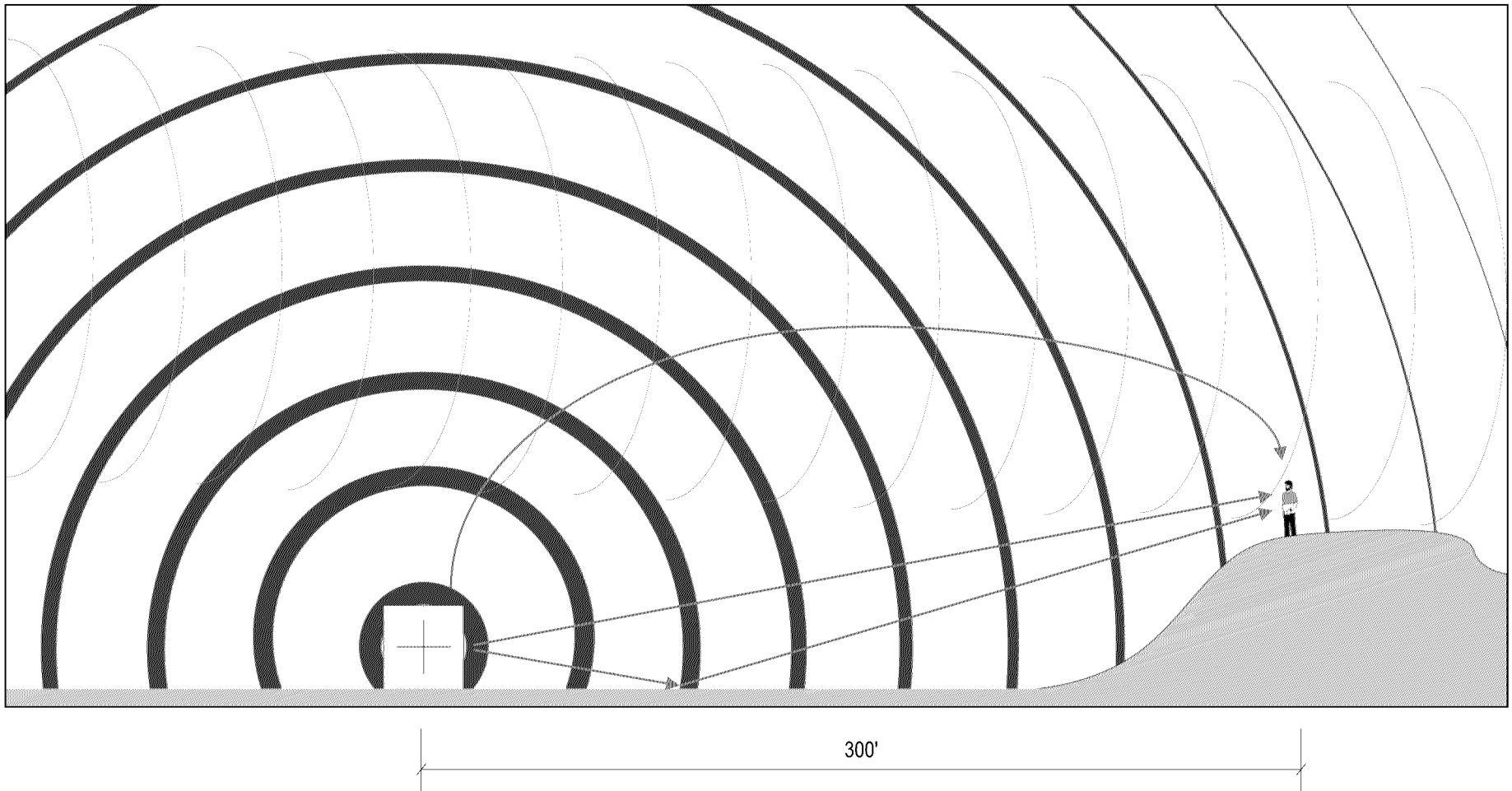
4000 Hz - 2.4 dB/1000 ft

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

