PSM LLC
Pickleball Sound Mitigation

Pickleball Sound Assessment Report with Recommendations

For Brooks CDD and Brooks II CDD

SWEET BAY ADDENDUM

by

Dale H. Van Scoyk

June 26, 2023

I. Overview of the Courts and Sweet Bay Area

Pickleball Sound Mitigation LLC has been requested to report on the effects of the planned sound mitigation barriers on propagated sound towards the Sweet Bay residences to the north of the courts, particularly the impacts from Phase 1 additions.

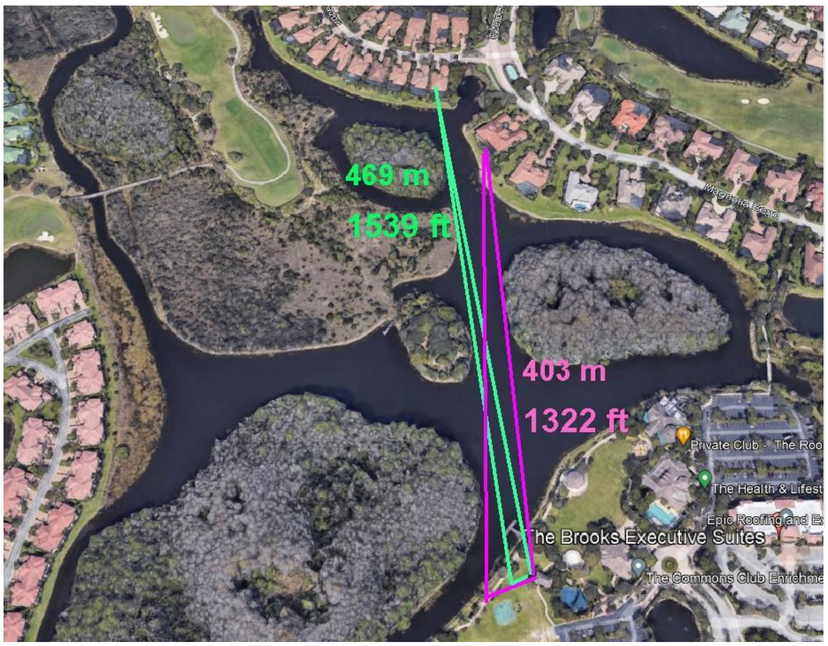
Phase 1 calls for the construction of four new pickleball courts northeast of the current three courts. The yellow rectangle describes the location.

Phase 2 calls for demolition of the current courts and construction of eight courts to the south of the Phase 1 courts. See the orange outline.

The use of sound mitigation panels has been recommended and adopted for the Phase 1 plan on most of the north and all of the east sides of the courts. The northern fence and sound panels are to be 10 ft high and the east fence and sound panels will be 10 ft high.

The original panel material recommended was Acoustifence, a highly reflective mass loaded vinyl style material; however, a new option has been recommended, which is a quilted and fiber-filled mass loaded vinyl manufactured by Insul-Quilts. The quilted version has better sound absorption qualities and an excellent track record of environmental longevity. The same positions and heights will be used.

The relative locations and distances of the Sweet Bay residences are shown in the next figure.



Pickleball sound propagates primarily on an unimpeded line-of-sight path. There are straight-line paths from only two homes in Sweet Bay to the Phase 1 pickleball courts. These are the only paths that go between the undeveloped nature islands and also avoid the restroom building:

- 9867 May Meadows   1539 ft   *(469m)*
- 10009 Magnolia Bend   1322 ft   *(403m)*

These paths end at courts 2, 3 and 4 of Phase 1. The northern 10 ft fence with sound barriers attached blocks sound towards the two paths.

