



PSM LLC
Pickleball Sound
Mitigation

**Pickleball Sound Assessment Report
For**

**River Run Country Club
Davidson, NC**

**With
Recommendations**

By

Robert M Unetich P.E.

And

John Robert Unetich, Technical Writer Intern

May 4, 2023

1811 Woodlands Circle, Pittsburgh, PA 15241
412-780-4575 rmu@pickleballsound.com

Table of Contents

Executive Summary	Page 3-4
Site Description	Page 5
Description of Pickleball Sound Characteristics	Page 6
Measurement of Pickleball Sound	Page 7
Davidson, NC Noise Ordinance	Page 8
Field Test Data	Page 9-10
Data Analysis	Page 11-12
Pickleball Sound Mitigation Methods	Page 13-15
Conclusions and Recommendations	Page 16
Author's CV	Page 17
Disclaimer	Page 18
Appendix A	Page 19-21
Appendix B	Page 22

Executive Summary

This is a pickleball sound assessment report for River Run Country Club. It includes data acquired during an on-site visit by Robert M Unetich on April 27 and the predictions of sound levels obtained from simulations of the site using Noise Tools software. River Run CC plans to build five pickleball courts, two near the location of existing tennis courts and three at the eastern end of their parking lot.

These two areas are located along Greyton Drive in a residential area. PSM LLC has been asked to make recommendations, based upon the field data and the computer predictions of sound levels, of what sound mitigation should be included to ensure compliance with local noise ordinances, which limits sound levels to 65 dBA at a property line in residential areas from 7 AM until 11 PM.

This Conceptual Site plan illustrates the planned court locations and the Google earth photo shows where homes are located:



There are residential properties on the north side of Greyton Lane, within 200 feet of the planned west courts and within 115 feet of the planned east courts. Pickleball sound levels will, if no sound mitigation is employed, reach and occasionally exceed 70 dBA in open space areas at 100 feet from players and because of the laws of physics, we can predict a level of about 64 dBA at 200 feet and 68 dBA at 115 feet.

The terrain at this site is not level and this reduces the level of ground reflected sound to some extent. The field test data confirms this expected result and the measured data indicates that the actual levels of pickleball sound is several decibels below the limit established by the ordinance at the west courts and just over the limits at the properties near the east court site. The field tests include the

measurement of pickleball sound levels with ordinary pickleball paddles and balls and with paddles and balls that have been found to be quieter.

The data collected indicated that a two decibel reduction could be obtained by selecting a quieter paddle often used at River Run club and another two decibel reduction can be achieved by selecting a softer quieter ball, the Onix Fuse, which is also already in use at River Run. These steps, along with the selection of a heavier than usual wind screen material plus the installation of dense shrubs along the north fences of the new courts will further attenuate the sound levels, sufficiently to comply with the ordinance, in our opinion.

A review of these options along with a consideration of using heavy sound barrier materials such as Acoustifence was done with George Husk after the field tests were concluded. Based on the test data and these discussions, we suggest these options:

Option A: Quieter gear and blocking windscreen plus thick shrubs

This option permits use of the Infinity Pro 16 mm paddle and any paddle listed on the PSM LLC Blue List along with any of the following balls: Onix Fuse Outdoor, Onix Pure 2, Wilson 32 and the Avioni Outdoor ball. Expected total benefit: 4 decibels minimum

It also requires that on the north fences of the new courts, a 100% blocking windscreen be installed from within one foot of the ground and up to at least the 8 ft high level of a chain link fence. Expected benefit: 2 decibels

In addition, dense shrubs or hedges will be installed along the north fence of at least the east courts. Expected benefit: up to 4 decibels sound reduction.

Total Expected benefit: up to 10 decibels of sound reduction with fully grown bushes. Pickleball sound level will be below 60 dBA at all neighboring property lines.

Option B: Use any pickleball gear and a mass-loaded vinyl sound barrier

This option enables the use of any player gear but it adds Fence Screen *SoundBlok* sound barrier or Acoustiblok *Acoustifence* or, similar mass-loaded vinyl, to the ten foot height point of new fencing. Expected benefit: 10 decibels of sound reduction.

Pickleball sound level would be below 60 dBA at all neighboring property lines.

Additional Recommendations: Limitations on hours of play and expanding the width of the hanging sound barriers and bushes