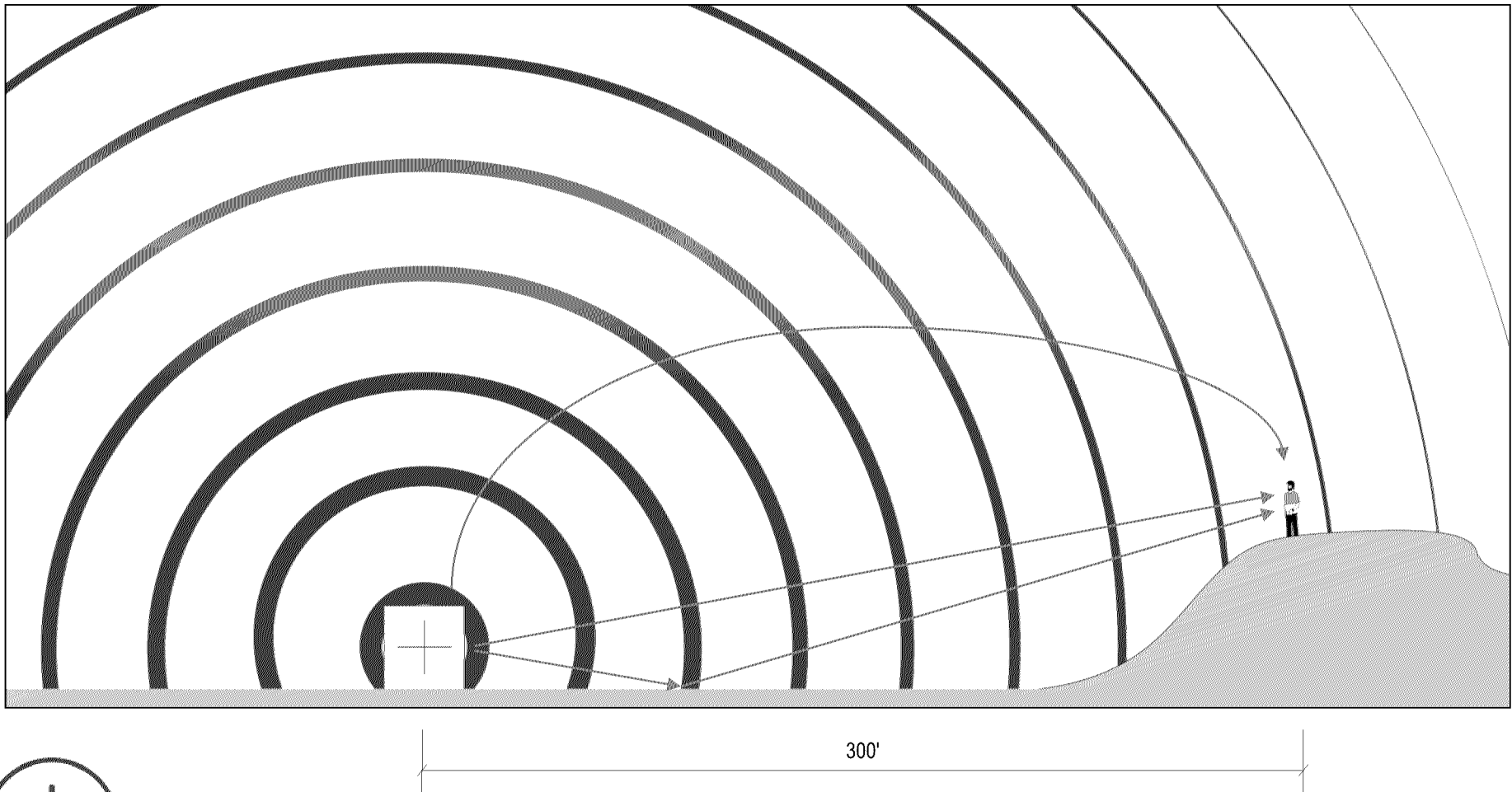
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Tends to bend the sound downward for downwind receivers