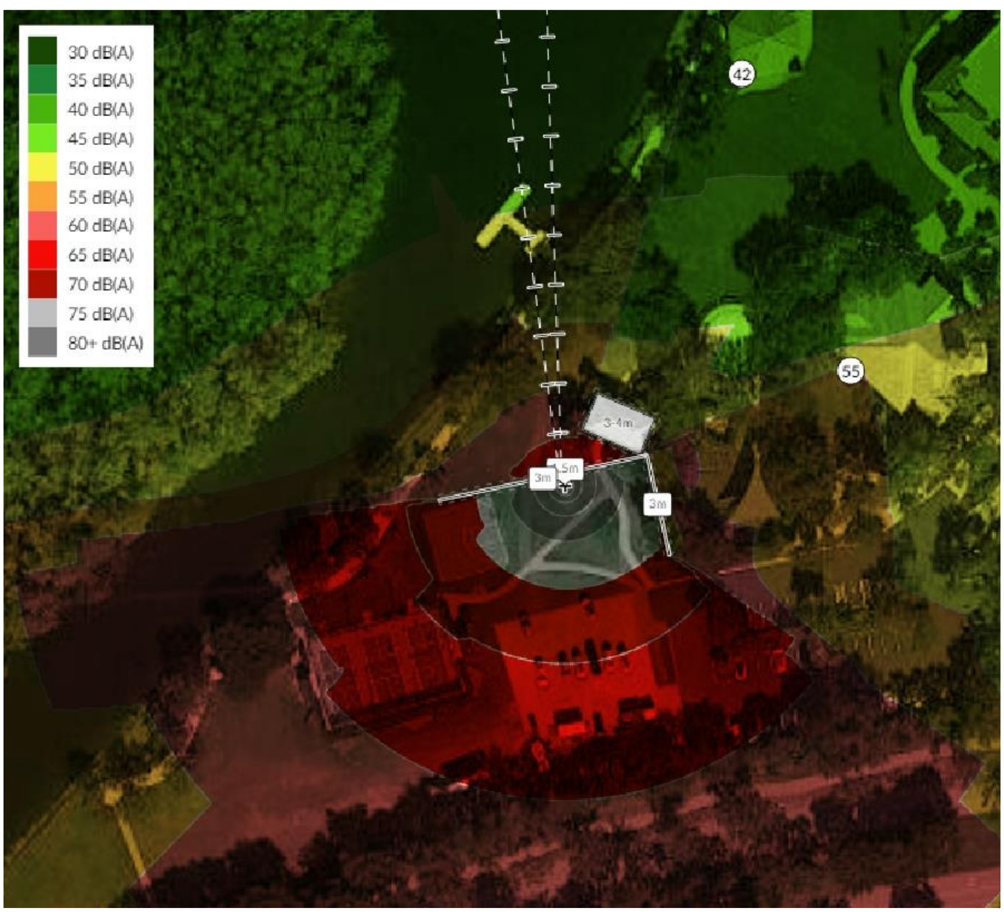
Recall that the **Village of Estero limits maximum sound levels to 76 dBA** from 7:00 a.m. to 10:00 p.m., after correcting +10 dB for impulse sound characteristics and that the **ANSI 12.9 Part 5 standards recommend a limit of 55 dBA** at residences. The ANSI standard is based on national studies of *annoyance levels* found to be acceptable to “reasonable people with normal sensitivities.”

II. Predicted Sound Levels with Barriers

Using advanced modeling software, it is possible to plot color sound maps describing the propagation of sound (with pickleball characteristics) from a point source, like at the pickleball courts. The following parameters were used for creating a sound map of the Commons campus and Sweet Bay areas:

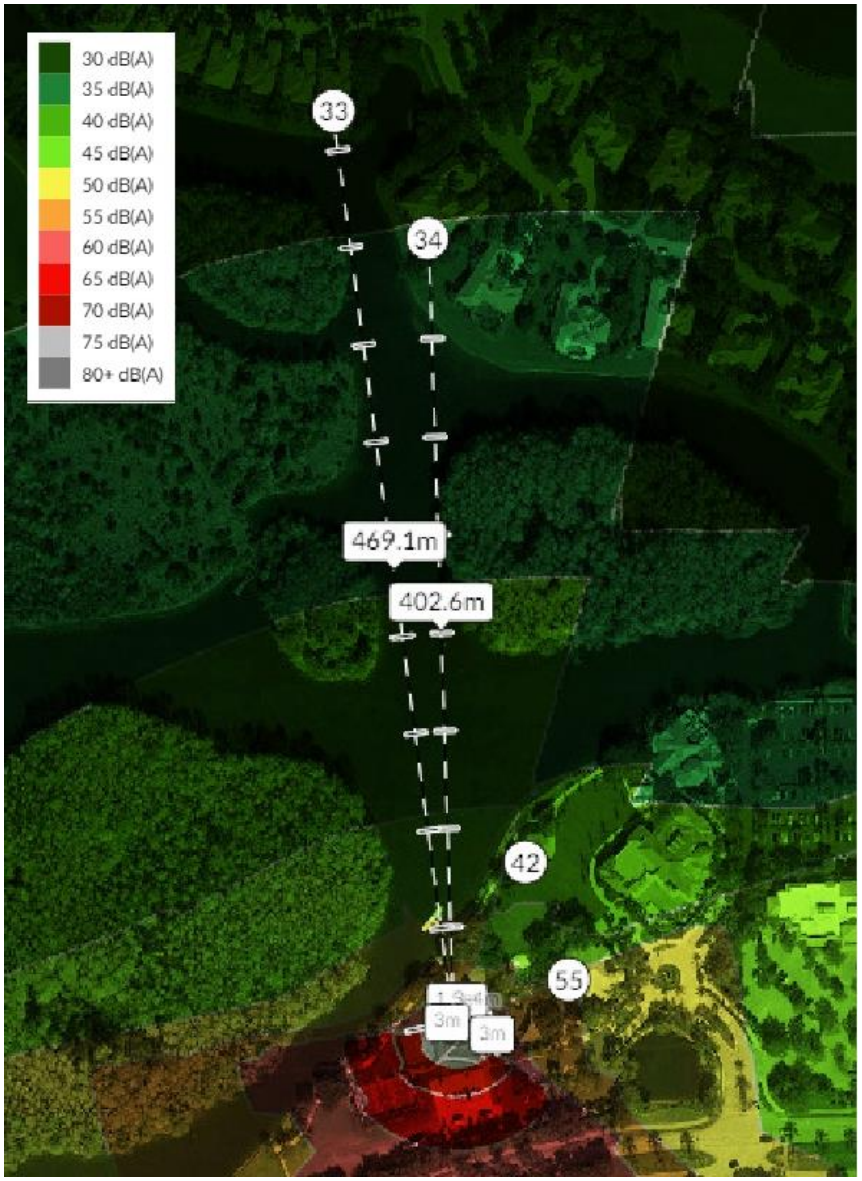
Sound Source -- 108 dB, 5 ft *(1.5m)* above courts, 1200 Hz, located Court 2
Receiving Points -- 5 ft *(1.5m)* above ground level
Northern barrier – 10 ft (*3.0m),* .43 Coefficient of reflectivity (low) both sides
Eastern barrier – 10 ft (3.0m), .43 Coefficient of reflectivity (low) both sides
Ground Factor – 0, “hard surface” simulating water, streets
Barrier Attenuation -- Includes vertical diffraction calculations
Restroom Bldg – peaked roof sloping from *3m* to *4m* high, 1.0 Coefficient of reflectivity (high)

<u>Sound Map of the Commons Campus Area</u>



Numbers in white circles indicate the sound level in dBA at that point. Colors show the sound pressure level gradient.

Sound Map Including Sweet Bay



Analysis and sound maps clearly show that sound pressure levels at the Sweet Bay properties are predicted to be much below the ANSI standard and not a problem: however, homeowners have expressed concerns about factors like "sound traveling across water," examples of personal experience with sound coming from events at the Commons Pagoda, the effects of wind on sound, etc. The following notes will provide more background on the science related to these factors.