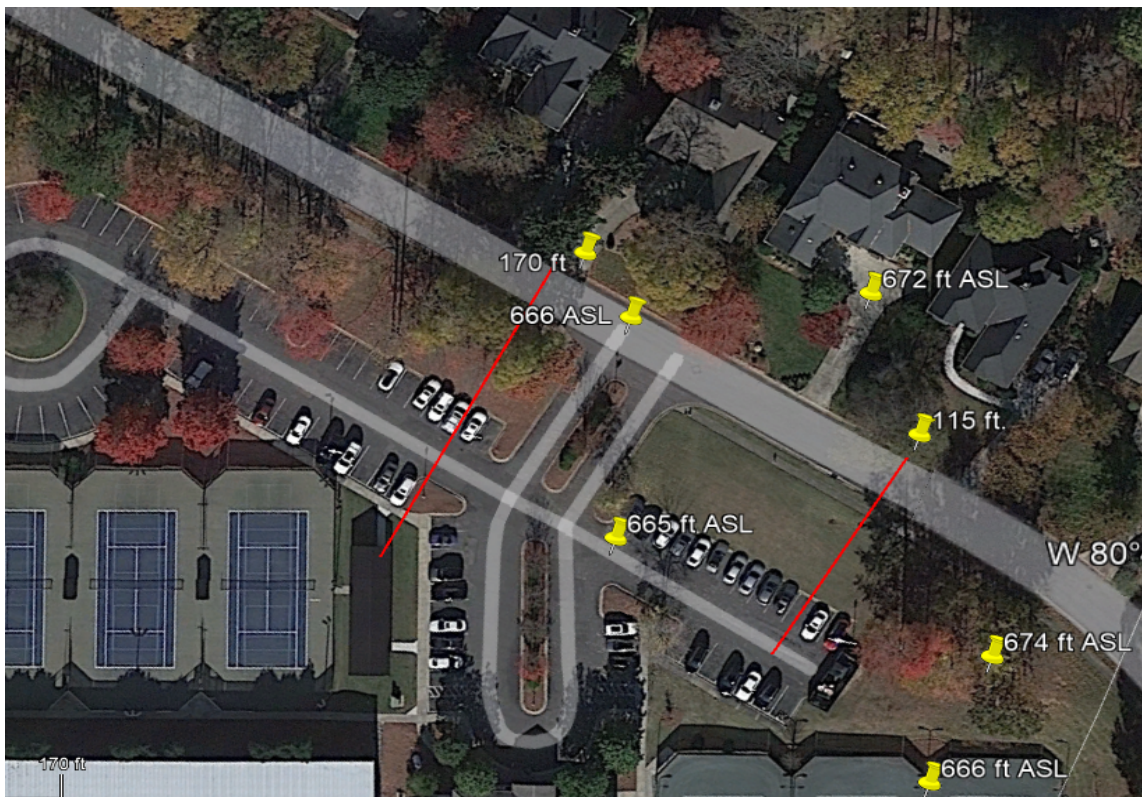
Recognizing that limiting the sound levels to below the limit set by the ordinance may result in audible

pickleball sound at the nearby homes, it is recommended that River Run Club limit the hours of play.

The sound of pickleball play will travel over and around the sound barriers. Expanding the width of both the sight-blocking windscreen and the bushes and shrubs can be expected to further reduce the sound levels at nearby homes.

Site Description

This Google Earth photo illustrates where the field tests were done on April 27, 2023. It includes the distances from the hitters.



It also shows elevations of the terrain in feet above sea level (ASL), taken from the Google Earth views. Note that Greyton Lane rises about 10 feet from west to east in front of the Club.

The locations for sound sources (pickleball players) were selected from the site plan:



Pickleball Sound

Pickleball is a game played with paddles, a ball, and a net on a court that is approximately one half the size of a tennis court. The paddles are made of wood, plastic, or composite materials, and the ball is made of plastic. The sound generated by pickleball is louder than the sound generated by tennis, and it has a higher, more annoying pitch. Homeowners in proximity to pickleball courts hear a louder sound than from tennis play. At some elevated sound level, pickleball sounds are considered as noise and become bothersome and intrusive.

Properties of Pickleball Sound

Sound is generated when an object vibrates and excites the air molecules with which it is in contact. These vibrating air molecules create sound waves that radiate outward from the source of the sound at a speed of 1087 feet per second. As sound moves away from the source, it decreases in amplitude at a rate of 6 dB for each doubling of distance. The sound level or loudness is measured in decibels (dB). The louder the sound, the higher the dB level that is measured, and the more likely the sound will be an annoyance. The tonal quality is the combination of low frequency and high frequency components of the sound. Frequency is measured in cycles per second or Hertz (Hz). Most sounds include a combination of low frequency booming tones and high frequency shrill or sharp tones. Sound also varies with time. A steady state noise is continuous with little or no change in level or frequency content. Impulse noises have a short duration and may or may not be repetitive and recurring.

Human Hearing and Annoyance

The human ear is sensitive to a sound's level, its frequency content, and its duration. The higher the sound level, the greater the annoyance becomes. Each 10 dB increase in sound level is perceived as a doubling in the sound level, which is a 100% increase. Each 6 dB increase is perceived as a 50% increase and each 3 dB increase is perceived as a 23% increase. The human ear is more sensitive to high frequency sounds than to low frequency sounds. It is also sensitive to the duration of noise.

Typical Sound Levels

Human hearing normally has a very large range of hearing capability, usually expressed in decibels above a selected sound pressure level of 20 micropascals and designated at zero dB. Human hearing has a lower sensitivity to low pitch sounds. Readings of meters and sound software are usually adjusted to account for this by using the A scale. As seen on the chart below, a quiet library is usually about 40 dBA.

This chart illustrates that sounds in the range of 60 to 75 dBA are comparable to the loudness of normal conversation and to the sound levels usually present in a busy restaurant. Pickleball sound at 100 ft. is usually under 70 dBA with no sound barrier and under 60 dBA with a 10 ft. high sound barrier. The height of the barrier can be adjusted to achieve sound level reduction with a basic goal of having pickleball sound not frequently exceed normal background sound levels.



Measurement of Pickleball Sound Levels

Sound is simply a variation in air pressure over a period of time. A calibrated microphone connected to

a device that measures the electrical output and records the peak sound pressure or averages the sound power over a defined period of time constitutes a sound measurement system. The measurements are generally done over time periods defined according to measurement standards and in the US those standards are set by the American National Standards Institute or ANSI.