Temperature Inversion

Tends to bend sounds wave downward



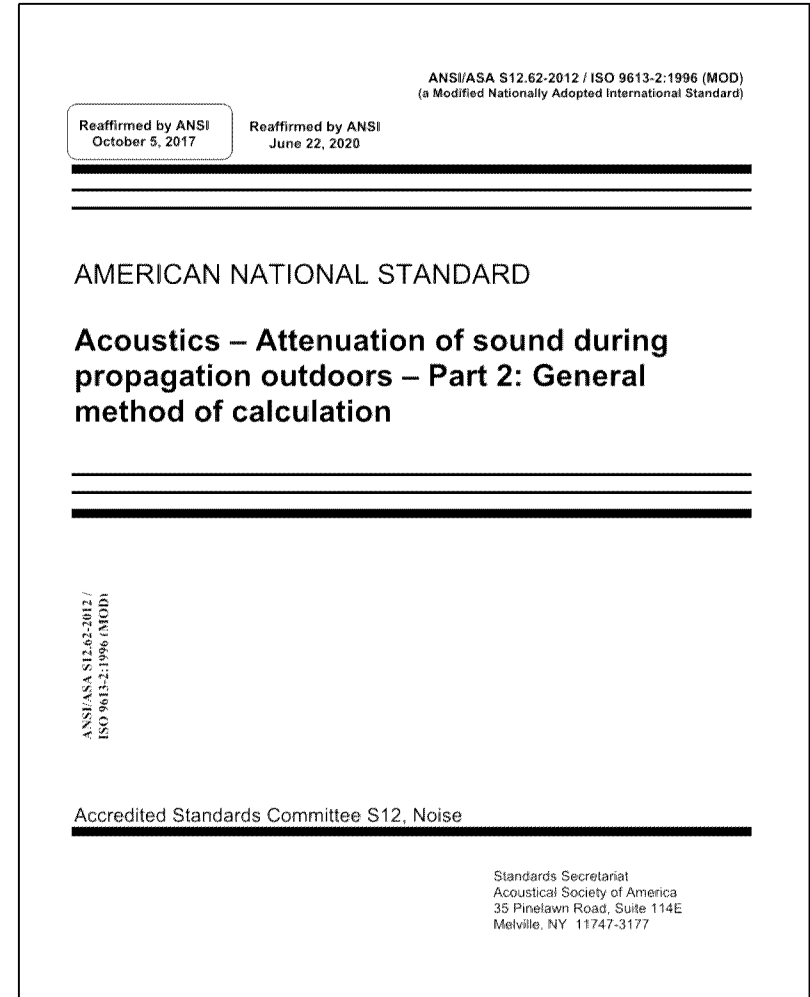
Calculation Methods

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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.”**



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

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- 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

