PICKLEBALL NOISE ASSESSMENT

Purpose

BC Recreation and Parks Association (BCRPA) is pleased to share the following BAP Acoustics report to inform municipal noise mitigation strategies as the first step in pickleball guideline development in BC.

BCRPA is collaborating with Pickleball BC, a Provincial Sport Organization, to provide a consistent approach to court development across BC, beginning with noise mitigation of outdoor pickleball courts.

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Noise Planning Guideline for Outdoor Pickleball Courts

BC Recreation and Parks Association
Pickleball BC

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Authorization

Noise Planning Guideline for Outdoor Pickleball Courts in British Columbia, Canada
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1 INTRODUCTION

This guideline is intended to provide Pickleball BC with planning strategies aimed at minimizing the potential community noise impacts associated with outdoor pickleball courts. The strategies provided herein were developed based on:

- Our experience with measuring, modelling, and assessing noise from outdoor pickleball courts in the province of British Columbia (BC), and
- The pickleball equipment sound level study that we conducted for Pickleball BC. The results of this study are presented in our August 31st, 2022, report: *Pickleball BC Noise Assessment – Equipment Sound Level Testing*.

2 PICKLEBALL NOISE

Based on our historical studies of pickleball noise, we have concluded that a single active pickleball court produces an A-weighted continuous equivalent sound level (L_{Aeq}) of 55 to 57dBA at a setback of 15m from the perimeter of the court lines.

There are two primary sources of noise associated with pickleball games:

- Ball hits (i.e., the ball contacting the paddle), and
- Players' voices.

Both noise sources have characteristics associated with increased risks of community noise annoyance. The ball hits create impulsive noise and the players' voices produce sound containing information.

The results of the equipment sound level testing indicate that ball hits are the dominant source of pickleball noise in terms of the L_{Aeq}. The player's voices, however, should still be considered an important source of noise due the characteristics discussed in the preceding section.

Please refer to Appendix A – Basics of Sound for a discussion of the relationship between the character of sound and community annoyance, and definitions of technical terms such as L_{Aeq} and dBA.

3 NOISE CRITERIA

The following discussion assumes that outdoor pickleball courts would not operate outside of the daytime period which is typically defined in noise regulation and guidelines as the period from 7:00 a.m. to 10:00 p.m.

3.1 Municipal Noise Bylaws

The typical daytime limit adopted by many municipalities in British Columbia for noise created and received in residential land parcels is 55dBA. Certain of these bylaws (e.g., City of Victoria, City of Richmond) also recommend lowering the limit by 5dBA when the noise in question contains an unpleasant characteristic such as tonality or impulsiveness.

3.2 Health Canada Noise Guidelines

A common approach to assessing environmental noise impacts during the daytime is to evaluate the potential for noise-induced speech interference. In their 2017 document *Guidance for Evaluating Human Health Impacts in Environmental Assessment: NOISE*, Health Canada recommend keeping outdoor noise levels below 55dBA to sustain adequate speech comprehension.

3.3 Recommended Criteria

The pickleball noise level limit recommended in this guideline is 50dBA as measured or predicted at the nearest residential property line.

This guideline limit is based on the 55dBA daytime noise level limit stipulated by municipal bylaws and the 55dBA daytime limit for noise-induced speech interference identified by Health Canada. The 50dBA target was arrived at by reducing the 55dBA limit by 5dBA to account for the impulsive character of pickleball noise.

4 NOISE CONTROL

The following section discusses various approaches to mitigating community noise impacts from pickleball courts. Since every situation will be unique, a qualified acoustical engineer should be consulted before implementing any of the mitigation measures discussed below.

4.1 Setback Distances

In most cases, maximizing the setback distance between outdoor pickleball courts and any nearby residences is the most cost-effective means of limiting pickleball noise impacts. Section 5.2 provides recommended setback distances.