While ANSI defines several acoustics terms, pickleball has a usual time duration of about 10 to 20 milliseconds (ms). PSM LLC selects the Fast mode for measuring these short duration sounds, which has a 125 ms averaging period. This metric is known as **LAFmax**. Since background noise naturally varies over time, we select the term **Leq** for Equivalent Level for determining average sound level.

This is “the sound” that neighbors will hear, as opposed to an averaging of that sound along with all other sounds over an arbitrary time period.

Applying the Davidson, NC Noise Ordinance

ARTICLE III. NOISE

Sec. 30-71. Purpose.

It is recognized that people have a right to, and should, be ensured an environment free from excessive sound and vibration that may jeopardize their health or safety or welfare or degrade the quality of their life. This article is enacted to protect, preserve and promote the health, safety, welfare and quality of life of the citizens of the town through the reduction, control and prevention of noise.

Sec. 30-72. Standards of measurement.

Standards, instrumentation, personnel, measurement procedures, and recording procedures to be used in the measurement of sound as provided for in this article shall be as follows:

- (1) Sound level measurement shall be made with a sound level meter using the "A" weighting scale.
- (2) Sound level meters shall be at least type two meeting American National Standard Institute Incorporated requirements.

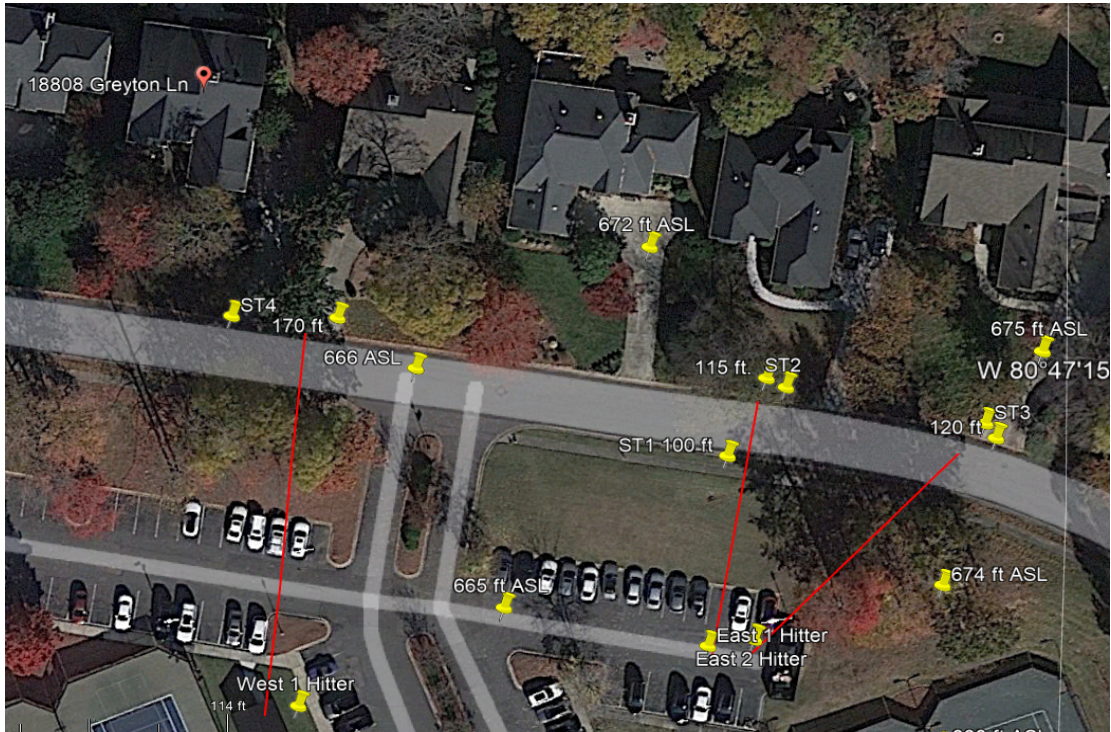
Sec. 30-73. Prohibited acts

(a) **It shall be unlawful for any person or entity to emit or cause to be emitted any noise across a property line or to a public street, sidewalk or public vehicular area or into another dwelling unit of a multifamily structure in excess of the noise levels established below:**

	Times	Residential	Multifamily	Commercial/ Institutional
Day	7:00 a.m.—11:00 p.m.	65 dBa	60 dBa	70 dBa
Night	11:00 p.m.—7:00 a.m.	60 dBa	55 dBa	65 dBa

Sound Level Data Collected on April 27, 2023

The photo on the next page identifies the location of hitters and receivers during these tests. The hitters were George Husk and another player who were asked to hit hard volleys and overheads with “put away” hard finishes. They were positioned so that George was in the likely location of the loudest hitters on the future courts.



There were four receiving locations. Designated ST1, ST2, ST3 and ST4. At each location a calibrated Sper Model 840015 Type 1 Sound Level Meter (SLM) was used to take readings of **LAFmax**. At ST1 and ST2, we also used a Windows 11 Dell Laptop running REW sound analysis software along with a Dayton Audio model UMM-6 calibrated microphone. The laptop tests enabled us to record average background noise (**Leq**) along with double checking the values of **LAFmax** measured with the Sper SLM.