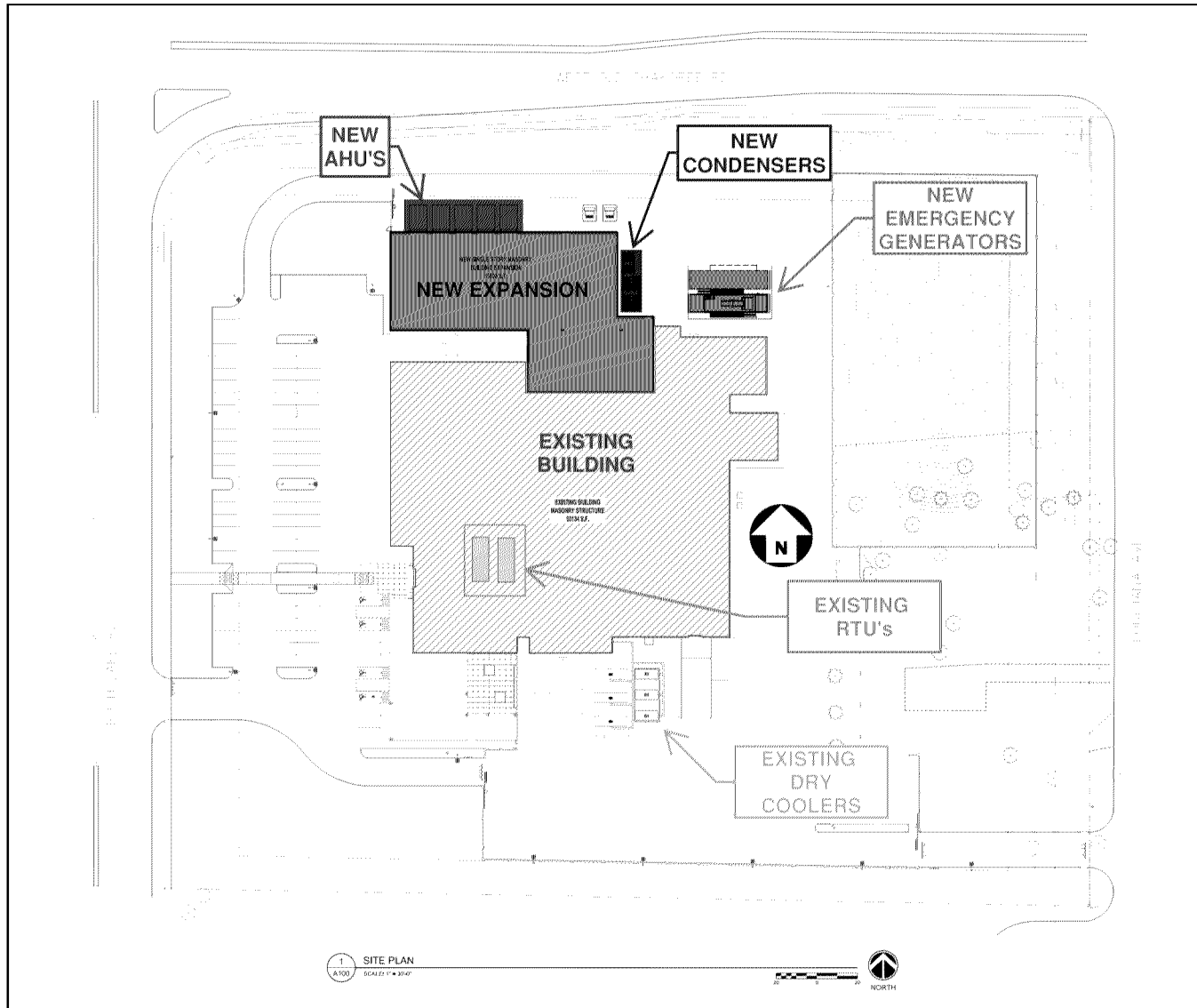
Subpart 1. Applicability. The noise area classification is based on the land use activity at the location of the receiver and determines the noise standards applicable to the land use activity....

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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Ambient Noise – Nighttime