4.2 Barriers

Installing noise barriers around the pickleball courts is the most practicable means of engineered noise control. There are noise barrier products available which are dense, heavy sheets that can be attached to the existing chain link fences that surround many pickleball courts (subject to wind loading and structural review). Examples of surface-mounted barrier products include the sound reflective material Acoustifence, and the sound absorptive material Kinetics KBC-100RBQ. It should be noted that the purpose of sound absorptive barriers is not to provide superior acoustical performance relative to sound reflective barriers (although they may do so in certain cases), but rather to avoid noise impacts due to reflected sound. Situations warranting the use of sound absorptive barriers are discussed later in this section.

Figure 1 shows an example of a sound reflective barrier material installed on the chain link fence at the Murdo Fraser pickleball courts in North Vancouver.

Figure 1: Pickleball courts surrounded by reflective noise barrier

Based on our analysis using computerized noise modelling, we expect a 3m tall reflective barrier to provide at least a 5dBA reduction in pickleball noise at a nearby, ground level receptor (i.e., a receptor within approximately 100m of the courts and elevated no more than 2m relative to the court surface).

To be effective, the barriers should have the following properties:

- A minimum surface density of 5kg/m^2.
- The barrier should extend at least 3m above the court surface and be largely free of gaps or holes.

- The barrier should surround at least three sides of the court. In cases where there are residences located within approximately 70m two or more sides of the court, the barrier should surround all four sides.
- Where three-sided barriers are used, the open side should face away from any residential receptors which are closer than the setback distances recommended in Section 5.2. If this is not possible, a sound absorptive barrier should be used. Otherwise, there is potential for reflected sound to impact nearby residences as shown in Figure 2.