We had periods of slight rain but no wind and the sound from the rain was below the background noise level. The lowest background noise measured (**LASmin**) was 47 dBA and the typical average noise level over a 5 minute period was about 51 dBA, mainly caused by occasional auto traffic.

At ST3 and ST4, the Sper meter was used alone. The tests were completed over a two hour period, during which the hitters moved between the three sound source locations. Two different paddle models and two different ball types were used

Data

Hitter Location	Receiver	Distance feet	LASmin	Leq	Paddle Pro Pickleball	Ball	LAFmax dBA
East 1	ST1	100	48	53	Tour	Dura Fast 40	71
East 1	ST1	100	49	55	Tour	Onix Fuse	69
East 1	ST1	100	47	52	Infinity 16 mm	Onix Fuse	67
							Net -4dB
East 1	ST2	115			Infinity 16 mm	Onix Fuse	65
East 2 (20 ft east of East 1)	ST3	120	48	52	Infinity 16.0 mm	Onix Fuse	64
West 1 (180 feet west of East 1)	ST4	170	47	55	Infinity 16.0 mm	Dura Fast 40	62

Test Procedure and Data Analysis

The first test positions at 100 feet from the hitter at East 1, a position called (ST1), was selected to permit us to verify that the test equipment was operating normally. At that location we used two sound measurement devices, a Sper Scientific model 840015 Type 1 sound level meter and a laptop running REW sound measurement software coupled to a Dayton Audio model UMM-6 calibrated microphone. At this position we measured about 20 hits with the louder hits measuring near 70 dBA on both measuring systems. This is the typical nominal sound level at 100 feet from hard hitters.

After verifying the accuracy of the measurements, we asked the hitters to change to the Onix Fuse ball and to resume hitting. This resulted in a 2 decibel reduction in the highest recorded measurements. (69 dBA). Next we asked them to use the Infinity paddle, a thicker and softer face higher level paddle, comparable to several pro models we have tested. This resulted in the max reading dropping to 67

dBa. This series of tests confirm our experience with the Onix Fuse ball and it confirmed that the thicker Infinity paddles were quieter than the Tour model.

Next we moved across the road to the approximate property line of 18746 Greyton Lane, ST2, a distance of about 115 feet to the hitter. Here the max SPL reading was 64 dBA using the Infinity paddle and the Onix Fuse ball, indicating that play at the location of these planned new courts would produce SPLs at or near the limit established by the Ordinance if quieter paddles and balls are used.

Pickleball sound is probabilistic and during a short test it is unlikely that the highest levels of sound will be measured. Therefore, this data does indicate that it will require some sound mitigation along the north fence of the courts to be sure that the SPL at the closest neighbor property line is within the limit set by the ordinance.

Next we moved to the east to verify that the SPL was no higher at the next property line to the east and the data (64 dBA max) confirmed this expectation.

Since two new courts are expected to be constructed west of these three courts, we moved the hitters about 170 feet to the west and we moved our sound level meter to in front of house number 18808. As expected at this greater distance, the measured SPL was lower, at about 62 dBA, which is below the ordinance limit. Further reduction with thick hedges or solid windscreen, would probably push these levels to below 60 dBA.

Pickleball Sound Mitigation Methods

At private pickleball courts, the use of quieter balls and paddles can mitigate the sound levels. At public courts, this is normally difficult to enforce but at River Run club, we will assume that enforcement is possible.

Limitations on the times that pickleball is played are common. When homes are within 500 ft. it is not unusual for times to be limited to daytime only or into early evening if lights are present.

While an effective sound barrier near pickleball courts can reduce the existing pickleball sound levels, this requires that the sound barrier blocks the line-of-sight path.

Effective sound barriers are made of heavy material. That includes earth, concrete walls, thick vegetation such as tall thick hedges and mass loaded vinyl.

Barriers can be sound reflecting or absorbing and several companies manufacture hanging sound barrier materials of both types. Examples include the frequently used mass loaded vinyl sheets called Acoustifence™, supplied by Acoustiblok and quilted fiberglass layers attached to mass-loaded vinyl sheets, like those offered by DDS Acoustics located in Massachusetts. These are the sound barriers of choice when there are severe sound level problems that need a ten decibel or greater reduction in sound level to comply with the ordinances or other limits established.

River Run could use materials such as heavy mass-loaded vinyl DDS Acoustics, if no other sound mitigation steps were adopted. The overall need for reduction at River Run is under 10 decibels to comply with the ordinance. As will be seen below, using quieter gear can achieve a 4 to 5 decibel reduction in sound level. If heavy shrubs and solid windscreens are used as the sound barriers on the north fencing, this combination will bring the sound levels to below the Davidson, NC noise ordinance limit of 65 dBA.

Mass-loaded vinyl that weighs about one-half pound per sq. ft. is durable and it is easy to hang on existing chain link fencing. To block the line-of-sight sound path, a barrier should be at least 8 ft. high. Ten feet or higher is more effective. We use a program called 'Noise Tools' to calculate the likely reduction in sound level for this type of barrier; we will use this tool along with sound power levels taken from our field test results to predict the sound levels with and without sound barriers of various heights.

Selecting Quieter Paddles and Balls

Pickleball paddles with hard surface faces, such as fiberglass, then to be louder by several decibels. Thicker paddles, such as the now common 16 mm thick models sold by several firms, tend to be both quieter and to have a lower pitch sound. PSM LLC, and its predecessor consulting firm, have been testing paddles for over 8 years and it publishes several lists of quieter paddles.

