PSM LLC
Pickleball Sound Mitigation

Pickleball Sound Assessment Report with Recommendations

For Brooks CDD and Brooks II CDD

Estero, FL
by

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I. Executive Summary

Pickleball is being played on three courts located near The Commons Club campus of amenities on Coconut Road; however, with the tremendous growth in popularity of the sport, both nationally and specifically with residents in The Brooks five developments, these courts are simply insufficient to meet the needs of hundreds of players.

To address this situation, it has been proposed that a new pickleball park be built, in three phases, culminating in the availability of 16 courts for enthusiasts.

The sound of pickleball play has become a contentious issue at some locations, so the Brooks CDD and Brooks II CDD have engaged Pickleball Sound Mitigation LLC to carefully analyze the proposed site to assure proper sound mitigation measures are applied and commercial and residential owners at surrounding properties are not adversely affected. The Village of Estero Noise Ordinances have also been researched to assure proper compliance with governmental requirements.

Pickleball Sound Mitigation LLC is an acoustics firm specializing in pickleball sound measurement and suppression solutions. Dale H. Van Scoyk, an acoustics engineer, has met on-site with The Brooks community leaders to review;

- The existing location buildings, elevations, vegetation, earth berms and barriers,
- The distances to closest existing residences at nearby Spring Run Golf Club, and to commercial and entertainment facilities at The Commons Club,
- Measurements of ambient noise levels, primarily from traffic on Coconut Road and from sound masking sources like the existing fountain and playground area.
- Measurements of the sound levels of pickleball hits at the Brooks courts using the two most popular outdoor pickleball balls – Franklin X-40 and Onyx Fuse G2.

In addition to on-site inspection, satellite photography has been used for measurement of distances and elevations of the proposed courts and surrounding earth barriers and buildings. Sophisticated software used by PSM LLC enables the prediction of sound levels at various distances and models the effects of multiple types of mitigation options.

After thorough research and analysis, we believe the location and design of the proposed Brooks pickleball park will meet noise ordinances and not adversely affect residential owners or commercial functions "of reasonable people with normal sensitivities," both at The Commons area and at surrounding properties, provided the proposed and recommended sound mitigation measures are used.

II. Overview of the Site

The current three pickleball courts are located West of the parking lot, restrooms, children's playground (under the triangular sunshade), a circular fountain and the Enrichment Center -- all are in a park like setting along Coconut Road.

(North)

(South)

To the West and North of the courts is a water way and nature preserve. South of the courts is Coconut Road and further South is the Spring Run Golf Course, a pond and a condominium building. There is a 4-6 feet earth barrier on the North side of Coconut and an 8-10 feet earth barrier on the South side, both of which are between the pickleball courts and the Condominium.

The yellow outline shows the general area where the proposed courts will be added and gives perspective to how far the residential building (South of the pond) is from pickleball play.

Orange line distance to the Condominium in Spring Run – 479 ft

Blue line distance to Enrichment Center – 167 ft

Green line distance to Gazebo – 272 ft

The reason these three locations and distances are highlighted is that they represent the most likely areas to be sensitive to pickleball sounds.

- The condominiums, because they are residences,
- The Enrichment Center is totally indoors with no windows that open towards the courts, but there are presentations, seminars and “quiet” activities inside,
- The Gazebo is an open pavilion, hosting receptions, weddings and morning yoga and meditation sessions. The line of sight to the nearest planned pickleball courts is mostly blocked by the restroom building and the design calls for a 12 ft high fence with sound mitigation barriers on the East side of the courts nearest the Gazebo and Enrichment Center. A clusia hedge is planned for the North side.

A significant influence we found when doing on-site sound measurements is the circular fountain behind the restroom building, and near the Gazebo and Enrichment Center.

When measuring ambient noise levels, we were able to test with the fountain running and while it was shut off. This style fountain sprouts many small bursts of water upward and then they fall on a hard shallow surface. It is especially effective at masking the sounds of children playing in the fountain and the playground and pickleball playing in the distance on the other side.

The proposed design in Phase I one calls for the demolition of the basketball court and the addition of 4 pickleball courts. Phase II has the existing three pickleball courts demolished and 4 new pickleball courts to be built. Phase III has 8 pickleball courts being added running along Coconut Road.

All 16 courts will be aligned mostly North-South, so somewhat more sound pressure would be directed toward the North and South direction and less to the East and West. Sound from hits propagates primarily 90 degrees away from the paddle face, thus toward the North and South. Of course, there are mishits, mistakes, so it’s not 100% in this orientation.

(North)

III. A Description of Pickleball Sound Characteristics

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 play, and it has a higher, more annoying, pitch. Homeowners in proximity to pickleball courts hear a louder sound than from tennis. At elevated sound level, pickleball sounds are considered as noise.

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.

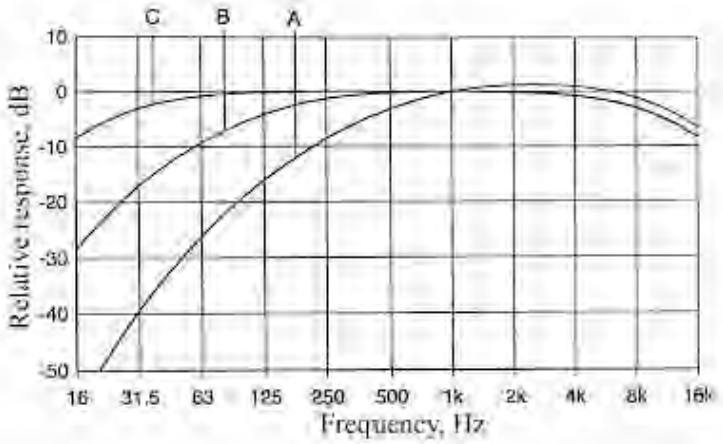
The tonal quality is the combination of low frequency and high frequency components of the sound. Frequency is measured in cycles per second or Hertz (Hz). Most sounds include a combination of low frequency booming tones and high frequency shrill or sharp tones. Pickleball sound is not a pure tone. There are multiple frequencies from each impact and different paddles produce different frequency patterns. Sound also varies with time. A steady state noise is continuous with little or no change in level or frequency content. Impulse noises have 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 (loudness), 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 a noise.

dBA vs. dBC

dBA and dBC are the two most common ways of weighting sound measurements. What this means is that the sound being measured is not measured equally at all frequencies. Below is a graph showing the actual measurement curves for A, B, and C.



These are important because they are approximations of how the human ear actually hears sound.

A sound level meter that measures the sound pressure level with a "flat" response will indicate the strength of low frequency sound with the same emphasis as higher frequency sounds. Yet our ear perceives low frequency sound to be of less loudness than higher frequency sound.

The A weighting curve is the most accurate approximation to the human ear at "normal" sound levels.

Unfortunately, human perception of loudness vis-a-vis frequency changes with loudness. When sound is very loud, 100 dB or more, the perception of loudness is more consistent across the audible frequency band. "B" and "C" Weightings reflect this trend. "B" weighting is rarely used these days.