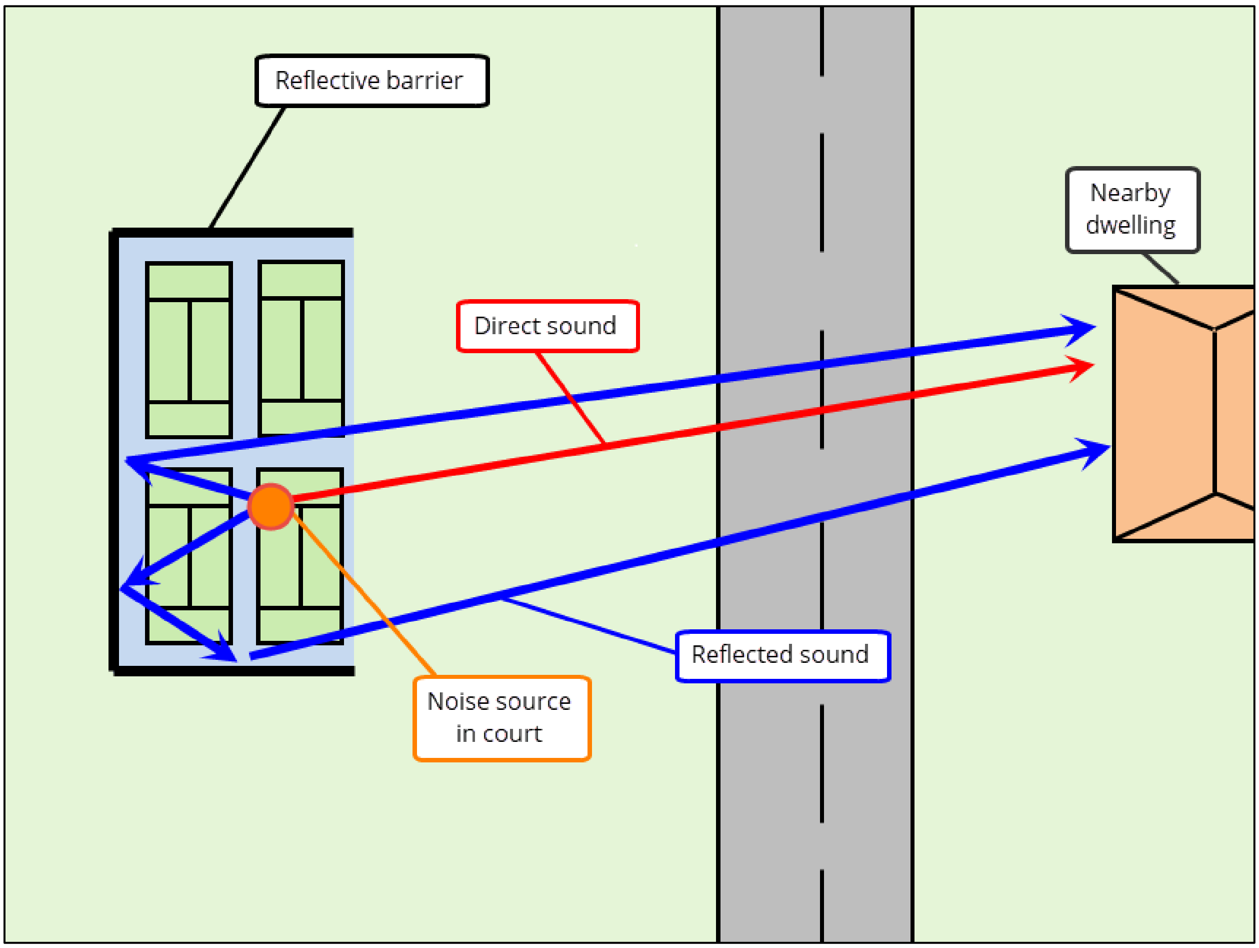

Figure 2: Reflected sound from barrier impacting residences facing the open side of the court

- Where dwellings overlook a pickleball court with barriers (i.e., upper storeys of buildings that still have a clear line of sight into the courts despite the presence of the barrier), sound absorptive barriers should be used if the setback distances recommended in Section 5.2 cannot be maintained. Otherwise, there is potential for reflected sound to impact nearby residences as shown in Figure 3 on the following page.