III. Sound Propagation Fundamentals

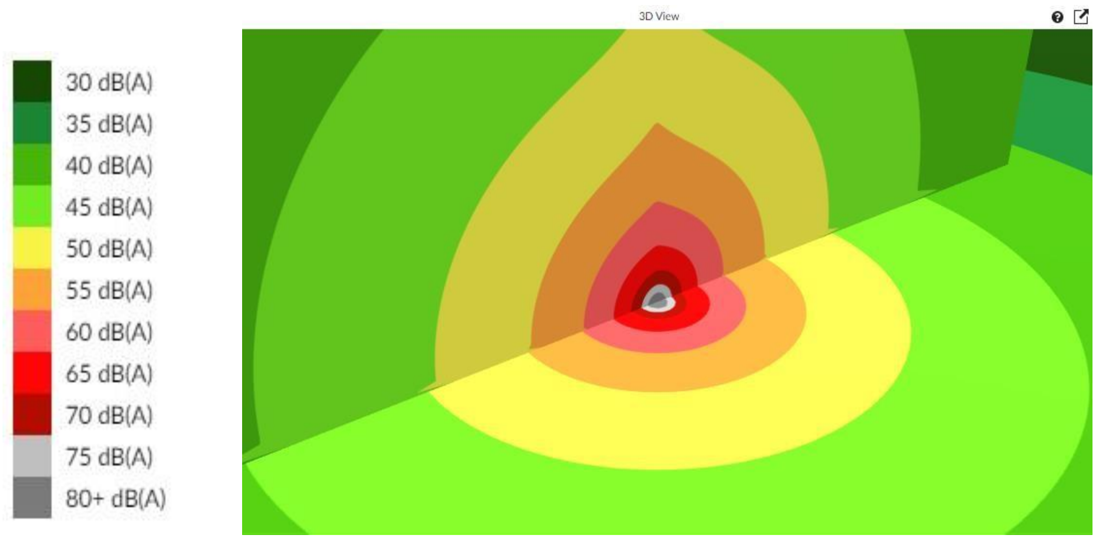
Sound is a sequence of waves of pressure which propagates (travels) through a compressible media such as air or water. During their propagation, waves can be **attenuated** (absorbed), **reflected**, **diffracted**, and **refracted** by the medium.

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.

Attenuation

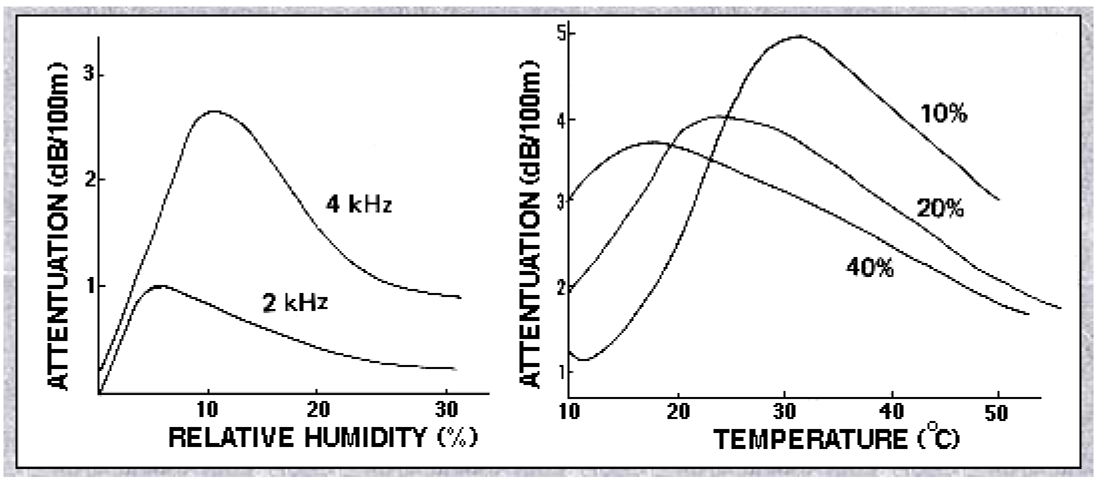
The following diagram shows sound propagating away from a point source over level ground using a noise modeling tool. This diagram shows the horizontal plane of sound propagation. Each colored ring represents a 5 dB decrease of sounds as indicated by the legend. Sound decreases in level as a listener moves away from a sound source or as the sound source is moved farther away from a stationary listener. The 6 dB reduction for every doubling of distance is evident in the increasing diameter of each ring outward from the center.