Notice that "C" weighting is appropriate when measuring very loud sounds. A Rock Concert is an example of when it should be used.

(Source: Bruce Jellison, "Understanding sound terms")

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 as zero dB. Human hearing has a lower sensitivity to low pitch sounds and readings of meters and sound software are usually adjusted to account for this by using the A scale. As will be 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 and comparable to the loudness of normal conversation and to the sound levels usually present in a busy restaurant.

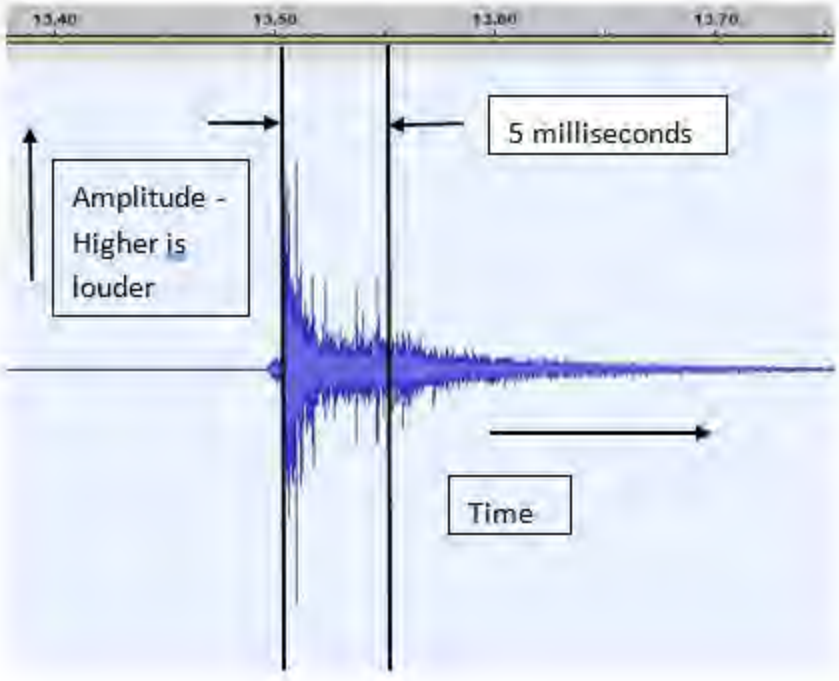
Pickleball sound at 100 feet is usually under 70 dBA with no sound barrier and under 60 dBA with a ten ft high sound barrier. The height of the barrier can be adjusted to achieve sound level reduction with a basic goal of having pickleball sound not frequently exceed normal background sound levels.

IV. The Measurement of Pickleball Sound Levels

Sound is 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 national measurement standards. In the US those standards are set by the American National Standards Institute or ANSI.

- **Slow** – This is a 1 second average of the high and low fluctuations over 1 second. This measurement is usually associated with a continuous sound.
- **Fast** - This is a 125 millisecond average of the high and low fluctuations over 125 milliseconds or 0.125 seconds.

Pickleball strikes have a usual time duration of about 10 to 20 milliseconds (ms).



PSM LLC recommends the Fast mode, which has a 125 ms averaging period, for measuring these short duration sounds.

The graphic represents the sound of one pickleball impact. In a game of pickleball, a rally will involve several impacts spaced by intervals of less than a second to more than 2 seconds until the rally is over. A game involves several rallies until a team wins. The result is that pickleball impacts will occur randomly during the duration of a game.

When pickleball play involves 2 or more courts, the sound from 2 or more games does not increase the maximum sound level. This is because each pickleball impact is a discrete event. The number of impacts per hour will increase from pickleball on multiple courts, but the measured sound levels will not increase. The occurrence of two 20 millisecond impacts at the same time is incredibly infrequent.

V. Village of Estero Noise Ordinances

We believe the applicable statute is:
Village of Estero, Florida Ordinance No. 2019 – 20 (adopted October 2, 2019)

The proposed project is also in Lee County and subject to Lee County Code Chapter 24 1 / 4 Noise Control; however, the Village of Estero Ordinance is an amended version of the Lee County Code and contains no substantive technical changes in definitions, limits or other sound related subjects.

Section 241/4-2. Findings and purpose.

(a) Estero finds that excessive, loud and raucous noise degrades the environment of the village to a degree that:
  (1) Is harmful to the health, welfare, and safety of its inhabitants and visitors;
  (2) Interferes with the comfortable enjoyment of life and property;
  (3) Interferes with the well-being, tranquility;
  (4) Can cause and aggravate health problems

(b) ……..

(c) This chapter is enacted to protect, preserve, and promote the health, safety, welfare, peace and quiet of the residents of Estero through the reduction, control, and preventive of excessive, loud and raucous noises that unreasonably disturb, alarm, injure, or endanger the comfort, repose, health, peace, or safety of reasonable persons with normal sensitivities.

Section 241/4-3 Definitions.

A-weighted level (dBA): The sound pressure level in decibels as measured using the A-weighting network on a sound level meter. The unit of measurement is the dBA. Sound level meter settings shall be for slow response.

Impulsive sound: A sound of short duration, usually less than one (1) second, with an abrupt onset and rapid decay. Examples of sources of impulsive sound include explosions and drop forge impacts.

Noise level. As referenced in this chapter, the noise level is the sound pressure level as measured in dBA unless otherwise specified. A measurement of noise must be at least five (5) dB above the ambient noise level.

Residential use: Land that is primarily for living and sleeping, parks, hospitals, schools, institutional, nursing homes or the individual plots within a mobile home park or any land use that is not commercial or industrial.

Sound source: The location from which the impermissible sound level or noise disturbance is emanating.

Section 241/4-f. Prohibited acts.

(a) Maximum permissible sound levels by receiving land. No person shall operate or cause to be operated any source of sound in such a manner as to create a sound level which exceeds the limits set forth for the receiving land use category in Table 1 when measured at or within the real property line of the receiving land.

Table 1. Sound Levels by Receiving Land Use

Land Use Category	*Time*	*Sound Level Limit dBA*
Residential, public space, or agricultural	7:00 a.m.—10:00 p.m.	66
	10:00 p.m.—7:00 a.m.	55
Commercial or business	7:00 a.m.—10:00 p.m.	72
	10:00 p.m.—7:00 a.m.	65
Manufacturing or industrial	At all times	75

(1) Correction for character of sound.

(a) For … pure tone…shall be reduced by five (5) dBA.

(b) For any source of impulsive sound which is of short duration with an abrupt onset, the maximum sound level limits set forth in Table 1 shall be increased by ten (10) dBA from 7:00 a.m. to 10:00 p.m.

Conclusions:

Based on the ordinance definitions and the limits in Table 1, with corrections for character of sound, we believe –

- The question of Land Use Category is not clearcut; however, the area where the proposed pickleball courts will be placed and the surrounding nature walk, children's playground, play fountain, and outdoor seating seem more like a public park than a commercial or business area, in our opinion. This is taking a conservative approach to setting noise limits, since commercial/business standards allow 6 dBA higher Sound Level Limits.
- Pickleball play creates an impulse sound; therefore, the correction factor of adding 10 dBA to the limit is appropriate.