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

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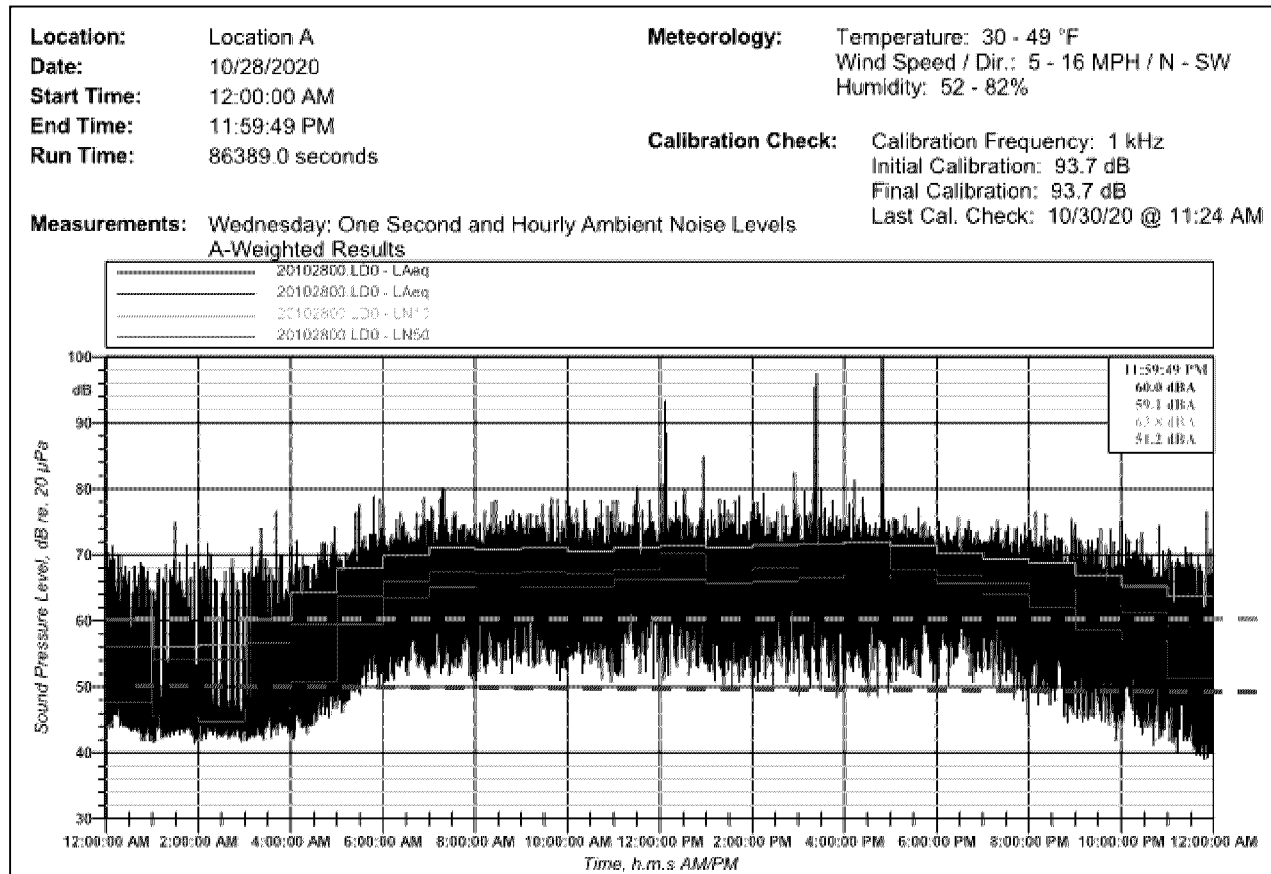
Results of Generator Noise Measurements on October 30th and November 13th, 2020

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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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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Anticipated worst-case conditions assumed