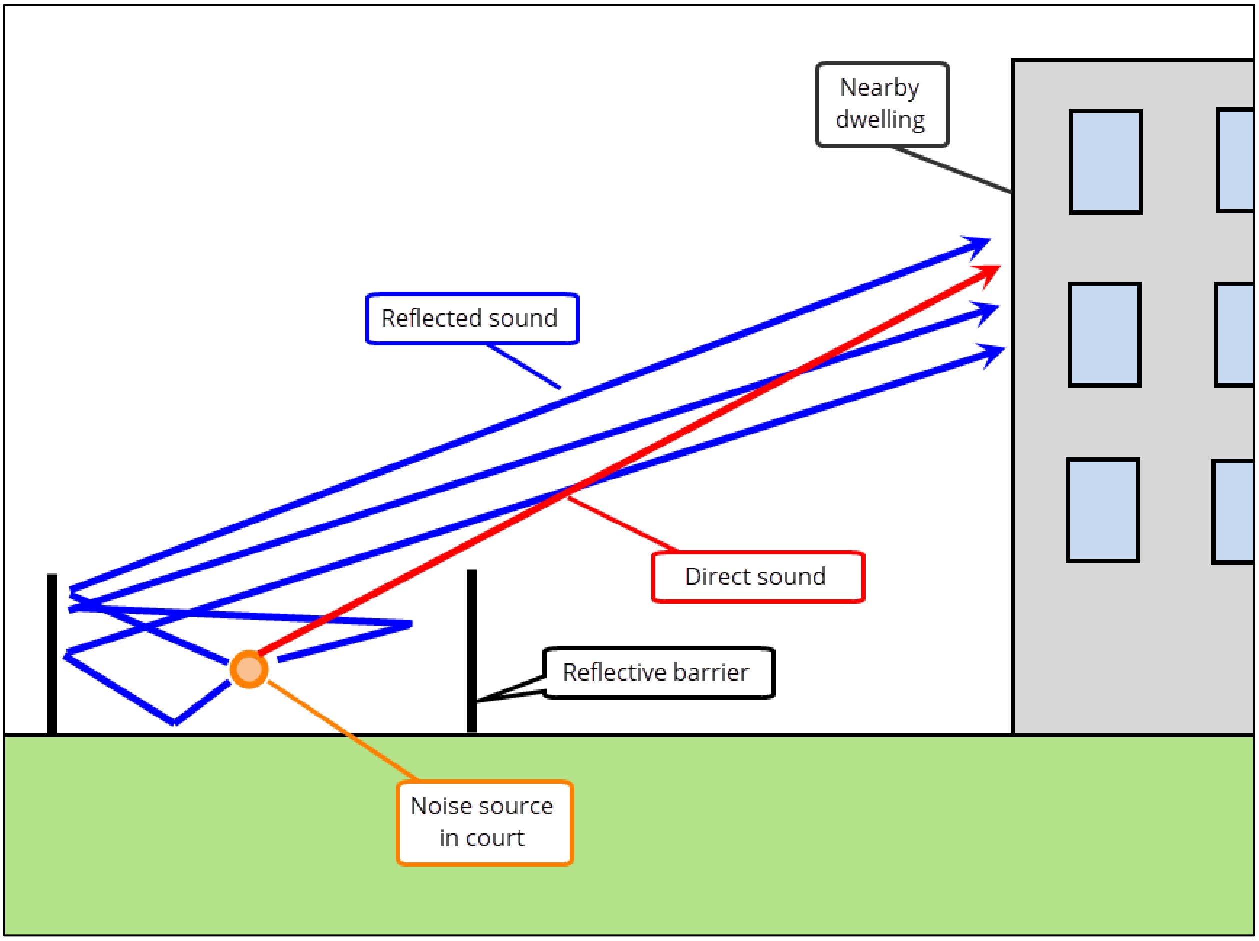

Figure 3: Reflected sound from barrier impacting multi-level building

4.3 Earth-Berms

Earth-berms can also act as effective sound barriers. Unlike vertical barriers made from common building materials, berms have an angled slope which is beneficial in controlling undesirable reflections. To be effective, an earth berm would typically need to be higher than a corresponding fence-line barrier since the berm would be located further away from the pickleball court. Given that berm slopes are typically at least 2:1 (horizontal:vertical), a 4m to 5m earth berm would require approximately 15m to 20m of land. As such, opportunities for their use will be limited by the amount of park area available.

4.4 Other approaches

Other approaches to mitigating pickleball noise include:

- Requiring players to use “quieter” equipment, and
- Introducing signage to remind players not to raise their voices or shout.

The results of the equipment sound level measurements presented in our August 31st, 2022, report found that certain equipment (i.e., “quieter” equipment) produced sound levels that were 5dBA lower than the average levels previously measured by BAP Acoustics. As such, it may be possible to reduce the typical noise levels produced by pickleball courts by up to approximately 5dBA through use of “quieter” equipment selections. A 5dBA reduction is significant as it is generally considered to be the threshold of effectiveness for community noise mitigation.

Since the approaches outlined above would be difficult to regulate, preference should be given to the other mitigation strategies presented in this guideline. As noted in our August 31st, 2022, report, further research is needed to verify the effectiveness of using “quieter” equipment to mitigate pickleball noise.

5 SITING

5.1 General Considerations

When considering a site for outdoor pickleball courts, the following should be considered:

- **Setback distance:** The setback distance between the courts and the nearest residential area will typically be the most important determinant of whether the introduction of a pickleball court will result in noise complaints. Please refer to Table 1 in Section 5.2 for recommended setback distances.
- **Ground type:** Preference should be given to sites where there is acoustically soft ground (e.g., grass, foliage) between the pickleball courts and residential areas.
- **Terrain obstacles:** Wherever possible, pickleball courts should be sited to take advantage of naturally occurring terrain obstacles (e.g., locating the pickleball courts behind a berm). Conversely, situations should be avoided where residences or the upper-level dwellings of high-rise buildings will overlook the courts.

- **Foliage:** In certain situations, it may be possible to site the pickleball courts to take advantage of the shielding provided by dense foliage. A 50m wide tree belt consisting of tall trees and dense foliage is expected to reduce pickleball noise by approximately 3 to 5dBA.

5.2 Recommended Setback Distances

Table 1 provides the minimum setback distances recommended to meet the 50dBA target. Note that these setback distances apply to the perimeter of the court lines, rather than to the court boundary (i.e., fence line). Specifying setbacks based on the court lines is more accurate as the distance between the court lines and court boundary will vary from court to court.