Balls also vary from hard to softer. PSM LLC publishes a list of balls ranked in loudness. The loudest balls are the balls most often used in tournaments but a club such as River Run can reduce overall sound levels of play by over 2 decibels by requiring a softer ball, such as the Onix Fuse outdoor ball.

The tests done along Greyton Lane used both hard balls (the Dura fast 40 and the Onix Fuse) and tests confirmed that a 2 to 3 decibel reduction in sound level could be measured. These tests also selected the two most common paddles used at River Run, the ½ inch thick pro pickleball Tour Wide Body model and the 16 mm thick pro pickleball Infinity Wide Body model. The Infinity model tested about 2 decibels quieter with the Dura Fast 40 ball and a total of 4 decibels quieter when using the Onix Fuse ball. The lower sound level of this paddle coupled with its lower pitch makes this an excellent choice for use at River Run, along with other paddles that have similar characteristics.

PSM LLC brought these two paddle models to its lab in Pittsburgh and some of the test data on these two models is provided in Appendix A. The list of quieter paddles published by PSM LLC, known as the Blue List, is included as Appendix B.

As will be seen below, PSM LLC is recommending that River Run enforce the use of either the Infinity model tested or any model on the Blue List. PSM LLC is available to test new models at a nominal charge when new models become available and River Run is encouraged to permit new models added to the Blue List.

Selecting Sound Barrier Materials

Options:

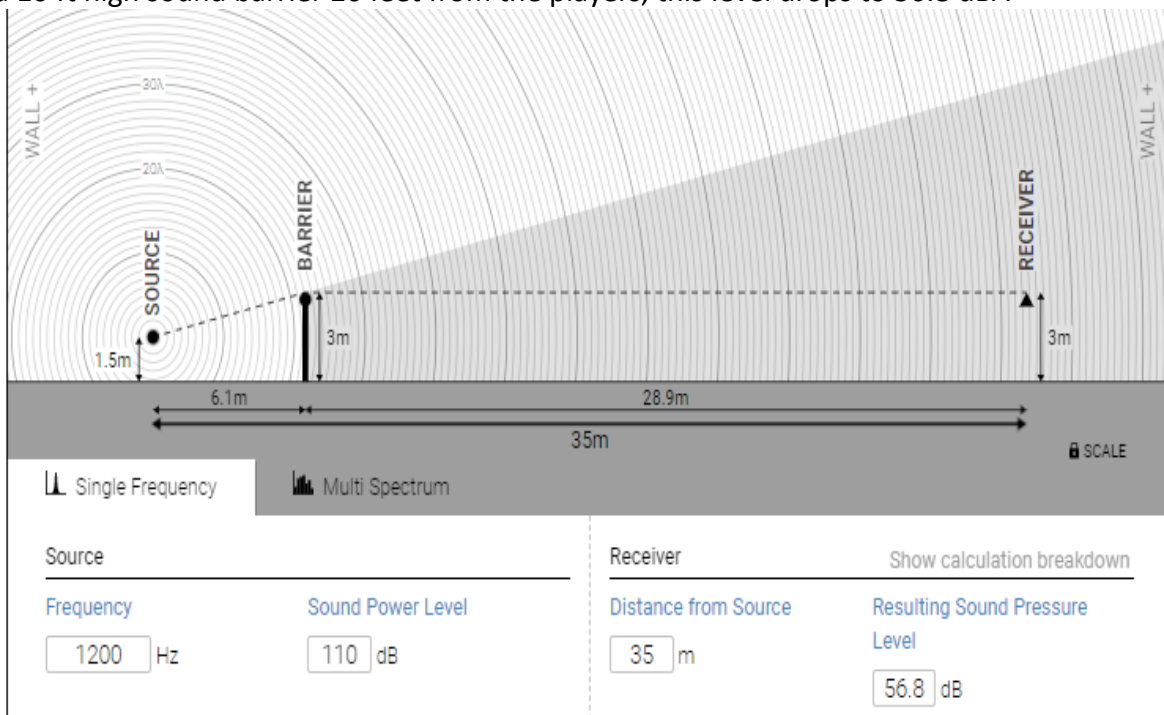
10 ft high mass-loaded vinyl (such as offered by DDS Acoustical Specialities) along the north fencing

This plot indicates the expected sound levels with no sound barrier, the predicted level at 115 feet is



67.6 dBA

With a 10 ft high sound barrier 20 feet from the players, this level drops to 56.8 dBA



This decrease of about 9 decibels assumes that a heavy mass-loaded vinyl is used. If the barrier material only has 2 decibels of loss and the bushes add an additional 4 dB. The sound level would drop to 61.6 dBA. If we reduce the sound level generated by play by 6 decibels, this level will drop to

61.4-6=55.4 dBA. This is a lower sound level than simply installing heavy mass loaded vinyl. In addition, the adoption of quieter gear is an evolving process since new paddles are being designed to both play well and to be quieter.

Conclusions

It can be expected that the sound levels at nearby property lines will exceed the limits set by the Davidson, NC ordinance of 65 dBA by as much as 7 decibels if no steps are taken to reduce the sound levels. River Run will need to mitigate this level with heavy duty sound barriers or requiring the use of quieter gear along with the use of modest sound barrier materials and thick vegetation along the north and along part of the east fencing of the new courts. If these steps are taken, we predict that there will be no violation of the local sound ordinance.