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

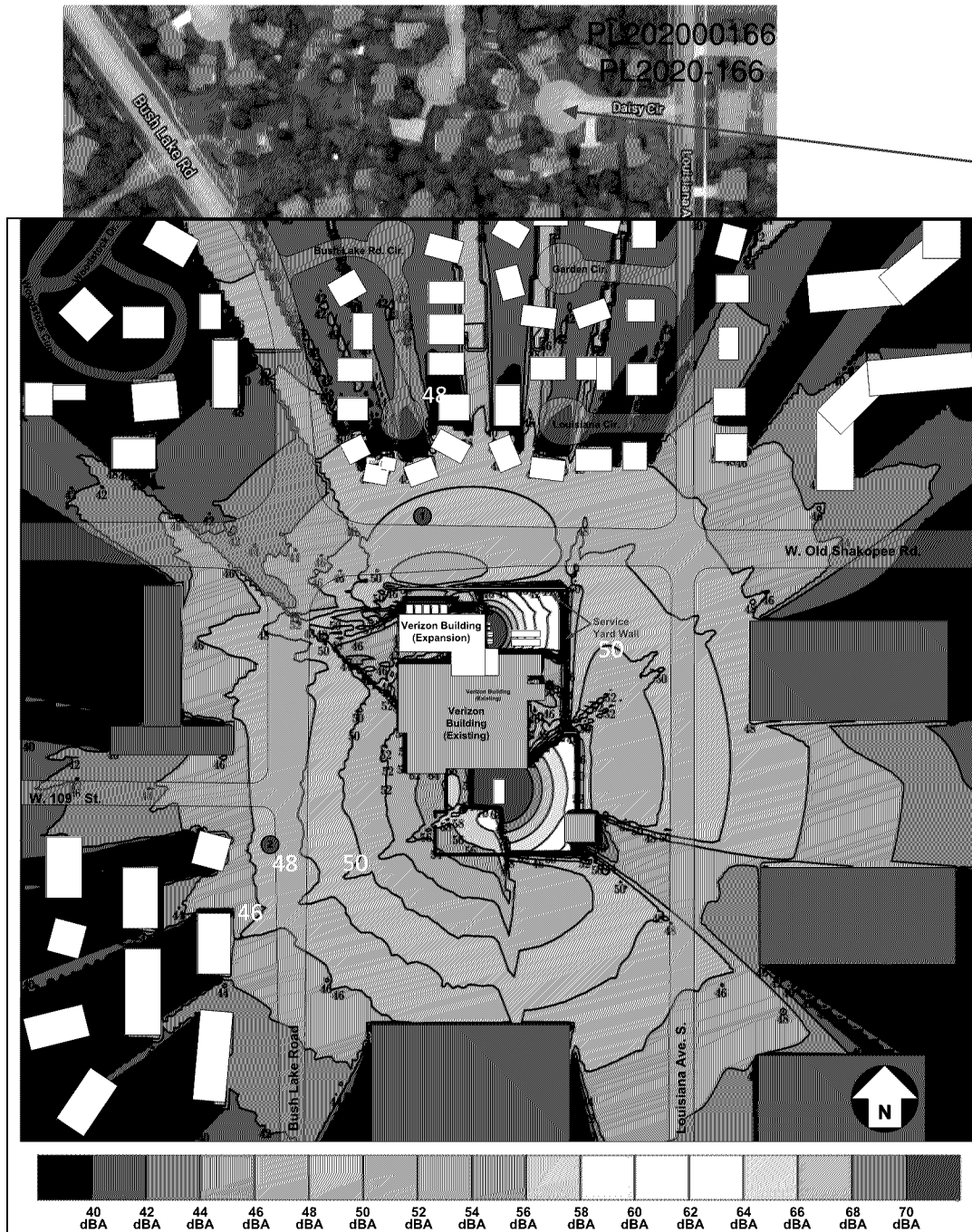
- (5) air handling units operating at 80% fan speed (may never happen)
 - (2) small condensing units at 100% (only one will operate at a time)
 - (4) large condensing units at 100% (only two will operate at a time)
 - (3) dry coolers on the south side of the buildings at 100%
 - Included topography
-
- Generators are separate issue. They will only operate during the daytime for maintenance and will be run alone.

$$50 \text{ dB} + 50 \text{ dB} = 53 \text{ dB}$$

$$50 \text{ dB} + 60 \text{ dB} = 60.4 \text{ dB}$$

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)