The table includes four columns of setback distances to address the following scenarios:

- No noise mitigation and intervening terrain between the courts and residences is acoustically hard (e.g., pavement).
- No noise mitigation and intervening terrain between the courts and residences is acoustically soft (e.g., grass, loose soil).
- 3m tall noise barrier around courts and intervening terrain between the courts and residences is acoustically hard (e.g., pavement).
- 3m tall noise barrier around courts and intervening terrain between the courts and residences is acoustically soft (e.g., grass, loose soil).

Table 1: Minimum setback distances to meet 50dBA

Number of Courts	Setback Distance required to meet 50dBA (m)			
	No Noise Mitigation		3m Noise Barrier[1]	
	Hard Ground	Soft Ground	Hard Ground	Soft Ground
2 (1x2 grid)	65	50	35	30
4 (2x2 grid)	90	75	50	45
6 (2x3 grid)	105	85	55	50
12 (3x4 grid)	160	115	75	60

Table Notes:

1. Does not apply to situations where the point of reception overlooks the court

We have also developed recommended setback distances based on the use of "quieter" equipment. These recommended setback distances assume the use of equipment that results in a single pickleball game producing an L_{Aeq} of 50 to 52dBA at setback distance of 15m. Table 2 presents these recommended setback distances.

Table 2: Minimum setback distances to meet 50dBA with the use of “quieter” equipment

Number of Courts	Setback Distance required to meet 50dBA (m)			
	Quieter Equipment, No Barrier		Quieter Equipment + 3m Noise Barrier[1]	
	Hard Ground	Soft Ground	Hard Ground	Soft Ground
2 (1x2 grid)	35	30	20	15
4 (2x2 grid)	50	45	25	20
6 (2x3 grid)	55	50	30	25
12 (3x4 grid)	75	60	40	35

Table Notes:

1. Does not apply to situations where the point of reception overlooks the court

Appendix A - Basics of Sound

The phenomenon we perceive as sound results from fluctuations in air pressure close to our ears. These fluctuations result from vibrating objects, such as human vocal cords, loudspeakers and engines etc. Sound pressure is measured using the Pascal. The ratio of the quietest to the loudest sound that the human ear can hear is a billion to one. Therefore, sound pressure is commonly expressed using the logarithmic decibel (dB) unit. When sound pressure is expressed in decibels, it is called sound pressure level. The loudest sound pressure level we can hear without immediately damaging our hearing is 120dB and the faintest sound we can detect is 0dB.

When sound is received at a given location from two or more sources, the contributions of each source will add together. When expressed in decibels, the addition occurs logarithmically rather than arithmetically. For example, two sound sources producing 50dB would add together to create a total sound level of 53dB; not 100dB. A 3dB change in noise level would be just noticeable to the human ear. A 10dB change in noise level is typically perceived as a halving or doubling of loudness (depending on whether the noise level increased or decreased).

Human sound perception depends on both the level and the frequency content of a given sound source. Frequency is defined as the number of times per second that pressure fluctuations occur. The frequency reflects the pitch of the sound. It is expressed in Hertz (Hz). The average young human listener can perceive sound frequencies from 20Hz to 20,000Hz. Human hearing is less sensitive to low frequency sound levels (below 200Hz) and to high frequency sound levels (above 5000Hz). The human ear is most “tuned” to the vocal frequency range between 200Hz and 5000Hz. For acoustic engineering purposes, the audible frequency range is normally divided up into discrete bands. The most commonly used bands are octave bands, in which the upper limiting frequency for any band is twice the lower limiting frequency, and one-third octave bands, which are the result of subdividing each octave band into three. The bands are described by their centre frequency value. The range that is typically used for environmental purposes is from 31Hz to 8kHz (octave bands).

Acoustic Metrics

A-weighting

The microphone of a sound level meter, unlike the human ear, is designed to be equally sensitive to sound throughout the audible frequency range. To compensate for this, the A-weighting filter of a sound level meter is used to approximate the frequency sensitivity of the human ear. As such, A-weighted sound pressure levels (dBA) give less emphasis to low and high frequencies, and are correspondingly tuned to the vocal frequency range between 200Hz and 5000Hz.