Recommendations

Since River Run is a private club, it has the authority to enforce the use of quieter gear, which is the approach PSM LLC recommends. In addition, we recommend that solid windscreen made by Fence Screen, or the vendor preferred by River Run staff, be installed all along the north fences. PSM LLC is available to test sample sound blocking wind screen materials if samples at least 4 ft x 7 Ft are sent to its lab in Pennsylvania. We will assume that a selection of heavy windscreen is made with at least 2 decibels of sound transmission loss .

In our experience, high and thick hedges can provide up to 4 decibels of additional sound reduction and we recommend that River Run install thick hedges at least along the north side of the east courts. It is also recommended that hedges of this type be installed at least part way along the east side of that fence to block the line-of-sight view of players from homes east of 18746 Greyton lane.

We also recommend that River Run stall initiate discussions with their preferred paddle vendor, pro pickleball, to encourage them to design quieter paddles and paddles with a lower pitch sound. The Infinity model is very close to meeting the requirements of being included on the PSM LLC Blue List of paddles and PSM LLC is available to test new paddle designs in an anechoic chamber designed for pickleball gear testing.

CV of the Author

Robert M. Unetich | Professional Engineer

1811 Woodlands Circle
Pittsburgh, PA 15241
Cell: 412-780-4575
Email: rmu@pickleballsound.com
and itsmu@aol.com

Professional Profile

An electrical engineer by training, active now as a consulting engineer specializing in pickleball sound mitigation.

Experienced in electronic product development and sound barrier design with over 50 years of engineering experience. Licensed as a professional Engineer in Pennsylvania since 1978.

Engineering and Management Career Summary

2022 – Present	Founder and owner of PSM LLC, also known as Pickleball Sound Mitigation, a firm specializing in reducing the impact of pickleball sound
2007 – Present	Owner of GigaHertz LLC, an electrical engineering and acoustics consulting firm located near Pittsburgh, PA. GigaHertz LLC has been active in pickleball acoustics consulting for about 8 years
2004 – 2007	Owner of Axcera LLC, a manufacturer of analog and digital radio frequency transmitters for television and wireless digital microwave services
1998 – 2004	Adjunct Professor of Engineering at Carnegie Mellon University Work included teaching courses in business for engineers and entry level electrical engineering
1982 – 1997	President of ITS Corporation, a manufacturer of television transmitters. ITS Corporation was acquired by ADC Telecommunications in 1996.
1978 – 1982	Engineering Manager of Broadcast Transmitters, RCA Corporation, Meadowlands, PA
1976 – 1978	Engineering Manager of Television Transmitters, Harris Corporation, Quincy, IL
1970 – 1976	VP of Engineering of EMCEE Broadcast Corporation, White Haven, PA
1968 – 1970	Design Engineer for Honeywell Information Systems, Clearwater, FL. Involved in the design of the early GPS known as the Navy Navigation Satellite System

Education

1964 – 1968 BSEE from Carnegie Mellon University, Pittsburgh, PA

Patents

Several granted patents including a novel power supply design, a waveguide microwave filter and inventions in the field of diathermy, plus one pending patent application.

Publications

Extensively published in the field of television technology and radio wave propagation. Currently the author of Pickleball Magazine's Rules Guru Column, the administrator of the facebook group Pickleball Sound Mitigation and the administrator of two pickleball referee facebook groups.

Disclaimer

The sound levels in this report are as measured or they are estimates of what levels should be expected. Actual levels will vary over time, and they are player and equipment dependent. Sound level is probabilistic, meaning that it has averages and other statistical characteristics including standard deviations and sound level probability distribution curves, but pickleball sound level has no exact single level.

This report makes no guarantee of performance of the sound mitigation methods described. In addition, it is not possible to determine what any person believes is an acceptable sound level. The measurements and estimates of background sound levels are also probabilistic in nature and these levels will vary from one neighborhood to another and from one measurement method to another over time.

Our recommendations for sound barrier types assume that the site will have proper structural support, designed by others. This should include an analysis of the wind-loading limitations of fences.