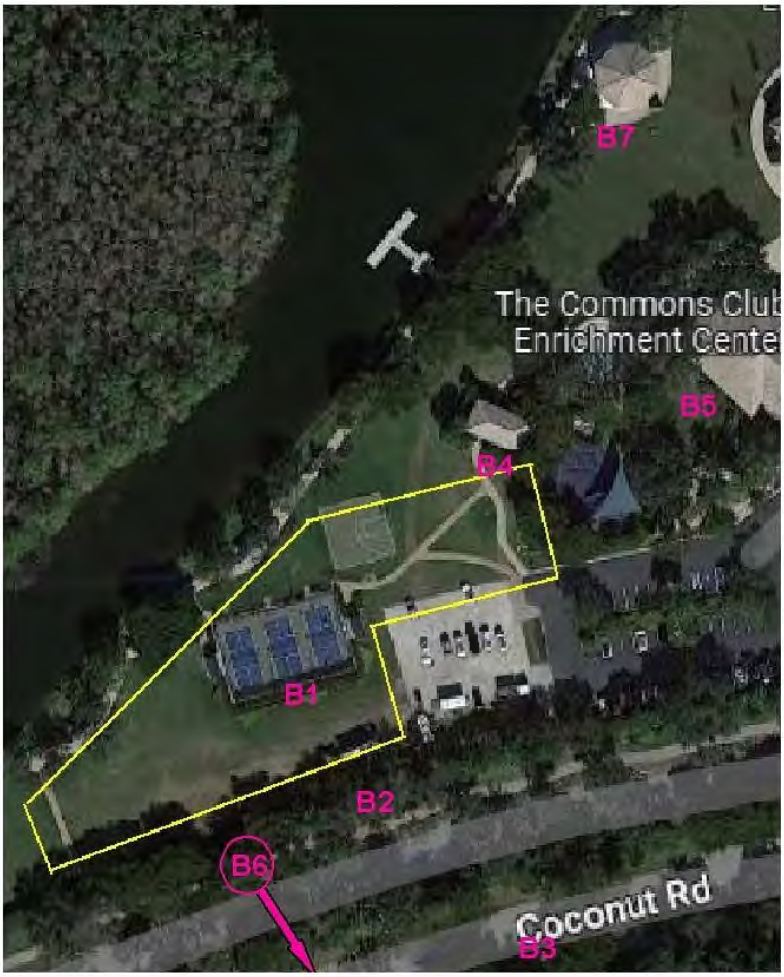
From 7:00 a.m. – 10:00 p.m. the limit is 66 dBA + 10 dB = 76 dBA

- In our opinion, the Village of Estero Code, adopted from Lee County, was written primarily to regulate continuous noise issues, like from motorcycles, cars, or amplified music, but does not adequately address the measurement and limitation of other impulse sound noise, in particular the characteristics of sound from pickleball play. Requiring that all measurements be made with the meter setting in Slow mode (1 second average), does not reflect the effect of random interval, 10-20 millisecond duration sounds. In fact, the longer averaging period tends to understate the actual noise effect. **We urge the Village of Estero (and Lee County) to consider changing the measurement method for pickleball play to FASmax -- A-weighted, Fast mode (125 millisecond average) with limitation(s) on maximum allowed sound pressure in dBA.**

VI. Field Test Results

On-site sound measurements were recorded at six locations near the proposed courts on Friday, April 14, at 9:00-11:20 a.m. The wind was light, less than 8 mph, and the temperature was 77° Fahrenheit. The details of equipment and methodology can be found in Appendix A, along with the specific readings at each location.

Point	Location Description	Measurement	Purpose
B1	Next to the existing courts on the south side approx 45 ft from nearest player	* Measure sound without play * Measure sound with Onyx ball * Measure sound with Franklin X-40	Determine sound levels with and without play. Determine difference between Onyx and Franklin balls.
B2	North of Coconut Road, South of courts approx 100 ft from nearest player	* Measure sound (with Franklin X-40)	Determine noise level from traffic.
B4	South of restroom bldg	* Measure sound (with Franklin X-40)	Determine current noise levels with play
B5	Next to West side of Enrichment Center	* Measure sound (with Franklin X-40)	Determine current noise levels with play. Determine effect of fountain noise.
B6	At Spring Run condominium	* Measure sound (with Franklin X-40)	Determine noise level, primarily from traffic.
B7	At Gazebo	* Measure sound (with Franklin X-40)	Determine current noise levels with play. Determine effect of fountain noise.



Results:

1. The first measurements taken at **B2** just North of Coconut Road gave ambient noise levels that averaged 65.9 dBA in Slow mode and 65.8 with Fast mode. The maximum was 70.6 dBA in Slow mode. The readings in either mode never got below 56.1 dBA. Primarily coming from traffic on Coconut Road, the **average ambient Slow sound level at this location is approximately 65.8 dBA**,
2. Next, measurements were taken at **B1** approximately 40 ft South of the nearest players on the existing center court. A variety of scenarios were tested: with no one playing, with all courts in use, with Onyx Fuse G2 balls and with Franklin X-40 balls, in Fast and in Slow mode.
   With no one playing, the average ambient sound pressure was 57.6 dBA. This is from the background noise at this location generated by traffic.
   Average maximum readings in Slow mode for both Onyx ball play and Franklin ball play were **63.5 dBA** and **65.5 dBA** respectively**. This indicates the difference in sound pressure between the two ball models is only about 2.0 dB.** This is very near the same findings from laboratory testing of these two balls. See Appendix C.

In Fast mode the Franklin balls measured an average of **73.8 dBA.** In Slow mode they measured **65.5 dBA**. This is an example of Slow mode potentially understating the results by having a longer averaging period.

3. At **B4** next to the restrooms and about 150 ft away from the nearest court, while pickleball play was in action, the **Slow reading of average maximum sound levels was 74.5 dBA**. **This means the ambient noise was higher than at B1 next to the courts! We believe the source of noise here is from the fountain.**
4. At **B5** just to the West of the Enrichment Center, about 325 ft away from the nearest current court, while play was in action, the **Slow reading of average maximum sound levels was 70.2 dBA. The lowest Slow recorded level was 66.6 dBA. The primary sources of noise here are traffic and the fountain.** In fact, while taking measurements, we could barely hear pickleball play, although we could see it.
5. At **B6** next to the Condominium building, we could not see or hear pickleball play, but we were informed it was happening. **The ambient noise Slow average maximum measured 79.0, which is primarily coming from traffic on Coconut Road.** A contributing factor is the pond, because sound propagates more over water than land.
6. At **B7**, the Gazebo, measurements were first taken **without the fountain and registered a Slow average maximum of 73.4 dBA. With the fountain running, the Slow average maximum reading was 76.6. T**here were some issues with maintenance equipment and furniture set-up requiring exclusion of some readings.