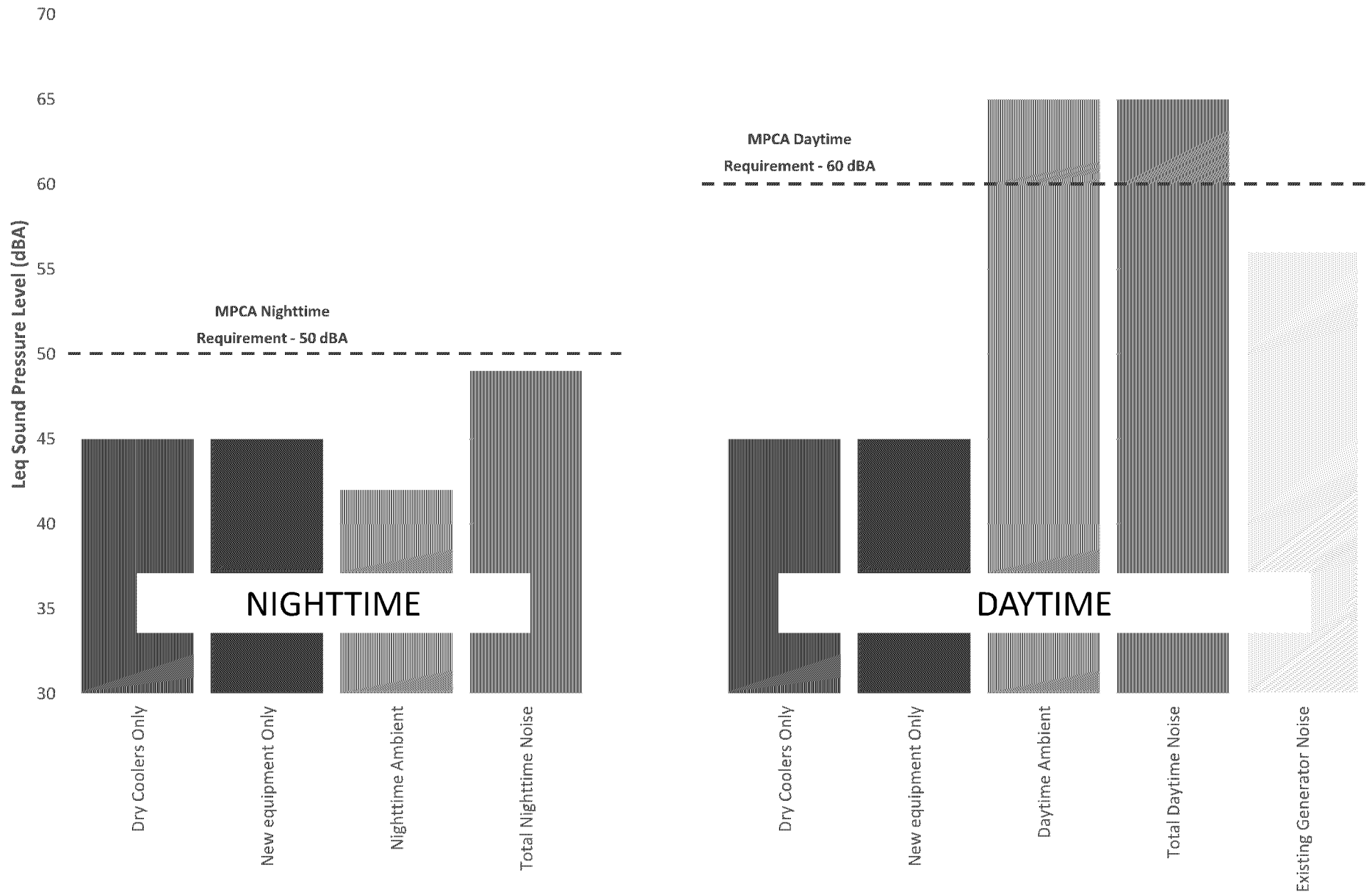
Loc. 2 – 47 dBA

(worst-case conditions)

Both meet the 50 dBA
requirement.