L_{Aeq}

The A-weighted equivalent continuous sound pressure level (L_{Aeq}) is the most common acoustic metric used to describe sound levels that vary over time. The L_{Aeq} is an energy average. It is calculated by storing and logarithmically averaging the sound of all events recorded during the measurement period. The L_{Aeq} can be measured over any time period.

L_d

The A-weighted equivalent continuous sound pressure level (L_{Aeq}) evaluated over the 15-hour time period between 07:00 to 22:00 hours.

L_n

The A-weighted equivalent continuous sound pressure level (L_{Aeq}) evaluated over the 9-hour time period between 22:00 to 07:00 hours.

L_{90}

The sound exceeded over 90% of the time during the measurement period. The L_{90} represents the background noise level measured between discrete noise events, such as car pass-bys.

Example: A quiet fan is running at a continuous level of 30dBA at a specific measurement location. During a 10-minute measurement period, there are 9 minutes of car pass-by events that exceed the sound level of the fan. The L_{90} of the measurement is 30dBA, because this level was exceeded for over 90% of the measurement duration.

Character of Sound

In addition to the level at which sound occurs, its character can also influence the degree to which it is perceived as unpleasant or undesirable. The two most common characteristics that tend to render sound more objectionable are tonality and impulsivity. It is common in noise legislation and published standard to apply penalties to sounds containing these characteristics.

Tonal Sound

Tonal sound refers to any sound where the acoustic energy is concentrated in a narrow part of the frequency spectrum. Examples of tonal sounds include the “hum” of a fan or heat pump, or the “whine” of a hydraulic pump or power saw.

Impulsive Sound

Impulsive sound refers to any sound with a brief duration, in which the onset is abrupt and the decay rapid. Examples of impulsive sounds include a nail struck by a hammer or a baseball hit with a bat.

Sounds containing information

Sounds that contain information, such as human voices, trigger auditory cognition. Consequently, these sounds tend to be more distracting and intrusive than sounds devoid of information.

Basics of Outdoor Sound Propagation

As sound waves propagate through the environment, energy is lost through geometrical divergence, atmospheric absorption, refraction in the atmosphere, ground effects and the screening of obstacles.

Geometrical Divergence

Sound intensity decreases with increasing distance from a sound source. Losses from geometrical divergence result from the spreading of the sound source energy over larger and larger areas as the distance between the original sound source and receiver position increases. Sound attenuation through geometrical divergence is nominally independent of frequency, weather and atmospheric absorption losses.

Atmospheric Absorption

Sound waves propagating through free air are attenuated through a combination of classical (heat conduction and shear viscosity) losses and molecular relaxation losses. At long outdoor propagation distances and for higher frequencies, attenuation due to atmospheric absorption is usually much greater than the attenuation due to geometrical divergence.

Refraction

The speed of sound relative to the ground is a function of temperature and wind velocity. Both temperature and wind velocity vary with height. Temperature and wind gradients therefore cause sound waves to propagate along curved paths. On a hot summer day, solar radiation heats the earth's surface resulting in warmer air near the ground. This condition is called a temperature lapse. It causes sound rays to curve upwards. An opposite condition, called a temperature inversion, results when air is cooler at the ground surface than at higher elevations. Sound paths curve downwards during such a condition.

Wind also causes sound waves to bend upwards or downwards. Sound will propagate upwind when a source is downwind of a receiver. Wind speeds increase with height and this leads to a negative sound speed gradient. Sound waves will bend upwards under this condition.

Ground Effect

The ground effect refers to the interference (destructive and constructive) between sound reflected off the ground surface and sound travelling directly between a source and receiver. Ground effect interference has the potential to both enhance and attenuate sound as it propagates through the outdoors. The ground effect is sensitive to the acoustical properties of the ground surface.

Screening

Intervening terrain and artificial barriers (such as buildings or noise barriers) can attenuate sound by interrupting its path to a receiver. Screening effects are most pronounced when the screening obstacle completely blocks line of sight from the receiver to the sound source.