Conclusions:

Point	Ave Slow dBA	Comments
B1, no play	57.6	Next to the current courts, when there was no play was the quietest reading in the area.
B1, with play	65.5	Even when there was pickleball being played, the average maximum reading was below maximum ordinance limits of 76 dBA
B2	65.8	Somewhat away from the courts but next to Coconut Rd, the ave maximum was the same.
B4	74.5	Moving away from the current courts but toward the fountain and traffic resulted in a higher ave maximum.
B5	70.2	Next to the Enrichment Center the contribution of sound levels from existing pickleball is not as much as from the fountain and traffic.
B6	79	At a distance of over 400 ft and with earth barriers, the sound from pickleball is not a factor.
B7, no fountain	73.4	Even with no fountain, the ambient sound levels are high, with little to no contribution from pickleball play.
B7, with fountain	76.6	With the fountain on, the sound of pickleball is almost totally masked.

VII. Pickleball Sound Mitigation Methods

Limitations on the times that pickleball can be played are common. For instance, when homes are within 400 ft, it is not unusual for play to be limited to daytime only.

While an effective **sound barrier** near pickleball courts can reduce the pickleball sound levels, this requires the sound barrier to block the line-of-sight path. When the elevation of the courts is lower than the receiving point, the barrier may be able to be lower and still achieve the same mitigation results.

Effective sound barriers are made of heavy material. That includes earth, concrete walls, very thick vegetation such as tall thick hedges and mass loaded vinyl. Barriers can be sound reflecting or absorbing; 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 Insul-Quilt™, which also offers basic mass-loaded vinyl. See Appendix D.

Mass-loaded vinyl that weighs about one pound per sq. ft. is durable and designed to hang on chain link fencing. The barrier must be high enough to block line of sight and account for diffraction (bending) of sound over/around the barrier. The professional acoustic modeling software Noise Tools is used to calculate the anticipated reduction in sound level.

Changing the **court orientation** 90 degrees can achieve a small reduction in noise levels for sound coming from the direction parallel to the net. This is because a slightly lower sound level is generated to the side of a paddle than from the front or the back of the paddle. The sound level to the side of a paddle is 3 to 5 dB less than from the front of the paddle, but this is not a constant, due to the movement of players on the court.

Sound masking is the introduction of a second sound that will override or interfere with the bothersome sound. Common outdoor masking sounds include the sound from a fountain, a waterfall, or ocean waves. Masking sound can also be artificially created with speakers to simulate any ambient sound. These masking sounds literally “swallow up” a lower level offensive sound, but the offending sound is now replaced by a higher level masking sound.

At private pickleball courts, the required use of **quieter balls and paddles** can mitigate the sound levels. At public or semi-public courts, however, it is difficult to police restricted use policies. Paddle tests and ball tests are conducted by Pickleball Sound Mitigation LLC in Pittsburg, PA in our custom-built anechoic chamber. In fact, USA Pickleball, the sport’s national governing body, has selected PSM LLC to help develop sound standards for equipment. Limiting which manufacturers and models of paddles and balls can be

used is one of the last choices of most pickleball players; however, in Appendices B and C are updated lists of paddle recommendations and of ball characteristics.

Please note that the difference in noise levels for the Onyx Fuse G2 and Franklin X-40 balls is relatively small, 2.1 dB, when measured in the laboratory test chamber.

VIII. Predicted Sound Levels at Receivers, Sourced from the New Courts

NoiseTools.net software is an international sound prediction and modeling tool used by Pickleball Sound Mitigation LLC. The most common pickleball paddle frequency for "loud" hits is 1200 Hz and the Sound Power Level can be as high as 108 dB at the point of impact. The height of the source and the receiver are both set at 5 ft (*1,5m*), except for the Spring Run condominium building, which is two-story, 21 ft (*6,4m*)

The primary locations for concern are:

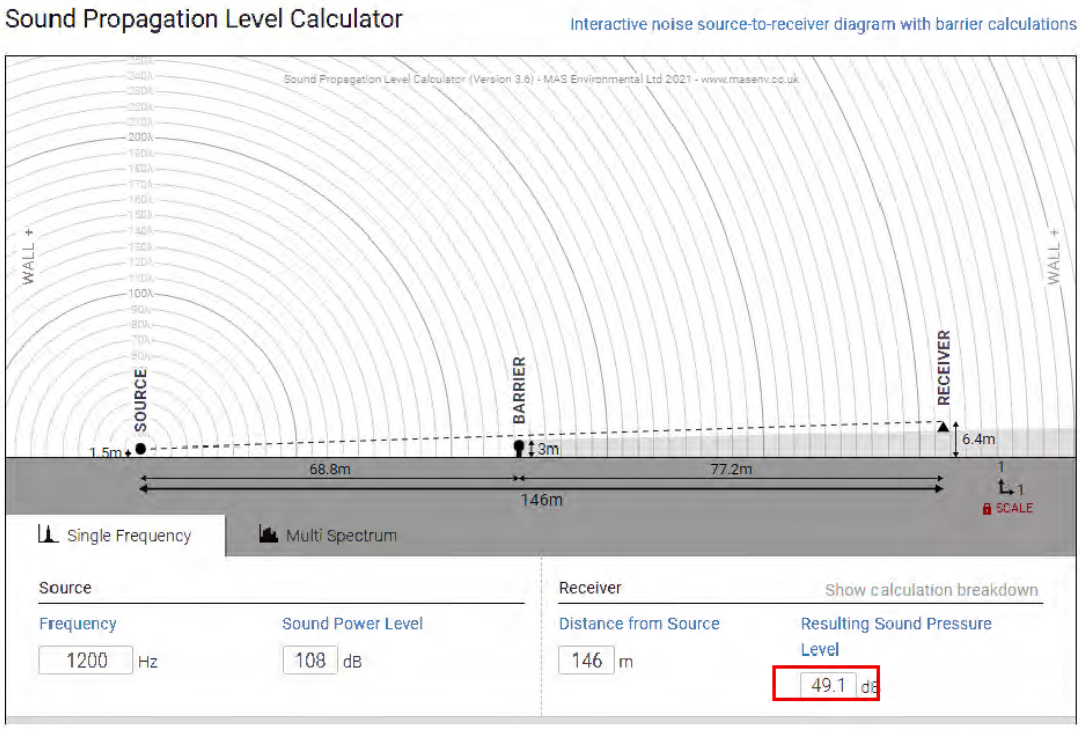
Orange line distance to the **Condominium in Spring Run** – 479 ft (*146m*)

Blue line distance to **Enrichment Center** – 167 ft (*50,9m*)