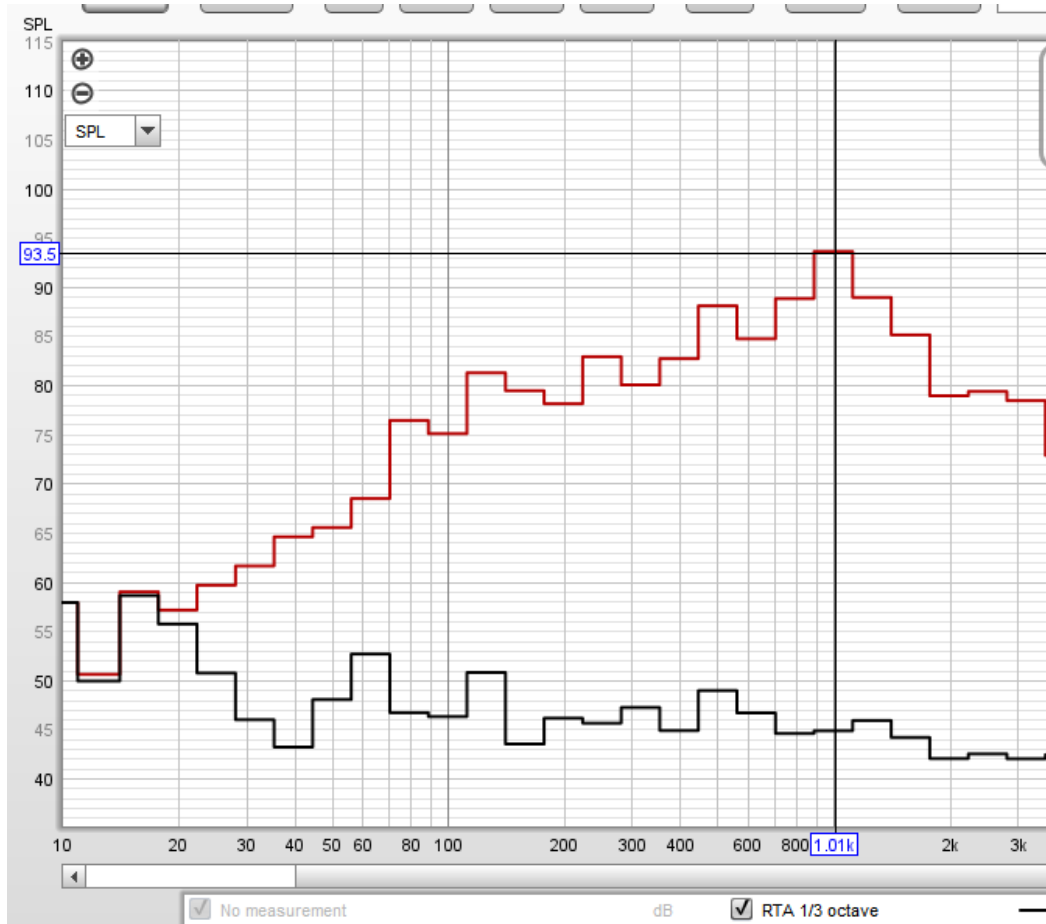
Appendix A includes plots of the audio spectrum produced by each of the three different paddles, the Tour, the Infinity and a CRBN1. The red graphs are stored maximum values of the different audio tones measured, The horizontal axis is a log plot of audio frequency.

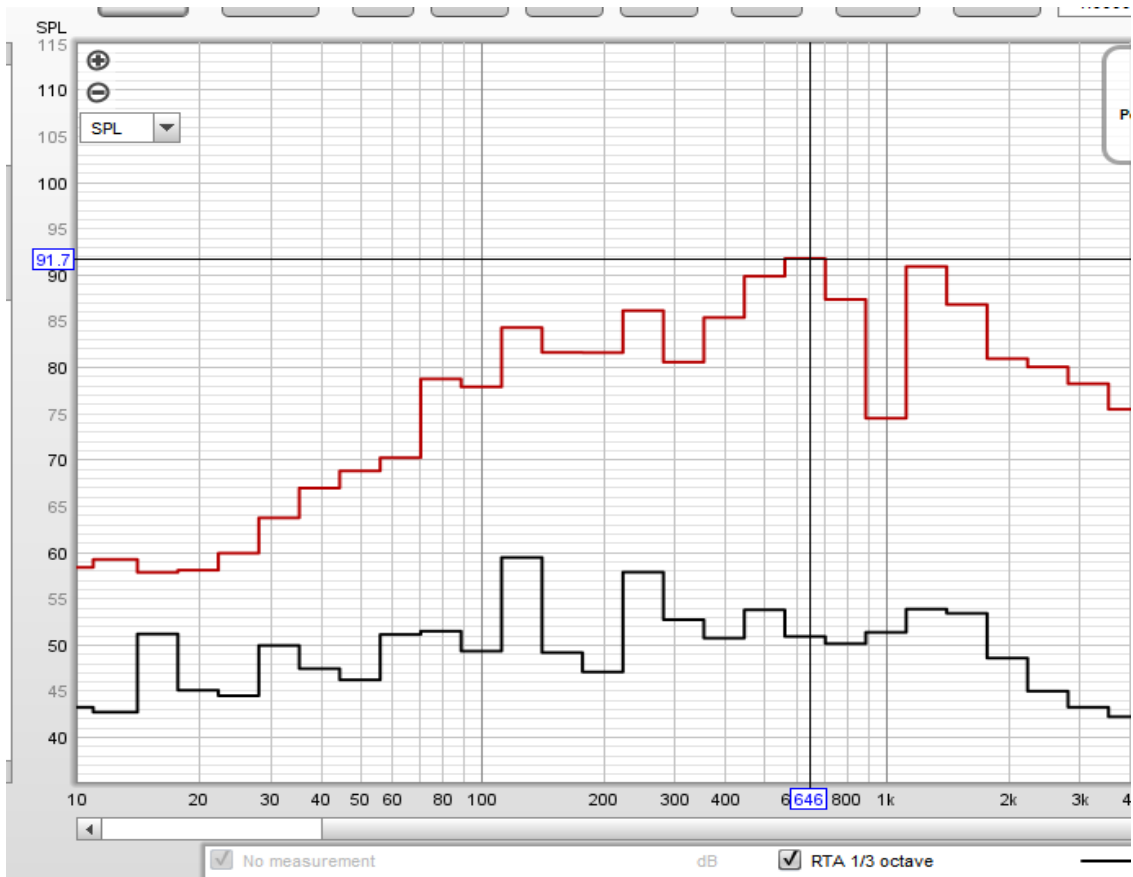
The curser crosshairs are set at the maximum value of the loudest component of pitch.