Sound also propagates away from a source in the vertical direction. The following diagram shows a three-dimensional view of the vertical plane of sound propagation together with the horizontal plane.

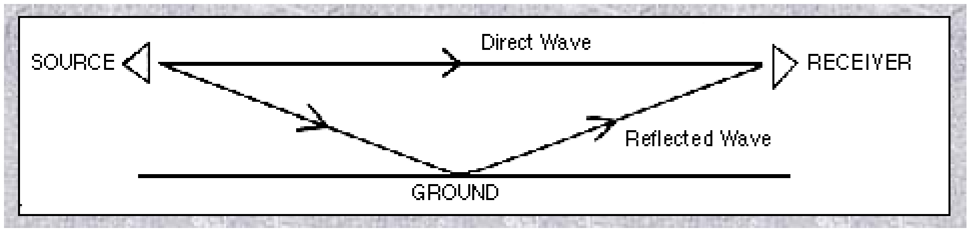


Atmospheric conditions affect propagation.

The wind, temperature and humidity of air, the primary medium for pickleball sound, affect attenuation, so changing conditions complicate prediction of losses. On calm, humid, warm days when the density of air molecules is greater, the losses are less and sound propagates further/faster. In mornings or evenings, versus midday, the different conditions will result in different reception of sound at distance.



Reflection



If sound is propagating over ground, attenuation will occur due to acoustic energy losses on reflection. The losses will depend on the surface. Smooth, hard surfaces and water will produce less absorption, whereas thick grass may result in sound levels being reduced more. Higher frequencies, like pickleball at 1000 Hz, are attenuated more than low frequencies.

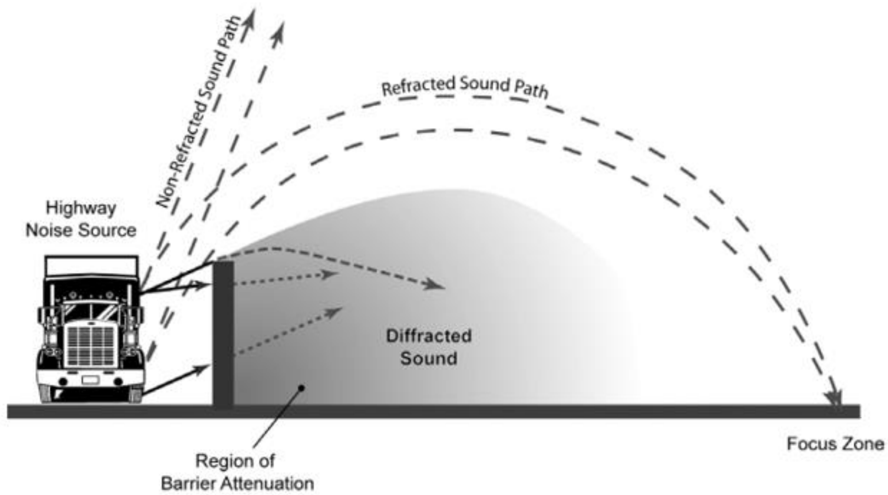
Note that wind in a specific direction may reduce absorption losses, resulting in higher SPL; however, if it has created waves in water over which the sound is traveling, it may reduce reflection and offset the higher SPL caused by the wind.

Reflection of sound off buildings, barriers, even poles and trees can result in reverberations and echoes. If a reflected sound reaches a human ear within 0.1 seconds of the original sound, it seems to the person that the sound is prolonged. These are reverberation effects.

If the elapsed time between reception of reflected sound waves is longer than 0.1 seconds, there will be an echo, instead of a reverberation.