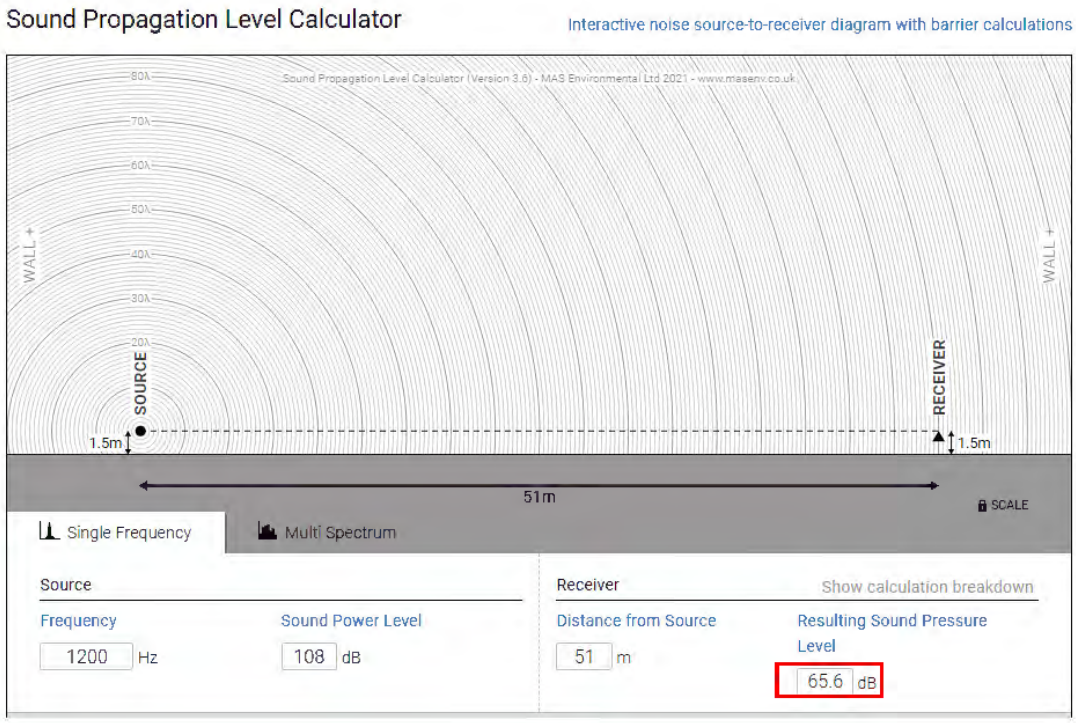
Green line distance to **Gazebo** – 272 ft (*82,9m*)

There is an earth barrier 10 ft (*3m*) high on the South side of Coconut Road 226 ft (*68,8m*) from the source point.

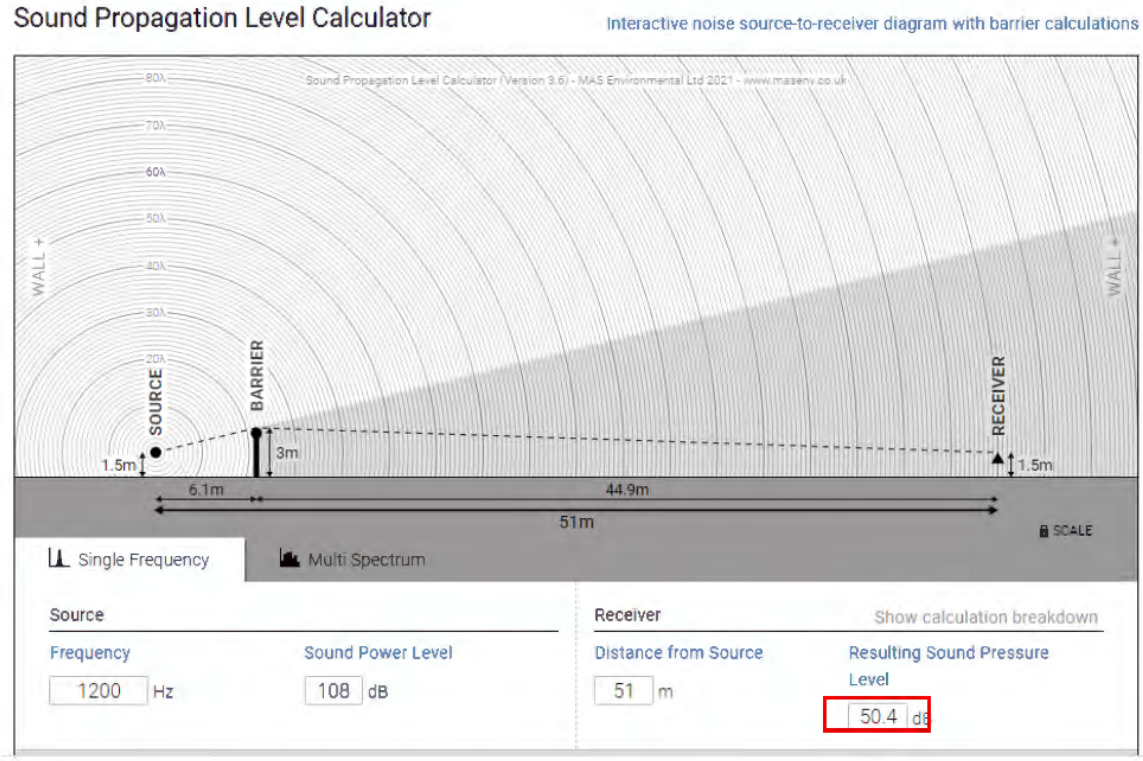
Predicted Sound Pressure Level at the Condominium (Gold line) is 49.1 dB



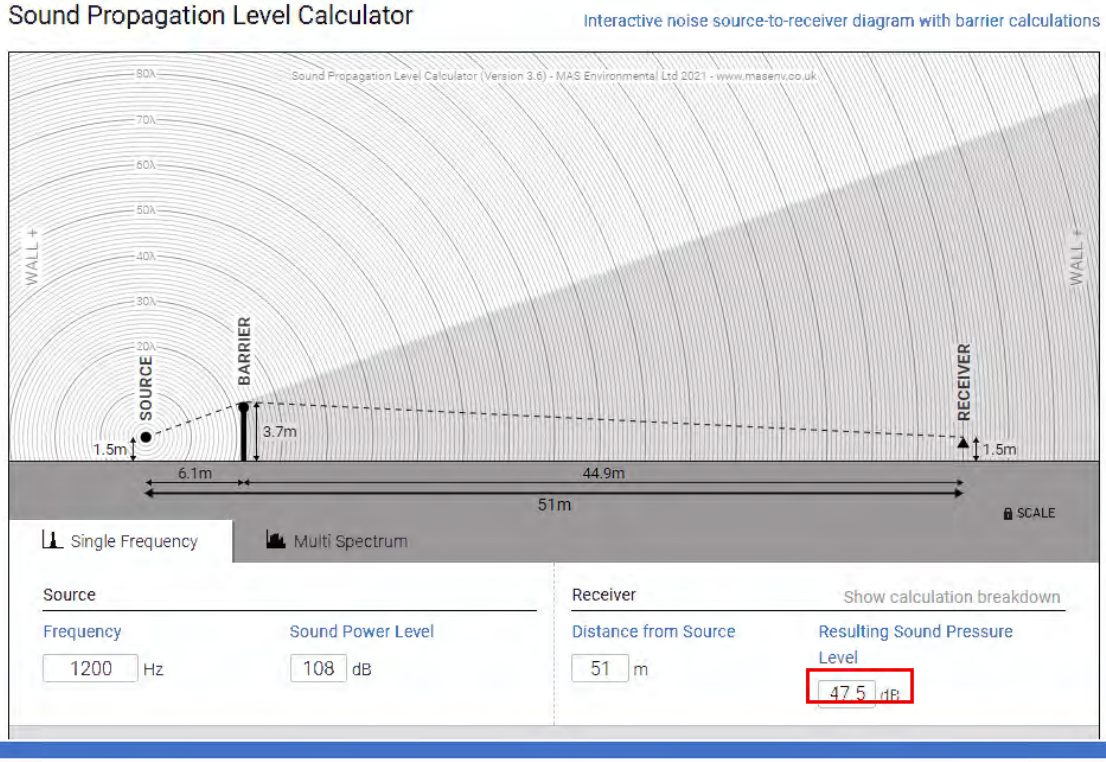
Without a barrier, predicted Sound Pressure Level at the Enrichment Center (Blue line) due to the proposed courts is 65.6 dB