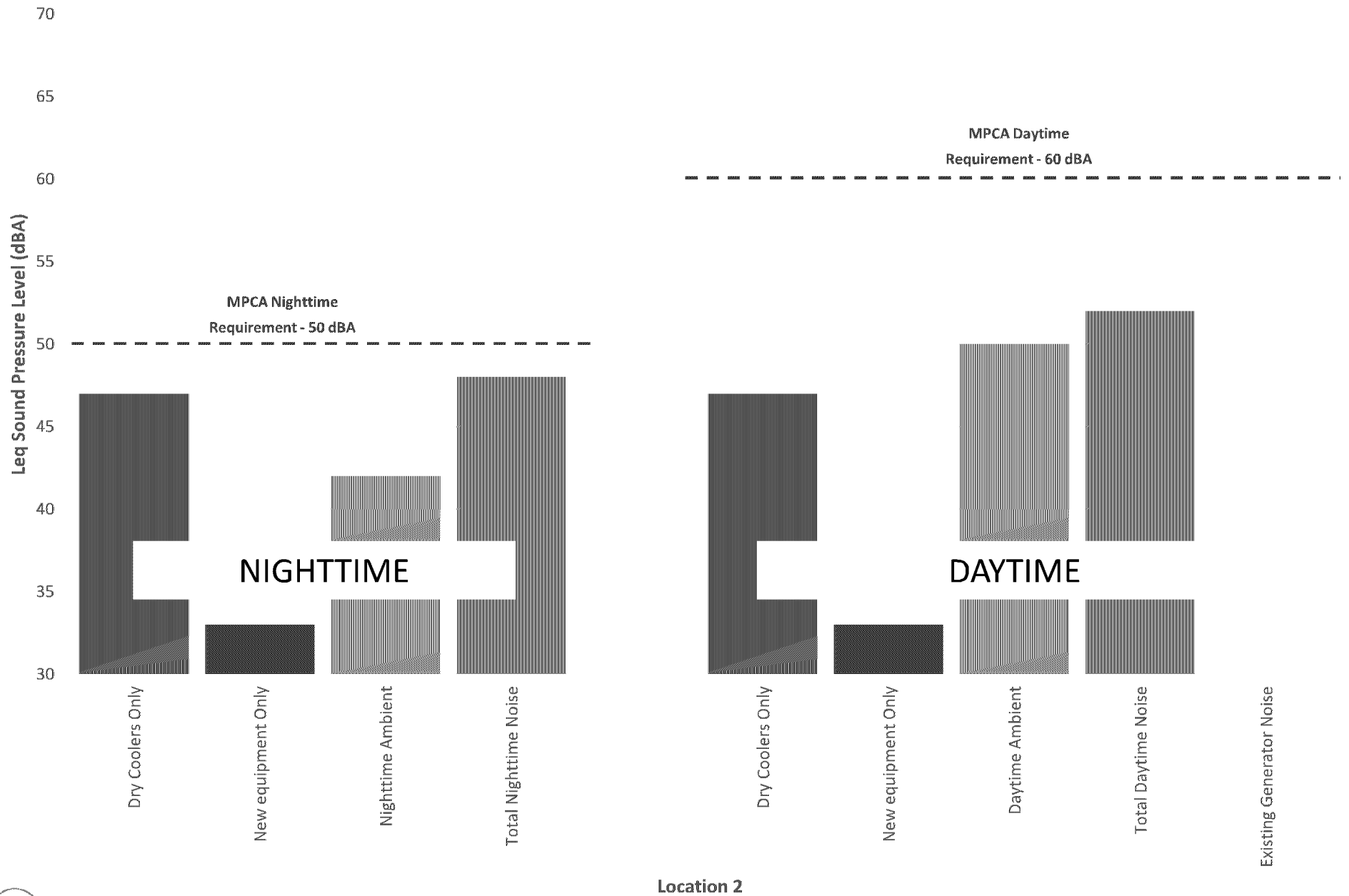
Confirmed with
additional hand
calculations

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 Predicted Noise Levels at Location #1



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
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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.