Appendix A

Paddle Pitch Comparisons

Comparing the sound of the propickleball Tour WideBody and the propickleball Infinity Wide body models using REW sound characteristics software:



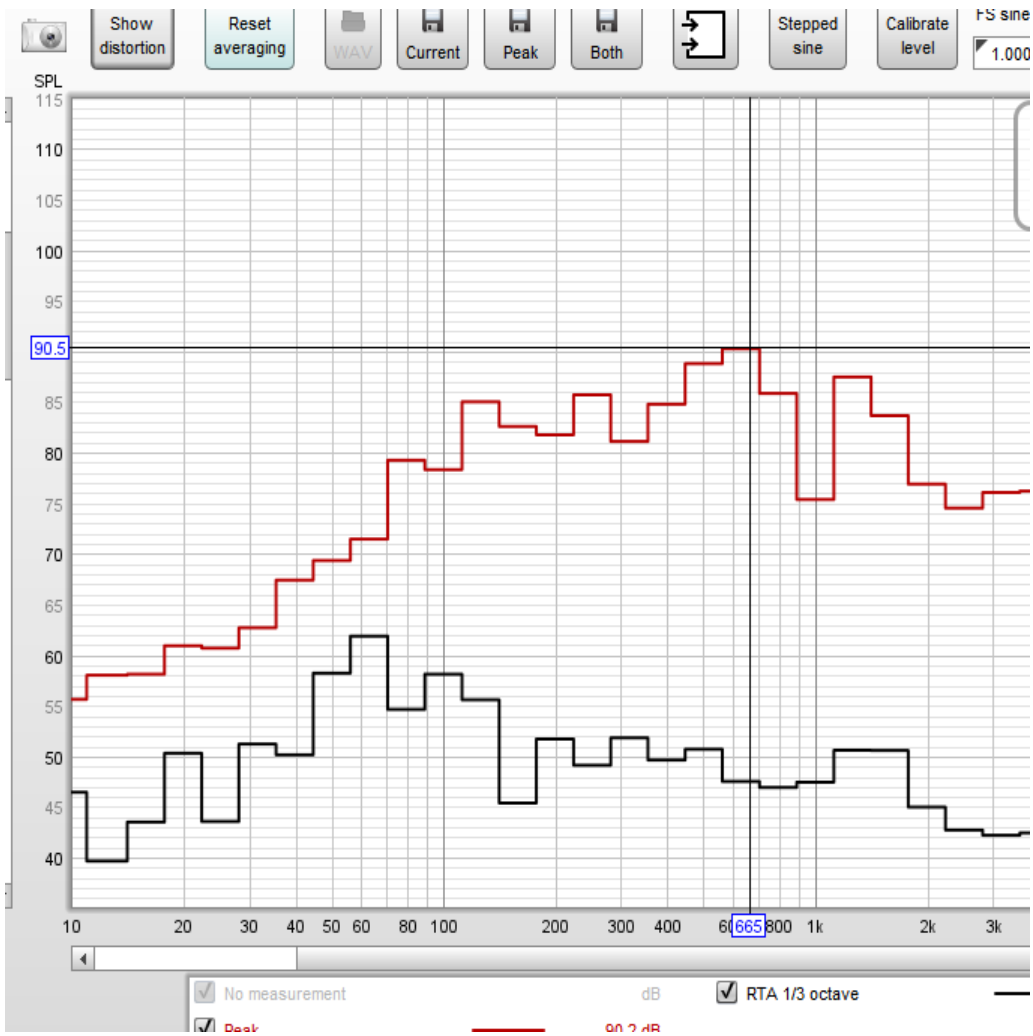


The Propickleball Infinity WideBody Paddle with the Dura Fast 40 ball:

Note that there is less energy above 1,000 Hz, making the sound of hits with this paddle less annoying to listeners.

These plots indicate that the Infinity paddle and others like it will be quieter and less annoying to neighbors.

The third plot is the spectrum of the toes produced by a different paddles listed on the Blue List published by PSM LLC.



Appendix B

THE PICKLEBALL PADDLE BLUE LIST
PICKLEBALL SOUND MITIGATION LLC
www.pickleballsound.com
 Updated: April 8, 2023

(paddles listed alphabetically by vendor name)

Paddle Vendor	Paddle Model Name	Notes
CRBN	1 and 1x	
CRBN	2	
Diadem	Vice	1
Diadem	Warrior	
E6	16s	
Electrum	E Pro II	
Franklin	Pro Series 16 mm	2
Gearbox	CX11	
Gearbox	CX14	
Gearbox	GX5 and GX6	
Joola	Ben Johns 16 mm	
Joola	Simone Jardim 16 mm	
Joola	Radius	
Master Athletics	Q1	1
One More	Vibe	
One More	Pro Custom	
Pro Drive	DRIVE	
Pro Kennex	Pro Speed	
Pro Kennex	Ovation	
Selkirk	Amped Epic	
Selkirk	Vanguard Invikta	
TMPR	Tantrum and TC-16	
Wild Monkeys	Grizzly	
Wolfe	Bite	

These older models meet the criteria but availability is unknown

Patriot Pickleball	Sniper
Your Pickleball Place	Maxor and Whisper QT

Notes:

1) This model is not USA Pickleball Approved for sanctioned tournament play

2) Formerly the Ben Johns model

Rev 1.6