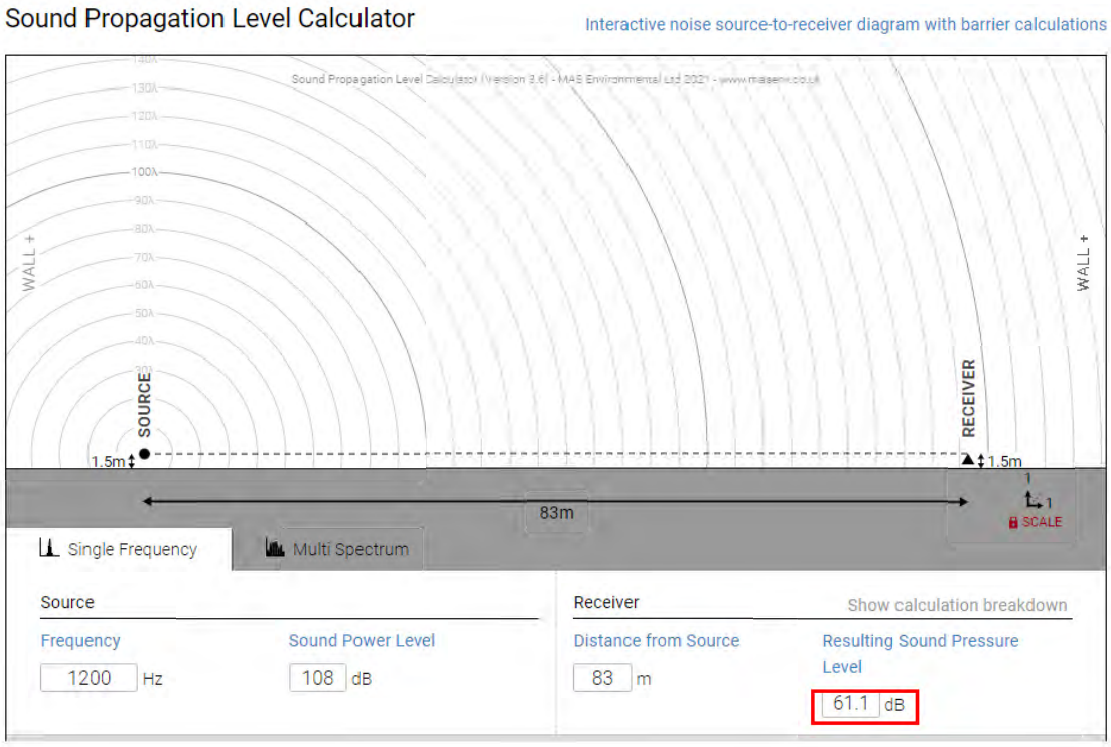
With a 10 ft (3,0m) sound barrier on the East side of the nearest court, the predicted Sound Pressure Level at the Enrichment Center (Blue line) is 50.4 dB.



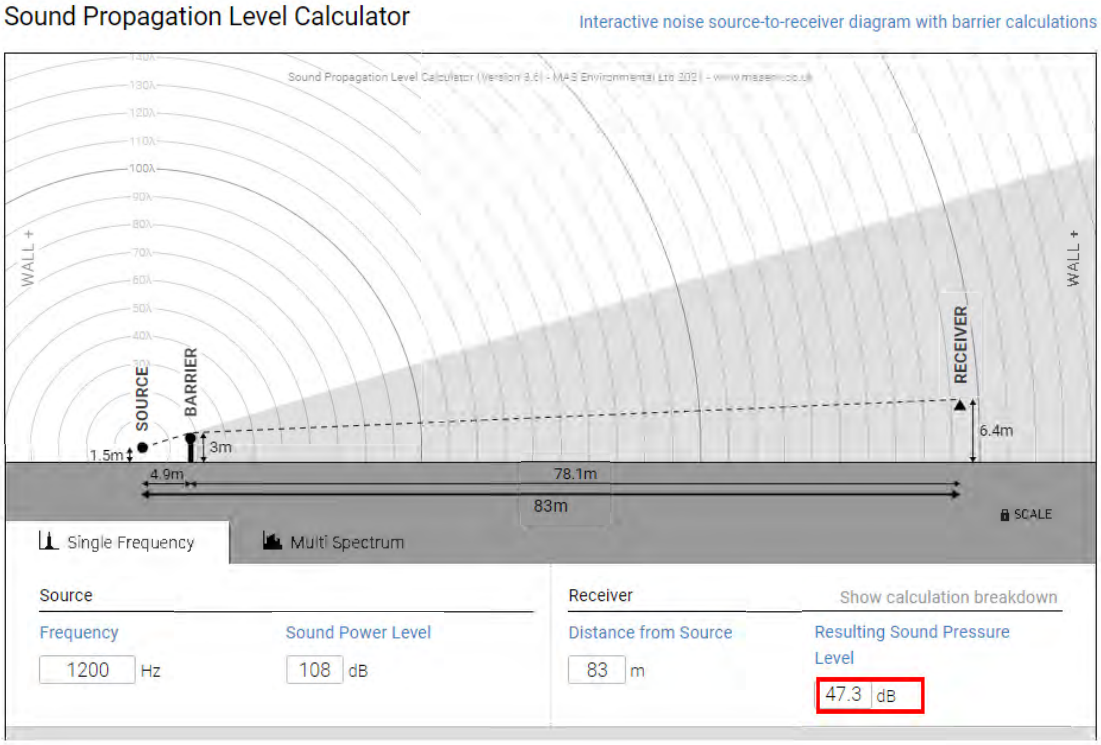
With a 12 ft (3,7m) sound barrier on the East side of the nearest court, the predicted Sound Pressure Level at the Enrichment Center (Blue line) is 47.5 dB



Without a barrier Predicted Sound Pressure at the Gazebo (Green line) is 61.1 dB.



With a 10 ft high sound barrier on the North fence of the nearest courts, the Predicted Sound Pressure at the Gazebo (Green line) is 47.3 dB.