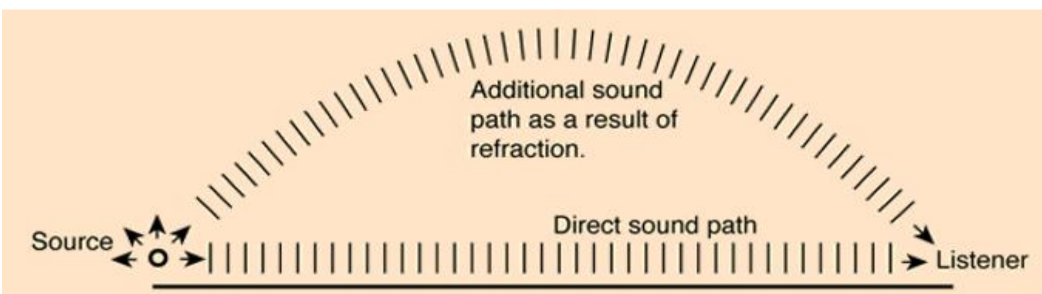
Diffraction

Diffraction involves the change in direction of sound waves as they pass through an opening or around a barrier in their path. The waves actually bend around the barrier.



This conceptual diagram shows how highway sound diffracts over and around the sides of barriers and can result in traffic noise propagation. Another common example of the principle is when people can hear conversations from another room or around corners, despite only slight openings. Higher barriers and careful closing of gaps between sound mitigation panels are important to achieving the desired results.

Refraction



Refraction of waves involves a change in the direction of waves as they pass from one medium to another. Refraction, or bending of the waves, is accompanied by a change in speed and wavelength of the waves. For example, sound waves are known to refract when traveling over water. Water has a moderating effect upon temperature of air, so the air directly above the water tends to be cooler than the air far above water. Sound waves travel slower in cooler air than in warmer air, so the two different medium's conditions can result in a bending wave – and a second sound path if there is a temperature inversion.

The phenomenon of sound refracting in air over water is more pronounced over longer distances, i.e. greater than 1000 ft. The effects of refraction over shorter distances, for instance less than 700 ft, are not as significant.

IV. Conclusions and Recommendations

The concerns of Sweet Bay homeowners are being taken seriously, as evidenced by this analysis and report regarding pickleball noise at their properties.

A. Sound mitigation barrier **panels have been added** to the north fence of Phase 1, the **fence has been increased in height** to 10 ft from 8 ft and **panel materials have been changed to Insul-Quilt** in all areas, which will more effectively attenuate sound in the direction of the Sweet Bay residences.

B. The combination of a relatively long distance, the barrier panels, and the narrowness of the unobstructed path for sound to propagate will result in **much less than 55 dBA** of noise at the Sweet Bay residences.

C. **Environmental Factors** may occasionally result in a low-level sound of pickleball play being audible under specific conditions, but the infrequency of these conditions and the modest severity of the effects are expected to make this tolerable.
   - At dusk, after a particularly warm day, the temperature of the water will cool and the air above will be warmer, setting up a temperature inversion condition that may be conducive to refracted sound. An additional path of sound might result in hearing the feint sounds of stronger pickleball hits. If so, the level of sound would be well under the level of normal conversation between two people and it would be intermittent, not continuous, because you are only hearing the hardest of strikes.
   - If there is a steady wind or strong gusts blowing from south to north, it may slightly increase the ability to distinguish pickleball play from other sounds from the Commons area. That wind condition will likely create a rougher water surface and reflection of sound will be less, thus an offsetting factor.

D. **Additional Sound Mitigation methods are still available, if needed.** The City of Estero PBZD voted to approve the construction of courts per the plan submitted; however, a condition was that if there were significant complaints about noise after placing them in play, the Brooks CDD was responsible for implementing a remedy.

Among the mitigation options that remain are:

- Limit the models of paddles that can be used to quieter types..
- Limit the types of balls that can be used.
- Limit the hours of play.
- Add a sound masking device, like a fountain in the lagoon between the courts and Sweet Bay.
- Add more sound mitigation devices, either blocking or absorbing – higher walls, block walls, vegetation, etc.

There are no recommended changes to the design at this time.

V. 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.

VI. 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.