Summary Table of Ordinances, Common Goals and Predicted Noise Levels

Receiver Location	Ordinance Limit dBA	Common Residential Goal	Without Barrier dBA	With 10 ft Barrier dBA	With 12 ft Barrier dBA
Condominium	76.0	50.0	49.1		
Enrichment Center	76.0	50.0	65.6	50.4	47.5
Gazebo	76.0	50.0	61.1	47.3	

IX. Conclusions and Recommendations

Attention has been focused on three areas:

- The residential Condominium building in Spring Run,
- The Enrichment Center in The Commons area,
- The Gazebo in The Commons area.

Two factors are important:

- Compliance with applicable noise ordinances,
- Acceptance of sound levels by “reasonable persons with normal sensitivities.”

After measurements of the ambient sound levels, review of the present and planned mitigation elements, predicted sound levels from the proposed expansion of courts and consideration of the noise ordinances and our experience with the generally recognized standards for acceptable sound levels in other communities in the U.S., we have the following conclusions:

Condominium Buildings at Spring Run

The combination of sound loss over the 479 ft distance and the existing earth barriers along Coconut Road mean that sound pressure levels created by the pickleball play at the planned additional courts will be negligible. The ambient (traffic) noise is already relatively high and residents are very likely to not even notice a change after all 16 courts are added.

There are no recommended changes related to this location.

The Enrichment Center at The Commons area

The predicted sound pressure level at the outside wall of Enrichment Center without any sound barrier on the East fence of the nearest planned court is 65.6 dBA. This is

significantly below the noise ordinance maximum limit of 76 dBA and below the current measured background noise level of 70.2 dBA.

Regardless of noise ordinances, there is a general goal for pickleball sound mitigation of achieving sound pressure levels at or below the ambient noise level and preferably no more than 50 dBA. This threshold has been found to be acceptable by most people, even in residential areas.

With a 10 ft high barrier, using mass-loaded vinyl curtains hung on a chain link fence, the predicted maximum level is 50.4 dBA, very near the goal. With a 12 ft high barrier, the predicted maximum level is 47.b dBA

It is our recommendation that a minimum 10 ft high barrier using reflective mass-loaded sound curtains, similar to AcoustiFence™ or equivalent, be installed as planned along the entire Eastern fence of the four Phase I courts. There should be no gaps at the top or bottom, or between panels. Attention to construction design should be given to ensure proper stability in case of high winds.

<u>The Gazebo at The Commons area</u>

The predicted sound pressure level at the Gazebo without any sound barriers is 61.1 dBA. This is significantly below the noise ordinance maximum limit of 76 dBA and more than 10 dB below the current measured background noise level of 73.4 dBA without the fountain and 76.6 dBA with the fountain running.

With the addition of a sound barrier on the North fence of the four Phase I courts, the maximum sound pressure level is predicted to drop to 47.3 dBA. This is well below the 50 dBA threshold goal.

It is our understanding this is a somewhat more user sensitive area, since there are yoga and meditation sessions held some mornings. There are two sound mitigation solutions proposed.

It is our recommendation that during especially sound sensitive periods, the fountain be turned on to mask pickleball and other sounds (lawn maintenance equipment, etc.) This naturally pleasing sound mitigation solution will cost very little, since the fountain is already installed, and be very effective. The fountain blocks both playground noise and pickleball noise.

It is also our recommendation that the proposed design be modified to have a 10' high barrier using reflective mass-loaded sound curtains, similar to AcoustiFence™ or equivalent, installed on the North side of the Phase I pickleball courts.

At a minimum, it should extend from the Western edge of this section for at least three courts (90 ft) towards the East. There should be no gaps at the top or bottom, or between panels. Attention to construction design should be given to ensure proper stability in case of high winds.

We recommend <u>not</u> restricting play to specific models of paddles or balls. This policy is difficult to enforce, costly for recreational players and very unpopular with higher skilled players who are training for local and national competitions. It is a tool, but a "last resort" type of approach, to be reserved for very difficult noise mitigation situations.

X. Author's Credentials

Dale Van Scoyk is a graduate of Purdue University, awarded a BS degree in Electrical Engineering. He has MBA training from Arizona State University.

He has over 25 years experience with industrial equipment design and manufacturing. He has written white papers and delivered presentations for the Institute of Electrical & Electronic Engineers (IEEE) on electromagnetic noise measurement and suppression, as well as light wave spectrum analysis, perceived light pollution and LED light technology topics.

Dale is a resident of Bonita Springs, FL and a year-round pickleball competitor in Wisconsin and Florida. He is a USA Pickleball Certified Referee, an Ambassador and a PPR Certified Pickleball Instructor. He has worked with multiple municipalities, communities and residential owners in California, the Midwest and Florida on new installations and tennis court conversions for use as pickleball courts in residential areas, where noise abatement techniques were required.

XI. 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; 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 and a plan to protect installed sound barriers from flood water.

Appendix A – On-Site Measurement of Sound

On-site sound measurements were recorded by an experienced acoustic engineer and sound technician at six locations near the proposed courts on Friday, April 14, 2023 between 9:00-11:20 a.m. The wind was light, less than 8 mph, the sky was partly cloudy, and the temperature was 77° Fahrenheit.

A Dayton Audio calibrated microphone, model UMM-6 with digital output was connected to an HP laptop running Windows 11 and REW sound measurement software. Ambient dBA sound pressure measurements were taken from a 4 ft height, consistent with the specifications in the applicable Village of Estero ordinances.

Summary Table:

Point	Ave Slow dBA	Comments
B1, no play	57.6	Next to the current courts, when there was no play was the quietest reading in the area.
B1, with play	65.5	Even when there was pickleball being played, the average maximum reading was below maximum ordinance limits of 76 dBA
B2	65.8	Somewhat away from the courts but next to Coconut Rd, the ave maximum was the same.
B4	74.5	Moving away from the current courts but toward the fountain and traffic resulted in a higher ave maximum.
B5	70.2	Next to the Enrichment Center the contribution of sound levels from existing pickleball is not as much as from the fountain and traffic.
B6	79	At a distance of over 400 ft and with earth barriers, the sound from pickleball is not a factor.
B7, no fountain	73.4	Even with no fountain, the ambient sound levels are high, with little to no contribution from pickleball play.
B7, with fountain	76.6	With the fountain on, the sound of pickleball is almost totally masked.

Raw Data (averages at bottom in boxes):

B1 – SOUTH OF COURTS

Playing

SLOW MAX	SLOW MIN
75.4	52.3
58.7	59.6
62.9	60.4
62.2	59.8
58.9	55.7
64.5	60
60.3	57
60.6	55.1
60.6	55.1
60	56.7
60.6	56.9
67.1	56.8
63	56.8
62.7	57.1

Playing

FAST MAX	FAST MIN
67.9	54.9
66.2	51
78.8	55
72.3	57.7
78.1	53.2
69.9	49.6
77.8	49.2
72.7	51.8
71	53.6
74.2	52.7
75.7	58.2
72.5	58.6
78	55.4
73.5	53.9

Not Playing

SLOW MAX	SLOW MIN
60.5	57.1
55.2	51.9
55.9	53.2
64.2	59.2
56.7	53
59.3	56.4
58.5	53.7
52.7	50.6
53.9	50.6
58.6	53.9
57.55	53.96

ONYX SLOW MAX	ONYX SLOW MIN
64.4	63.3
63.2	59.1
63.5	57.8
61.8	55.6
65.1	59.6
64	58.2
64.7	54.2
62.1	55.8
62.9	58.5
63.5	53.4
63.5	57.6

FRANKLIN SLOW MAX	FRANKLIN SLOW MIN
68.7	60.2
66.9	60.4
65.8	58.5
67.7	58.2
66.4	59.6
67	59.8
65.5	55.9
62.3	57.1
66.3	57.4
58.7	56.6
65.5	58.4

B2 – NORTH SIDE COCONUT ROAD

Playing with Franklin

SLOW MAX	SLOW MIN
62.3	57.8
69.6	59.1
65.5	64.2
65.5	59.4
65.5	56.1
65.5	56.1
65.5	56.1
70.6	56.1
65.3	57.7
63.8	59.5
65.91	58.21

Playing with Franklin

FAST MAX	FAST MIN
68.7	57.8
67.6	60.2
63.7	58.2
65.2	58.2
66.3	63.4
66.8	63.4
64.6	59.6
60	59.6
68.3	59.6
66.5	62.6
65.77	60.26

B4 – NEAR RESTROOMS

Playing

SLOW MAX	SLOW MIN
74.8	73.1
75.5	74.7
73.2	72.4
74	72.7
73.5	72.9
76.3	72.9
74.6	72.9
74.3	73.3
75.2	73.5
74	73.3
74.54	73.17

Playing

FAST MAX	FAST MIN
73.7	71.4
78.8	72.8
75.7	72.3
77	71.6
76.6	72
72.1	69
71.9	68.7
71.1	68.7
71.2	67.8
72.8	65.5
74.09	69.98

B5 – ENRICHMENT CENTER

Playing

SLOW MAX	SLOW MIN
68	66.6
70.3	69.2
71.8	70.8
71.8	70.3
68.8	68.4
70	68.9
69.7	68.6
70.6	69.4
70	69.5
71.1	69.1
70.21	69.08

Playing

FAST MAX	FAST MIN
73.9	68.6
75.3	72.9
76.2	72.2
72.6	69.2
70.9	69.8
71.3	70.2
73.5	69.9
72.5	69.1
72.9	67.8
72.2	69.2
73.13	69.89

B6 – SPRING RUN CONDOMINIUM

Playing

SLOW MAX	SLOW MIN
81	79.5
80.8	77.8
79	77.7
81.1	79
78.4	75.7
75.7	73.3
79.8	73.8
78.4	75.8
77.9	75.6
77.9	75.1
79.00	76.33

Playing

FAST MAX	FAST MIN
81.7	75.1
84.7	75.2
76.5	75.1
83	74.1
76.2	74.8
81.5	78.8
85.8	76.6
78.4	76.5
75.4	73.7
78.1	74
80.13	75.39

Appendix B – Pickleball Sound Mitigation LLC Paddle Blue List

The Pickleball Paddle Blue List

Quieter Pickleball Paddles

List updated: April 8, 2023

Introduction: The following paddles have been selected and qualified for 'Blue List' status through a testing procedure that uses a combination of metrics in addition to loudness (sound pressure). THis includes the 'pitch' and duration of the sound produced when a pickleball is struck by a paddle.

These metrics were selected after reviewing with players and non-players the characteristics of a typical pickleball hit including input from some who consider impulse sounds of this type to be annoying.

The resulting criteria were established by PSM LLC in 2022 as a means of recommending paddles to communities and pickleball clubs that are attempting to mitigate the sound of pickleball.

Test Procedure: PSM LLC is a pickleball acoustics consulting firm. We have built an echo free (or anechoic) chamber for testing pickleballs and paddles. A calibrated microphone is mounted in this chamber and a computer outside the chamber analyzes the microphone output.

Criteria: The paddles listed have a sound pressure level (SPL) below that generated by standard ½ inch thick fiberglass faced paddles. In addition, these paddles have a main pitch below 1.000 Hz and a decay time of the primary vibration mode under 5 milliseconds.

Using This List: PSM LLC updates the list as it tests and identifies additional paddles that meet the criteria.

Updating This List: To arrange additional paddle or pickleball testing, contact PSM LLC via email at rmu@pickleballsound.com.

For an updated version of The Blue List, see the PSM LLC website (pickleballsound.com) as well as the Pickleball Sound Mitigation Facebook group page. The Pickleball Paddle Blue List is copyright free.

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

Appendix C – Pickleball Sound Mitigation LLC Pickleball Ball Data (03/09/2023)

Brand	Model	Condition	dBA	Raw delta		Broken-in Dura 40 Reference
Dura yellow	Fast 40	Brand new	87.4	0db		0.5
Dura neon	Fast 40	Brand new	87.0	-0.4		0.1
Dura yellow		Slightly worn	86.9	-0.5	0 db	
Dura neon		Slightly worn	86.8	-0.6		-0.1
Dura yellow		used	86.4	-1		-0.5
Franklin	X	new	86.3	-1.1		-0.6
Core	Outdoor	new	86.1	-1.3		-0.8
Wilson	32	new	85.8	-1.6		-1.1
Engage	Tour	new	85.7	-1.7		-1.2
Franklin	X	used	85.4	-2		-1.5
Monarch	Tournament	new	85.1	-2.3		-1.8
Penn		new	85.0	-2.4		-1.9
Gamma	Indoor	new	84.7	-2.7		-2.2
Aviana		new	84.7	-2.7		-2.2
Ianoni		new	83.8	-3.6		-3.1
Onyx	Fuse	new	83.3	-4.1		-3.6
Jugs	infoor	new	83.1	-4.3		-3.8
Onix	Pure 2	very used	82.8	-4.6		-4.1
Monarch	Outdoor	new	81.6	-5.8		-5.3
Gamma	Foam	Not a Pickleball	77.7	-9.7		-9.2

Notes:

1) These ball tests were done in a high bay anechoic chamber. Each ball model was dropped onto the face of a paddle held in a vice and a microphone picked up the sound for procession. Ten drops were used for each model ball and the average sound level measured is shown above.

2) The Dura Fast 40 ball was the loudest but it varied with the wear evident on the ball. Even the color of the Dura Fast 40 mattered, at least in these tests, but no very much.

3) The slightly worn Dura Fast 40 was selected as our reference sound level for a variety of reasons.

4) PSM LLC would be pleased to test additional ball models if you can arrange to send at least two of any other model to our office in Pittsburgh. We would retain any ball types sent to us for future testing. You can call us at 412-780-4575

Appendix D – Recommended Vendors for Barrier Walls

- **Aoustiblock**,, AcoustiFence™ Tampa, FL, 813-980-1400,
  https://acoustiblok.com/acoustiblok-soundproofing-product-lines/acoustifence-noise-reducing-fences/
- **eNoise Control**, Noblesville, IN 866-481-2024,
  https://www.enoisecontrol.com/
- **Insul-Quilts™** South El Monte, CA 833-853-6444,
  https://www.insulquilt.com/